This is the EgyptAir Flight Crew Operating Manual – Volume 1, Issue No. 013.

To bring this manual up to date, remove old pages and insert revised pages as follows:

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Model BD–500–1A11

EgyptAir

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The Flight Crew Operating Manual, Volume 1, is valid only when all the issued revisions are incorporated. Record the date you insert each revision in your manual.

Issue	Description of change	Signature / Date Incorporated
001	Introduces changes to incorporate new engineering, miscellaneous comments and editorial changes.	Signature on file Sept 09/2016
002	Introduces changes to incorporate new engineering, miscellaneous comments and editorial changes.	Signature on file Nov 03/2016
003	Introduces changes to incorporate new engineering, miscellaneous comments and editorial changes. Added and corrected illustrations.	Signature on file Dec 09/2016
004	Introduces changes to incorporate new engineering, miscellaneous comments and editorial changes. Added and corrected illustrations.	Signature on file Jan 18/2017
005	Introduces changes to incorporate new engineering, miscellaneous comments and editorial changes. Added and corrected illustrations.	Signature on file Mar 17/2017
006	Introduces changes to incorporate new engineering, miscellaneous comments and editorial changes. Added and corrected illustrations.	Signature on file Sep 14/2017
007	Introduces changes to incorporate new engineering, miscellaneous comments and editorial changes. Added and corrected illustrations.	Signature on file Jan 16/2018
008	Introduces changes to incorporate new engineering, miscellaneous comments and editorial changes. Added and corrected illustrations.	Signature on file Aug 06/2018

Issue	Description of change	Signature / Date Incorporated
009	Introduces changes to incorporate new engineering, miscellaneous comments and editorial changes. Added and corrected illustrations.	Signature on file Oct 11/2018
010	Introduces changes to incorporate new engineering, miscellaneous comments and editorial changes. Added and corrected illustrations.	Signature on file Dec 13/2018
011	Introduces changes to incorporate new engineering, miscellaneous comments and editorial changes. Added and corrected illustrations.	Signature on file May 16/2019
012	Introduces changes to incorporate new engineering, miscellaneous comments and editorial changes. Added and corrected illustrations.	Signature on file Jul 26/2019
013	Introduces changes to incorporate new engineering, miscellaneous comments and editorial changes. Added and corrected illustrations.	Signature on file Sep 23/2019

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	–14	Dec 13/2018			

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Page		Date	Page		Date
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	–2	Jul 26/2019		–24	Dec 13/2018
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	–11	May 16/2019		–33	Dec 13/2018
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Page		Date	Page		Date
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Page			Date	Page		Date
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	–23	*	Sep 23/2019		–7	Dec 13/2018
	–24		Dec 13/2018		–8	Dec 13/2018
					–9	Dec 13/2018
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Page			Date	Page		Date
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Page		Date	Page		Date
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	–4	Jul 26/2019			
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Page		Date	Page		Date
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06–03	–1	Dec 13/2018		–11	Dec 13/2018
	–2	Dec 13/2018		–12	Dec 13/2018
	–3	Dec 13/2018	06–07	–1	Dec 13/2018
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	–6	Dec 13/2018		–4	* Sep 23/2019
				–5	May 16/2019

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Page			Date	Page		Date
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07−04	−1		Dec 13/2018		−17	Dec 13/2018
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	−8		Dec 13/2018		−24	Dec 13/2018
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	–2	Dec 13/2018		–33	Dec 13/2018
08–02	–1	Dec 13/2018		–34	May 16/2019
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Page			Date	Page			Date
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08–04	–1	Dec 13/2018		–36	Dec 13/2018
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Page		Date	Page		Date
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Page			Date	Page			Date
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Page			Date	Page			Date
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Page			Date	Page			Date
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16–07	–1	Dec 13/2018		–3	*	Sep 23/2019
	–2	May 16/2019		–4	*	Sep 23/2019
	–3	May 16/2019		–5	*	Sep 23/2019
	–4	Dec 13/2018		–6	*	Sep 23/2019
				–7	*	Sep 23/2019

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	–8	*	Sep 23/2019		–4		Dec 13/2018
	–9	*	Sep 23/2019		–5		Dec 13/2018
	–10	*	Sep 23/2019		–6		Dec 13/2018
	–11	*	Sep 23/2019	18–02	–1		Dec 13/2018
	–12	*	Sep 23/2019		–2		Dec 13/2018
	–13	*	Sep 23/2019		–3		Dec 13/2018
	–14	*	Sep 23/2019		–4		Dec 13/2018
	–15	*	Sep 23/2019		–5		Dec 13/2018
	–16	*	Sep 23/2019		–6		Dec 13/2018
	–17	*	Sep 23/2019		–7		Dec 13/2018
	–18	*	Sep 23/2019		–8		Dec 13/2018
	–19	*	Sep 23/2019	18–03	–1		Dec 13/2018
	–20	*	Sep 23/2019		–2		Dec 13/2018
17–04	–1	*	Sep 23/2019		–3		Dec 13/2018
	–2	*	Sep 23/2019		–4		Dec 13/2018
	–3	*	Sep 23/2019		–5		Dec 13/2018
	–4		Dec 13/2018		–6		Dec 13/2018
17–05	–1	*	Sep 23/2019		–7		Dec 13/2018
	–2		Dec 13/2018		–8		Dec 13/2018
18–00	–1		Dec 13/2018		–9		Dec 13/2018
	–2	*	Sep 23/2019		–10		Dec 13/2018
	–3		Dec 13/2018		–11		Dec 13/2018
	–4		Dec 13/2018		–12		Dec 13/2018
	–5		Dec 13/2018		–13		Dec 13/2018
	–6		Dec 13/2018		–14		Dec 13/2018
	–7	*	Sep 23/2019	18–04	–1		Dec 13/2018
	–8		Dec 13/2018		–2		Dec 13/2018
	–9		Dec 13/2018		–3		Dec 13/2018
	–10		Dec 13/2018		–4		Dec 13/2018
18–01	–1	*	Sep 23/2019		–5		Dec 13/2018
	–2		Dec 13/2018		–6		Dec 13/2018
	–3		Dec 13/2018		–7		Dec 13/2018
					–8		Dec 13/2018

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	–10		Dec 13/2018		–16		Dec 13/2018
18–05	–1	*	Sep 23/2019	18–08	–1		Dec 13/2018
	–2		Dec 13/2018		–2	*	Sep 23/2019
	–3	*	Sep 23/2019		–3	*	Sep 23/2019
	–4	*	Sep 23/2019		–4	*	Sep 23/2019
	–5	*	Sep 23/2019		–5	*	Sep 23/2019
	–6	*	Sep 23/2019		–6	*	Sep 23/2019
	–7	*	Sep 23/2019	18–09	–1		Dec 13/2018
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	–10	*	Sep 23/2019		–4		Dec 13/2018
18–06	–1		Dec 13/2018		–5		Dec 13/2018
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	–6		Dec 13/2018		–10		Dec 13/2018
18–07	–1		Dec 13/2018		–11		Dec 13/2018
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	–4		Dec 13/2018		–14		Dec 13/2018
	–5		Dec 13/2018		–15	*	Sep 23/2019
	–6		Dec 13/2018		–16		Dec 13/2018
	–7		Dec 13/2018		–17		Dec 13/2018
	–8		Dec 13/2018		–18		May 16/2019
	–9		Dec 13/2018		–19		Jul 26/2019
	–10		Dec 13/2018		–20		Dec 13/2018
	–11		Dec 13/2018		–21		Dec 13/2018
	–12		Dec 13/2018		–22		Dec 13/2018
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					–25		Dec 13/2018

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	–26		Dec 13/2018		–3		Dec 13/2018
	–27		Dec 13/2018		–4		Dec 13/2018
	–28		Dec 13/2018	19–04	–1	*	Sep 23/2019
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	–30		Dec 13/2018		–3		Dec 13/2018
	–31		Dec 13/2018		–4		Dec 13/2018
	–32		Dec 13/2018		–5		Dec 13/2018
	–33		Dec 13/2018		–6		Dec 13/2018
	–34		Dec 13/2018	19–05	–1		Dec 13/2018
	–35		Dec 13/2018		–2		Dec 13/2018
	–36		Dec 13/2018		–3		Dec 13/2018
	–37		Dec 13/2018		–4		Dec 13/2018
	–38		Dec 13/2018		–5		Dec 13/2018
	–39		Dec 13/2018		–6		Dec 13/2018
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	–42		Dec 13/2018	20–01	–1		Dec 13/2018
	–43		Dec 13/2018		–2		Dec 13/2018
	–44		Dec 13/2018	20–02	–1		Dec 13/2018
19–00	–1		Dec 13/2018		–2		Dec 13/2018
	–2		Dec 13/2018		–3		Dec 13/2018
	–3		Dec 13/2018		–4		Dec 13/2018
	–4		Dec 13/2018		–5		Dec 13/2018
19–01	–1		Dec 13/2018		–6		Dec 13/2018
	–2		Dec 13/2018	20–03	–1		Dec 13/2018
19–02	–1		Dec 13/2018		–2		Dec 13/2018
	–2		Dec 13/2018		–3		Dec 13/2018
	–3		Dec 13/2018		–4		Dec 13/2018
	–4		Dec 13/2018	20–04	–1		Dec 13/2018
19–03	–1		Dec 13/2018		–2		Dec 13/2018
	–2		Dec 13/2018				

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21–00	–1		Dec 13/2018		–10		Dec 13/2018
	–2		Dec 13/2018		–11		Dec 13/2018
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	–4		Dec 13/2018		–13		Dec 13/2018
21–01	–1		Dec 13/2018		–14		Dec 13/2018
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	–3		Dec 13/2018		–16		Dec 13/2018
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	–6		Dec 13/2018		–19		Dec 13/2018
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	–8		Dec 13/2018		–21		Dec 13/2018
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	–19		Dec 13/2018		–32		Dec 13/2018
	–20		Dec 13/2018		–33		Dec 13/2018
21–02	–1		Dec 13/2018		–34		Dec 13/2018
	–2		Dec 13/2018	21–03	–1		Dec 13/2018
	–3		Dec 13/2018		–2		Dec 13/2018
	–4		Dec 13/2018	22–00	–1	*	Sep 23/2019
	–5		Dec 13/2018		–2	*	Sep 23/2019
	–6		Dec 13/2018		–3	*	Sep 23/2019
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	–8		Dec 13/2018		–5		Jul 26/2019
	–9		Dec 13/2018		–6	*	Sep 23/2019

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	–7	*	Sep 23/2019		–26		Dec 13/2018
	–8	*	Sep 23/2019		–27		Dec 13/2018
	–9	*	Sep 23/2019		–28		Dec 13/2018
	–10	*	Sep 23/2019		–29		Dec 13/2018
	–11	*	Sep 23/2019		–30		May 16/2019
	–12	*	Sep 23/2019		–31		May 16/2019
					–32		Dec 13/2018
22–01	–1		May 16/2019		–33		Dec 13/2018
	–2		May 16/2019		–34		Dec 13/2018
22–02	–1		May 16/2019		–35		Dec 13/2018
	–2		May 16/2019		–36		Dec 13/2018
	–3		May 16/2019		–37		Dec 13/2018
	–4		May 16/2019		–38		Dec 13/2018
	–5		May 16/2019		–39		May 16/2019
	–6		May 16/2019		–40		May 16/2019
	–7		May 16/2019		–41		May 16/2019
	–8		May 16/2019		–42		May 16/2019
	–9		Dec 13/2018		–43		May 16/2019
	–10		May 16/2019		–44		May 16/2019
	–11		May 16/2019		–45		May 16/2019
	–12		Dec 13/2018		–46		May 16/2019
	–13		May 16/2019		–47		May 16/2019
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	–15		May 16/2019		–49	*	Sep 23/2019
	–16		May 16/2019		–50	*	Sep 23/2019
	–17		May 16/2019		–51	*	Sep 23/2019
	–18		Dec 13/2018		–52	*	Sep 23/2019
	–19		Dec 13/2018		–53	*	Sep 23/2019
	–20		Dec 13/2018		–54	*	Sep 23/2019
	–21		Dec 13/2018		–55	*	Sep 23/2019
	–22		Dec 13/2018		–56	*	Sep 23/2019
	–23		Dec 13/2018		–57	*	Sep 23/2019
	–24		Dec 13/2018		–58	*	Sep 23/2019
	–25		Dec 13/2018		–59	*	Sep 23/2019

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–60 *	Sep 23/2019	–94 *	Sep 23/2019
–61 *	Sep 23/2019	–95 *	Sep 23/2019
–62 *	Sep 23/2019	–96 *	Sep 23/2019
–63 *	Sep 23/2019	–97 *	Sep 23/2019
–64 *	Sep 23/2019	–98 *	Sep 23/2019
–65 *	Sep 23/2019	–99 *	Sep 23/2019
–66 *	Sep 23/2019	–100 *	Sep 23/2019
–67 *	Sep 23/2019	–101 *	Sep 23/2019
–68 *	Sep 23/2019	–102 *	Sep 23/2019
–69 *	Sep 23/2019	–103 *	Sep 23/2019
–70 *	Sep 23/2019	–104 *	Sep 23/2019
–71 *	Sep 23/2019	–105 *	Sep 23/2019
–72 *	Sep 23/2019	–106 *	Sep 23/2019
–73 *	Sep 23/2019	–107 *	Sep 23/2019
–74 *	Sep 23/2019	–108 *	Sep 23/2019
–75 *	Sep 23/2019	–109 *	Sep 23/2019
–76 *	Sep 23/2019	–110 *	Sep 23/2019
–77 *	Sep 23/2019	–111 *	Sep 23/2019
–78 *	Sep 23/2019	–112 *	Sep 23/2019
–79 *	Sep 23/2019	–113 *	Sep 23/2019
–80 *	Sep 23/2019	–114 *	Sep 23/2019
–81 *	Sep 23/2019	–115 *	Sep 23/2019
–82 *	Sep 23/2019	–116 *	Sep 23/2019
–83 *	Sep 23/2019	–117 *	Sep 23/2019
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–87 *	Sep 23/2019	–121 *	Sep 23/2019
–88 *	Sep 23/2019	–122 *	Sep 23/2019
–89 *	Sep 23/2019	–123 *	Sep 23/2019
–90 *	Sep 23/2019	–124 *	Sep 23/2019
–91 *	Sep 23/2019	–125 *	Sep 23/2019
–92 *	Sep 23/2019	–126 *	Sep 23/2019
–93 *	Sep 23/2019		

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Page			Date	Page			Date
	–127	*	Sep 23/2019		–33	*	Sep 23/2019
	–128	*	Sep 23/2019		–34	*	Sep 23/2019
22–03	–1	*	Sep 23/2019		–35	*	Sep 23/2019
	–2	*	Sep 23/2019		–36	*	Sep 23/2019
	–3	*	Sep 23/2019		–37	*	Sep 23/2019
	–4	*	Sep 23/2019		–38	*	Sep 23/2019
	–5	*	Sep 23/2019		–39	*	Sep 23/2019
	–6	*	Sep 23/2019		–40	*	Sep 23/2019
	–7	*	Sep 23/2019		–41	*	Sep 23/2019
	–8	*	Sep 23/2019		–42	*	Sep 23/2019
	–9	*	Sep 23/2019		–43	*	Sep 23/2019
	–10	*	Sep 23/2019		–44	*	Sep 23/2019
	–11	*	Sep 23/2019		–45	*	Sep 23/2019
	–12	*	Sep 23/2019		–46	*	Sep 23/2019
	–13	*	Sep 23/2019		–47	*	Sep 23/2019
	–14	*	Sep 23/2019		–48	*	Sep 23/2019
	–15	*	Sep 23/2019		–49	*	Sep 23/2019
	–16	*	Sep 23/2019		–50	*	Sep 23/2019
	–17	*	Sep 23/2019		–51	*	Sep 23/2019
	–18	*	Sep 23/2019		–52	*	Sep 23/2019
	–19	*	Sep 23/2019		–53	*	Sep 23/2019
	–20	*	Sep 23/2019		–54	*	Sep 23/2019
	–21	*	Sep 23/2019		–55	*	Sep 23/2019
	–22	*	Sep 23/2019		–56	*	Sep 23/2019
	–23	*	Sep 23/2019		–57	*	Sep 23/2019
	–24	*	Sep 23/2019		–58	*	Sep 23/2019
	–25	*	Sep 23/2019		–59	*	Sep 23/2019
	–26	*	Sep 23/2019		–60	*	Sep 23/2019
	–27	*	Sep 23/2019		–61	*	Sep 23/2019
	–28	*	Sep 23/2019		–62	*	Sep 23/2019
	–29	*	Sep 23/2019		–63	*	Sep 23/2019
	–30	*	Sep 23/2019		–64	*	Sep 23/2019
	–31	*	Sep 23/2019		–65	*	Sep 23/2019
	–32	*	Sep 23/2019		–66	*	Sep 23/2019

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	–67	*	Sep 23/2019	
	–68	*	Sep 23/2019	
	–69	*	Sep 23/2019	
	–70	*	Sep 23/2019	
	–71	*	Sep 23/2019	
	–72	*	Sep 23/2019	
	–73	*	Sep 23/2019	
	–74	*	Sep 23/2019	
22–04	–1		May 16/2019	
	–2		May 16/2019	

* The asterisk indicates pages changed, added or deleted.

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The option codes that follow appear adjacent to the applicable text.

Absence of an option code means that the data are applicable to all.

Option code	Description
<Metric>	ON A/C ALL Metric
<21310001D>	ON A/C ALL Outflow valve – Muffler – Not installed
<23120003C>	ON A/C 55058–55059 HF radio system – Dual installation
<23120005C>	ON A/C 55060–55063, 55068, 55074, 55077, 55081, 55087, 55091 HF radio system – Single installation with dual HF provisions
<23129001C>	ON A/C ALL Combined options: HF communication <23120001C> or <23120003C> or <23120005C>
<23150004C>	ON A/C 55058–55059 SATCOM Iridium system – Installed
<23150006C>	ON A/C ALL AFIRS™ Iridium SATCOM system – Installed
<23210004C>	ON A/C ALL SELCAL – Installed
<23220001C>	ON A/C ALL Flight deck printer
<23240001C>	ON A/C ALL CPDLC – Aeronautical Telecommunication Network (Link 2000+)
<23249001C>	ON A/C ALL Combined options: CPDLC <23240001C> or <23240002C>
<23410001D>	ON A/C ALL Ground headset connection – Single jack

Option code	Description
<23520024C>	ON A/C ALL Audio control panels – HF1 + HF2 + NAV3 + SATCOM + dual ADF
<23520052C>	ON A/C 55060–55063, 55068, 55074, 55077, 55081, 55087, 55091 Audio control panels – INOP decals – HF2
<23520054C>	ON A/C 55058–55059 Audio control panels – INOP decals – SATCOM
<23529001C>	ON A/C ALL Combined options: Audio control panels – SATCOM <23520023D> or <23520024C> or <23520054C>
<23730002C>	ON A/C ALL Flight deck door surveillance system – Flight displays only
<25150001C>	ON A/C ALL Pilot electrical foot warmers – Installed
<26240002C>	ON A/C ALL Cargo FIREX – 120 minute diversion capability
<31000008C>	ON A/C ALL Customized instrumentation – 8.33 kHz VHF tuning
<31100001D>	ON A/C ALL Overhead panel toggle switches – Activate downward
<31340001C>	ON A/C ALL High load event indication function
<32510001D>	ON A/C ALL Nosewheel Steering (NWS) control for copilot – Not installed
<33200010C>	ON A/C ALL Ordinance signs – WI-FI
<33201001D>	ON A/C ALL Cabin lighting – White wash lighting

Option code	Description
<34320001D>	ON A/C ALL Head-Up Display (HUD) system – Not installed
<34430001C>	ON A/C ALL TCAS – Dual directional antenna
<34521003C>	ON A/C ALL Dual Automatic Direction Finder (ADF) – Installed
<44301201C>	ON A/C ALL Ku-band connectivity system (Panasonic eXConnect®)
<44309210C>	ON A/C ALL Combined options: Ku-band connectivity <44300201C> or <44300210C> or <44301201C> or <44301211C> or <44300202C> or <44301202C> or <44300212C>
<44309212C>	ON A/C ALL Combined options: Ku-band connectivity – Panasonic eXConnect® <44300201> or <44300202C> or <44301201C> or <44301202C>
<52201001D>	ON A/C ALL Two overwing emergency exit doors
<72211001D>	ON A/C ALL Standard thrust rating – PW1521G-3

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A reference to the service bulletins that follow appears above applicable boxed text.

Service bulletin	Description
There are no applicable service bulletins at this time.	

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A reference to the modifications that follow appears above applicable boxed text.

Modification	Description
240006	ON A/C ALL Electrical/towing service panel – Installed in production

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CHAPTER 1 – GENERAL INFORMATION

INTRODUCTION

AIRCRAFT GENERAL

List of figures

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OVERVIEW

The Flight Crew Operating Manual (FCOM) is designed to provide the flight crew with readily accessible operational information. For optimum utilization of the manual, read this introduction carefully.

The purpose of the FCOM is to provide information regarding operational procedures, performance and limitations:

- Standardize terminology and behavioral patterns,
- Provide rapid access to reference procedures, and
- Provide information on aircraft systems and operations that are controlled and revised.

The FCOM is divided into two volumes, as follows:

- Volume 1 – System description, and
- Volume 2 – Limitations, procedures, and performance.

Throughout this manual, the experience of the typical crew is recognized and, for this reason, basic systems are omitted. For example, the text is not intended to teach the crew how to fly an aircraft, but to enable an experienced crew to operate the aircraft safely and proficiently.

Specific items requiring emphasis are expanded upon and ranked in increasing order of importance in the form of a NOTE, CAUTION or WARNING.

NOTE

Expands on information that is considered essential to emphasize. Information contained in notes may also be safety related.

CAUTION

Provides information that may result in damage to equipment if not followed.

WARNING

Emphasizes information that may result in personal injury or loss of life if not followed.

A. Volume 1 – System description

Volume 1 contains descriptive aircraft system information and is presented by system name in alphabetical order.

Each chapter is subdivided into sections related to the subsystems of the chapter. This information is flight crew oriented with the description designed to support the procedures published in Volume 2.

Primary emphasis is on the end result of an operation of a control or unit, or required operation by the crew, rather than a detailed description of how the system operates.

Descriptive text is used to support the functional diagrams, but only when necessary for complete understanding. The color amber is used to describe all crew indications that are displayed in various shades of yellow. Functional diagrams are used to show what happens when a control is actuated rather than to illustrate how the system works. When used, the diagram illustrates an operational condition that will be meaningful to the flight crew.

This document uses the action select or press to describe the manipulation of controls.

Select is used when it is necessary to move, turn, or choose the controls that follow:

- Hard switches,
- Levers,
- Control cursor line items, and
- Soft tile switches.

Press is used when it is necessary to put pressure on hard switches.

List of chapters

Chapter 1 – General information: Change record, volume description, pagination, option codes, units of measure, reference tables, and abbreviations.

Chapter 2 – Air conditioning, bleed air and pressurization

Chapter 3 – Auto flight

Chapter 4 – Auxiliary Power Unit

Chapter 5 – Communication

Chapter 6 – Doors

Chapter 7 – Electrical

Chapter 8 – Electronic display

Chapter 9 – Fire and overheat protection

Chapter 10 – Flight controls

Chapter 11 – Fuel

Chapter 12 – Hydraulic

Chapter 13 – Ice and rain protection

Chapter 14 – Landing gear

Chapter 15 – Lights

Chapter 16 – Navigation

Chapter 17 – Oxygen and emergency equipment

Chapter 18 – Power plant

Chapter 19 – Recording

Chapter 20 – Water and waste

Chapter 21 – Electronic checklist

Chapter 22 – Flight management system

Chapter 23 – Surface Management System (Optional)

Chapter 24 – Head-Up guidance system (Optional)

B. Volume 2 – Limitations, procedures, and performance

Refer to Volume 2 – Introduction.

C. Pagination

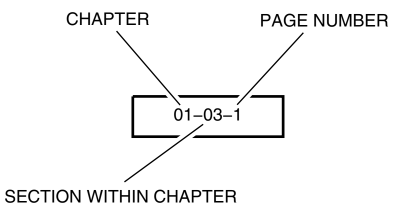
Each chapter of Volume 1 and Volume 2 of the Flight Crew Operating Manual is subdivided into sections categorized by the subject or type of material presented (refer to Figure 01–01–1).

This permits issuance of small blocks of revision pages without renumbering and reprinting complete sections of the manual.

Volume 1 and Volume 2 are paginated with a Volume Chapter/Section/Page numbering system.

Additional identification data in the margin of the page includes the date of issue or revision printed below the page number and the chapter title and subject in the page header.

Blank pages that must be arranged as facing pages at the end of a section are defined by “This Page Intentionally Left Blank”. In the List of Effective Pages, these blank pages are included in the total page count of each affected chapter.



Pagination
Figure 01–01–1

D. Airworthiness authority codes

Applicable pages of this manual contain Airworthiness authority codes adjacent to the applicable text when a specific paragraph, procedure or illustration is unique to the specified Authority. Example: <TC>, <FAA>, <EASA>, etc.

E. Revision system

Revisions to this manual are issued when necessary and are numbered consecutively. Each revision must be inserted immediately and entered in the change record.

Alterations made during the revision cycles are identified by a strong vertical line (revision bar), except when an entire chapter or section is revised. In this case, the reason for revision is given in the change record.

F. Option codes

A complete list of applicable option codes is available in section 00–04, at the beginning of this manual.

Option codes appear adjacent to the applicable text, to indicate an optional configuration component.

Absence of an option code means that the data are applicable to all.

G. Service bulletins

A complete list of applicable service bulletins is available in section 00–05, at the beginning of this manual.

A reference to a service bulletin condition appears above applicable boxed text. A Pre–SB condition is applicable to aircraft that have not incorporated the service bulletin. A Post–SB condition is applicable to aircraft that have incorporated the service bulletin.

H. Modifications

A complete list of applicable modifications is available in section 00–06, at the beginning of this manual.

A reference to a modification appears above applicable boxed text. These modifications are incorporated in production and do not require a service bulletin.

ABBREVIATIONS

The abbreviations that follow are found throughout the manual. Some abbreviations can also appear in lowercase letters. Abbreviations that have very limited usage are explained in the chapters where they are used.

A

A/C	Air-Conditioning, Aircraft
A/ICE	Anti-Ice
AAE	Above Aerodrome Elevation
ABS	Absolute altitude
AC	Advisory Circular, Alternating Current
ACARS	Aircraft Communications Addressing and Reporting System
ACC	Active Clearance Control
ACMF	Aircraft Condition Monitoring Function
ACMP	Alternating Current Motor Pump (electric pump)
ACP	Audio Control Panel
ADC	Air Data Computer
ADF	Automatic Direction Finder
ADI	Attitude Direction Indicator
ADRF	Aircraft Data Recording Function
ADS	Air Data System, Automatic Dependent Surveillance
ADS-B	Automatic Dependent Surveillance Broadcast
ADS-C	Automatic Dependent Surveillance Contract
ADSP	Air Data System Probe

AEO	All Engines Operating
AFCS	Automatic Flight Control System
AFCU	Alternate Flight Control Unit
AFIRS™	Automated Flight Information Reporting System
AFM	Airplane Flight Manual
AFN	ATS Facilities Notifications
AGB	Angle Gearbox
AGCU	APU Generator Control Unit
AGL	Above Ground Level
Ah	Ampere-hour
AHMS	Aircraft Health Management System
AID	Aircraft Interface Device
AIL	Aileron
AIM	Align-In-Motion
AIS	Aircraft Information Server
ALT	Altimeter, Altitude, Altitude Hold (PFD/FD)
ALT CAP	Altitude Capture
ALTN	Alternate
ALTS	Altitude Selected
AM	Amplitude Modulation
AME	Amplitude Modulation Equivalent
AMM	Airport Moving Map
AMP	Aircraft Maintenance Publication
ANSP	Air Navigation Service Provider
AOA	Angle Of Attack
AOC	Aeronautical Operational Control, Air/Oil Cooler, Airline Operational Communication or Airline Operations Center
AOHE	Air/Oil Heat Exchanger
AP	Autopilot
A/P DISC PTY	Autopilot Disconnect Priority

APM	Aircraft Personality Module
APPR	Approach
APR	Automatic Power Reserve
APU	Auxiliary Power Unit
APV	Approach Procedure with Vertical Guidance
ARINC	Aeronautical Radio Incorporated
ARP	Airport Reference Point
ARR	Arrival
ARTCC	Airport or Air Route Traffic Control Center
ASA	Approach Status Annunciator
ASDA	Accelerate-Stop Distance Available
A/T	Autothrottle
AT	Autothrottle
ATC	Air Traffic Control
ATIS	Automatic Terminal Information System
ATM	Air Traffic Management
ATS	Air Turbine Starter, Air Traffic Services
AUTO	Automatic
AVAIL	Available
AVIO	Avionic

B

BALODS	Bleed Air Leak and Overheat Detection System
BARO	Barometric
BATT	Battery
BAV	Buffer Air Valve
BDCU	Brake Data Concentration Unit
BGM	Boarding Music
BIT	Built-In-Test
BOC	Bottom Of Climb
BPCU	Bus Power Control Unit

BRG	Bearing
BRT	Bright, Brightness
BTL	Bottle
BTMS	Brake Temperature Monitoring System
BTS	Bleed Temperature Sensor

C

CAB	Cabin
CAB ALT	Cabin Altitude
CAFM	Computerized Airplane Flight Manual
CAI	Cowl Anti-Ice
CAIS	Cowl Anti-Ice System
CAIT	Cowl Anti-Ice Temperature Sensor
CAIV	Cowl Anti-Ice Valve
CAS	Crew Alerting System, Calibrated Airspeed
CB	Circuit Breaker
CBV	Cross-Bleed Valve
CCP	Cursor Control Panel
CCU	Camera Control Unit
CDA	Current Data Authority
CDC	Control and Distribution Cabinet
CFIT	Controlled Flight Into Terrain
CG	Center of Gravity
CHKL	Checklist
CIFP	Computerized In-Flight Planning
CKPT	Cockpit
CLB	Climb
CLSD	Closed
CMS	Cabin Management System
CMU	Communication Management Unit
CNCL	Cancel

CNS	Communication, Navigation and Surveillance
COM	Communication
CONFIG	Configuration
CPD	Circuit Protection Device
CPDLC	Controller–Pilot Data Link Communication
CPLT	Copilot
CRT	Cathode Ray Tube
CSD	Customer System Display
CSS	Constant Speed Segment
CT	Crew Terminal
CTL	Countertop Light
CTP	Control Tuning Panel
CTRL	Control
cTWLU	Cellular Terminal Wireless LAN Unit
CVR	Cockpit Voice Recorder
CWLU	Crew Wireless LAN Unit

D

DA	Decision Altitude
DBASE	Database
DC	Direct Current
DCL	Departure Clearance
DDC	Digital Departure Clearances
DCS	Data Concentrator System
DCU	Data Concentrator Unit
DDG	Dispatch Deviation Guide
DEP	Departure
DEST	Destination
DET	Detection
DH	Decision Height
DIFF	Differential

DIR	Direct
DISC	Disconnect
DIST	Distance
DLIC	Data Link Initiation Capability
DLK	Data Link
DMC	DCU Module Cabinet
DME	Distance Measuring Equipment
DN	Down
DPLY	Deploy
DR	Dead Reckoning
DSK	Double Stack Knob
DSP	Data Link Service Provider
DSPL	Display
DTG	Distance to Go
DTK	Desired Track
DU	Display Unit

E

EAS	Equivalent Airspeed
EASA	European Aviation Safety Agency (EU)
ECB	Electronic Circuit Breaker
ECDU	Emulated Control Display Unit
ECL	Electronic Checklist
ECS	Environmental Control System
ECU	Electronic Control Unit, External Compensation Unit
EDM	Emergency Descent Mode
EDP	Engine Driven Pump
EDU	Electronic Display Unit
EEC	Electronic Engine Control
EFB	Electronic Flight Bag
EFCS	Electrical Flight Control System

EFIS	Electronic Flight Instrument System
EGPWS	Enhanced Ground Proximity Warning System
EGNOS	European Geostationary Navigation Overlay Service
EGT	Exhaust Gas Temperature (°C)
EICAS	Engine Indication and Crew Alerting System
ELEV	Elevator, Elevation
ELT	Emergency Locator Transmitter
EMA	Electromechanical Actuator
EMAC	Electric Motor Actuator Controller
EMCU	Electric Motor Control Unit
EMER	Emergency
EMPC	Emergency Power Control
EMU	Expansion Module Unit
ENG	Engine
ENS	Ethernet Network Switch
EPC	Electrical Power Center
EPGDS	Electrical Power Generation and Distribution System
EPSU	Emergency Power Supply Unit
EPU	Estimated Position of Uncertainty
EQUIP	Equipment
ESS	Essential
ETA	Estimated Time of Arrival
ETE	Estimated Time En route
ETP	Equal Time Point
EVAC	Evacuation
EVS	Enhanced Vision System
EXT	Exterior

F

FA	Flight Attendant
FAA	Federal Aviation Administration (USA)

FACF	Final Approach Course Fix
FADEC	Full Authority Digital Engine Controller
FANS	Future Air Navigation System
FAV	Fan Air Valve
FBW	Fly-By-Wire
FBWPC	Fly-By-Wire Power Converter
FCC	Flight Control Computer
FCOM	Flight Crew Operating Manual
FCP	Flight Control Panel
FCU	Flight Control Unit
FD	Flight Director
FD/AT	Flight Director/Alternate
FDAU	Flight Data Acquisition Unit
FDDSS	Flight Deck Door Surveillance System
FDE	Flight Deck Effect
FDGS	Fan Drive Gear System
FDR	Flight Data Recorder
FDS	Flight Display System
FDRAS	Flight Deck Remote Access System
FF	Fuel Flow
FG	Flight Guidance
FIDEX	Fire Detection and Extinguishing
FIR	Flight Information Region
FIREX	Fire Extinguishing System
FL	Flight Level
FLC	Flight Level Change
FLEX	Reduced takeoff thrust
FLT	Flight
FMA	Flight Mode Annunciator
FMS	Flight Management System
FOB	Fuel On Board

FOHE	Fuel/Oil Heat Exchanger
FPA	Flight Path Angle
FO	First Officer
FOHE	Fuel/Oil Heat Exchanger
FPLN	Flight Plan
FPV	Flight Path Vector
fpm	Foot (feet) per minute
FQC	Fuel Quantity Computer
FSB	Fasten Seat Belt
ft	Foot (feet)
FTIS	Fuel Tank Inerting System
FWD	Forward
FWSOV	Firewall Shutoff Valve

G

G	Force of gravity
GA	Go-Around
GAGAN	GPS Aided Geo-Augmented Navigation
GCS	Ground Clutter Suppression
GCU	Generator Control Unit
GEN	Generator
GFP	Graphical Flight Planning
GLD	Ground Lift Dumping
GND	Ground
GNSS	Global Navigation Satellite System
GOLD	Global Operational Data Link Document
GP	Glide Path
GPU	Ground Power Unit
GPM	Gallon Per Minute
GPS	Global Positioning System
GPWS	Ground Proximity Warning System

GS	Glideslope, Ground Speed, Ground Spoiler
GSE	Ground Support Equipment
GTF	Geared Turbofan
GW	Gross Weight
GWX	Graphical Weather

H

H STAB	Horizontal Stabilizer
HAAO	High Altitude Airfield Operations
HAP	High Angle-of-attack Protection
HCU	Hydraulic Control Unit
HDG	Heading
HF	High Frequency
HI	High
HLEIF	High Load Event Indication Function
HMU	Health management Unit
hPa, HPA	Hectopascal
HPC	High Pressure Compressor
HPGC	High Pressure Ground Connection
HPL	Horizontal Protection Level
HPT	High Pressure Turbine
HPV	High Pressure Valve
HRD	High Rate Discharge
HSI	Horizontal Situation Indicator
HSTA	Horizontal Stabilizer Trim Actuator
HSTAB	Horizontal Stabilizer
HUD	Head-Up Display
HYD	Hydraulic
Hz	Hertz

I

IAF	Initial Approach Fix
IAMS	Integrated Air Management System
IAP	Instrument Approach Procedure
IAS	Indicated Airspeed
IASC	Integrated Air System Controller
IB	Inboard
IBIT	Initiated Built-In-Test
ICAO	International Civil Aviation Organization
ICT	Installation Configuration Table
IDENT	Identification
IFEC	In Flight Entertainment and Connectivity
IFIS	Integrated Flight Information System
IFMS	Integrated Flight Management System
IFPC	Integrated Fuel Pump and Control
IFR	Instrument Flight Rules
IGV	Inlet Guide Vane
IIM	Inceptor Interface Module
ILS	Instrument Landing System (LOC and GS)
IMAS	Information Modular Avionic System
IMC	Instrument Meteorological Conditions
IMS	Information Management System
INBD	Inboard
in., IN	Inch
inHg	Inches of mercury
INHIB	Inhibit
INIT	Initiate, Initialize, Initialization
INT	Intercom
I/O	Input / Output
IPC	Integrated Processing Cabinet

IPCV	Intermediate Pressure Check Valve
IPS	Integrated Processing System
IRS	Inertial Reference System
IRU	Inertial Reference Unit
ISA	International Standard Atmospheric conditions
ISI	Integrated Standby Instrument
ISPC	In-Seat Power Controller
ITT	Inter Turbine Temperature
ITU	International Telecommunication Union

J

JOSV	Journal Oil Shuttle Valve

K

KANDU	Ku-band Aircraft Networking Data Unit
kg	Kilogram(s)
KIAS	Knots Indicated Airspeed
KPH	Kilograms Per Hour
KRFU	Ku-band Radio Frequency Unit
KT	Knot(s)
kt	Knot(s)
kVA	Kilovolt-ampere(s)

L

L	Left
L	Liter(s)
L-R	Left and Right
LAN	Local Area Network
LAV	Lavatory
lb	Pound(s)
lbf	Pound-force

LCD	Liquid Crystal Display
LDG	Landing
LDG ELEV	Landing Elevation
LED	Light-Emitting Diode
LGSCU	Landing Gear Steering Control Unit
LH	Left Hand
LIM	Limit
LNAV	Lateral Navigation
LO	Low
LOA	Letter Of Authorization
LOC	Localizer
LPC	Low Pressure Compressor
LPGC	Low Pressure Ground Connection
LPT	Low Pressure Turbine
LPV	Localizer Performance with Vertical Guidance
LRCS	Long Range Communication System
LRD	Low Rate Discharge
LRU	Line Replaceable Unit
LSB	Lower Sideband
LSK	Line Select Key
LTS	Lights
LV	Lower sideband Voice
LVL	Level
LVTO	Low Visibility Takeoff
LW	Landing Weight
LWD	Left Wing Down
LWR	Lower

M

m	Meter
M	Mach number

M_I	Indicated Mach Number
M_T	True Mach Number
MAA	Missed Approach Altitude
MAN	Manual
MAR	Maritime
MAX	Maximum
MB	Marker Beacon
MCE	Motor Control Electronics
MCL	Maximum Climb Thrust
MCT	Maximum Continuous Thrust
MDA	Minimum Descent Altitude
MED	Medium
MFD	Multifunction Display(s)
MFP	Multifunction Probe(s)
MFS	Multifunction Spoiler(s)
MFW	Multifunction Window, Minumum Fuel Weight
MGB	Main Gearbox
MIC	Microphone
MISALIGN	Misalignment
MISCONFIG	Misconfiguration
MKP	Multifunction Keyboard Panel
MLG	Main Landing Gear
MLW	Maximum Landing Weight
MMEL	Master Minimum Equipment List
MRW	Maximum Ramp Weight
MSAS	Multifunctional Transport Satellite (MTSAT) Satellite Augmentation System
MSG	Message
MSL	Mean Sea Level
MTO	Maximum Takeoff
MTSAT	Multifunctional Transport Satellite

MTOW	Maximum Takeoff Weight
MZFW	Maximum Zero Fuel Weight

Miscellaneous

%	Percent
°C	Degree(s) Celsius
°F	Degree(s) Fahrenheit
ΔP	Pressure differential

N

N	Normal
N/A	Not Applicable
N_1	Low pressure rotor speed
N_2	High pressure rotor speed
NADP	Noise Abatement Departure Procedure
NAT	North Atlantic
NAV	Navigation
ND	Nose Down
NDA	Next Data Authority
NEA	Nitrogen-Enriched Air
NiCad	Nickel Cadmium
NLG	Nose Landing Gear
nm	Nautical Miles
No.	Number
NPV	Non-Precision Approach
NU	Nose Up
NORM	Normal
NWS	Nosewheel Steering

O

OAT	Outside Air Temperature
OB	Outboard
OCM	Oil Control Module
ODL	Onboard Data Loader
ODM	Oil Debris Monitoring
ODU	Oxygen Dispensing Unit
OEI	One Engine Inoperative
OELT	Opposite Engine Low Thrust
OFV	Outflow Valve
OLD	Operational Landing Distance
OMS	Onboard Maintenance System
OOHE	Oil/Oil Heat Exchanger
OOOI	Out-Off-On-In
OPU	Overvoltage Protection Unit
ORT	Owner Requirements Table
OT	Other Traffic
OVHT	Overheat
OVLY	Overlay
OVRD	Override
OWE	Operating Weight Empty
OXY	Oxygen

P

P/N	Part Number
PA	Passenger Address, Precision Approach
PAC	Path Attenuation Correction
PARK	Parking
PAX	Passenger
PBA	Pushbutton Annunciator
PBE	Protective Breathing Equipment

PCE	Pre-Cooler Exhaust
PCU	Power Control Unit
PDU	Power Drive Unit
PED	Personal Electronic Device
PEV	Pressure Equalization Valve
PERF	Performance
PF	Pilot Flying
PFCC	Primary Flight Control Computer
PFCS	Primary Flight Control System
PFD	Primary Flight Display
PHMU	Prognostics and Health Monitoring Unit
PIC	Pilot-in-Command
PLT	Pilot
PM	Pilot Monitoring
PMAG	Permanent Magnet Alternator/Generator
PMG	Permanent Magnet Generator
POS	Position
PPH	Pounds Per Hour
PRAM	Pre Recorded Announcement and Music
PRESS	Pressure
PRSOV	Pressure Regulating Shutoff Valves
PSA	Print Server Application
PSA	Preselected Altitude
psi	Pound(s) per Square Inch
psi-A	Pound(s) per Square Inch - Absolute
psid	Pound(s) per Square Inch Differential
psig	Pound(s) per Square Inch Gauge
PSTN	Public Switched Telephone Network
PSU	Passenger Service Unit
PT	Proximate Traffic
PTM	Pitch Target Marker

PTT	Push-To-Talk
PTU	Power Transfer Unit
PV	Priority Valve
PWR	Power

Q

QAK	Quick Access Key
QNH	Barometric pressure adjusted to sea level
QRH	Quick Reference Handbook
QTY	Quantity

R

R	Right
RA	Radio Altitude, Resolution Advisory
RAD ALT	Radio Altimeter
RAIM	Receiver Autonomous Integrity Monitoring
RAT	Ram Air Turbine
RCL	Recall
RECIRC	Recirculation
REF	Reference
REL	Relative Altitude
REQ	Required
RET	Retract
REU	Remote Electronics Unit
REV	Reversion
RF	Radio Frequency, Radius-to-Fix
RGC	Ram Air Turbine Generator Control
RIU	Radio Interface Unit
RNG	Required Navigation Performance
rpm	Revolutions Per Minute
RSP	Reversion Switch Panel

RT	Receiver–Transmitter
RTD	Resistance Temperature Device
RTE	Route
RTO	Rejected Takeoff
RTSA	Radio Tuning System Application
RUD	Rudder
RVSM	Reduced Vertical Separation Minimum
RWD	Right Wing Down
RWY	Runway

S

SA	Stationary Alignment
SAT	Static Air Temperature
SATCOM	Satellite Communication
SAV	Starter Air Valve
SBAS	Satellite Based Augmentation System
SBD	Short Burst Data
SCDA	Stabilized Constant Descent Angle
SCM	SDU Configuration Module
SDU	Satellite Data Unit
SEL	Select
SELCAL	Selective Calling
SEQ	Sequence
SERV	Service
SFECU	Slat Flap Electronic Control Unit
SFX	Secure File Exchange
SHX	Skin Heat-Exchanger
SIM	Subscriber Identification Module
SLIPCOMP	Sideslip Compensation
SLOP	Strategic Lateral Offset Procedures
SLS	Sea Level Standard

SMS	Surface Management System
SOV	Shutoff Valve
SPD	Airspeed control, Speed
SPED	Speed
SPKR	Speaker
SPLRS	Spoilers
SQ	Squelch
SRC	Source
SSEC	Static Source Error Connection
SSC	Side Stick Controller
SSPC	Solid State Power Controller
STAB	Stabilizer
STAR	Standard Time Arrival Route
STBY	Standby
STD	Standard
SYN	Synoptic page

T

TA	Traffic Advisory
TAPRV	Trim Air Pressure-Regulating Valve
TAS	True Airspeed
TASOV	Trim Air Shutoff Valve
TAT	Total Air Temperature
TAWS	Terrain Awareness and Warning System
TC	Transport Canada
TCAS	Traffic Alert and Collision Avoidance System
TCB	Thermal Circuit Breaker
TCF	Terrain Clearance Floor
TEMP	Temperature
TERR	Terrain
TEW	True Empty Weight

TFC	Traffic
TGL	Temporary Guidance Leaflet
TIC	Turbine Intermediate Case
TLA	Thrust Lever Angle
TLAF	Takeoff and Landing Awareness Function
TO	Takeoff
TOC	Top Of Climb
TOD	Top Of Descent
TODA	Takeoff Distance Available
TOGA	Takeoff/Go−Around
TORA	Takeoff Run Available
TOW	Takeoff Weight
TQA	Throttle Quadrant Assembly
TR or T/R	Thrust Reverser
TRV	Thrust Reference Value
TRU	Transformer Rectifier Unit
TSE	Total System Error
TSS	Traffic Surveillance System
TURB	Turbulence
TX	Transmitter, Transmission
TXFR	Transfer

U

UBMF	Usage Based Monitoring Function
ULB	Underwater Locating Beacon
UPR	Upper
USB	Universal Serial Bus, Upper Sideband
UTC	Universal Time Coordinate
UTIL	Utility
U.S. gal	United States gallon(s)
USPD	Under-speed

UV	Ultra Violet, Upper Sideband Voice

V

V STAB	Vertical Stabilizer
V/S	Vertical speed
V_	V_{SPEED}
V_1	Take-off decision speed
V_{1MBE}	Maximum V_1 for brake energy
V_{1MCG}	Maximum V_1 limited by control on the ground
V_2	Take-off safety speed
V_{2GA}, $V_{2GO\text{-}AROUND}$	Approach climb speed
V_A	Design maneuvering speed
V_{AC}	Approach/climb speed
V_{AOA}	Vane Angle-Of-Attack speed
V_{EF}	Critical engine failure speed
V_{ENR}	Climb speed during the enroute phase for one engine inoperative
V_{FE}	Maximum flap extended speed
V_{FTO}	Final take-off speed
V_{GA}	Climb speed for all engines go-around
V_{LC}	Climb speed during the landing climb
V_{LE}	Maximum landing gear extended speed
V_{LO}	Maximum landing gear operating speed
V_{MC}	Minimum control speed
V_{MCA}	Minimum control speed, air
V_{MCG}	Minimum control speed, ground
V_{MCL}	Minimum control speed, landing
V_{MO}	Maximum operating speed (in knots)
V_{MO}/M_{MO}	Maximum operating speed / Mach number
V_R	Rotation speed

V_{REF}	Landing reference speed
V_S	Stalling speed
V_{S1G}	Reference stall speed based on 1.0 g criteria
V_{SR}	Reference stall speed
VAC	Volts, Alternating Current
VAFN	Variable Area Fan Nozzle
VALT	VNAV altitude hold
VALTS	Vertical Navigation – Altitude preselect mode
VALTV	Vertical Navigation – Altitude
VDC	Volts, Direct Current
VDL	VHF Digital Link
VFR	Visual Flight Rules
VFG	Variable Frequency Generator
VFPA	Vertical Navigation – Flight Path Angle mode
VFLC	Vertical Navigation – Flight Level Change mode
VGA	VNAV Go-Around
VGP	Vertical Navigation – Glide Path mode
VHF	Very High Frequency
VIGV	Variable Inlet Guide Vane
VLV	Valve
VMC	Visual Meteorological Conditions
VNAV	Vertical Navigation
VNAV	Vertical Navigation – Flight Management System
VOC	Volatile Organic Compound
VOR	VHF Omnidirectional Range
VPATH	Vertical Navigation – Path
VSD	Vertical Situation Display
VSI	Vertical Speed Indicator
VSPDS	V_{SPEED}
VTO	VNAV Takeoff
VTU	Video Transmission Unit

VVS	Vertical Navigation – Vertical Speed mode

W

WAAS	Wide Area Augmentation System
WAI	Wing Anti-Ice
WAIS	Wing Anti-Ice System
WAIT	Wing Anti-Ice Temperature
WAITS	Wing Anti-Ice Temperature Sensor
WAIV	Wing Anti-Ice Valve
WLAN	Wireless Local Area Network
WBM	Weight and Balance Manual
WDW	Window
WINDSHLD	Windshield
WIPC	Window Ice Protection Controller
WOW	Weight-On-Wheels
WOFFW	Weight-Off-Wheels
WSHLD	Windshield
WSHR	Windshear
WWSC	Water Waste System Controller
WX	Weather
WXR	Weather Radar System

X

XBLEED	Cross bleed
XFR	Transfer
XPDR	Transponder

Y

YD	Yaw Damper
Y/D	Yaw Damper

Z

ZFW	Zero Fuel Weight
ZULU	Universal Coordinated Time

MEASUREMENTS

A. ICAO standards

Units of measurement

The aircraft displays units that conform to ICAO standards. Weight and barometric pressure are expressed in accordance with either the International System of Units (SI) or the British Engineering System of Units (B.E.S.).

ICAO standards

- Distance: Nautical Miles (nm),
- Speed: Knots (kt),
- Altitude, elevation and height: Feet (ft), Meter (m),
- Time: Day, Hour, Minute, Second (d, h, min, s),
- Temperature: Degree Celsius (°C),
- Electric current: Ampere (A),
- Voltage: Volts (V), Volts DC (VDC), Volts AC (VAC), Kilovolt-ampere(s) kVA,
- Frequency: Hertz (Hz),
- Noise level: Decibel (dB),
- Static pressure: Pascal (Pa), and
- Volume: Liter (L).

SI units used in «metric» aircraft

- Altitude, elevation and height: Meter (m),
- Vertical speed: Meter per minute (m/min),
- Weight: Kilogram (kg),

- Barometric pressure: Hectopascal (hPa) and
- Pressure: Kilopascal (kPa).

B.E.S. units used in «imperial» aircraft

- Altitude, elevation, height and vertical speed: Feet (ft),
- Vertical speed: Feet per minute (f/min),
- Weight: Pounds (lb),
- Barometric pressure: Inches of mercury (in. Hg), and
- Pressure: Pound per square inch (psi).

B. Conversion factors

Conversion factors					
Multiply	**By**	**To obtain**	**Multiply**	**By**	**To obtain**
cm	0.3937	in.	in.	2.54	cm
cm^2	0.155	in^2	in^2	6.452	cm^2
cm^3	0.061	in^3	in^3	16.387	cm^3
m	3.281	ft	ft	0.348	m
m^2	10.76	ft^2	ft^2	0.0929	m^2
m^3	35.3115	ft^3	ft^3	0.0283	m^3
kt	1.151	mph	mile	5280	ft
nm	1.151	mile	mile	0.869	nm
km	0.6214	mile	mile	1.609	km
km	0.54	nm	nm	1.852	km
km/h	0.54	kt	kt	1.852	km/h
km/h	0.6214	mph	mph	1.609	km/h
kg	2.205	lb	lb	0.45	kg
L	0.2642	Gal (U.S.)	Gal (U.S.)	3.785	L

Conversion factors					
Multiply	**By**	**To obtain**	**Multiply**	**By**	**To obtain**
L	0.22	Gal (Imp)	Gal (Imp)	4.546	L
Gal (U.S.)	0.8327	Gal (Imp)	Gal (Imp)	1.201	Gal (U.S.)
kPa	0.145	psi	psi	6.895	kPa

C. Barometric pressure conversion

The barometric pressure conversions are shown in Figure 01–01–2.

hPa	0	1	2	3	4	5	6	7	8	9
	Inches of Mercury (In Hg)									
940	27.76	27.79	27.82	27.85	27.88	27.91	27.94	27.96	27.99	28.02
950	28.05	28.08	28.11	28.14	28.17	28.20	28.23	28.26	28.29	28.32
960	28.05	28.38	28.41	28.44	28.47	28.50	28.53	28.56	28.58	28.61
970	28.64	28.67	28.70	28.73	28.76	28.79	28.82	28.85	28.88	28.91
980	28.94	28.97	29.00	29.03	29.06	29.09	29.12	29.15	29.18	29.20
990	29.23	29.26	29.29	29.32	29.35	29.38	29.41	29.44	29.47	29.50
1000	29.53	29.56	29.59	29.62	29.65	29.68	29.71	29.74	29.77	29.80
1010	29.83	29.85	29.88	29.91	29.94	29.97	30.00	30.03	30.06	30.09
1020	30.12	30.15	30.18	30.21	30.24	30.27	30.30	30.33	30.36	30.39
1030	30.42	30.45	30.47	30.50	30.53	30.56	30.59	30.62	30.65	30.68
1040	30.71	30.74	30.77	30.80	30.83	30.86	30.89	30.92	30.95	30.98
1050	31.01	31.04	31.07	31.09	31.12	31.15	31.18	31.21	31.24	31.27

Barometric Pressure Conversion
Figure 01–01–2

D. Altitude ISA temperature conversion

The altitude ISA temperature conversions are shown in Figure 01–01–3.

- °C to °F:(°C × 9/5) + 32 = °F
- °F to °C:(°F – 32) × 5/9 = °C

Alt. ft.	ISA -30C		ISA -20C		ISA -10C		ISA		ISA +10C		ISA +20C		ISA +30C	
	C	F	C	F	C	F	C	F	C	F	C	F	C	F
0	-15.0	5.0	-5.0	23.0	5.0	41.0	15.0	59.0	25.0	77.0	35.0	95.0	45.0	113.0
1000	-17.0	1.4	-7.0	19.4	3.0	37.4	13.0	55.4	23.0	73.4	33.0	91.4	43.0	109.4
2000	-18.9	-2.1	-8.9	15.9	1.1	33.9	11.1	51.9	21.1	69.9	31.1	87.9	41.1	105.9
3000	-20.9	-5.7	-10.9	12.3	-0.9	30.3	9.1	48.3	19.1	66.3	29.1	84.3	39.1	102.3
4000	-22.9	-9.3	-12.9	8.7	-2.9	26.7	7.1	44.7	17.1	62.7	27.1	80.7	37.1	98.7
5000	-24.9	-12.8	-14.9	5.2	-4.9	23.2	5.1	41.2	15.1	59.2	25.1	77.2	35.1	95.2
6000	-26.9	-16.4	-16.9	1.6	-6.9	19.6	3.1	37.6	13.1	55.6	23.1	73.6	33.1	91.6
7000	-28.9	-20.0	-18.9	-2.0	-8.9	16.0	1.1	34.0	11.1	52.0	21.1	70.0	31.1	88.0
8000	-30.8	-23.5	-20.8	-5.5	-10.8	12.5	-0.8	30.5	9.2	48.5	19.2	66.5	29.2	84.5
9000	-32.8	-27.1	-22.8	-9.1	-12.8	8.9	-2.8	26.9	7.2	44.9	17.2	62.9	27.2	80.9
10000	-34.8	-30.7	-24.8	-12.7	-14.8	5.3	-4.8	23.3	5.2	41.3	15.2	59.3	25.2	77.3
11000	-36.8	-34.2	-26.8	-16.2	-16.8	1.8	-6.8	19.8	3.2	37.8	13.2	55.8	23.2	73.8
12000	-38.8	-37.8	-28.8	-19.8	-18.8	-1.8	-8.8	16.2	1.2	34.2	11.2	52.2	21.2	70.2
13000	-40.8	-41.4	-30.8	-23.4	-20.8	-5.4	-10.8	12.6	-0.8	30.6	9.2	48.6	19.2	66.6
14000	-42.7	-44.9	-32.7	-26.9	-22.7	-8.9	-12.7	9.1	-2.7	27.1	7.3	45.1	17.3	63.1
15000	-44.7	-48.5	-34.7	-30.5	-24.7	-12.5	-14.7	5.5	-4.7	23.5	5.3	41.5	15.3	59.5
16000	-46.7	-52.1	-36.7	-34.1	-26.7	-16.1	-16.7	1.9	-6.7	19.9	3.3	37.9	13.3	55.9
17000	-48.6	-55.6	-38.6	-37.6	-28.6	-19.6	-18.6	-1.6	-8.6	16.4	1.4	34.4	11.4	52.4
18000	-50.7	-59.2	-40.7	-41.2	-30.7	-23.2	-20.7	-5.2	-10.7	12.8	-0.7	30.8	9.3	48.8
19000	-52.7	-62.8	-42.7	-44.8	-32.7	-26.8	-22.7	-8.8	-12.7	9.2	-2.7	27.2	7.3	45.2
20000	-54.6	-66.3	-44.6	-48.3	-34.6	-30.3	-24.6	-12.3	-14.6	5.7	-4.6	23.7	5.4	41.7
21000	-56.6	-69.9	-46.6	-51.9	-36.6	-33.9	-26.6	-15.9	-16.6	2.1	-6.6	20.1	3.4	38.1
22000	-58.6	-73.5	-48.6	-55.5	-38.6	-37.5	-28.6	-19.5	-18.6	-1.5	-8.6	16.5	1.4	34.5
23000	-60.5	-77.0	-50.5	-59.0	-40.5	-41.0	-30.5	-23.0	-20.5	-5.0	-10.5	13.0	-0.5	31.0
24000	-62.5	-80.6	-52.5	-62.6	-42.5	-44.6	-32.5	-26.6	-22.5	-8.6	-12.5	9.1	-2.5	27.4
25000	-64.5	-84.2	-54.5	-66.2	-44.5	-48.2	-34.5	-30.2	-24.5	-12.2	-14.5	5.8	-4.5	23.8
26000	-66.5	-87.7	-56.5	-69.7	-46.5	-51.7	-36.5	-33.7	-26.5	-15.7	-16.5	2.3	-6.5	20.3
27000	-68.5	-91.3	-58.5	-73.3	-48.5	-55.3	-38.5	-37.3	-28.5	-19.3	-18.5	-1.3	-8.5	16.7
28000	-70.5	-94.9	-60.5	-76.9	-50.5	-58.9	-40.5	-40.9	-30.5	-22.9	-20.5	-4.9	-10.5	13.1
29000	-72.4	-98.4	-62.4	-80.4	-52.4	-62.4	-42.4	-44.4	-32.4	-26.4	-22.4	-8.4	-12.4	9.6
30000	-74.4	-102.0	-64.4	-84.0	-54.4	-66.0	-44.4	-48.0	-34.4	-30.0	-24.4	-12.0	-14.4	6.0
31000	-76.4	-105.6	-66.4	-87.6	-56.4	-69.6	-46.4	-51.6	-36.4	-33.6	-26.4	-15.6	-16.4	2.4
32000	-78.4	-109.1	-68.4	-91.1	-58.4	-73.1	-48.4	-55.1	-38.4	-37.1	-28.4	-19.1	-18.4	-1.1
33000	-80.4	-112.7	-70.4	-94.7	-60.4	-76.7	-50.4	-58.7	-40.4	-40.7	-30.4	-22.7	-20.4	-4.7
34000	-82.4	-116.3	-72.4	-98.3	-62.4	-80.3	-52.4	-62.3	-42.4	-44.3	-32.4	-26.3	-22.4	-8.3
35000	-84.3	-119.8	-74.3	-101.8	-64.3	-83.8	-54.3	-65.8	-44.3	-47.8	-34.3	-29.8	-24.3	-11.8
36000	-86.3	-123.4	-76.3	-105.4	-66.3	-87.4	-56.3	-69.4	-46.3	-51.4	-36.3	-33.4	-26.3	-15.4
37000	-86.5	-123.7	-76.5	-105.7	-66.5	-87.7	-56.5	-69.7	-46.5	-51.7	-36.5	-33.7	-26.5	-15.7
38000	-86.5	-123.7	-76.5	-105.7	-66.5	-87.7	-56.5	-69.7	-46.5	-51.7	-36.5	-33.7	-26.5	-15.7
39000	-86.5	-123.7	-76.5	-105.7	-66.5	-87.7	-56.5	-69.7	-46.5	-51.7	-36.5	-33.7	-26.5	-15.7
40000	-86.5	-123.7	-76.5	-105.7	-66.5	-87.7	-56.5	-69.7	-46.5	-51.7	-36.5	-33.7	-26.5	-15.7
41000	-86.5	-123.7	-76.5	-105.7	-66.5	-87.7	-56.5	-69.7	-46.5	-51.7	-36.5	-33.7	-26.5	-15.7

Altitude ISA temperature conversion
Figure 01−01−3

E. Temperature conversion

The temperature conversion is shown in Figure 01–01–4.

- °C to °F:(°C × 9/5) + 32 = °F
- °F to °C:(°F – 32) × 5/9 = °C

°C	°F	°C	°F	°C	°F	°C	°F
-45	-49.0	-21	-5.8	3	37.4	27	80.6
-44	-47.2	-20	-4.0	4	39.2	28	82.4
-43	-45.4	-19	-2.2	5	41.0	29	84.2
-42	-43.6	-18	-0.4	6	42.8	30	86.0
-41	-41.8	-17	1.4	7	44.6	31	87.8
-40	-40.0	-16	3.2	8	46.4	32	89.6
-39	-38.2	-15	5.0	9	48.2	33	91.4
-38	-36.4	-14	6.8	10	50.0	34	93.2
-37	-34.6	-13	8.6	11	51.8	35	95.0
-36	-32.8	-12	10.4	12	53.6	36	96.8
-35	-31.0	-11	12.2	13	55.4	37	98.6
-34	-29.2	-10	14.0	14	57.2	38	100.4
-33	-27.4	-9	15.8	15	59.0	39	102.2
-32	-25.6	-8	17.6	16	60.8	40	104.0
-31	-23.8	-7	19.4	17	62.6	41	105.8
-30	-22.0	-6	21.2	18	64.4	42	107.6
-29	-20.2	-5	23.0	19	66.2	43	109.4
-28	-18.4	-4	24.8	20	68.0	44	111.2
-27	-16.6	-3	26.6	21	69.8	45	113.0
-26	-14.8	-2	28.4	22	71.6	46	114.8
-25	-13.0	-1	30.2	23	73.4	47	116.6
-24	-11.2	0	32.0	24	75.2	48	118.4
-23	-9.4	1	33.8	25	77.0	49	120.2
-22	-7.6	2	35.6	26	78.8	50	122.0

Temperature conversion
Figure 01–01–4

AIRCRAFT CHARACTERISTICS

The aircraft is a single-aisle, twin-engine, medium range aircraft.

The flight compartment accommodates two pilots and one observer. The cabin has a seating capability from 125 passengers in a standard dual-class configuration to 150 occupants in a high density configuration, including the five flight attendants. The aircraft also includes two pressurized cargo compartments located under the cabin floor.

The fuselage is primarily made of aluminum-lithium alloy. The wings, center wing box, wing-to-body fairing, empennage, aft fuselage, and engine nacelles are made of composite materials.

Two pressurized cargo compartments are located under the cabin floor.

The aircraft has a Fly-By-Wire (FBW) control system, and is powered by two wing–mounted, fan–drive geared, ultra-high bypass ratio PW1500G power plants. The engines are controlled by a Full Authority Digital Electronic Computer (FADEC).

The C Series family includes the CS100 and the CS300 models. These models have extensive operational commonality in the following areas:

- Spare parts,
- Aircraft maintenance,
- Pilot/maintenance training, and
- Crew rating.

A. Operational weights

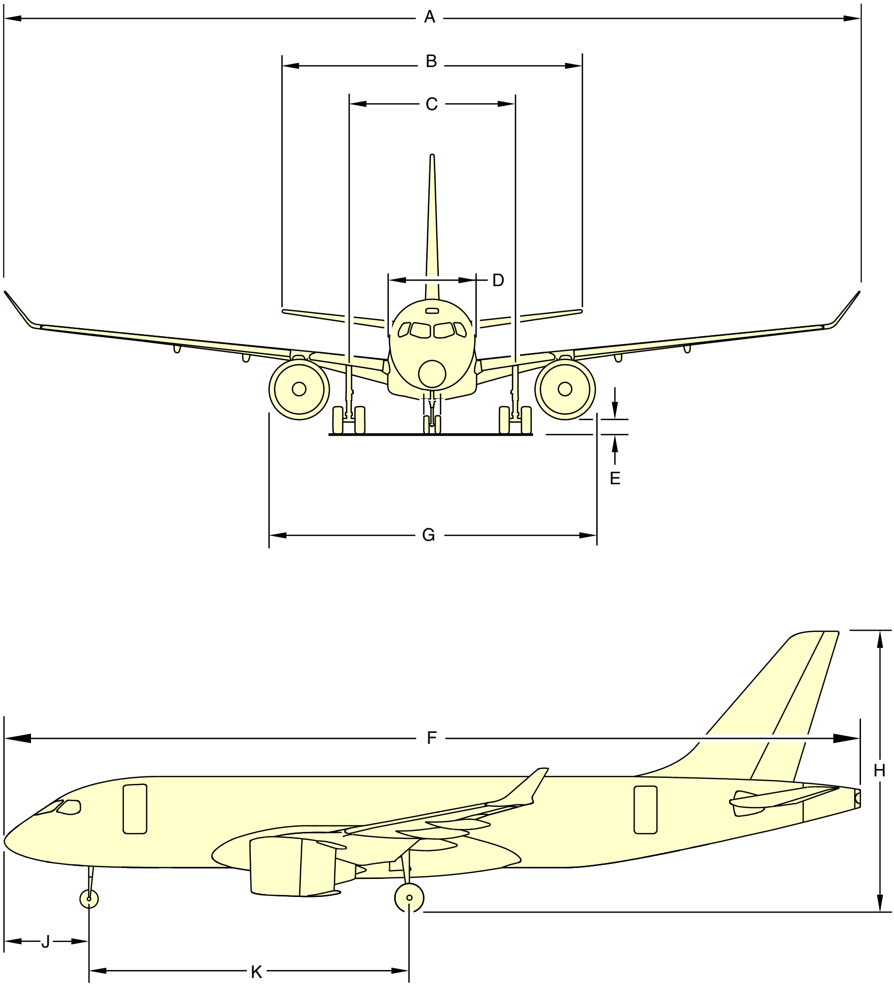
Refer to Airplane Flight Manual (AFM), (BD500–3AB48–32200–00), Chapter 2 – Limitations – Structural weight – Structural weight limits.

AIRCRAFT DIMENSIONS

A. General dimensions

For aircraft external dimensions, refer to the table that follows and to Figure 01–02–1.

Aircraft external dimensions <Metric>			
Locator	**Dimension**	**Locator**	**Dimension**
A	35.1 m	F	38.7 m
B	12.3 m	G	13.4 m
C	6.7 m	H	11.5 m
D	3.5 m	J	3.4 m
E	0.51 m	K	15.2 m

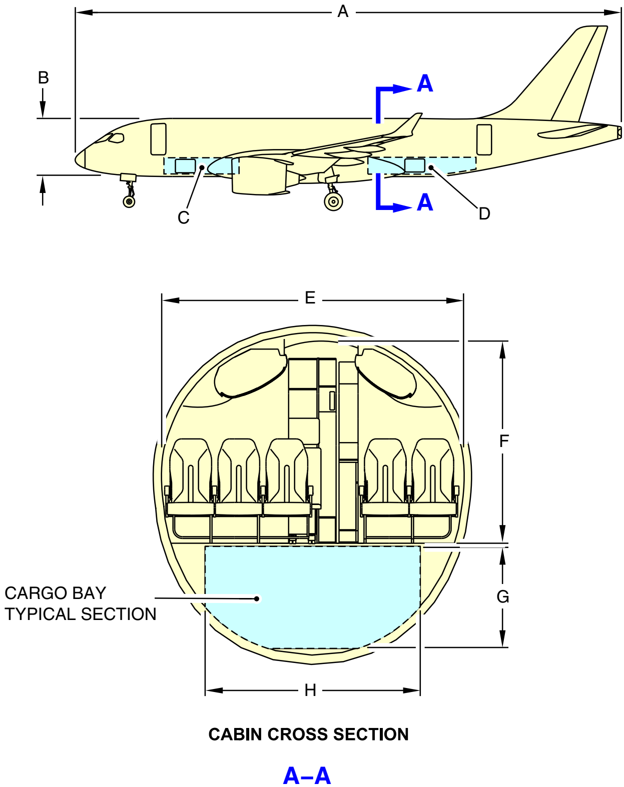


Aircraft external dimensions
Figure 01−02−1

B. Fuselage dimensions

For the dimensions of the fuselage, refer to the table that follows and to Figure 01–02–2.

Fuselage dimensions <Metric>			
Locator	**Dimension**	**Locator**	**Dimension**
A	38.7 m	E	3.28 m
B	3.7 m	F	2.1 m
C	14.8 m^3	G	1.1 m
D	16.8 m^3	H	2.2 m



Fuselage dimensions
Figure 01–02–2

GROUND HANDLING

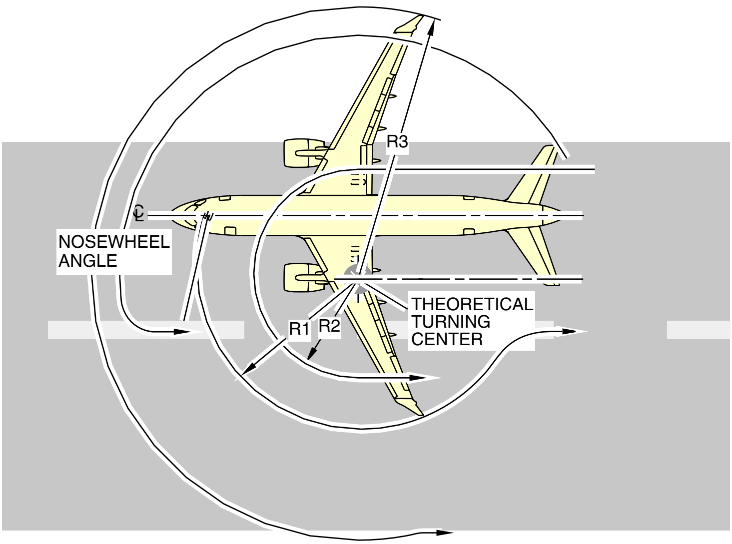
A. Aircraft turning radius

The aircraft can perform a 180-degree turn under its own power on a runway width of no more than 23.50 m. <Metric>

The nosewheel steering is able to deflect up to 80 degrees left or right of the aircraft center.

Refer to the table that follows and Figure 01–02–3 for the turning radius of the aircraft.

Turning angle (in degrees) with 3-degree tire slip	80 degrees
R1: Nose gear outside face	15.94 m
R2: Main gear outside face	7.04 m
R3: Wing tip	21.74 m
Minimum pavement width for 180-degree turn	23.50 m



Aircraft turning radius
Figure 01–02–3

NOTE

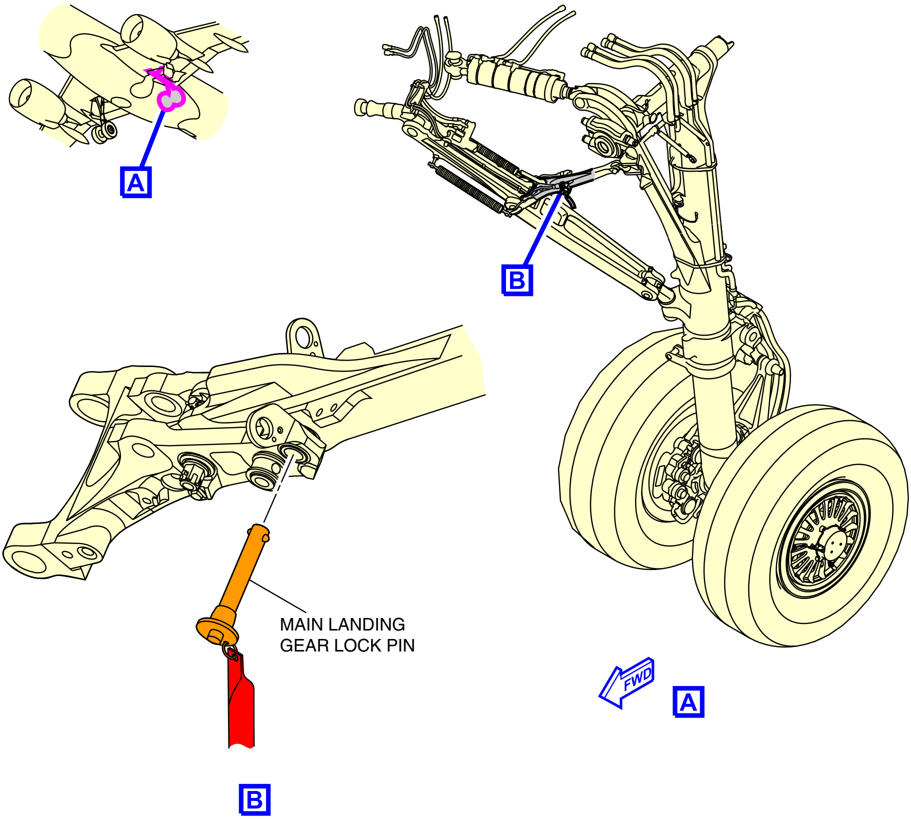
The turning radius performance of the aircraft is based on the conditions that follow:

- Symmetrical thrust,
- No differential braking,
- Slow continuous turning, and
- Dry surface.

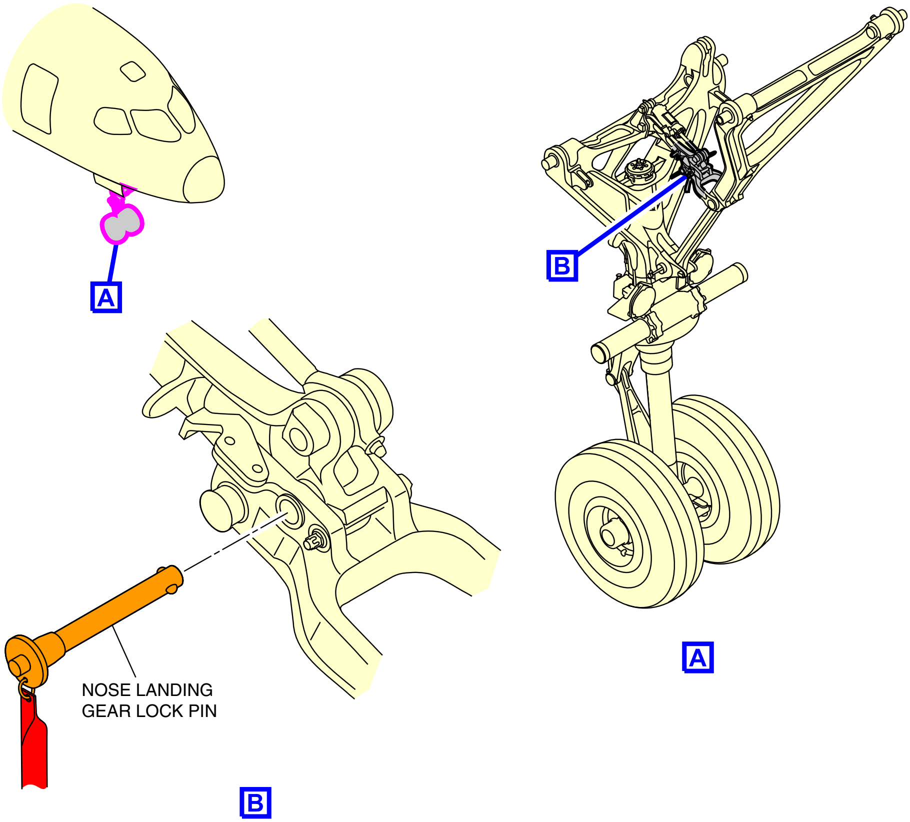
B. Ground lock pins

The lock pins are used on the ground for the landing gear system and the Ram Air Turbine (RAT).

The landing gear system has three lock pins. One lock pin is installed in each main landing gear (refer to Figure 01–02–4) and one is installed in the nose landing gear (refer to Figure 01–02–5).

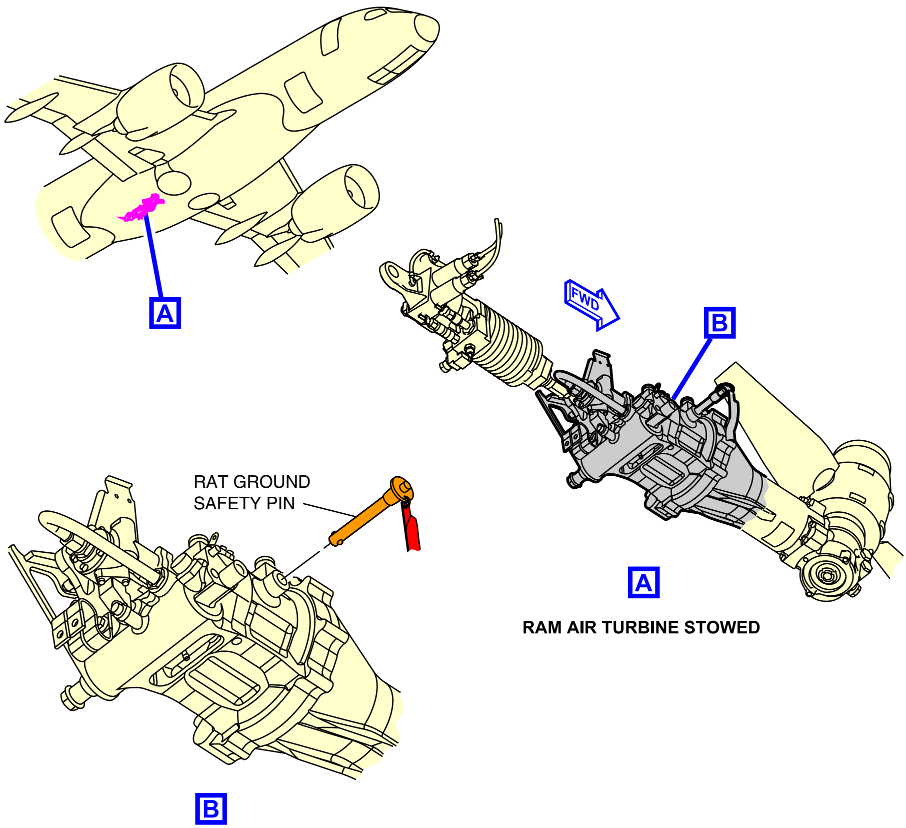


Main landing gear lock pin
Figure 01–02–4



Nose landing gear lock pin
Figure 01–02–5

The RAT has one lock pin (refer to Figure 01–02–6). When installed by the ground personal, the red Remove Before Flight flag on this lock pin is visible from under the wing-to-body fairing.



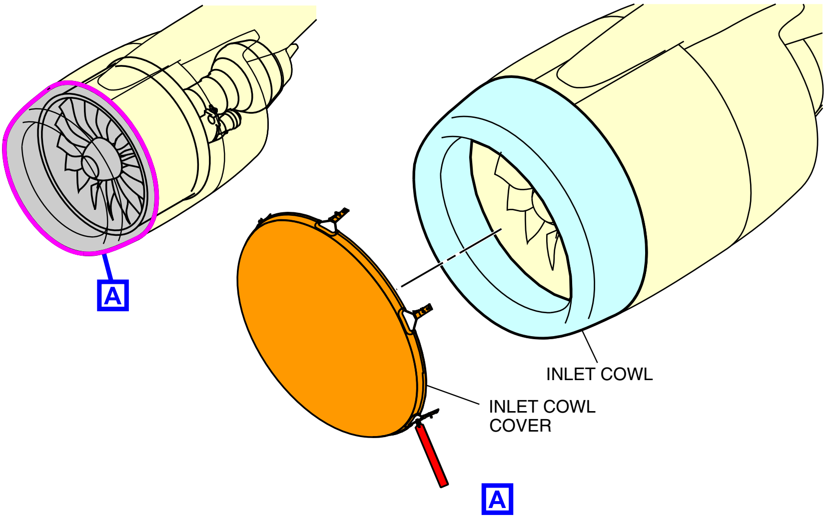
Ram Air Turbine (RAT) lock pin
Figure 01–02–6

C. Covers

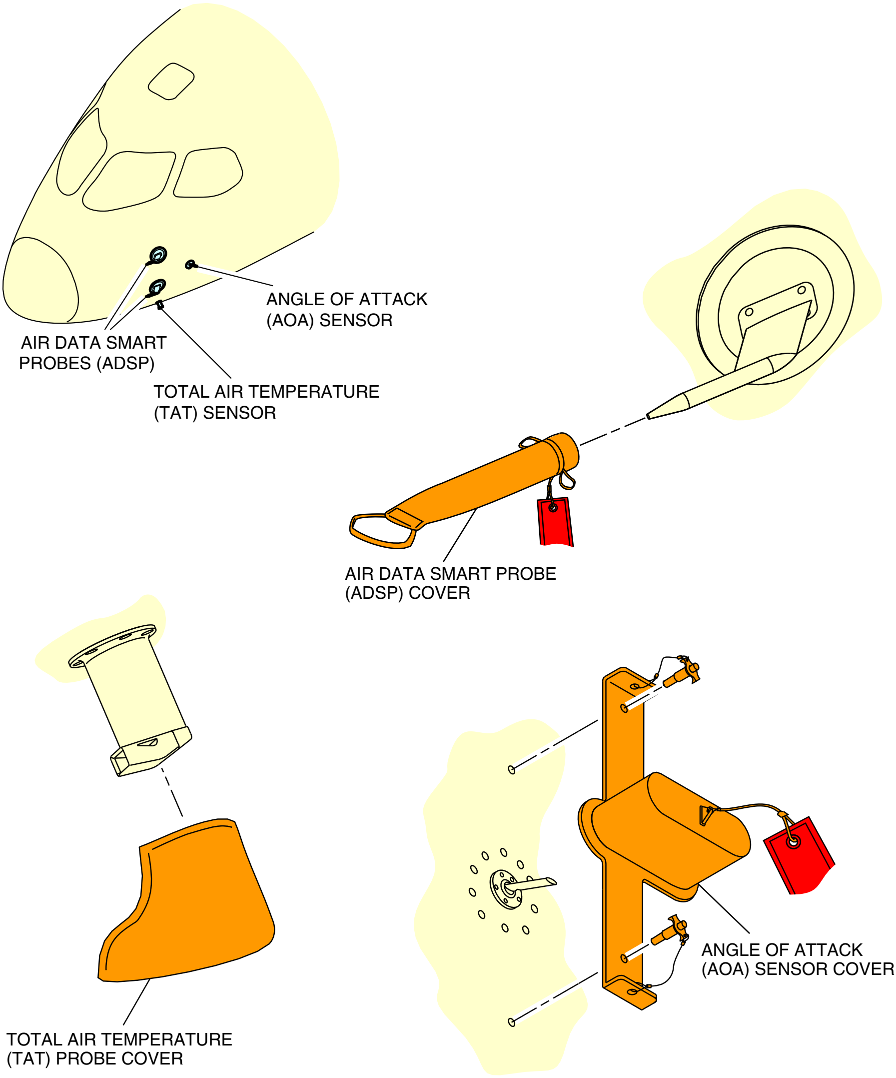
Covers are available for the aircraft components that follows:

- Inlet cowl (refer to Figure 01–02–7),
- Air Data Smart Probe (ADSP) (refer to Figure 01–02–8),
- Total Air Temperature (TAT) probe (refer to Figure 01–02–8),
- Angle Of Attack (AOA) sensor (refer to Figure 01–02–8), and

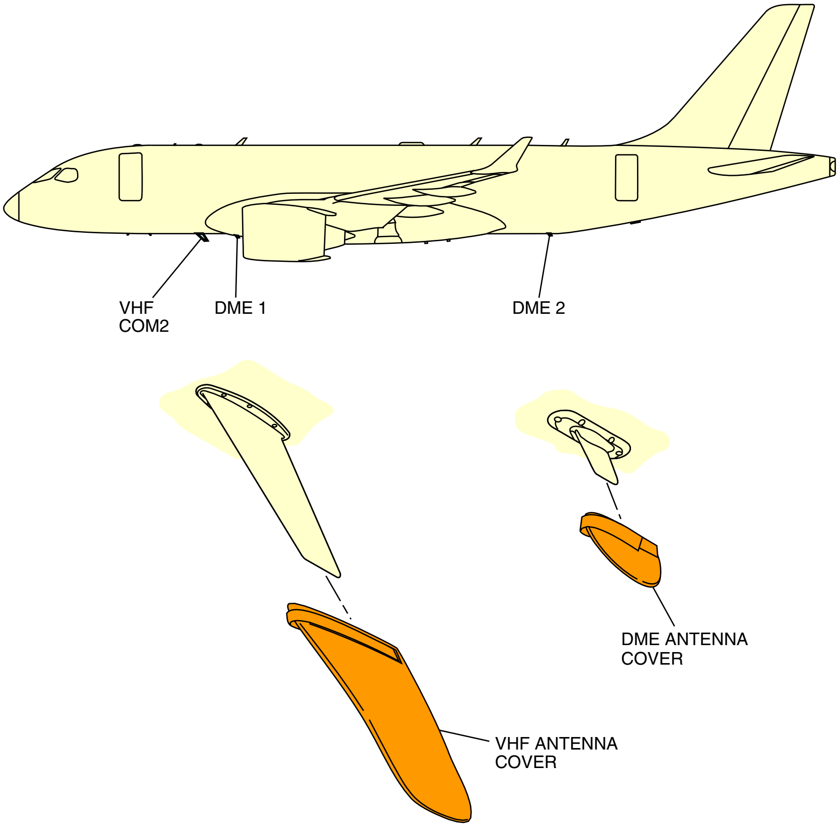
- Antenna covers (refer to Figure 01–02–9).



Inlet cowl cover
Figure 01–02–7



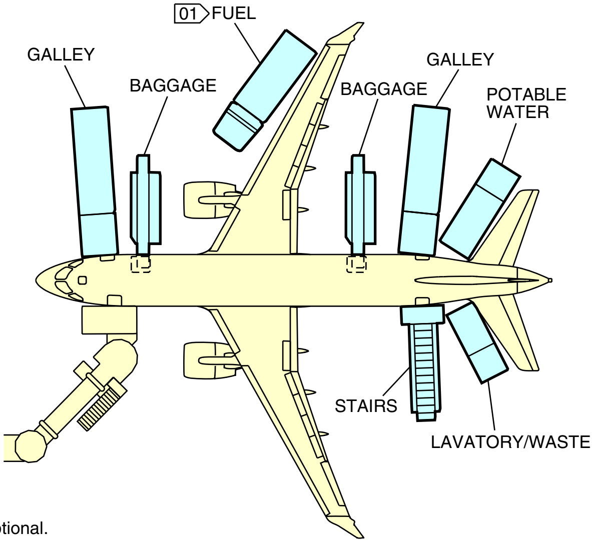
Sensor covers for ADSP, TAT, and AOA
Figure 01–02–8



Antenna covers
Figure 01–02–9

D. Aircraft servicing points

The typical ground servicing layout for the aircraft is shown in Figure 01–02–10.

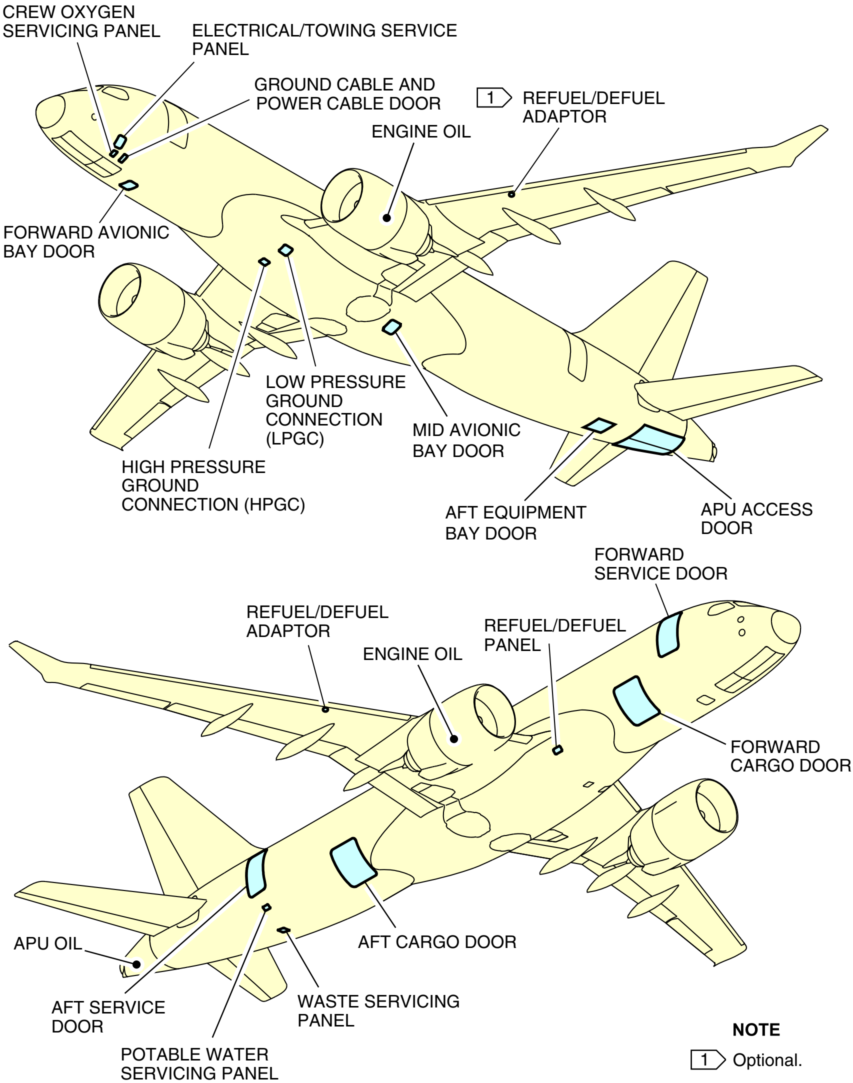


NOTE

01 Left side optional.

Aircraft servicing arrangement
Figure 01–02–10

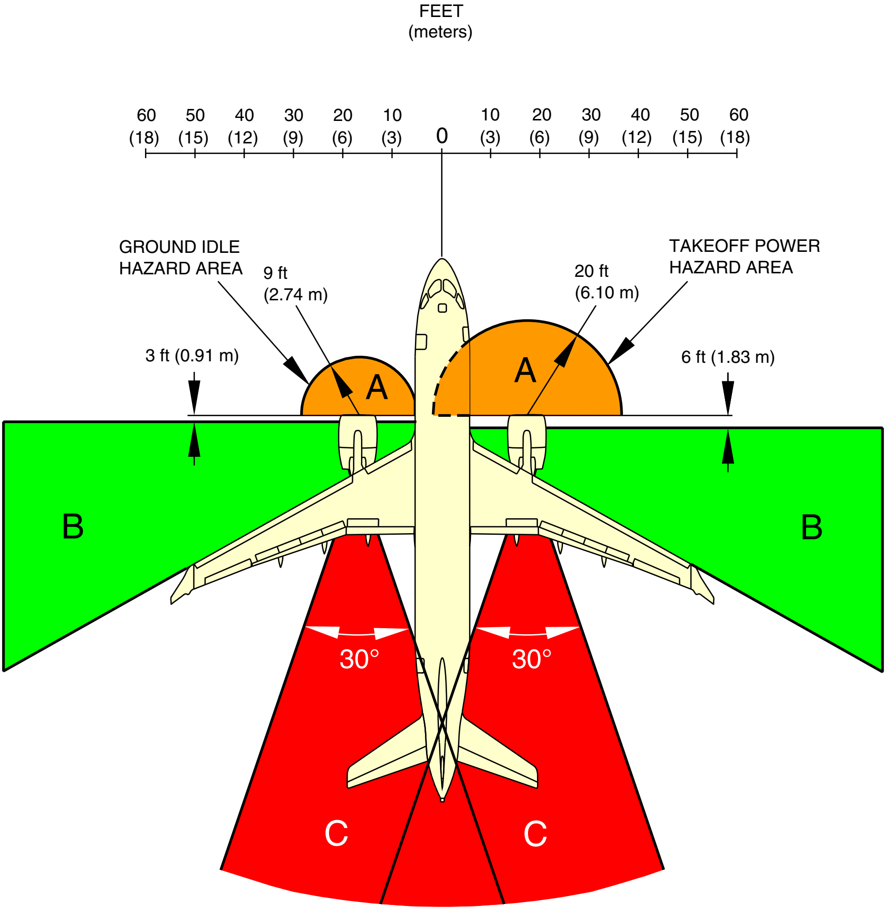
The servicing point locations are shown in Figure 01–02–11.



Ground servicing access locations
Figure 01−02−11

E. Engine hazard areas

The engine hazard areas are shown in Figure 01–02–12.



LEGEND

AREA A INTAKE SUCTION DANGER AREA

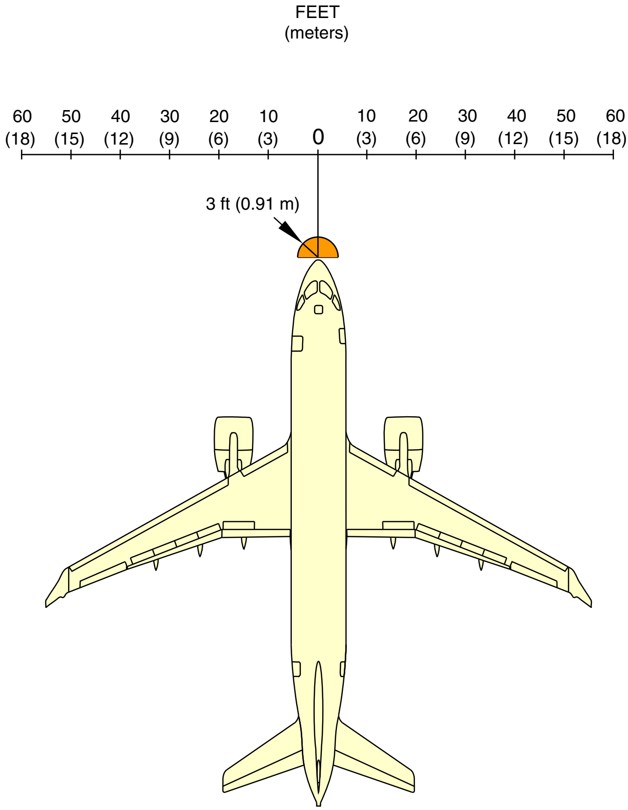
AREA B ENTRY CORRIDOR

AREA C EXHAUST DANGER AREA (AFT OF EXHAUST NOZZLE):
200 ft (61 m) – GROUND IDLE (20 kt HEADWIND)
600 ft (183 m) – TAKEOFF POWER (20 kt HEADWIND)

Engine intake and exhaust hazard areas
Figure 01–02–12

F. Weather radar hazard area

The aircraft uses the MultiScan weather radar antenna. The radar antenna hazard areas are shown in Figure 01–02–13.



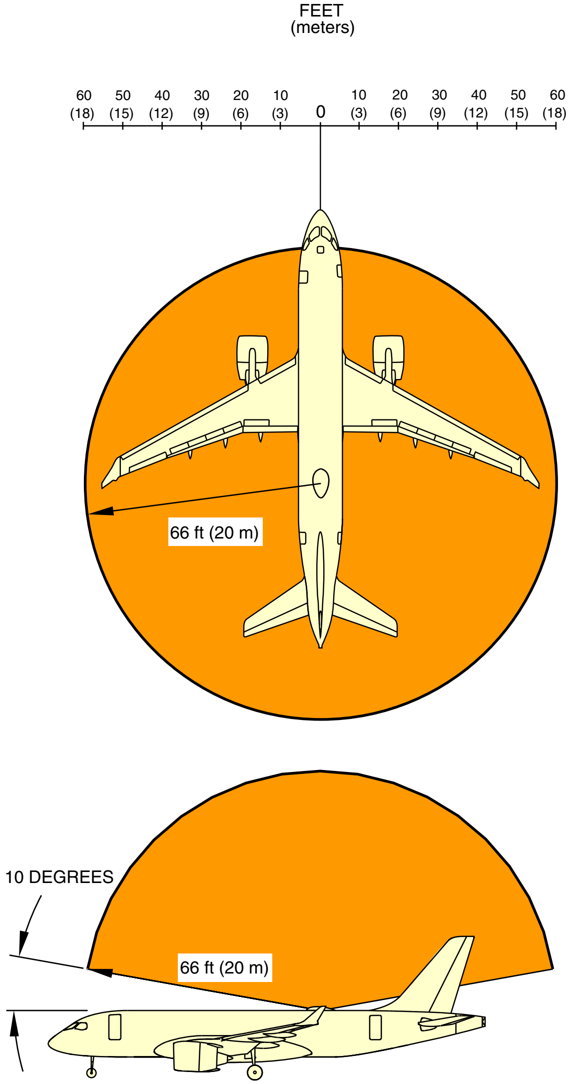
Weather radar hazard area
Figure 01–02–13

For more information about the weather radar, refer to Chapter 16 – Navigation – Section 04 – Weather radar (WXR) system.

G. Ku-band connectivity hazard area <44309210C>

The Ku-band connectivity hazard area is shown in Figure 01–02–14.

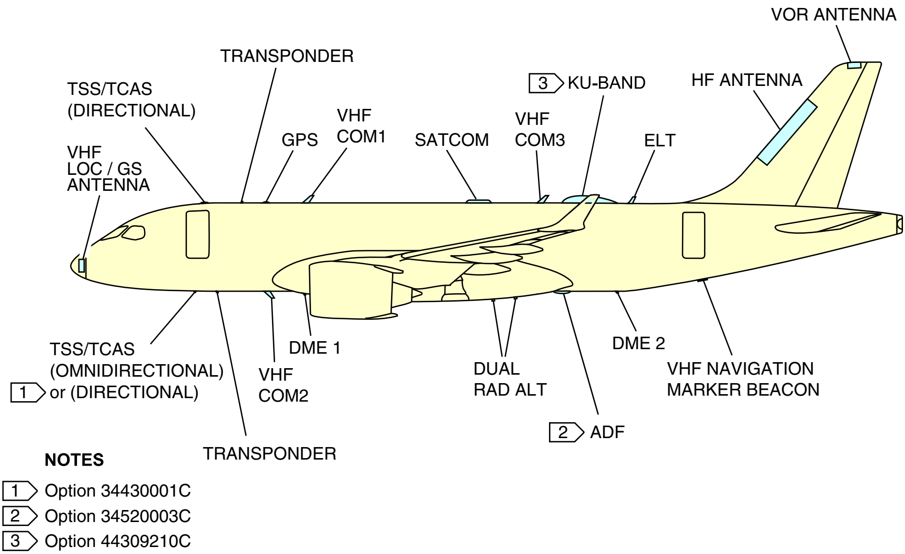
For more information about the Ku-band connectivity system, refer to Chapter 05 – Communication – Section 01 – Ku-band connectivity system (Panasonic eXConnect). <44309212C>



Ku–band hazard area
Figure 01–02–14

H. Aircraft antenna locations

The locations of antennas installed on the aircraft are shown in Figure 01–02–15.

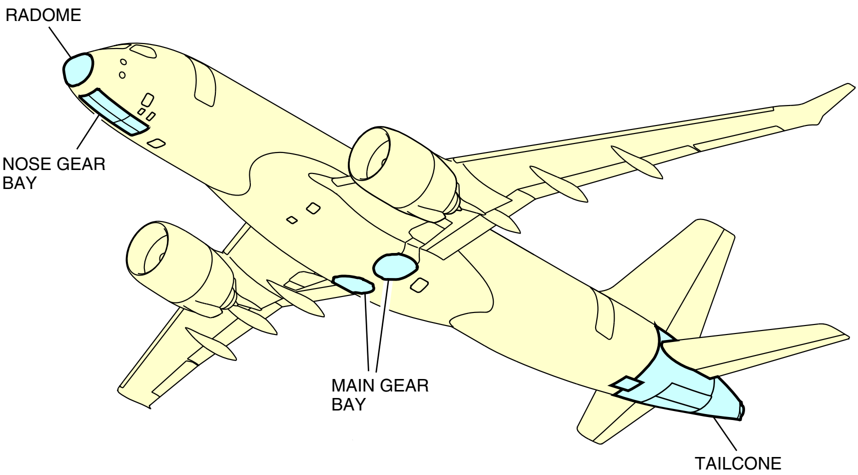


Aircraft antenna locations
Figure 01–02–15

I. Unpressurized areas

The areas that follow are not pressurized (refer to Figure 01–02–16):

- The radome,
- the nose gear bay,
- the main gear bay, and
- the tailcone.



Unpressurized areas
Figure 01–02–16

FLIGHT DECK

A. Flight compartment – Overview

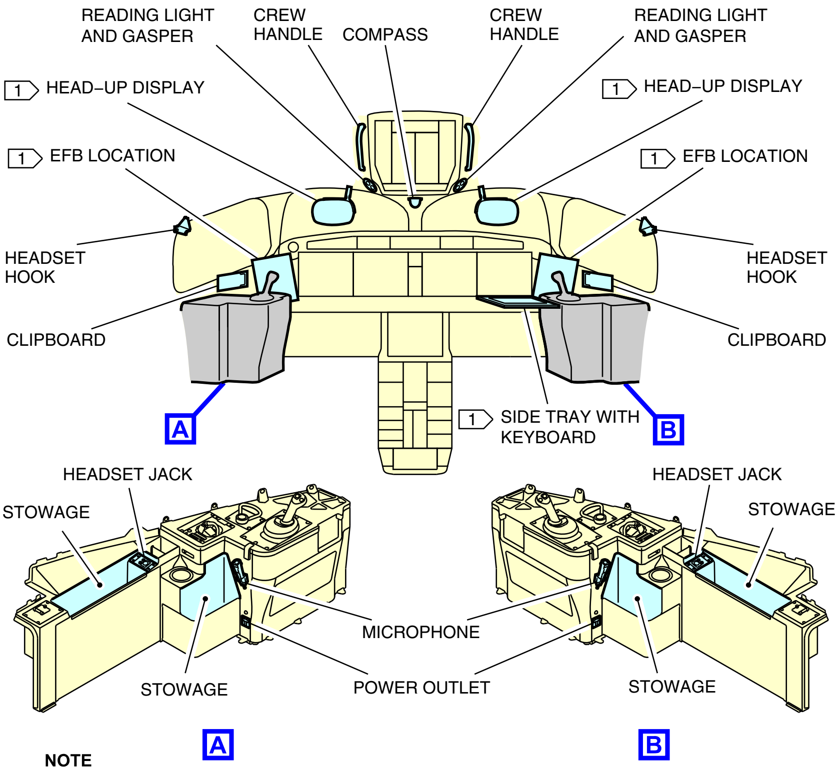
The flight compartment provides the pilots with a modern, ergonomically-designed working environment to reduce the flight crew workload and optimize aircraft safety.

Figure 01–02–17 shows the flight compartment – Front view.

Figure 01–02–18 shows the flight compartment – Rear, left view.

Figure 01–02–19 shows the flight compartment – Rear, right view.

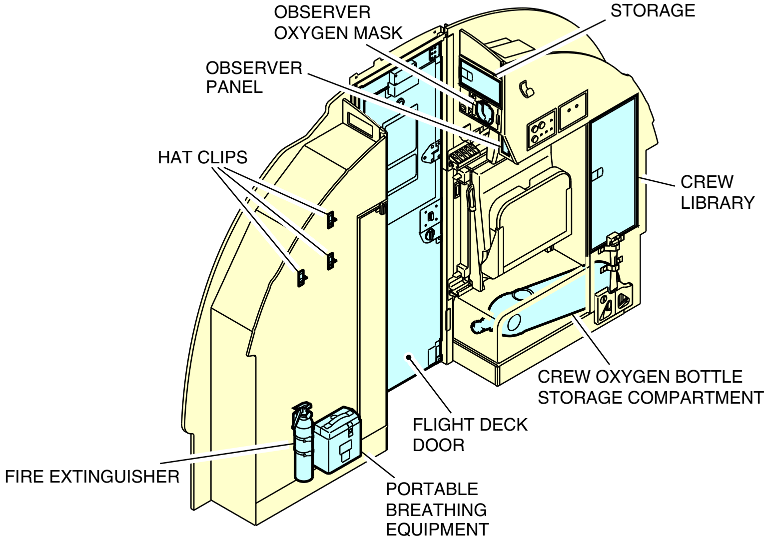
Figure 01–02–20 shows the flight deck.



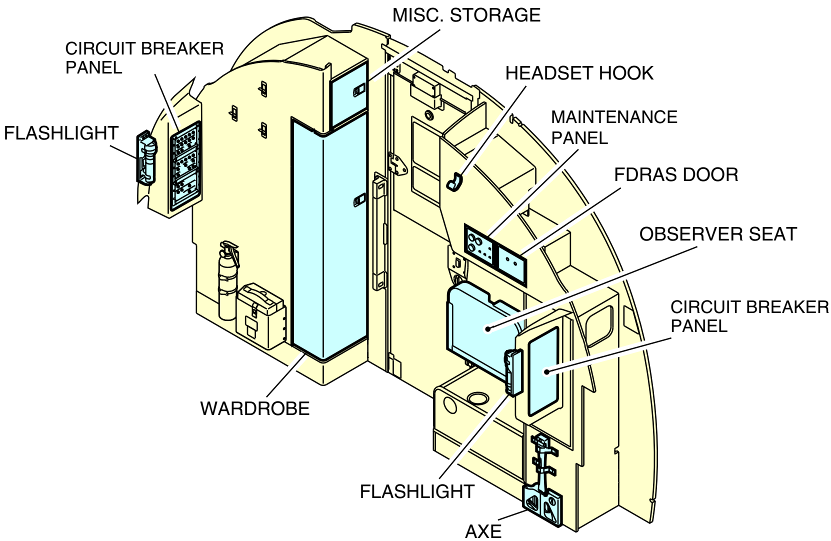
NOTE

1 Optional.

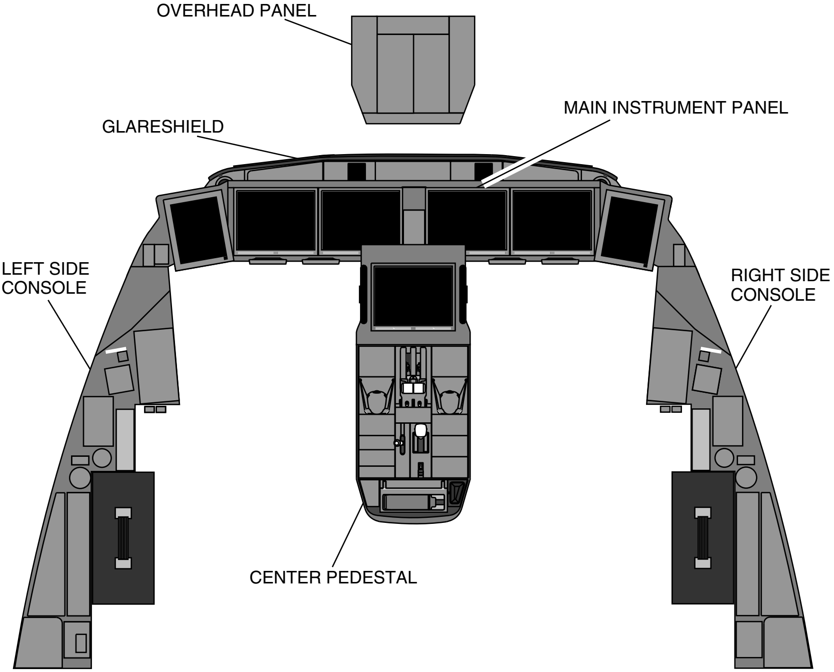
Flight compartment – Front view
Figure 01–02–17



Flight compartment – Rear, left view
Figure 01–02–18



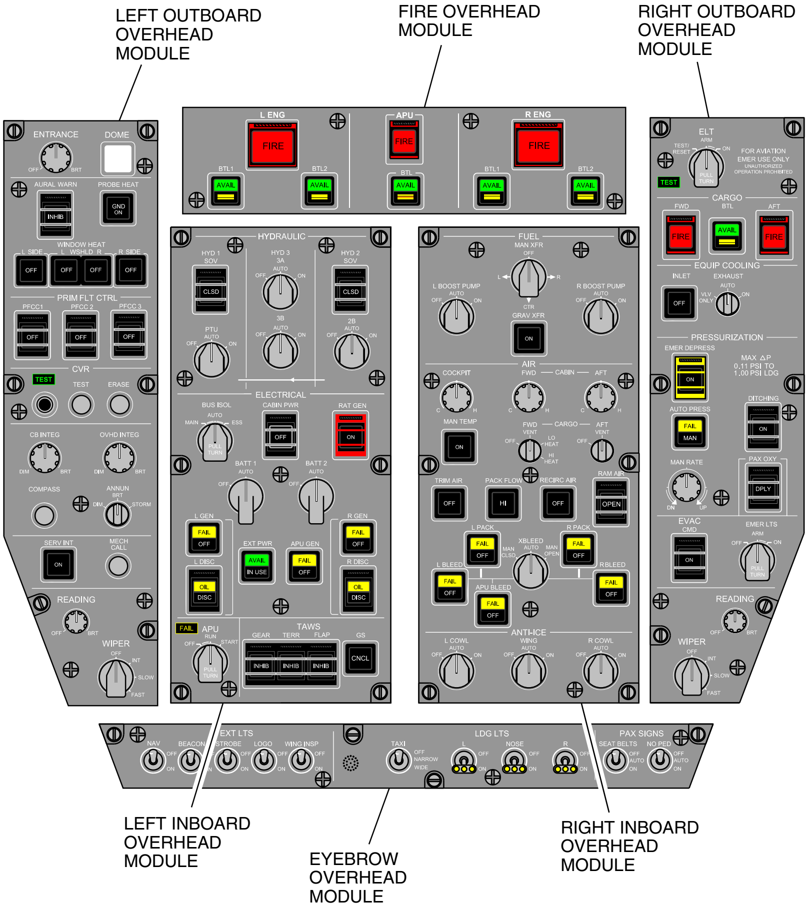
Flight compartment – Rear, right view
Figure 01–02–19



Flight deck control panel overview
Figure 01–02–20

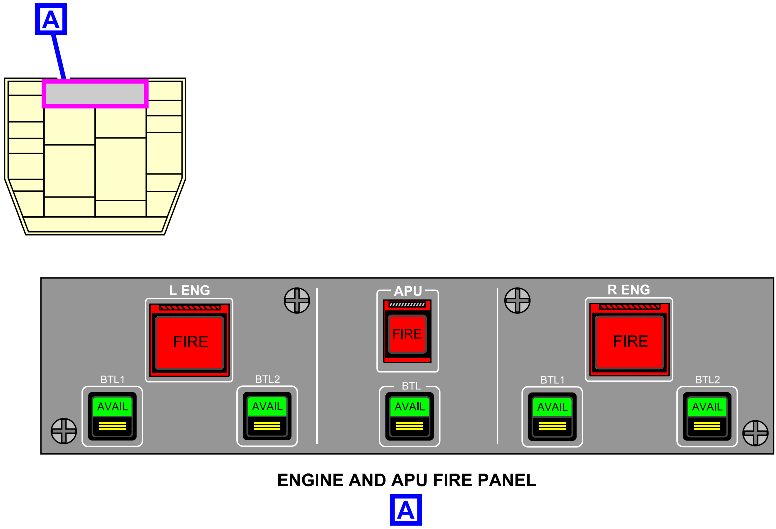
B. Overhead panel

The overhead panel (refer to Figure 01–02–21) is divided into six modules which includes the systems control panels.



Overhead panel
Figure 01–02–21

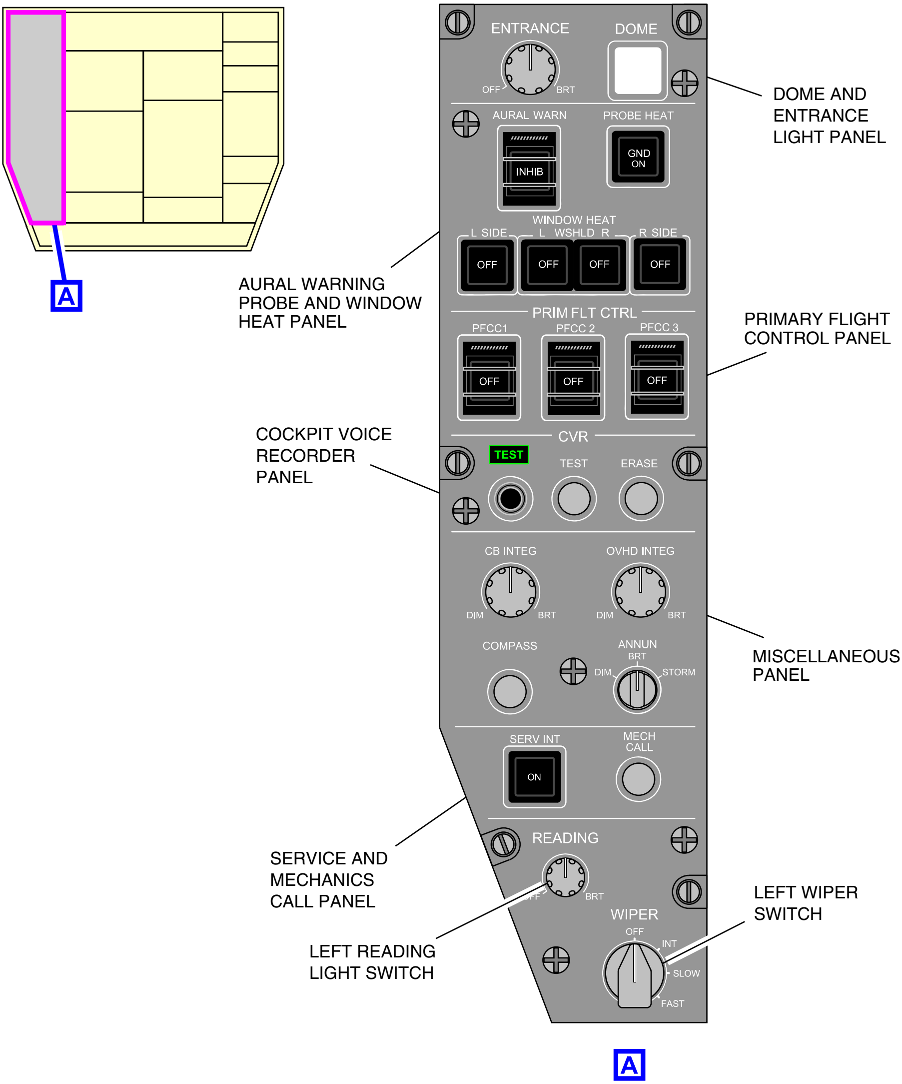
The fire overhead module includes the engine and APU fire panel (refer to Figure 01–02–22).



Engine and APU fire panel
Figure 01–02–22

The left outboard overhead module (refer to Figure 01–02–23) includes:

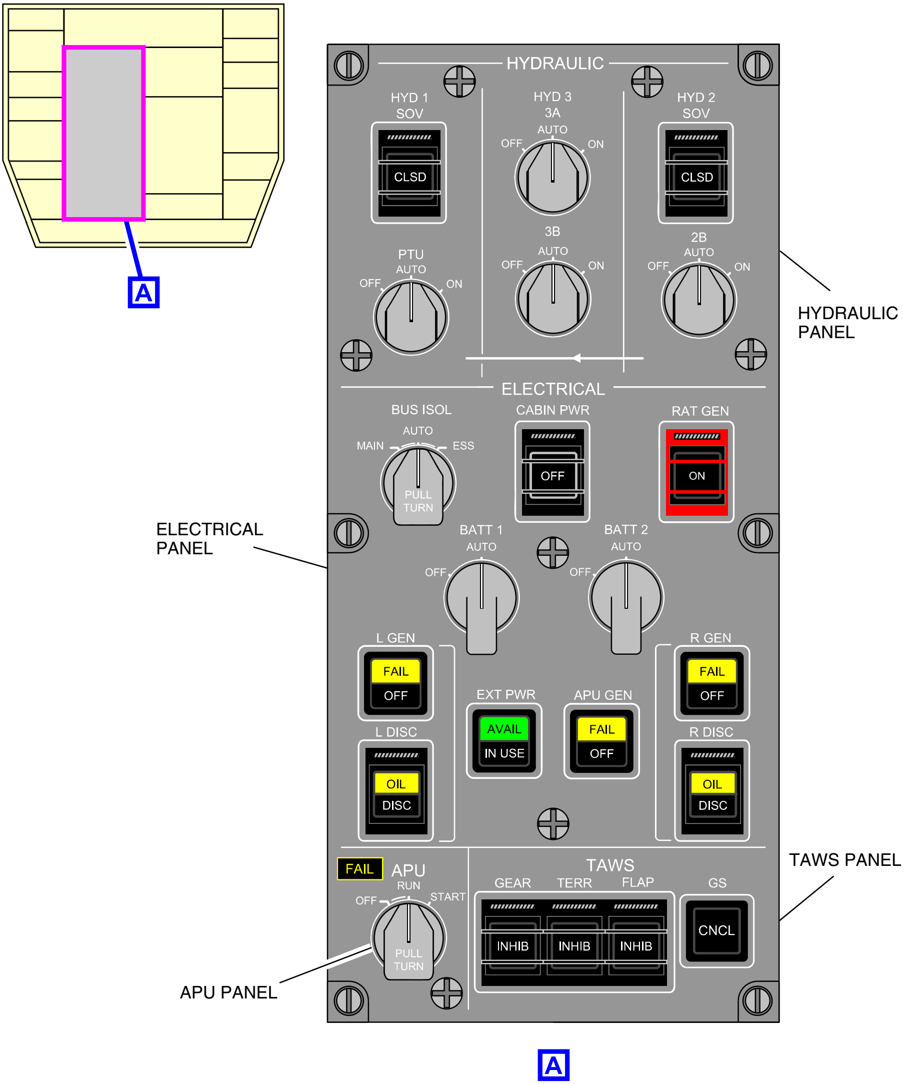
- The DOME and ENTRANCE light panel,
- The AURAL WARNING, PROBE HEAT and WINDOW HEAT panel,
- The PRIM FLT CTRL (primary flight control) panel,
- The CVR (cockpit voice recorder) panel,
- The miscellaneous panel,
- The SERVICE and MECH (mechanics) call panel,
- The left READING light switch, and
- The left windshield WIPER switch.



Left outboard overhead module
Figure 01–02–23

The left inboard overhead module (refer to Figure 01–02–24) includes:

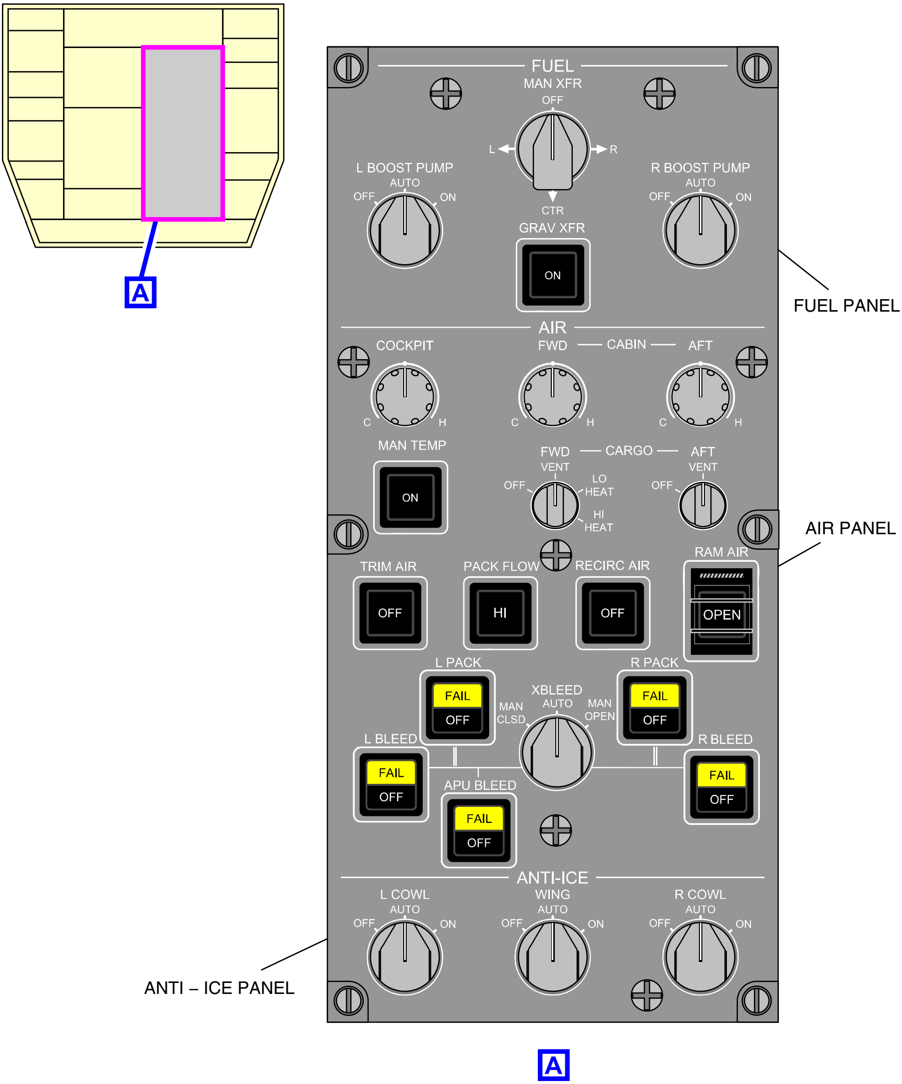
- The HYDRAULIC panel,
- The ELECTRICAL panel,
- The APU switch, and
- The TAWS panel.



Left inboard overhead module
Figure 01–02–24

The right inboard overhead module (refer to Figure 01–02–25) includes:

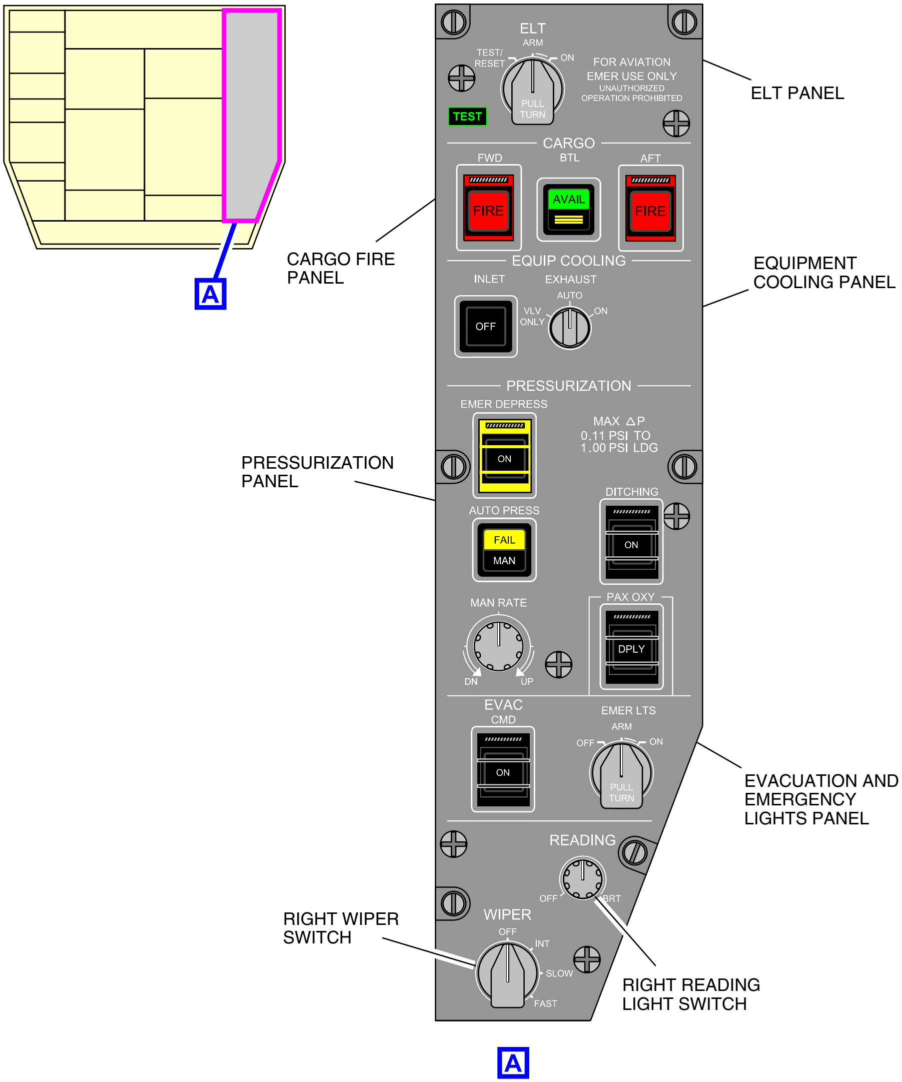
- The FUEL panel,
- The AIR panel, and
- The ANTI-ICE panel.



Right inboard overhead module
Figure 01–02–25

The right outboard overhead module (refer to Figure 01–02–26) includes:

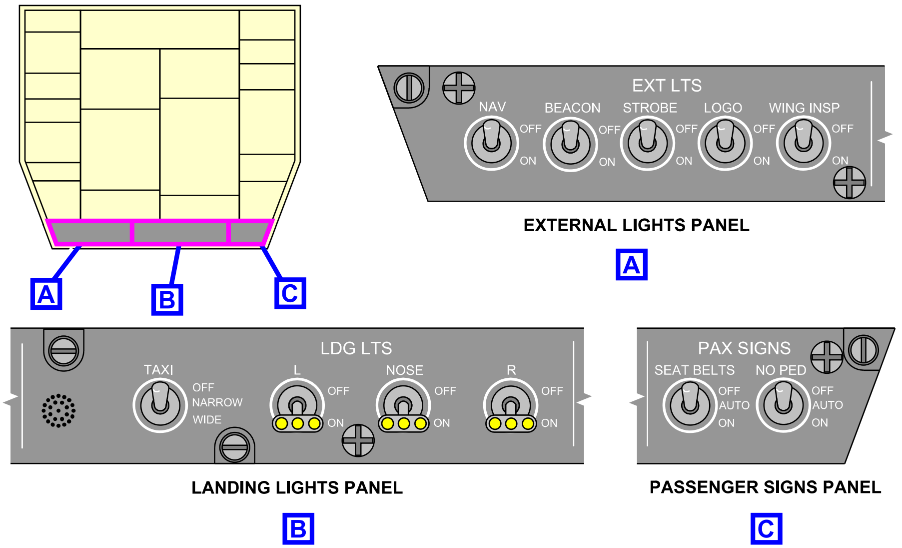
- The ELT panel,
- The CARGO fire panel,
- The EQUIP COOLING (equipment cooling) panel,
- The PRESSURIZATION panel,
- The EVAC and EMER LTS (evacuation and emergency lights) panel,
- The right READING light switch, and
- The right windshield WIPER switch.



Right outboard overhead module
Figure 01–02–26

The lights overhead module (refer to Figure 01–02–27) includes: <31100001D>

- The EXT LTS (external lights) panel,
- The LDG LTS (landing lights) panel, and
- The PAX SIGNS (passenger signs) panel.

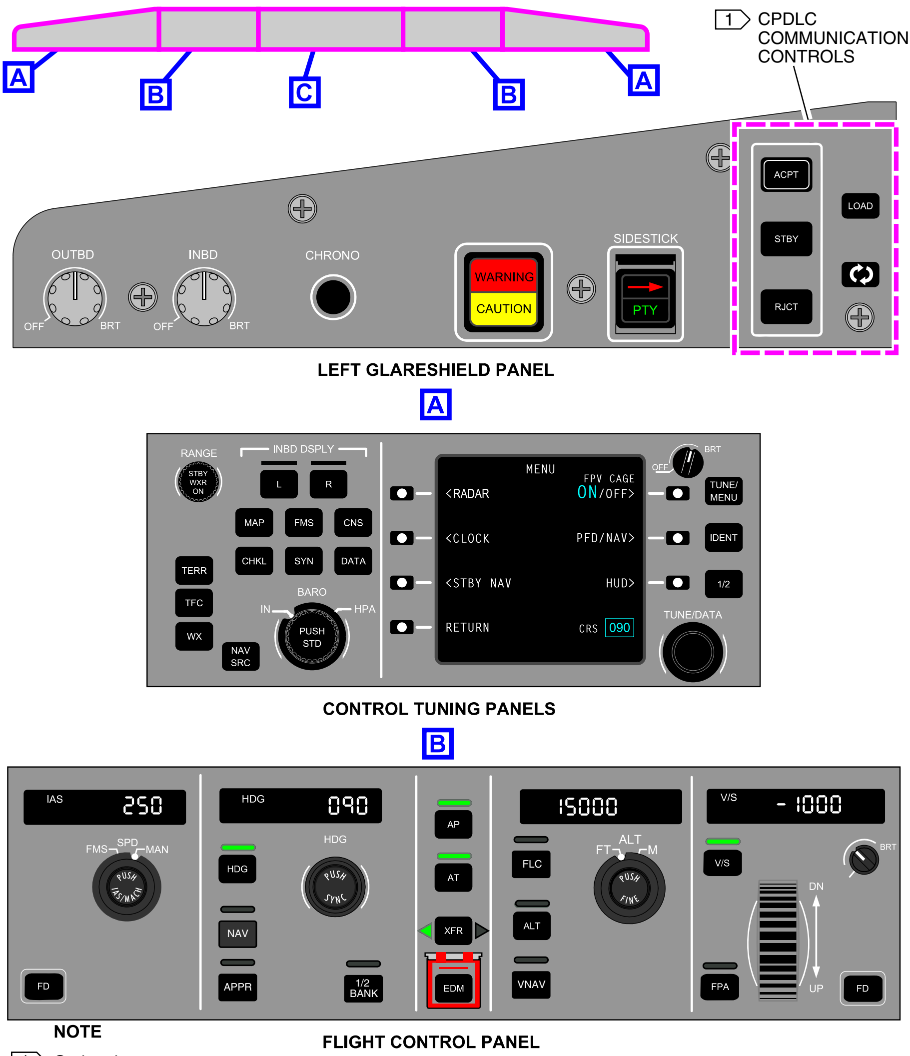


Eyebrow overhead module – Activate downward <31100001D>
Figure 01–02–27

C. Glareshield

The glareshield (refer to Figure 01–02–28) includes:

- The left and right glareshield panels,
- The left and right Controller Pilot Data Link Communication (CPDLC) panels, <23249001C>
- The left and right control tuning panels (CTP), and
- The Flight Control Panel (FCP).



NOTE

1 Optional.

FLIGHT CONTROL PANEL

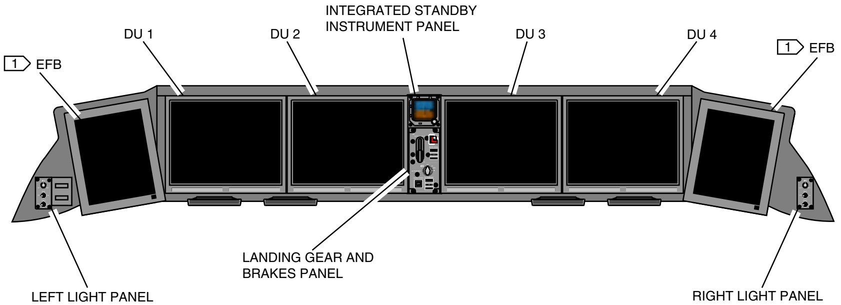
C

Glareshield
Figure 01–02–28

D. Main instrument panel

The main instrument panel (refer to Figure 01–02–29) has four Liquid Crystal Display (LCD) adaptive Display Units (DUs) which provide the flight crew with flight and navigation information. It also includes:

- The left and right DU light panels,
- The Integrated Standby Instrument System (ISIS), and
- The gear and brakes panel.



NOTE

1 Optional.

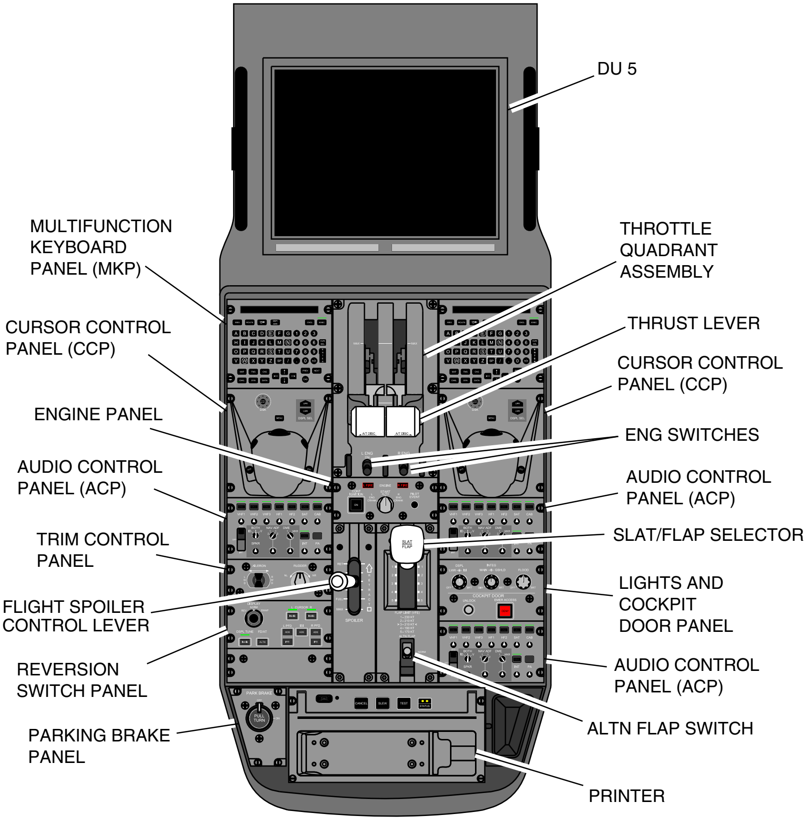
Main instrument panel
Figure 01–02–29

E. Center pedestal

The center pedestal (refer to Figure 01–02–30) includes:

- The DU 5,
- The left and right Multifunction Keyboard Panels (MKP),
- The left and right Cursor Control Panel (CCPs),

- Three Audio Control Panels (ACPs),
- The trim control panel,
- The Reversion Switch Panel (RSP),
- The PARK BRAKE (parking brake) panel,
- The printer, <23220001C>
- The Throttle Quadrant Assembly (TQA),
- The ENGINE panel,
- The flight spoiler lever,
- The slat/flap lever panel, and
- The lights and COCKPIT DOOR panel.



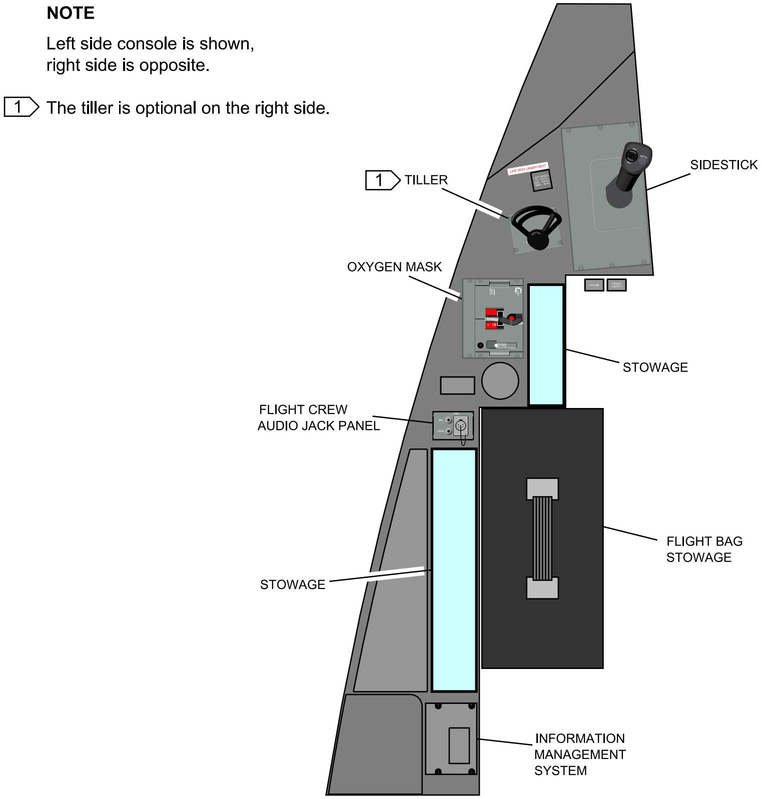
Center pedestal
Figure 01–02–30

F. Side consoles

The left and the right side consoles (refer to Figure 01–02–31) are similar, and include:

- The left and right sidesticks,
- The left tiller,
- The left and right oxygen masks,

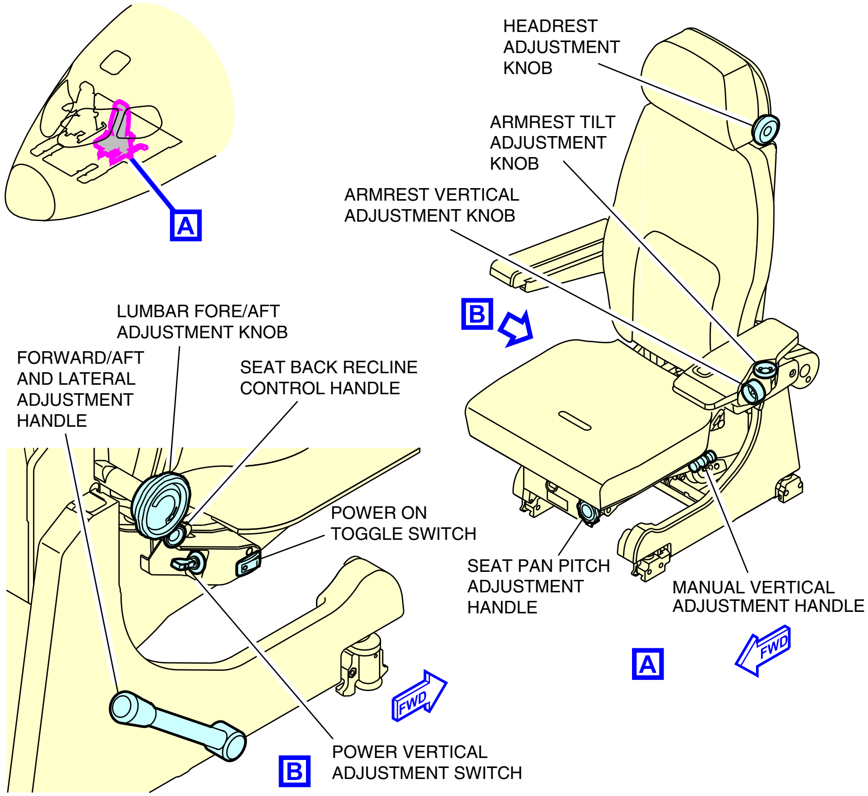
- Stowage, and
- The left and right circuit breaker panels.



Side console
Figure 01–02–31

G. Flight deck seats

The flight deck accommodates two pilot seats (refer to Figure 01–02–32).



Flight deck pilot seats
Figure 01–02–32

The main features of the pilot seats are:

- F-track – Mechanical adjustment forward and aft,
- Electric vertical adjustment with mechanical backup,
- Adjustable arm rests (with position scale and controls outboard) and,
- Pocket in back of seat for light stowage (walk-around vest).

(1) Vertical adjustment movement

The seats have electrically and mechanically actuated height adjustment. Each seat has 7 inches of vertical seat movement with a power switch and mechanical backup adjustment system.

Electrical vertical control of the seats is accomplished by two switches located on the inboard side of each seat bucket. The power cut-off switch is labeled POWER and the vertical power adjustment switch is labeled HEIGHT.

- The HEIGHT switch is a three-position switch. The positions are up, down, and center neutral.
- Setting the HEIGHT switch up or down for brief durations permits minor adjustments to the seat height.
- Setting the HEIGHT switch up or down for a longer duration permits the maximum adjustment speed of 1 inch/second.

A manual override function is available so that the flight crew can adjust the seat if power is lost. A release handle on the side of the seat is pulled, which disengages the actuator and permits manual adjustment.

The manual power cut-off switch is located on the inboard side of the seat bucket side panel. This component is a mechanical switch with two positions ON and OFF.

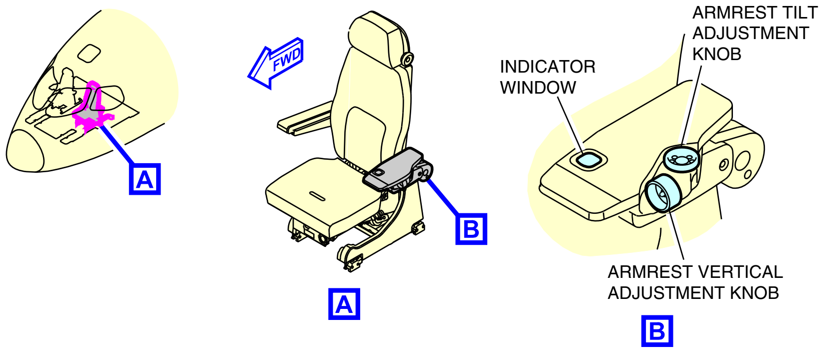
During normal seat operation, the power cut-off switch stays in the ON position to supply 28 VDC to the actuator.

(2) Lateral adjustment movement

The forward, aft, and lateral adjustment handle is located on the inboard side of the seat to operate the seat along the F-tracks.

(3) Outboard armrest

Figure 01–02–33 shows the outboard armrest.



Outboard armrest
Figure 01–02–33

A visual indicator on the top surface of the armrest permits the occupant to rapidly adjust the armrest height and tilt to their preferred position.

An increment scale of 1 to 4 defines the height position of the armrest, while an increment scale of A to E defines the tilt position of the armrest.

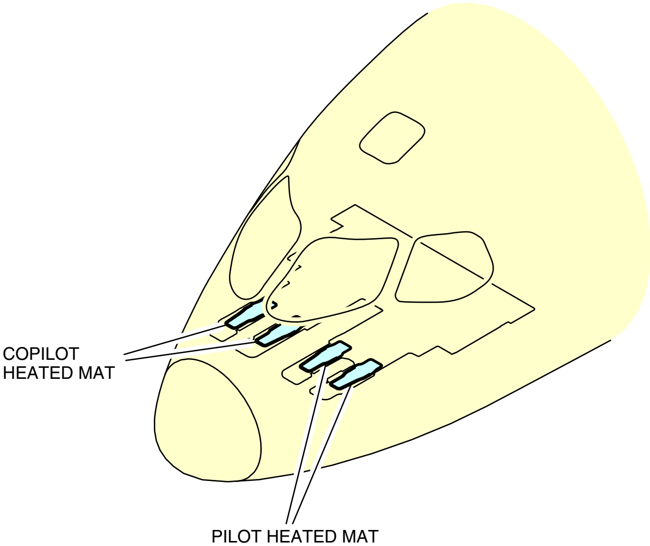
Rotating the knob clockwise tilts the front of the armrest down.

Rotating the knob counter-clockwise tilts the front of the armrest up.

H. Pilot electrical foot warmer <25150001C>

The electrical foot warmers create a warm surface below the pilot and the copilot feet. The kick plates reduce the thermal losses and are automatically controlled.

The four heated mats (refer to Figure 01–02–34) are installed between the composite floor panel and the stainless steel kick plates at the pilot and copilot positions in the flight compartment.

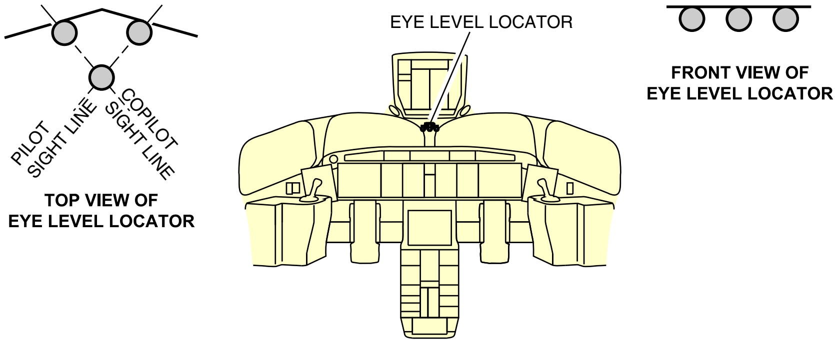


Pilot electrical foot warmers <25150001C>
Figure 01−02−34

I. Flight deck vision

The alignment balls (eye level locators, refer to Figure 01−02−35) are used to locate the ideal seat placement for all operations. The correct seat placement (height, fore, and aft) is achieved when:

- All flight controls are unrestricted throughout full travel,
- Flight instruments and warning lights are visible and unobstructed,
- Outside visibility is unobstructed,
- Seat position is the same for VFR or IFR, and
- Seat position is comfortable.



Eye level locators
Figure 01–02–35

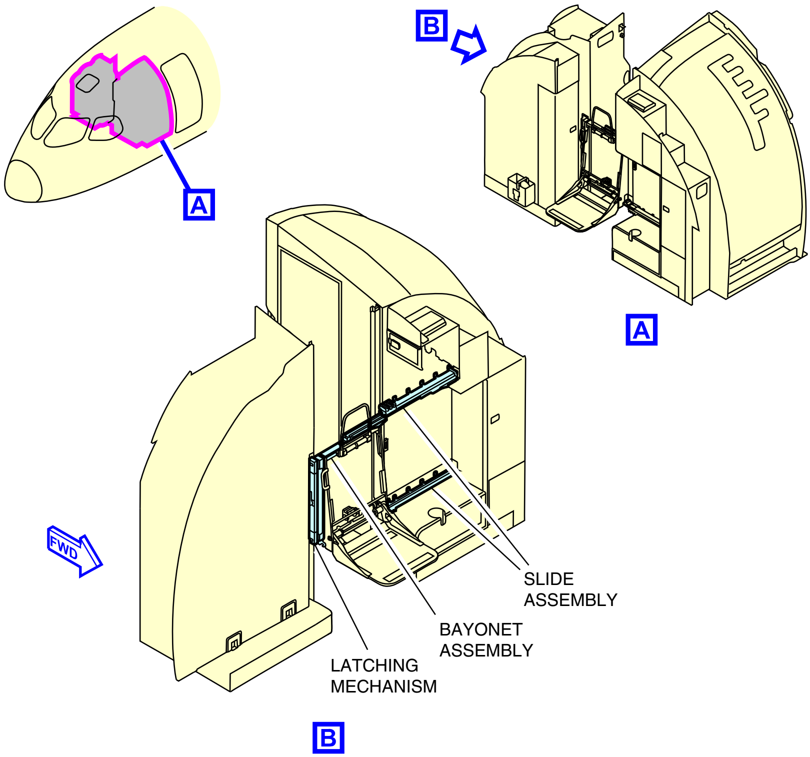
The optional Head-Up Display (HUD) enhances safety by allowing the pilot to scan flight information while viewing the approaching airport.

J. Flight deck jump seat (observer seat)

In the flight deck, the observer seat (refer to Figure 01–02–36) has the following characteristics and features:

- Auto fold-up seat base,
- Combined shoulder harness, and
- Safety belt with a single point release.

To operate the observer seat, the observer must face the flight compartment door, slide the observer seat to the left and clip it to the latching mechanism located on the left side of the flight deck door. (Refer to Figure 01–02–38 and Figure 01–02–39).

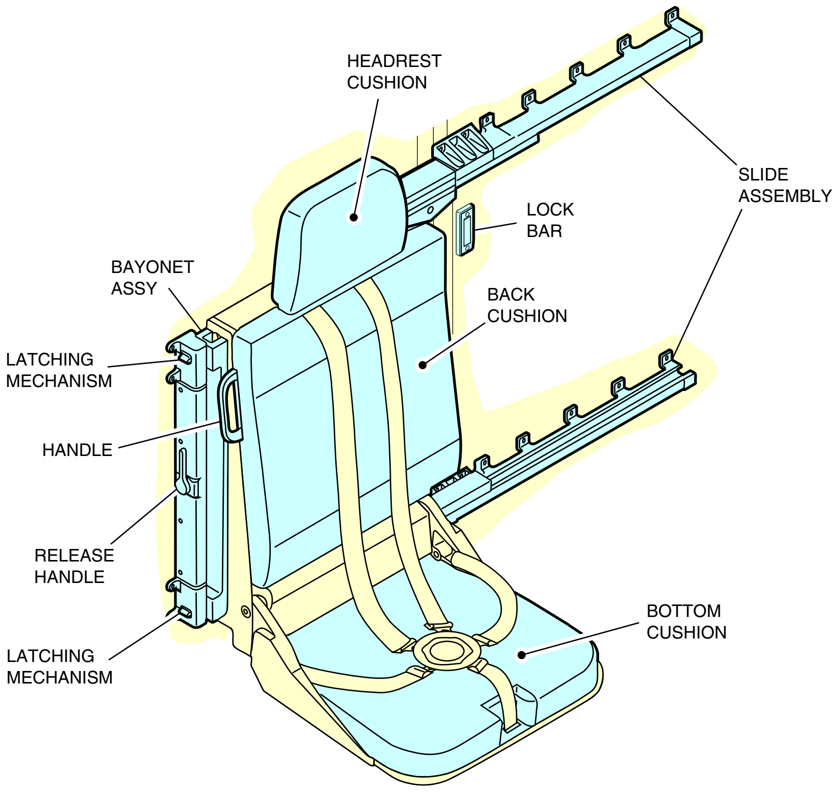


Flight deck jump seat (observer seat)
Figure 01–02–36

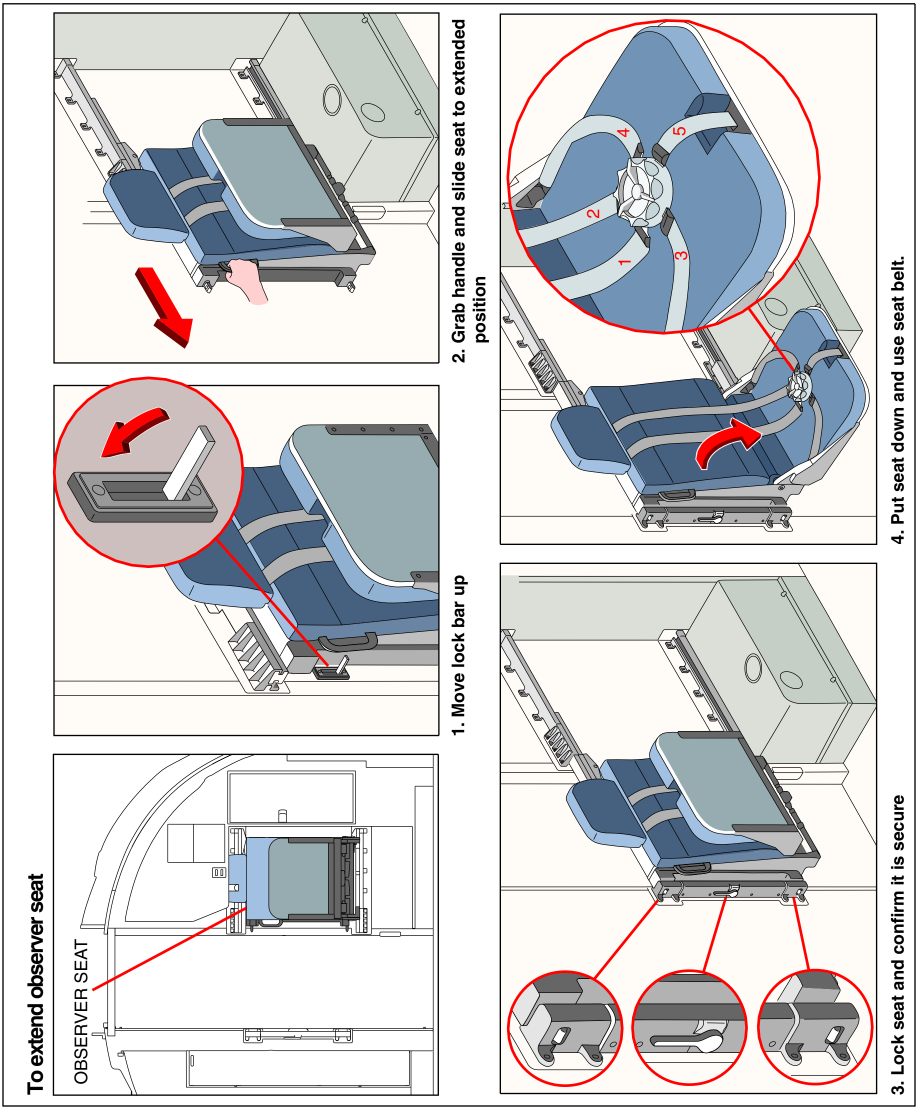
The observer seat includes the items (refer to Figure 01–02–37) that follow:

- Slide assembly,
- Lock bar,
- Headrest cushion,
- Back cushion,
- Bottom cushion,

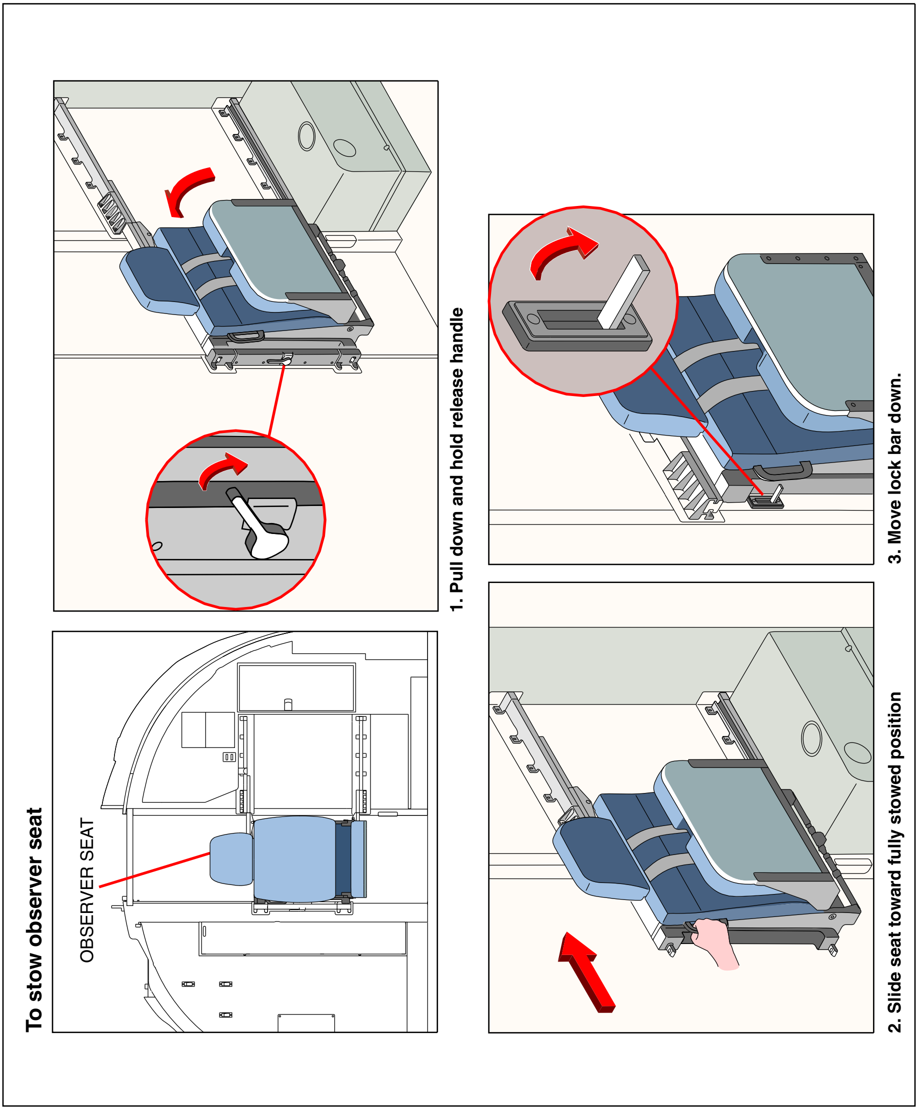
- Bayonet assembly,
- Latching mechanism,
- Handle, and
- Release handle.



Flight deck jump seat (observer seat) – Description
Figure 01–02–37



Observer seat safety card
Figure 01–02–38



Observer seat safety card
Figure 01–02–39

CABIN LAYOUT

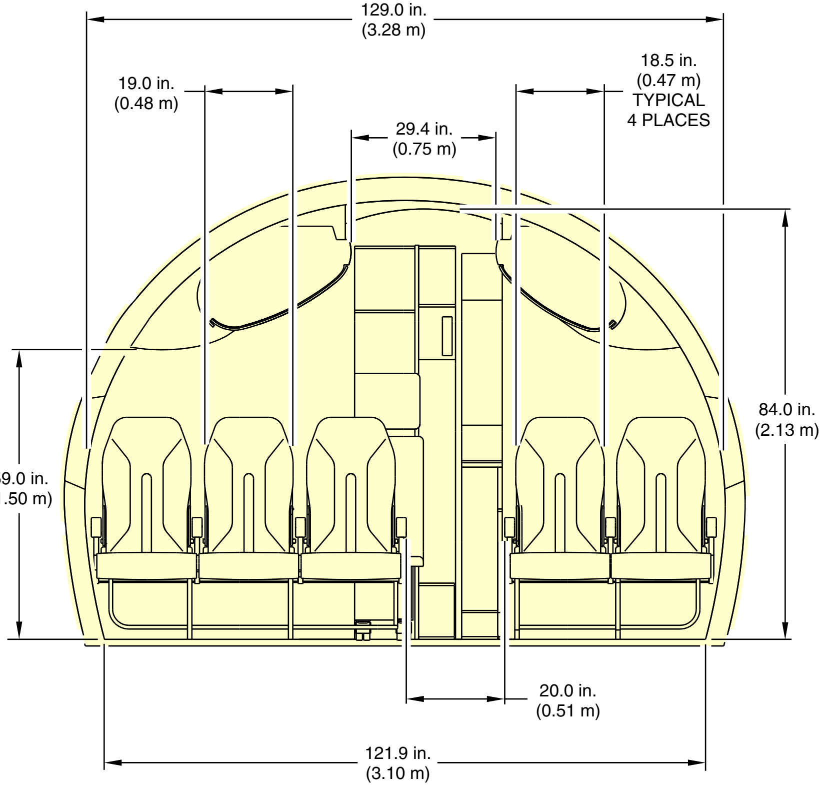
A. Cabin layout – Overview

The cabin layout includes the main components that follow:

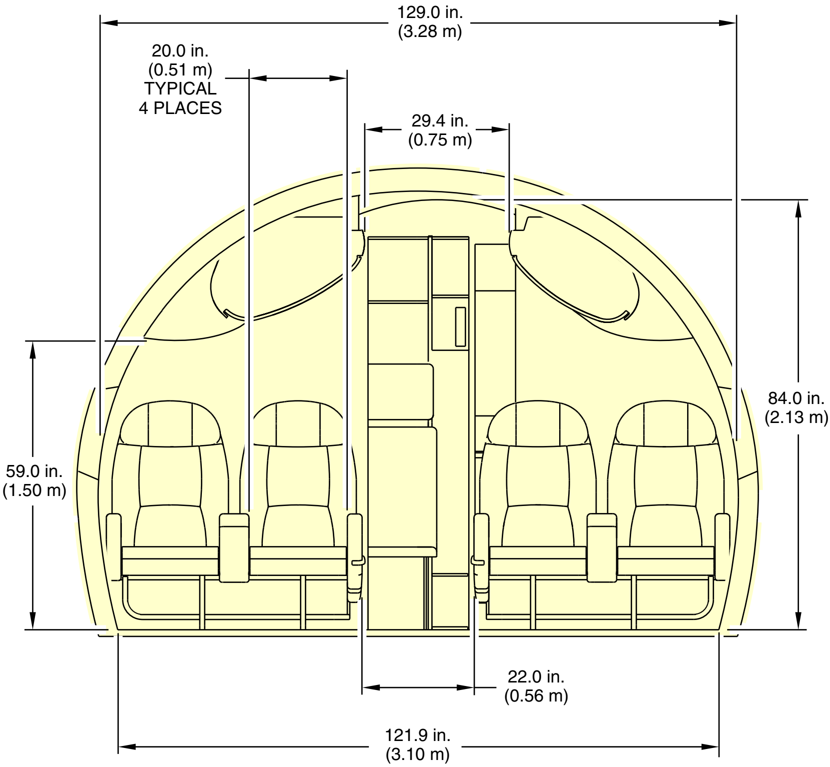
- Passenger seats,
- Overhead storage bins,
- Passenger Service Units (PSUs),
- Galleys,
- Lavatories, and
- Flight attendant jump seats.

B. Passenger seat – Layout

The aircraft single-aisle cabin layout can support five abreast economy seating (3 x 2) (refer to Figure 01–02–40) or four abreast business class seating (2 x 2) (refer to Figure 01–02–41).



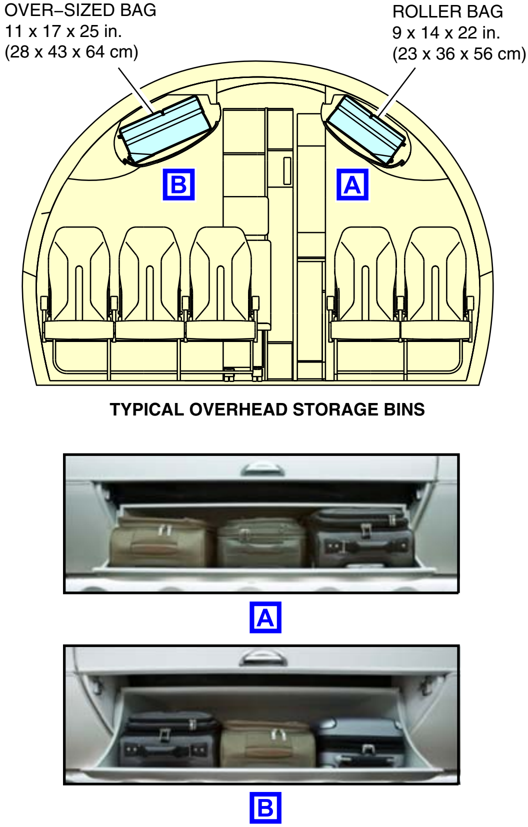
Typical class section
Figure 01–02–40



Business class section (optional)
Figure 01–02–41

C. Overhead storage bins

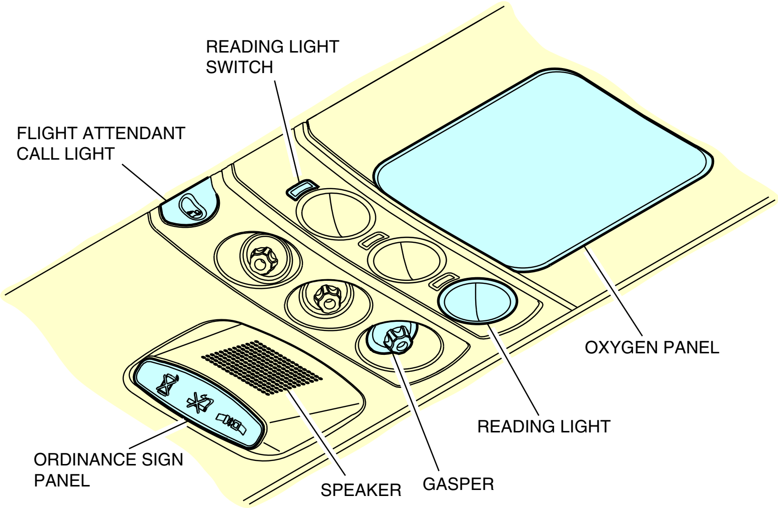
Figure 01–02–42 shows the overhead storage bins.



Typical overhead storage bins
Figure 01–02–42

D. Passenger Service Units (PSUs)

The Passenger Service Units (PSUs) are located under the overhead storage bins (refer to Figure 01–02–43).



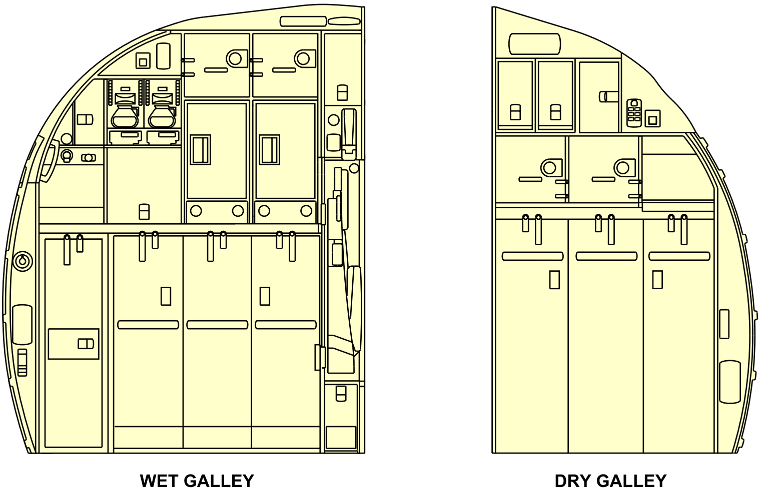
NOTE

The ordinance sign panel may be different from the ones installed on your aircraft.

Passenger Service Unit (PSU)
Figure 01–02–43

E. Galleys

The galleys are available in different configurations, which include dry and wet galleys (refer to Figure 01–02–44).



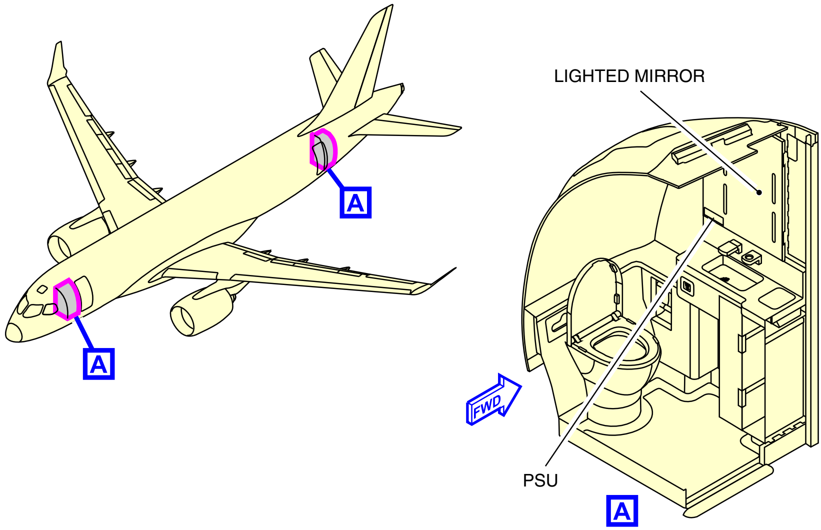
Typical galleys
Figure 01−02−44

F. Lavatory

Each lavatory has a supply of water and provides waste disposal. Refer to Figure 01−02−45.

NOTE

Optional lavatory for wheelchair access is available.



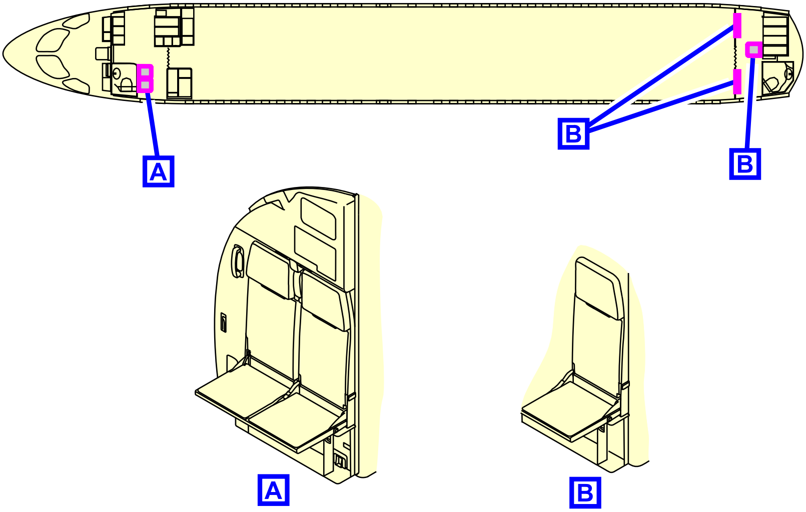
Lavatory
Figure 01–02–45

G. Flight attendant jump seat

The aircraft has three to five dedicated flight attendant seats.

In the flight attendant station (refer to Figure 01–02–46), each seat has the following characteristics and features:

- Auto fold-up seat base combined with a shoulder harness,
- Safety belt with a single point release, and
- Inertia reel retractor.



Flight attendant seat locations
Figure 01–02–46

CABIN MANAGEMENT SYSTEM (CMS)

A. CMS – Overview

The CMS provides an interface with the systems that follow:

- Cabin lighting,
- Passenger reading lights,
- Passenger call lights,
- Ordinance signs,
- Flight deck audio and Cockpit Voice Recorder (CVR),
- Potable water system,
- Waste system,
- Electrical system,
- Galley system,

- Passenger door system,
- Environmental Control System (ECS),
- FIDEX (Lavatory (LAV) smoke detector),
- Fuel system,
- Passenger oxygen system,
- Avionics,
- Integrated Air Management System (IAMS), and
- Integrated Cockpit Control Panel (ICCP).

B. CMS – Screens

The CMS includes the five main pages that follow:

- Passenger Address (PA),
- Cabin,
- System,
- Seats, and
- Messages.

Four of the five main pages have additional tabs to provide multiple system access.

1. The tabs on the PA page provide access to:
   - Customer System Display (CSD),
   - Pre-Recorded Announcements and Music (PRAM), and
   - Boarding Music (BGM).
2. The tabs on the CABIN page provide access to:
   - In-Seat Power Controller (ISPC),
   - Temperature, and
   - Lighting.

3. The tabs on the SYSTEM page provide access to:
   - Galleys,
   - Doors, and
   - Lavatory.
4. The tabs on the SEATS page provide access to:
   - Passenger call lights, and
   - Reading lights.

CHAPTER 2 – AIR–CONDITIONING, BLEED AIR AND PRESSURIZATION

GENERAL

BLEED AIR SYSTEM

PRESSURIZATION SYSTEM

List of figures

AIR–CONDITIONING SYSTEM

PRESSURIZATION SYSTEM

INTEGRATED AIR MANAGEMENT SYSTEMS (IAMS) – OVERVIEW

The aircraft has an Integrated Air Management System (IAMS). It consists of:

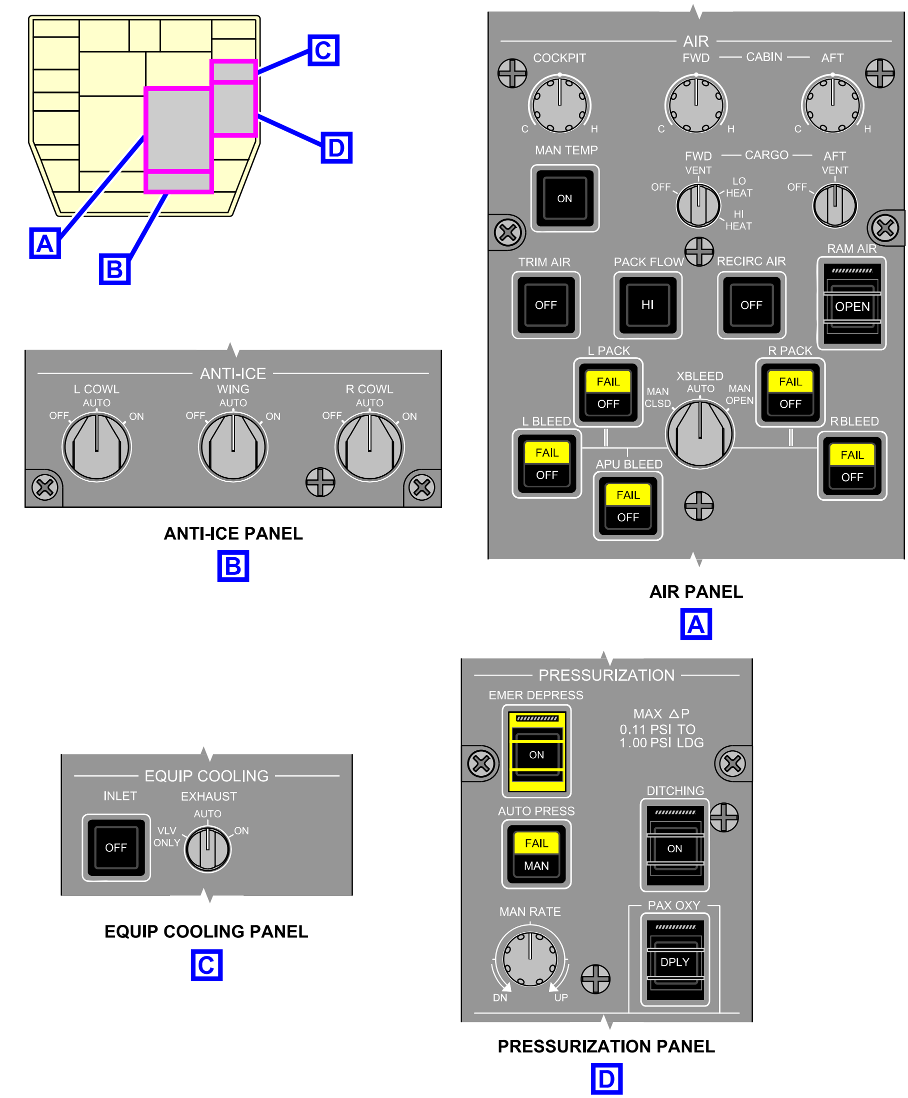
- Bleed air system,
- Bleed Air Leak and Overheat Detection System (BALODS),
- Air-conditioning system,
- Avionics cooling and heat extraction system, and
- Pressurization system,

Engine cowl and wing anti-ice systems use bleed air but are addressed in the Ice and Rain chapter.

Two dual-channel Integrated Air System Controllers (IASCs) manage, monitor, and control the systems. The specific relation between the IASCs and each system will be covered in the components description section.

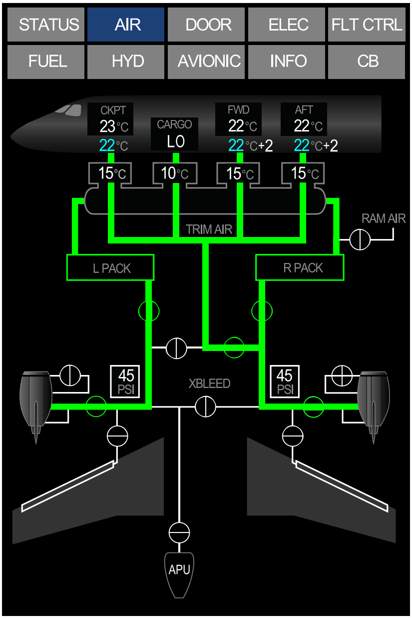
System controls (refer to Figure 02–01–1) are on the:

- AIR panel,
- PRESSURIZATION panel,
- EQUIP COOLING panel, and
- ANTI-ICE panel (refer to Ice and rain protection).

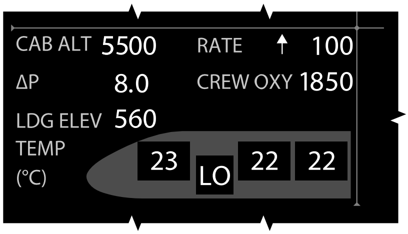


Integrated air management system controls
Figure 02–01–1

System status is displayed on the AIR synoptic page and on the air section of the EICAS page (refer to Figure 02–01–2). Status and fault messages are reported on the EICAS page.



AIR SYNOPTIC PAGE



EICAS PAGE - AIR SECTION

Integrated air management system indications
Figure 02–01–2

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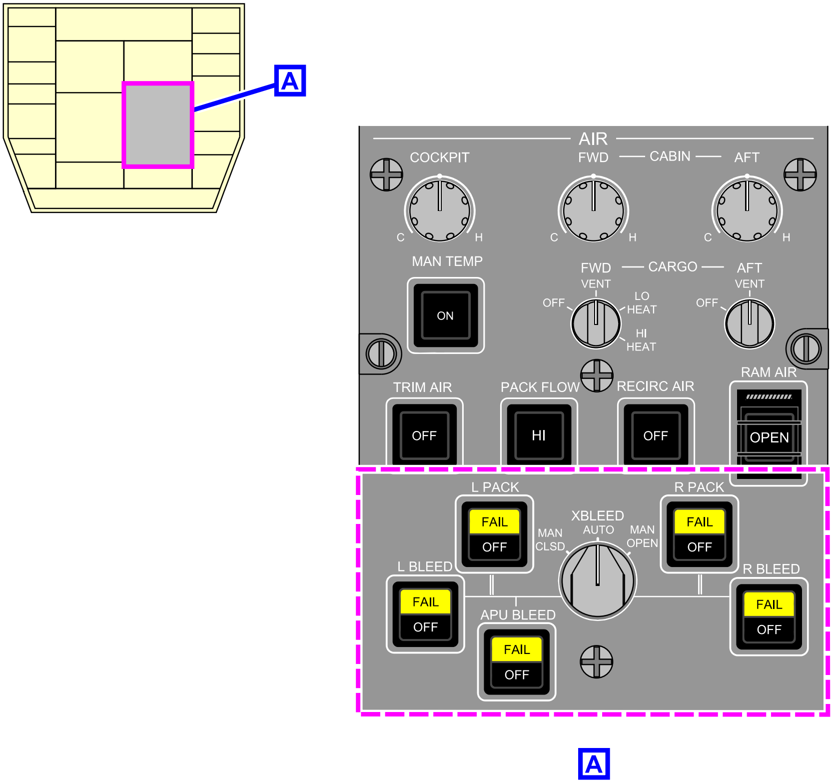
BLEED AIR SYSTEM – OVERVIEW

The pneumatic or bleed air system receives pressurized air from the engines, the Auxiliary Power Unit (APU), or from an external air source. Bleed air is distributed through a common manifold and used for:

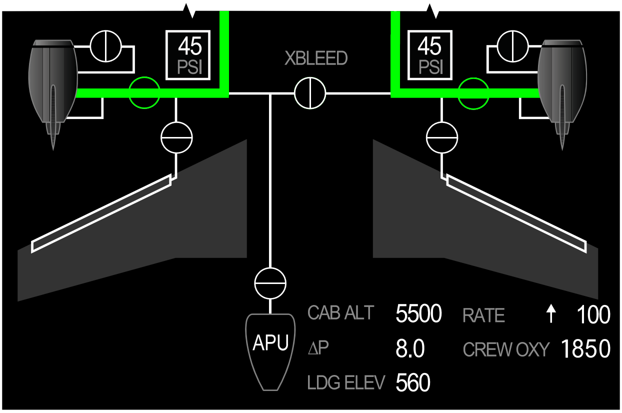
- Air conditioning and pressurization,
- Cowl and wing anti-icing,
- Main engine starting, and
- Fuel inerting.

The system is controlled by two dual-channel Integrated Air System Controllers (IASCs) that automatically select, manage, and control the bleed air sources and users. To override the IASCs, the flight crew can close the bleed air valves on the AIR panel (refer to Figure 02–02–1).



AIR panel – Bleed air system controls
Figure 02–02–1

System status and fault messages are reported on the EICAS page and system status is displayed on the AIR synoptic page (refer to Figure 02–02–2).



AIR synoptic page – Bleed air system indications
Figure 02–02–2

Without external bleed air connected and while on BATT power only, it is possible that the EXT AIR symbol is displayed (green) on the AIR synoptic page, while the L and R bleed pressure readouts can vary between 9 PSI and 16 PSI (instead of 0 PSI). This is because data from ASDP 1, ASDP 2 and DMC 2B is unavailable and the IASC uses the default pressure altitude of 41000 ft while the aircraft is on BATT power. These PSI values represent the delta between the absolute pressure sensed by PIPS and the aircraft pressure altitude.

BLEED AIR SYSTEM – DESCRIPTION AND OPERATION

A. Components

The bleed air system includes the components and systems that follow:

- Bleed air manifold,
- Cross bleed valve,
- Engine bleed air system,

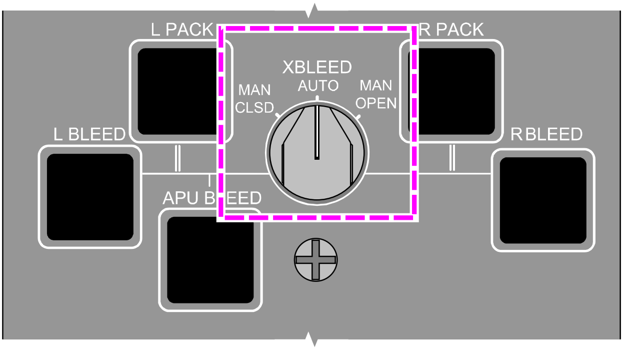
- APU bleed air system,
- High Pressure Ground Connection (HPGC),
- Integrated Air System Controllers (IASCs), and
- Bleed Air Leak and Overheat Detection System (BALODS).

B. Bleed air manifold

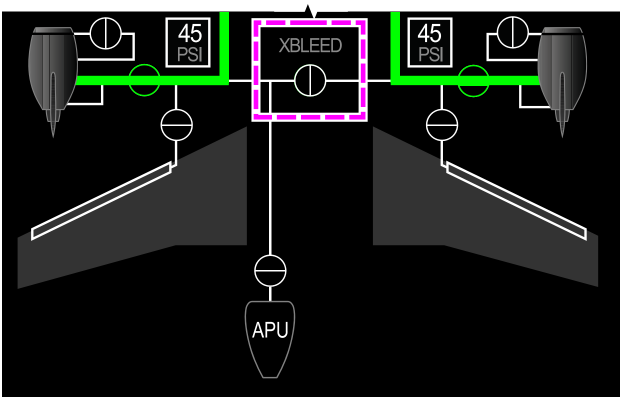
The bleed air manifold routes bleed air to the pneumatic system. The left side of the manifold can be pressurized from the left engine, the APU, or the High Pressure Ground Connection (HPGC). The right engine normally supplies bleed air to the right side of the manifold. A cross bleed valve, normally controlled by the IASC, separates the bleed air manifold and allows both sides of the manifold to be pressurized from a single source.

C. Cross bleed valve

The cross bleed valve is a butterfly valve that is operated by a DC motor. This valve isolates or connects the two sides of the bleed air manifold. It is normally controlled by the IASC but can be manually selected open or closed with the XBLEED switch on the AIR panel (refer to Figure 02–02–3).



AIR PANEL – XBLEED SWITCH



AIR SYNOPTIC PAGE – CROSS BLEED VALVE

Cross bleed valve control and indication
Figure 02–02–3

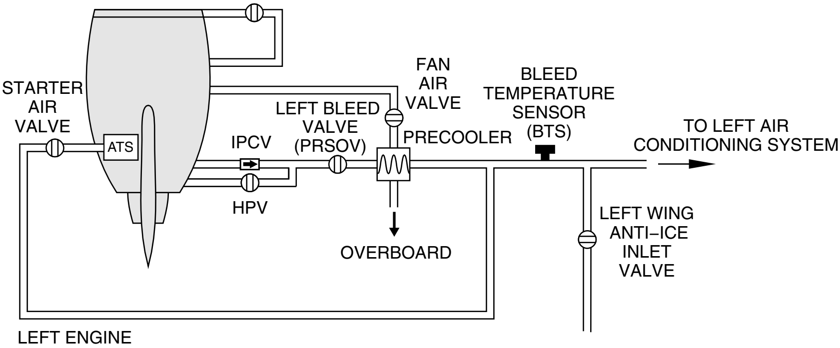
D. Engine bleed air system

The engine bleed air system has the components that follow:

- Intermediate Pressure Check Valve (IPCV),
- High Pressure Valve (HPV),
- Pressure Regulating Shutoff Valve (PRSOV) (or bleed valve),
- Fan Air Valve (FAV),
- Precooler, and
- Bleed Temperature Sensor (BTS).

Bleed air from the 4th stage or 8th stage of the engine compressor section is the primary source of pneumatic power for the aircraft.

The 4th stage air flows through the IPCV. The 8th stage air flows through the HPV. The IASC determines which stage of the engine compressor bleed to use based on the aircraft thrust setting and pneumatic demand. Regardless of the stage used, the bleed air flows through the PRSOV where it is pressure-regulated before it enters the manifolds (refer to Figure 02–02–4).



Engine bleed air system
Figure 02–02–4

The bleed air from the PRSOV is cooled in the precooler with engine fan air. The BTS downstream of the precooler allows the IASC to adjust the FAV to keep the engine bleed air temperature within limits.

E. Intermediate Pressure Check Valve (IPCV)

The IPCV prevents bleed air backflow to the engine compressor when the HPV is open.

F. High Pressure Valve (HPV)

The HPV allows the 8th stage engine bleed air to flow from the engine to the bleed air manifold when the thrust settings are low, or when the demand is too high for 4th stage air. The HPV is pneumatically operated and electrically controlled by the IASC. It closes any time the bleed valve is closed.

G. Pressure Regulating Shutoff Valve (PRSOV) (bleed valve)

The PRSOV, or bleed valve, receives engine bleed air from either the HPV or the IPCV. It regulates the bleed air to maintain a constant pressure in the bleed manifold (approximately 45 PSI). When closed, it isolates the engine air from the aircraft pneumatic system.

The bleed valve is pneumatically operated and electrically controlled by the IASC. It can also be manually closed when the L BLEED or R BLEED switch on the AIR panel is pushed, and when the L ENG FIRE or R ENG FIRE switch on the Engine and APU fire panel is pushed.

H. Fan Air Valve (FAV)

The FAV directs cooling air from the engine fan section to the bleed air precooler. It is pneumatically operated and electrically controlled by the IASC. The IASC modulates the FAV as necessary to keep the engine bleed air temperature within limits. The BTS downstream of the precooler gives the IASC the necessary feedback to adjust the FAV.

The FAV closes any time the bleed valve is closed or when the L ENG FIRE or R ENG FIRE switch is pushed. The valve is not shown on the AIR synoptic page.

I. Precooler

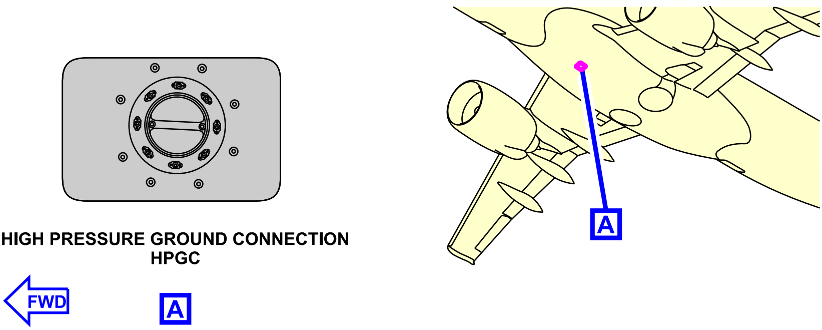
The precooler is a heat exchanger that uses engine fan air to cool engine air as it enters the bleed air manifold.

J. Bleed Temperature Sensor (BTS)

The BTS, located downstream of the precooler, monitors engine bleed air temperature and sends the information to the IASC to adjust the FAV. Excessive bleed air temperature causes the **L BLEED OVHT** or **R BLEED OVHT** caution message to be displayed on the EICAS page.

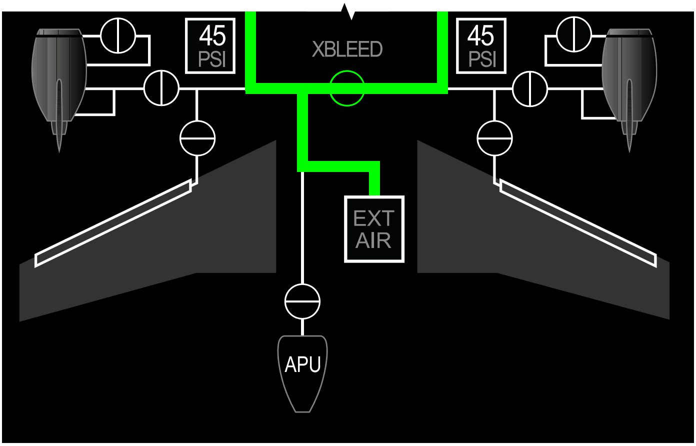
K. High Pressure Ground Connection (HPGC)

A HPGC located on the left forward side of the wing-to-body fairing allows external high pressure air to be used for engine starting or to supply air to one or both air-conditioning packs (refer to Figure 02–02–5).



High pressure ground connection
Figure 02–02–5

When high-pressure air is connected, EXT AIR and associated flow lines are displayed on the AIR synoptic page (refer to Figure 02–02–6).



AIR SYNOPTIC PAGE

High pressure ground connection indication
Figure 02–02–6

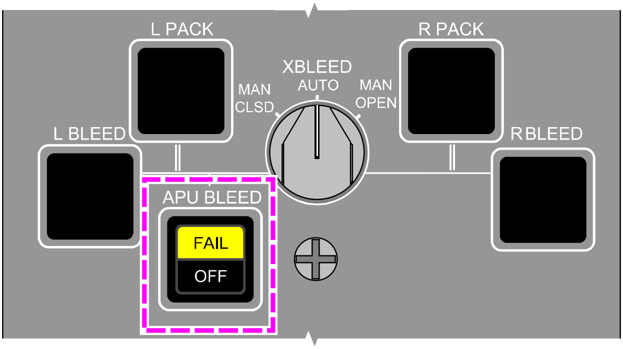
L. APU bleed air system

The APU supplies high-pressure bleed air when the engines are off, or when the engine bleed valve is manually closed or in AUTO mode when the APU has priority.

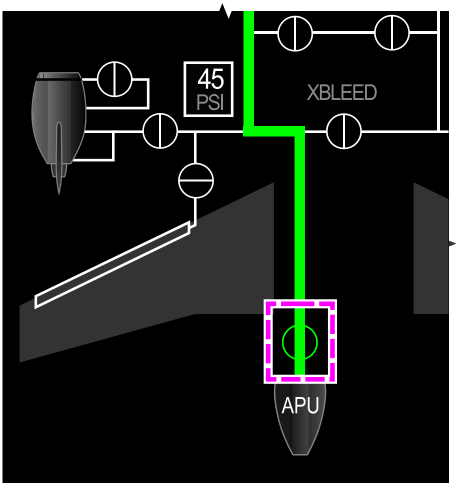
Bleed air from the APU enters the bleed air manifold through the APU bleed shutoff valve. The valve is pneumatically operated and electrically controlled by the IASC. A one-way check valve downstream of the bleed valve prevents backflow to the APU. The IASC determines when the APU bleed is used in the pneumatic system (refer to the note in Wing Anti-Ice System (WAIS) – Component description and Cowl Anti-Ice System (CAIS) – Operation).

The IASC relays pneumatic demand to the Electronic Control Unit (ECU) to adjust the APU Inlet Guide Vanes (IGV) to deliver the requested volume of bleed air.

The APU bleed shutoff valve can be manually closed when the APU BLEED switch on the AIR panel is pushed (refer to Figure 02–02–7).



AIR PANEL – APU BLEED SWITCH



AIR SYNOPTIC PAGE – APU BLEED SHUTOFF VALVE

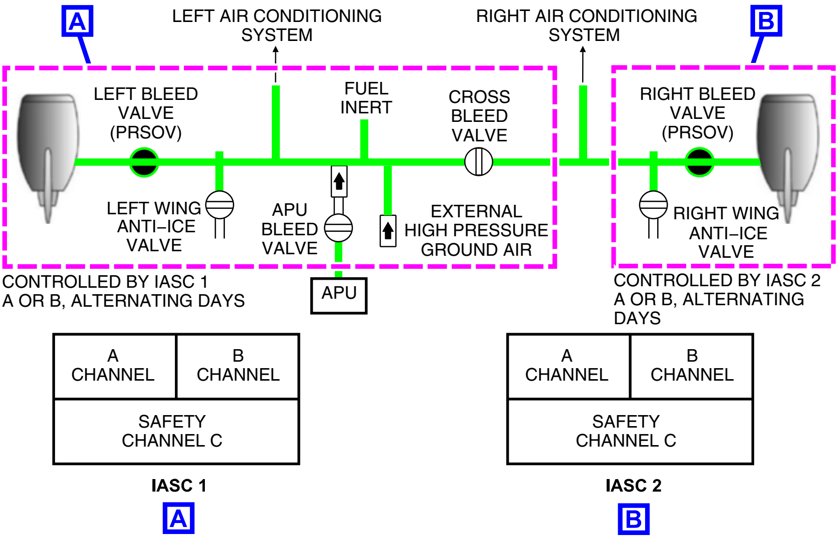
APU bleed air system control and indication
Figure 02–02–7

INTEGRATED AIR SYSTEM CONTROLLER (IASC) – BLEED AIR

A. IASC normal operation for bleed air

Two Integrated Air System Controllers (IASCs) manage and control all the aircraft bleed valves. Each IASC has three channels: A channel, B channel, and a safety channel (refer to Figure 02–02–8). Channels A and B alternate control on a daily basis.

IASC 1 normally controls the left engine bleed air valve, the left HPV, the left FAV, the APU bleed valve, the cross bleed valve, and the left wing anti-ice valve. IASC 2 normally controls the right engine bleed air valve, the right HPV, the right FAV, and the right wing anti-ice valve.

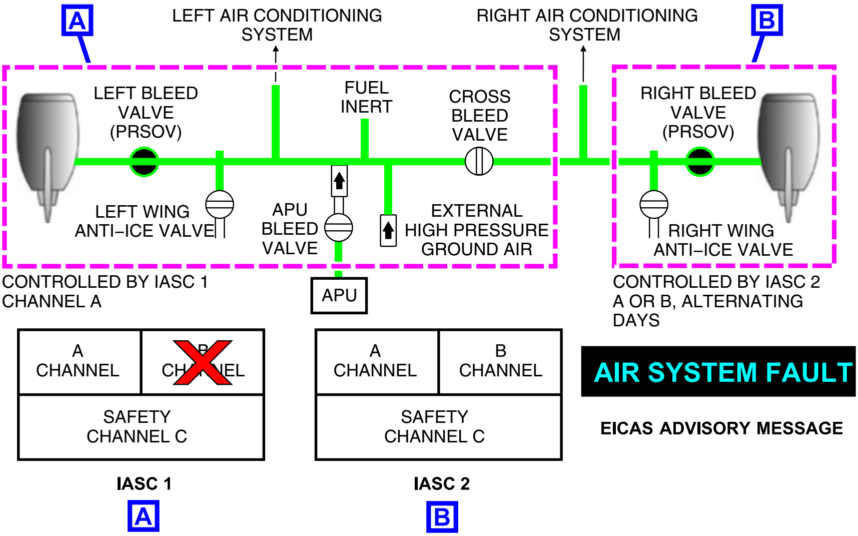


IASC normal operations for bleed air
Figure 02–02–8

B. IASC degraded operations for bleed air

If a single IASC channel fails, the remaining channel assumes control of the IASC functions and an advisory message **AIR SYSTEM FAULT** displays on the EICAS page. There is only a loss of redundancy for the IASC.

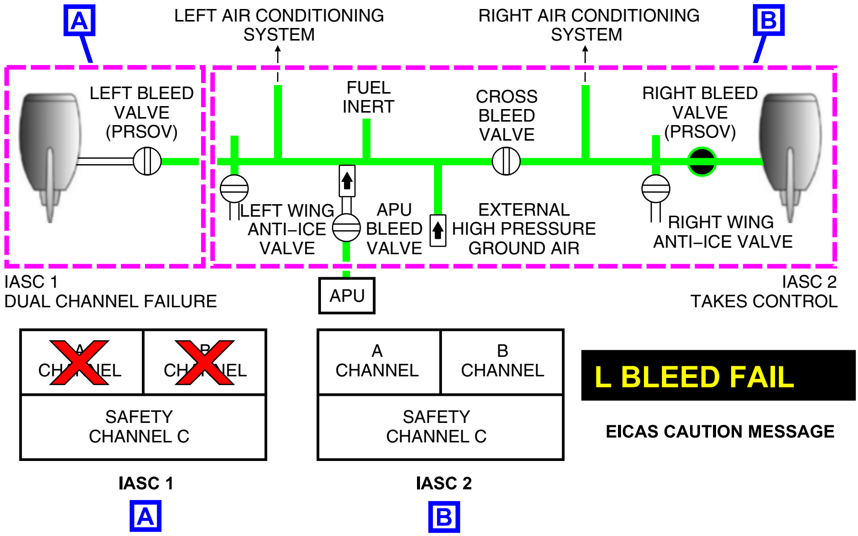
Figure 02–02–9 shows the IASCs control under a single IASC channel failure.



IASC degraded operations for bleed air
Figure 02–02–9

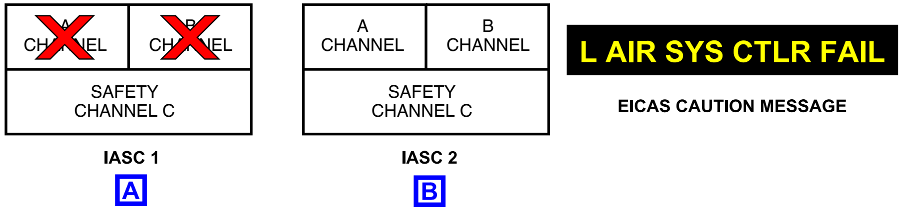
If both channels fail (complete IASC failure), the remaining IASC assumes control of all bleed air valves except the engine bleed valve of the failed IASC. The engine bleed valve of the failed IASC closes automatically and the **L BLEED FAIL** or **R BLEED FAIL** caution message displays on the EICAS page.

Figure 02–02–10 shows the IASCs control under a complete IASC failure.



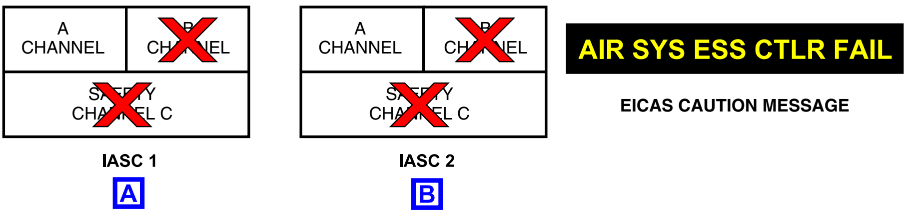
IASC complete failure effect on the bleed air valves
Figure 02–02–10

If both channels fail (complete IASC failure), the remaining IASC assumes control of all bleed air valves except the engine bleed valve of the failed IASC. The engine bleed valve of the failed IASC closes automatically and the **L AIR SYS CTLR FAIL** or **R AIR SYS CTLR FAIL**caution message displays on the EICAS page (refer to Figure 02–02–11).



IASC complete failure effect on the bleed air valves
Figure 02–02–11

If both IASC 1 B and C and IASC 2 B and C fails, the **AIR SYS ESS CTLR FAIL** caution message displays on the EICAS page (refer to Figure 02–02–12).



IASC failure operations for bleed air
Figure 02–02–12

C. APU and engine bleed priority

When APU and engine bleed air are both available, the IASC will use engine bleed air under any of the conditions that follow:

- Wing anti-ice is active or selected ON,

- Aircraft is in clean configuration (flaps or slats retracted),
- Aircraft altitude is above 16500 feet.

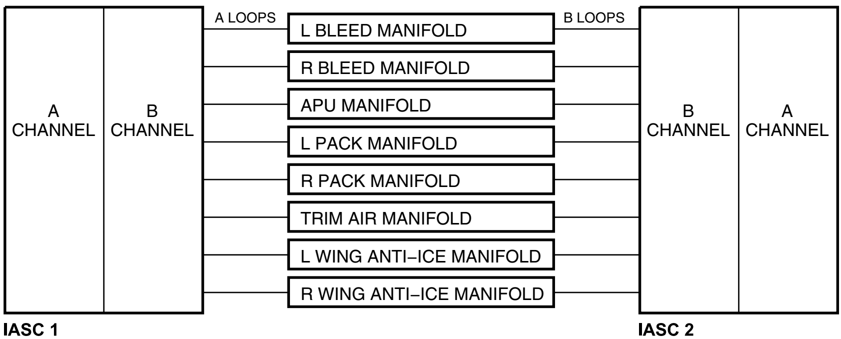
BLEED AIR LEAK AND OVERHEAT DETECTION SYSTEM (BALODS)

A. Leak detection

The BALODS protects the aircraft systems and structures by detecting bleed air leaks in:

- Bleed air manifold (left and right),
- Wing anti-ice manifold (left and right),
- Air-conditioning packs and manifolds,
- Trim air manifold, and
- APU bleed air manifold.

Dual independent heat detection loops run along the exterior of each manifold and in critical components such as the packs. The B channel of Integrated Air System Controller (IASC 1) monitors loop A in all eight manifolds and the B channel of IASC 2 monitors loop B (refer to Figure 02–02–13). To minimize false leak indications, both loops must detect a leak to trigger an alert.

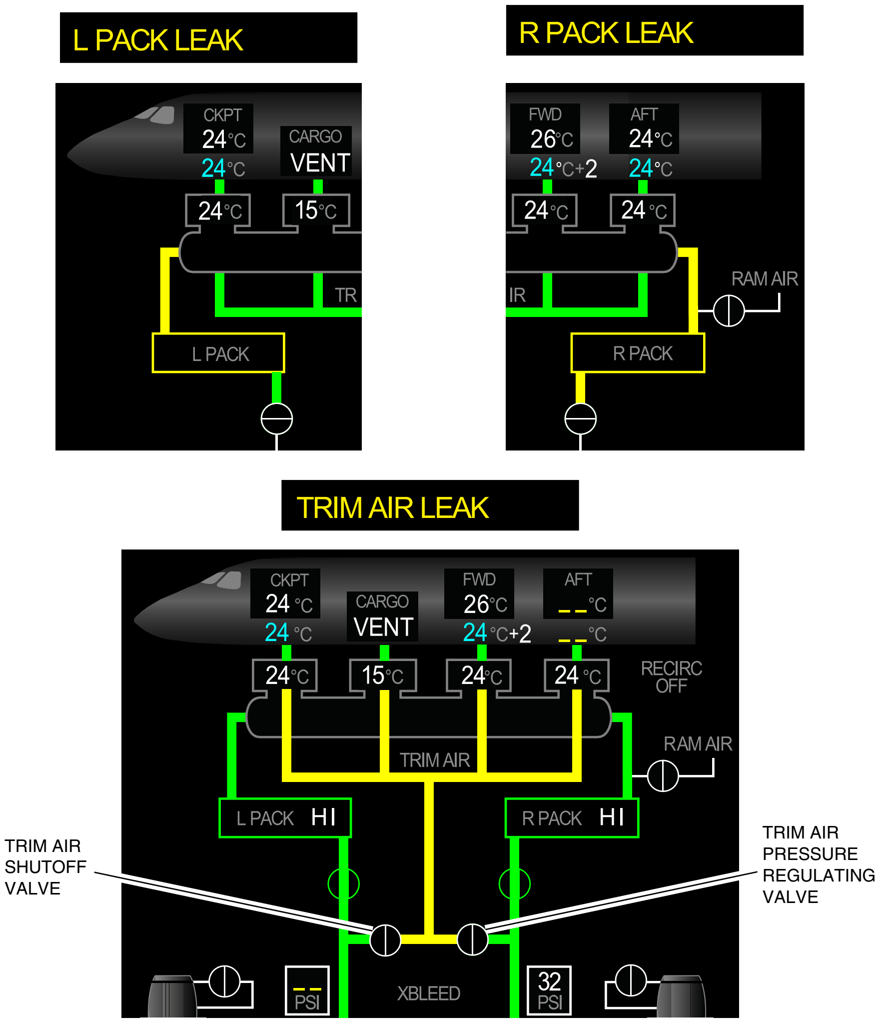


BALODS loops
Figure 02–02–13

When a bleed air leak or overheat is detected, the IASC isolates the leak automatically by closing the appropriate valve and alerts the flight crew with a leak or overheat caution message for the respective manifold. For more details, refer to the table that follows:

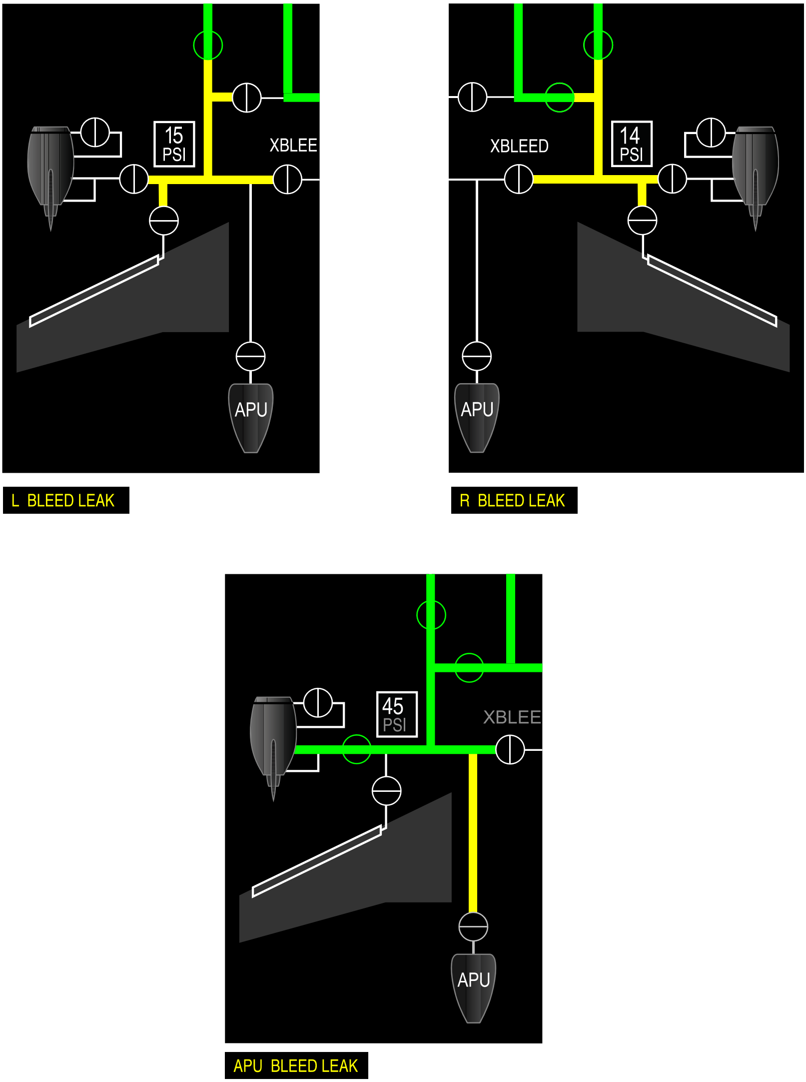
Leak location	Indication	Action
Left bleed air manifold (refer to Figure 02–02–15).	L BLEED LEAK	Automatic closure of the left PRSOV, the cross bleed valve and the APU bleed valve (if operating).
Right bleed air manifold	R BLEED LEAK	Automatic closure of the right PRSOV, the cross bleed valve and the APU bleed valve (if operating).
APU bleed air manifold (refer to Figure 02–02–15)	APU BLEED LEAK	Automatic closure of the cross bleed valve and the APU bleed valve.
Left air-conditioning pack (refer to Figure 02–02–14)	L PACK LEAK	Automatic closure of the left pack valve.
Right air-conditioning pack	R PACK LEAK	Automatic closure of the right pack valve.
Wing anti-ice manifolds (refer to Figure 02–02–16)	WING A/ICE LEAK	Automatic closure of the left and/or right wing anti-ice valves.

Figure 02–02–14 shows a PACKS and trim air leak indications on the AIR synoptic page.



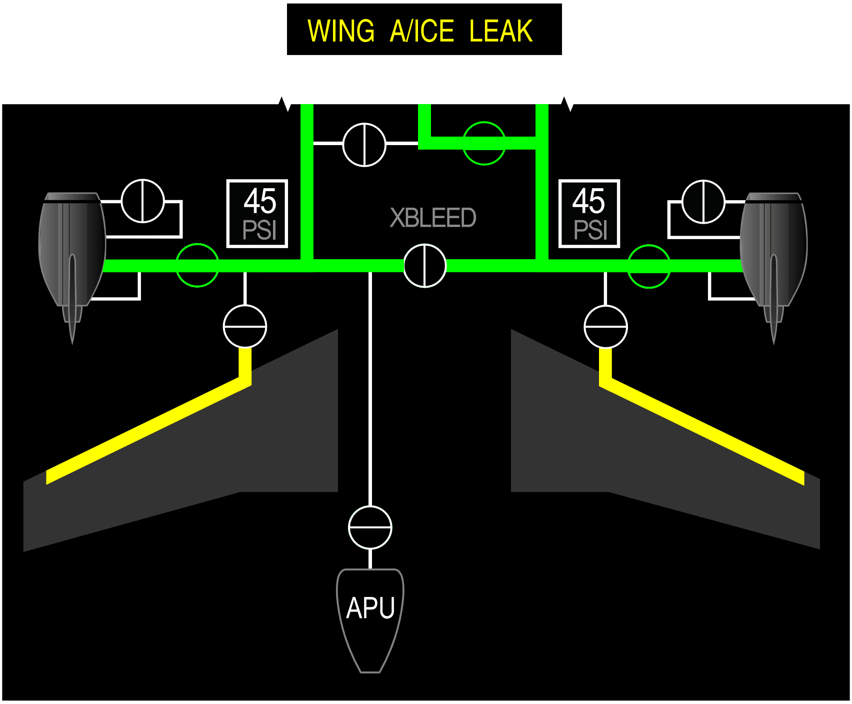
AIR synoptic page – PACK and trim air leak indications
Figure 02–02–14

Figure 02–02–15 shows an engine and APU leak indications on the AIR synoptic page.



AIR synoptic page – Engine and APU bleed leak indications
Figure 02–02–15

Figure 02–02–16 shows a wing anti-ice leak indications on the AIR synoptic page.

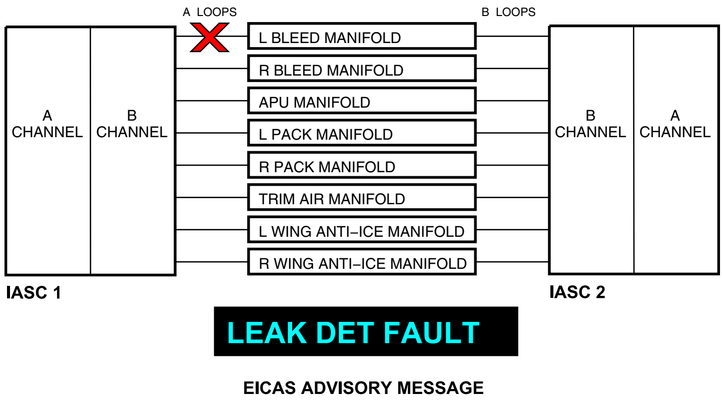


AIR synoptic page – Wing anti–ice leak indications
Figure 02–02–16

B. Leak detection degraded operations

(1) Single loop failure

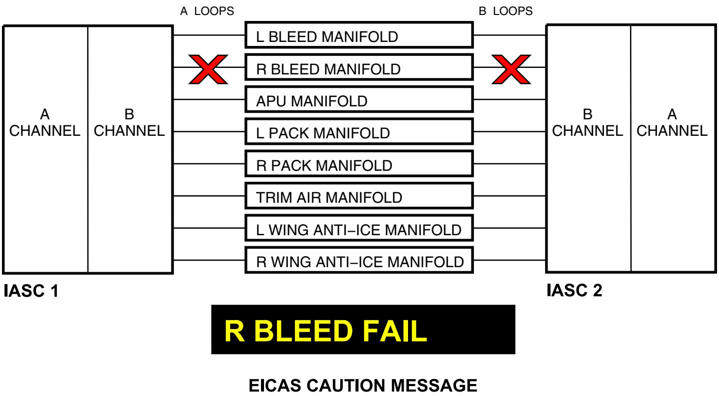
If a loop fails or if the channel B of either IASC fails, bleed air detection is maintained with the functioning loop and a **LEAK DET FAULT** advisory message displays on the EICAS page.



Single BALODS loop failure
Figure 02–02–17

(2) Dual loop failure

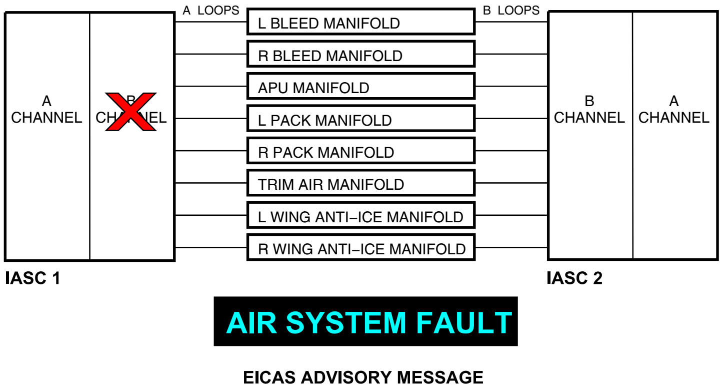
If both loops of any manifold fail, a caution message associated with this specific manifold failure will display on the EICAS page. For example, if the dual loop of the right bleed manifold fails, the right PRSOV with the cross bleed valve and the APU bleed valve close automatically and the caution message **R BLEED FAIL** displays on the EICAS page (refer to Figure 02–02–18.)



Dual loop failure – R BLEED FAIL
Figure 02–02–18

(3) Single channel failure

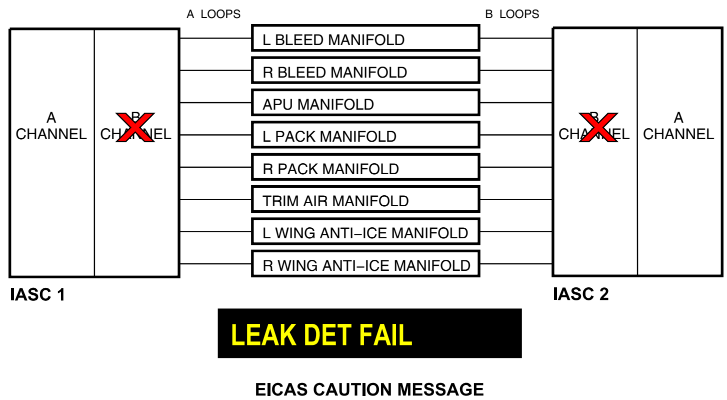
If the B channel of either IASC fails (refer to Figure 02–02–19), bleed air leak detection redundant function is lost and a **AIR SYSTEM FAULT** advisory message displays on the EICAS page.



Loss of B channel effect on BALODS
Figure 02–02–19

(4) Dual channel failure

If both B channels fail, the entire bleed air system automatically shut down and a **LEAK DET FAIL** displays on the EICAS page.This alerts the flight crew that bleed air leak detection is no longer available (refer to Figure 02–02–20).

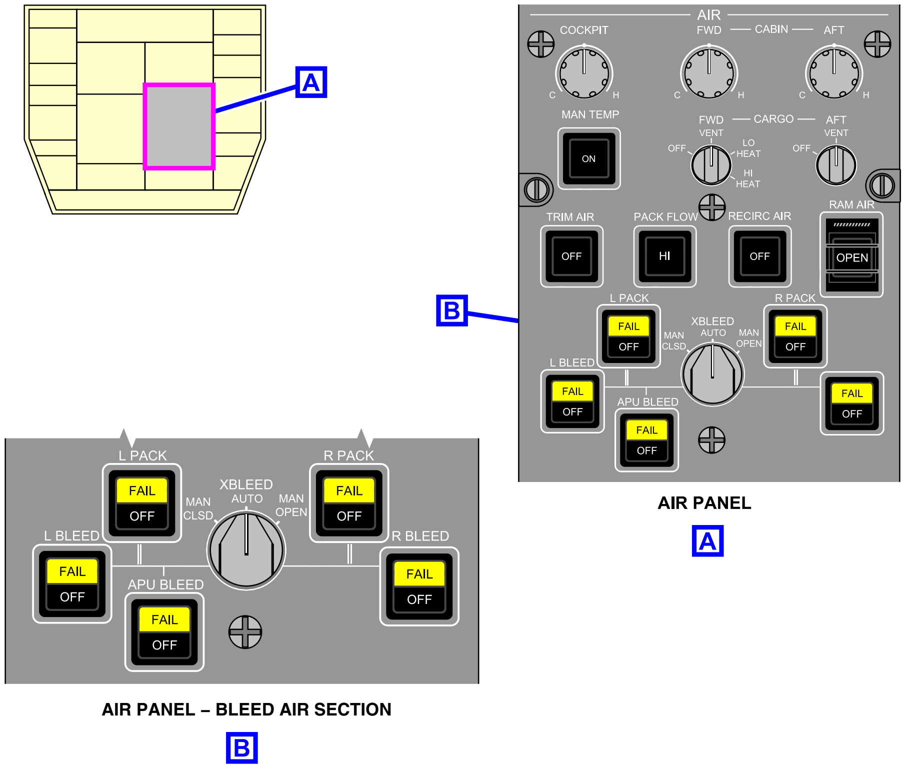


Loss of both B channels effect on BALODS
Figure 02–02–20

BLEED AIR SYSTEM – CONTROLS AND INDICATIONS

A. AIR panel

The bleed air system controls are located on the AIR panel (refer to Figure 02–02–21.)



AIR panel – Bleed air section
Figure 02–02–21

B. L BLEED and R BLEED switches

The L BLEED and R BLEED switches (refer to Figure 02–02–22) have two positions:

FAIL: Indicates that the bleed air is not available when commanded by the IASC and may include the situations that follow:

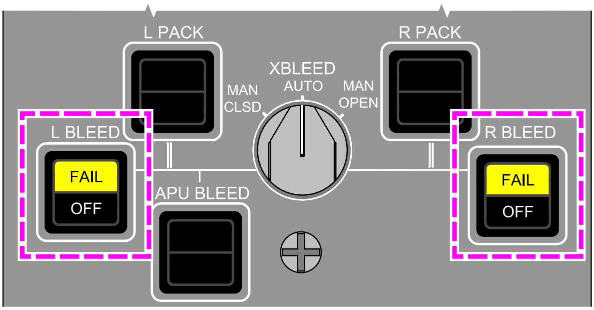
- Bleed valve (PRSOV) failure,
- Dual loss of Bleed Temperature Sensor (BTS) sensing elements,

- Loss of associated bleed air leak detection, or
- IASC 1 or IASC 2 failure.

OFF: Indicates that the associated bleed valve is selected OFF.

NOTE

The bleed valve closes when it fails, except if the bleed valve fails open.

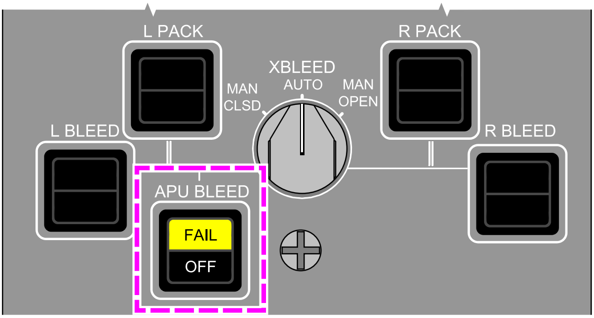


AIR panel – L BLEED switch and R BLEED switch
Figure 02–02–22

C. APU BLEED switch

The APU BLEED switch (refer to Figure 02–02–23) has two positions:

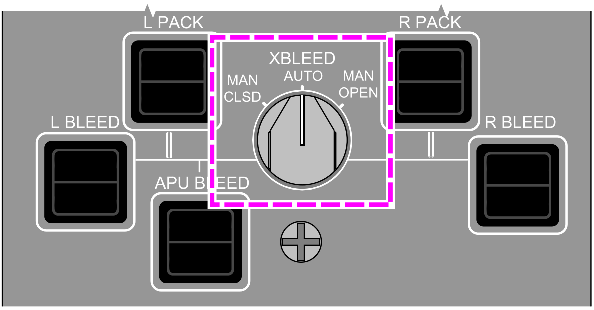
- FAIL: Illuminates if APU bleed air is not available when commanded by the IASC and may include the situations that follow:
  - APU bleed valve failure, or
  - Loss of APU bleed air leak detection.
- OFF: Indicates that the APU bleed valve is selected OFF.



AIR panel – APU BLEED switch
Figure 02–02–23

D. XBLEED switch

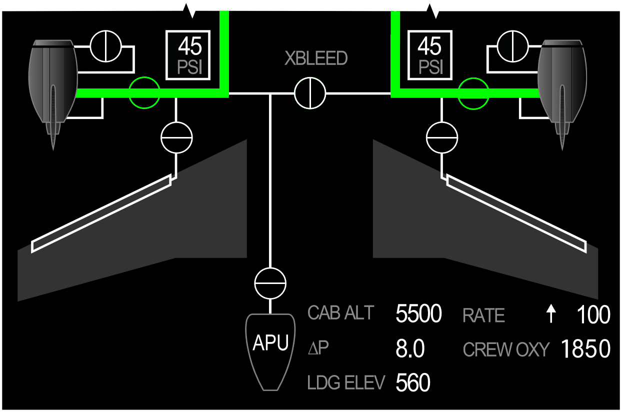
- AUTO: IASC takes control of the cross bleed valve.
- MAN OPEN: Cross bleed valve manually open.
- MAN CLSD: Cross bleed valve manually closed.



AIR panel – XBLEED switch
Figure 02–02–24

E. AIR synoptic page

The bleed air system status is displayed on the AIR synoptic page (refer to Figure 02–02–25 and Figure 02–02–26) .



AIR synoptic page – Bleed air system indications
Figure 02–02–25

VALVE POSITION NORMAL OPERATION	
Symbol	Condition
	Closed
	Open with flow
	Open with no flow

VALVE POSITION FAILED OPERATION	
Symbol	Condition
	Failed closed
	Failed open with flow
	Failed open with no flow
	Invalid

PRESSURE READOUT AND OUTLINE READOUT	
Symbol	Condition
5 PSI	Abnormal
75 PSI	Normal
-- PSI	Invalid

ENGINE REPRESENTATION (MANAGED BY FADEC AND APU)	
Symbol	Condition
APU	Running
APU	Not running
APU	Invalid

DECLUTTERED SYMBOLOGY LOGIC	
Symbol	Condition
EXT AIR	To be shown only when pressure is detected and no bleeds are ON.

FLOW LINES	
Symbol	Condition
	Normal flow
	No flow
	Abnormal flow (overheat, out of range pressure, leak)

AIR synoptic page description for the bleed air system
Figure 02–02–26

BLEED AIR SYSTEM – EICAS MESSAGES

A. Warning messages

None

B. Caution messages

Message	Description	Inhibit
AIR SYS ESS CTLR FAIL	IACS 1 failure due to channel B and C failure and IACS 2 failure due to channel B and C failure, or not received by DMC.	TO, LDG
APU BLEED LEAK	APU bleed leak detected.	TO, LDG
ENG BLEED MISCONFIG	XBLEED valve selected open and both engine bleed selected on or low flow on APU and L/R ENG bleed off.	TO, LDG
L AIR SYS CTLR FAIL	IACS 1 failure due to channel A and B failure or not received by DMC.	TO, LDG
L BLEED FAIL	Left engine bleed failure, loss of L BLEED leak detection, or loss of both IASC 1 channels.	TO, LDG
L BLEED LEAK	Left bleed leak detected.	TO, LDG
L BLEED OVHT	Left engine bleed overtemperature detected.	TO, LDG
L PACK LEAK	Left PACK leak detected.	TO, LDG
LEAK DET FAIL	Entire leak detection system failed.	TO, LDG
R AIR SYS CTLR FAIL	IACS 2 failure due to channel A and B failure or not received by DMC.	TO, LDG
R BLEED FAIL	Right engine bleed failure, loss of R BLEED leak detection, or loss of both IASC 2 channels.	TO, LDG
R BLEED LEAK	Right bleed leak detected.	TO, LDG

Message	Description	Inhibit
R BLEED OVHT	Right engine bleed overtemperature detected.	TO, LDG
R PACK LEAK	Right PACK leak detected.	TO, LDG
XBLEED FAIL	XBLEED valve failed in position in AUTO or MAN mode.	TO, LDG

C. Advisory messages

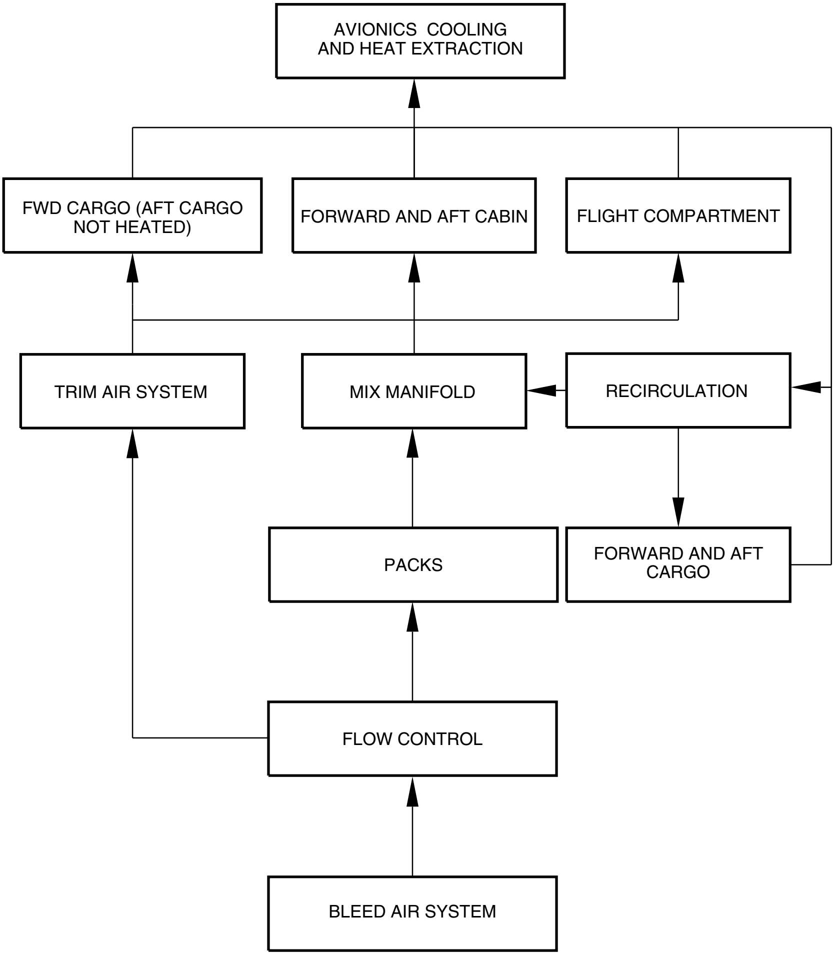
Message	Description	Inhibit
AIR SYSTEM FAULT	Loss of redundant or non-critical function for the air system (bleed air or trim air) or Emergency Ram Air Valve (ERAV) inoperative.	TO, LDG
LEAK DET FAULT	Single loop leak detection failure.	TO, LDG

D. Status messages

Message	Description	Inhibit
APU BLEED OFF	APU bleed selected off.	None
L BLEED OFF	Left engine bleed selected off.	None
R BLEED OFF	Right engine bleed selected off.	None
XBLEED MAN CLSD	Cross bleed valve manually selected and confirmed closed.	None
XBLEED MAN OPEN	Cross bleed valve manually selected and confirmed opened.	None

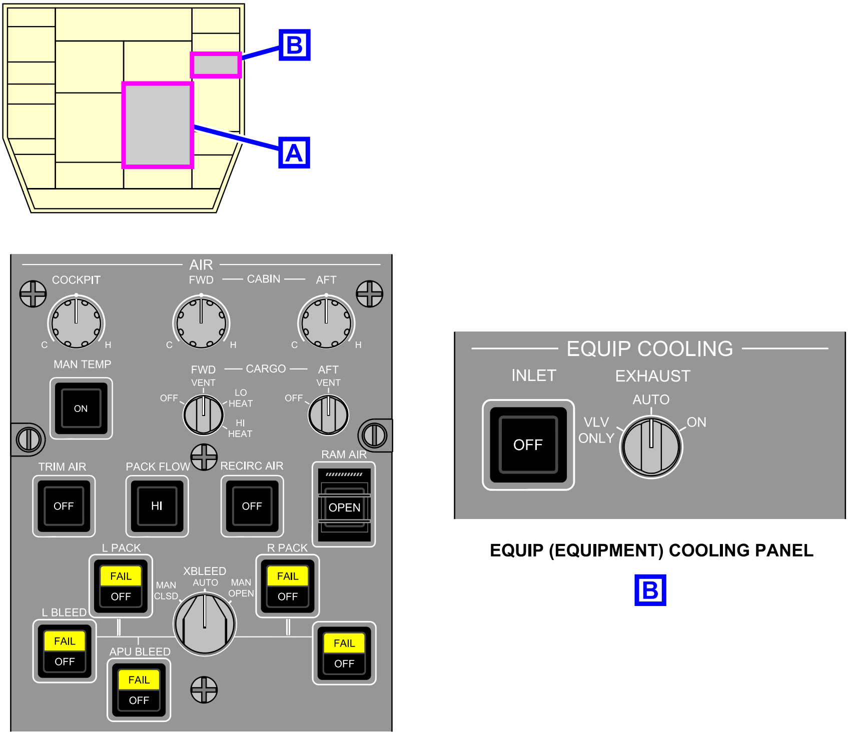
AIR-CONDITIONING SYSTEM – OVERVIEW

The air-conditioning system (refer to Figure 02–03–1) uses hot bleed air from the engines or the APU. This air is converted by the air-conditioning PACKS for ventilation, cooling, heating, and pressurization of the cabin, flight compartment, and cargo compartments.



Air–conditioning system – Overview
Figure 02–03–1

The system is controlled and monitored by two dual-channel Integrated Air System Controllers (IASCs) and the controls are located on the AIR and EQUIP COOLING panels (refer to Figure 02–03–2).



EQUIP (EQUIPMENT) COOLING PANEL

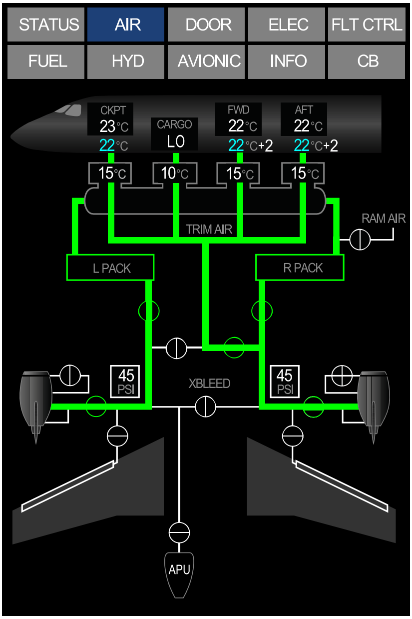
B

AIR PANEL

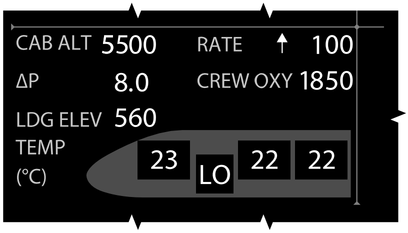
A

Air–conditioning system controls
Figure 02–03–2

The system status is shown on the AIR synoptic page and on the air section of the EICAS page (refer to Figure 02–03–3). Status and fault messages are reported on the EICAS page.



AIR SYNOPTIC PAGE



EICAS PAGE - AIR SECTION

Integrated air management system indications
Figure 02–03–3

AIR-CONDITIONING SYSTEM – DESCRIPTION AND OPERATION

A. Components

The air-conditioning system includes the components that follow:

- Air-conditioning units (packs),
- Flow control system,
- Trim air system,

- Temperature control system,
- Cabin air distribution and recirculation system,
- Cargo compartment ventilation and heating system,
- Low Pressure Ground Connection (LPGC),
- Avionics equipment cooling and heat extraction system, and
- Ram air ventilation.

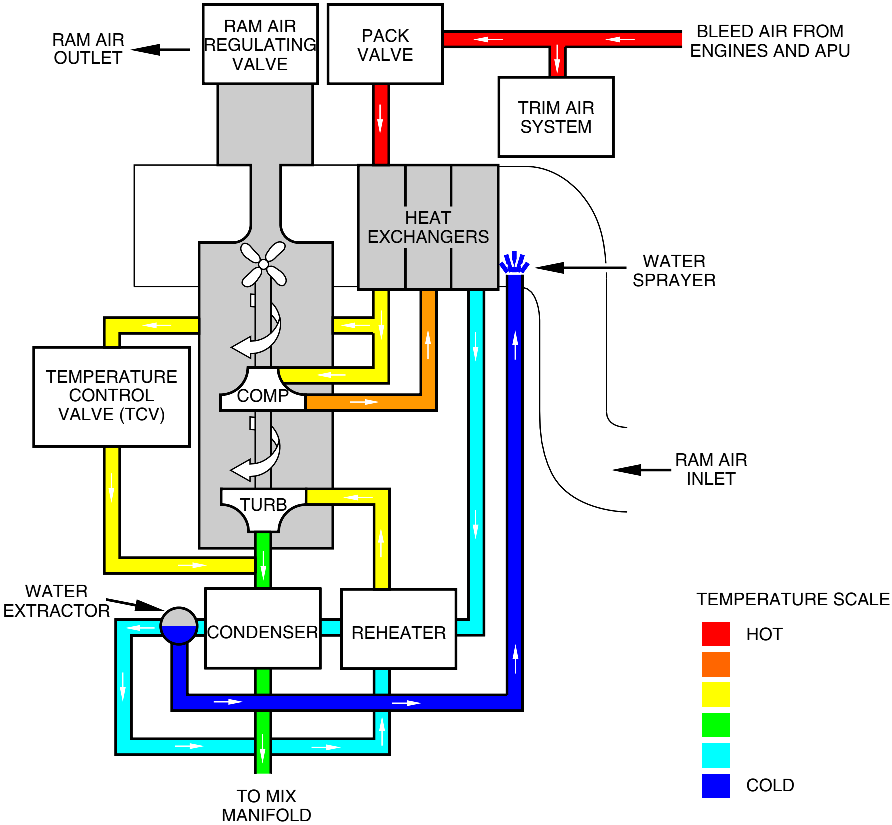
B. Air-conditioning units (packs)

Two air-conditioning units (packs), installed in the wing-to-body fairing below the center wing box structure, provide a source of cold air for the air-conditioning system. Each pack includes:

- Dual heat exchangers,
- Air cycle machine,
- Water extraction loop,
- Ram air system with a Ram Air Regulating Valve (RARV), and
- Temperature Control Valve (TCV).

The bleed air enters the primary heat exchanger and is first cooled by external ram air. After exiting the primary heat exchanger, the bleed air is used to rotate the compressor/turbine assembly (air cycle machine) of the pack then returned to the secondary heat exchanger for additional cooling.

After the second cooling, the bleed air is routed through the reheater, the condenser, and to the turbine, where it is cooled by expansion. The resulting cold air is sent to the duct for distribution (refer to Figure 02–03–4).



Air–conditioning units (packs) – Airflow
Figure 02–03–4

The Temperature Control Valve (TCV), controlled by the IASCs, adds hot air at the pack discharge for icing protection and for temperature adjustment.

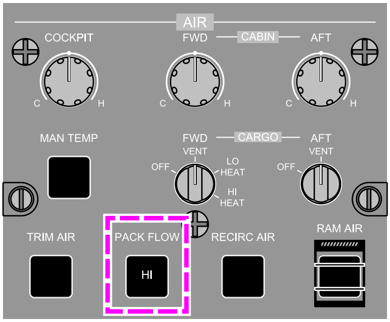
On the ground, the fan draws air across the heat exchangers, adjusted by the Ram Air Regulating Valve (RARV).

C. Flow control modes

The two flow modes are automatic mode and high flow mode. In the automatic mode, the airflow is automatically adjusted by the IASCs based on the number of cabin occupants (passengers and cabin crew) entered in the FMS. If no cabin occupant data is entered in the FMS, the system assumes that the cabin is full. A lower number of passengers will reduce the bleed flow consumption when maximum cooling and heating demand is not required.

The high-flow mode is automatically selected when necessary (APU operation on the ground, high or low mix duct temperature). The mode can be selected by pressing the PACK FLOW switch on the AIR panel.

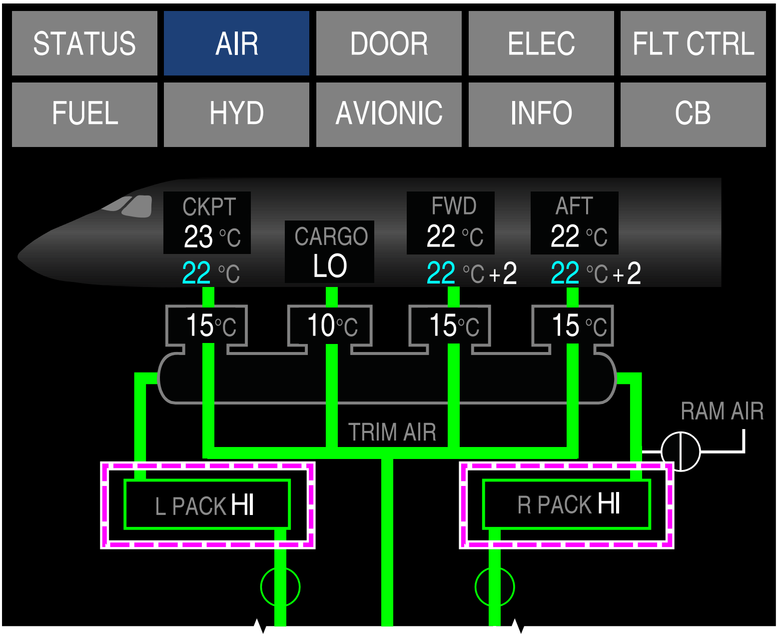
When the high flow mode is selected, HI displays in the PACK symbol on the AIR synoptic page and a **PACK FLOW HI** status message displays on the EICAS page (refer to Figure 02–03–5).



AIR PANEL - PACK FLOW SWITCH

PACK FLOW HI

EICAS STATUS MESSAGE



AIR SYNOPTIC PAGE - PACKS HIGH FLOW INDICATION

PACKS high flow control and indication
Figure 02–03–5

D. Packs operation

The packs default to the automatic mode when the FAIL and OFF labels are not illuminated on the PACK switches. The IASC commands the applicable pack valve (Flow Control Valve (FCV)) to open and supply hot bleed air to the corresponding pack. The controller modulates the pack valve to provide the volume of air for the number of cabin occupants entered in the FMS and the operating conditions.

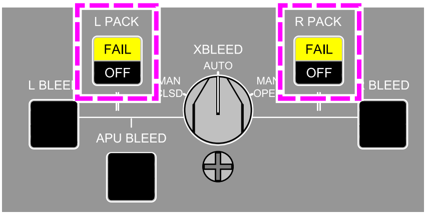
The pack valve positions and associated flow lines display on the AIR synoptic page (refer to Figure 02–03–6).

NOTE

If no data is entered in the FMS, the system will assume that the cabin is full.

When the L or R PACK switch is pressed (selected OFF), the corresponding pack valve closes and a **L or R PACK OFF** status message displays on the EICAS page. When selected OFF, the PACK switch can be used to reset the pack for overtemperature or overpressure conditions by selecting again to automatic mode.

If an air-conditioning pack fails, the FAIL label on the PACK switch illuminates amber and the caution message **L PACK FAIL** or **R PACK FAIL** display on the EICAS page. The pack will also be automatically selected off.



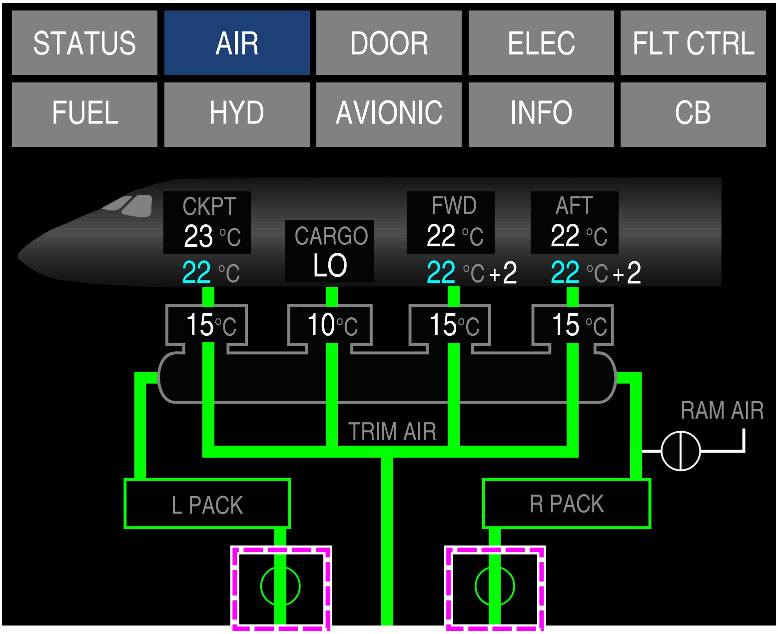
AIR PANEL -
LEFT AND RIGHT PACK SWITCHES

L PACK FAIL
R PACK FAIL
L PACK LEAK
R PACK LEAK
L PACK OVHT
R PACK OVHT

EICAS
CAUTION MESSAGES

L PACK OFF
R PACK OFF

EICAS
STATUS MESSAGES

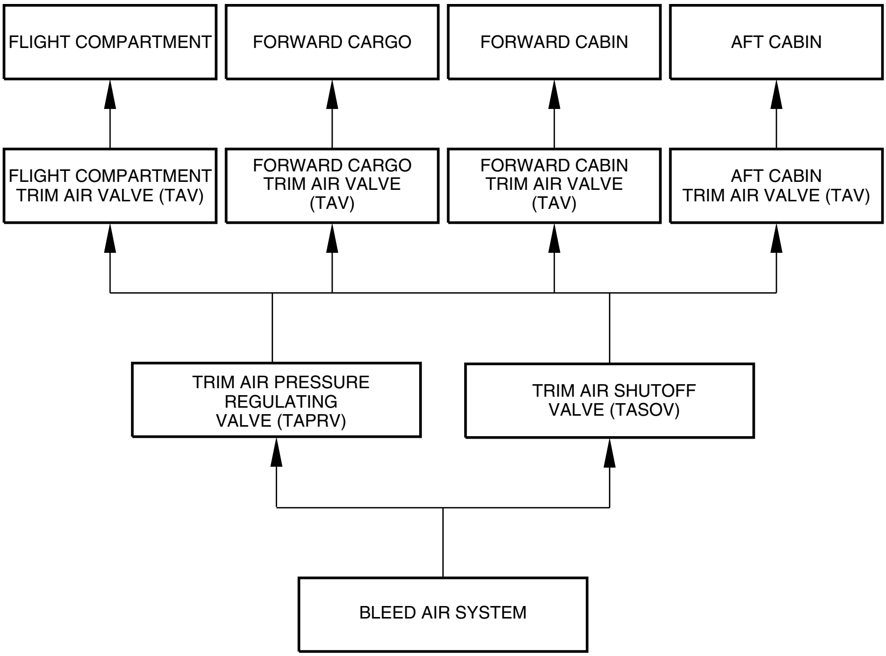


AIR SYNOPTIC PAGE - LEFT AND RIGHT PACK VALVES

PACKS control and indication
Figure 02–03–6

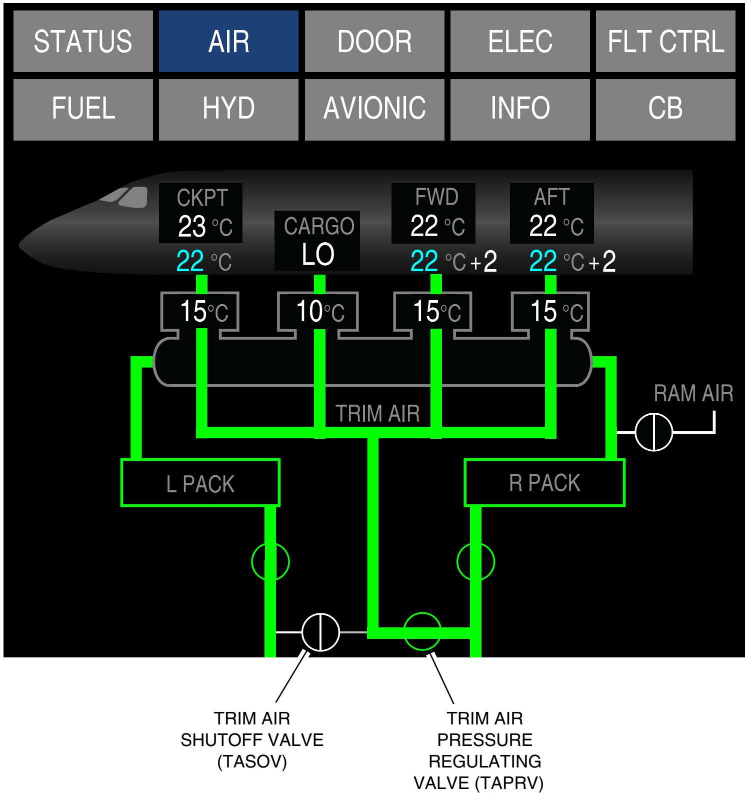
E. Trim air system

The trim air system (refer to Figure 02–03–7) provides additional hot bleed air through four Trim Air Valves (TAVs) (one for each air-conditioned zone) where it is mixed with the cold air from the packs. These valves are not shown on the AIR synoptic page



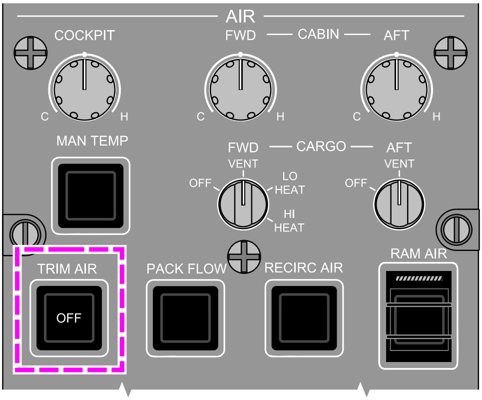
Trim air system overview
Figure 02–03–7

A Trim Air Pressure Regulating Valve (TAPRV) regulates the volume of hot bleed air to the TAVs and a Trim Air Shutoff Valve (TASOV) opens when additional heating is required on the ground and also acts as a backup to the TAPRV. If the TAPRV fails closed or when additional heating is required on the ground, the TASOV opens. The TAPRV and TASOV positions and flow lines are displayed on the AIR synoptic page (refer to Figure 02–03–8).



AIR synoptic page – Trim air system indication
Figure 02–03–8

The TRIM AIR switch on the AIR panel (refer to Figure 02–03–9) is used to shut off the trim air supply in case of bleed air leak.



EICAS STATUS MESSAGE

AIR panel – TRIM AIR switch
Figure 02–03–9

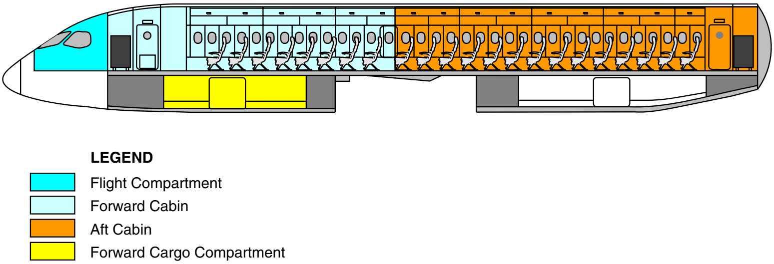
F. Temperature control system

The air-conditioning system provides temperature-controlled air to four independent zones:

- Flight compartment (COCKPIT switch),
- Forward cabin (FWD CABIN switch), which includes forward galley and forward lavatory,
- Aft cabin (AFT CABIN switch), which includes aft galley and aft lavatory, and
- Forward cargo compartment (FWD CARGO switch).

NOTE

The aft cargo compartment is not heated. It is only ventilated.



Temperature controlled zones
Figure 02–03–10

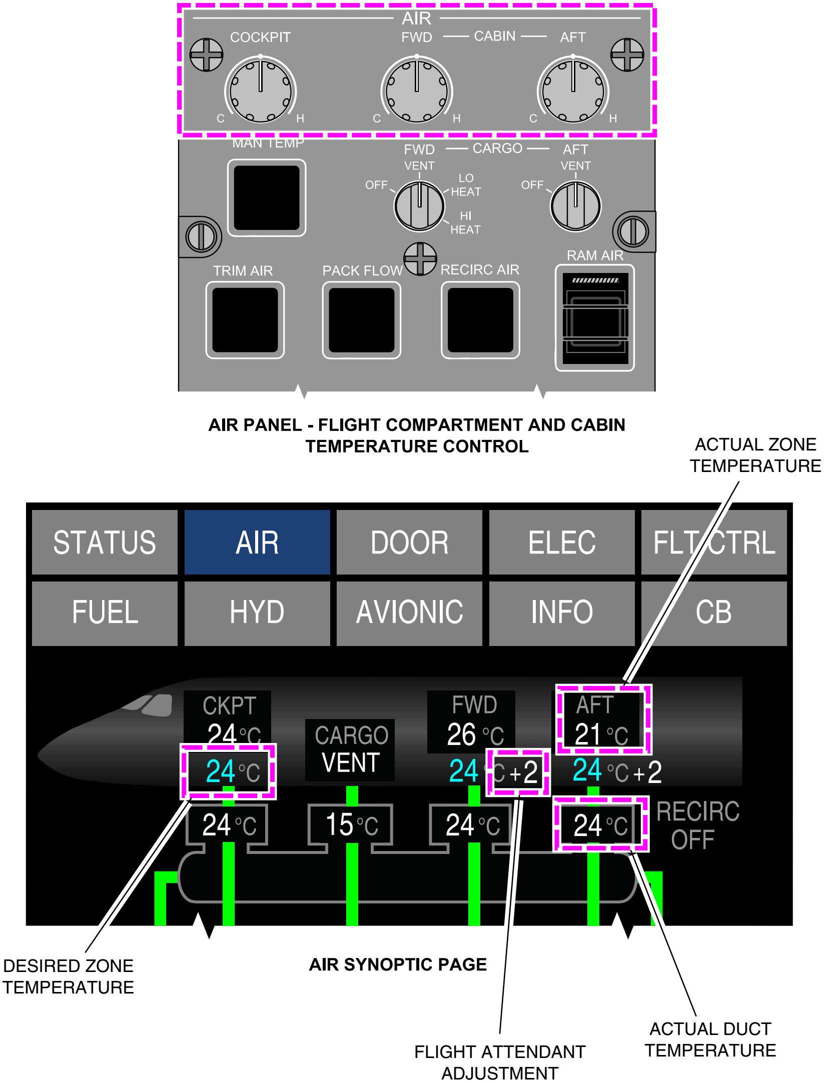
The temperature in the flight compartment and the cabin can be controlled in automatic or manual mode.

(1) Automatic mode

In automatic mode, the IASCs use temperature sensor information from each zone and regulate the trim air valves to maintain the selected zone temperature.

The temperature switches (COCKPIT, FWD CABIN, and AFT CABIN) are used to set the temperature for the flight compartment, forward and aft cabin zones. On the AIR synoptic page, the actual zone temperature is displayed in white and the desired zone temperature is displayed in cyan. In the cabin, the flight attendants can adjust the desired temperature by ± 3 degrees from the pilot selection. The cabin adjustment displays in white to the right side of the desired zone temperature (refer to Figure 02–03–11).

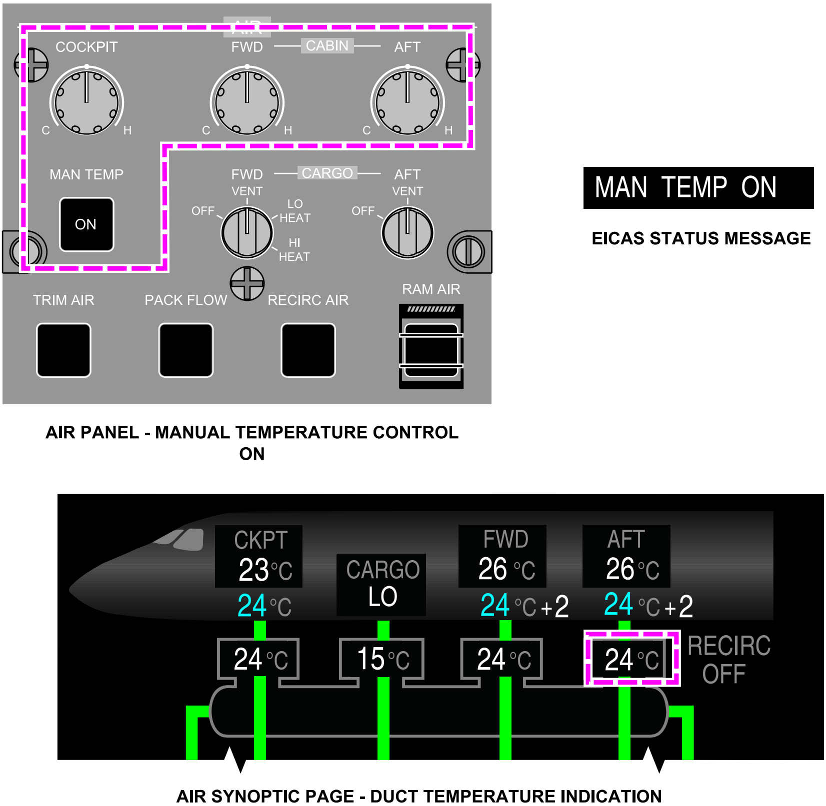
If the zone temperature sensors in the flight compartment or cabin fail, a manual temperature control mode is available by pressing the MAN TEMP switch on the AIR panel to ON (refer to Figure 02–03–12).



Automatic temperature control
Figure 02–03–11

(2) Manual mode

When the MAN TEMP switch is pressed on the AIR panel (refer to Figure 02–03–12), the temperature control changes to manual mode and a **MAN TEMP ON** status message displays on the EICAS page. In this mode, the temperature control switches on the AIR panel select the desired duct temperature instead of the zone temperature. The IASC then regulates the Trim Air Valves (TAVs) to maintain a specific duct temperature.



Manual temperature control
Figure 02–03–12

(3) Forward cargo heating

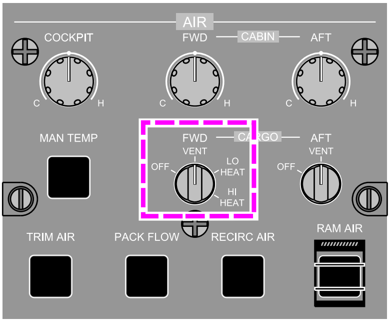
The forward cargo compartment temperature control uses the FWD CARGO switch on the AIR panel to select between three settings:

LO HEAT: To maintain a cargo temperature between 15 °C and 20 °C.

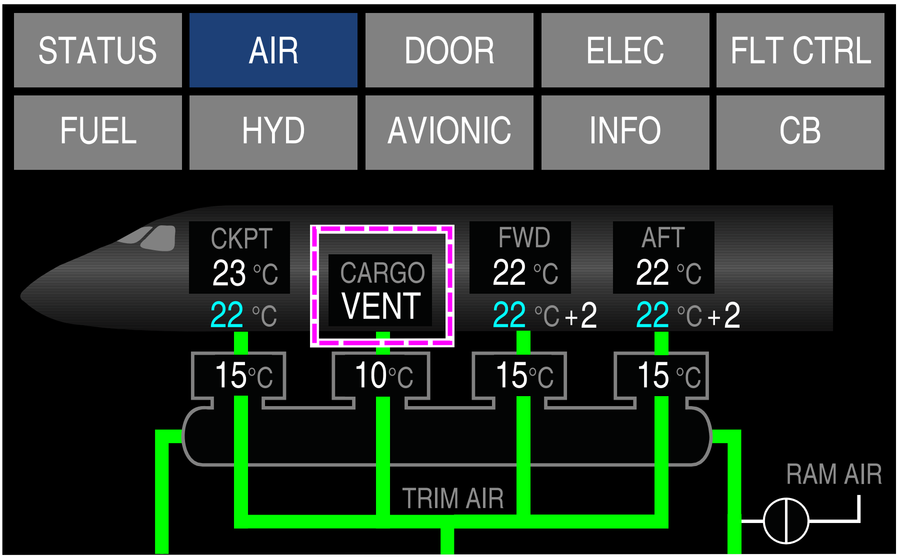
HI HEAT: To maintain a cargo temperature between 20 °C and 25 °C.

VENT: To Ventilate only.

The temperature settings (LO, HI, and VENT) and the cargo duct temperature display on the AIR synoptic page (refer to Figure 02–03–13).



AIR PANEL - FWD CARGO SWITCH

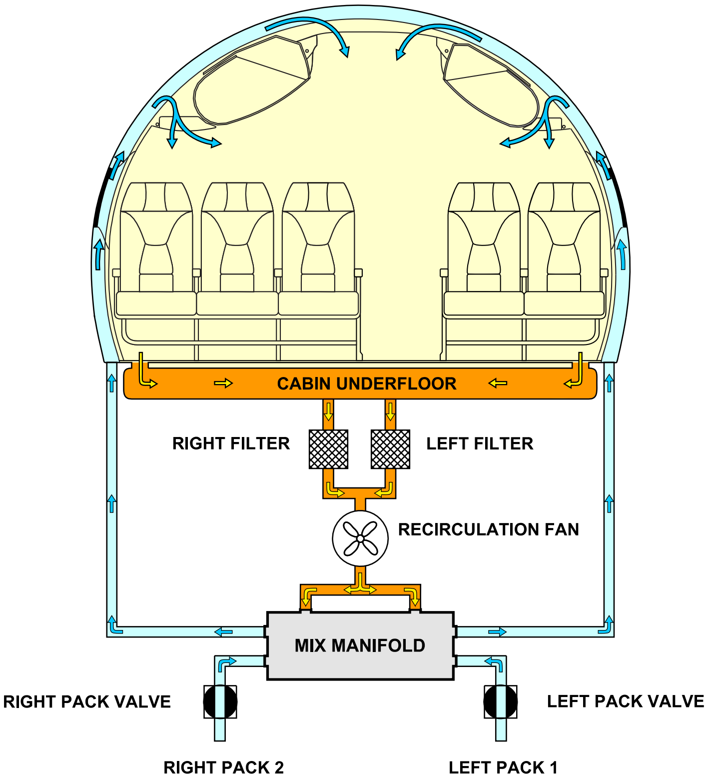


AIR SYNOPTIC PAGE

Forward cargo temperature control
Figure 02–03–13

G. Cabin air distribution and recirculation system

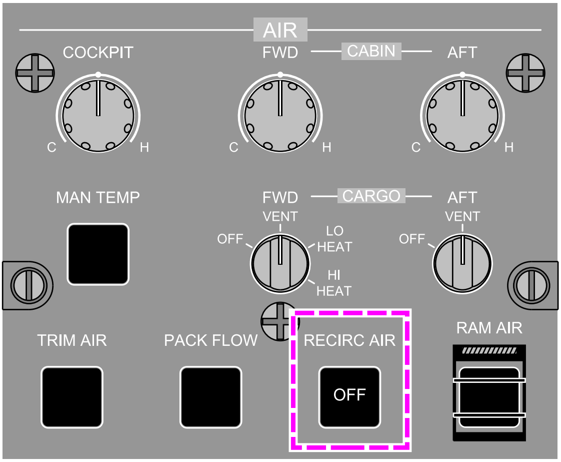
The cabin air distribution system ensures optimal and consistent temperature throughout the four temperature zones. The cabin air is distributed from the upper and lower sides of the overhead stowage bins and exhausted through floor level ducts that run along the length of the cabin (refer to Figure 02–03–14).



Cabin air distribution and recirculation
Figure 02–03–14

Recirculating air reduces the demand on the air-conditioning system, and provides a more rapid warming of the cabin. Approximately 35% to 40% of cabin air is recirculated. A recirculation fan draws air through two recirculation filters and mixes it in the mix manifold with the conditioned air from the packs. It is then redistributed back into the flight compartment and cabin zones.

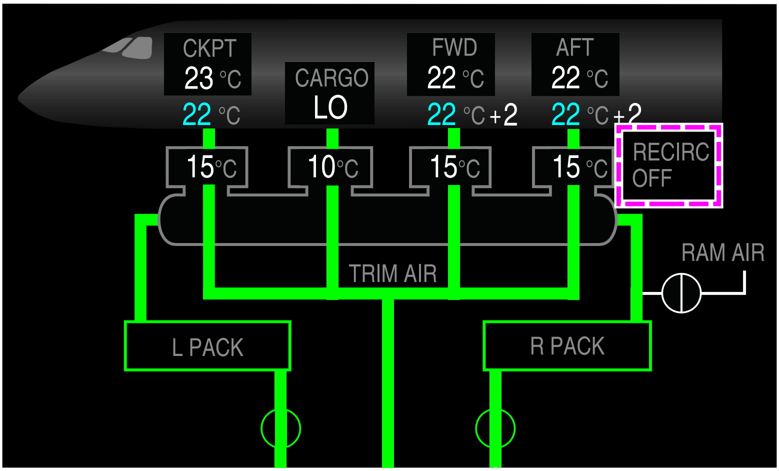
The recirculation fan is automatically controlled by the IASCs . When the RECIRC AIR switch (refer to Figure 02–03–15) is pressed, the recirculation fan is turned off, an OFF legend illuminates on the switch, and a **RECIRC AIR OFF** status message displays on the EICAS page. A RECIRC OFF message also displays on the AIR synoptic page.



AIR PANEL - RECIRCULATION SWITCH OFF

RECIRC AIR OFF

EICAS STATUS MESSAGE



AIR SYNOPTIC PAGE - RECIRCULATION OFF

Recirculation fan control
Figure 02–03–15

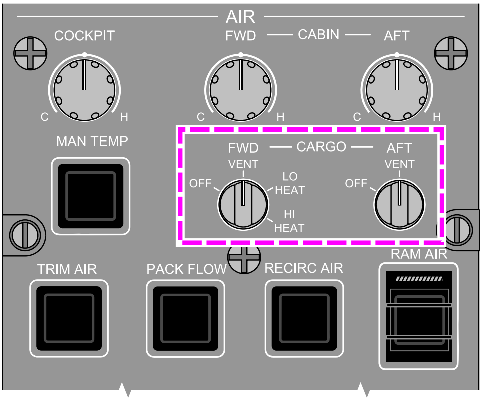
H. Cargo compartment ventilation and heating system

Each cargo compartment (forward and aft) includes two cargo shutoff valves for heating and ventilation. One valve acts as an inflow valve, the other as an outflow valve. If smoke is detected in either cargo compartment, the associated valves close automatically.

The heat for the forward cargo compartment is supplied by a TAV and is selectable as LO (Low) or HI (High) HEAT on the AIR panel (refer to Figure 02–03–16).

NOTE

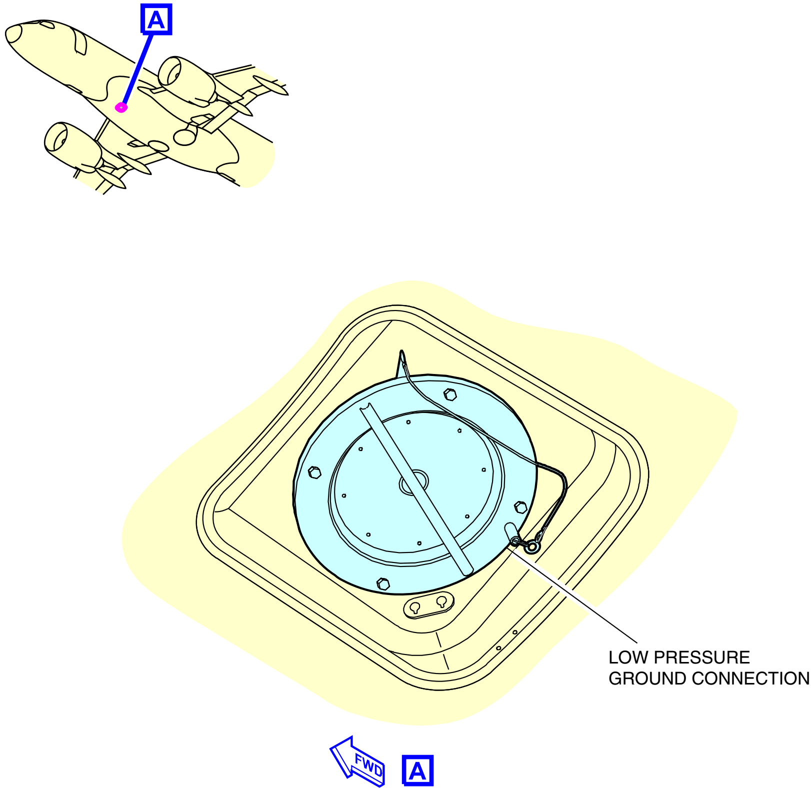
The aft cargo compartment is not heated. It is only ventilated.



AIR panel – FWD CARGO switch and AFT CARGO switch
Figure 02–03–16

I. Low Pressure Ground Connection (LPGC)

An external air conditioning source can be connected to the LPGC forward of the left wing (refer to Figure 02–03–17). The LPGC supplies air to the mix manifold to distribute it throughout the flight compartment and the cabin.



Low pressure ground connection
Figure 02–03–17

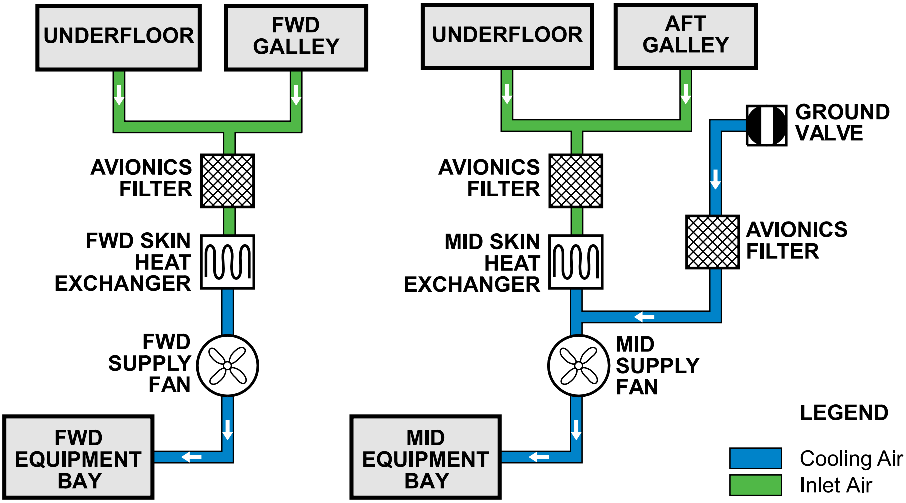
J. Avionics cooling system

The aircraft has separate avionics equipment cooling and heat extraction systems (refer to Figure 02–03–18) that work together to maintain electrical equipment at the correct temperature.

The avionics cooling system consists of:

- One ground valve,
- Two supply fans,
- Two Skin Heat-Exchangers (SHXs), and
- Two particle filters.

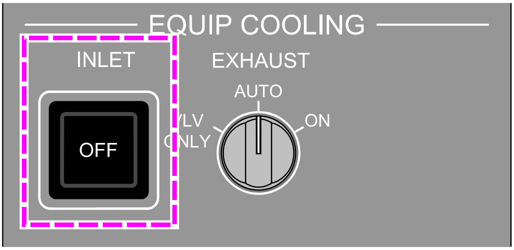
The system operates at all times and is controlled by the IASCs. In flight, the air is drawn from the galleys and the under floor area by two cooling fans (one in the forward and one in the mid equipment bay). The drawn air is cooled by two skin heat exchangers, and then directed into the forward and mid equipment bays. It is then exhausted through the outflow valve by the avionics heat extraction system.



Avionics cooling system
Figure 02–03–18

When the aircraft is on the ground, the ground valve installed on the skin on the lower right side of the fuselage opens and provides additional cooling to the mid equipment bay if the Outside Air Temperature (OAT) is between 3 °C and 30 °C (37 °F and 86 °F). Before takeoff, the ground valve is closed by the IASC when all doors are closed and locked. At landing, the ground valve opens 1 minute after touchdown.

The INLET switch, located on the EQUIP COOLING panel (refer to Figure 02–03–19), allows the flight crew to select the cooling system from AUTO (controlled by the IASC) to OFF. When selected to OFF, the status message **INLET AIR OFF** displays on the EICAS page.



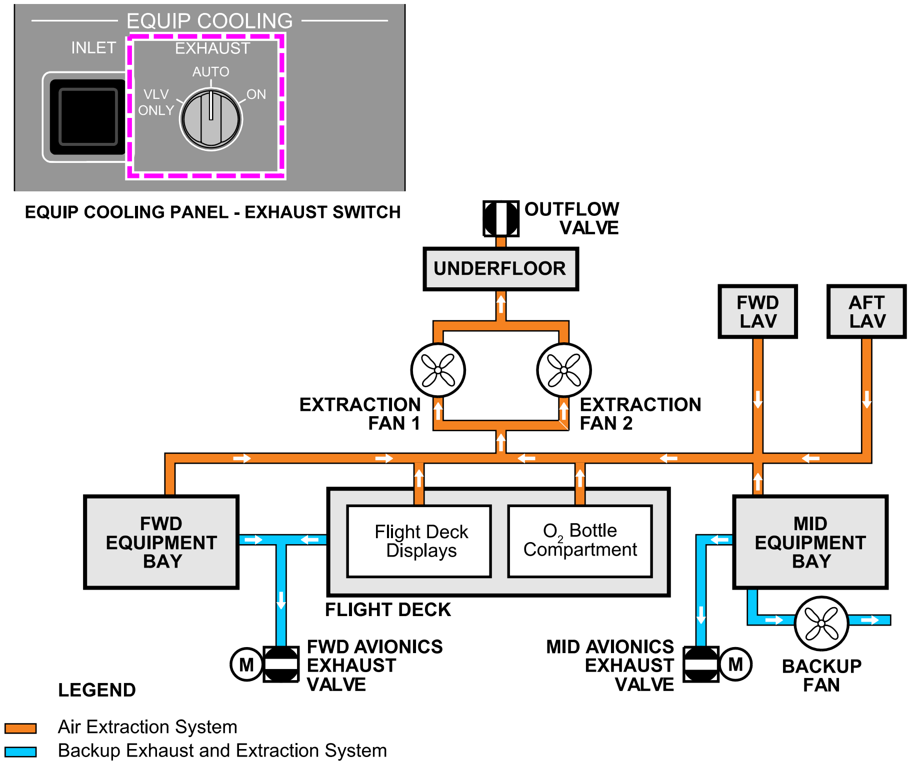
EICAS STATUS MESSAGE

EQUIP COOLING panel – INLET switch
Figure 02–03–19

K. Avionics heat extraction system

The heat generated by the flight compartment displays and the avionics equipment is extracted by one of the two extraction fans (refer to Figure 02–03–20). The fans are controlled by the IASCs, and alternate operation on a daily basis. The air is extracted from the zones that follow:

- Flight compartment displays,
- Crew oxygen bottle compartment,
- Forward and mid equipment bays,
- Forward and aft lavatories, and
- Forward and aft galleys.



Heat extraction system
Figure 02–03–20

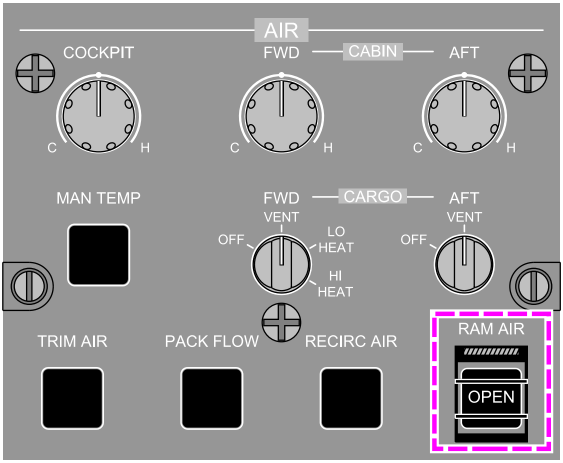
If a single extraction fan fails, the system switches automatically to the serviceable extraction fan and the advisory message **EQUIP BAY COOL FAULT** is displayed on the EICAS page. If both extraction fans fail, two Avionics Exhaust Valves (AEVs) open, a backup fan is automatically activated, and the caution message **EQUIP BAY COOL FAIL** is displayed on the EICAS page.

During flight, the cabin differential pressure forces air out through the AEVs.

The EXHAUST switch on the EQUIP COOLING panel allows the flight crew to control the AEVs and the backup fan (for details, refer to Air-conditioning system – Controls and indications).

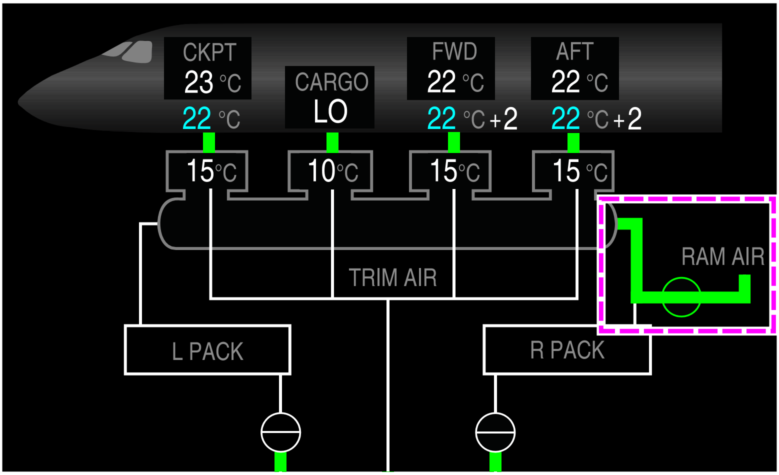
L. Ram air ventilation

The ram air ventilation is used to supply fresh air to the cabin and to the flight compartment if both packs fail, causing unpressurized operation. The ram air ventilation is controlled by the RAM AIR guarded switch on the AIR panel (refer to Figure 02–03–21).



AIR PANEL - RAM AIR GUARDED SWITCH
(VALVE OPEN)

EICAS STATUS MESSAGE



AIR SYNOPTIC PAGE - RAM AIR VENTILATION ON

Ram air ventilation
Figure 02–03–21

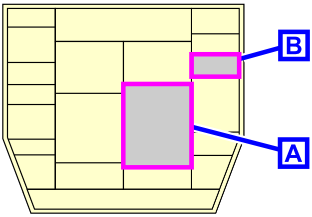
When the switch is pressed, an OPEN legend illuminates on the switch, the Emergency Ram Air Valve (ERAV) opens and a **RAM AIR OPEN** status message displays on the EICAS page.

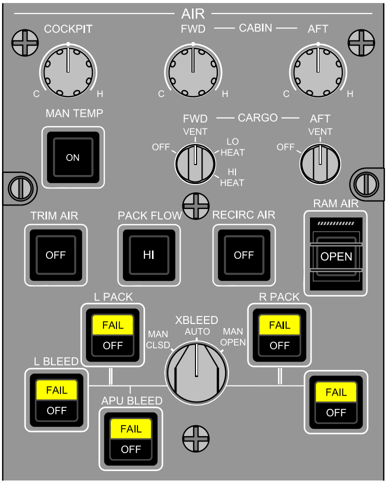
AIR-CONDITIONING SYSTEM – CONTROLS AND INDICATIONS

A. AIR panel and EQUIP COOLING panel

The air-conditioning system controls are located on the AIR panel and the EQUIP COOLING panel (refer to Figure 02–03–22). The controls are as follows:

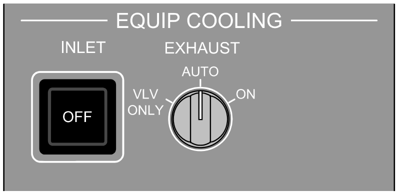
- L PACK and R PACK switches,
- TRIM AIR switch,
- PACK FLOW switch,
- RECIRC AIR switch,
- RAM AIR guarded switch,
- COCKPIT switch,
- FWD CABIN and AFT CABIN switches,
- MAN TEMP switch,
- FWD CARGO and AFT CARGO switches,
- INLET switch, and
- EXHAUST switch.





AIR PANEL

A

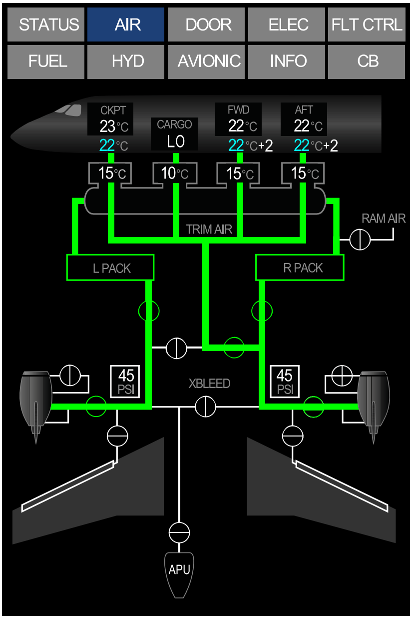


EQUIP COOLING PANEL

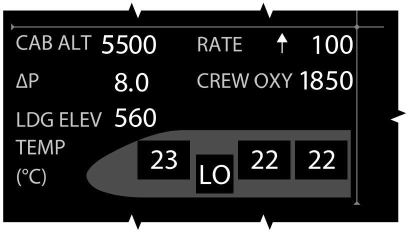
B

AIR panel and EQUIP COOLING panel
Figure 02–03–22

The system indications display on the AIR synoptic page and on the air section of the EICAS page.



AIR SYNOPTIC PAGE



EICAS PAGE - AIR SECTION

Integrated air management system indications
Figure 02–03–23

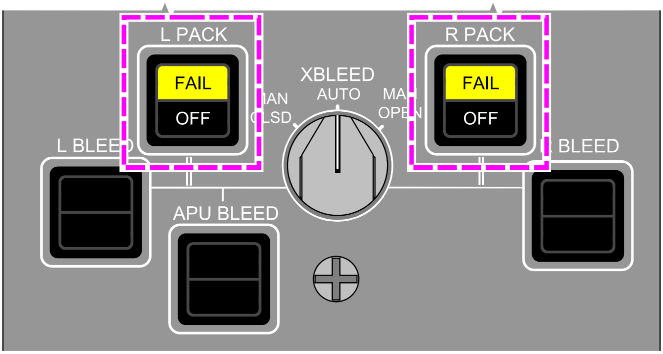
B. L PACK switch and R PACK switch

The L PACK and R PACK switches (refer to Figure 02–03–24) control the left and right pack valves (Flow Control Valves (FCV)). Each switch has three indications:

- Auto (not illuminated): This mode is the default mode. The IASCs control the airflow using the respective pack valve.

- OFF: When pressed in, the OFF label illuminates white and turns off the respective pack.
- FAIL: Illuminates amber when the associated pack valve fails.

If the flight crew presses the switch to OFF and then back to auto, it resets the pack.



L PACK FAIL
R PACK FAIL
L PACK LEAK
R PACK LEAK
L PACK OVHT
R PACK OVHT

EICAS CAUTION MESSAGES

L PACK OFF
R PACK OFF

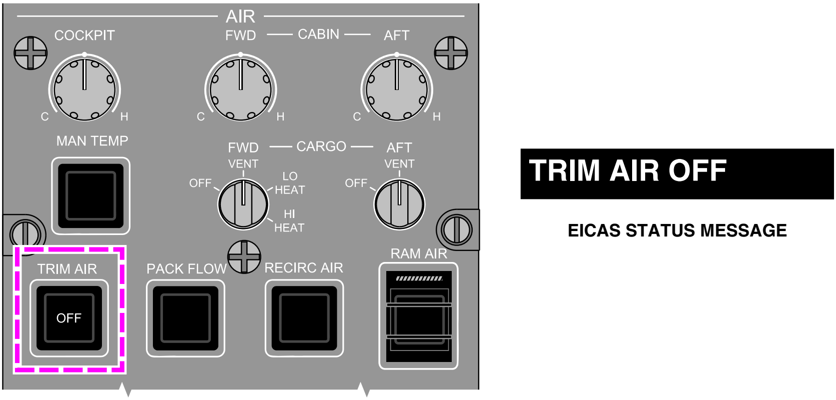
EICAS STATUS MESSAGES

AIR panel – L PACK switch and R PACK switch
Figure 02–03–24

C. TRIM AIR switch

The TRIM AIR switch (refer to Figure 02–03–25) has two positions:

- Auto (not illuminated): When the switch is pressed out, the trim air system is in automatic mode.
- OFF: When pressed in, the trim air system is off (valves closed).

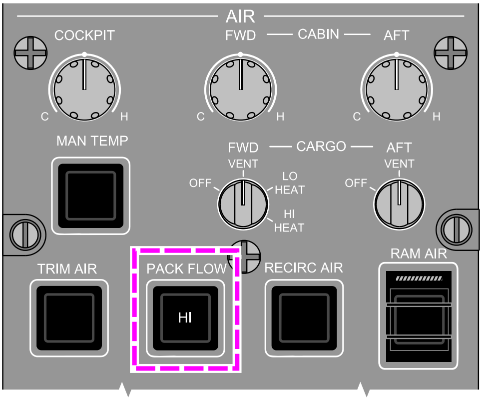


AIR panel – TRIM AIR switch
Figure 02–03–25

D. PACK FLOW switch

The PACK FLOW switch (refer to Figure 02–03–26) has two positions:

- Auto (not illuminated): This mode is the default mode. The IASC controls the airflow based on the number of cabin occupants entered in the Flight Management System (FMS).
- HI: When the switch is pressed in, the HI label on the switch illuminates and activates the high flow mode. This mode is mainly for smoke and odor evacuation.



PACK FLOW HI

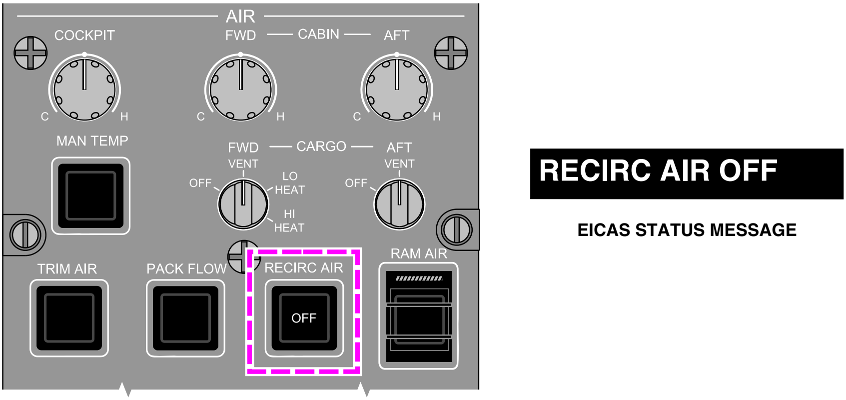
EICAS STATUS MESSAGE

AIR panel – PACK FLOW switch
Figure 02–03–26

E. RECIRC AIR switch

The RECIRC AIR switch (refer to Figure 02–03–27) controls the recirculation fan. It has two positions:

- Auto (not illuminated): This mode is the default mode. The recirculation fan is on.
- OFF: When the switch is pressed in, the OFF label on the switch illuminates white and the recirculation fan is turned off.

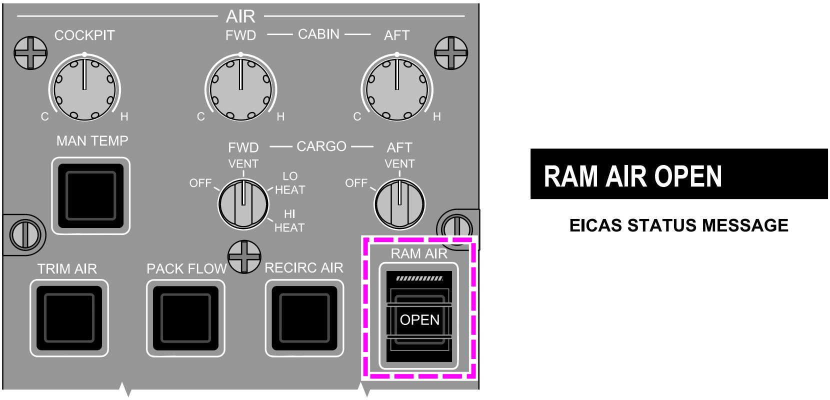


AIR panel – RECIRC AIR switch
Figure 02–03–27

F. RAM AIR guarded switch

The RAM AIR guarded switch (refer to Figure 02–03–28) controls the Emergency Ram Air Valve (ERAV) and is used to ventilate the flight compartment and the cabin compartment at low altitude. The switch has two positions:

- Closed (not illuminated): This is the default switch position. The ERAV is closed.
- OPEN: When the guarded switch is pressed in, the OPEN label on the switch illuminates white and the ERAV and the Outflow Valve (OFV) open.

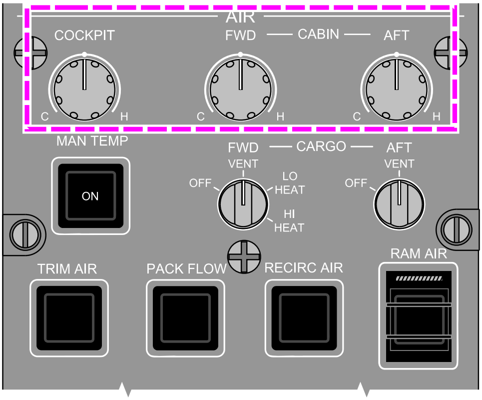


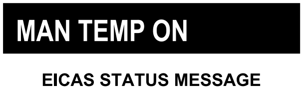
AIR panel – RAM AIR guarded switch
Figure 02–03–28

G. COCKPIT, FWD CABIN, and AFT CABIN switches

The COCKPIT, FWD CABIN, and AFT CABIN switches (Figure 02–03–29) control the flight compartment and cabin temperatures (duct temperature in manual mode). The flight crew can select a range of temperatures from 18 °C (64 °F) to 30 °C (86°F) with a center position of 24 °C (75 °F).

The cabin crew can also control the cabin temperature by making small adjustments of ±3 °C (±5 °F) from the Cabin Management System (CMS). These adjustments are displayed on the AIR synoptic page and are reset when the flight crew changes the cabin temperature.



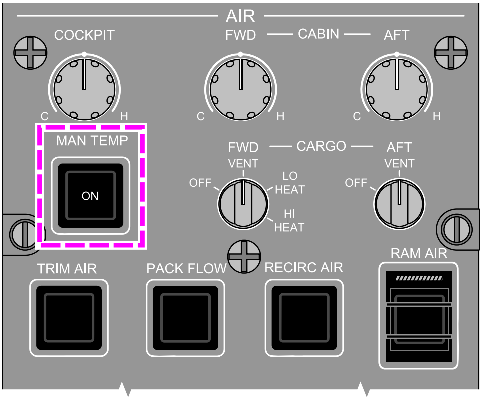


AIR panel – COCKPIT, FWD CABIN, AFT CABIN switches
Figure 02–03–29

H. MAN TEMP switch

The MAN TEMP switch (refer to Figure 02–03–30) activates or deactivates the manual temperature control mode. When manual mode is selected, the COCKPIT, FWD CABIN and AFT CABIN switches control the supplied duct temperature instead of the zone temperature. The MAN TEMP switch has two positions:

- Auto (not illuminated): When the switch is pressed out, the temperature control system is in automatic mode.
- ON: When pressed in, the ON label illuminates white and the temperature control system is in manual mode.



MAN TEMP ON

EICAS STATUS MESSAGE

AIR panel – MAN TEMP switch
Figure 02–03–30

I. FWD CARGO switch and AFT CARGO switch

The FWD CARGO and AFT CARGO switches (refer to Figure 02–03–31) allow the control of the cargo valves for ventilation and heating (forward cargo only).

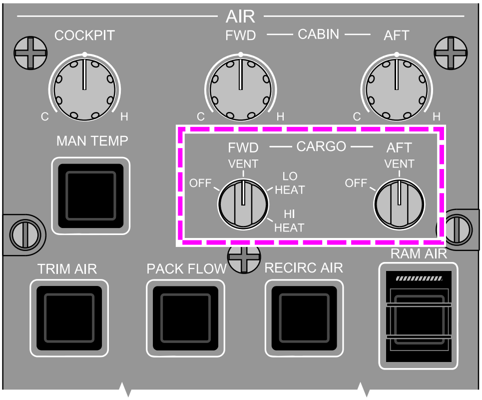
(1) FWD CARGO switch has four positions:

- OFF: The forward cargo compartment is not ventilated and not heated.
- VENT: The forward cargo compartment is ventilated and not heated.
- LO HEAT: The forward cargo compartment is ventilated and heated to a temperature that ranges between 15 °C (59 °F) and 20 °C (68 °F).

- HI HEAT: The forward cargo compartment is ventilated and heated to a temperature that ranges between 20 °C (68 °F) and 25 °C (77 °F).

(2) AFT CARGO switch has two positions:

- OFF: The aft cargo compartment is not ventilated.
- VENT: The aft cargo compartment is ventilated.



AIR panel – FWD CARGO switch and AFT CARGO switch
Figure 02–03–31

J. INLET switch

The INLET switch (refer to Figure 02–03–32) controls the forward and mid equipment bay heat exchanger fans and the ground valve. The switch has two positions:

- Auto (not illuminated): When the switch is pressed out, the IASC controls the forward and mid equipment bay supplemental cooling. This is the default switch position.

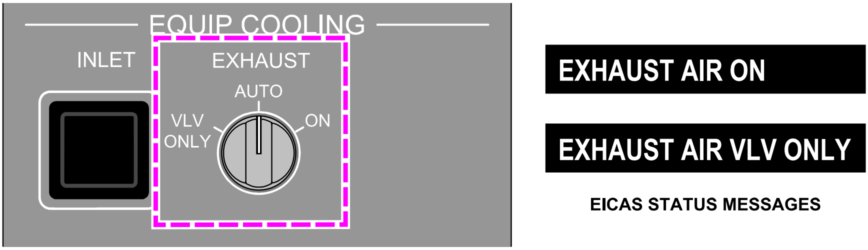
- OFF: When the switch is pressed in, the OFF label on the switch illuminates white and the forward and mid equipment bay heat exchanger fans are turned off, and the ground valve closes.

EQUIP COOLING panel – INLET switch
Figure 02–03–32

K. EXHAUST switch

The EXHAUST switch (refer to Figure 02–03–33) controls the Avionics Exhaust Valves (AEVs) and the backup fan. The switch has three positions:

- AUTO: This is the default position and when selected, the IASCs have full control on the Avionics Cooling and heat Extraction System (ACES).
- ON: When selected, both AEVs are driven fully open and the backup fan is turned on.
- VLV ONLY: When selected, the AEVs are driven fully open and the backup fan is off.

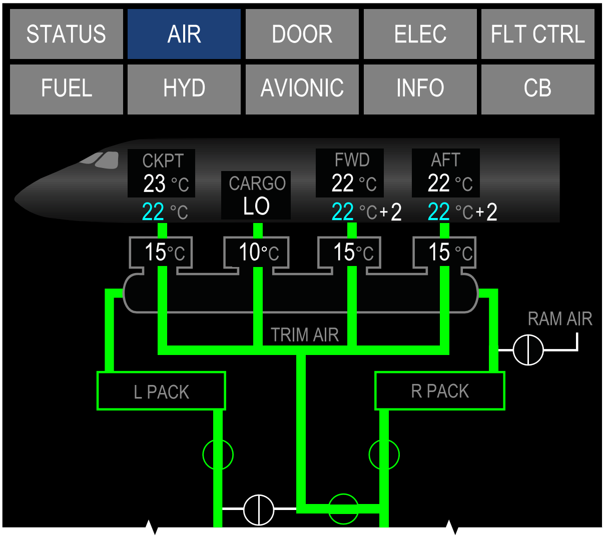


EQUIP COOLING panel – EXHAUST switch
Figure 02–03–33

L. AIR synoptic page

The air-conditioning system status displays on the AIR synoptic page (refer to Figure 02–03–34)

Figure 02–03–35 and Figure 02–03–36 describe the air-conditioning indications on the AIR synoptic page.



AIR synoptic page – Air–conditioning system
Figure 02–03–34

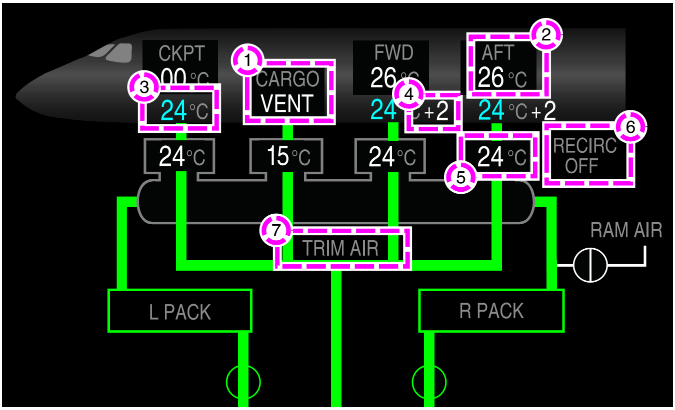
VALVE POSITION NORMAL OPERATION	
Symbol	**Condition**
	Closed
	Open with flow
	Open with no flow

FLOW LINES	
Symbol	**Condition**
	Normal flow
	No flow
	Abnormal flow (overheat, out of range pressure, leak)

VALVE POSITION FAILED OPERATION	
Symbol	**Condition**
	Failed closed
	Failed open with flow
	Failed open with no flow
	Invalid

PACKS	
Symbol	**Condition**
L PACK	Failed or leaked
L PACK	Active
L PACK	Invalid
L PACK	Normal OFF

AIR synoptic page – Air–conditioning system description
Figure 02–03–35



AIR SYNOPTIC PAGE

AIR CONDITIONING INDICATIONS		
1	CARGO VENT	Fwd cargo selection indicator (white): • OFF – no heating, no ventilation • VENT – cargo ventilation only • LO HEAT – vent and low heating level (15-20 °C) • HI HEAT – vent and warmer heating level (20-25 °C)
2	AFT 26 °C	Actual cabin temperature (white): • Dashed line "–––" represents a temp sensor failure or operating in manual mode
3	24 °C	Selected temperature (cyan): • Automatic mode – desired ZONE temperature • Manual mode – desired DUCT temperature
4	+2	Flight attendant adjustment (white): ±3 °C
5	24 °C	Duct temperature
6	RECIRC OFF	Recirculation fan status
7	TRIM AIR	Trim air status: • Normal operation – green • No operation – gray • Failed – amber

AIR synoptic page – Air–conditioning indications
Figure 02–03–36

AIR-CONDITIONING SYSTEM – EICAS MESSAGES

A. Warning messages

Message	Description	Aural	Inhibit
EQUIP BAY OVHT	Forward equipment bay or mid equipment bay over-temperature detected (more than 67 °C (152 °F)).	None	None

B. Caution messages

Message	Description	Inhibit
AIR SYS ESS CTRL FAIL	IASC 1 failed, channel B and C failed and IASC 2 channel B and C failed.	TO, LDG
EQUIP BAY COOL FAIL	Loss of both extraction FANS confirmed by IASC channel (safety or control) or both fans are running or total loss of one zone temperature measurement.	TBD
L AIR SYS CTRL FAIL	IASC 1 failed, channel A and channel B failed or not received by DMC.	TO, LDG
L PACK FAIL	Left pack inoperative, or loss of left pack leak detection, or loss of both IASC 1 channels.	TO, LDG
L PACK OVHT	Left compressor discharge temperature overheat or left pack discharge temperature overheat.	TO, LDG
R AIR SYS CTRL FAIL	IASC 2 failed, channel A and channel B failed or not received by DMC.	TO, LDG
R PACK FAIL	Right pack inoperative, or loss of right pack leak detection, or loss of both IASC 2 channels.	TO, LDG

Message	Description	Inhibit
R PACK OVHT	Right compressor discharge temperature overheat or right pack discharge temperature overheat.	TO, LDG
RAM AIR FAIL	RAM AIR switch selected OPEN and Emergency Ram Air Valve (ERAV) not detected open, or RAM AIR switch selected to CLOSE and ERAV not detected closed.	TO, LDG
RECIRC AIR FAIL	RFAN internal failure detected or communication failure.	TO, LDG
TRIM AIR FAIL	Trim air failure or loss of trim air leak detection or loss of both IASC 1 channels.	TO, LDG
TRIM AIR LEAK	Trim air leak detected.	TO, LDG

C. Advisory messages

Message	Description	Inhibit
AVIONIC FAULT	Loss of redundant or non-critical function for the avionics system.	TO, LDG
AVIONIC FAN FAULT	Loss of fan functionality within avionics LRUs.	TO, LDG
EQUIP BAY COOL FAULT	Loss of redundant or non-critical function for the air-conditioning system.	TO, LDG
PACK FAULT	Loss of redundant or non-critical function for the air-conditioning system.	TO, LDG

D. Status messages

Message	Description	Inhibit
AFT CARGO AIR OFF	AFT CARGO selected and confirmed OFF.	None
FWD CARGO AIR OFF	FWD CARGO selected and confirmed OFF.	None
EXHAUST AIR VLV ONLY	Exhaust valves open manually.	None
EXHAUST AIR ON	Exhaust air system manually selected on (supplemental fan turns on and valves open).	None
INLET AIR OFF	Inlet air system (skin heat exchanger) selected off (fans turn off and valves close).	None
MAN TEMP ON	Temperature control selected manually.	None
PACK FLOW HI	Cabin airflow selected to HI.	None
L PACK OFF	Left pack selected to OFF.	None
R PACK OFF	Right pack selected to OFF.	None
RAM AIR OPEN	Ram air selected to OPEN.	None
TRIM AIR OFF	Trim air selected to OFF.	None

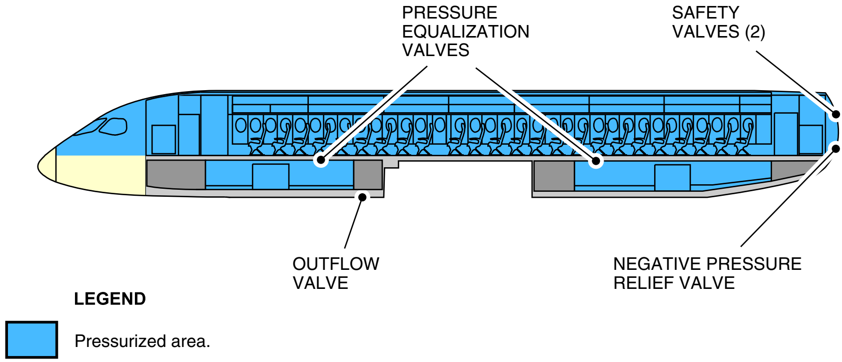
PRESSURIZATION SYSTEM – OVERVIEW

Aircraft pressurization is achieved by controlling the outflow of cabin air provided by the packs. This is accomplished by modulating the position of the Outflow Valve (OFV), which is located at the midway bottom of the aircraft. The two Integrated Air System Controllers (IASCs) control the OFV in automatic or manual mode. Independent, fully pneumatic, safety valves and a Negative Pressure Relief Valve (NPRV) protect the system from overpressure and negative pressure conditions.

The main components of the pressurization system are:

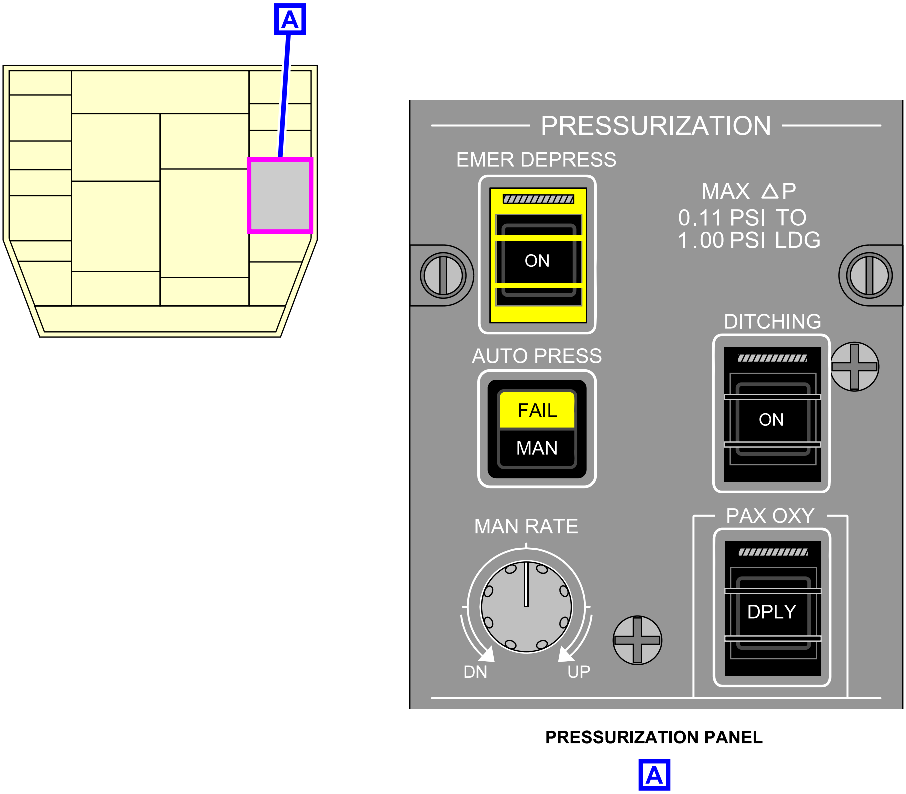
- Outflow Valve (OFV),
- Safety valves,
- Negative Pressure Relief Valve (NPRV), and
- Pressure Equalization Valves (PEVs).

The pressurized sections of the aircraft include the flight deck and cabin, the underfloor areas, and the cargo compartments (refer to Figure 02–04–1).

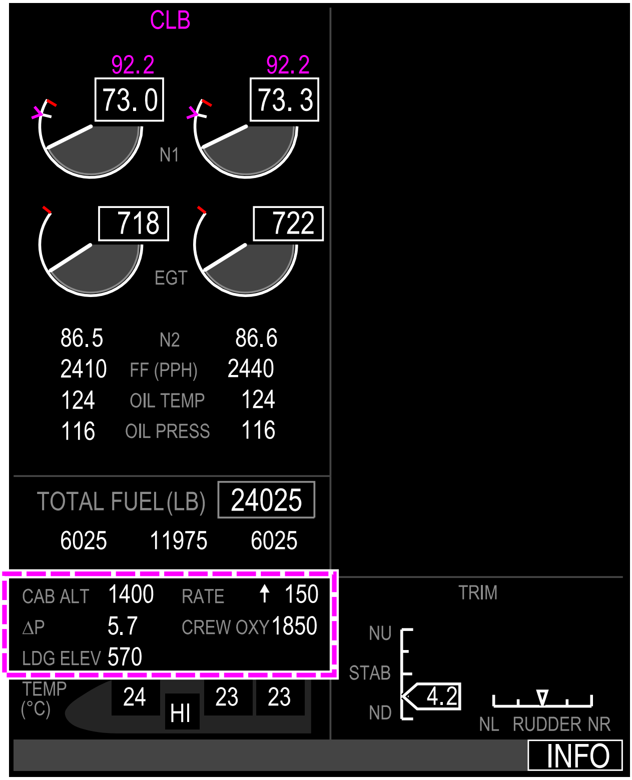


Pressurized area
Figure 02–04–1

The system is controlled from the PRESSURIZATION panel (refer to Figure 02–04–2). The avionics system allows input of landing elevation for pressurization control and provides feedback to the IASCs about the current aircraft conditions. The pressurization information is reported on the air section of the EICAS page and AIR synoptic page (refer toFigure 02–04–3).



Pressurization system controls
Figure 02–04–2



EICAS

Pressurization system indications
Figure 02–04–3

PRESSURIZATION SYSTEM – DESCRIPTION AND OPERATION

A. Outflow Valve (OFV)

A single Outflow Valve (OFV), located on the aft pressure bulkhead of the FWD cargo compartment, controls the amount of air discharged from the aircraft in order to maintain a specific cabin pressure. It consists of a single butterfly valve that is electrically operated by an actuator. The actuator has two automatic modes controlled by the A channel of each individual IASC. The actuator also has a manual mode controlled by the safety channel of both IASCs through a relay. The maximum positive and negative differential pressures are 60.67 kPa (8.8 psid) and –3.45 kPa (–0.5 psid) respectively. There is no muffler installed with the OFV. <21310001D>

B. Safety Valves

Two safety valves are located on the aft pressure bulkhead. They have an overpressure and a negative pressure relief function determined by the pressure differential between the aircraft interior and the outside atmosphere. The safety valves operate pneumatically and are completely independent of the other pressurization components.

C. Negative Pressure Relief Valve (NPRV)

The Negative Pressure Relief Valve (NPRV) is located on the aft pressure bulkhead. It has a redundant negative pressure relief function.

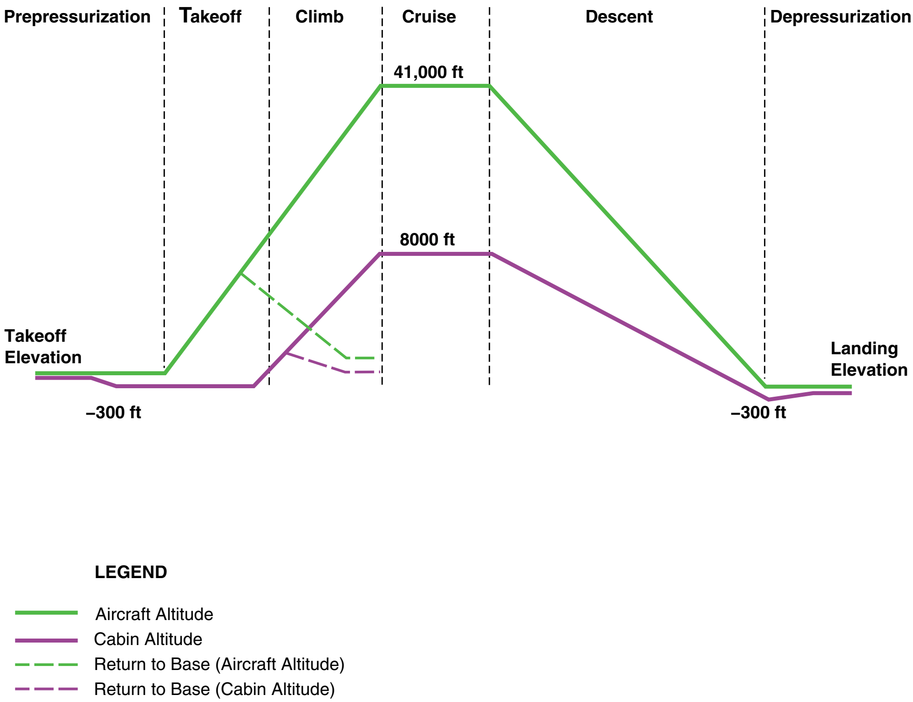
D. Pressure Equalization Valves (PEVs)

The four Pressure Equalization Valves (PEVs) prevent excessive pressure differential between the cabin and the cargo compartments. Each cargo compartment is equipped with large and small PEVs. The large PEVs prevent the cabin from pressurizing when a cargo door is not safely closed. The small PEVs equalize pressure between the cargo compartments and the cabin during fast climbs.

INTEGRATED AIR SYSTEM CONTROLLER (IASC) – PRESSURIZATION SYSTEM CONTROL AND MODES

A. Automatic mode (IASC control)

The IASCs control the OFV to maintain cabin pressure on a pre-programmed schedule based on the aircraft flight profile entered into the Flight Management System (FMS). Each controller incorporates a primary channel (A channel) dedicated to automatic cabin pressure control. In automatic mode (refer to Figure 02–04–4), the IASCs alternate control with one being active and the other in standby mode. If there is a fault in the active IASC A channel, the standby A channel of the other IASC becomes active and takes control of the OFV. Manual mode is explained below.



Pressurization automatic mode
Figure 02–04–4

B. Pre-pressurization mode

The pre-pressurization mode is activated on the ground when the thrust levers are advanced for takeoff. The IASC pressurizes the aircraft to 300 feet below airport elevation to eliminate any perceptible pressure changes at takeoff.

C. Takeoff mode

As soon as the aircraft is weight-off-wheels, the takeoff mode is initiated. The system will begin a gradual cabin pressurization.

D. Return to base mode

Return to base mode begins if the aircraft descends at a rate greater than 500 ft/min for more than 10 seconds within 10 minutes of takeoff or prior to reaching 5000 feet above takeoff field elevation. In return to base mode, the IASC depressurizes the aircraft to the takeoff field elevation.

E. Climb mode

The IASC activates the climb mode once the aircraft reaches 5000 feet above takeoff field elevation or 10 minutes after takeoff. The IASC sets a rate of change that is controlled for passenger comfort.

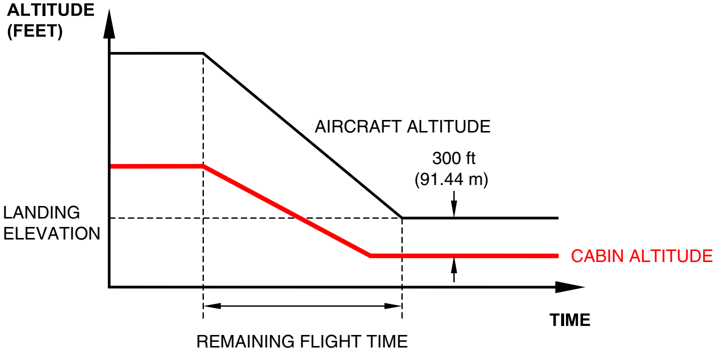
The cabin climb rate profile varies directly in relation to the aircraft climb rate. When step climbs are performed at high altitude and at large climb rates, the cabin climb rate might exceed the maximum normal limit due to safety valve overpressure protection. In this case, the cabin rate of climb will be proportional to the aircraft vertical speed.

F. Cruise mode

The IASC activates the cruise mode if the aircraft rate of climb is less than 500 ft/min for 10 seconds. The cabin altitude stabilizes at a level in accordance with the cabin pressure schedule.

G. Descent mode

The IASC activates the descent mode when the aircraft descends at a rate greater than 500 ft/min for 10 seconds (refer to Figure 02–04–5). The rate of cabin descent is directly related to the aircraft's rate of descent. Cabin altitude descends on schedule until the cabin altitude is 300 feet below landing elevation. During a high speed descent, the cabin rate of descent is increased to match the remaining flight time.



Descent mode
Figure 02–04–5

H. Depressurization mode

After landing or after an aborted takeoff, the OFV fully opens and remains in that configuration while on the ground.

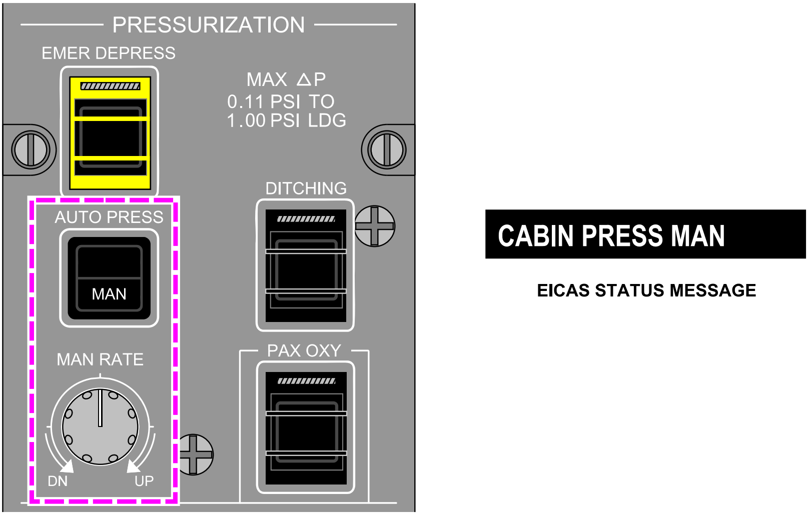
I. Manual pressurization mode

In manual pressurization mode, the IASCs maintain the cabin pressurization rate set by the flight crew. In manual mode, both IASC primary channels (A channels) become inactive and the IASCs (B channels) take direct control of the OFV utilizing the pressurization system relay.

The manual mode is active when the AUTO PRESS switch is pressed in on the PRESSURIZATION panel. A MAN label illuminates on the switch, and the status message **CABIN PRESS MAN** displays on the EICAS page (refer to Figure 02–04–6). The MAN RATE switch allows adjustments to the manual pressurization rate DN or UP positions, as described below:

- The 12 o’clock position has a detent corresponding to 0 ft/min.
- The 9 o’clock and 3 o’clock positions have detents corresponding to −1000 and +1000 ft/min, respectively.

- Counter-clockwise, between the 9 o’clock and DN positions, the rate of change can be adjusted from −1000 to −2500 ft/min. And clockwise, between 3 o’clock and UP positions, the rate of change can be adjusted from 1000 to 2500 ft/min.



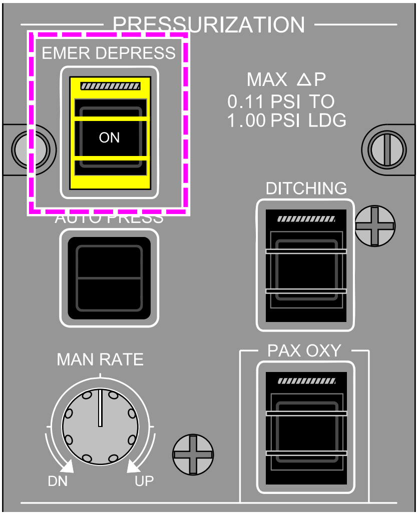
PRESSURIZATION panel – MAN RATE switch
Figure 02–04–6

When the desired cabin altitude is reached, the MAN RATE switch is rotated to the center position to stabilize the cabin at the current cabin altitude.

The actual cabin rate of change is measured from the cabin pressure sensors embedded in the B channels of the controllers and is used to limit the selected rate for the maximum comfort of the passengers. The display of the actual cabin rate is on the EICAS primary page (normal mode) and AIR synoptic page (reversion mode only). When the switch is in motion, the displayed value on the EICAS corresponds to the selected cabin rate.

J. Emergency depressurization function

Emergency depressurization is available in automatic and manual modes. When the EMER DEPRESS guarded switch is pressed in, the OFV opens and the caution message **EMER DEPRESS ON** displays on the EICAS page (refer to Figure 02–04–7). When selected, the cabin will depressurize to 15000 feet cabin altitude or the aircraft altitude, whichever is lower.



PRESSURIZATION panel – EMER DEPRESS guarded switch
Figure 02–04–7

If the automatic pressurization is selected, the cabin rate of change is limited to 2500 ft/min. If manual pressurization is selected, the cabin rate of change is limited to 3500 ft/min. In both cases the cabin rate of change limitation is ensured by the active IASC.

K. Ditching function

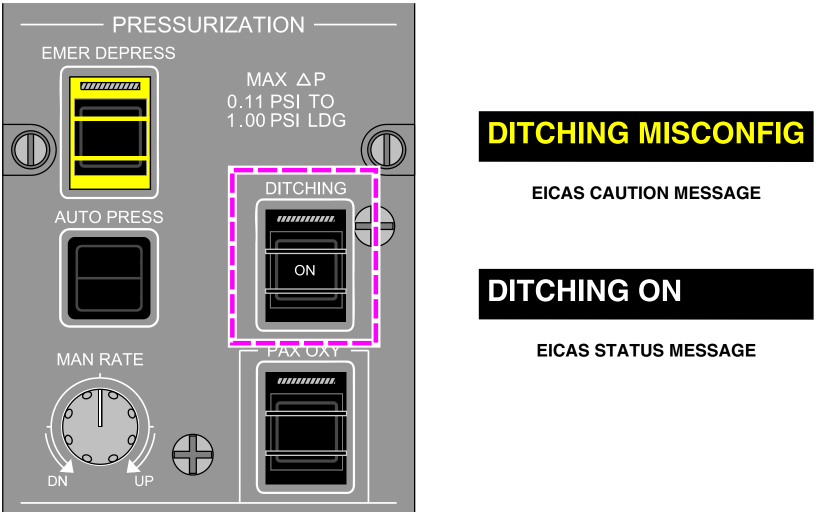
The ditching function is available in both automatic and manual pressurization modes. When the DITCHING guarded switch is pressed, all valves below the aircraft flotation line close, except for the ram air valve, which is directly controlled by the RAM AIR switch. The ON label on the DITCHING switch is illuminated and the status message **DITCHING ON** appears on the EICAS page (refer to Figure 02–04–8). The valves that are closed by the DITCHING guarded switch are:

- Avionics Exhaust Valve (AEV),
- Flow Control Valve (FCV),
- Trim Air Pressure Regulating Valve (TAPRV),
- Bulkhead check valve, and
- Outflow Valve (OFV), which is closed last.

If the ram air valve is open, the **DITCHING MISCONFIG** caution message displays on the EICAS.

NOTE

The ram air valve is not controlled by the DITCHING guarded switch. To close the ram air valve, the flight crew must manually select the RAM AIR switch, on the AIR panel, to OFF.



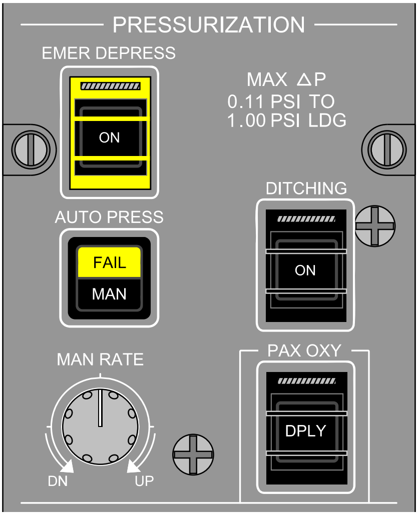
PRESSURIZATION panel – DITCHING guarded switch
Figure 02–04–8

PRESSURIZATION SYSTEM – CONTROLS AND INDICATIONS

A. PRESSURIZATION panel

The PRESSURIZATION panel (refer to Figure 02–04–9) has the switches that follow:

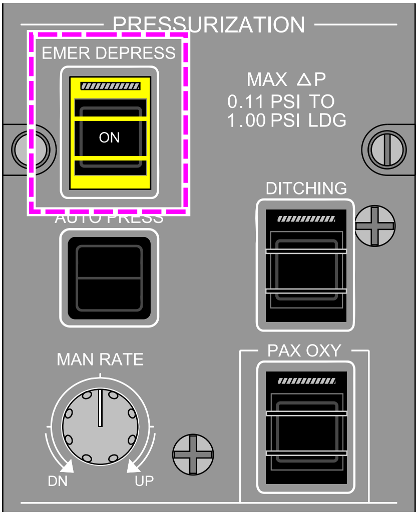
- EMER DEPRESS guarded switch,
- AUTO PRESS switch,
- DITCHING guarded switch,
- MAN RATE switch and
- PAX OXY guarded switch.



PRESSURIZATION panel
Figure 02–04–9

B. EMER DEPRESS guarded switch

When the EMER DEPRESS guarded switch is pressed (refer to Figure 02–04–10), the ON label on the switch illuminates white and the emergency depressurization mode is activated.



PRESSURIZATION panel – EMER DEPRESS guarded switch
Figure 02–04–10

ON: Opens the Outflow Valve (OFV).

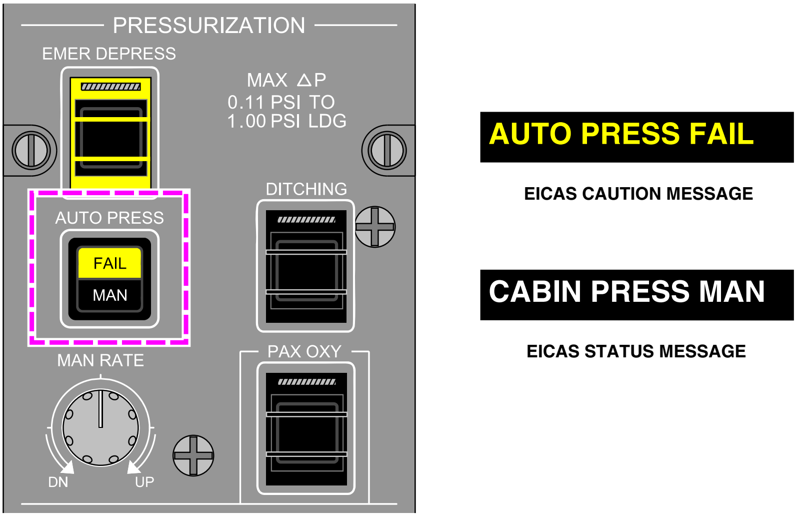
C. AUTO PRESS switch

The AUTO PRESS (refer to Figure 02–04–11). The switch labels indicate the modes that follow:

- No labels visible: The FAIL and MAN labels are not illuminated. The cabin pressurization system is controlled automatically by the IASC.
- FAIL: Illuminates amber when there is a failure of the automatic pressure control mode.
- MAN: The MAN label illuminates white when the AUTO PRESS switch is pressed in to indicate that the manual pressurization mode is active. The status message **CABIN PRESS MAN** displays on the EICAS page. The manual pressurization mode is controlled with the MAN RATE switch.

NOTE

To change the IASC automatic control channel, the flight crew has to cycle the AUTO PRESS switch from automatic to MAN and then back to automatic.

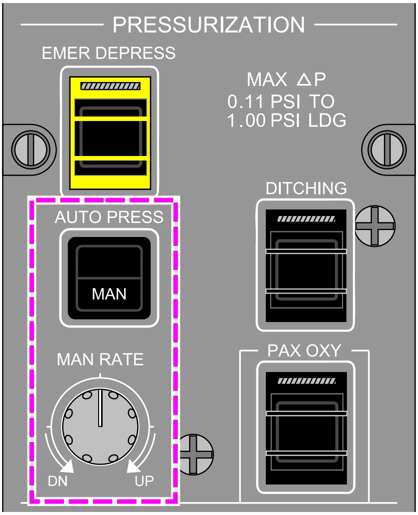


PRESSURIZATION panel – AUTO PRESS switch
Figure 02–04–11

D. MAN RATE switch

The MAN RATE switch (refer to Figure 02–04–12) is activated only when the AUTO PRESS switch is pressed in and the MAN label is illuminated. When in motion, the displayed value on EICAS corresponds to the selected cabin rate.

- UP: Full clockwise position corresponds to maximum up rate.
- DN: Full counter-clockwise position corresponds to maximum down rate.



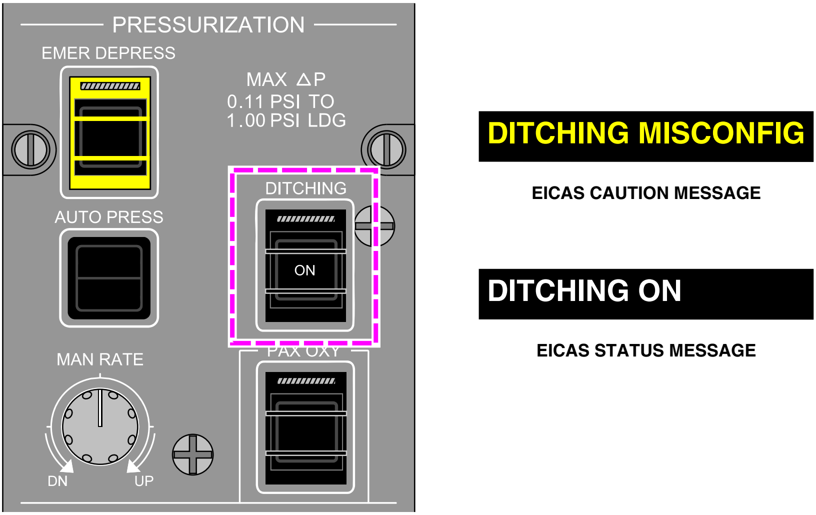
PRESSURIZATION panel – MAN RATE switch
Figure 02–04–12

E. DITCHING guarded switch

When the DITCHING guarded switch (refer to Figure 02–04–13) is pressed, the ditching sequence activates. When the sequence is completed, the **DITCHING ON** status message displays on the EICAS page.

NOTE

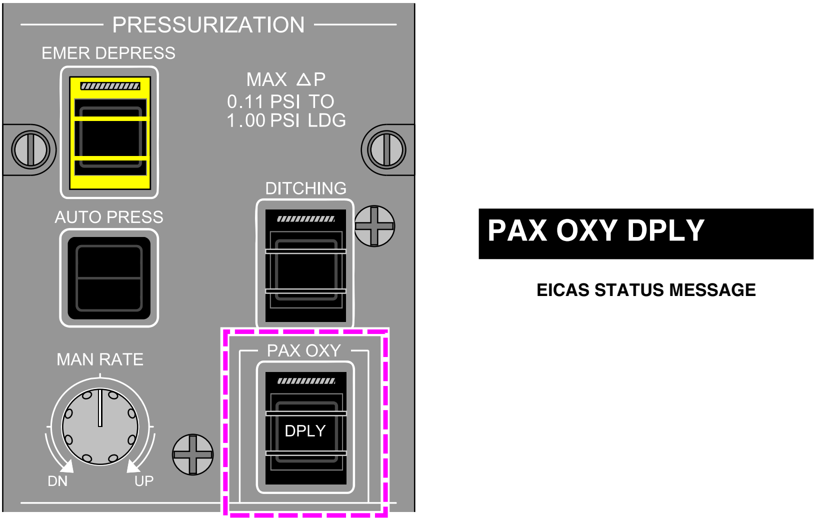
The ram air valve is not automatically controlled by the DITCHING guarded switch. To close the ram air valve, the flight crew must manually select the RAM AIR switch, on the AIR panel, to OFF.



PRESSURIZATION panel – DITCHING guarded switch
Figure 02–04–13

F. PAX OXY guarded switch

When the PAX OXY guarded switch is pressed (refer to Figure 02–04–14), the DPLY label on the switch illuminates white to indicate that the passenger oxygen masks are deployed. The DPLY label also illuminates white when the masks are automatically deployed. When deployed, a **PAX OXY DPLY** status message displays on the EICAS page.



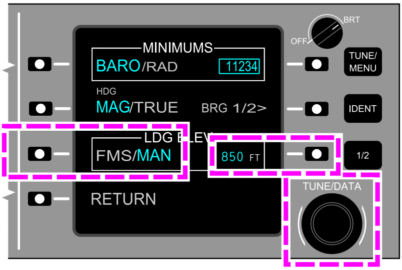
PRESSURIZATION panel – PAX OXY guarded switch
Figure 02–04–14

G. Landing elevation selection

The cabin pressurization system is designed to support landing elevations between 1000 feet below sea level (–1000 feet) and 14500 feet. In normal conditions, the cabin altitude for landing elevation is automatically set when the destination airport is entered in the FMS. Manual selection of the landing elevation can be set on the:

- Control Tuning Panel (CTP),
- CTP tab on the AVIONIC page, or
- Communication Navigation and Surveillance (CNS).

If the landing elevation is selected manually, a white MAN will be indicated on the AIR synoptic page and EICAS page, and a cyan MAN will be indicated on the CTP.



CTP 2

AVIONIC SYNOPTIC PAGE

Manual landing elevation selection
Figure 02–04–15

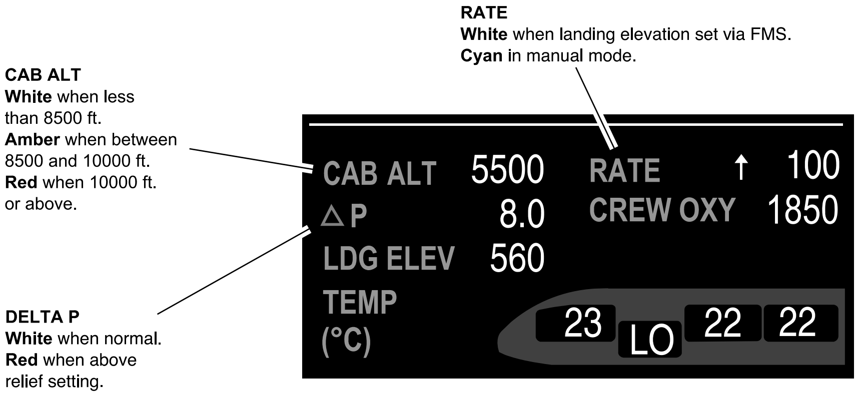
H. Pressurization indications

The pressurization system indications display on the air section of the EICAS page (refer to Figure 02–04–16) . When the EICAS is in compressed mode, the pressurization data displays on the bottom of the AIR synoptic page (refer to Figure 02–04–17).

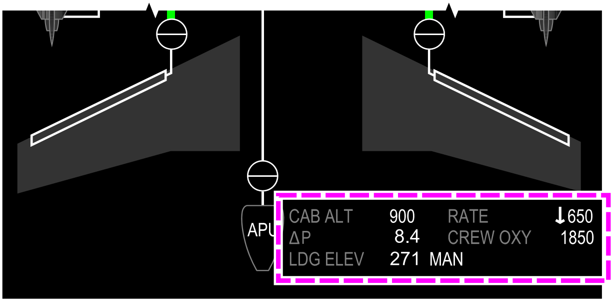
The displayed data is as follows:

- Cabin altitude (CAB ALT),

- Pressure differential (∆ P),
- Landing elevation (LDG ELEV),
- Cabin rate of change (RATE), and
- Crew oxygen quantity (CREW OXY).



Pressurization data description
Figure 02–04–16



AIR synoptic page – Pressurization indications
Figure 02–04–17

PRESSURIZATION SYSTEM – EICAS MESSAGES

A. Warning messages

Message	Description	Aural	Inhibit
CABIN ALT	Cabin altitude more than 10000 feet or up to 15000 feet High Altitude Airfield Operation (HAAO).	Cabin altitude	None
CABIN DIFF PRESS	Positive differential pressure is more than the pneumatic relief setting.	Cabin pressure	None

B. Caution messages

Message	Description	Inhibit
AUTO PRESS FAIL	Both cabin pressure control auto functions are failed.	TO, LDG

Message	Description	Inhibit
CABIN ALT	Cabin altitude between 8500 feet and 10000 feet, or up to 15000 feet (HAAO), or above 10000 feet for 30 minutes (HAAO).	TO, LDG
DITCHING MISCONFIG	DITCHING guarded switch selected to ON and RAM AIR switch selected OPEN.	TO, LDG
EMER DEPRESS ON	EMER DEPRESS guarded switch selected to ON confirmed by either one auto mode or one manual mode.	TO, LDG
LDG ELEV MISCONFIG	High airport elevation landing is selected and HAAO option is not present on aircraft.	TO, LDG

C. Advisory messages

Message	Description	Inhibit
CABIN ALT LEVEL HI	Cabin altitude caution and warning thresholds higher due to high altitude landing field elevation mode.	TO, LDG
PRESSURIZATION FAULT	Loss of redundant or non-critical function for the pressurization system.	TO, LDG

D. Status messages

Message	Description	Inhibit
CABIN PRESS MAN	Manual pressurization mode selected.	None
DITCHING ON	DITCHING switch selected to ON and sequence completed.	None

CHAPTER 3 – AUTOMATIC FLIGHT

GENERAL

FLIGHT GUIDANCE (FG)

AUTOTHROTTLE (AT) SYSTEM

AFCS – CONTROLS AND INDICATIONS

List of figures

FLIGHT GUIDANCE (FG)

AUTOPILOT (AP) SYSTEM

AUTOLAND (AL) SYSTEM

AUTOTHROTTLE (AT) SYSTEM

AFCS – CONTROLS AND INDICATIONS

AUTOMATIC FLIGHT CONTROL SYSTEM (AFCS) – OVERVIEW

The Automatic Flight Control System (AFCS) features the integrated functions of the:

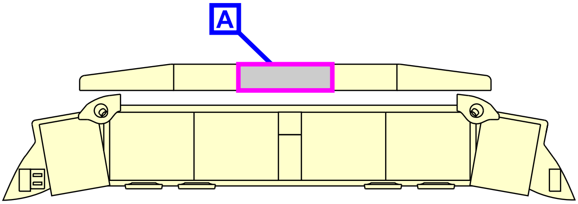
- Flight Director (FD),
- Autopilot (AP),
- Autoland (AL), and
- Autothrottle (AT).

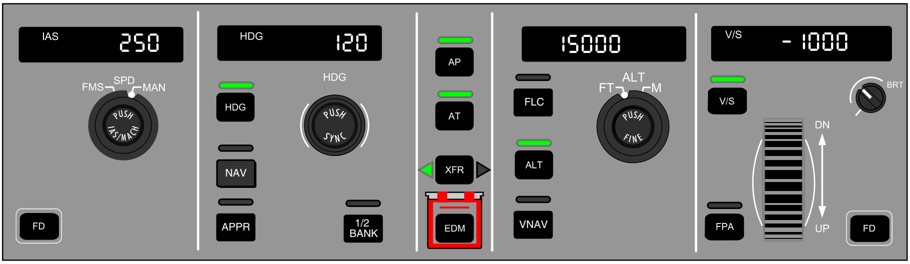
The AFCS computes guidance commands to follow a predetermined flight trajectory at a given speed.

The AFCS also provides flight guidance commands for automatic landing (autoland).

Each AFCS (AFCS 1 and AFCS 2) includes (refer to Figure 03–01–1):

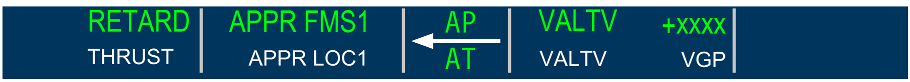
- Two Flight Guidance (FG) systems,
- One Autothrottle (AT) system, and
- One AFCS monitoring function.





FLIGHT CONTROL PANEL (FCP)

A



PFD - FLIGHT MODE ANNUNCIATOR (FMA)

LEFT DMC

CHANNEL A	**CHANNEL B**
• FLIGHT GUIDANCE (FG) FUNCTION 1 (LEFT) • AFCS MONITORING FUNCTION 1	• FLIGHT GUIDANCE (FG) FUNCTION 1 (RIGHT) • AUTOTHROTTLE (AT) FUNCTION 1

AUTOFLIGHT CONTROL SYSTEM 1

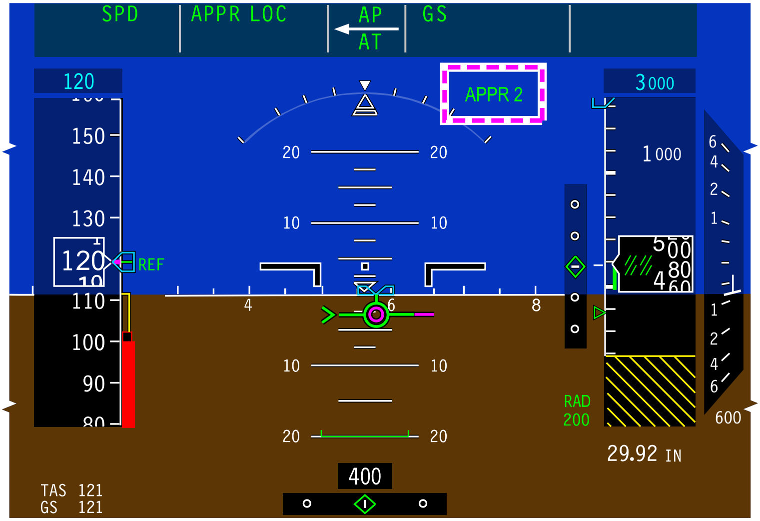
RIGHT DMC

CHANNEL A	**CHANNEL B**
• FLIGHT GUIDANCE (FG) FUNCTION 2 (LEFT) • AFCS MONITORING FUNCTION 2	• FLIGHT GUIDANCE (FG) FUNCTION 2 (RIGHT) • AUTOTHROTTLE (AT) FUNCTION 2

AUTOFLIGHT CONTROL SYSTEM 2

Autoflight Control System (AFCS) overview
Figure 03–01–1

The FD provides pitch and roll commands to the AP system to control the primary flight control surfaces, and displays information on the Primary Flight Display (PFD) for the Flight Path Vector (FPV). Refer to Figure 03–01–2.



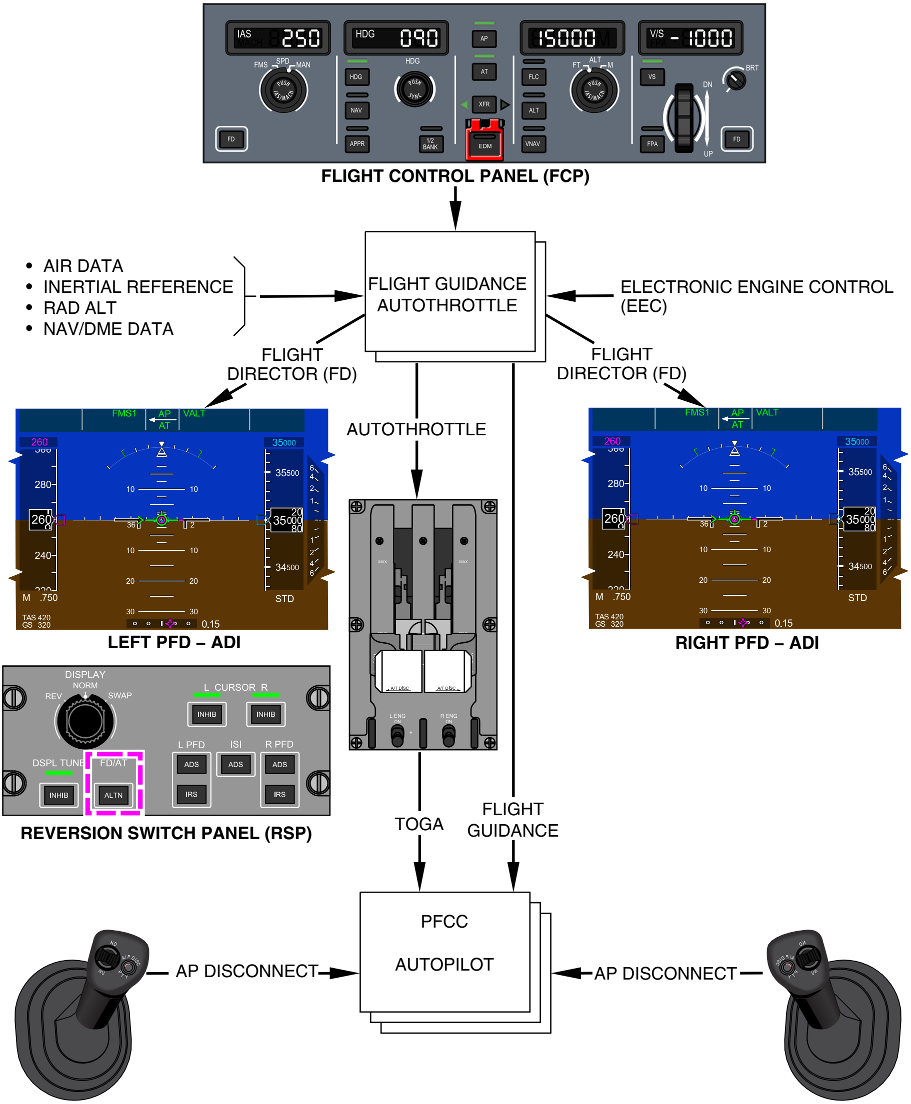
ADI

ADI – Approach Status Annunciator
Figure 03–01–2

The AP system processes the FD commands within the flight envelope, and controls the engage and disengage logic. The AT system controls the thrust and aircraft speed by changing the position of the thrust levers.

The AFCS controls (refer to Figure 03–01–3) are located on the:

- Flight Control Panel (FCP),
- Reversion Switch Panel (RSP),
- Flight Management System (FMS),
- Thrust levers, and
- Sidesticks.



AFCS – Controls
Figure 03–01–3

FD mode indications are displayed on the Flight Mode Annunciator (FMA) on the PFD. System status and faults are reported on the EICAS page.

The FD and the AT systems are paired together. Only one FD/AT combination is active at a time.

The FD and AP/AT controls are on the Flight Control Panel (FCP) in the center section of the glareshield, and on the Reversion Switch Panel (RSP) on the center pedestal.

Takeoff/Go-Around (TOGA) and AT switches are located on the thrust levers. The AP disconnect switches are located on each sidestick.

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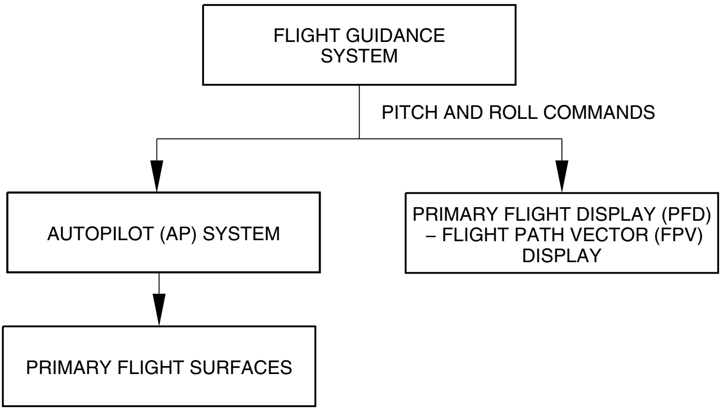
FLIGHT DIRECTOR (FD) – OVERVIEW

The Flight Director (FD) gives Flight Guidance (FG) (refer to Figure 03–02–1) and provides pitch and roll commands to the Autopilot (AP) system, to the Primary Flight Control Computer (PFCC), and to the Primary Flight Display (PFD).



Flight Guidance (FG) system overview
Figure 03–02–1

The FD system is installed in each channel of the Data Concentrator Unit Module Cabinets (DMCs) installed in the mid equipment bay compartment. Refer to Figure 03–02–2.

LEFT DCU MODULE CABINET	
CHANNEL A	CHANNEL B
FLIGHT GUIDANCE FUNCTION (LEFT)	FLIGHT GUIDANCE FUNCTION (RIGHT)

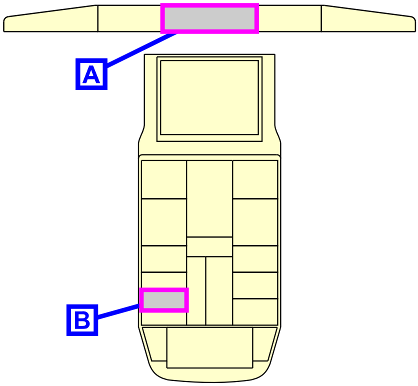
AUTOFLIGHT CONTROL SYSTEM 1 (AFCS 1)

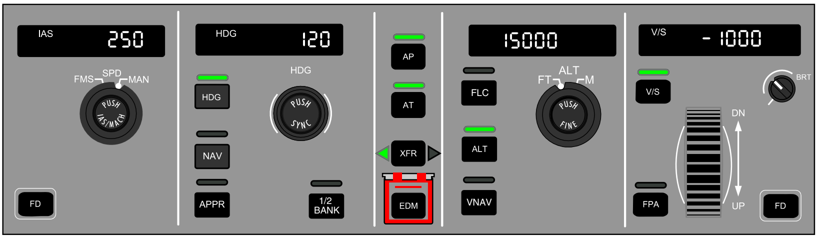
RIGHT DCU MODULE CABINET	
CHANNEL A	CHANNEL B
FLIGHT GUIDANCE FUNCTION (LEFT)	FLIGHT GUIDANCE FUNCTION (RIGHT)

AUTOFLIGHT CONTROL SYSTEM 2 (AFCS 2)

Flight Guidance (FG) system location
Figure 03–02–2

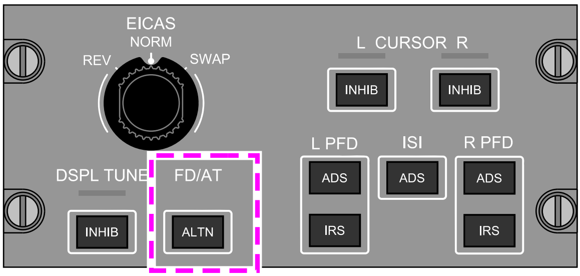
The controls are on the Flight Control Panel (FCP) and on the Reversion Switch Panel (RSP). The indications are shown on the PFD (FMA and ADI). System status and faults are displayed on the EICAS page. Refer to Figure 03–02–3.





FLIGHT CONTROL PANEL (FCP)

A



REVERSION SWITCH PANEL (RSP) – FD/AT ALTN (ALTERNATE) SWITCH

B

Flight Guidance (FG) system controls
Figure 03–02–3

FD FUNCTION – DESCRIPTION AND OPERATION

The FD system computes pitch and roll commands according to the guidance mode selected by the flight crew on the Flight Control Panel (FCP) or by the Flight Management System (FMS). The guidance modes are:

- Lateral modes,
- Vertical modes, and
- Multi-axis modes.

The FCP is divided into the five sections that follow:

- Speed control,
- Lateral modes,
- Autopilot/Autothrottle (AP/AT),
- Vertical modes (FLC, ALT and VNAV), and
- Vertical modes (VS and FPA).

The FD uses data from several systems and sensors. This data includes attitude, heading, air data, radio altimeter, navigation, and manual inputs.

Several lateral and vertical FD modes can be selected to control the aircraft trajectory. Only one lateral mode and one vertical mode are active at a time. However, one lateral mode and up to three vertical modes can be armed to transition to an active status.

The FD switches at each end of the FCP (refer to Figure 03–02–4) control the display of the FD cue on their respective PFD and use the logic that follows:

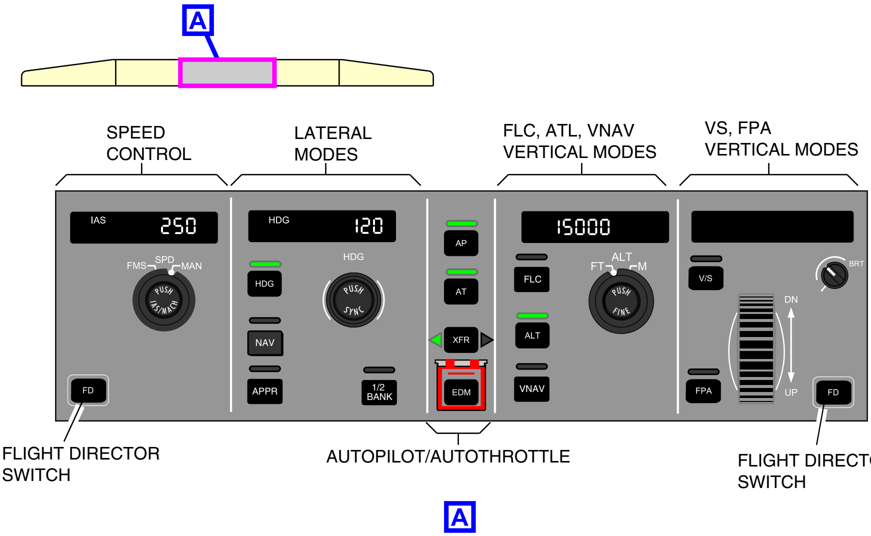
- On the coupled PFD:
  - If the AP is engaged, selection of the FD switch has no effect.
  - If there is an active approach status displayed on the ASA and the AP is disengaged (if initially engaged), either FD switch can be selected to control the FD cue.

NOTE

When above 200 feet AGL, selection of the TO/GA switches can also re–enable the FCP.

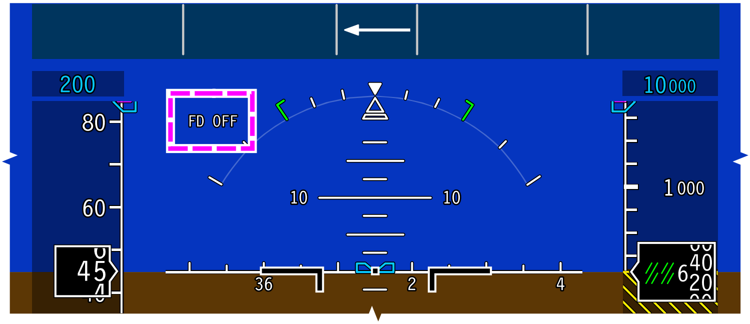
– During all other phases of flight, if the AP is disengaged (if initially engaged), only the coupled-side FD switch can be used to control the FD cue.

- On the uncoupled PFD, regardless of AP engagement, selection of the FD switch removes or displays the FD cue.



Flight Control Panel (FCP)
Figure 03–02–4

When a FD cue is removed from the PFD, a white FD OFF message is displayed on the PFD. Refer to Figure 03–02–5.



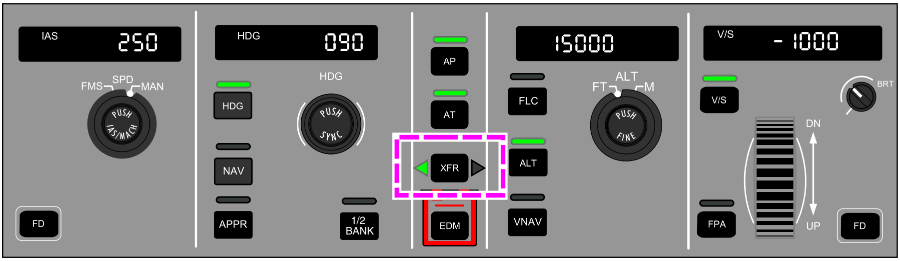
ADI

ADI – FD OFF Message
Figure 03–02–5

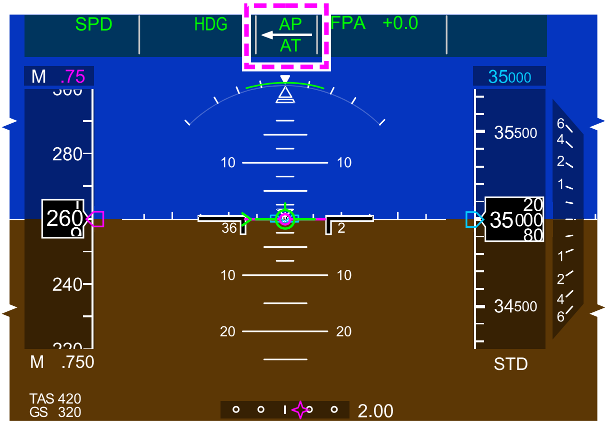
A. Data source selection

The FD uses two data sources. The data source can be selected by pressing the XFR switch on the FCP.

Only one FD system (one channel) inside the DMC is active at a time, while the other is on standby. In normal operation, automatic selection of the active DMC is based on odd and even days. The XFR (transfer) switch on the FCP determines which FG system (channel A or channel B) will be used inside the DMC (refer to Figure 03–02–6). It also determines which data source will feed the FD system and the AT system. The selected data source is indicated by a white arrow on the FMA and by a green arrow beside the XFR switch.



FCP – XER (TRANSFER) SWITCH



ADI

EICAS CAUTION MESSAGE

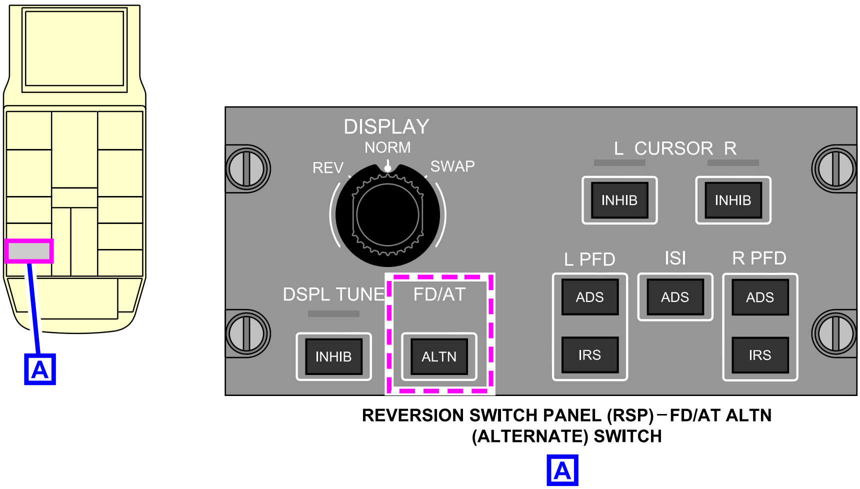
Flight Director (FD) – Data source indication
Figure 03–02–6

Pressing the XFR switch resets all the FD modes to basic. A **FD MODE CHANGE** caution message is displayed on the EICAS page. The FD modes must be reselected.

B. Reversion Switch Panel (RSP) – FD/AT ALTN switch

Two FD/AT computers are available for flight guidance but only one is active at a time. They alternate automatically every day, or in case of failure of the active dual channel.

The FD/AT can be manually changed by pressing the ALTN switch on the Reversion Switch Panel (RSP), which is located on the center pedestal. Refer to Figure 03–02–7.



Reversion Switch Panel (RSP) – FD/AT ALTN (alternate) switch
Figure 03–02–7

If a failure of the active DMC is detected in flight, the system automatically selects the alternate source. The flight crew can also select the alternate source manually with the FD/AT ALTN switch on the RSP.

C. Flight director cue

The flight director cue displays as a magenta circle with lateral bars, that is smaller than the Flight Path Vector (FPV) symbol (refer to Figure 03–02–8). The flight director cue moves on the Attitude Direction Indicator (ADI) to provide steering commands.

ADI – Flight director cue and Flight Path Vector (FPV)
Figure 03–02–8

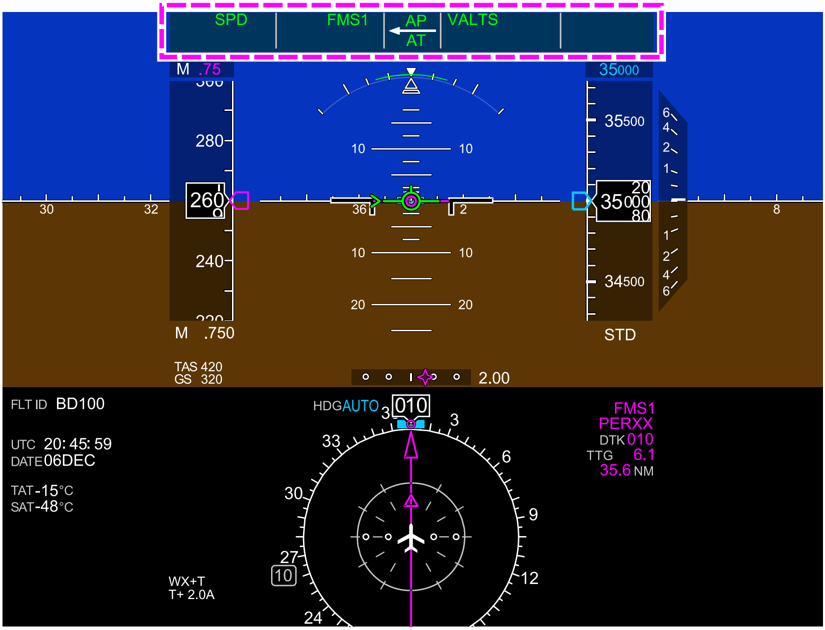
To follow the FD commands, the aircraft must be maneuvered, either manually or by the Autopilot (AP), so that the FPV is over the flight director cue.

D. Flight Mode Annunciator (FMA)

The Flight Mode Annunciator (FMA) displays the active and armed FD modes, Autopilot (AP), and Autothrottle (AT) status. The FMA is divided into five sections separated by a vertical white line (refer to Figure 03–02–9). The sections are as follows (from left to right):

- Autothrottle (AT) mode: Indicates autothrottle operating mode and status.
- Lateral mode: Indicates the FD lateral operating mode and status.
- Autopilot, autothrottle, and data source: Indicates status and used data source.
- Vertical mode: Indicates the FD vertical operating mode and status.

- Alternate source selection: Used to indicate alternate data source in use.



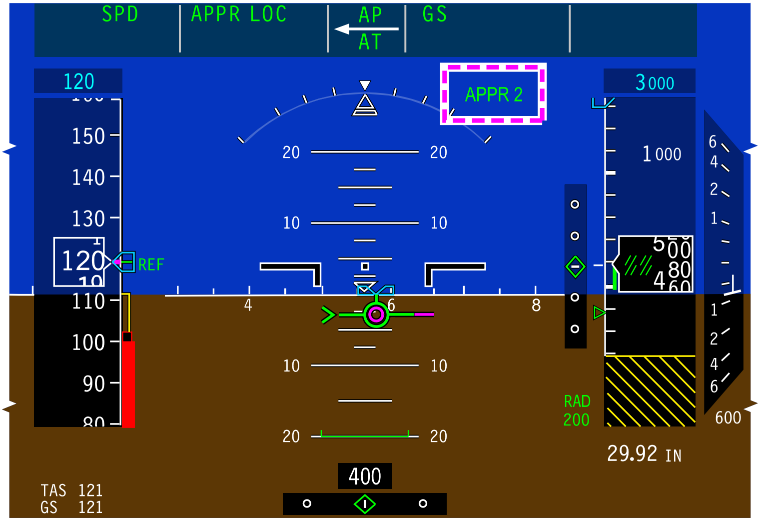
PFD – Flight Mode Annunciator
Figure 03–02–9

E. Approach Status Annunciator (ASA)

The ASA displays below the FMA on the right side of the PFD (refer to Figure 03–02–10). The ASA displays the active approach status in reference to:

- Autoland capability (LAND3 or LAND2),

- ILS approach capability (APPR2 or APPR1), or
- Steep approach (STEEP).



ADI

ADI – Approach Status Annunciator
Figure 03–02–10

FD – LATERAL GUIDANCE MODES

Lateral guidance includes modes related to heading, bank angle selection, or navigation tracking. Activation of the FD lateral modes results from the flight crew selections on the FCP. Each lateral mode is annunciated on the FMA. The table that follows shows each lateral mode with the associated control and FMA annunciation.

Mode	Associated FCP switch	FMA annunciation
Heading	HDG	HDG
• Navigation (FMS source)	NAV	• FMS1 (FMS2)

Mode	Associated FCP switch	FMA annunciation
• Navigation (LOC source) • Navigation (VOR source)		• LOC1 (LOC2) • VOR1 (VOR2)
• Approach (VOR source) • Approach (FMS source) • Back Course approach (B/C source)	APPR	• APPR VOR1 (VOR2) • APPR FMS1 (FMS2) • APPR B/C1 (B/C2)
1/2 BANK	1/2 BANK	Green arc on the ADI roll scale

(1) FD – Heading (HDG) mode

The HDG mode (refer to Figure 03–02–11) is the basic lateral mode and is enabled when:

- AP is engaged with no mode previously selected,
- No mode previously selected,
- Mode lost or deselected, or
- Vertical mode is selected without lateral mode selected.

If the Primary Flight Control Computer (PFCC) cannot maintain the heading, or when below 200 feet RA, the roll mode replaces the heading mode (HDG). The bank angle is then maintained and a green ROLL message displays on the FMA.

ADI – Heading Mode
Figure 03–02–11

To select the heading mode, the HDG switch on the FCP must be pressed (refer to Figure 03–02–12). Once selected, a mode selection light illuminates above the HDG switch. When the mode is active, a green HDG message displays in the left section of the FMA.

To change the heading, rotate the HDG switch on the FCP. The selected heading displays in the heading window, above the HDG switch on the FCP, and the cyan heading bug is positioned to the selected heading HSI.

Turns are started in the same direction as the HDG switch rotation.

PFD – Heading Mode
Figure 03–02–12

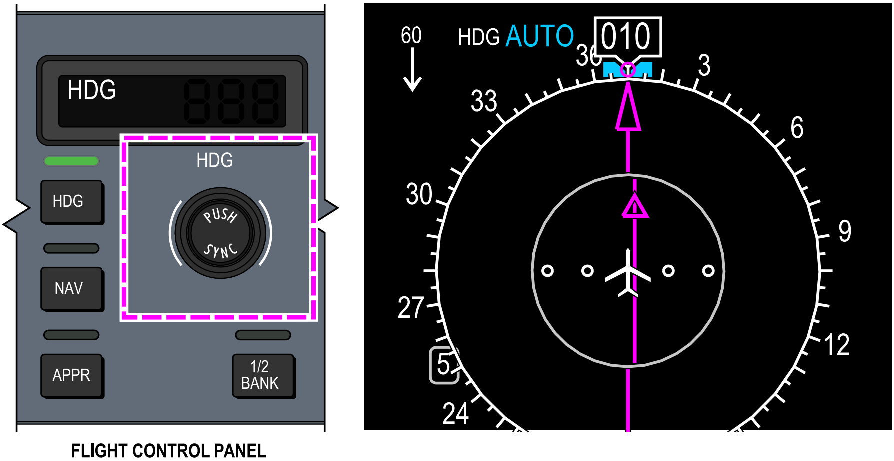
A. FD – Heading synchronization

When the HDG switch is pressed (PUSH SYNC), the heading bug is automatically maintained, synchronized with the actual heading. A cyan AUTO message replaces the selected heading and the heading window on the FCP is blank. Refer to Figure 03–02–13.

Rotating the HDG switch during AUTO cancels auto-synchronization.

Heading synchronization is automatic when either:

- In TO lateral mode and the aircraft is on the ground,
- The GA mode is active, or
- In basic mode.



FCP – Heading Synchronization
Figure 03–02–13

B. FD – Navigation (NAV) mode

The NAV mode tracks a predetermined course from either the:

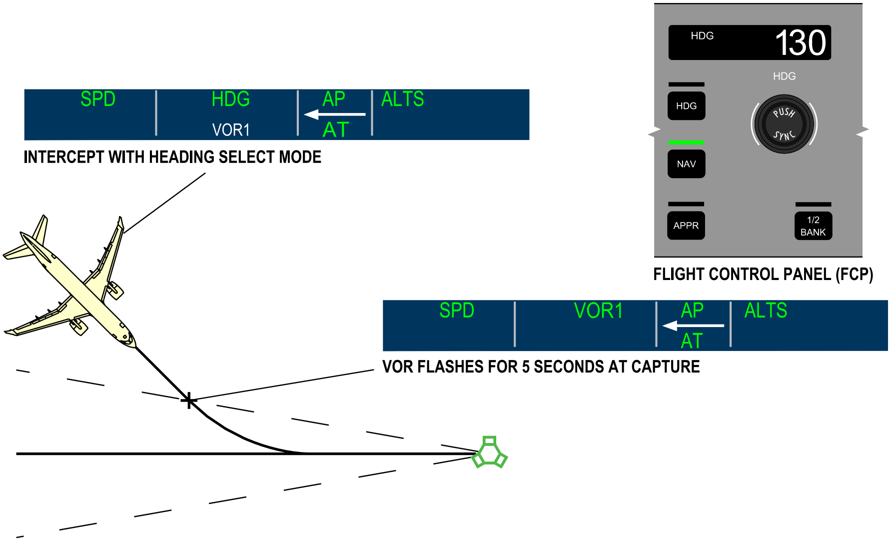
- VOR or localizer (LOC), or
- Flight Management System (FMS).

(1) FD – NAV mode – VOR

When VOR1 or VOR2 is selected as the navigation source, the FD provides lateral commands to track the selected VOR course.

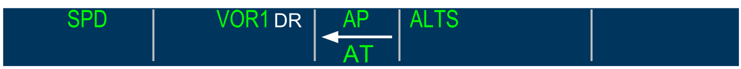
Upon initial NAV mode selection and prior to course capture, the heading (HDG) mode is activated. The heading is manually set by the HDG switch to intercept the desired course. During the intercept, HDG displays in green (as the active mode) and VOR1 or VOR2 displays below it in white (armed mode). Refer to Figure 03–02–14.

When capturing the desired track, HDG is removed and a green VOR1 or VOR2 indication flashes for 5 seconds, then becomes steady.



FMA – NAV Mode VOR
Figure 03–02–14

When the aircraft is over the VOR station, DR displays in white on the FMA to the right of the displayed VOR1 (VOR2). Refer to Figure 03–02–15.

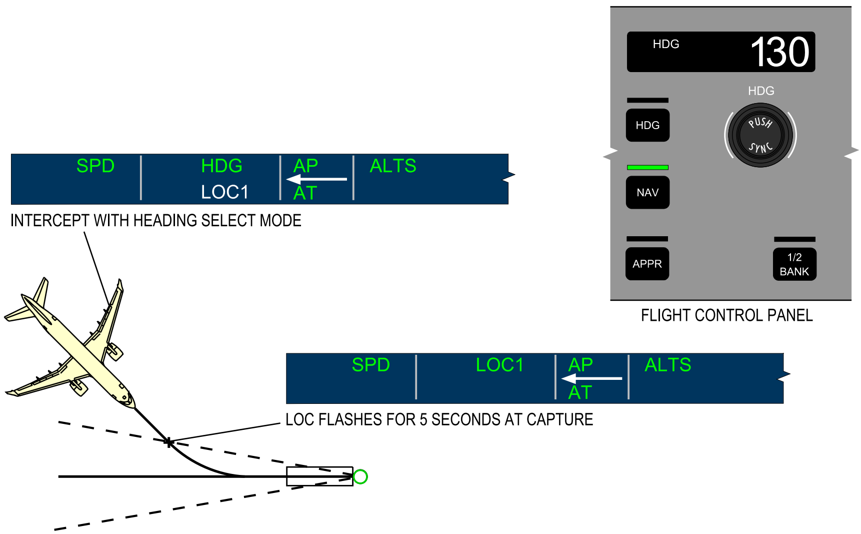


FMA – NAV Mode – VOR 1 DR
Figure 03–02–15

(2) FD – NAV mode – Localizer (LOC)

The LOC mode is enabled by selecting the NAV or APPR switch on the FCP when the LOC1 or LOC2 is the navigation source on the coupled FD. The mode automatically captures and tracks a front course localizer independently of the glide path.

After NAV mode selection and prior to course capture, the heading (HDG) mode is activated. The heading is manually set by the HDG switch to intercept the desired course. During interception, HDG displays in green (as active mode) and LOC1 or LOC2 displays below it in white (armed mode) (refer to Figure 03–02–16).



FMA – NAV Mode – LOC
Figure 03–02–16

The localizer capture point is determined by:

- Ground speed,
- Localizer deviation,
- Intercept angle, and

- Distance from the station.

When capturing the localizer, HDG is removed and LOC1 or LOC2 flashes green for 5 seconds then displays steady as the active lateral mode.

(3) FD – NAV mode – FMS

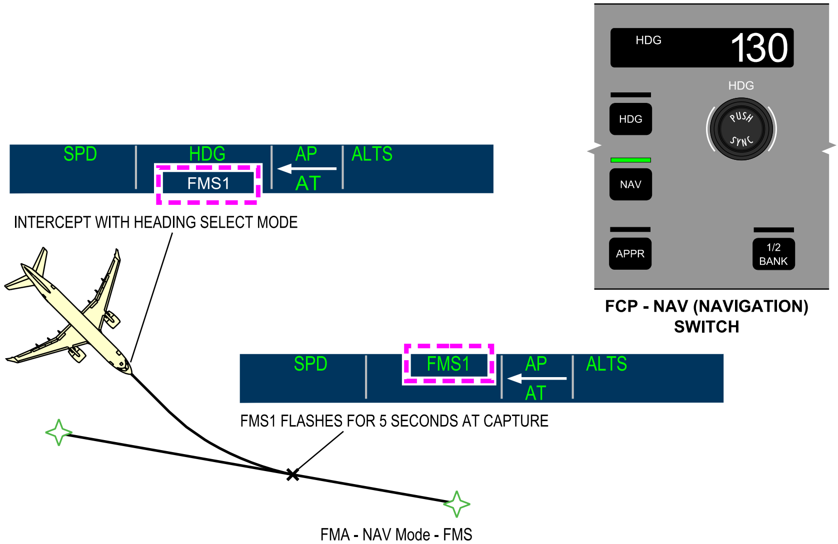
The FMS navigation mode is enabled by pressing the NAV switch on the FCP when FMS is the navigation source on the coupled FD.

NOTE

Changing from one FMS source to another does not cause the mode to cancel.

If not already on the desired track when selected, the heading select mode displays as the active mode, while the navigation mode is armed (FMS1 or FMS2 displays in white) (refer to Figure 03–02–17). The FD commands a capture heading to the desired track. Capture also occurs if the aircraft is moving away from, but within 2.5 nm of the desired track. If the distance is greater than 2.5 nm from the track, an intercept heading must be manually set.

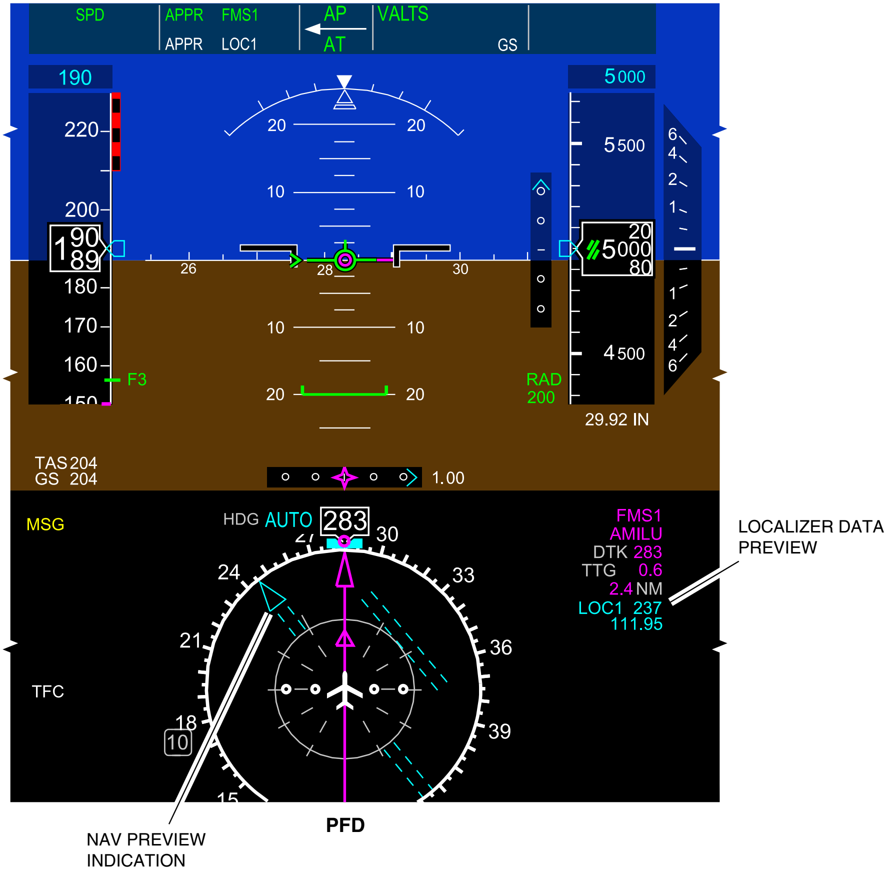
Once captured, the navigation modes activates. FMS1 or FMS2 flashes green for 5 seconds during the transition, then becomes steady.



FMA – NAV Mode – FMS
Figure 03–02–17

(4) FD – NAV Preview

A navigation preview feature is available when the FMS is the navigation source. This function permits the preview of the localizer indications on the horizontal situation indicator (HSI) before the localizer becomes the navigation source (refer to Figure 03–02–18).



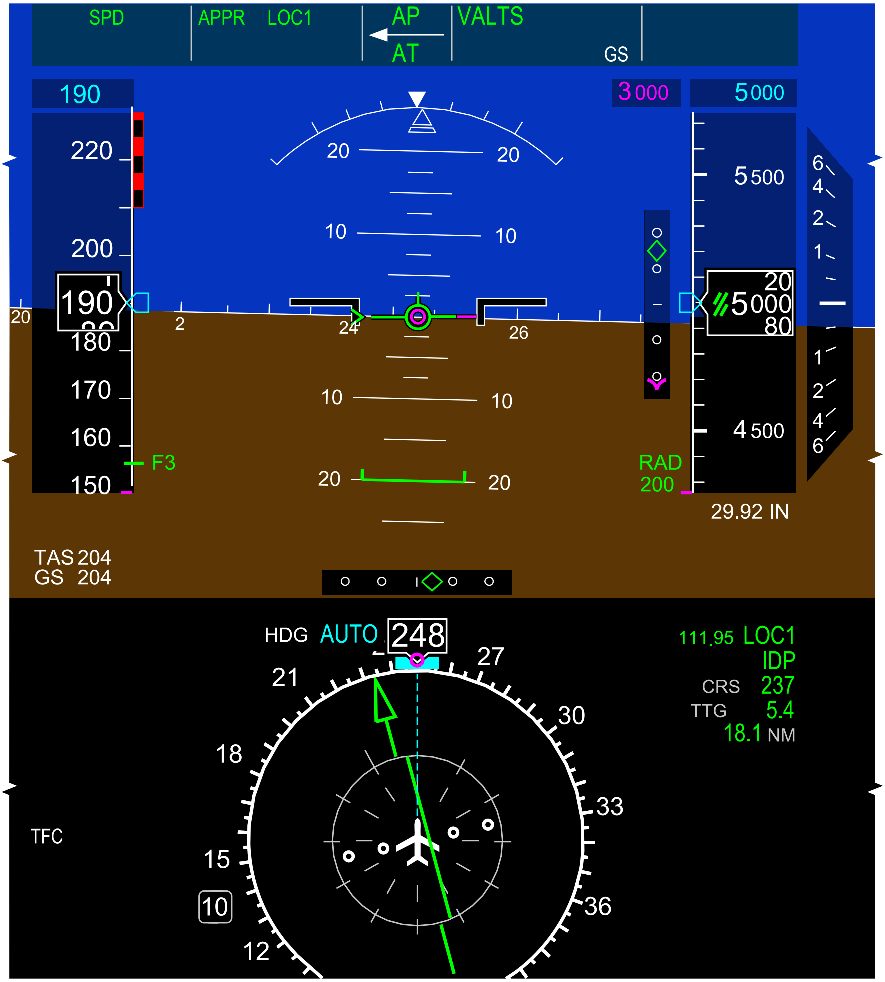
PFD – NAV Preview
Figure 03–02–18

The preview function is available for localizer and ILS approaches. When the aircraft is within a specific distance of the station and the FMS has auto-tuned the localizer frequency, the localizer approach course, frequency, and course pointer display in cyan on the HSI.

When the approach course is intercepted, the navigation source automatically transfers from FMS to VHF-NAV (LOC, VOR), and the FD automatically tracks the LOC or VOR when:

- In FMS lateral mode,
- APPR mode selected (APPR switch pressed on the FCP), or
- Approach course captured.

The lateral mode on the FMA automatically changes from APPR FMS1 (FMS2) to APPR LOC1 (LOC2), or APPR VOR1 (VOR2). The HSI pointer changes from magenta (FMS) to green (LOC). Refer to Figure 03–02–19.



PFD

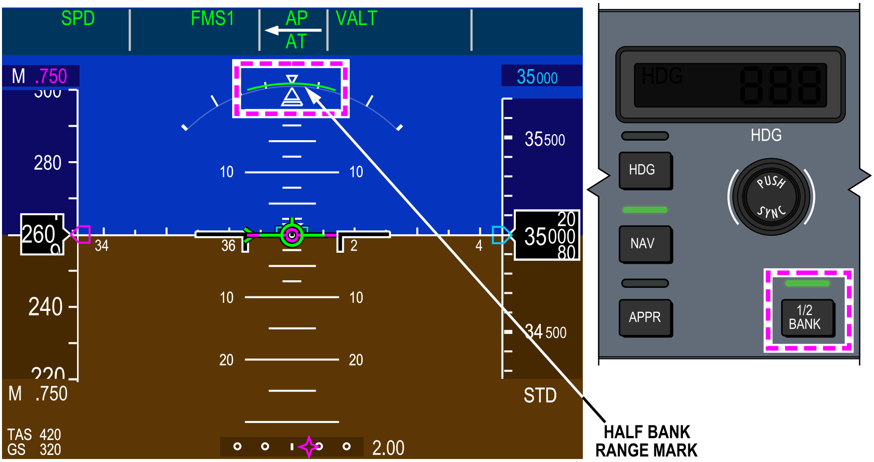
PFD – NAV–to–NAV Transfer
Figure 03–02–19

C. FD – Half bank mode

The half bank mode limits the maximum bank angle used by the FD to 17 degrees (from 30 degrees). It is automatically activated in NAV and HDG lateral modes when the aircraft climbs through 31500 feet.

When the half bank mode is active, a green arc is displayed at the top edge of the attitude indicator on the Primary Flight Display (PFD) and the green mode selection light above the 1/2 BANK switch comes on. Refer to Figure 03–02–20.

The half bank mode is manually activated below 31500 feet when the 1/2 BANK switch on the FCP is pushed. It is available in HDG mode only.



1/2 Bank mode selection and indication
Figure 03–02–20

FD – VERTICAL GUIDANCE MODES

Vertical guidance includes modes related to:

- Flight Path Angle (FPA),
- Vertical Speed (VS),
- Altitude Preselected (ALTS),
- Altitude Hold (ALT),
- Flight Level Change (FLC),
- Takeoff (TO),
- Go-Around (GA), and
- Approach (APPR).

Vertical guidance modes can be manually selected using the VS or FPA switches on the FCP, or managed by the vertical navigation (VNAV) function of the FMS when the VNAV switch on the FCP is pressed.

To differentiate between a selected and a VNAV vertical mode, the letter V is added to the navigation mode message on the FMA. For example, the altitude hold mode displays as ALT when manually selected, and displays as VALT when managed by the VNAV.

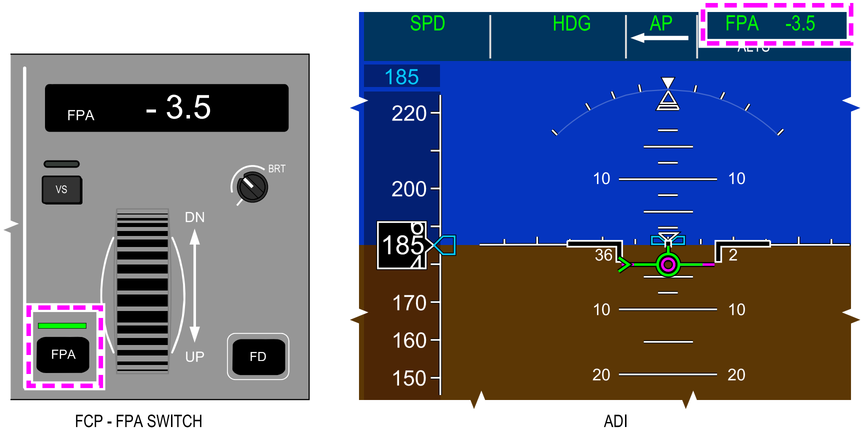
A. FD – Flight Path Angle (FPA) mode

The FPA mode is the basic vertical mode. It is enabled when:

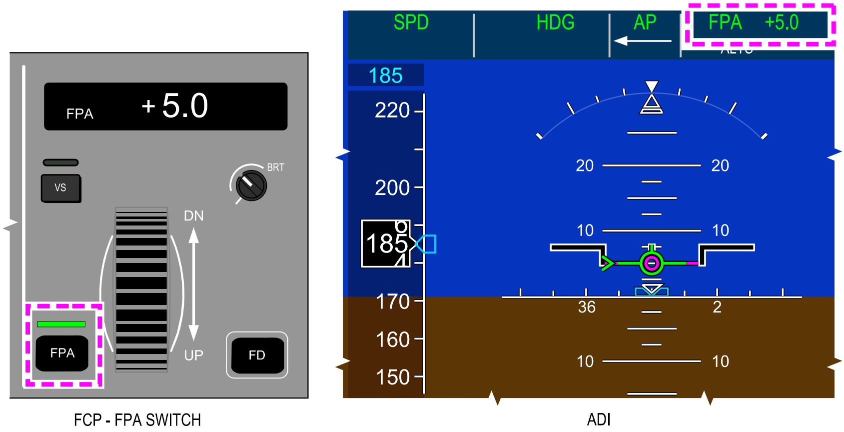
- Autopilot (AP) is engaged with no mode previously selected,
- A selected mode is lost or de-selected, or
- A lateral mode is selected with no vertical mode enabled.

In the FPA mode, the aircraft pitch changes to maintain the selected flight path angle. The selected FPA value displays to the right of the FPA message on the FMA, and is changed by rotating the VS/FPA wheel (0.1 degree for each detent) toward DN to decrease the FPA , and toward UP to increase the FPA. The path angle selection is limited to ±9.9 degrees and the pitch angle commands are limited to ±15 degrees.

When the FPA mode is active, a green FPA message displays on the FMA. Refer to Figure 03–02–21 and Figure 03–02–22.



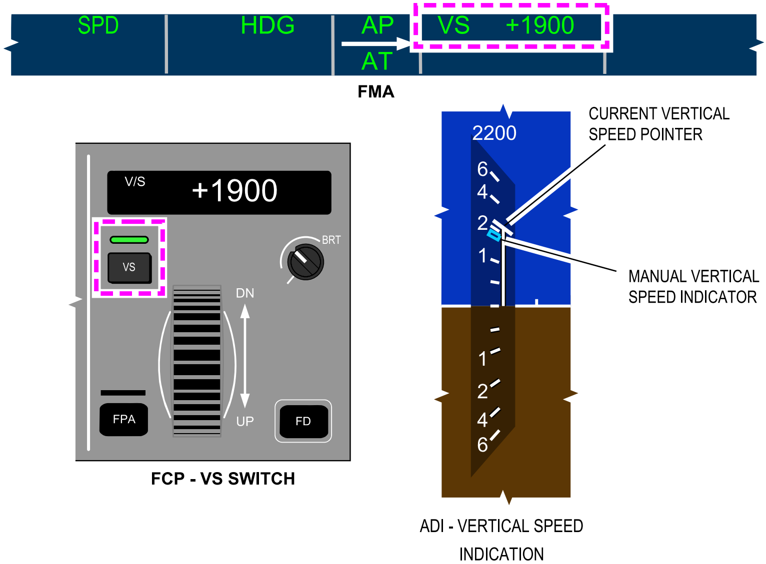
Flight Path Angle (FPA) – Negative angle
Figure 03–02–21



Flight Path Angle (FPA) – Positive angle
Figure 03–02–22

B. FD – Vertical Speed (VS) mode

The VS mode maintains a selected vertical speed (climbing or descending) by changing aircraft pitch. The mode is enabled by selecting the VS switch on the FCP. When the mode is active, VS displays in green in the right section of the FMA. Refer to Figure 03–02–23.



Vertical Speed Mode – VS
Figure 03–02–23

The desired vertical speed is set by rotating the VS/FPA wheel. The selected vertical speed displays:

- To the right of VS on the FMA,
- In the V/S window above the VS/FPA wheel, and
- As a cyan bug on the Vertical Speed Indicator (VSI).

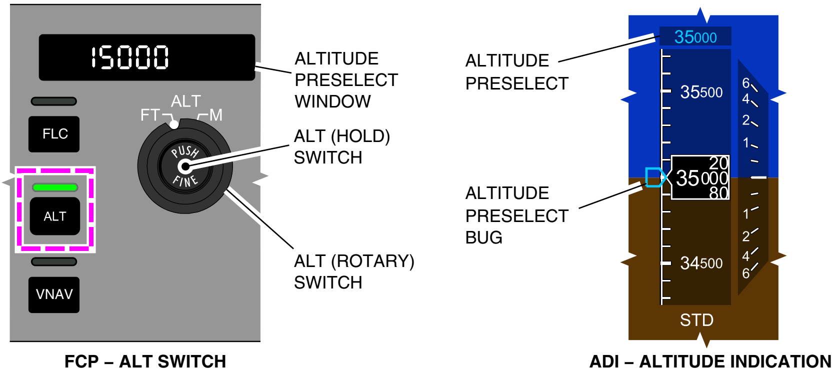
The selected vertical speed range is ± 9900 fpm.

C. FD – Altitude Preselect (ALTS) mode

The ALTS mode is used to capture and maintain (level off) a preselected barometric altitude. The altitude reference is from the coupled side barometric altimeter.

The preselected altitude is set with the ALT (rotary) switch on the FCP (refer to Figure 03–02–24). Rotating the ALT switch adjusts the altitude preselect in increments of 1000 feet. Rotating the ALT switch while pressing on the center (PUSH FINE) adjusts the increments to 100 feet.

The preselect altitude displays on the FCP altitude window, in cyan above the altitude tape on the ADI, and as a cyan bug on the altitude tape.



Altitude Preselect
Figure 03–02–24

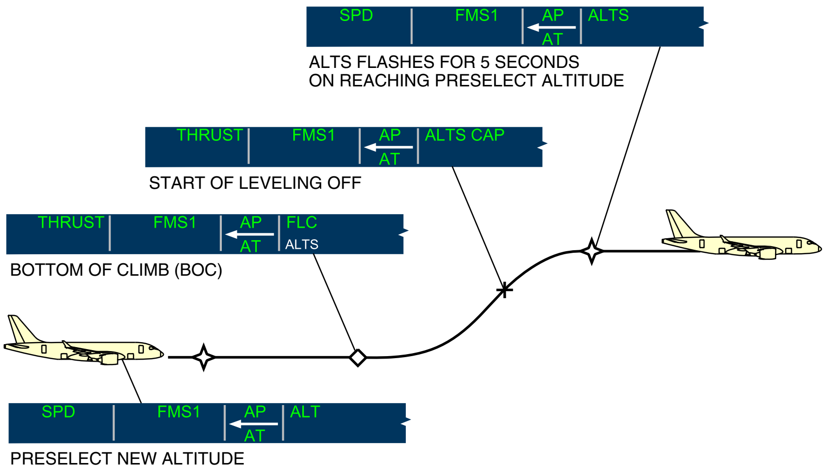
The ALTS mode is automatically armed at the time of altitude selection in any vertical mode, except Altitude Hold (ALT) and vertical approach modes. When the altitude preselect mode is armed, a white ALTS displays in the right section of the FMA (refer to Figure 03–02–25). The capture point is calculated, based on the vertical speed of the aircraft, to provide a smooth transition to level off at the selected altitude.

NOTE

During the (V) ALTS CAP mode, the flight guidance/autopilot may not maintain the selected airspeed. Crew intervention may be required to maintain the selected airspeed.

NOTE

When a Preselected Altitude (PSA) change on the Flight Control Panel (FCP) is made within 50 milliseconds of the ATLS CAP being activated, the vertical FMA will indicate ALTS CAP and begin tracking the newly set PSA. To maintain the selected speed, there may be a pitch change that will require pilot input. The corresponding guidance pitch up or pitch down (limited between +20/−15 degrees) will be proportional to the altitude difference between the newly selected PSA value and the current aircraft baro-corrected altitude.



Altitude Preselect Mode
Figure 03–02–25

During the level off, a green ALTS CAP annunciation displays in the right section of the FMA and the white ALTS is removed. When the level off is complete, the selected altitude is maintained and a green ALTS annunciation displays in the right section of the FMA.

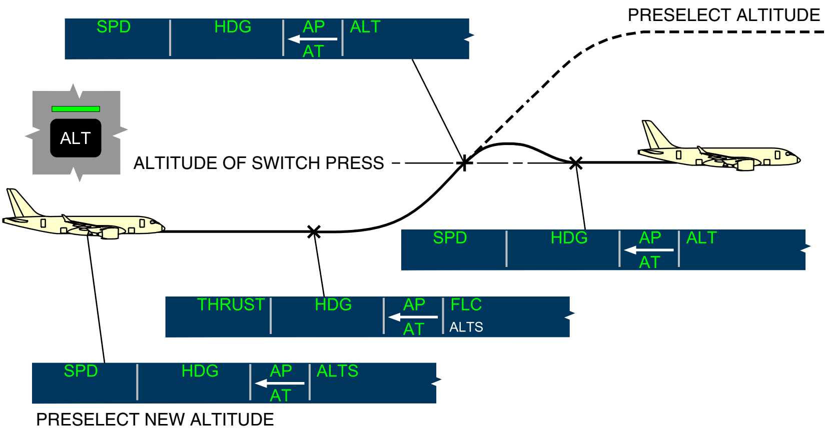
NOTE

If the preselected altitude is changed during altitude capture, ALTS CAP is replaced by ALT CAP. At level off, ALT CAP is replaced by ALT. The AFCS continues to capture and track the original preselected altitude displayed while ALTS CAP is active.

D. FD – Altitude hold (ALT) mode

The ALT mode is used to maintain a barometric altitude. It is activated by pressing the ALT switch on the FCP. The altitude maintained is the aircraft altitude at the time of mode selection. The mode is also automatically activated after a captured preselect altitude change.

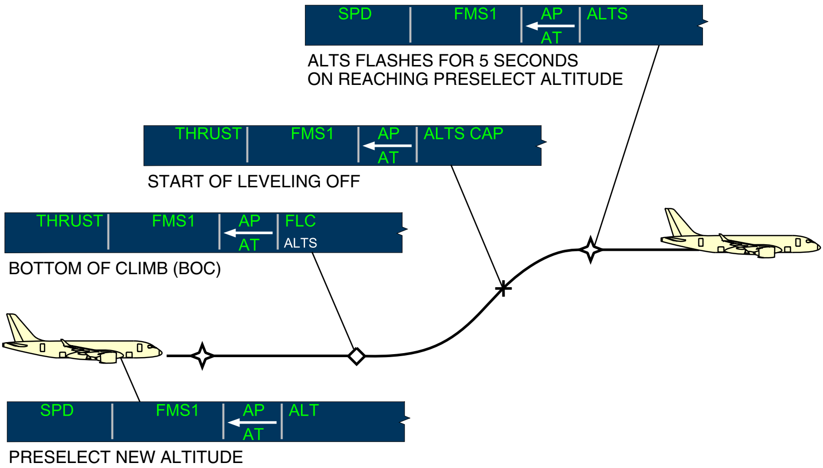
When the ALT mode is active, ALT displays in green in the right section of the FMA (refer to Figure 03–02–26). ALT flashes for 5 seconds upon altitude capture.



Altitude Hold
Figure 03–02–26

E. FD – Flight Level Change (FLC) mode

The FLC mode is used to climb or descend while maintaining a selected airspeed or Mach number. The mode is selected by pressing the FLC switch on the FCP. The flight level change speed can be manually selected or automatically provided by the FMS. When the mode is active, FLC displays in green in the right section of the FMA (refer to Figure 03–02–27). Selection of the FLC mode overrides all active vertical modes.



Flight Level Change (FLC) mode active
Figure 03–02–27

The speed is set manually by selecting the outer SPD switch to MAN and selecting the desired speed using the inner SPD switch. The selected speed displays above the SPD switch and on top of the airspeed scale. A cyan bug also displays at the selected speed on the airspeed scale. Pressing the center of the SPD switch alternates between indicated airspeed in knots and Mach.

When the SPD switch is set to FMS, the FMS provides climb or descent speed. The speed displays in magenta on top of the airspeed tape and the speed bug displays in magenta. The speed indicated on the FCP (above the SPD switch) is removed and replaced by white dashes.

F. FD – Overspeed (OVSP) protection

Overspeed protection automatically activates in FBW normal or PFCC direct modes.

When the speed trend vector extends beyond V_{MAX}, the airspeed value displays in amber and a single "OVERSPEED" aural warning sounds.

When the speed is greater than V_{MAX}, the airspeed displays in red and a continuous "OVERSPEED" aural warning sounds.

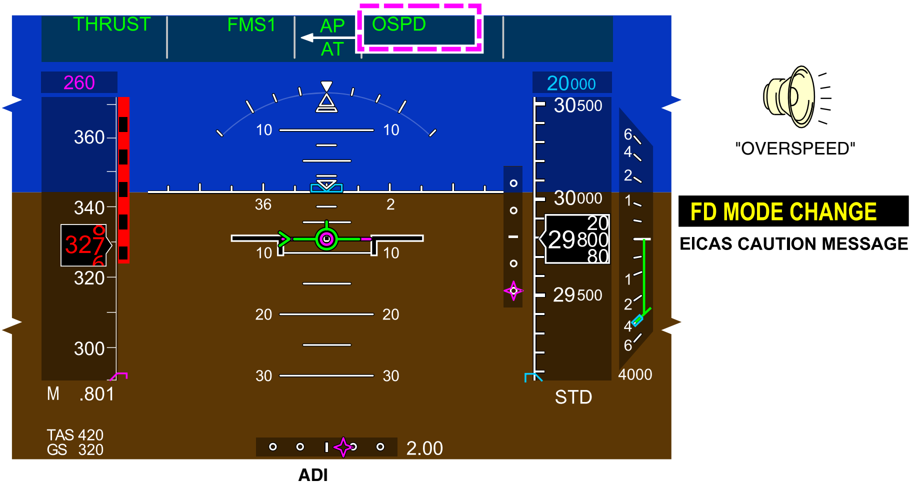
The autothrottle, if engaged, reduces thrust until the reference speed is regained.

An additional flight guidance function activates when operating in FPA, FLC, VS, and corresponding VNAV modes. The flight director cue appears if previously selected off, and provides pitch guidance to recapture the reference airspeed.

When overspeed protection activates, OSPD displays in green in the FMA vertical mode section (refer to Figure 03–02–28). The **FD MODE CHANGE** caution message displays on the EICAS page indicating a non-pilot selected mode change. When the speed reduces below V_{MAX}, the OSPD is replaced by the FLC mode.

NOTE

The autopilot and autothrottle are not automatically engaged when overspeed is active.



ADI – Overspeed protection indication
Figure 03–02–28

G. FD – Underspeed (USPD) protection

Underspeed protection automatically activates in FBW normal or PFCC direct modes.

When the speed trend vector extends into the red and black low speed marker, or the current speed is below $V_{MIN\ TRIM}$, the airspeed value displays in amber and a single **"SPEED"** aural warning sounds.

When the current speed is in the red and black low speed marker, the airspeed value displayed in red and a continuous **"SPEED"** aural warning sounds.

Depending on the active vertical guidance mode, protection is provided by either the autothrottle, or flight director guidance:

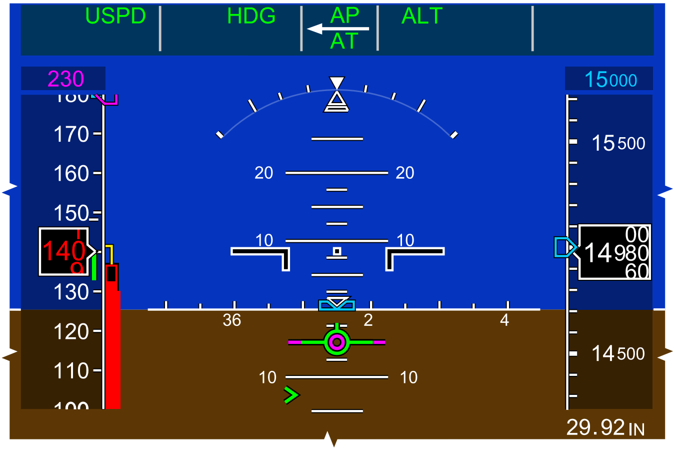
- In all altitude or altitude capture modes, the autothrottle, if engaged, increases thrust to N_1 reference until the reference speed is regained. USPD displays in green in the FMA vertical mode section while underspeed protection is active

- When operating in FPA, FLC, VS, and corresponding VNAV modes, the flight guidance underspeed function activates. The flight director cue appears if previously selected off, and provides pitch guidance to recapture the airspeed reference. USPD displays in green in the FMA vertical mode section. When the speed increases above $V_{MIN\ TRIM}$, the USPD vertical mode is replaced by the FLC mode.

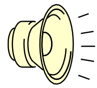
The **FD MODE CHANGE** caution message displays on the EICAS indicating a non-pilot selected mode change (refer to Figure 03–02–29).

NOTE

The autopilot and autothrottle are not automatically engaged when underspeed protection is active.

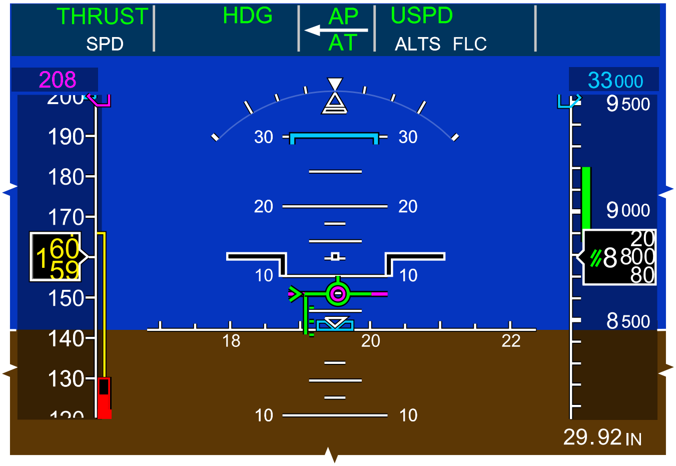


AUTOTHROTTLE UNDERSPEED MODE



FD MODE CHANGE

EICAS CAUTION MESSAGE



FLIGHT GUIDANCE UNDERSPEED MODE

ADI – Underspeed protection indication
Figure 03–02–29

H. FD – Vertical Navigation (VNAV) modes

Vertical Navigation (VNAV) modes allow the FD to follow FMS-managed vertical navigation profiles. The FMS contains programmed vertical navigation profiles that include:

- Takeoff,
- Climb,
- Descent, and
- Approach.

VNAV mode is enabled by selecting the VNAV switch on the FCP. The FMS-managed vertical modes are similar to the selected vertical modes but display with the letter V. They include the modes that follow:

- VNAV Flight Path (VFPA),
- VNAV Vertical Speed (VVS),
- VNAV Flight Level Change (VFLC),
- VNAV Altitude select (VALTS),
- VNAV Altitude hold (VALT),
- VNAV FMS Altitude (VALTV),
- VNAV Path (VPATH),
- VNAV glide path (VGP),
- VNAV Takeoff (VTO), and
- VNAV Go-Around (VGA).

(1) VNAV deviation indicator

The VNAV deviation pointer (refer to Figure 03–02–30) and the vertical deviation scale display beside the altitude tape when VNAV is enabled. Each dot on the scale represents a 250-foot deviation, and full scale deflection represents a 500-foot deviation from the VNAV path. The scale changes to 75 feet of deviation for each dot when an approach (APPR) mode is selected.

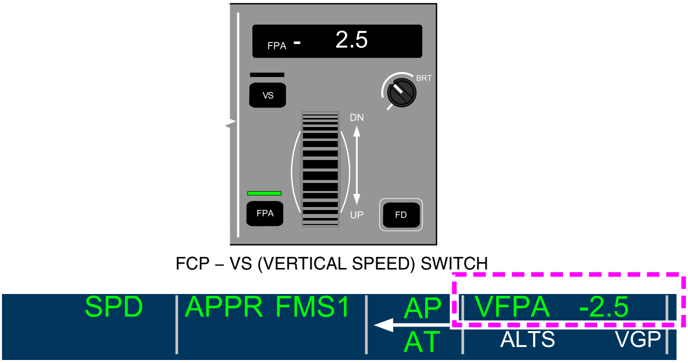
ADI – VNAV Indications
Figure 03–02–30

The VNAV altitude constraint displays in magenta above the vertical deviation scale, and as a magenta bug on the altitude tape. The required vertical speed to maintain the vertical path displays as a magenta circle on the VSI.

Alerts for Top Of Descent (TOD) and Bottom of Climb (BOC) display in the FMS message line on the PFD. The alerts display for 60 seconds before an altitude change, and flash for 5 seconds before the altitude change, accompanied by double C-chord aural tone. The alerts is removed when the altitude change begins.

(2) VNAV Flight Path (VFPA)

The Vertical Navigation (VNAV) Flight Path Angle (VFPA) mode is the basic VNAV mode. Operation and limits are similar to the Flight Path Angle (FPA) mode. It displays on the FMA as VFPA (refer to Figure 03–02–31). The VFPA is also enabled if other selected VNAV modes are lost or de-selected.



VNAV Flight Path Angle (VFPA) Mode
Figure 03–02–31

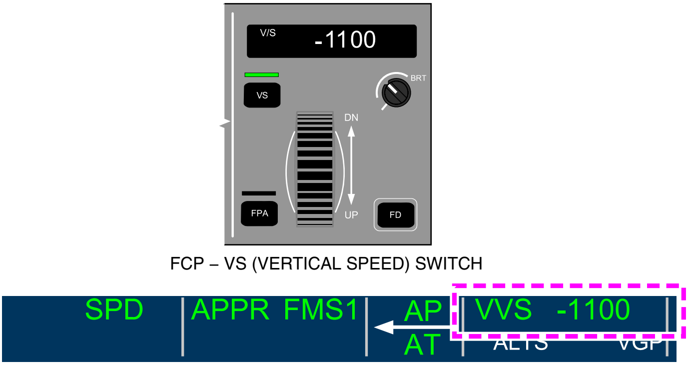
The flight path reference displayed on the FPA can be changed by rotating the VS/FPA switch on the FCP.

NOTE

When operating in VFPA mode, an airspeed protection function commands an aircraft pitch change if the airspeed is approaching V_{MO}/M_{MO}.

(3) VNAV Vertical Speed (VVS)

Pressing the VS switch on the FCP while a VNAV is active enables the VVS mode. A green VVS displays in the right section of the FMA when active. Refer to .Figure 03–02–32



VNAV Vertical Speed (VVS) mode
Figure 03–02–32

The vertical speed indications display in magenta on the VSI.

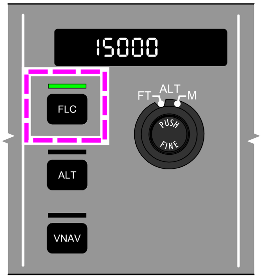
The VVS mode maintains the aircraft at a FMS-selected climb or descent rate. The vertical speed value can be manually adjusted using the VS/FPA switch (wheel). The manual vertical speed adjustment overrides FMS control.

NOTE

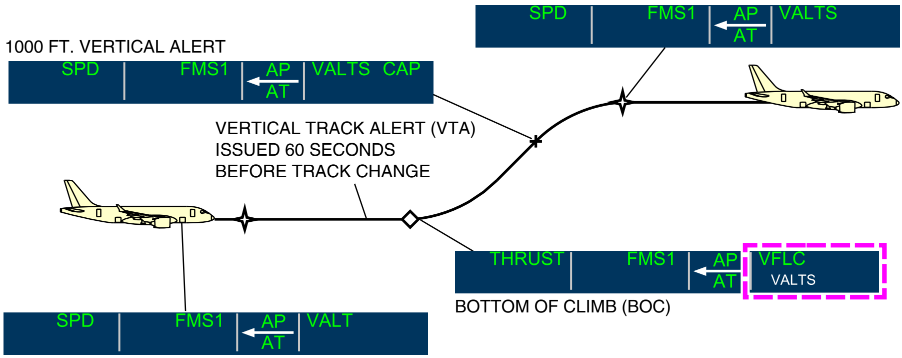
When operating in VVS mode, an airspeed protection function commands an aircraft pitch change if the airspeed is approaching V_{MO}/M_{MO}.

(4) VNAV Flight Level Change (VFLC)

The VFLC mode is activated by the FMS as a function of the programmed vertical navigation profile. VFLC mode can also be manually selected by pressing the FLC switch when VNAV is active. A green VFLC displays on the FMA when the mode is active. Refer to Figure 03–02–33.



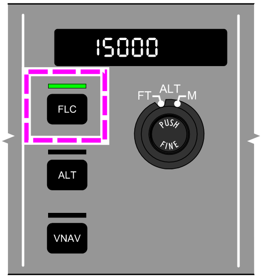
FCP – FLC (FLIGHT LEVEL CHANGE) SWITCH



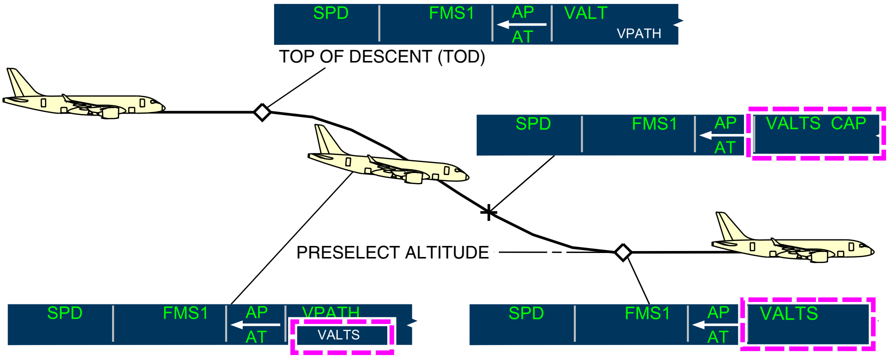
VNAV Flight Level Change (VFLC) Mode
Figure 03–02–33

(5) VNAV Altitude select (VALTS)

When a desired altitude is selected and a VNAV mode is engaged, VALTS mode is armed and displays in white on the FMA (refer to Figure 03–02–34). When the altitude is captured, a green VALTS CAP flashed for 5 seconds, than changes to VALTS.



FCP – FLC (FLIGHT LEVEL CHANGE) SWITCH



VNAV Altitude Select – VALTS
Figure 03–02–34

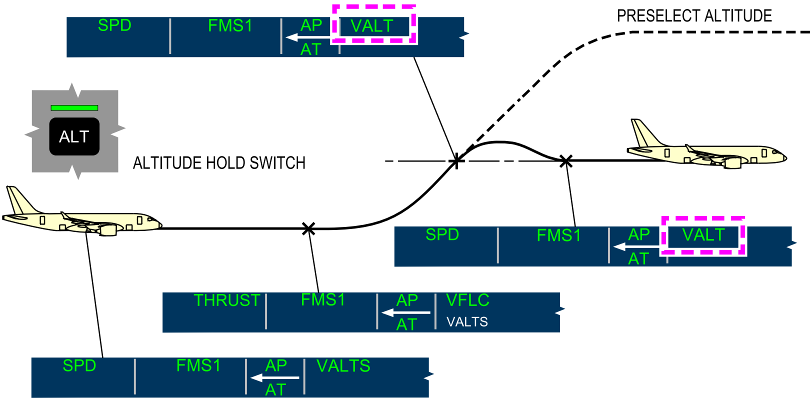
NOTE

When VALTS is active, any change in the altimeter setting causes the aircraft to return to the selected attitude.

(6) VNAV Altitude hold (VALT)

In VALT mode, the FMS provides the selected altitude to maintain.

VALT mode engages automatically when the selected altitude is reached. The mode also engages when VNAV is activated via the VNAV switch and the aircraft is within 250 feet of the selected altitude. Refer to Figure 03–02–35.

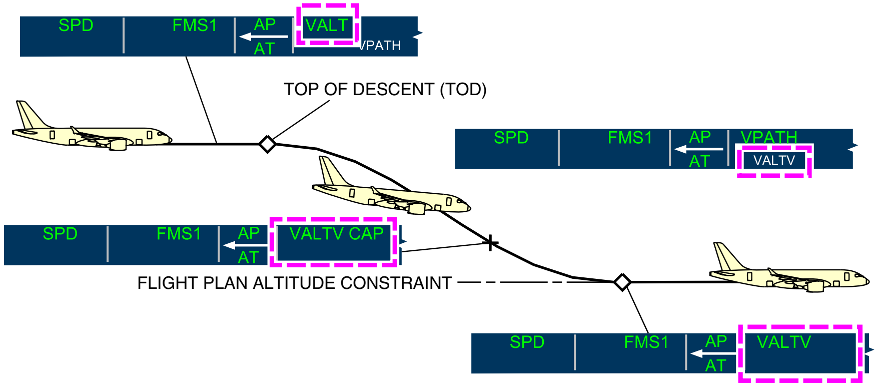


VNAV Altitude hold – VALT
Figure 03–02–35

(7) VNAV FMS Altitude (VALTV)

The VALTV mode activates to maintain an intermediate level off (altitude constraint) when included in the FMS vertical profile (climb or descent). To initiate a climb profile or descent profile, the desired altitude must be preselected first.

The VALTV mode arms and displays in white on the FMA. When the altitude constraint is captured, the indication changes to green VALTV CAP then to VALTV. Refer to Figure 03–02–36.



VNAV FMS Altitude (VALTV)
Figure 03–02–36

NOTE

When it reaches the preselected altitude, the aircraft levels off, and VALTS displays in green on the FMA. The aircraft is never commanded to climb or descend through the preselected altitude.

(8) VNAV Path (VPATH)

The VPATH mode provides guidance to fly the FMS barometric/GNSS descent path from the TOD point to a FMS-programmed altitude or the preselected altitude, whichever is higher, at an angle defined in the FMS. Refer to Figure 03–02–37.

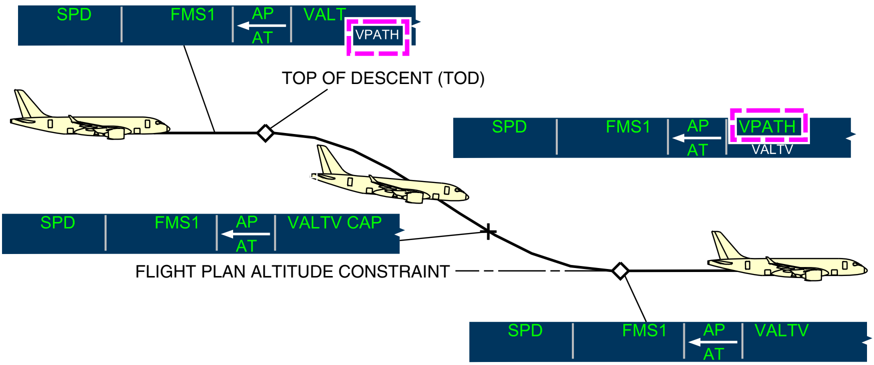
The FMS altitude constraint is indicated in magenta above the VNAV deviation scale, while deviation from descent path is indicated by the VNAV deviation pointer.

The VPATH mode activates at the TOD point in the FMS flight plan. VALTV is armed for the altitude constraint. The FD uses pitch to control the vertical path. The AT controls the speed via the engine thrust setting. Path control has priority overspeed control.

If necessary, early or late descents can be done using the VFLC or VVS mode to capture the original planned path.

If speed increases as the FD attempts to maintain the descent path, a DECELERATE message displays on the FMS message line. If the airspeed continues to increase, the VPATH mode is canceled, and the overspeed protection (OVSP) mode activates.

VPATH mode is available for route descents and for VNAV approaches where a level off is required (for example, MDA).



VNAV Path (VPATH) – Altitude Constraint
Figure 03–02–37

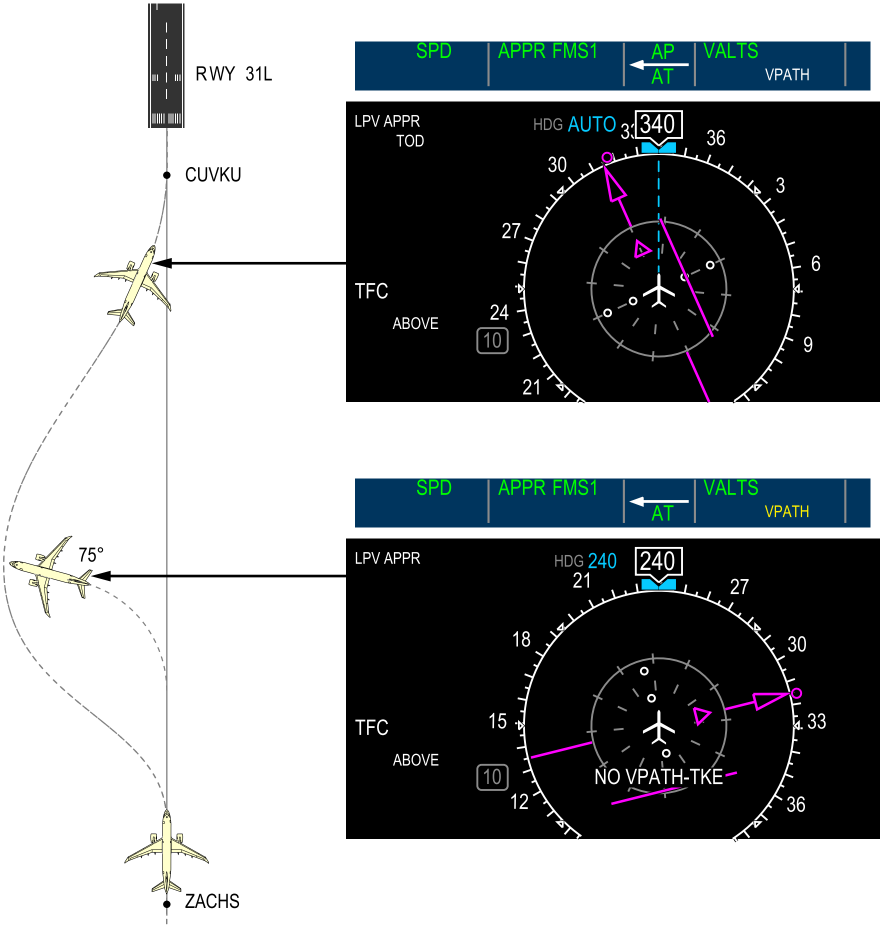
NOTE

When the aircraft route becomes undefined, VPATH automatically reverts to VFPA descent (for example, during a FMS discontinuity).

(9) VNAV Track Angle Error

During enroute, terminal, or approach operations, whenever a track angle error exceeds 75 degrees, a NO VPATH-TKE message displays on the HSI, and a flashing amber VPATH displays on the FMA. Refer to Figure 03–02–38.

VPATH will re-arm when the track error is less than 75 degrees.

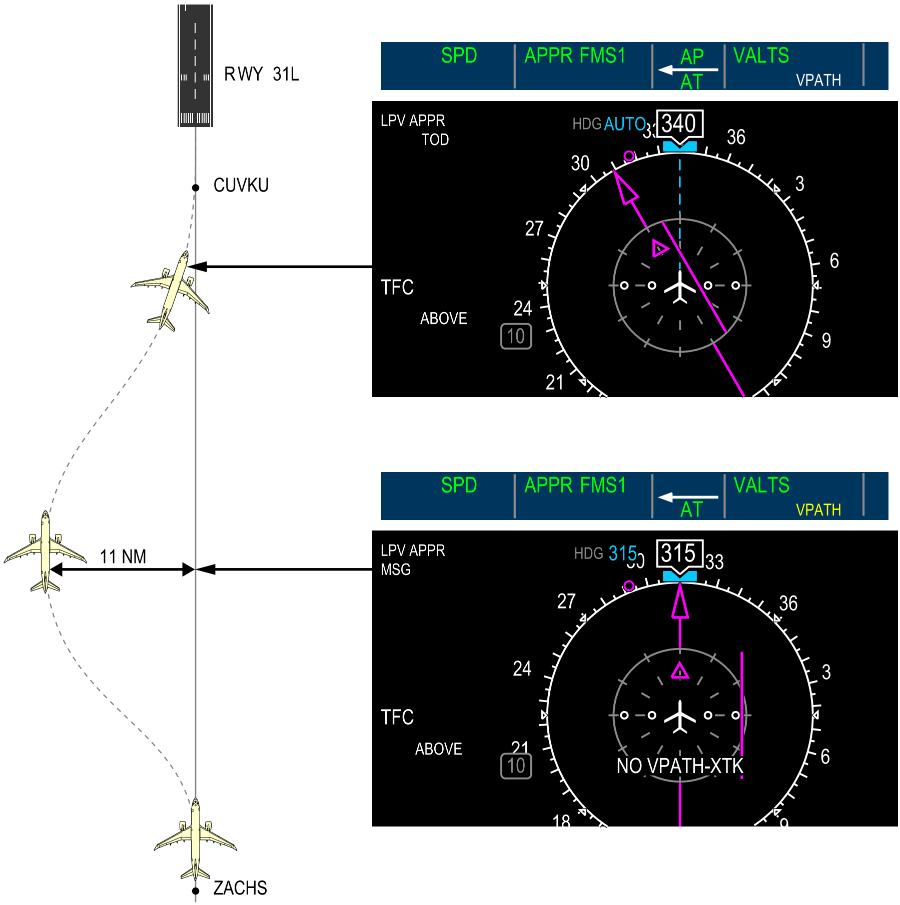


VNAV Track Angle Error
Figure 03–02–38

(10) VNAV Cross Track Deviation

During enroute, terminal, or approach operations, whenever a cross track error exceeds 10 nm, a NO VPATH-XKE message displays on the HSI, and a flashing amber VPATH displays on the FMA. Refer to Figure 03–02–39.

VPATH will re-arm when the track error is less than 10 nm.

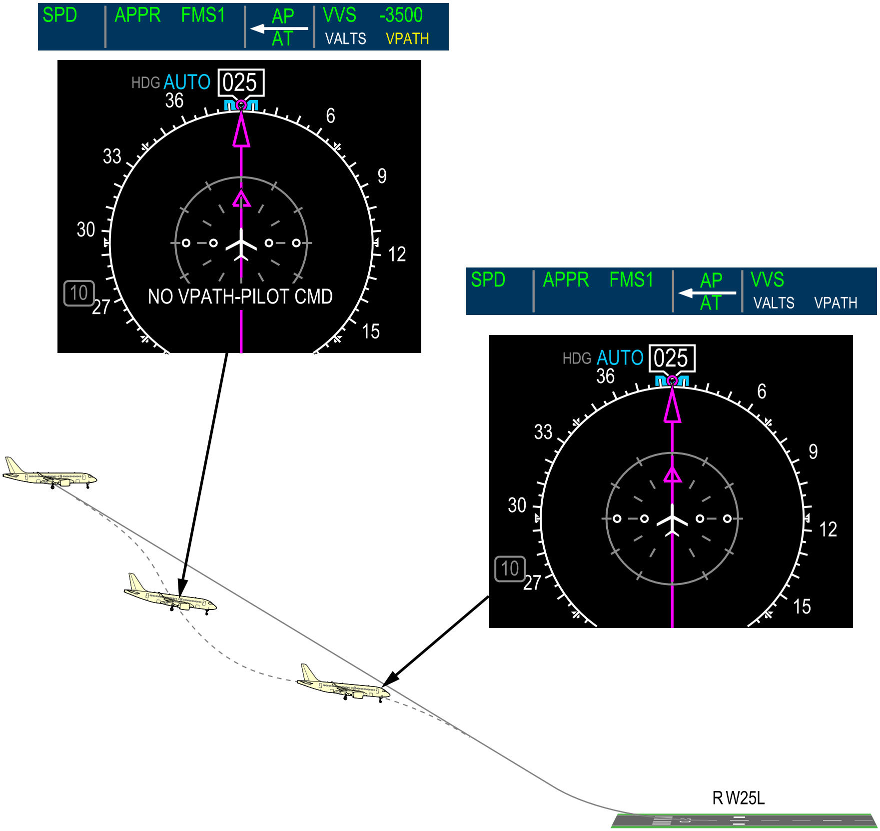


VNAV Cross Track Deviation
Figure 03–02–39

(11) VNAV Path Deviation

During VPATH operations, when pilot-selected vertical modes such as VVA are used, a NO VPATH-PILOT CMD message displays on the HSI, and a flashing amber VPATH annunciation displays on the FMA. Refer to Figure 03–02–40.

When the aircraft recaptures the FMS flight path, the HSI message is removed, and a white VPATH displays.



VNAV Path Deviation
Figure 03–02–40

FD – MULTI-AXIS MODES

Activation of the FG system multi-axis modes results from the flight crew selections on the FCP and the TOGA switch on the thrust levers. Certain FD mode selections exist as combined lateral and vertical modes for specific purpose or function. The table that follows shows the multi-axis modes with the associated controls and FMA annunciations.

Mode	FCP/Thrust levers	Lateral FMA annunciation	Vertical FMA annunciation	AT mode
ILS approach (FG)	APPR	APPR LOC...	GS	Speed (SPD)
ILS approach (AL)	APPR	APPR LOC	GS	Speed (SPD)
ILS approach (AL)	None	ALIGN	FLARE	Retard (RETARD)
Takeoff (TO)	TOGA	TO	TO/VTO	Thrust hold (HOLD)
Go Around (GA)	TOGA	GA	GA/VGA	Thrust (THRUST)
Windshear escape guidance	TOGA	GA	WSHR	Thrust (THRUST)

A. FD – ILS Approach mode

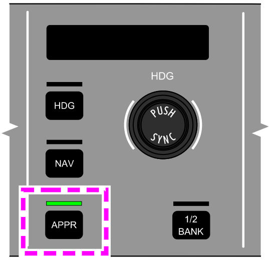
The approach (APPR) mode provides for the automatic intercept, capture, and tracking of the front course localizer and glideslope.

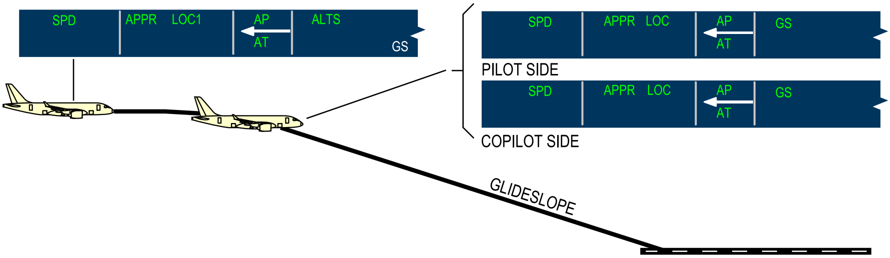
When the ILS approach is selected in the FMS and the aircraft is approximately 30 nm from the airport, the localizer frequency is automatically tuned, the LOC preview mode is enabled, and the course indicator sets to the localizer course.

When the APPR switch is selected, if the aircraft is outside of the localizer capture range, APPR FMS1 displays in green, and APPR LOC1 (LOC2) mode is armed and displays in white on the FMA. At localizer capture, APPR LOC1 (LOC2) flashes green for 5 seconds, then becomes steady. Refer to Figure 03–02–41.

GS is armed and displays white on the FMA when APPR mode is selected. At the glideslope capture, GS activates, flashes green for 5 seconds, and then becomes steady on the FMA.

After GS is captured and aircraft is descending below 1500 feet RA, the flight guidance is transferred to the PFCC for precision ILS approach capability. A green APPR LOC displays on the FMA.



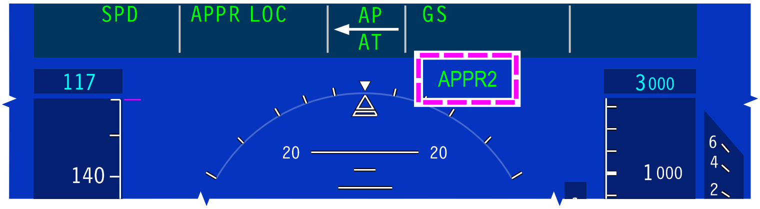


ILS Approach Mode
Figure 03–02–41

(1) ASA indications

When all the necessary onboard equipment is functioning correctly, and the radio signal quality meets the ILS criteria, one of the following messages displays on the Approach Status Annunciator (ASA) (refer to Figure 03–02–42) on the PFD:

- APPR2: The aircraft is capable of ILS CAT II, and
- APPR1: The aircraft is capable of ILS CAT I.



ADI

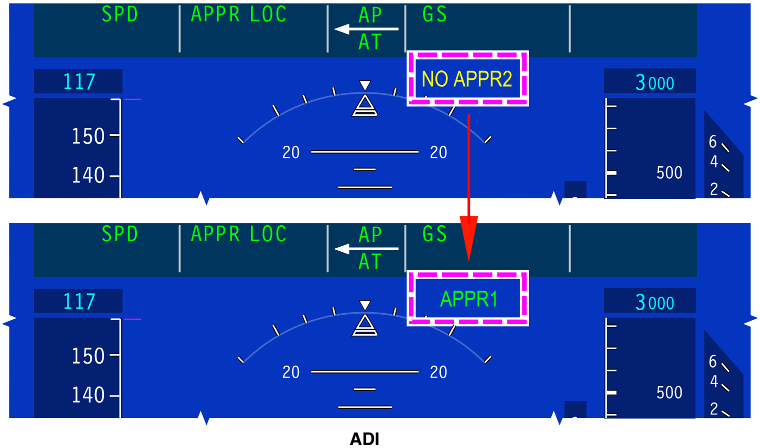
ADI – ILS CAT II
Figure 03–02–42

(2) Changes in approach capability

If the approach capability degrades during the approach, the system displays the highest available approach capability on the Approach Status Annunciator (ASA).

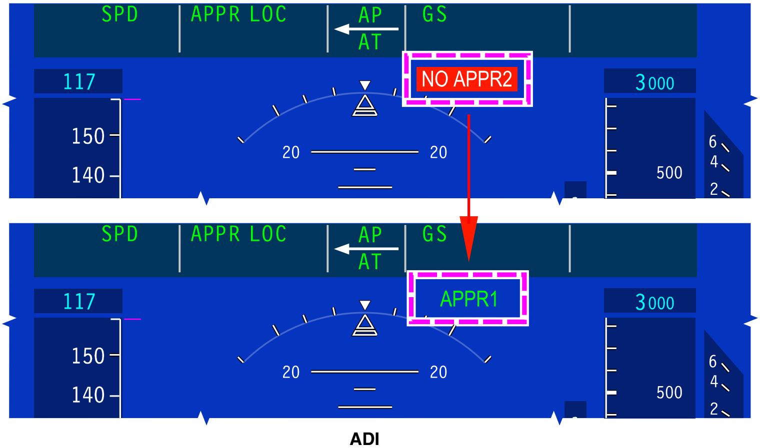
(3) APPR2 to APPR1 degradation

If the approach mode degrades from APPR2 to APPR1 and the aircraft is above 200 ft RA, a NO APPR2 message flashes in amber for 5 seconds, followed by a steady green APPR1 message. Refer to Figure 03–02–43.



ADI – APPR2 to APPR1 Degradation – Above 200 ft RA
Figure 03–02–43

If this approach mode degradation occurs when the aircraft is at or below 200 ft RA, the NO APPR2 message flashes red for 5 seconds, followed by a steady green APPR1 message. Refer to Figure 03–02–44.



ADI – APPR2 to APPR1 Degradation – Below 200 ft RA
Figure 03–02–44

(4) Loss of all approach modes

If all the approach modes are lost when the aircraft is above 200 ft RA, a NO APPR2 message flashes amber for 5 seconds and is removed.

If all the approach modes are lost when the aircraft is below 200 ft RA, a NO APPR2 message flashes red for 5 seconds and is removed.

If the APPR1 approach mode is lost, a NO APPR1 flashes in amber for 5 seconds and is removed.

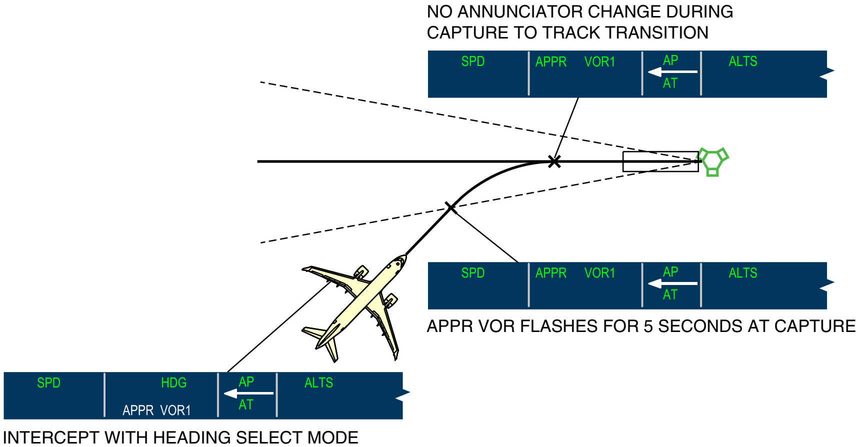
In all cases, the AL function is disabled.

B. FD – VOR Approach (APPR VOR1 (VOR2)) mode

The VOR Approach (APPR VOR1 (VOR2)) mode is used for non-precision approach using VOR source. The mode is enabled by pressing the APPR switch when VOR is the navigation source.

After selecting the APPR switch, the Heading (HDG) mode is activated and displays green, and APPR VOR1 (VOR2) mode is armed and displays white on the FMA (refer to Figure 03–02–45). The intercept heading is automatically set if either the DME or FMS distance from the station is available. The intercept heading can also be manually set using the HDG switch (rotary).

Upon interception, HDG is removed and APPR VOR1 (VOR2) activates and displays green. When APPR VOR is active, the bank angle limit is 15 degrees.



VOR Approach
Figure 03–02–45

C. FD – VNAV GLIDE PATH (VGP)

The VNAV Glide Path (VGP) mode is used during a FMS/VNAV approach. Vertical guidance is provided with reference to satellite-based positioning (SBAS). Without SBAS, a continuous descent is made with reference to the barometric altimeter.

VGP provides guidance from below the preselected altitude to the runway, unless another mode is selected.

VGP mode is armed when the APPR switch on the FCP is selected and:

- FMS is selected as the NAV source,
- A non-localizer based approach is selected,
- Predictive RAIM is available,
- The aircraft is in the terminal area (within approximately 30 nm from destination), and
- FMS is not in Dead Reckoning (DR).

After the APPR mode is selected, if the VGP arming criteria is not met, an invalid amber VGP message is displayed on the FMA.

The VGP mode activates when APPR FMS1 (FMS2) is active (refer to Figure 03–02–46) and either:

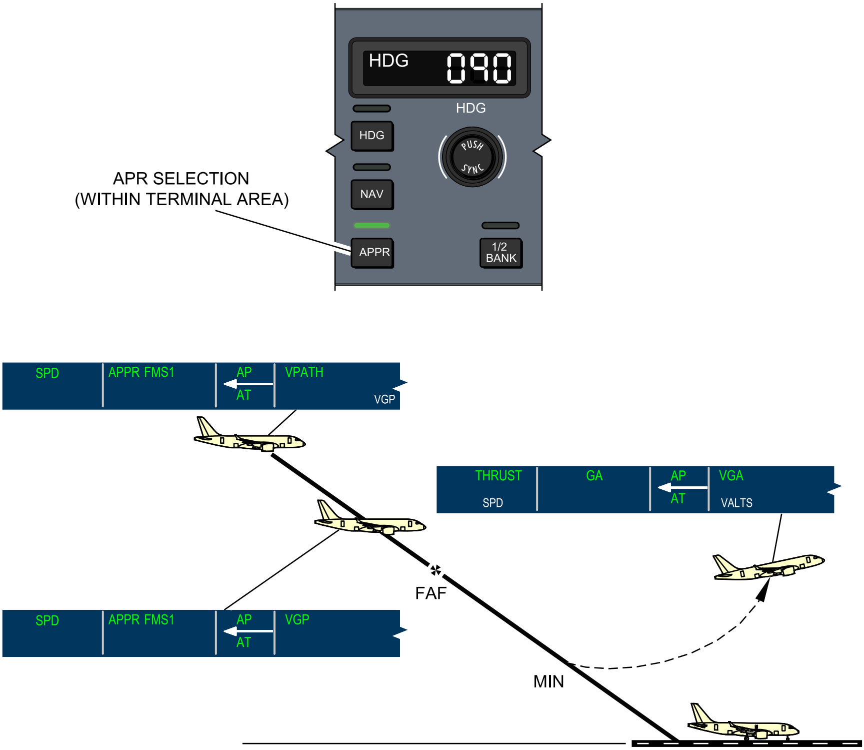
- The Final Approach Fix (FAF) or MAP is the active waypoint, and
- The distance to the FAF is less than 2 nm.

A white APPR message that is associated with the selected approach displays on the PFD when the required position accuracy is available to continue the approach past the FAF.

The VNAV deviation pointer indicates the glide path deviation.

NOTE

The altitude alert function and automatic arming of VALTS is inhibited when VGP mode is active.

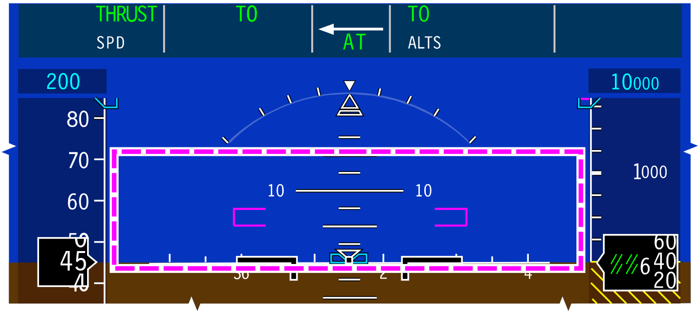


VNAV Vertical Glide Path (VGP)
Figure 03–02–46

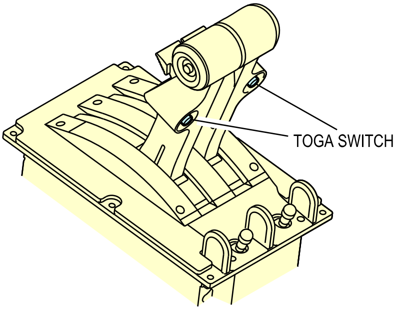
D. FD – Takeoff (TO) mode

Takeoff (TO) mode is activated on the ground by pressing one of the TOGA switches on the thrust lever. When TO mode is selected, a wings level pitch target marker displays at the appropriate pitch angle based on the selected takeoff V-speeds and aircraft weight. The pitch target marker is automatically adjusted during One Engine Inoperative (OEI).

TO displays green on the left (lateral mode) and right (vertical mode) sections of the FMA. When airborne, the TO mode captures and maintains the runway heading. Refer to Figure 03–02–47 and Figure 03–02–48.

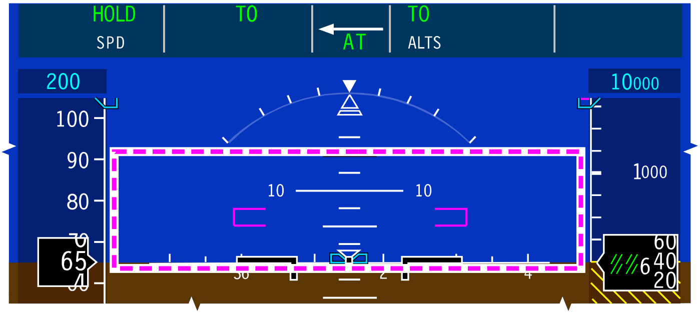


ADI

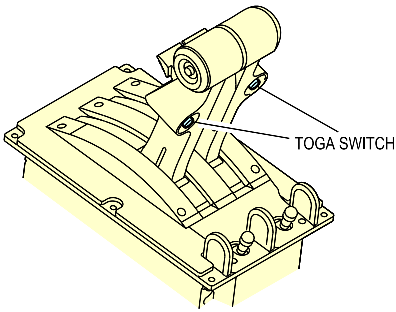


THROTTLE QUADRANT ASSEMBLY
(TQA) - TOGA SWITCHES

Takeoff Mode – On ground below 60 kt
Figure 03–02–47



ADI



THROTTLE QUADRANT ASSEMBLY
(TQA) - TOGA SWITCHES

Takeoff Mode – On ground above 60 kt
Figure 03–02–48

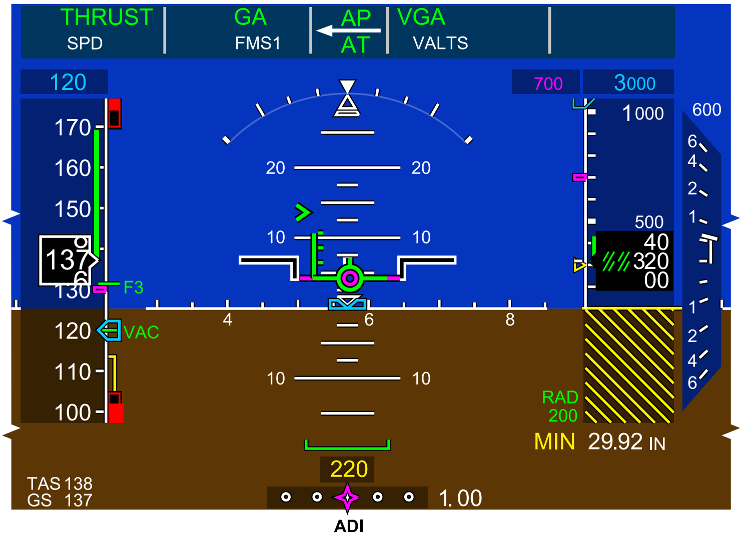
E. FD – Go-Around (GA) mode

The Go-Around (GA) mode provides pitch and lateral commands for a transition from an approach to climb out when a missed approach is initiated.

The mode is activated by pressing one of the TOGA switches. When the mode is activated, the Autopilot (AP) remains engaged and the Autothrottle (AT) engages, if not already engaged.

During a go-around followed by a NAV-to-NAV transfer to an ILS approach: (refer to Figure 03–02–49).

- The navigation source automatically transfers from VHF-NAV to FMS, and the course arrow, deviation bar, and navigation data display in magenta.
- A green GA displays as the active lateral mode, and the heading at the go-around is maintained. During initial climb, the lateral mode changes from GA to FMS and the missed approach course is tracked.
- A green VGA (VNAV Go-Around) displays as the active vertical mode. The missed approach climb profile is tracked (speed and altitude).



ADI – ILS Approach Go–Around After NAV–to–NAV Transfer
Figure 03–02–49

When go-around is activated (refer to Figure 03–02–50) after a FMS approach:

- A green FMS displays as the active lateral mode and the heading at go-around engagement is maintained. At 400 ft RA the missed approach course is tracked, and
- A green VGA displays as active vertical mode. The missed approach climb profile is tracked (speed and altitude).

ADI– FMS Approach Go–Around
Figure 03–02–50

When a go-around is activated followed by a non-FMS approach, a green GA displays as the active lateral and vertical mode (refer to Figure 03–02–51.

To provide a safe climb, the heading at go-around activation is maintained, a pitch up command is generated, and a reference airspeed is maintained.

When FMS speed is selected, the reference airspeed is V_{GA} for an all engine go-around.

For a single engine go-around, the reference speed is V_{AC}.

When MAN speed is selected, the reference speed is the selected.

ADI

ADI – Non–FMS Approach Go–Around
Figure 03–02–51

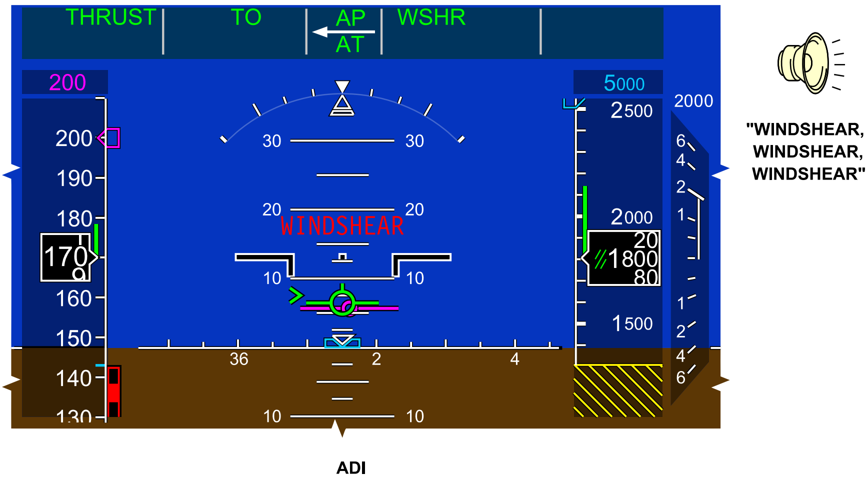
When the preselected altitude is reached, the vertical mode changes to ALTS or VALTS, and the preselected altitude is maintained.

F. FD – Windshear (WSHR) escape guidance

The windshear escape guidance mode provides vertical guidance to escape windshear detected by the TAWS.

When a windshear warning is detected, pressing any TOGA switch on the thrust levers activates the WSHR escape guidance mode. The mode generates vertical guidance to provide an optimal windshear escape maneuver using a blend of airspeed, radio altitude, and angle-of-attack data.

When the mode is active, a green WSHR message displays on the vertical mode section (right side) of the FMA (refer to Figure 03–02–52). A green TO or GA displays on the lateral mode section (left side) of the FMA depending on whether the windshear is encountered during takeoff (TO) or approach (GA). If the autothrottle is engaged, a green THRUST displays on the left side of the FMA and the aural message “WINDSHEAR, WINDSHEAR, WINDSHEAR” sounds in the flight deck.



ADI – Windshear escape guidance mode indications
Figure 03–02–52

NOTE

The windshear warning mode cannot be canceled during windshear warning conditions. Once the windshear warning condition has cleared, the mode can be changed by selecting any vertical FD mode.

G. FD – Emergency Descent Mode (EDM)

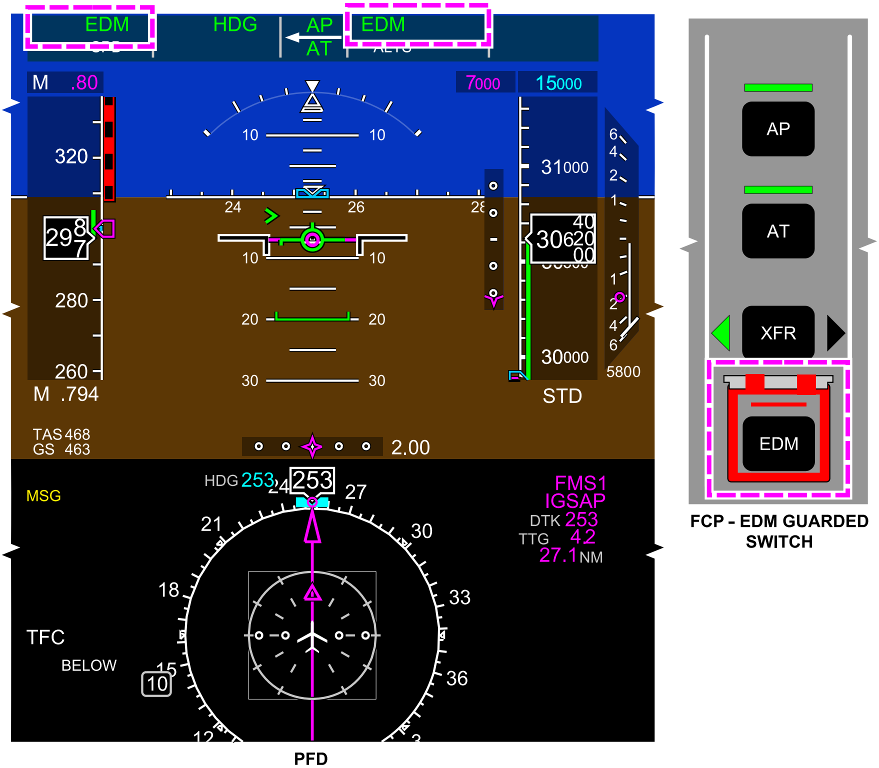
When activated, the EDM initiates a high speed autopilot-controlled descent to 15000 feet using the FLC and the HDG modes.

The EDM is automatically activated if the cabin altitude exceeds 14500 feet and the aircraft is above 25000 feet. When the aircraft altitude is above 25000 feet, the EDM can be manually activated by pressing the guarded EDM switch on the FCP.

When the EDM is activated, the following actions occur:

- Mode selection light above the EDM guarded switch illuminates,
- "EMERGENCY DESCENT" aural alert sounds,
- AP engages (if not already engaged),
- AT engages (if not already engaged) and thrust is reduced to flight idle,
- Altitude preselect is set to 15000 feet,
- Heading mode (HDG) is engaged and present heading is maintained,
- Descent speed is set to V_{MO} –10 kt, or M_{MO} –0.02M,
- Transponder code is set to 7700 (automatic activation only), and
- Seat belt signs are turned on (automatic activation only).

EDM displays in the left and right sections of the FMA (refer to Figure 03–02–53). The **EMERGENCY DESCENT** warning message displays on the EICAS page when the EDM is automatically activated. If it is manually activated, the **EMERGENCY DESCENT** caution message displays on the EICAS page.



PFD – Emergency Descent Mode indication
Figure 03–02–53

When the preselected altitude (15000) feet is reached, the AP and AT remain engaged and the altitude and the heading are maintained. The speed is automatically set to 250 knots.

Pressing the EDM guarded switch a second time the EDM guard switch or pressing the AP or A/P DISC PTY switch on either sidestick disengages the EDM. The FD resets to HDG and FLC (ALT) if level.

Re-engaging the AP does not re-engage the EDM.

NOTE

Heading, airspeed, altitude preselect, and the transponder code can be changed during EDM descent.

H. FD – Steep approach mode

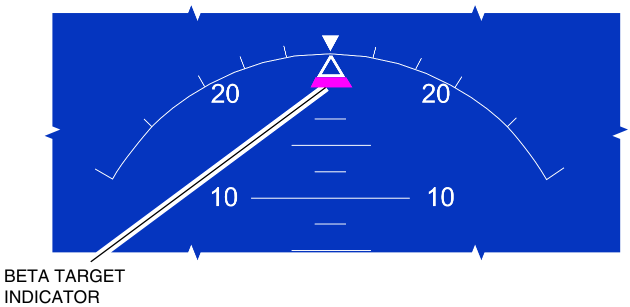
The function provides steep approach capability on glideslope beams up to 5.5 degrees (e.g. London City). Category 1 operations are authorized.

I. FD – One Engine Inoperative (OEI) guidance mode

The One Engine Inoperative (OEI) guidance mode gives the flight crew visual guidance that, if followed, will maximize the aircraft rate of climb during asymmetrical thrust. This guidance is shown on the ADI by the beta target indicator (refer to Figure 03–02–54). The OEI guidance mode is available during the takeoff phase (weight-off-wheels) and go-around, and it is active until the flaps and slats are fully retracted.

During OEI guidance, the beta target indicator replaces the slip indicator. It has the same shape but the color is magenta.

With the autopilot off during OEI, the pilot uses rudder inputs to center the beta target and maintains heading using roll commands. With the autopilot engaged, the pilot centers the beta target with rudder inputs, and the autopilot maintains the heading.



Attitude Direction Indicator (ADI) – Beta target indicator
Figure 03–02–54

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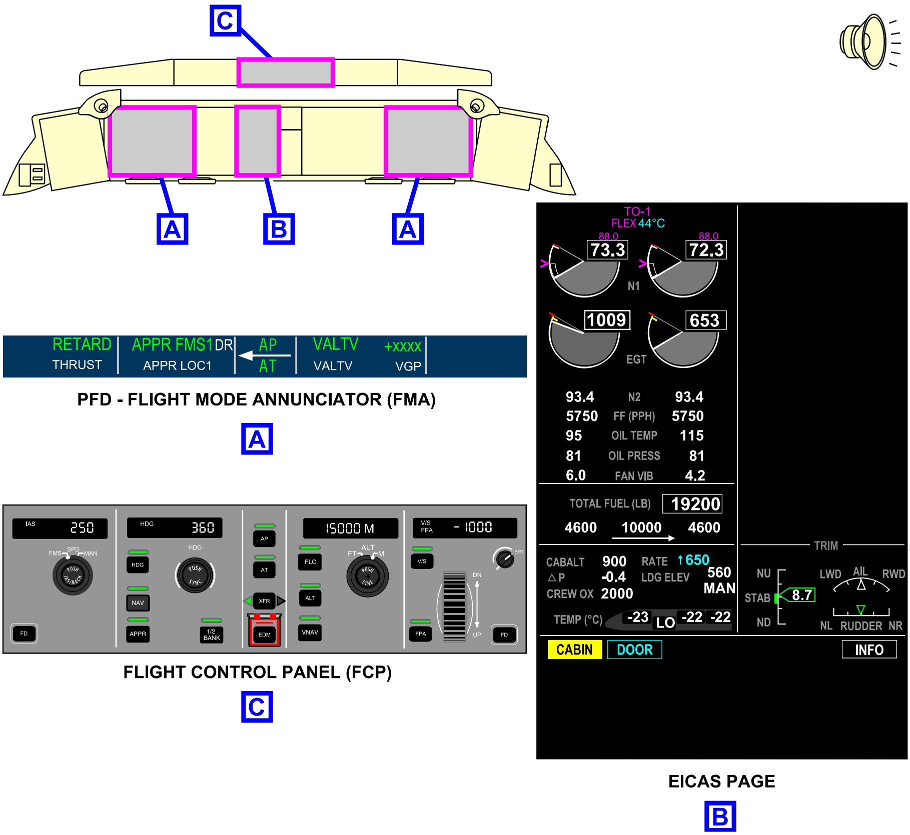
AP SYSTEM – OVERVIEW

The autopilot (AP) is a function integrated within each of the three Primary Flight Control Computers (PFCCs). The AP function on the active PFCC is used, the others are on standby. The AP monitor function will disengage the autopilot if the roll rate, pitch rate, or acceleration are outside limits or are expected to exceed limits.

The AP system functions are:

- Processing the FD system commands for the primary flight control surfaces,
- Limiting FD system commands,
- Flight envelope protection,
- Turn coordination,
- Yaw damping,
- Autotrim, and
- Engage and disengage logic control.

The AP system controls are located on the Flight Control Panel (FCP) and on the sidesticks. Indications are displayed on the Flight Mode Annunciator (FMA) and on the EICAS page. There is also an aural alert when the AP is disengaged. Refer to Figure 03–03–1.



Autopilot (AP) system controls and indications
Figure 03–03–1

NOTE

The fly-by-wire (FBW) system has envelope protection outside the envelope of the AFCS. The FBW envelope protection has priority over any AFCS command.

AP SYSTEM – DESCRIPTION AND OPERATION

A. Operation

The AP system is only available in FBW Normal Mode. The monitor function inside the system protects it from erroneous inputs. The AP system limiting function protects the aircraft flight envelope by limiting the FD pitch and roll commands as follows:

- Pitch is limited to between 15 degrees nose down and 20 degrees nose up,
- Pitch rate is limited to ±3 degrees per second,
- Roll rate is limited to 30 degrees left or right, and
- Roll rate is limited to ±5 degrees per second.

The AP system inputs are received from the:

- FG system,
- Flight Control Panel (FCP),
- Fly-By-Wire (FBW) system,
- Flight Management System (FMS),
- Air Data System (ADS),
- Navigation system, and
- Other systems.

B. AP engagement

The AP engages when the sidesticks are in the neutral position, the AP switch on the FCP is pushed, and the aircraft attitudes that follow are met:

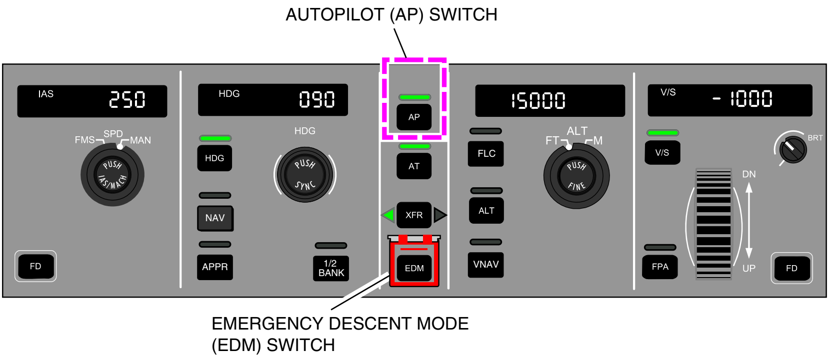
- Sidestick is in the neutral position,
- Bank angle is within ±45 degrees,
- Pitch change rate is less than 10 degrees per second,
- Roll rate is less than 15 degrees per second, and

- Load factor is between certified limits.

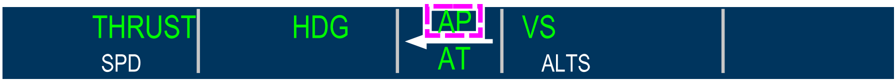
The AP engagement limits are defined in the table that follows.

Aircraft attitude	Limits
Pitch angle	Pitch attitude is between +25 degrees and –18 degrees,
Pitch change rate	Pitch change rate is less than 10 degrees per second,
Bank angle	Bank angle is within ±45 degrees,
Roll rate	Roll rate is less than 15 degrees per second, and
Acceleration	Load factor is between certified limits.

The AP system is engaged when the AP switch on the FCP is selected. It also engages when the Emergency Descent Mode (EDM) is activated (manually or automatically). AP system status is annunciated on the FMA. Refer to Figure 03–03–2.



FLIGHT CONTROL PANEL (FCP) - AUTOPILOT (AP) FUNCTION ACTIVATION



FMA - AUTOPILOT (AP) ACTIVATION INDICATION

Autopilot (AP) system activation
Figure 03–03–2

The AP can be engaged regardless of the flight director status. If no vertical or lateral FD mode is armed at AP engagement, the Flight Path Angle (FPA) and heading (HDG) modes are activated.

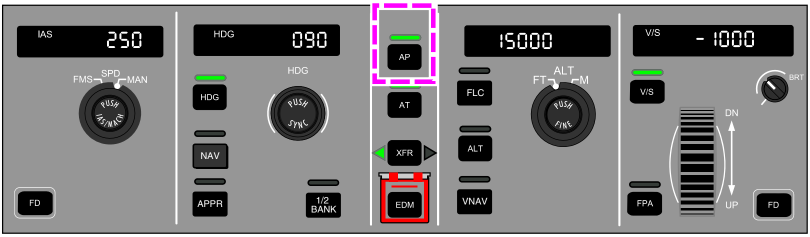
C. AP disengagement

The autopilot will disengage automatically in any of the conditions that follow:

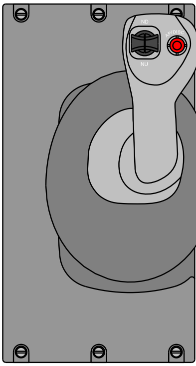
- Reversion of the FBW system to direct mode,
- Invalid data,
- AP monitor fault detected,
- Stick shaker (except in the windshear alert mode), or
- Below 50 ft in APPR 1 or APPR 2 approach modes.

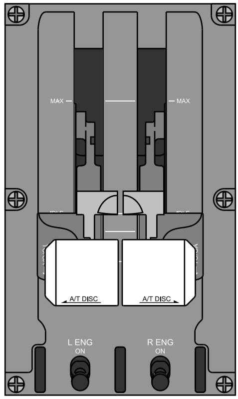
The autopilot will disengage manually (refer to Figure 03–03–3) in any of the conditions that follow:

- Pressing the red AP/PTY switch on the sidestick (refer to Figure 03–03–4),
- Pressing the AP pushbutton on the FCP, except during autoland in LAND 2 or LAND 3 are displayed,
- Operating the trim pitch switch on the sidestick,
- Moving the sidestick,
- Moving the tiller or rudder pedals (more than 0.8 inches) during autoland ground roll, or
- Pressing the TOGA pushbutton on the ground for more than 2 seconds, except when autoland ROLLOUT is active.

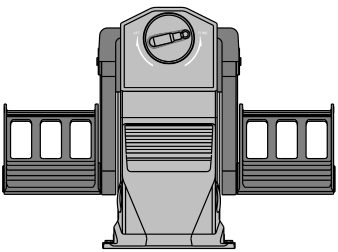


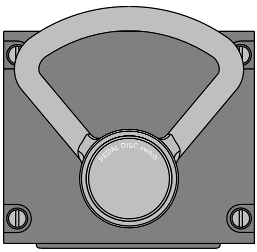
FLIGHT CONTROL PANEL (FCP) – AP (AUTOPILOT) SWITCH


SIDESTICK - AP/DISC PTY (AUTOPILOT DISCONNECT PRIORITY) SWITCH AND NU (NOSE UP) AND ND (NOSE DOWN) SWITCHES

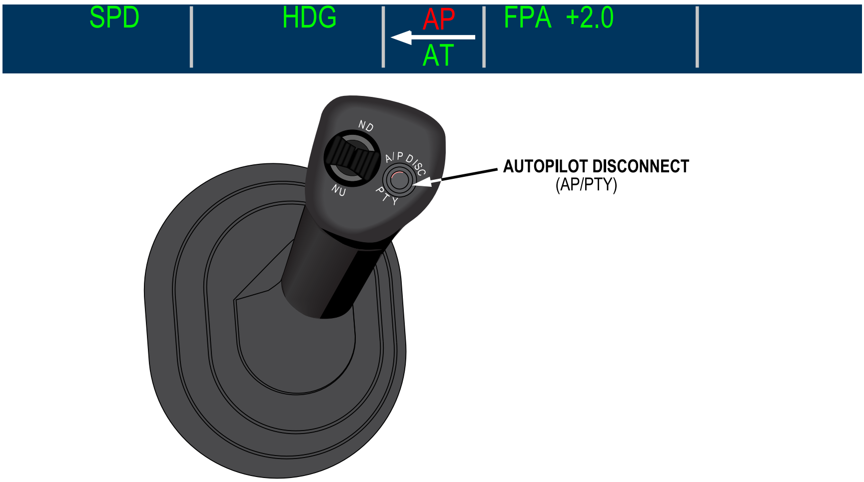


THROTTLE QUADRANT ASSEMBLY (TQA) TO/GA (TAKE OFF/GO AROUND) SWITCHES


RUDDER PEDALS


STEERING TILLER

Autopilot (AP) system disengage controls
Figure 03–03–3

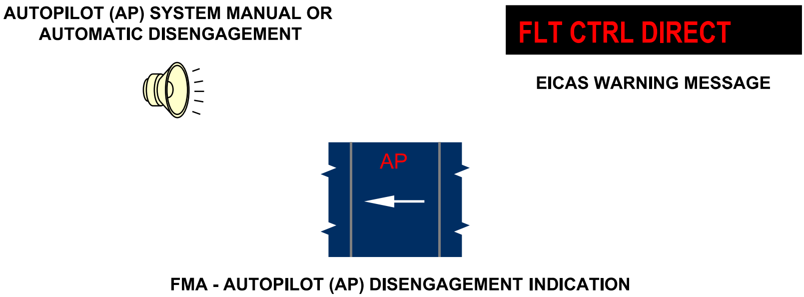


Autopilot (AP) disengage
Figure 03–03–4

NOTE

AP disengagement is not available on the disabled sidestick.

When the AP disengages (manually or automatically), AP flashes red on the FMA and a cavalry charge aural alert sounds continuously until the A/P DISC PTY switch on either sidestick is pressed. Refer to Figure 03–03–5.



Autopilot (AP) system disengage indications
Figure 03–03–5

AP – EMERGENCY DESCENT MODE (EDM)

A. AP – EDM activation – Automatic

The EDM automatically engages when the cabin altitude exceeds 14500 feet and the aircraft altitude is higher than 25000 feet. When the EDM engages:

- The red light above the EDM guarded switch on the Flight Control Panel (FCP) illuminates,
- The Autopilot (AP) system and the Autothrottle (AT) system engage (if not already engaged),
- The aural alert “EMERGENCY DESCENT” is heard in the flight compartment,

- The warning message **EMERGENCY DESCENT** is displayed on the EICAS page,
- The transponder code changes to 7700 (can be modified by the flight crew),
- The passenger oxygen masks deploy,
- The status message **PAX OXY DPLY** is displayed on the EICAS page,
- The thrust levers move to the idle position,
- Aircraft descends to 15000 feet at V_{MO}–5 knots (can be modified by the flight crew), and
- Aircraft maintains the current heading.

Disengaging the AP will deactivate the EDM mode. Re-engagement of the AP system does not re-engage the EDM.

NOTE

EDM activation does not automatically deploy the spoilers.

B. AP – EDM activation – Manual

The EDM can be activated manually with the EDM switch on the FCP if the aircraft altitude is higher than 25000 feet.

When the EDM switch is selected:

- The red light above the EDM guarded switch on the Flight Control Panel (FCP) illuminates,
- The Autopilot (AP) system and the Autothrottle (AT) system engage (if not already engaged),
- The aural alert "EMERGENCY DESCENT" is heard in the flight compartment,
- The caution message **EMERGENCY DESCENT** is displayed on the EICAS page,

- The thrust levers move to the idle position,
- Aircraft descends to 15000 feet (can be modified by the flight crew), and
- Aircraft maintains the current heading.

NOTE

EDM activation does not automatically deploy the spoilers.

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AUTOLAND (AL) SYSTEM – OVERVIEW

After an ILS approach, the AL function supplies:

- Approach tracking,
- Runway alignment de-crab during crosswind conditions,
- Landing flare, and
- Ground steering control on the runway during the landing rollout.

The aircraft is designed to have the highest possible approach capability (automatic up-mode capability), based on the aircraft systems status. There is no flight crew selection for autoland.

Between 1500 ft and 800 ft Above Aerodrome Elevation (AAE) during an ILS approach with the glideslope captured, the Fly-By-Wire (FBW) control is changed from the DCU Module Cabinets (DMCs) to the Primary Flight Control Computers (PFCCs) (Flight Mode Annunciator (FMA) lateral mode changes from APPR LOC 1(2) to APPR LOC) and the autoland capability is displayed on the Approach Status Annunciator (ASA) on the Primary Flight Display (PFD) (and Head-Up Display (HUD), if installed).

One of the messages that follow is displayed on the ASA on the PFD and on the HUD (if installed):

- APPR 1 – No autoland (a manual landing is required),
- APPR 2 – No autoland (a manual landing is required),
- LAND 2 – Fail passive autoland (ILS CAT III with Decision Height (DH)), or

During an approach, the terms Above Ground Level (AGL) or Above Aerodrome Elevation (AAE) are used, depending upon terrain on the approach. Autothrottle (AT) items are in AGL, while AL items are in AAE.

NOTE

For non-ILS based approaches, autoland is not available and the ASA stays blank.

AL SYSTEM – DESCRIPTION AND OPERATION

A. Fail passive autoland system (LAND 2)

Fail passive (LAND 2) is an autoland system that causes no significant deviation of the aircraft flight path or attitude if there is a failure. The capability to continue the operation may be lost and an alternate course of action (i.e. a missed approach or manual landing) may be required.

B. Alert height

Alert height is the height above a runway for Category III fail operational systems at which the approach must be discontinued if a required aircraft system or ground system has failed at an altitude above the alert height. The alert height has been established at 200 ft AGL.

C. Aircraft configuration for autoland and associated ASA messages

The AL configuration is FLAP 4 or 5, spoilers retracted, and autopilot engaged. When the correct landing configuration is set and all on-board and on-ground equipment is functioning correctly, LAND 2 or LAND 3 (if installed) is displayed on the ASA (refer to Figure 03–04–1).

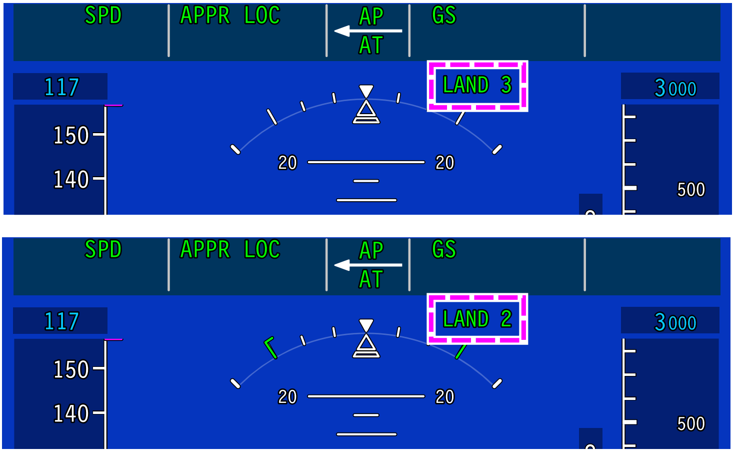
If the on-board equipment is not adequate for AL operation, APPR 2 or APPR 1 may be displayed on the ASA. If this occurs, autoland capability is lost and a manual landing is required (refer to Figure 03–04–2).

When there are no failures, if the slats/flaps are not in the landing configuration, or the flight spoilers are deployed, APPR 1 is displayed on the ASA. When the correct configuration is achieved, the ASA will display the highest available capability (APPR 2, or LAND 2, or LAND 3).

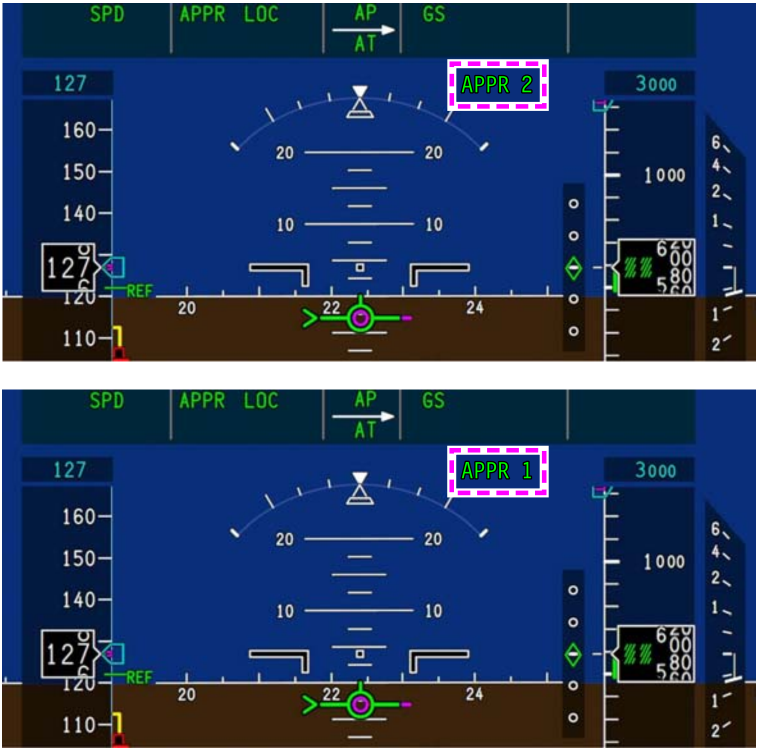
If the correct landing configuration is not set before 800 ft AAE, the system cannot up-mode the autoland and APPR 1 will continue to be displayed. A manual landing is required.

Above 1500 ft AAE and in the correct landing configuration, if the flight crew is manually flying the approach, the LAND 2 NOT AVAIL or LAND 3 NOT AVAIL advisory message is displayed. In this case, APPR 2 is the highest lading capability until the autopilot is engaged. As soon as APPR 2 is displayed on the ASA, the Engine Indication and Crew Alerting System (EICAS) advisory is removed. When the autopilot is engaged, the EICAS advisory on the ASA changes to LAND 2 (or LAND 3).

LAND 2 NOT AVAIL or LAND 3 NOT AVAIL can also be shown if a sensor failure occurs. Continued flight with one of these messages shown is permitted if the planned approach is not predicated on that level of autoland.



LAND 3 and LAND 2 indications
Figure 03–04–1



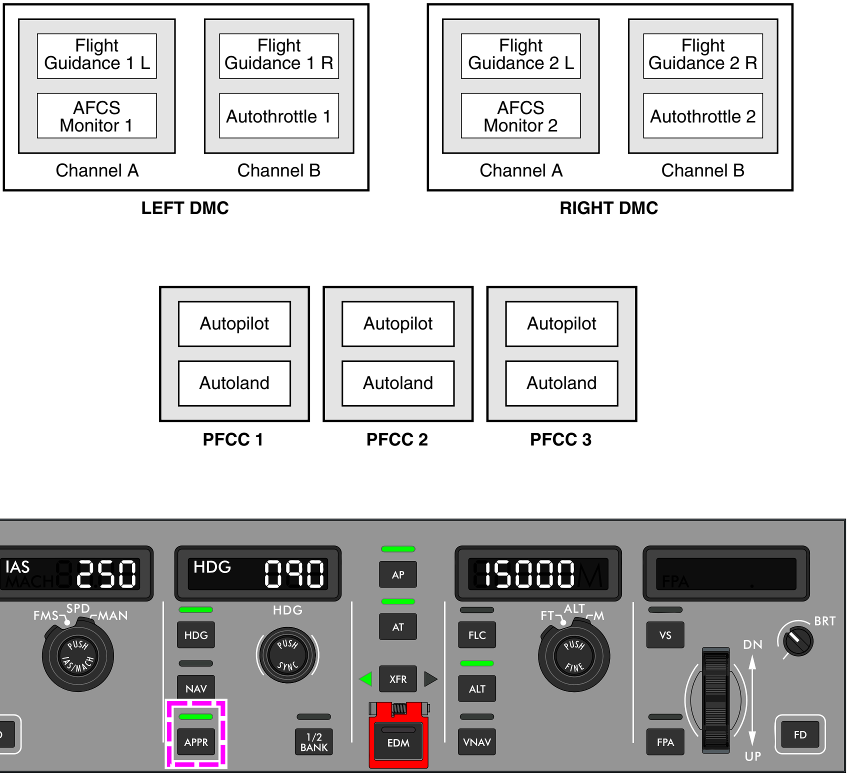
APPR 2 and APPR 1 indications
Figure 03–04–2

D. Autoland system logic description

There is an AL function included in each PFCC, independent from the autopilot. The AL function on the active PFCC is used, the others are on standby.

The DMC contains the flight guidance and autothrottle functions (refer to Figure 03–04–3).

The approach is engaged when the APPR switch on the Flight Control Panel (FCP) is pushed.



Autoland system logic
Figure 03–04–3

E. Autoland modes and profile

The autoland function supplies approach, landing, and runway ground steering control during the modes that follow:

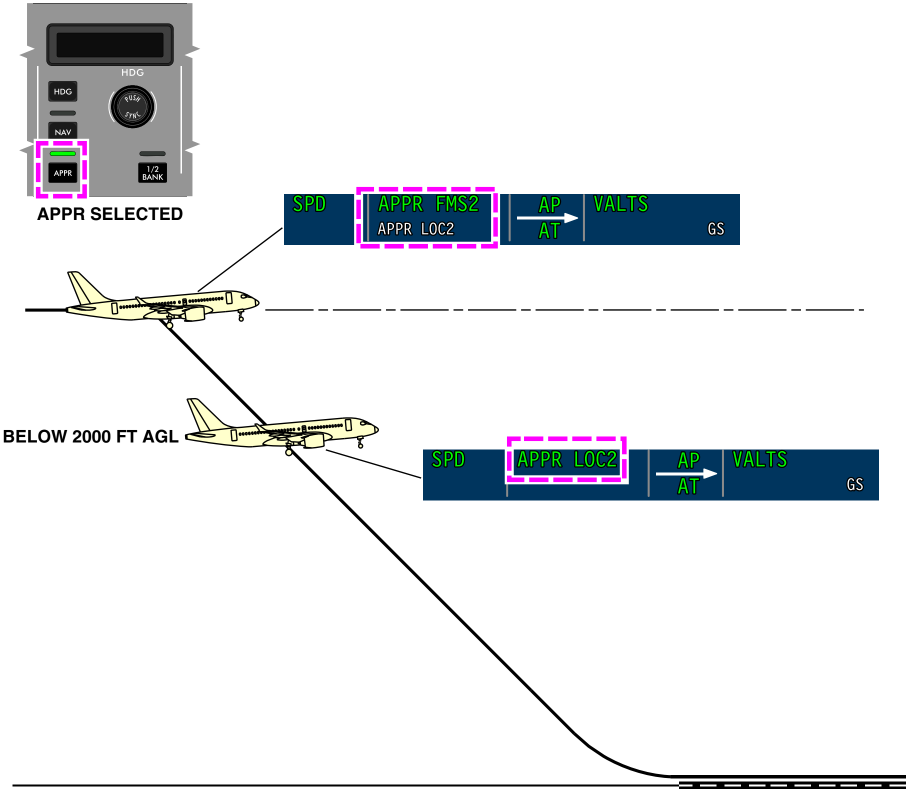
- Approach mode,
- ALIGN and FLARE modes,

- FLARE and RETARD modes, and
- ROLLOUT mode.

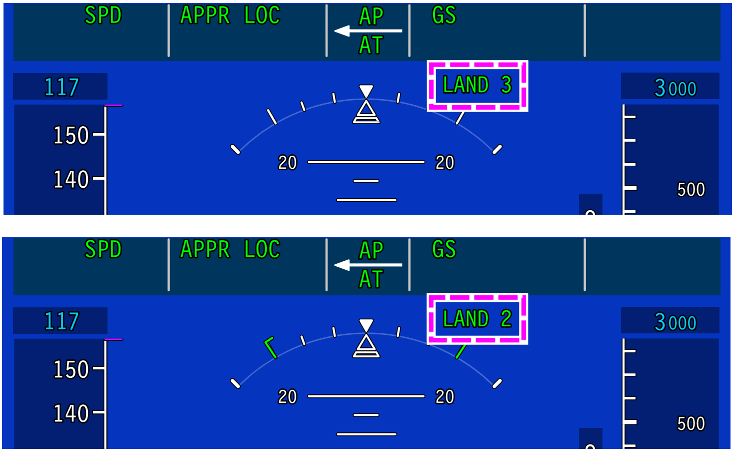
(1) Approach mode

When the approach mode is armed, the following occurs (refer to Figure 03–04–4 and Figure 03–04–5):

- APPR LOC1(2) replaces APPR FMS1(2) as the active mode and is displayed on the FMA after a NAV-to-NAV transfer (on PFD and HUD (if installed)).
- Below 2000 ft AGL, the FBW system transfers control from the DMCs to the PFCCs. APPR LOC1(2) changes to APPR LOC as the active lateral mode and is displayed on the FMA (PFD and HUD (if installed)).
- Between 1500 ft and 800 ft AAE, if the aircraft is configured for landing, Glideslope (GS) is captured and the autopilot is engaged, the autoland system displays the highest available autoland capability, LAND 2 or LAND 3 (if installed).



Approach mode
Figure 03–04–4

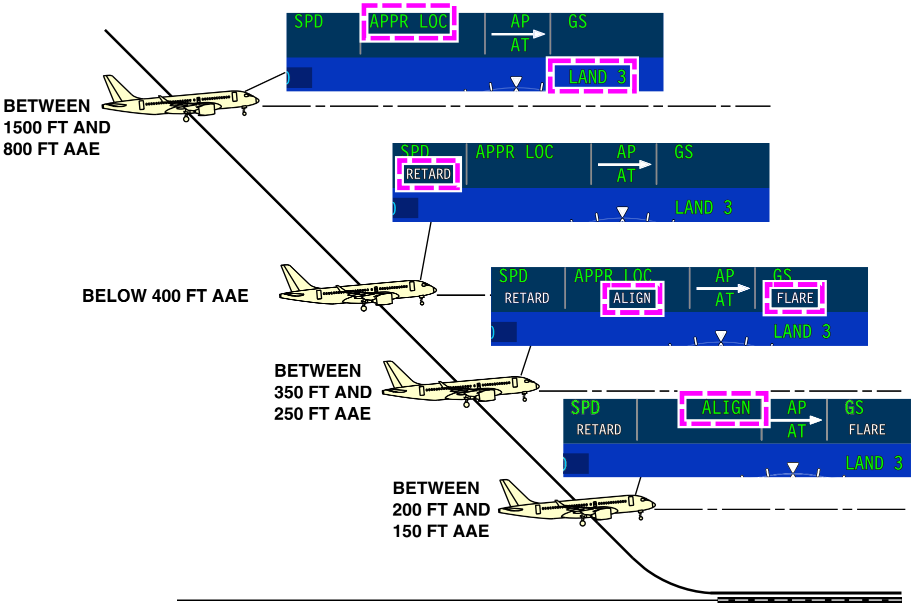


LAND 3 and LAND 2 indications
Figure 03–04–5

F. ALIGN and FLARE modes

After the autoland capability (LAND 2 or LAND 3) is displayed on the ASA, as the aircraft continues on the approach (refer to Figure 03–04–6):

- Below 400 ft AAE, RETARD arm mode is displayed on the FMA (PFD and HUD (if installed)).
- Between 350 ft and 250 ft AAE, ALIGN and FLARE arm mode are displayed on the FMA (PFD and HUD (if installed)).
- Between 200 ft and 150 ft AAE, ALIGN active mode is displayed on the FMA (PFD and HUD (if installed)), and the aircraft aligns toward the runway.



ALIGN and FLARE modes
Figure 03–04–6

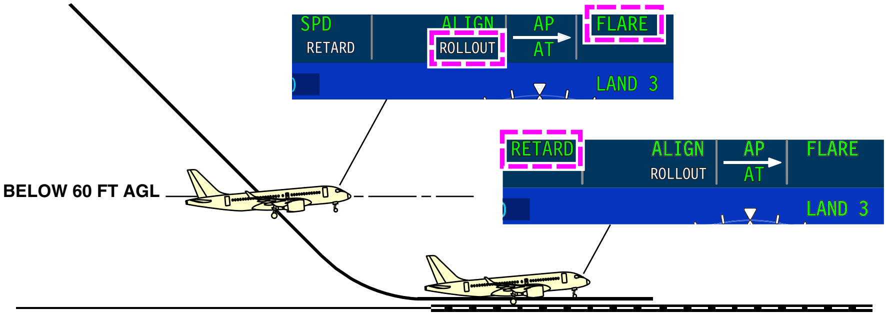
G. FLARE and RETARD modes

As the aircraft continues on the approach, below 65 ft AGL (refer to Figure 03–04–7):

- FLARE mode activates and the ROLLOUT mode is armed. The landing flare starts.

And finally, below 20 ft AGL:

- RETARD mode activates and the throttles are reduced to flight idle.



FLARE and RETARD modes
Figure 03–04–7

H. ROLLOUT mode

When the main landing gear touch down (refer to Figure 03–04–8, Figure 03–04–9):

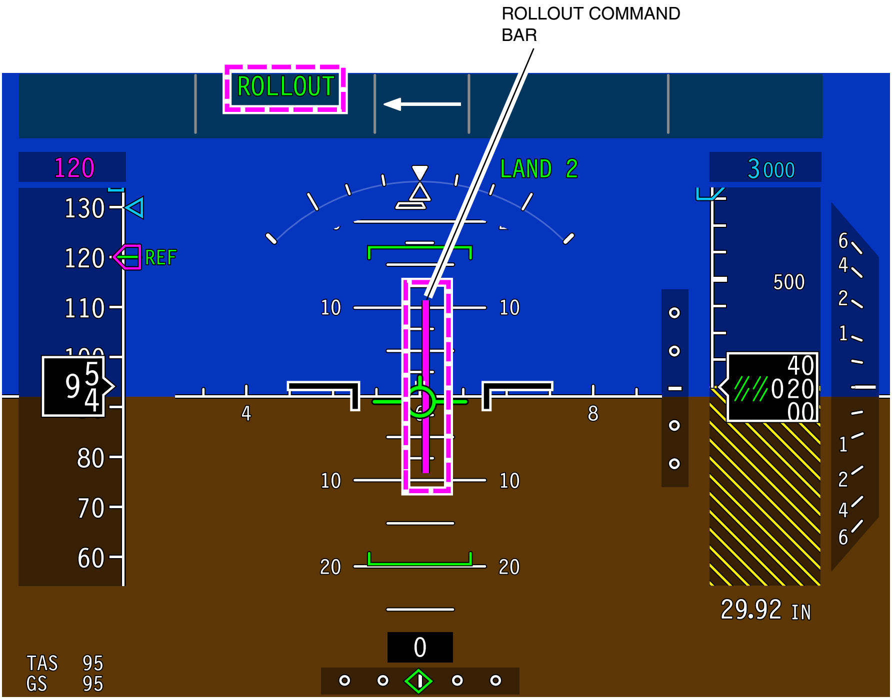
- ROLLOUT mode starts 2 seconds after Weight-On-Wheels (WOW).
- ROLLOUT arm mode changes to ROLLOUT active lateral mode, and the active vertical field of the FMA is removed.
- Aircraft de-crabs during crosswind conditions, and completes the de-rotation.
- ROLLOUT mode activates and uses rudder and Nosewheel Steering (NWS) to track the localizer beam down the runway.
- Autopilot rollout command bar is displayed on the PFD and on the HUD (if installed).
- All other FMA indications are removed.

The autopilot ROLLOUT command bar shows directional information toward the localizer centerline. It is used by the autoland system to track the localizer beam during the rollout. The autopilot stays engaged until the aircraft has come to a full stop. While the aircraft tracks the rollout commands, the rollout command bar is removed from the PFD (and HUD) at less than 30 kt ground speed.

Use of the NWS tiller or rudder pedal inputs will disengage the autopilot during the rollout.

NOTE

The AP disconnect switch on the FCP is disabled during autoland. Flight crews must use the A/P DISC on the sidestick.



ROLLOUT mode more than 30 kt ground speed
Figure 03–04–8

ROLLOUT mode less than 30 kt ground speed
Figure 03–04–9

I. Approach capability degradation (down-mode)

If the approach/autoland capability degrades during the approach, the system displays the highest available approach capability on the ASA.

(1) LAND 3 to LAND 2 degradation

If the approach mode degrades (down-modes) from LAND 3 to LAND 2 above 200 ft AGL, a NO LAND 3 message flashes in amber for 5 seconds, followed by a green LAND 2 steady message. HUD indications (if installed) are the same as the PFD (refer to Figure 03–04–10).

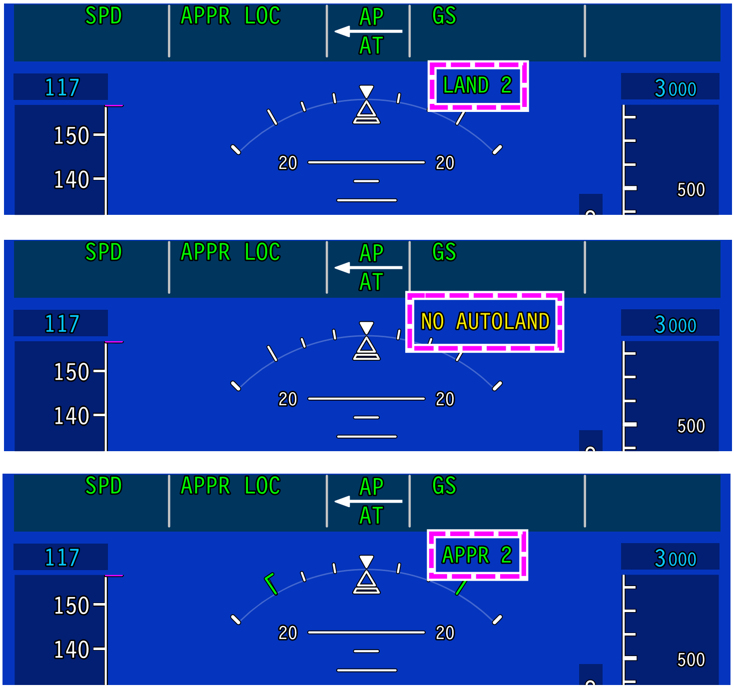
A triple click aural alert sounds when a degradation occurs.

Degradation LAND 3 to LAND 2
Figure 03–04–10

(2) LAND 2 to APPR 2 or APPR 1 degradation

If the approach capability degrades from LAND 2 to APPR 2 or APPR 1 above 200 ft AGL, an amber NO AUTOLAND message flashes for 5 seconds followed by a green steady APPR 2 or APPR 1 message. HUD indications (if installed) are the same as the PFD (refer to Figure 03–04–11).

A triple click aural alert sounds when a degradation occurs.



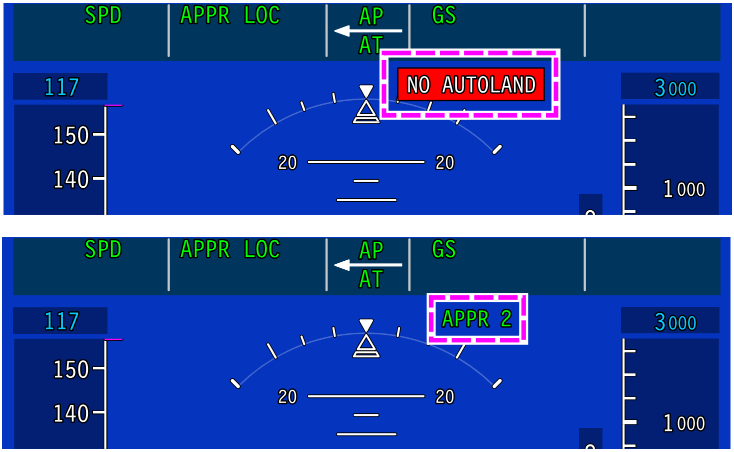
LAND 2 to APPR 2 or APPR 1 degradation above 200 ft AGL
Figure 03–04–11

(3) Loss of autoland capability below 200 ft AGL

If the LAND 2 approach mode degradation occurs below 200 ft AGL, the NO AUTOLAND warning message (white text on red background) flashes for 5 seconds, followed by a steady APPR 2 or APPR 1 message (green text). HUD indications (if installed) are the same as the PFD (refer to Figure 03–04–12).

A triple click aural alert sounds when a degradation occurs.

In this case, the AL function is no longer available.

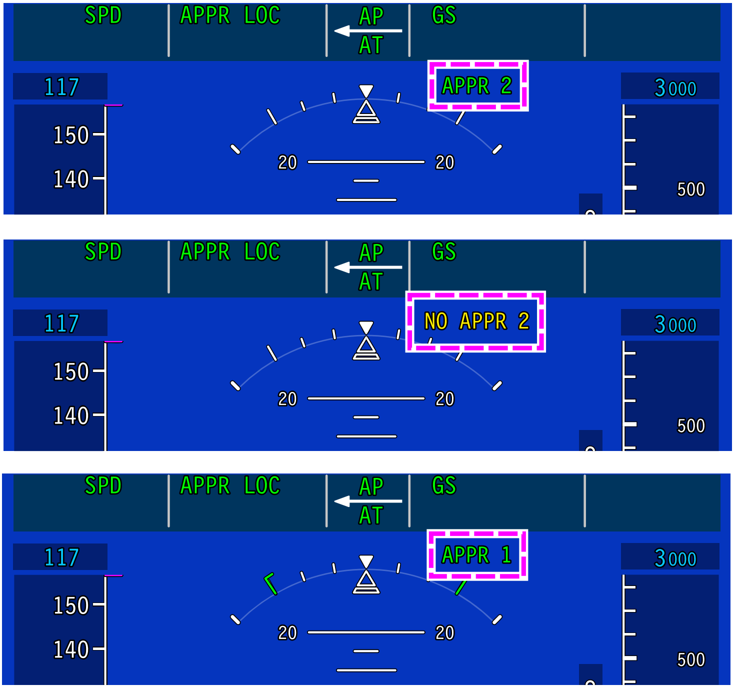


LAND 2 to APPR 2 below 200 ft AGL
Figure 03–04–12

(4) APPR 2 to APPR 1 degradation

If the approach capability degrades from APPR 2 to APPR 1 above 200 ft AGL, a NO APPR 2 message (amber text) flashes for 5 seconds, followed by a steady APPR 1 message (green text). HUD indications (if installed) are the same as the PFD (refer to Figure 03–04–13).

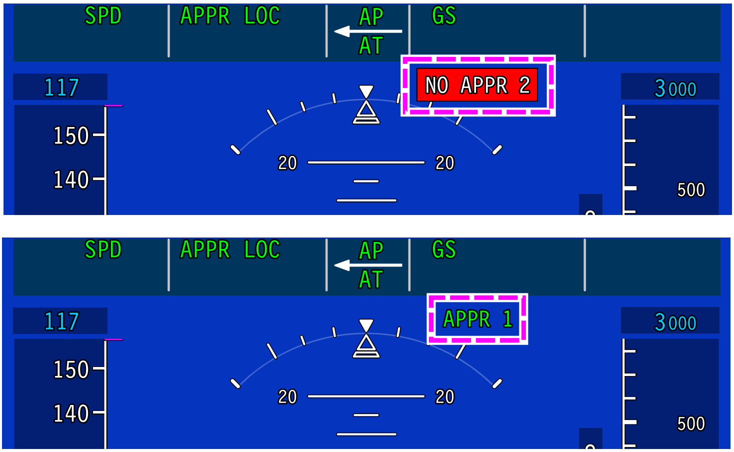
A triple click aural alert sounds when a degradation occurs.



APPR 2 to APPR 1 above 200 ft AGL
Figure 03–04–13

Below 200 ft AGL, the NO APPR 2 message (white text on red background) flashes for 5 seconds, followed by a steady APPR 1 message (green text). HUD indications (if installed) are the same as the PFD (refer to Figure 03–04–14).

A triple click aural alert sounds when a degradation occurs.



APPR 2 to APPR 1 below 200 ft AGL
Figure 03–04–14

J. Approach status annunciation

The table that follows gives all possible ASA annunciations and their operational descriptions (refer to Figure 03–04–15).

ASA	OPERATIONAL DESCRIPTION
NO AUTOLAND	Loss of autoland function at or below 200 ft AGL
NO APPR 2	Loss of ILS CAT II approach capability at or below 200 ft AGL
NO APPR 1	Loss of ILS approach capability above 200 ft AGL
NO APPR 2	Loss of ILS CAT II approach capability above 200 ft AGL
NO LAND 2	Loss of ILS CAT IIIA approach capability above 200 ft AGL
NO LAND 3	Loss of ILS CAT IIIB approach capability above alert height
NO AUTOLAND	Loss of autoland function above 200 ft AGL
APPR 1	ILS CAT I approach capable (no autoland)
APPR 2	ILS CAT II approach capable (no autoland)
LAND 2	ILS CAT III fail passive capable
LAND 3	ILS CAT III fail passive capable

Approach status annunciation
Figure 03–04–15

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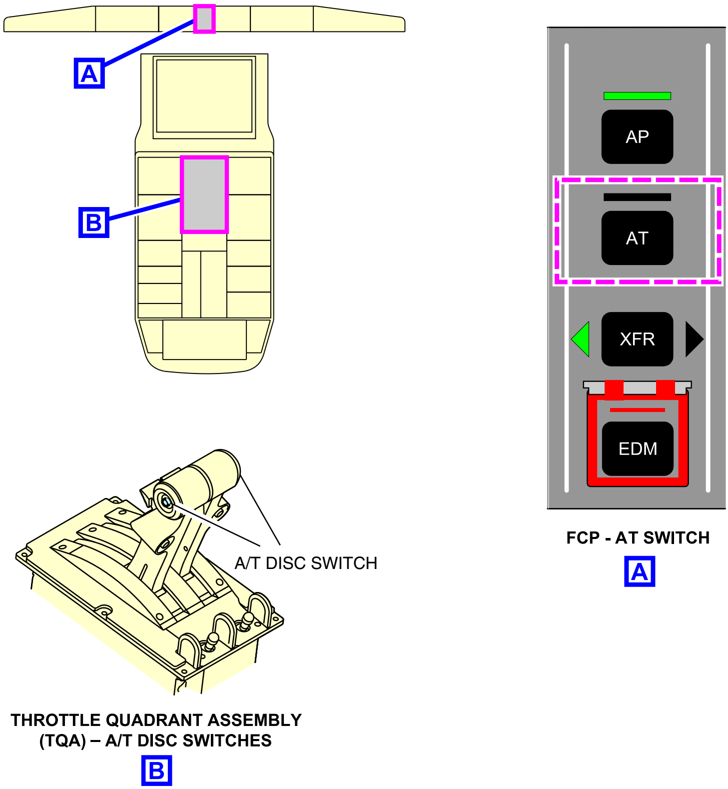
AT – OVERVIEW

The AT system automatically manages the engine thrust. During the complete flight profile, servomotors in the Throttle Quadrant Assembly (TQA) automatically position the thrust levers. The AT includes engine synchronization and is available during single-engine operation.

The AT system controls are on the FCP (AT switch) and on the TQA (A/T DISC switch) (refer to Figure 03–05–1).



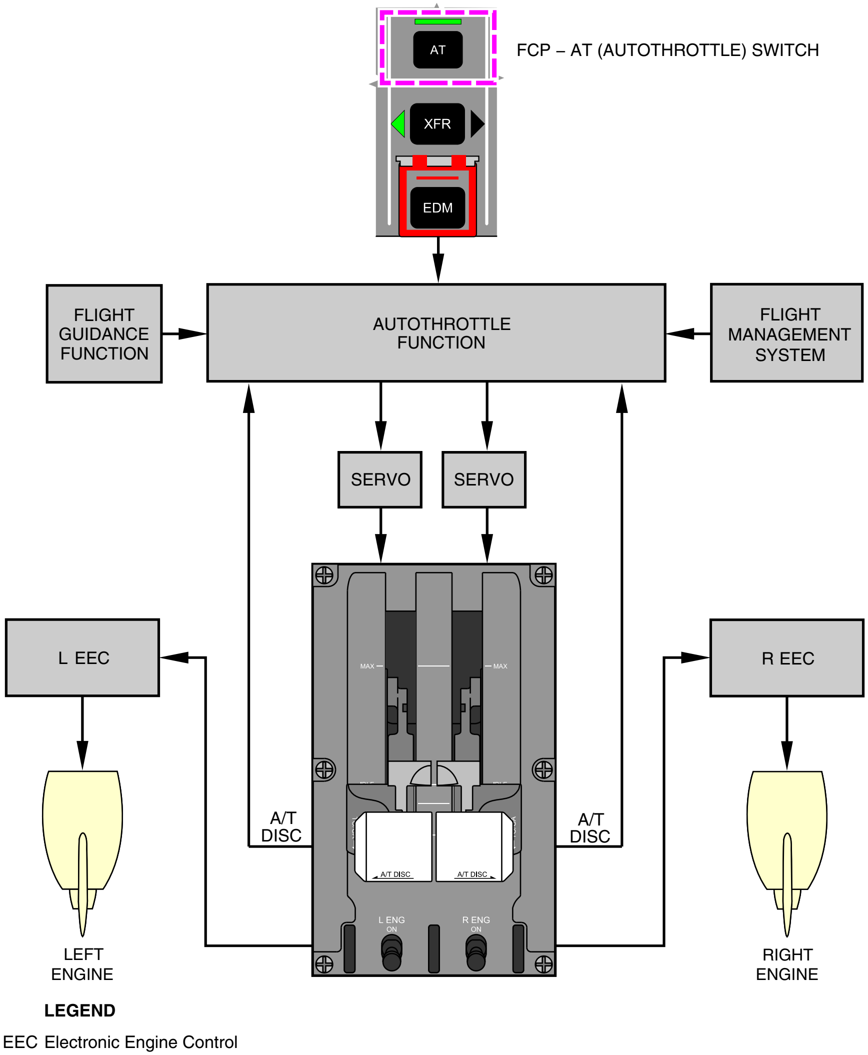
Autothrottle (AT) system controls
Figure 03–05–1

The AT is normally engaged manually. IT can also be engaged automatically in specific modes such as go-around, windshear escape modes, or EDM. The AT can be disengaged at any time.

The AT operation is highly integrated with the AFCS and FMS.

Each AFCS has one AT system application in each Data Concentrator Unit Module Cabinet (DMC). The AT system receives inputs from:

- The Flight Guidance (FG) system,
- The Electronic Engine Control (EEC),
- The Flight Control Panel (FCP),
- The Flight Management System (FMS), and
- Other systems. Refer to Figure 03–05–2.

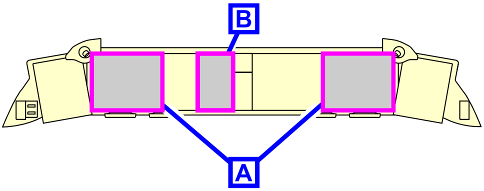


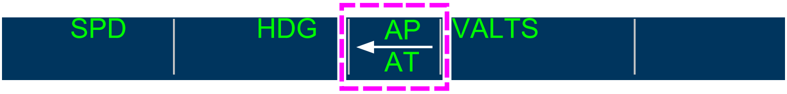
Autothrottle (AT) system
Figure 03–05–2

The AT sets a calculated thrust setting during takeoff, go-around, and flight level change vertical modes. In all other vertical modes it controls engine thrust to maintain the aircraft at a selected airspeed.

The AT also provides speed and thrust envelope limiting. Thrust envelope limiting is based on the active N1 thrust rating, while speed envelope limiting is based on minimum speed limits as well as limitations and maximum structural speeds.

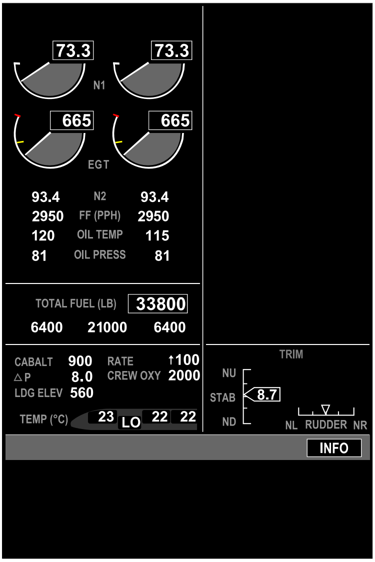
The AT system status is displayed on the FMA and fault messages are displayed on the EICAS page (refer to Figure 03–05–3).





FLIGHT MODE ANNUNCIATOR (FMA)

A



EICAS PAGE

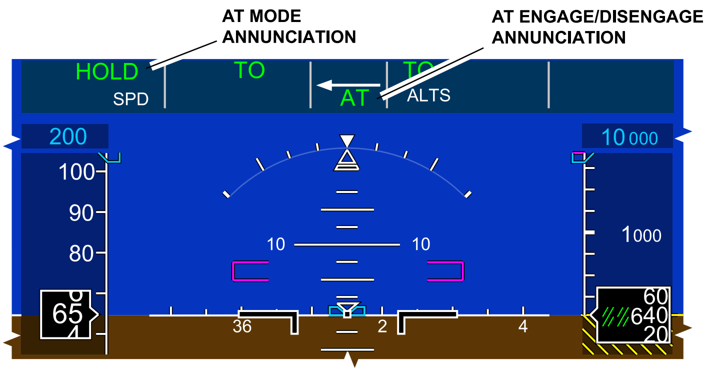
B

EICAS ADVISORY MESSAGE

Autothrottle (AT) system indications
Figure 03–05–3

(1) Autothrottle Operating Modes

The AT operating mode depends on the active FD vertical mode. The AT modes display on the left section of the FMA. Refer to Figure 03–05–4.



ACTIVE MODE INDICATIONS (AT MODE)	
SPD	Speed or Mach Control
THRUST	Thrust Control
HOLD	Takeoff Throttle Hold
RETARD	Retard
USPD	Underspeed
EDM	Emergency Descent Mode
LIM	Airspeed Limiting

ARMED MODE INDICATIONS (AT MODE)	
THRUST	Thrust Armed
SPD	Speed Armed
RETARD	Retard Armed

ADI – Autothrottle mode indications
Figure 03–05–4

The AT operates in the takeoff hold mode (HOLD) to maintain takeoff thrust from 60 knots to 400 feet AGL.

The AT operates in thrust mode (THRUST) and maintains a specific thrust setting when the following FD vertical modes are active:

- Takeoff (TO),
- Flight level change (FLC),
- Go-Around (GA), and
- Windshear escape (WSHR).

The AT operates in speed control mode (SPD), by controlling thrust lever movement to maintain a selected or FMS-controlled airspeed in the following FD vertical modes:

- Altitude hold (ALTS),
- Vertical speed (VS),
- Vertical path (VPATH),
- Vertical glide path (VGP),
- Glideslope (GS), and
- Flight path angle (FPA).

NOTE

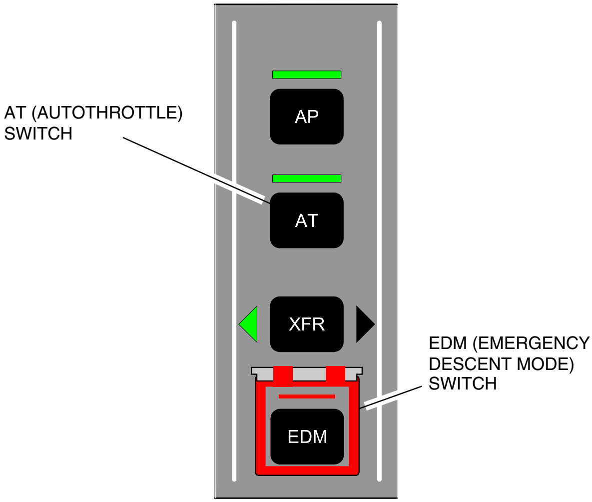
The AT mode flashes for 5 seconds on the FMA when the AT mode changes, then becomes steady.

AT – DESCRIPTION AND OPERATION

A. AT engagement

(1) Manual engagement

On ground, pressing the AT switch on the FCP (refer to Figure 03–05–5) arms the AT system. Thrust mode is armed and THRUST displays in white in the autothrottle section of the FMA (far left).



FCP – AT (Autothrottle) and EDM (Emergency Descent Mode) switch
Figure 03–05–5

The AT engages when the thrust levers move past the 23-degree Thrust Lever Angle (TLA) position. The AT modes display as active and/or armed, according to the flight segment (takeoff, climb, cruise, approach).

In flight, the AT system engages regardless of thrust lever position when:

- The AT switch is pressed,
- The TOGA switch is pressed, or
- The Emergency Descent Mode (EDM) switch is pressed.

(2) Automatic engagement

The AT system will automatically engage in specific modes as:

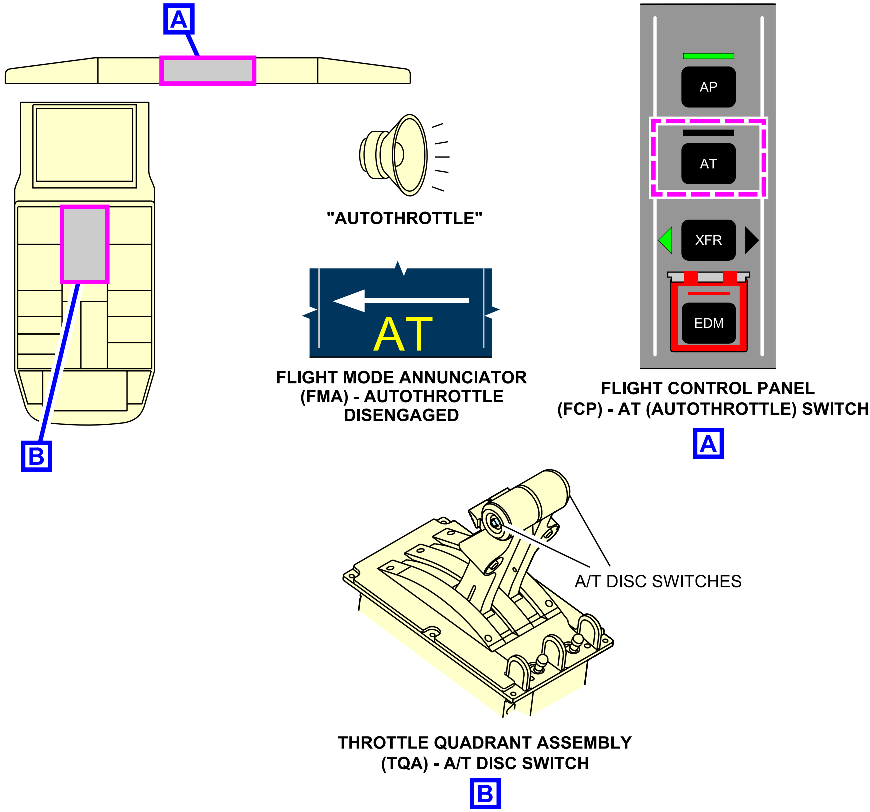
- EDM (activated either manually or automatically),
- Go-Around (is selected), or

- Windshear escape guidance mode.

B. AT disengagement

The AT system is disengaged (refer to Figure 03–05–6) by the actions that follow:

- Pressing the A/T DISC switch on the thrust levers,
- Moving the thrust levers (some force may be necessary),
- Pressing the AT switch on the FCP if engaged, or
- AT system failure detected (advisory EICAS message **AT FAIL** is displayed on the EICAS page).



Autothrottle (AT) system disengagement
Figure 03–05–6

C. AT – Thrust mode

During the thrust control mode, the AT system controls engine thrust to an N1 rating based on the current phase of flight. The thrust control mode is associated with the FG modes that follow:

- Takeoff (TO, VTO),

- Emergency Descent Mode (EDM),
- Flight Level Change (FLC, VFLC), and
- Go-Around (GA, VGA).

The AT provides thrust to maintain a programmed rate of climb or descent proportional to the magnitude of the selected altitude change.

When the selected altitude is captured, the AT thrust mode (THRUST) changes to speed mode (SPD).

D. AT – Takeoff Mode (TO)

During the TO mode, the AT system sets the engine thrust to the takeoff (N1) rating selected through the FMS. When the GA mode is selected, the AT system sets the thrust to a GA thrust rating.

At takeoff, the AT operates in two modes: THRUST mode and HOLD mode.

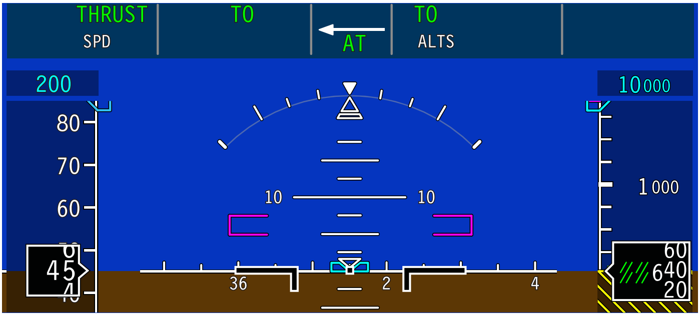
Before takeoff, the AT is armed by pressing the AT switch on the FCP. The takeoff thrust mode is armed and THRUST displays white on the far left side of the FMA (autothrottle section).

At sea level condition, when the thrust levers are advanced through the 23-degree thrust lever angle position (approximately 68% of N1), the AT activates and takes over thrust lever control to reach and maintain the takeoff N1 selected through the FMS. THRUST displays in green and SPD displays white (armed).

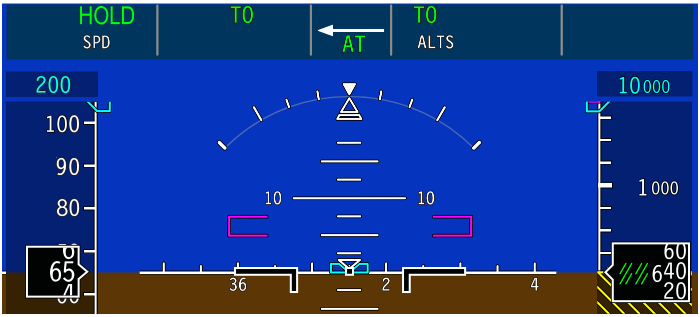
When the airspeed increases above 60 KIAS, the HOLD mode activates to maintain the current thrust until the aircraft reaches 400 ft AGL. HOLD displays in green on the FMA.

Above 400 ft AGL, the THRUST mode reactivates and THRUST displays in green on the FMA. The AT maintains the active N1 engine rating (manually or automatically selected). Refer to Figure 03–05–7.

ON GROUND THRUST ARMED



ON GROUND BELOW 60 KT THRUST TO TAKEOFF

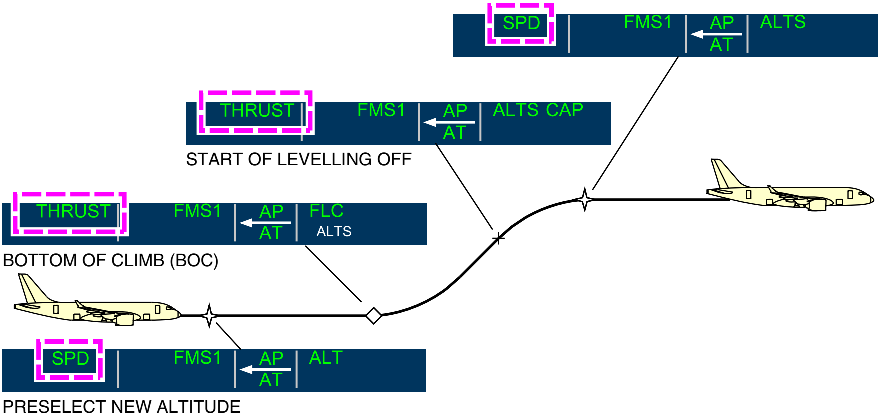


ON GROUND ABOVE 60 KT

ADI – Takeoff mode
Figure 03–05–7

E. AT – Flight Level Change (FLC, VFLC)

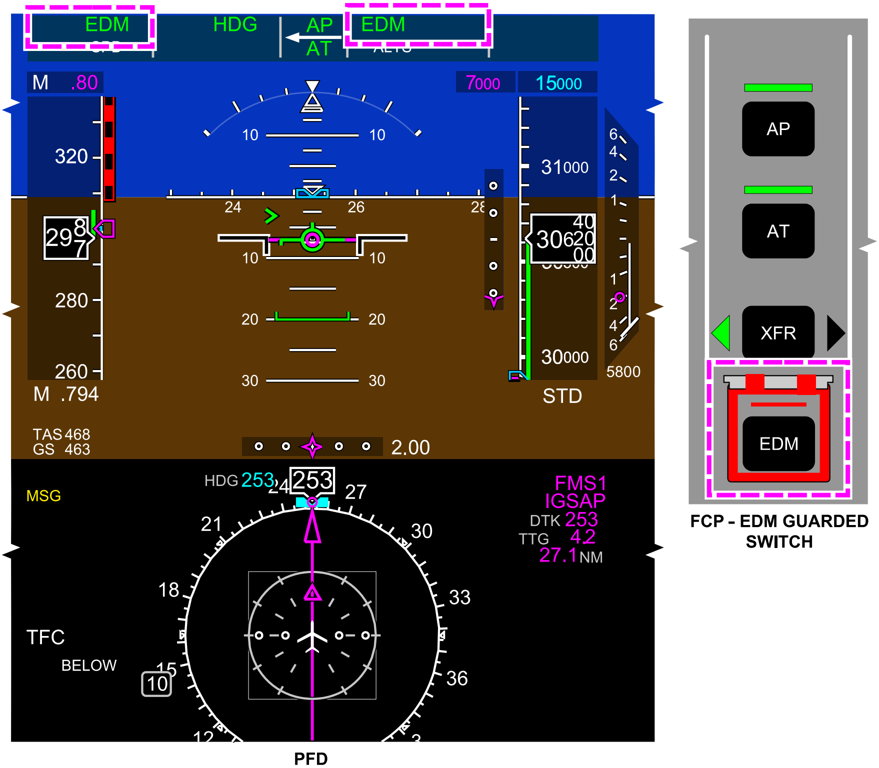
When the FLC mode is selected through the FCP or by the FMS (VFLC mode) in a VNAV mode, the AT system will set climb thrust for a climb or flight idle for a descent. The climb thrust rating can be selected manually by the flight crew through the FMS as CLB, CLB1 or CLB2. Refer to Figure 03–05–8.



THRUST mode
Figure 03–05–8

F. AT – Emergency Descent Mode (EDM)

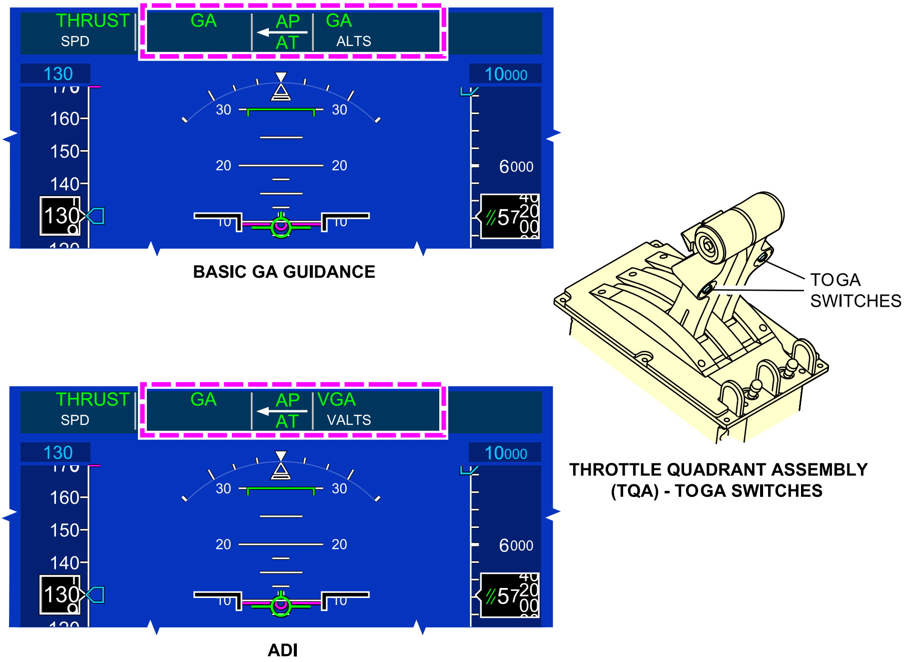
When the EDM is activated manually (EDM guarded switch on the FCP) or automatically, the AT system retards the thrust levers to the idle position. Refer to Figure 03–05–9.



PFD – Emergency Descent Mode indication
Figure 03–05–9

G. AT – Go-Around

When either TOGA switch is pressed, the AT advances the thrust lever to go-around thrust. The AT thrust mode is activated and THRUST displays in green on the FMA. If the aircraft is in the rollout mode during autoland, the TOGA switch is inhibited (refer to Figure 03–05–10).



TOGA switches engage indications
Figure 03–05–10

H. AT – Speed (SPD) mode

The AT SPD mode maintains the indicated airspeed (or Mach number) selected with the SPD switch on the FCP, or automatically selected from FMS active flight plan.

The mode is active with AT engaged and with one of the active modes that follow:

- Altitude select (ALTS, VALTS),

- Altitude hold (ALT, VALT),
- Vertical Speed (VS, VVS),
- Vertical Path (VPATH),
- Vertical Glide Path (VGP),
- Glideslope (GS), and
- Flight Path Angle (FPA, VFPA).

In the airspeed control mode (SPD), the AT maintains a selected IAS or MACH when one of the following FD vertical modes is selected:

- Altitude hold (ALT and ALT CAP),
- Vertical Speed (VS),
- Flight Path Angle (FPA), or
- Vertical Navigation (VNAV–VPATH or VNAV–VGP).

The speed reference used by the AT system can be selected manually with the SPD switch on the FCP, or through the FMS. When it is selected, SPD (green) indication is displayed on the FMA. Refer to Figure 03–05–11.

ADI

ADI – Speed (SPD) mode indication
Figure 03–05–11

If a speed reference cannot be achieved by the AT, a LIM (amber) indication is displayed on the FMA. The AT is limited to the N1 speed limit displayed on the EICAS page (engine section). If no FG system is active, the AT provides a basic speed hold control. Refer to Figure 03–05–12.

ADI

Speed Mode Limits indication
Figure 03–05–12

The low speed protection mode works to maintain the airspeed within the upper and lower speed limits. The AT reduces the engine thrust to not exceed upper speed limits (V_{MO}, M_{MO}, gear, flap, or placarded speeds). When the airspeed is below a minimum speed, the AT increases engine thrust to increase speed.

I. AT – Retard mode

The AT retard mode (RETARD) automatically reduces both thrust levers to idle at a fixed rate. The mode activates when the aircraft reaches approximately 30 ft AGL. When conducting an autoland, the T+RETARD will reduce the throttles to idle between 20 ft and 15 ft AGL. The AT stays engaged until touchdown to supply go-around thrust, if required. The AT automatically disconnects 2 seconds after main wheel touchdown, however the “AUTOTHROTTLE” aural alert will not sound.

NOTE

If the necessary conditions are not met for the retard mode, the AT remains in speed mode until touchdown. The AT disengages upon landing but the thrust levers are not reduced to idle.

J. AT system – One Engine Inoperative (OEI)

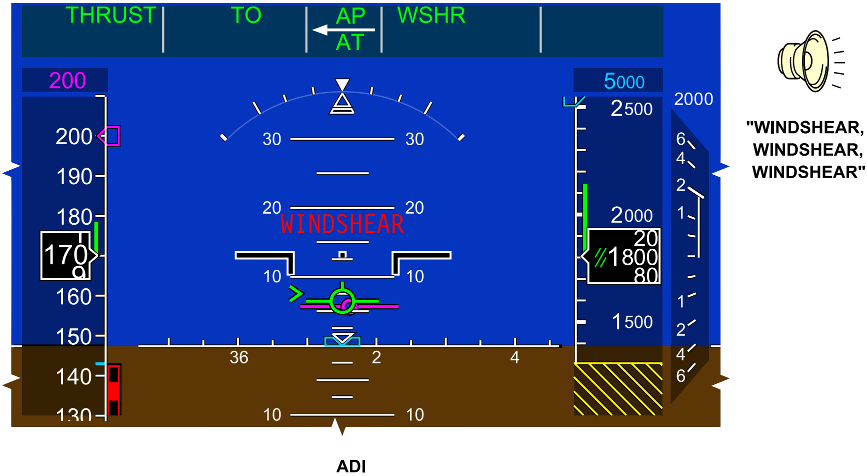
The AT stays active during OEI. The AT system stops commanding the thrust lever for the inoperative engine. Even if the flight crew moves the thrust lever for the failed engine, it will not affect the AT and the system will stay engaged. If the flight crew moves the thrust lever for the operating engine, the AT system will disengage.

If a failed engine is restarted, the AT does not control the restarted engine. The AT pushbutton must be pressed twice (OFF/ON) for the AT to control both engines.

K. AT – Windshear (WSHR) escape mode.

When in the windshear escape mode (activated by a TAWS windshear warning and by pressing the TO/GA switch), the AT system moves the thrust levers to Takeoff (TO) or Go Around (GA). The AT system keeps the thrust rating until the windshear warning is no longer present. Refer to Figure 03–05–13.

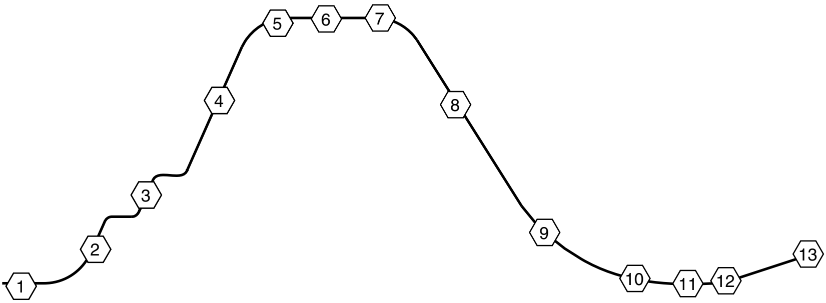
The flight crew can override the AT system by moving the thrust levers to a maximum rating.



ADI – Windshear escape guidance mode indications
Figure 03–05–13

L. AT and FD modes summary

Figure 03–05–14 describes the different possible modes for various phases of flight.



FLIGHT PHASE	FD VERTICAL MODE	AUTOTHROTTLE FUNCTION
1 Takeoff Roll	Takeoff (TO)	Sets takeoff or flex thrust to the MAX or FLEX N1 rating.
2 Climb Out	Takeoff (TO)	Throttle servos remain depowered until 400 ft. Above 400 ft AGL A/T controls to active MAX or FLEX T/O EPR rating.
3 Small Flight Level Changes	FLC, VLFC, FPA, VS	Reduced climb thrust during FLC and VFLC. Airspeed control during FPA and VS.
4 Large Flight Level Changes	FLC, VLFC, FPA, VS	Full climb thrust during FLC and VFLC. Airspeed control during FPA and VS.
5 Top of Climb	ALT CAP, VALT CAP	Airspeed control.
6 Cruise	ALT, VALT, ALTS	Airspeed control.
7 Top of Descent	FLC, VFLC, VS	Transition to idle thrust during FLC and VFLC. Airspeed control for VS.
8 Descent	FLC, VFLC, FPA, VS, VPATH	Full idle thrust during FLC and VFLC. Airspeed control during FPA, VS and VPATH.
9 Approach	Glideslope/Glidepath Track	Airspeed control.
10 Flare	Glideslope/Glidepath Track	Thrust retard to idle stop.
11 Landing/Roll	N/A	Disengaged.
12 Go–Around	Go–Around	Sets TO.
13 Windshear	Windshear	Sets TO.

Example Autothrottle (AT) profile
Figure 03–05–14

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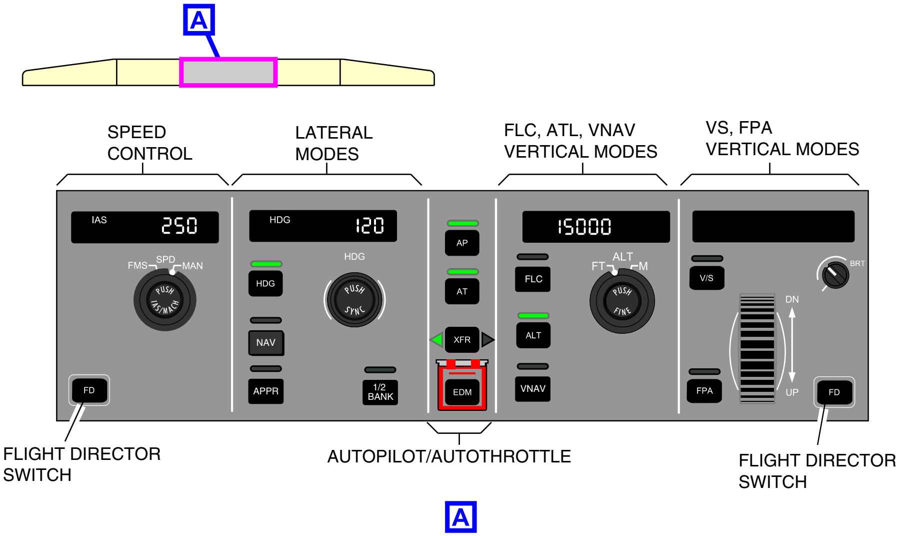
FLIGHT CONTROL PANEL (FCP)

The flight crew uses the Flight Control Panel (FCP) on the glareshield to provide data inputs to the Automatic Flight Control System (AFCS).

The FCP (refer to Figure 03–06–1) has the following available selections:

- Airspeed and vertical speed,
- Flight Director (FD),
- Lateral mode,
- Vertical mode,
- Altitude pre-selection, and
- Autopilot (AP), Autothrottle (AT), and transfer (XFR).



Flight Control Panel (FCP)
Figure 03–06–1

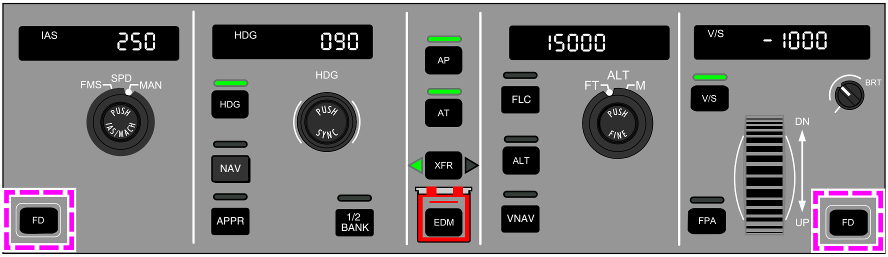
The FCP controls are:

- Two FD (Flight Director) switches,

- SPD (Speed) rotary switch,
- HDG (Heading) rotary switch,
- HDG (Heading) switch,
- NAV (Navigation) switch,
- APPR (Approach) switch,
- 1/2 BANK switch,
- AP (Autopilot) switch,
- AT (Autothrottle) switch,
- XFR (Transfer) switch,
- EDM (Emergency Descent Mode) guarded switch,
- FLC (Flight Level Change) switch,
- ALT (Altitude) rotary switch,
- ALT (Altitude) hold switch,
- VNAV (Vertical Navigation) switch,
- V/S (Vertical Speed) switch,
- FPA (Flight Path Angle) switch,
- UP/DN wheel, and
- BRT (Brightness) switch.

A. FD switch

There are two FD switches: one for the pilot and one for the copilot (refer to Figure 03–06–2). The FD switch displays the Flight Guidance (FG) system pitch and roll commands on the Primary Flight Display (PFD) and the associated mode on the Flight Mode Annunciator (FMA). The FG commands are displayed on both PFDs regardless of which FD switch is pressed. The FD switch selection and display follows a logic that depends on the AP system status.



Flight Director (FD) switch
Figure 03–06–2

If the AP is engaged:

- The FD switch selection on the coupled side is deactivated, and
- The FD switch selection on the uncoupled side toggles the FD on or off only on the uncoupled side.

If the AP is engaged or disengaged and the APPR (Approach) mode is active (LOC and GS are captured):

- The FD switch selections on both sides are deactivated.

NOTE

If the FD system fails, the caution message **FD FAIL** is displayed on the EICAS page.

B. SPD switch (rotary)

The SPD switch lets the flight crew select the speed reference source from either the FMS (Flight Management System) or MAN (Manual). It also allows selection of the display format of the speed reference in the readout window on the FCP in either Indicated Air Speed (IAS) or MACH.

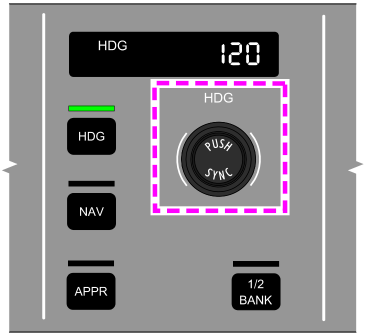
With the FMS speed reference source is selected, the speed reference is automatically computed, the speed readout window on the FCP goes blank, and if the switch is rotated while FMS is selected, the speed value will change on the readout window and then it will time out and go blank.

With the MAN speed reference source is selected, the speed reference value is manually selected with the rotating SPD switch. The speed value will be displayed on the readout window on the FCP, and the speed bug will be displayed on the airspeed tape on the PFD.

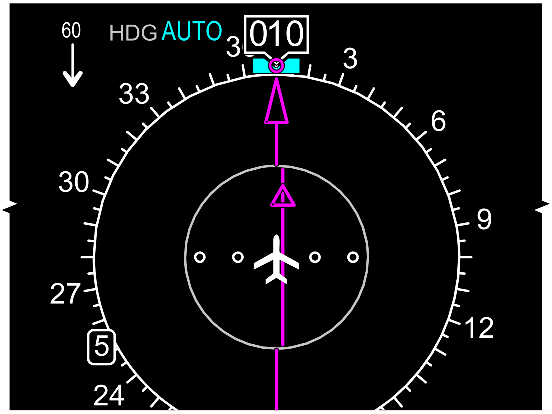
Pushing the SPD switch selects the speed display on the readout window between IAS and MACH. The airspeed value on the readout window switches automatically to MACH when the aircraft altitude is above 31500 feet. If MACH is selected, the value displayed on the PFD (on the airspeed tape and the speed bug) stays in knots. The speed display reverts to IAS when the aircraft altitude descends below 31500 feet.

C. HDG switch (rotary)

Turning the HDG rotary switch selects the heading value to be displayed on the heading readout window of the FCP (refer to Figure 03–06–3).



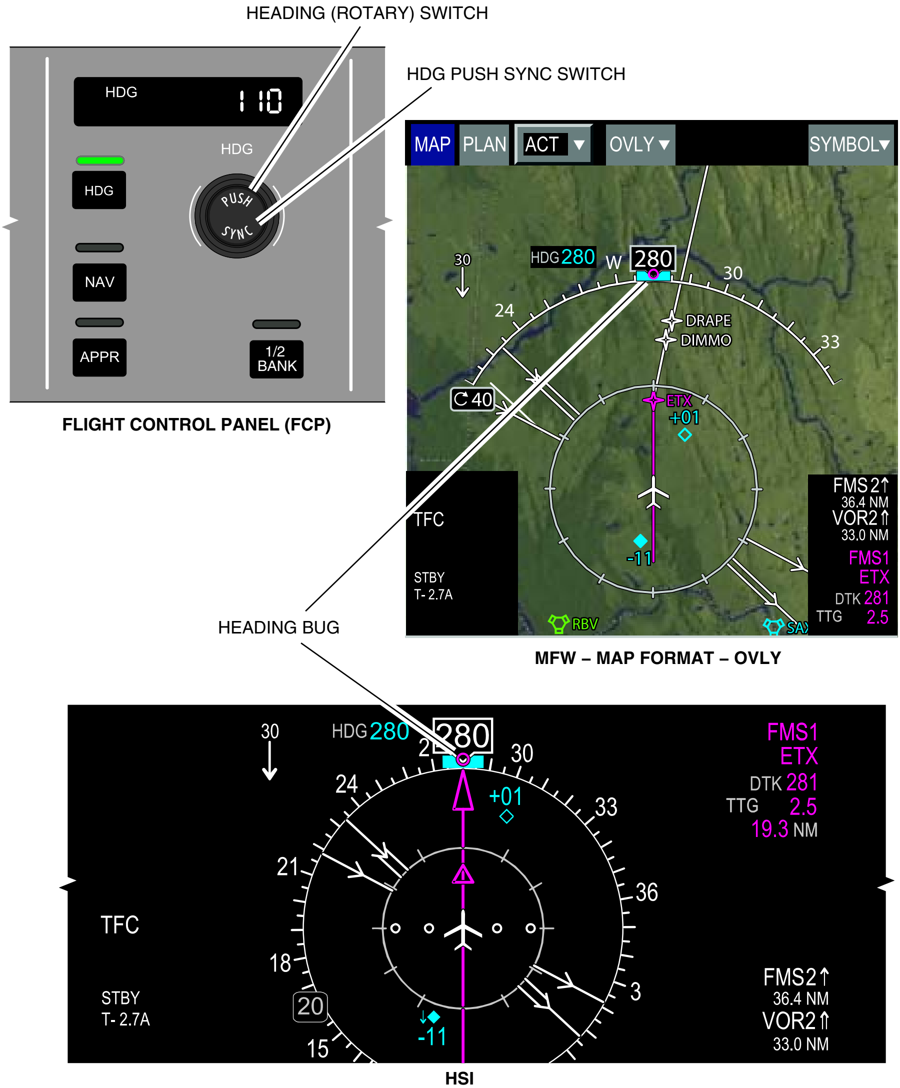
FCP – HDG ROTARY SWITCH



HSI

FCP – HDG rotary switch
Figure 03–06–3

It also moves the heading bug on the MAP and on the HSI. Refer to Figure 03–06–4.



Heading bug display
Figure 03–06–4

The heading bug automatically synchronizes with the actual aircraft heading during the situations that follow:

- When the Takeoff (TO) or Go Around (GA) mode is active,
- When the AFCS fails and reverts to basic lateral mode (heading), or
- When the PUSH SYNC switch is pressed.

If the PUSH SYNC switch is pressed while the NAV or APPR mode is active:

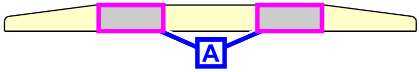
- The heading bug synchronizes with the actual aircraft heading,
- AUTO is displayed on the HSI, and
- The HDG readout window goes blank.

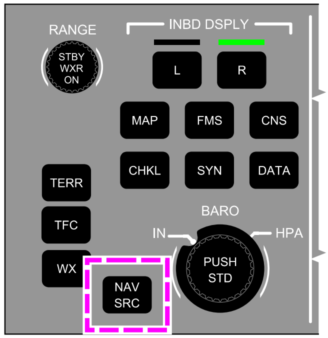
D. HDG switch

The HDG switch selection activates the heading mode to capture and maintain the selected heading. When selected, HDG is shown on the FMA.

E. NAV switch

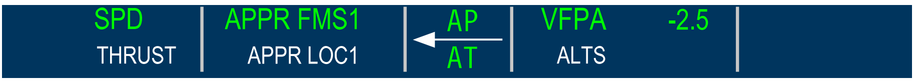
The NAV switch is used to select the lateral NAV mode. The source (FMS, LOC, or VOR) for the NAV mode is selected with the NAV SRC switch on the Control Tuning Panel (CTP). The source selection is indicated on the FMA (FMS, LOC, or VOR). Refer to Figure 03–06–5.





CTP - NAV SRC (NAVIGATION SOURCE) SWITCH

A

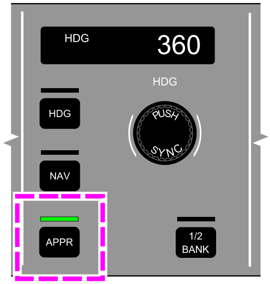


FMA - NAVIGATION SOURCE INDICATION

Navigation source selection
Figure 03–06–5

F. APPR switch

The APPR switch is used to select the approach mode (VOR approach, FMS approach, or ILS front or back course approach). Roll commands are generated by the Flight Guidance (FG) system to capture the lateral navigation source (FMS, VOR, or LOC). Once the lateral source is captured, pitch commands are generated by the FG system to capture the vertical navigation source (Glideslope (GS) or FMS). The approach mode has an associated APPR annunciation on the FMA. Refer to Figure 03–06–6.



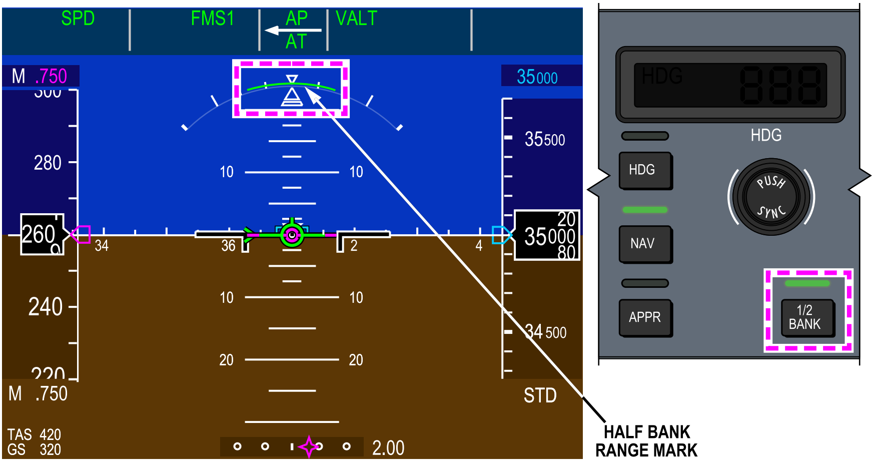
FLIGHT CONTROL PANEL (FCP) - APPR (APPROACH) SWITCH

FMA - APPROACH MODE INDICATION

Approach mode selection and indication
Figure 03–06–6

G. 1/2 BANK switch

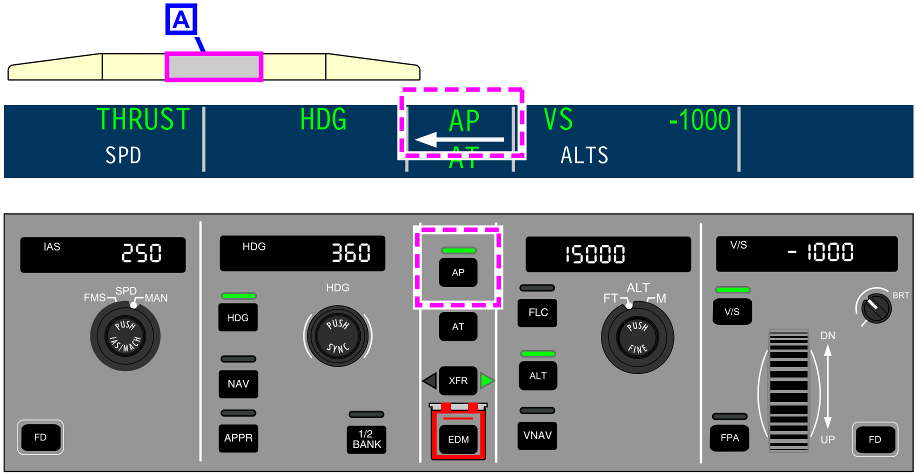
The 1/2 BANK switch selection reduces the bank limit of the AP system. The 1/2 BANK switch can be manually selected. The function is automatically selected as the aircraft climbs through 31500 feet or deactivated as the aircraft descends through 31500 feet. When the switch is pressed, a green arc is displayed on the top of the Attitude Direction Indicator (ADI) on the PFD. If the switch is pressed again, the 1/2 bank function deactivates. The switch can also be manually deactivated by the pilot above 31500 feet. Refer to Figure 03–06–7.



1/2 Bank mode selection and indication
Figure 03–06–7

H. AP switch

The AP switch is used to engage and disengage the AP system. The selection has an associated annunciation on the FMA. Refer to Figure 03–06–8.



FLIGHT CONTROL PANEL - AUTOPILOT (AP) SWITCH

A

Flight Control Panel (FCP) – AP (Autopilot) switch
Figure 03–06–8

When the AP switch is pressed:

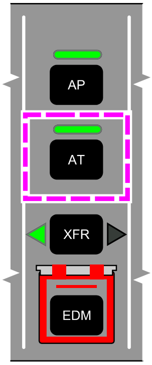
- The AP system engages,
- The green light above the switch illuminates, and
- The AP indication is displayed in green on the FMA.

If the AP switch is pressed a second time:

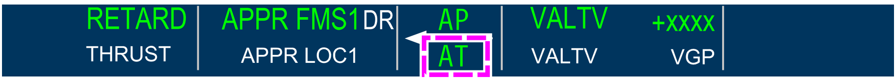
- The AP system disengages,
- The green light above the AP switch goes out,
- The AP indication displayed on the FMA flashes red, and
- There is an aural alert in the flight compartment.

I. AT switch

The AT switch on the FCP is used to engage and disengage the AT function (refer to Figure 03–06–9).



FLIGHT CONTROL PANEL (FCP) - AT (AUTOTHROTTLE) SWITCH



FMA - AT INDICATION

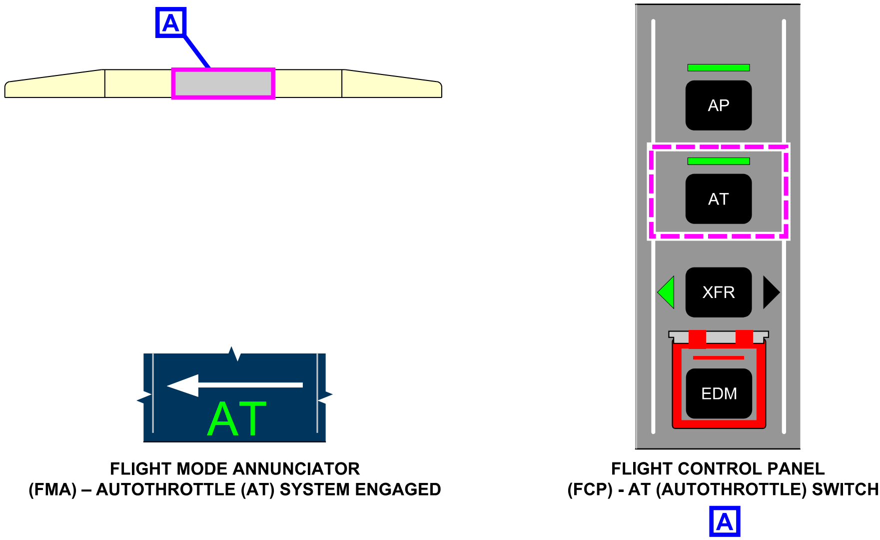
Autothrottle (AT) system selection and indication
Figure 03–06–9

(1) On ground

The AT system is armed by pressing the AT switch on the FCP. When it is armed, a white AT indication will be displayed on the FMA. The AT engages when the thrust levers are moved past 23 degrees TQA angle. When the AT system is engaged, the green light above the switch illuminates and a green AT indication is displayed on the FMA.

When the AT switch is pressed a second time, the AT system disengages and the green light above the switch goes out.

Figure 03–06–10 shows the AT system engaged.



Autothrottle (AT) system engagement
Figure 03–06–10

(2) In flight

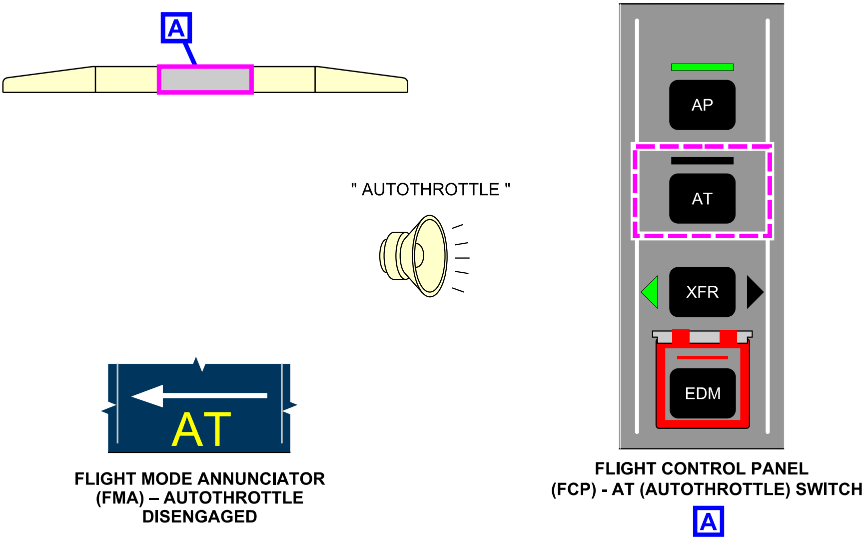
When the AT switch is pressed:

- The AT system engages,
- The green light above the switch illuminates, and
- A green AT indication is displayed on the FMA.

When the AT switch is pressed a second time:

- The AT system disengages,
- The green light above the switch goes out,
- A flashing amber AT indication is displayed on the FMA, and
- An "AUTOTHROTTLE" aural alert is heard in the flight compartment and continues until it is acknowledged by the flight crew.

Figure 03–06–11 shows the AT system disengaged.



Autothrottle (AT) system disengagement – AT switch
Figure 03–06–11

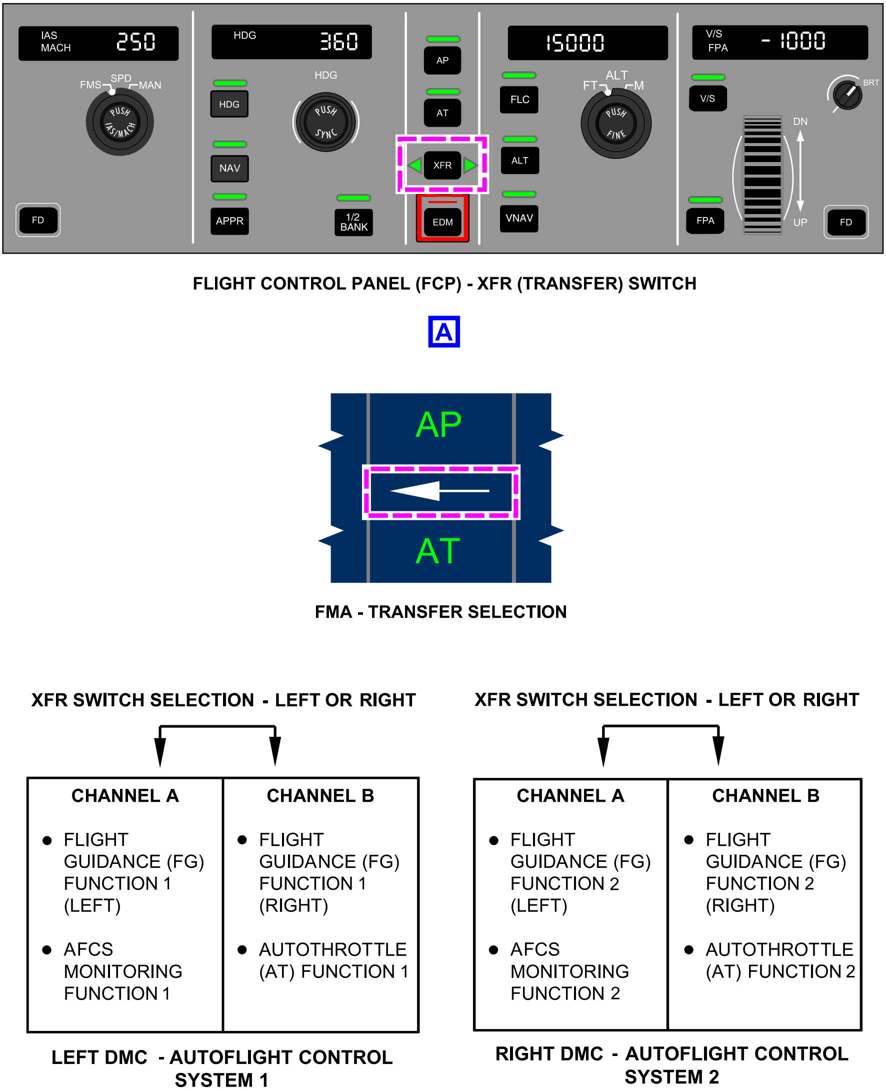
J. XFR switch

The XFR switch on the FCP is used to select which channel (A or B) in the DCU Module Cabinet (DMC) will supply the flight guidance. It also selects which sensors will be used by the Flight Director (FD) system.

When the XFR switch on the FCP is pushed (refer to Figure 03–06–12):

- The FD and the AT systems revert to the other source (in either DMC channel A or channel B),
- The direction of the coupled white arrow on the FMA changes, and
- The left or right green light beside the XFR switch on the FCP is illuminated (based on the selected direction).

When the XFR switch is selected, the lateral and vertical mode will revert to basic mode of HDG and FPA for the selected side. The autopilot will follow the current selected heading and vertical path of the aircraft until a different selection is made.



Flight Control Panel (FCP) – XFR (transfer) switch
Figure 03–06–12

K. EDM guarded switch

The EDM guarded switch selection on the FCP activates an emergency descent. When the EDM guarded switch is activated, the AP system and the AT system engage (if not already engaged) and the EDM annunciation is displayed on the FMA.

For more details, refer to the Emergency Descent Mode (EDM) section.

L. FLC switch

The FLC switch is used to select the flight level change mode. When the FLC switch is pressed, the green light above it illuminates. The FG system generates commands to capture the preselected altitude while maintaining the reference speed. In FLC mode, the AT will go to either flight idle or climb thrust, while the elevator is used to maintain speed. The switch selection shows an FLC or a Vertical Navigation Flight Level Change (VFLC) annunciation on the FMA.

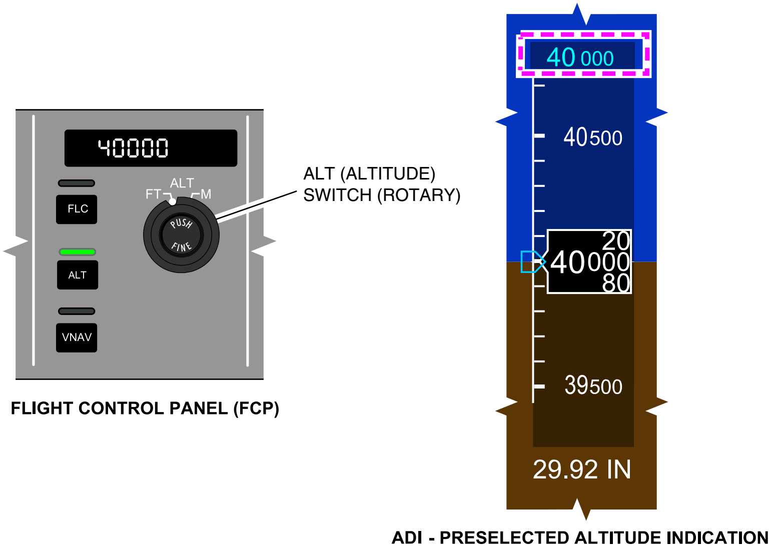
When VNAV mode is active, the first selection of the FLC switch engages the VFLC mode and the second selection disengages VFLC.

NOTE

The FLC mode is inhibited when GS is the active vertical mode.

M. ALT rotary switch

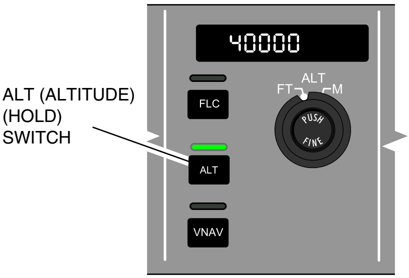
The ALT rotary switch is used to set the altitude which is displayed on the altitude tape on the PFD and in the window on the FCP (refer to Figure 03–06–13). The outer knob of the switch is used to select the units of altitude in feet (FT) or meters (M). The inner knob (PUSH FINE) is used to select the desired altitude. The default altitude increments are in 1000 feet or 100 meters. Pressing the PUSH FINE switch changes the increments to 100 feet or 10 meters.



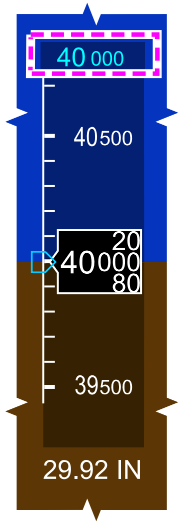
Altitude selection and indication – ALT (altitude) switch (rotary)
Figure 03–06–13

N. ALT hold switch

When the ALT hold switch is pressed, the altitude hold mode is activated to maintain the current aircraft altitude, and the green light above the switch illuminates. The altitude hold mode is also engaged when the preselected altitude is reached. An ALT annunciation is displayed on the FMA. Refer to Figure 03–06–14.



FLIGHT CONTROL PANEL (FCP)



ADI - PRESELECTED ALTITUDE INDICATION

Altitude selection and indication – ALT (Altitude) (hold) switch
Figure 03–06–14

O. VNAV switch

When the VNAV switch is pressed, the green light above the switch illuminates, and the FG system generates pitch commands to follow the vertical navigation profile of the FMS flight plan. When the VNAV mode is selected, the AT system will control either speed or thrust depending on the vertical mode active at the time. The associated FMA annunciation is preceded by a V.

(1) VNAV deviation indicator

When the VNAV mode is enabled, the ADI on the PFD displays the VNAV deviation pointer and the vertical deviation scale beside the altitude tape. Each dot on the scale represents a 250-foot deviation, and full scale deflection represents a 500-foot deviation from the VNAV path. The scale changes to 75 feet of deviation for each dot when an approach mode (APPR) is selected.

The VNAV altitude constraint displays in magenta above the vertical deviation scale, and as a magenta bug on the altitude tape. The required vertical speed to maintain the vertical path displays as a magenta circle on the VSI. Refer to Figure 03–06–15.

ADI – VNAV Indications
Figure 03–06–15

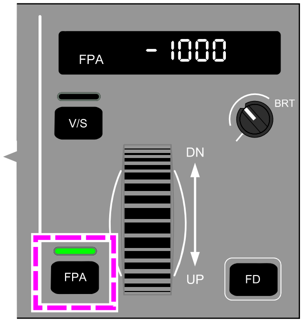
Alerts for Top Of Descent (TOD) and Bottom Of Climb (BOC) display in the FMS message line on the PFD. The alerts display for 60 seconds prior to an altitude change, and flash 5 seconds before the altitude change, accompanied by a double C-chord aural tone. The alert is removed when the altitude change begins.

P. VS switch

The VS switch activates the vertical speed mode. When the switch is pressed and the vertical speed mode is activated, the green light above the switch illuminates. The flight crew adjusts the vertical speed with the UP/DN wheel on the FCP. When the VS switch is selected, the FG system generates pitch commands to maintain the selected vertical speed.

Q. FPA switch

The FPA switch activates the Flight Path Angle (FPA) mode. When the switch is pressed and the FPA mode is activated, the green light above the switch illuminates. The flight crew adjusts the FPA value with the UP/DN wheel on the FCP. The FPA value is displayed in the window and on the FMA next to the FPA mode annunciation. When the FPA switch is selected, the FG system generates pitch commands to maintain the selected reference vertical flight path angle. Refer to Figure 03–06–16.



Flight Control Panel (FCP) – FPA (Flight Path Angle) switch
Figure 03–06–16

R. BRT switch

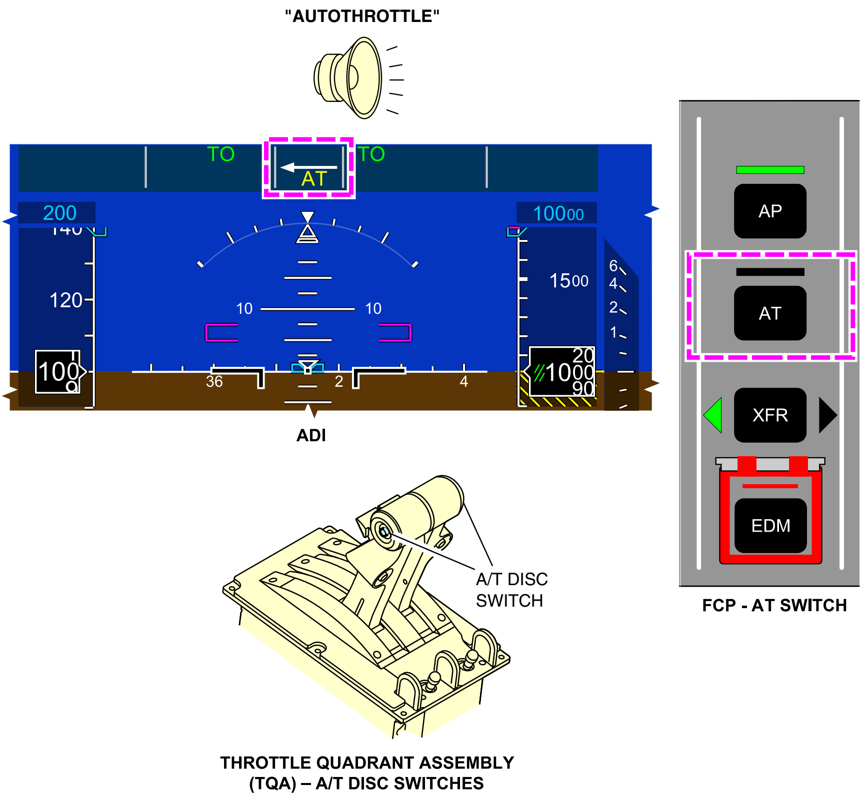
The BRT switch is used to adjust the brightness of the FCP readout windows.

THROTTLE QUADRANT ASSEMBLY (TQA) LEVERS

A. AT/DISC switches

The AT/DISC switches (refer to Figure 03–06–17) are located on the TQA.

When the AT/DISC switches are pressed, the AT system disengages and a flashing amber AT indication is displayed on the FMA with an "AUTOTHROTTLE" aural alert.

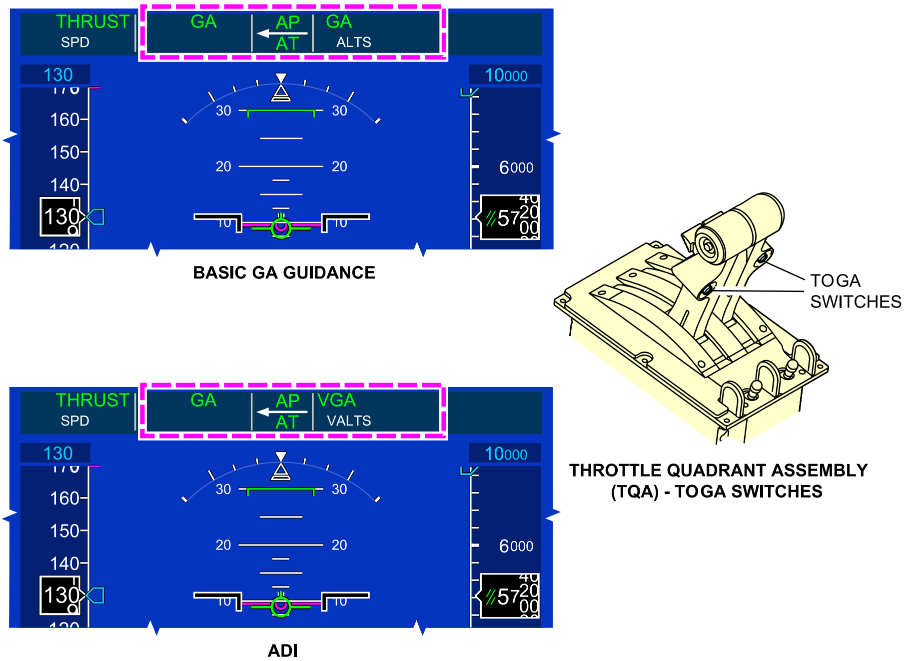


A/T DISC switches disconnect indication
Figure 03–06–17

B. TOGA switches

The TOGA switches are located on the TQA.

When the TOGA switch is pressed, the Takeoff (TO) mode or Go Around (GA) mode engages and the corresponding mode is displayed on the FMA. Refer to Figure 03–06–18.

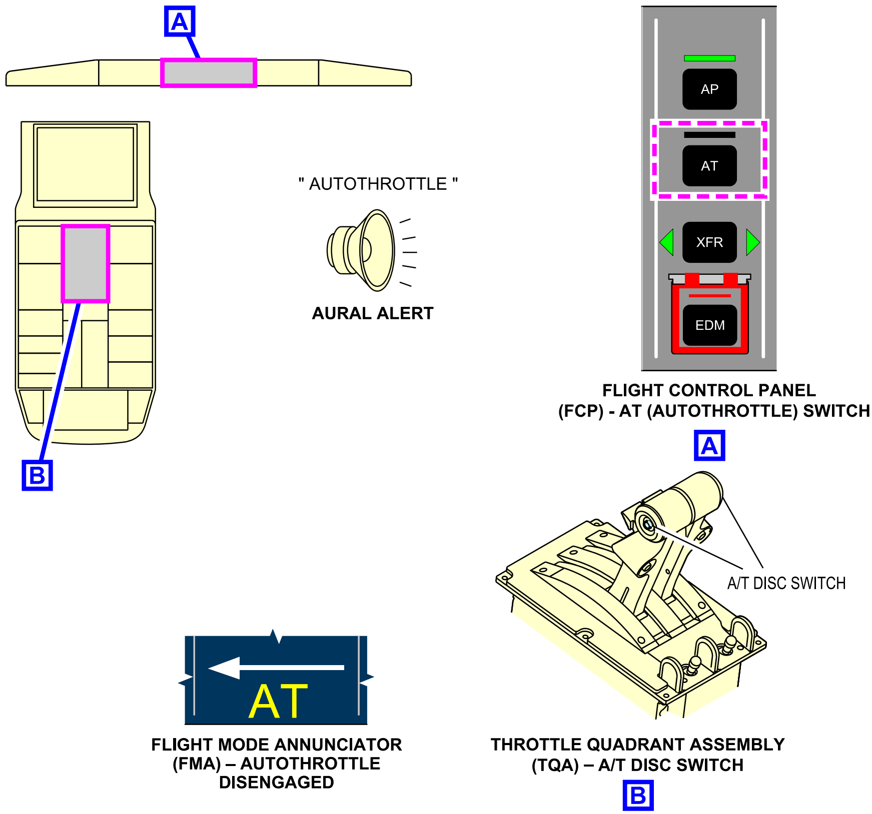


TOGA switches engage indications
Figure 03–06–18

C. TQA – A/T DISC switch

When the A/T DISC switch on the thrust lever is pressed:

- The AT system disengages,
- A flashing amber AT indication is displayed on the FMA, and
- An "AUTOTHROTTLE" aural alert is heard in the flight compartment. Refer to Figure 03–06–19.



Autothrottle (AT) system disengagement – A/T DISC switch
Figure 03–06–19

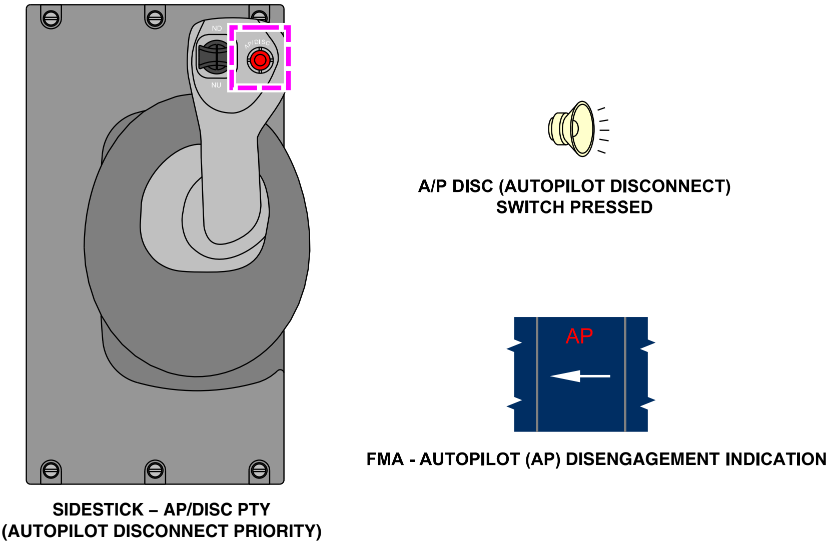
SIDESTICKS

A. A/P DISC PTY switch

There is an A/P DISC PTY (Autopilot Disconnect Priority) switch located on each sidestick. This switch has a dual purpose, it disengage the autopilot and/or disables the other sidestick.

When the red AP/DISC PTY switch (refer to Figure 03–06–20) is pressed on either sidestick:

- The AP system disengages,
- A red AP indication flashes on the FMA, and
- There is an aural alert in the flight compartment.



Sidestick – A/P DISC PTY (Autopilot Disconnect or autopilot priority) switch
Figure 03–06–20

If the A/P DISC PTY is pressed and held in, it will disengage the autopilot (if engaged), and disable the other sidestick.

If the autopilot is not engaged, pressing the A/P DISC PTY switch will give momentary priority to that sidestick, accompanied by an associated "PRIORITY LEFT" or "PRIORITY RIGHT" aural alert.

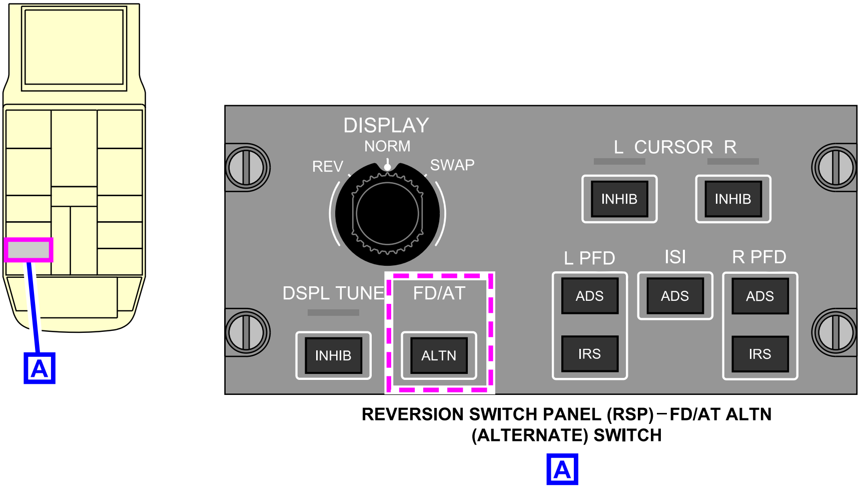
REVERSION SWITCH PANEL (RSP)

A. Reversion Switch Panel (RSP) – FD/AT ALTN switch

The FD/AT ALTN switch is located on the RSP (refer to Figure 03–06–21).

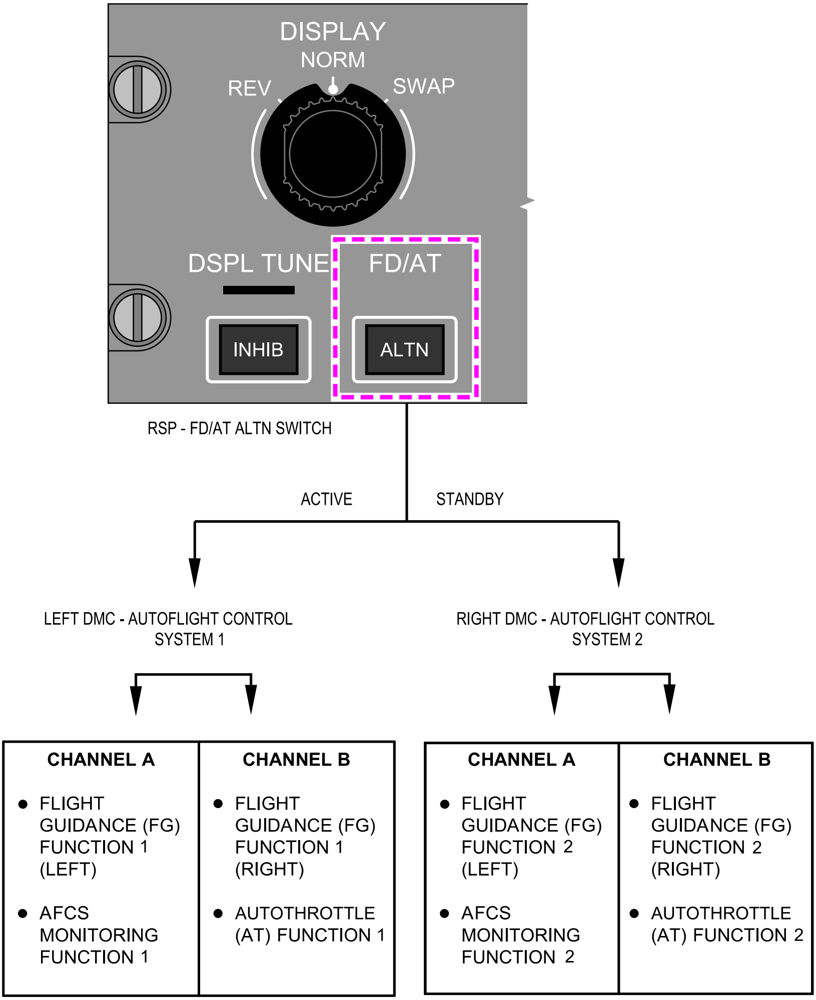
When the FD/AT ALTN switch is pressed:

- AFCS (1 or 2) is selected and used for guidance, and



Reversion Switch Panel (RSP) – FD/AT ALTN (alternate) switch
Figure 03–06–21

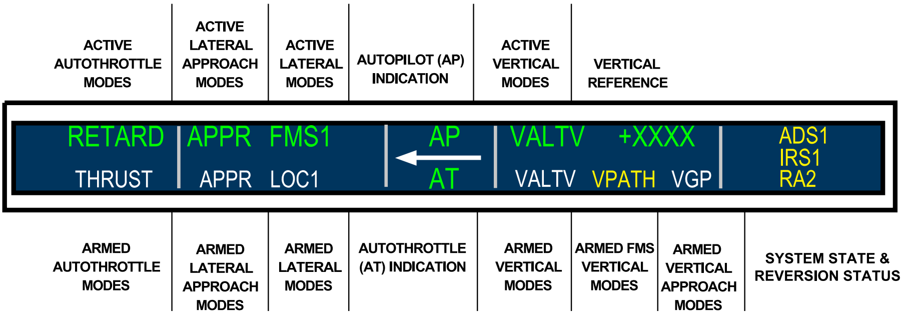
There is one AFCS (AFCS 1 or AFCS 2) active at a time while the other one is on standby. They automatically alternate control on a daily basis. If the flight crew presses the FD/AT ALTN switch, it manually selects the standby AFCS which becomes active (refer to Figure 03–06–22).



FD/AT ALTN (alternate) switch
Figure 03–06–22

PFD – FLIGHT MODE ANNUNCIATOR (FMA)

The FMA bar located at the top of the PFD displays all the AFCS modes (refer to Figure 03–06–23). The FMA is divided into columns depending on the type of mode and status (active or armed).



FMA – Autoflight Control System (AFCS) modes and indications
Figure 03–06–23

The FMA displays FD modes and status using the following color convention:

- Green for active mode,
- White for armed mode,
- Amber mode sustainable, and
- Red for AP disconnect only.

AFCS – EICAS MESSAGES

A. Warning messages

Message	Description	Aural	Inhibit
CONFIG AP	Autopilot (AP) engaged on takeoff.	"CONFIG AUTO–PILOT"	None
EMERGENCY DESCENT	Emergency Descent Mode (EDM) automatically activated.	"EMER–GENCY DES–CENT"	None

B. Caution messages

Message	Description	Aural	Inhibit
FD MODE CHANGE	Uncommanded flight director mode changed to basic mode.	None	TO
AT RETARD INHIBIT	Autothrottle (AT) system retard mode inoperative due to radio altimeter failure.	None	TO
STEEP NOT AVAIL	Steep approach automatic flight mode not available and detected while mode is armed.	None	TO

Message	Description	Aural	Inhibit
EMERGENCY DESCENT	Emergency Descent Mode (EDM) is active and it has been manually engaged.	"EMER–GENCY DES–CENT"	None
FD FAIL	AFCS coupled left and FD channels 1A and 2A failed.	None	TO, LDG

C. Advisory messages

Message	Description	Inhibit
APPR1 NOT AVAIL	ILS CAT I not supported due to sensor failure.	TO, LDG
APPR2 NOT AVAIL	ILS CAT II not supported due to sensor failure.	TO, LDG
AT FAIL	Both autothrottle channels failed.	TO, LDG
AUTO FLIGHT FAULT	Loss of redundant or non–critical function for the auto flight systems.	TO, LDG
LAND2 NOT AVAIL	LAND2 (CAT III fail passive) capability not supported due to sensor failure.	TO, LDG
LAND3 NOT AVAIL	LAND3 (CAT III fail operational) capability not supported due to sensor failure.	TO, LDG
L ENG A/T OFF	Left engine AT command is off.	TO, LDG
R ENG A/T OFF	Right engine AT command is off.	TO, LDG

D. Status messages

None

RESUME MODE LIST

A. FD – Lateral mode

The tables that follow (refer to Figure 03–06–24 and Figure 03–06–25) display the FD lateral mode on the Flight Mode Annunciator (FMA).

MESSAGE	DESCRIPTION
HDG	Heading mode active.
ROLL	Roll mode active.
TO	Lateral takeoff mode track runway heading.
GA	Lateral go-around mode track aircraft heading.
FMS1	FMS 1 navigation active.
FMS2	FMS 2 navigation active.
APPR FMS1	FMS 1 approach mode active.
APPR FMS2	FMS 2 approach mode active.
APPR LOC1	Localizer 1 approach mode active.
APPR LOC2	Localizer 2 approach mode active.
APPR LOC	Localizer approach mode active and transferred to PFCC for autoland (ILS only).
LOC1	Localizer 1 navigation mode active.
LOC2	Localizer 2 navigation mode active.
APPR B/C1	Localizer back course 1 approach mode active.
APPR B/C2	Localizer back course 2 approach mode active.
VOR1	VOR 1 navigation mode active.
VOR2	VOR 2 navigation mode active.
APPR VOR1	VOR 1 approach mode active.
APPR VOR2	VOR 2 approach mode active.
ALIGN	Align lateral mode active (autoland).
ROLLOUT	Rollout mode active (autoland).
FMS 1	FMS 1 navigation armed.
FMS 2	FMS 2 navigation armed.
APPR FMS1	FMS 1 approach mode armed.
APPR FMS2	FMS 2 approach mode armed.
APPR LOC1	Localizer 1 approach mode armed.

FD lateral mode part 1
Figure 03–06–24

MESSAGE	DESCRIPTION
APPR LOC2	Localizer 2 approach mode armed.
LOC1	Localizer 1 navigation mode active.
LOC2	Localizer 2 navigation mode active.
APPR B/C1	Localizer back course 1 approach mode armed.
APPR B/C2	Localizer back course 2 approach mode armed.
VOR1	VOR 1 navigation mode armed.
VOR2	VOR 2 navigation mode armed.
APPR VOR1	VOR 1 approach mode armed.
APPR VOR2	VOR 2 approach mode armed.
ALIGN	Align lateral mode armed (autoland).
ROLLOUT	Rollout mode armed (autoland).
DR	Dead reckoning during VOR navigation.
APPR FMS1	FMS 1 approach mode cannot arm because of no FMS flight plan or discontinuity.
APPR FMS2	FMS 2 approach mode cannot arm because of no FMS flight plan or discontinuity.
APPR LOC1	Localizer 1 approach mode cannot arm.
APPR LOC2	Localizer 2 approach mode cannot arm.
APPR VOR1	VOR 1 approach mode cannot arm.
APPR VOR2	VOR 2 approach mode cannot arm.
APPR B/C1	Localizer back course 1 approach mode cannot arm.
APPR B/C2	Localizer back course 2 approach mode cannot arm.
FMS1	FMS 1 NAV mode cannot arm because of no FMS flight plan or discontinuity.
FMS2	FMS 2 NAV mode cannot arm because of no FMS flight plan or discontinuity.
LOC1	Localizer 1 NAV mode cannot arm.
LOC2	Localizer 2 NAV mode cannot arm.
VOR1	VOR 1 navigation mode cannot arm.
VOR2	VOR 2 navigation mode cannot arm.

FD lateral mode part 2
Figure 03–06–25

B. FD – Vertical mode

The tables that follow (refer to Figure 03–06–26 and Figure 03–06–27) display the FD vertical mode on the Flight Mode Annunciator (FMA):

Message	Description
EDM	Emergency descent mode activated manually or automatically.
VVS	Vertical speed mode active in VNAV.
VGP	Vertical glidepath mode active.
VPATH	Path mode active in VNAV.
VFLC	Flight level change mode active in VNAV.
VALT CAP	Altitude capture mode active in VNAV.
VALT	Altitude hold mode active in VNAV.
VGA	Go-around mode active in VNAV.
VTO	Takeoff mode active in VNAV.
USPD	Underspeed protection mode active.
OPSD	Overspeed protection mode active.
GS	Glideslope tracked.
TO	Takeoff mode active.
WSHR	Windshear escape guidance mode active.
GA	Go-around mode active.
VS	Vertical speed mode active.
FLC	Flight level change mode active.
ALT	Altitude hold mode active.
ALT CAP	Altitude capture mode.
FPA	Flight path angle mode active.
ALTS	Preselect altitude hold mode.
VALTS	Preselected altitude hold mode active in VNAV.
ALTS CAP	Preselect altitude capture mode.
VALTV CAP	FMS altitude (constraint) capture mode in VNAV.
VFPA	Flight path angle mode active in VNAV.

FD vertical mode part 1
Figure 03–06–26

Message	Description
VALTV	FMS altitude (constraint) hold mode in VNAV.
VALTS CAP	Preselect altitude capture mode in VNAV.
PITCH	Pitch mode active (below 200 ft AGL).
WSHR	Underspeed protection mode active.
ALTS	Preselect altitude hold mode armed.
VALTV	FMS altitude (constraint) mode in VNAV command.
VPATH	Path mode armed in VNAV.
ALT	Altitude hold mode active.
FLC	Flight level change mode armed.
VFLC	Flight level change mode in VNAV armed.
VFPA	Flight path angle mode armed in VNAV.
VVS	Vertical speed in VNAV armed.
GS	Glideslope mode armed.
VGP	Vertical glide path armed.
VALTS	Preselect altitude hold mode in VNAV armed.
VNAV	VNAV not available.
VALTV	FMS altitude (constraint) mode not available.
ALTS	Preselect altitude hold mode not available.
VALTS	Preselect altitude hold mode in VNAV not available.
VPATH	VNAV path mode not available.
VFLC	Flight level change mode in VNAV not available.
VFPA	VNAV flight path angle mode not available.
GS	Glideslope not available.
VGP	Vertical glide path not available.

FD vertical mode part 2
Figure 03–06–27

C. Approach status annunciator

The table that follows (refer to Figure 03–06–28) describes the approach status annunciations on the Flight Mode Annunciator (FMA):

Message	Description
NO APPR 2	Loss of ILS CAT II approach capability at or below 200 ft AGL.
NO APPR 1	Loss of ILS approach capability.
NO APPR 2	Loss of ILS CAT II approach capability above 200 ft AGL.
STEEP	Steep approach mode active.
APPR 1	ILS CAT I approach capable.
APPR 2	ILS CAT II approach capable.
STEEP	Steep approach mode armed.

Approach status annunciator
Figure 03–06–28

D. AP status annunciation

The AP system has one associated indication on the FMA. The table that follows describes the AP system status on the FMA.

Flag	Status	Description
AP (green)	Active	AP system engaged
AP (flashing red)	Warning	AP system disengaged

E. AP and AT mode annunciation

The table that follows gives a short description of the Autopilot (AP) and Autothrottle (AT) mode annunciation on the FMA.

Annunciation	Description	Status
AP	Autopilot (AP) engaged (green) or disengaged (flashing red)	Active (green) or disengaged (warning)
AT	Autothrottle (AT) engaged (green), armed (white), or disengaged (flashing amber)	Active (green), armed (white), or disengaged (caution)
DR	FG system is providing Dead Reckoning (DR)	Active (white)
←→	Indicates the direction of the command source used by the FG system	Active (white)

F. AT mode and FMA annunciation – Vertical mode

Selections made by the flight crew on the FCP activate the FD vertical modes. When AT is engaged, each vertical mode has an associated AT system mode and an FMA annunciation. The table that follows shows each vertical mode with its associated control, FMA annunciation, and AT mode.

Mode	FCP switch	FMA annunciation	AT mode
Pitch hold	None	PITCH	Speed (SPD)
Flight Path Angle (FPA) (basic mode when AP is engaged and no other vertical mode is selected)	FPA	FPA	Speed (SPD)
Vertical Speed (V/S)	V/S	VS	Speed (SPD)

Mode	FCP switch	FMA annunciation	AT mode
Flight Level Change (FLC)	FLC	FLC	Thrust (THRUST)
Altitude hold	ALT	• ALT • ALT CAP	• Speed (SPD) • Speed (SPD)
Vertical navigation (as requested by the FMS)	VNAV	• VALTV • VALTV CAP • VGP • VPATH • VALT • VALT CAP • VALTS • VALTS CAP • VFLC • VFPA • VVS	• Speed (SPD) • Speed (SPD) • Speed (SPD) • Speed (SPD) • Speed (SPD) • Speed (SPD) • Speed (SPD) • Speed (SPD) • Thrust (THRUST) • Speed (SPD) • Speed (SPD)
Emergency Descent Mode (EDM)	EDM	EDM	EDM

NOTE

If the AT is automatically disengaged, the aural alert “AUTOTHROTTLE” is repeated until acknowledged.

If the AT is manually disengaged, there is an aural alert of “AUTOTHROTTLE” for 2 seconds.

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CHAPTER 4 – AUXILIARY POWER UNIT

GENERAL

APU – DESCRIPTION AND OPERATION

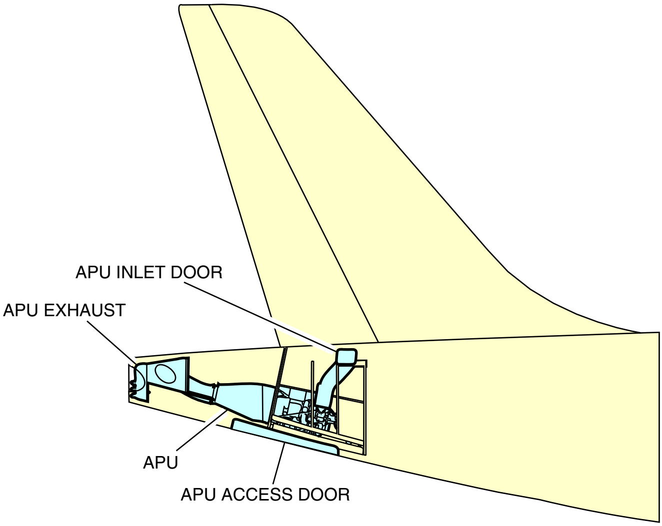
APU – CONTROLS AND INDICATIONS

List of figures

APU – CONTROLS AND INDICATIONS

APU – OVERVIEW

The Auxiliary Power Unit (APU) is a self–contained gas turbine engine installed in a closed, fireproof titanium box in the tail section of the aircraft (refer to Figure 04–01–1). Clamshell doors provide access from below.

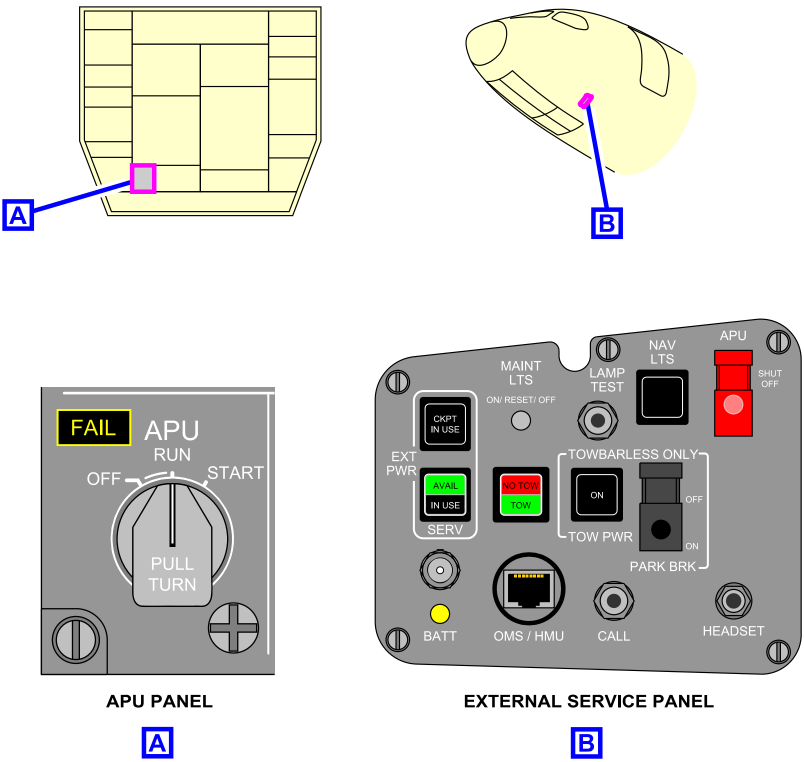


APU compartment
Figure 04–01–1

The APU provides an alternate source of AC electrical power and bleed air for main engine starting and air conditioning. An accessory gearbox attached to the APU drives a 3-phase, 400 Hz, 115 VAC variable frequency generator that can generate 75 kVA.

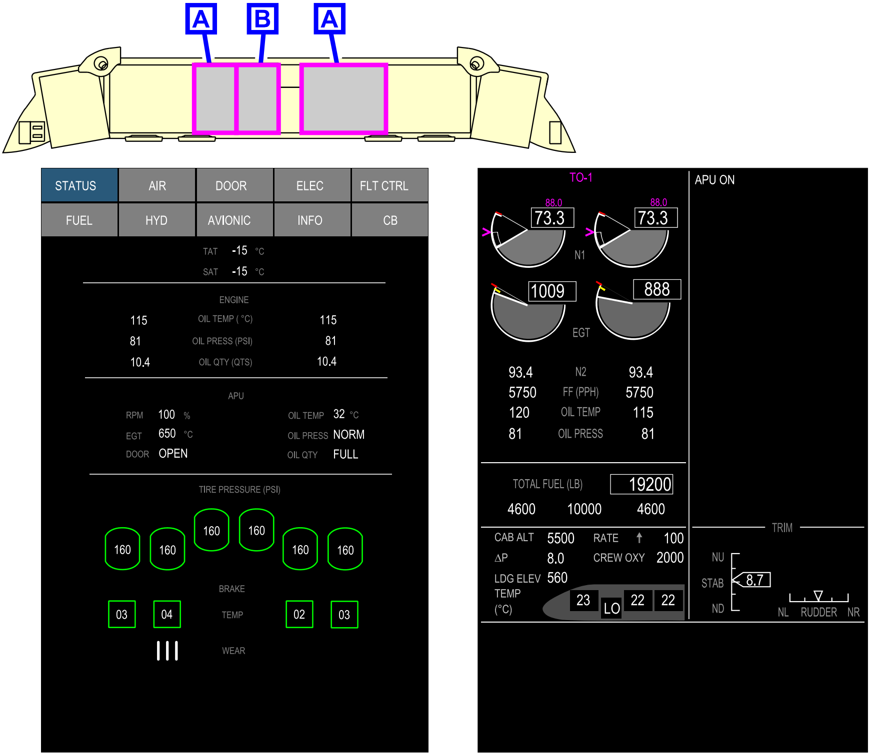
The APU is self-governing, with automatic start sequencing and automatic protective shutdown on the ground and in flight. It is monitored and controlled by an Electronic Control Unit (ECU) and certified for unattended operation on the ground.

APU controls are located on the APU panel, and on the external service panel (refer to Figure 04–01–2). In addition, an APU shutoff switch is located in the APU compartment.



APU controls
Figure 04–01–2

APU indications are reported on the STATUS synoptic page and status and fault messages are reported on the EICAS page (refer to Figure 04–01–3 and Figure 04–01–4 for an example of EICAS advisory message).



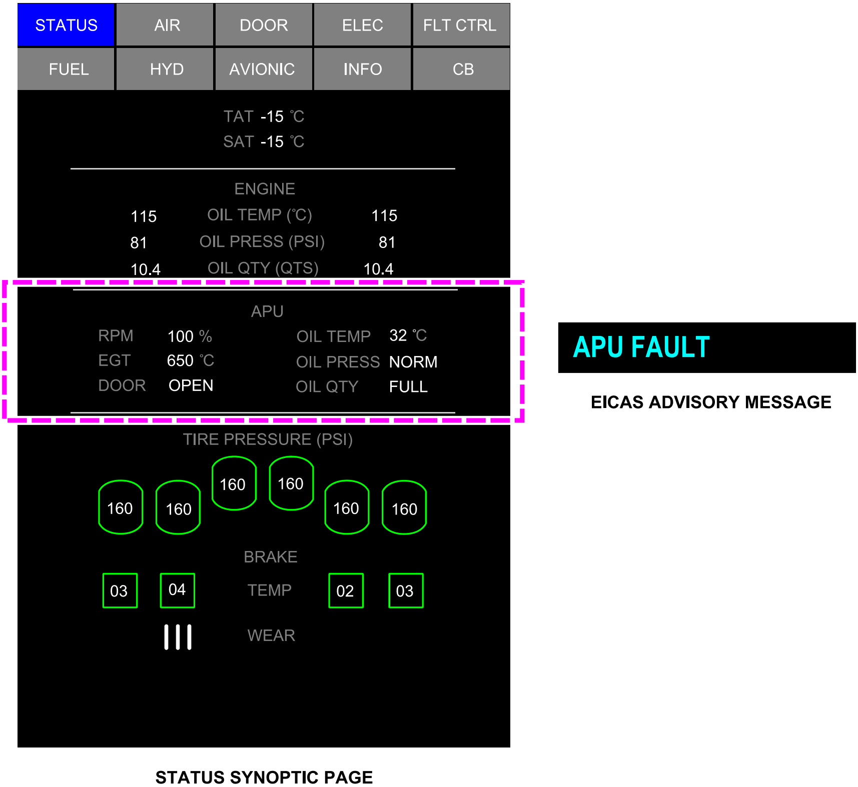
STATUS PAGE

A

EICAS PAGE

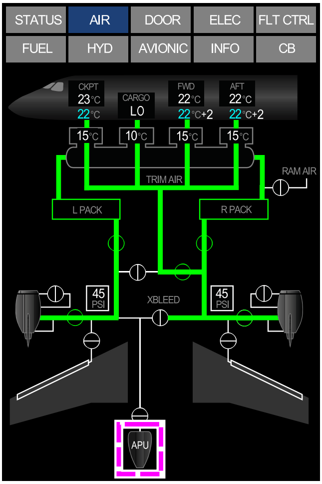
B

APU indications
Figure 04–01–3

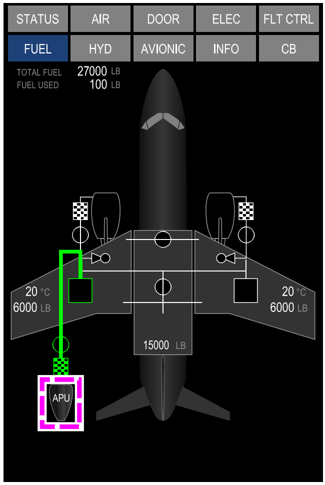


STATUS synoptic page – EICAS advisory message
Figure 04–01–4

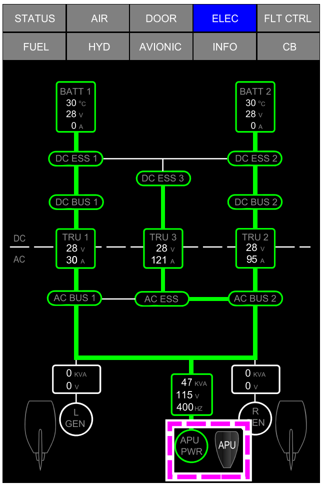
The AIR, Electrical (ELEC) and FUEL system synoptic pages also contain APU indications (refer to Figure 04–01–5).



AIR SYNOPTIC PAGE



FUEL SYNOPTIC PAGE



ELECTRICAL (ELEC) SYNOPTIC PAGE

APU indications on synoptic pages
Figure 04–01–5

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APU – DESCRIPTION

A. APU assembly

The APU assembly includes:

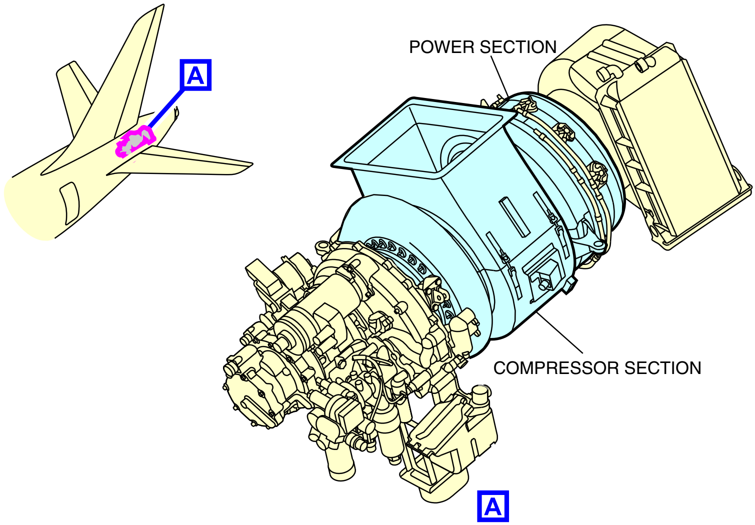
- An engine,
- An Electronic Control Unit (ECU),
- An inlet door,
- An accessory gearbox,
- A fuel system, and
- A lubrication system.

B. Engine

The APU engine is a two-stage, axial flow, non-propulsion turbine engine and incorporates:

- A power section, and
- A compressor section.

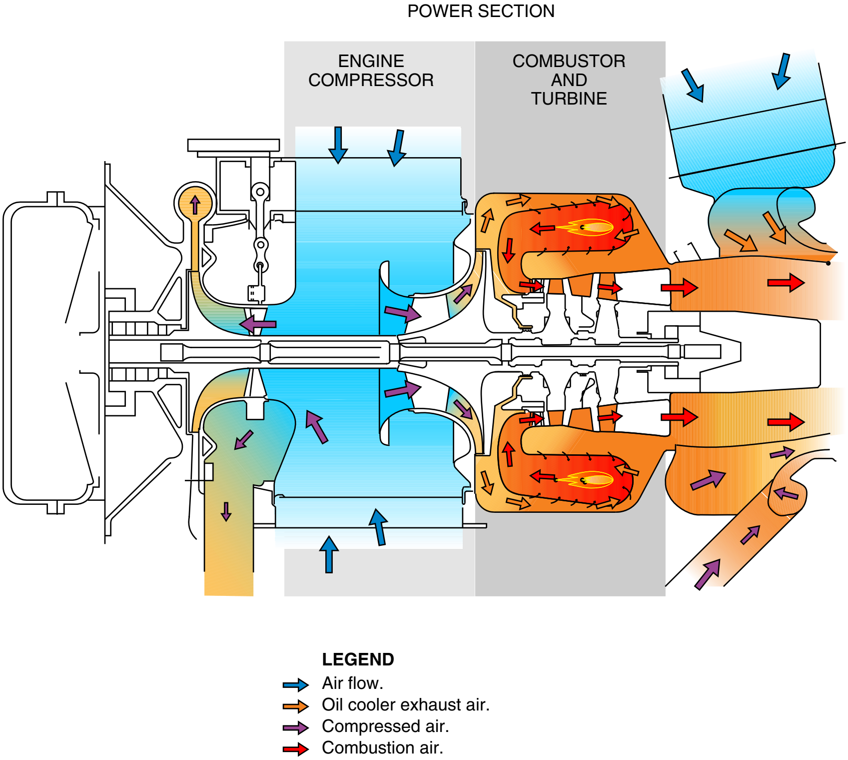
Figure 04–02–1 shows the power and compressor sections of the APU.



Compressor and power sections
Figure 04–02–1

(1) Power section

The power section of the APU supplies the necessary horsepower to drive the accessory gearbox and the compressor (refer to Figure 04–02–2).



APU engine
Figure 04–02–2

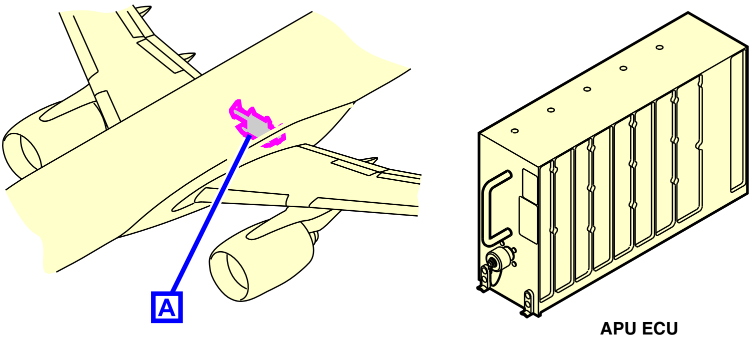
(2) Compressor section

The compressor section supplies bleed air to the pneumatic system for engine start and air conditioning.

Based on aircraft pneumatic demand, the ECU adjusts the inlet guide vanes in the APU compressor section to vary the volume of bleed air supplied.

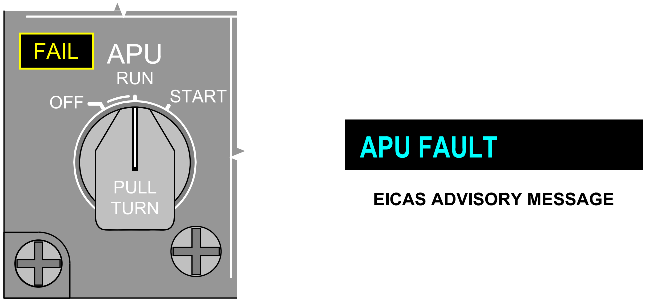
C. APU – Electronic Control Unit (ECU)

The ECU is located in the mid equipment bay (refer to Figure 04–02–3). It controls and monitors the APU from start to shutdown, the position of the APU inlet door, and the adjustment of the inlet guide vanes in the APU compressor section. The ECU receives its primary power from the DC ESS 2 with the DC EMER BUS as the secondary source.



Electrical Control Unit (ECU)
Figure 04–02–3

The ECU is continuously self-monitoring. It initiates an internal power-up BITE test when either BATT 1 or BATT 2 switch on the ELECTRICAL panel is set to AUTO. If it fails the BITE test, the FAIL light on the APU panel illuminates and an **APU FAULT** advisory message is displayed on the EICAS page (refer to Figure 04–02–4).

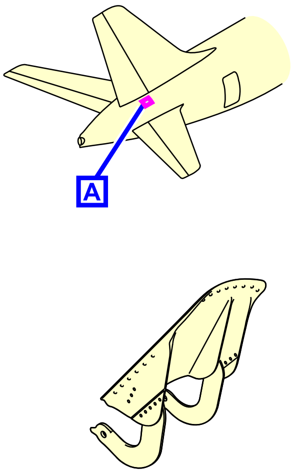


APU panel – FAIL light
Figure 04–02–4

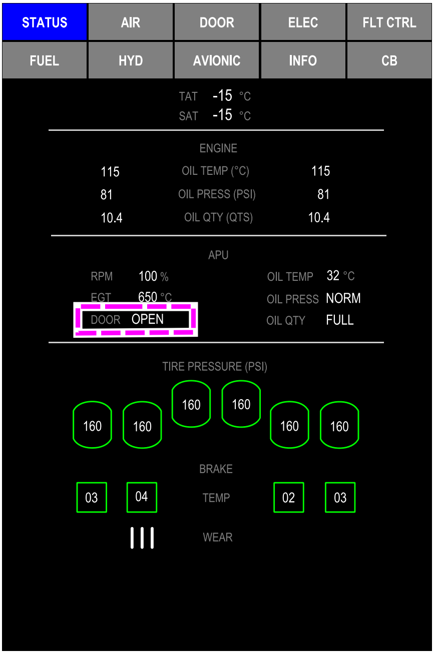
D. APU – Inlet door

The inlet door directs air into the APU and splits the air into two sections. Some air is directed to the APU compressor and the rest cools the APU compartment. The inlet door position is controlled by the ECU, depending on various inputs such as weight-on-wheels signal, Mach number, Total Air Temperature (TAT), and Air Data System (ADS). The position of the inlet door is either fully open, intermediate, or fully closed. The inlet door position is shown on the STATUS synoptic page, and displays OPEN or CLOSED.

Figure 04–02–5 shows the inlet door location and its indication on the STATUS synoptic page.



APU INLET DOOR
A

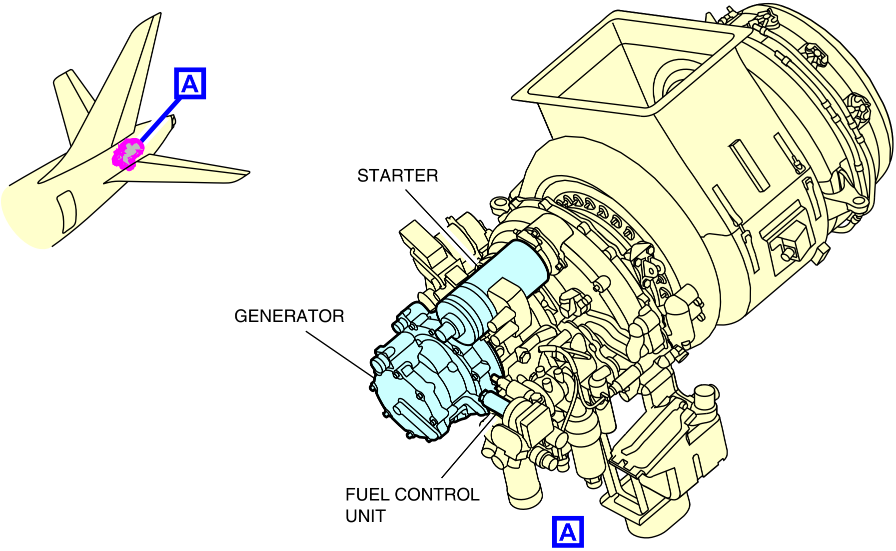


STATUS PAGE - INLET DOOR POSITION

APU inlet door location and indication
Figure 04–02–5

E. APU – Accessory gearbox

The accessory gearbox contains the APU variable frequency generator, a DC starter motor, and the APU Fuel Control Unit (FCU) (refer to Figure 04–02–6).



Accessory Gearbox
Figure 04–02–6

The 115 VAC generator provides the aircraft with an alternate source of AC power. When the APU has established on speed, the AC power can be used by the electrical system of the aircraft.

The DC starter motor, and the FCU are controlled by the ECU.

The FCU controls the pressure and the quantity of fuel that goes to the fuel nozzels.

F. APU – Fuel supply

Fuel to the APU is fed from the left engine/APU fuel line through the APU shutoff valve.

Fuel can be supplied to the APU by:

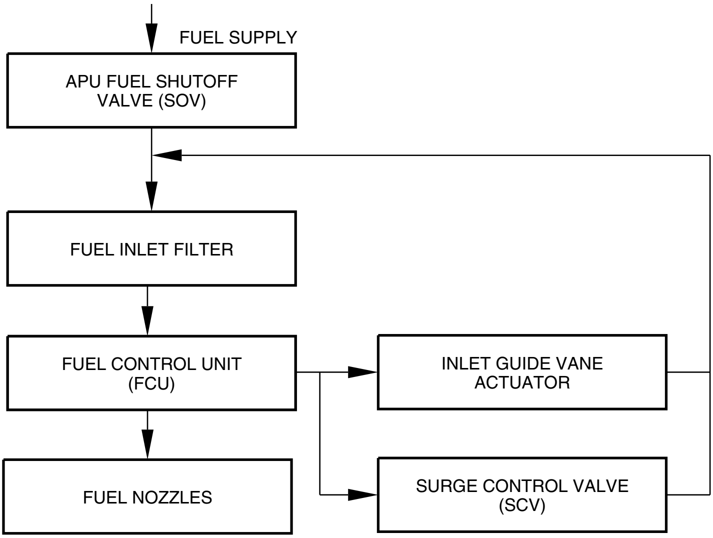
- The left main engine fuel ejector pump if the left engine is operating,
- Either of the fuel tank AC boost pumps, or

- Suction-feed if AC power is not available and the left engine is not operating.

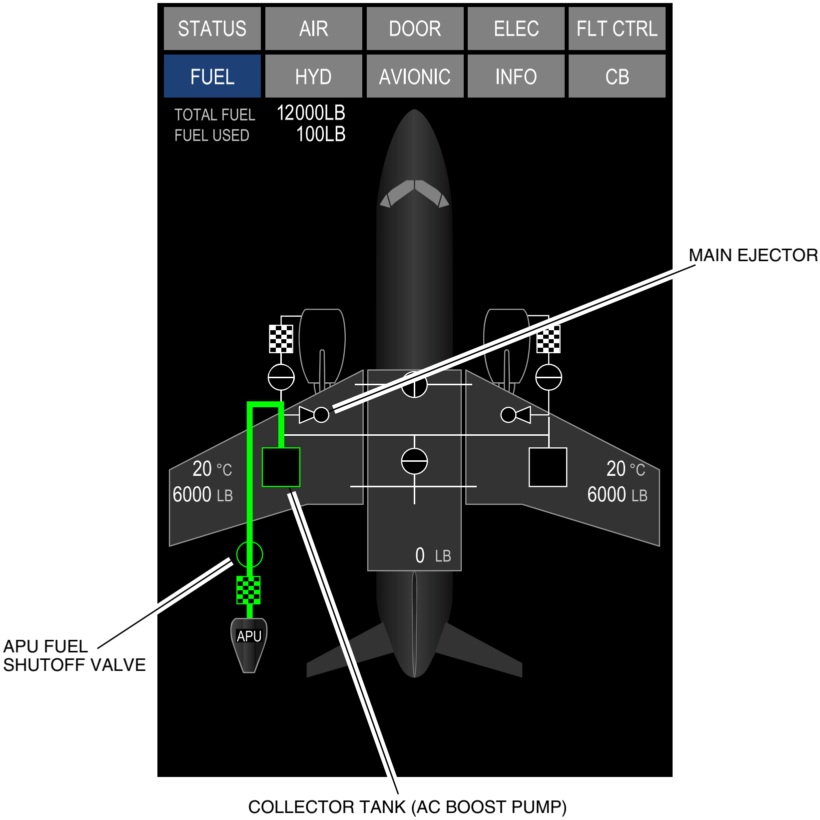
The FCU is controlled by the ECU. During start, the FCU provides the correct amount of fuel for start and acceleration to full rated speed. Once rated speed is reached, fuel flow is modulated to meet the demands of varying pneumatic and electrical loads while maintaining a constant speed.

Figure 04–02–7 shows a simplified schematic of the APU fuel system.

Figure 04–02–8 shows the APU fuel feed operation on the FUEL synoptic page.



APU – Fuel system
Figure 04–02–7



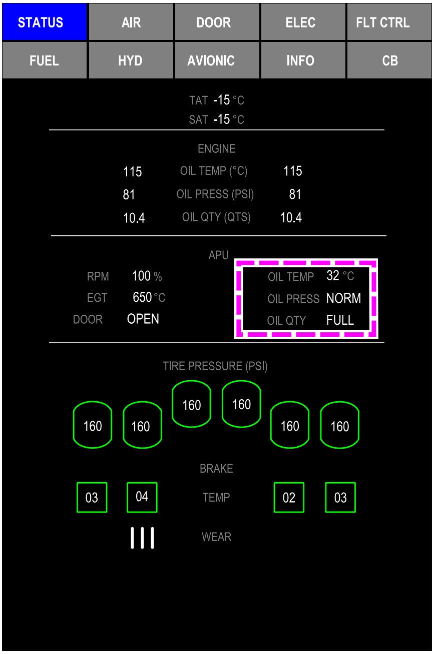
FUEL synoptic page – APU fuel supply indication
Figure 04–02–8

G. APU – Oil supply

The APU engine and generator share the same oil for lubrication and cooling. The oil is cooled by an air/oil heat exchanger.

Oil quantity, pressure, and temperature are monitored by the ECU and displayed on the STATUS synoptic page.

Figure 04–02–9 shows the APU oil indications on the STATUS synoptic page.



STATUS synoptic page – Oil indications
Figure 04–02–9

APU – OPERATION

A. Overview

The APU operation includes:

- Starting,
- Shutdown, and
- Automatic shutdown.

B. APU starting

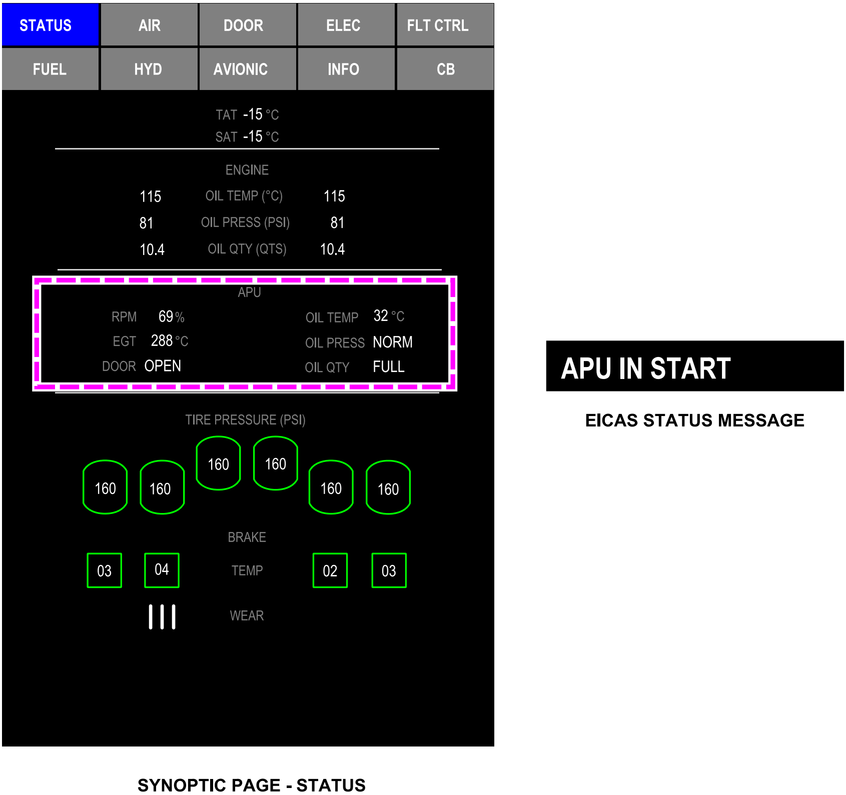
The aircraft battery bus supplies electrical power to start the APU. The DC power energizes the ignition and the starter motor.

The APU requires either the Transformer Rectifier Unit 3 (TRU 3) when external AC power is available, or both batteries for starting. The electrical power provides mechanical energy through the starter motor to rotate the engine and energizes the ignition unit. The ECU prevents APU start from TRU 3 if any TRU is inoperative. When the batteries are used for starting the APU, battery 1 powers the ECU while battery 2 turns the APU starter.

When the APU switch is selected and held to the START position for at least three seconds, the ECU:

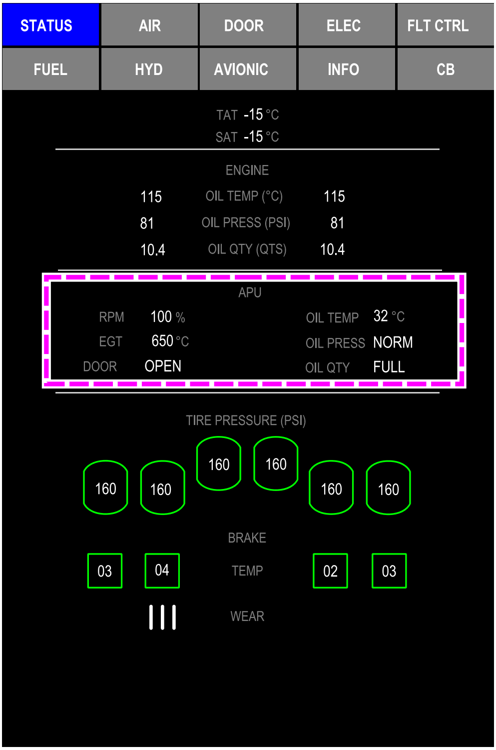
- Commands an APU BITE test,
- Opens the APU inlet door,
- Opens the APU fuel shutoff valve,
- Turns on the left AC fuel boost pump (on the ground with left engine off and AC power available), and
- Begins the APU start sequence.

With the RPM below 70% during start sequence, the **APU IN START** status message appears (refer to Figure 04–02–10).



STATUS synoptic page – APU IN START
Figure 04–02–10

When the RPM is above 70%, the status message changes to **APU ON** (refer to Figure 04–02–11).



SYNOPTIC PAGE - STATUS

EICAS STATUS MESSAGE

STATUS synoptic page – APU ON
Figure 04–02–11

When the RPM reaches 95%, it is ready for electrical and pneumatic loading.

The APU is limited to a maximum of three start attempts within one hour, with two minutes between each start. The ECU prevents restart until RPM drops below 7%.

NOTE

Use of electrical and pneumatic power produced from the APU is described in the electrical and pneumatic chapters of this publication.

C. APU shutdown

When the APU switch is selected OFF, the ECU starts a 60 second cool down period. After the cool down is completed, the ECU shuts down the APU, and closes the inlet door.

D. Automatic shutdown

The ECU will initiate an automatic shutdown under the conditions given in the table that follows:

CONDITION	AUTO SHUTDOWN ON GROUND	AUTO SHUTDOWN IN FLIGHT
Failed/slow/hot/hung start	YES	YES
RPM underspeed	YES	NO
RPM overspeed/signal loss	YES	YES
Critical ECU fault (i.e. loss of DC power)	YES	YES
Loss of ARINC inputs to the ECU	YES	YES
APU fire	YES	NO
EGT overtemperature/signal loss	YES	NO
APU door position uncommanded/signal loss	YES	NO
Excessive oil temperature	YES	NO
Low oil pressure	YES	NO
Oil filter clogged	YES	NO

CONDITION	AUTO SHUTDOWN ON GROUND	AUTO SHUTDOWN IN FLIGHT
APU inlet overheat/reverse flow	YES	NO

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APU – CONTROLS

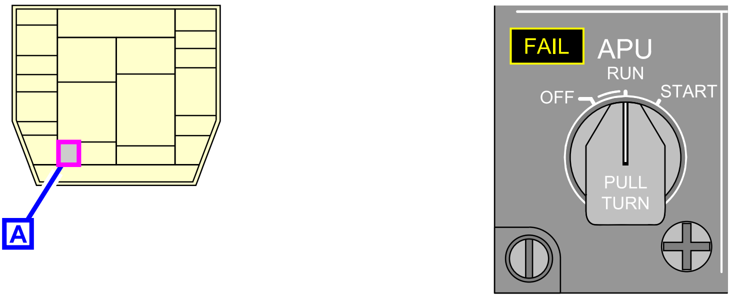
A. APU panel

The APU panel includes the APU switch and the APU FAIL light. The APU switch is a spring-loaded switch, and has three positions:

The APU switch is a spring-loaded switch, and has three positions:

- OFF: The APU shuts down.
- RUN: The APU is running.
- START: When held for three seconds, the APU initiates the start sequence.

Figure 04–03–1 shows the APU panel.



APU panel – APU switch
Figure 04–03–1

The APU FAIL light illuminates when the conditions that follow occur:

- APU or Electronic Control Unit (ECU) fails a BITE test,
- APU fire detection fails on the ground, and
- Failed start.

NOTE

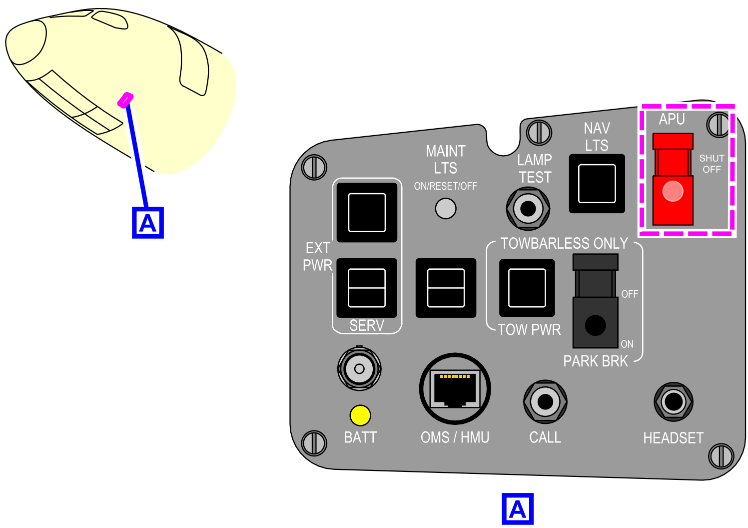
For a failed start, the **APU SHUTDOWN** advisory message is displayed on the EICAS page in addition to the FAIL light on the APU panel.

The FAIL light goes off when the APU is selected OFF.

B. External service panel – APU SHUT OFF switch

The APU can be shut down from outside the flight compartment through the APU SHUT OFF switch on the external service panel.

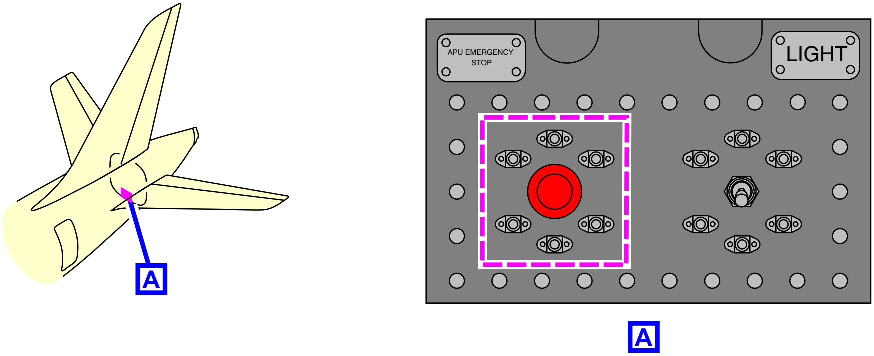
Figure 04–03–2 shows the external service panel location and the APU SHUT OFF switch.



External service panel – APU SHUTOFF switch
Figure 04–03–2

C. APU compartment – APU shutoff switch

The APU compartment has an APU shutoff switch located in the forward firewall enclosure of the APU compartment (refer to Figure 04–03–3). When the switch is pressed, it commands the Electronic Control Unit (ECU) to shut down the APU.



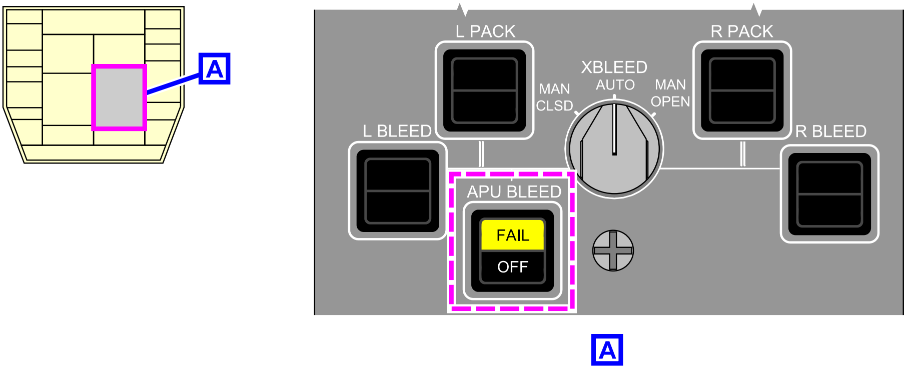
APU compartment – APU shutoff switch
Figure 04–03–3

D. AIR panel – APU BLEED switch

The APU BLEED switch controls the APU bleed valve.

For details, refer to Chapter 02 – APU bleed switch

Figure 04–03–4 shows the APU BLEED switch.



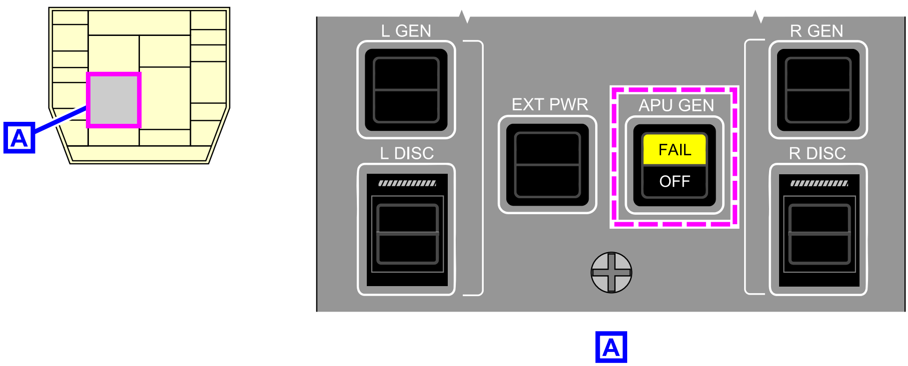
AIR panel – APU BLEED switch
Figure 04–03–4

E. ELECTRICAL panel – APU GEN switch

The APU GEN switch on the ELECTRICAL panel controls the APU generator.

For details, refer to Chapter 07 – APU GEN switch.

Figure 04–03–5 shows the APU GEN switch on the ELECTRICAL panel.

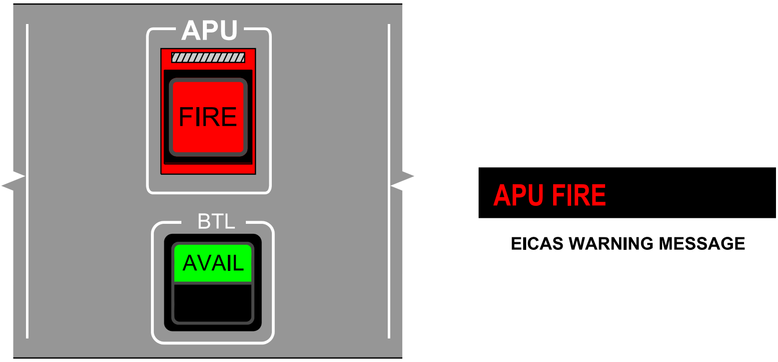


ELECTRICAL panel – APU GEN switch
Figure 04–03–5

F. ENGINE AND APU FIRE panel – APU FIRE switch

The APU FIRE switch (refer to Figure 04–03–6) on the ENGINE AND APU FIRE panel arms the APU fire-extinguishing bottle.

For details, refer to Chapter 09 – APU fire extinguishing.

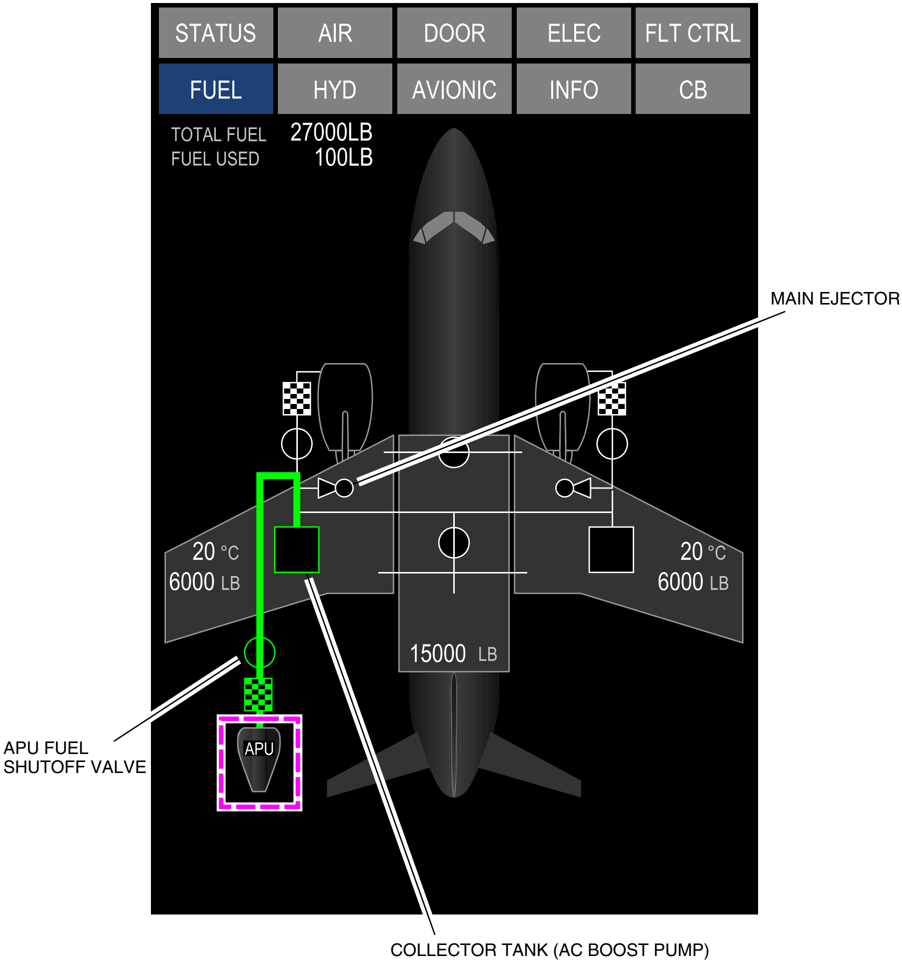


FIRE panel – APU fire switch
Figure 04–03–6

APU – INDICATIONS

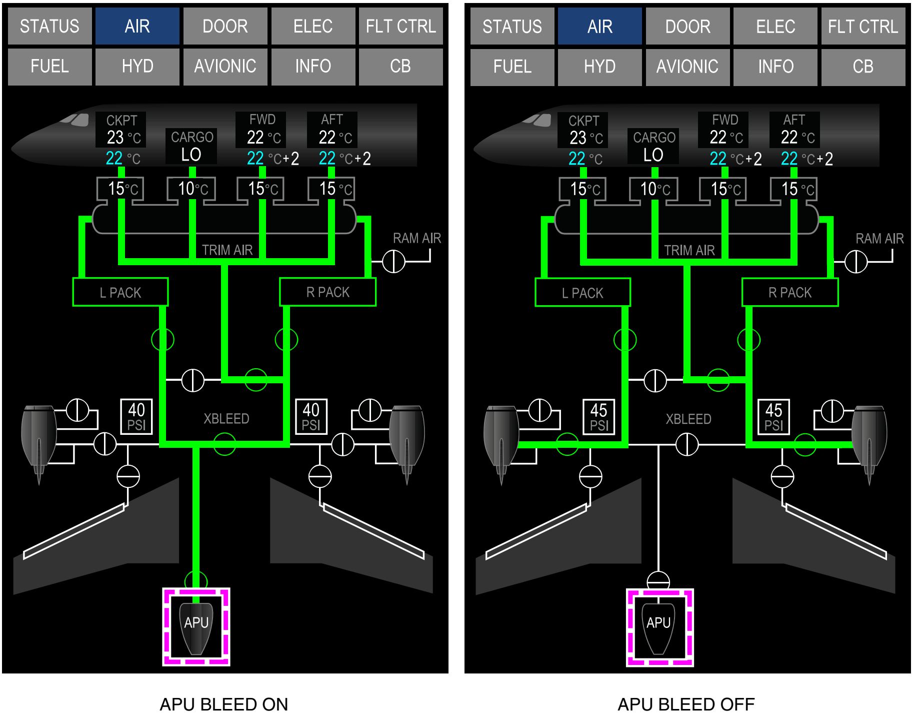
A. AIR, FUEL and ELEC synoptic pages

The APU indications are also provided by the AIR, FUEL, and electrical (ELEC) synoptic pages. The FUEL synoptic page provides indications related to the APU fuel feed (refer to Figure 04–03–7).



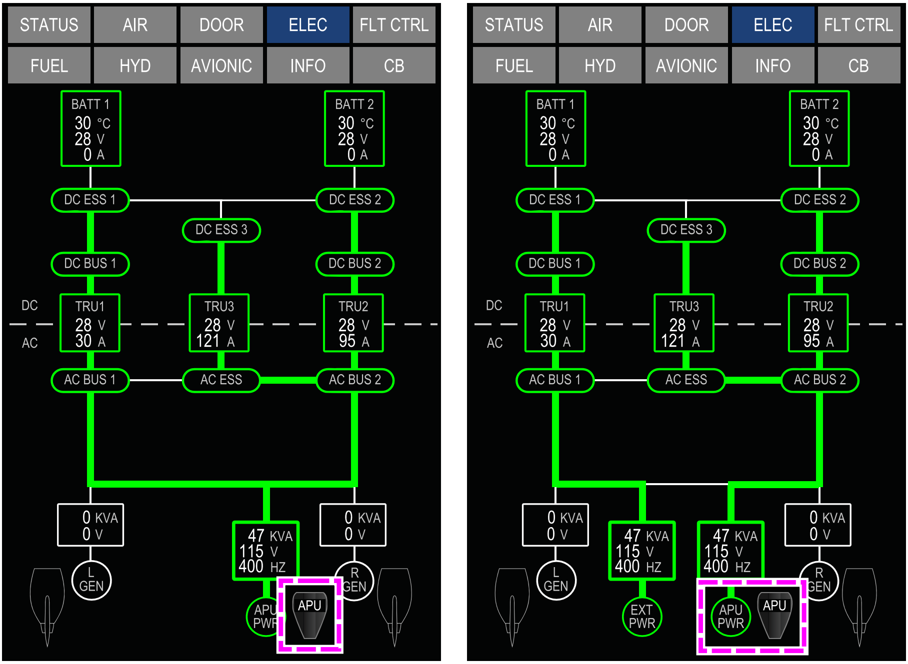
FUEL synoptic page – APU fuel supply indications
Figure 04–03–7

The AIR synoptic page provides indications related to the APU bleed air (refer to Figure 04–03–8).



AIR synoptic page – APU bleed air indication
Figure 04–03–8

The ELEC synoptic page provides indications on the APU generator load and electrical distribution (refer to Figure 04–03–9).



APU PWR ONLINE

EXT PWR IN USE AND APU PWR ONLINE

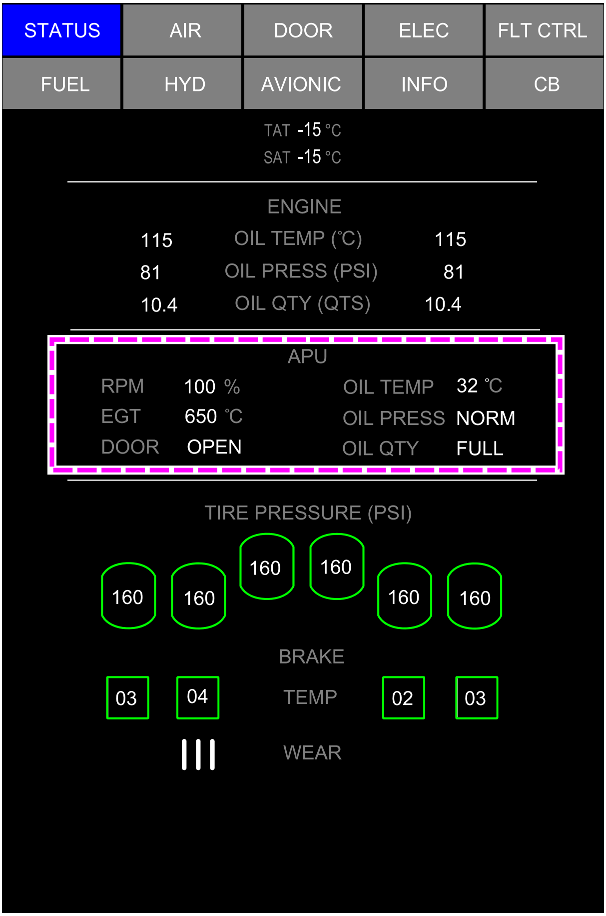
ELEC synoptic page – APU GEN online indications
Figure 04–03–9

B. STATUS synoptic page

The APU indications on the STATUS synoptic page (refer to Figure 04–03–10) include:

- APU speed (RPM) (refer to Figure 04–03–11),
- APU Exhaust Gas Temperature (EGT) (refer to Figure 04–03–11),
- APU inlet door position (DOOR) (refer to Figure 04–03–12),

- APU oil temperature (OIL TEMP) (refer to Figure 04–03–11),
- APU oil pressure (OIL PRESS) (refer to Figure 04–03–12), and
- APU oil quantity (OIL QTY) (refer to Figure 04–03–12).



STATUS synoptic page – APU indications
Figure 04–03–10

APU RPM (RPM in grey)

Symbol	Color	Description
85	WHITE	APU operating at or below red line
107	RED	APU operating above red line (overspeed)
---	YELLOW	APU RPM value is invalid

APU EGT (EGT in grey)

Symbol	Color	Description
650	WHITE	APU operating at or below red line
820	RED	APU operating above red line (overtemperature)
---	YELLOW	APU EGT invalid

APU OIL TEMPERATURE (OIL TEMP in grey)

Symbol	Color	Description
32	WHITE	APU oil temperature in normal range
350	YELLOW	Oil temperature at or above high oil temperature yellow line threshold
---	YELLOW	Invalid oil temperature

STATUS synoptic page – APU indication legend (part 1)
Figure 04–03–11

APU OIL PRESSURE (OIL PRESS in grey)		
Symbol	**Color**	**Description**
NORM	WHITE	Oil press in normal range
LOW	YELLOW	Oil press below low oil press threshold
--	YELLOW	Oil pressure invalid

APU OIL QUANTITY (OIL QTY in grey)		
Symbol	**Color**	**Description**
FULL	WHITE	Oil quantity full
LOW	YELLOW	Oil quantity below low threshold
NORM	WHITE	Oil quantity in normal range
--	YELLOW	Oil quantity invalid

APU DOOR (DOOR in grey)		
Symbol	**Color**	**Description**
OPEN	WHITE	APU door open and not fail
CLOSED	WHITE	APU door closed and not fail
OPEN	YELLOW	APU door open and fail
CLOSED	YELLOW	APU door closed fail
--	YELLOW	APU door invalid

STATUS synoptic page – APU indication legend (part 2)
Figure 04–03–12

APU – EICAS MESSAGES

A. Warning messages

Message	Description	Aural	Inhibit
APU FIRE	APU fire detected.	"APU FIRE"	None
APU OVERSPEED	APU has experienced an overspeed condition (above 106% and has not shut down.	None	None

B. Caution messages

Message	Description	Inhibit
APU	APU failure in flight that does not lead to automatic shutdown.	TO, LDG
APU BLEED FAIL	Failure of the APU to provide bleed air when requested or bleed leak detection fails.	TO, LDG
APU DOOR OPEN	APU inlet door failed to close when commanded.	TO, LDG
APU FIRE DET FAIL	Failure of the APU fire detection syste.	TO, LDG

C. Advisory messages

Message	Description	Inhibit
APU FAULT	Loss of redundant or non-critical function for the APU.	TO, LDG
APU OIL LO QTY	APU low oil quantity detected on ground while APU is not running.	TO, LDG
APU SHUTDOWN	Failures detected that will cause the APU to shut down.	TO, LDG

D. Status messages

Message	Description	Inhibit
APU IN START	APU is performing the startup sequence.	None
APU ON	APU is running.	None

CHAPTER 5 – COMMUNICATION

GENERAL

RADIO COMMUNICATION

RADIO CONTROL AND TUNING

SATELLITE COMMUNICATIONS (SATCOM) <23150006C>

DATA LINK (DLK) COMMUNICATION

CONTROLLER–PILOT DATA LINK COMMUNICATIONS (CPDLC) – LINK 2000+ <23240001C>

COMMUNICATION – CONTROLS AND INDICATIONS

List of figures

CABIN AND GROUND CREW COMMUNICATION

SATELLITE COMMUNICATIONS (SATCOM) <23150004C>

SATELLITE COMMUNICATIONS (SATCOM) <23150006C>

DATA LINK (DLK) COMMUNICATION

CONTROLLER–PILOT DATA LINK COMMUNICATIONS (CPDLC) – LINK 2000+ <23240001C>

COMMUNICATION – CONTROLS AND INDICATIONS

COMMUNICATION SYSTEM

A. Overview

The communication system provides external and internal communications.

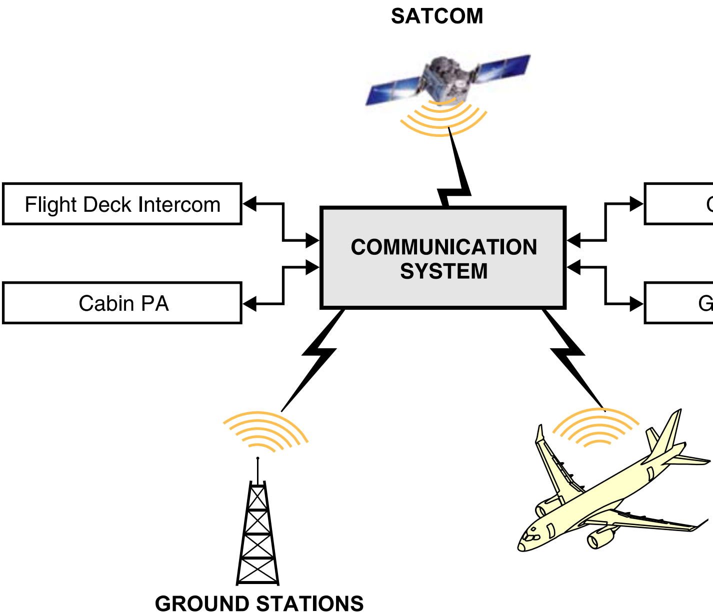
External communications consist of:

- Air Traffic Control (ATC),
- Communication with other aircraft,
- Ground maintenance stations (if installed),
- Satellite (if installed), and
- Ground weather stations (if installed).

Internal communications consist of:

- Communication between flight crew,
- Communication between flight crew and cabin crew,
- Communication between flight crew and ground personnel with interphone, and
- Passenger Address (PA).

Figure 05–01–1 shows the communication system overview.



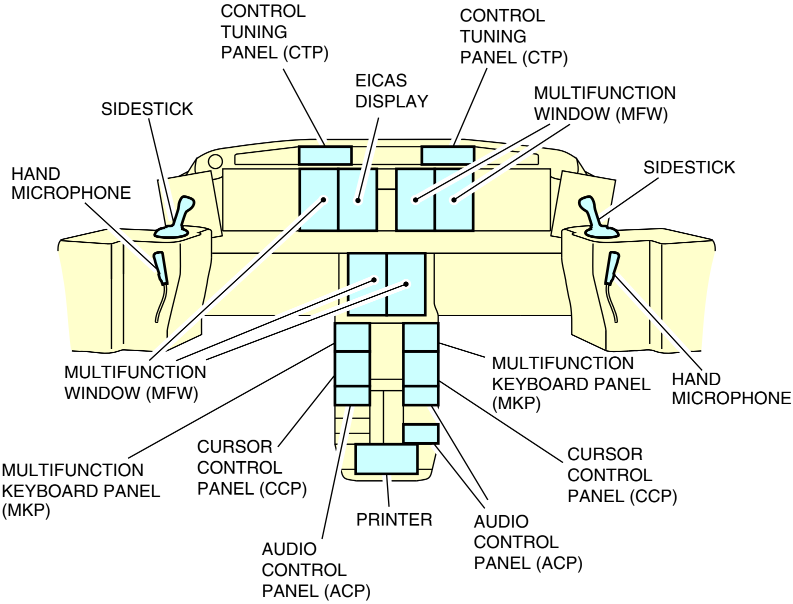
Communication system
Figure 05–01–1

The communication system uses the transceivers that follow:

- VHF1, VHF2 and VHF3 for communication and data exchange,
- HF1 for communication, <23120001C> or <23120005C>
- HF1 and HF2 for communication, <23120003C>
- Selective Calling (SELCAL) system, <23210004C>
- Satellite Communication (SATCOM) system, <23150004C>

- Data Link (DLK) communication system,
- Controller–Pilot Data Link Communication (CPDLC) system (ATN B1), <23249001C>
- Graphical Weather (GWX) communication system,
- Internal communication (INTERCOM) system,
- Passenger Address (PA) system, and
- Radio Interface Units (RIUs).

Figure 05–01–2 shows the location of flight deck controls for the communication system.



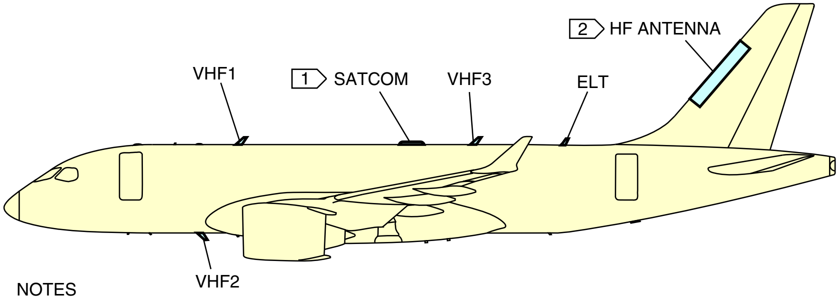
Communication system and controls
Figure 05–01–2

The communication system uses the antennas that follow:

- VHF1 antenna,
- VHF2 antenna,
- VHF3 antenna,
- SATCOM antenna, <23150004C>
- HF1 antenna for communication, <23120001C> or <23120005C>

- HF1 and HF2 antennas for communication, <23120003C>
- Emergency Locator Transmitter (ELT).

Figure 05–01–3 shows the locations of the antennas for the communication system.



NOTES
1 Option code 23150004C.
2 Option code 23129001C.

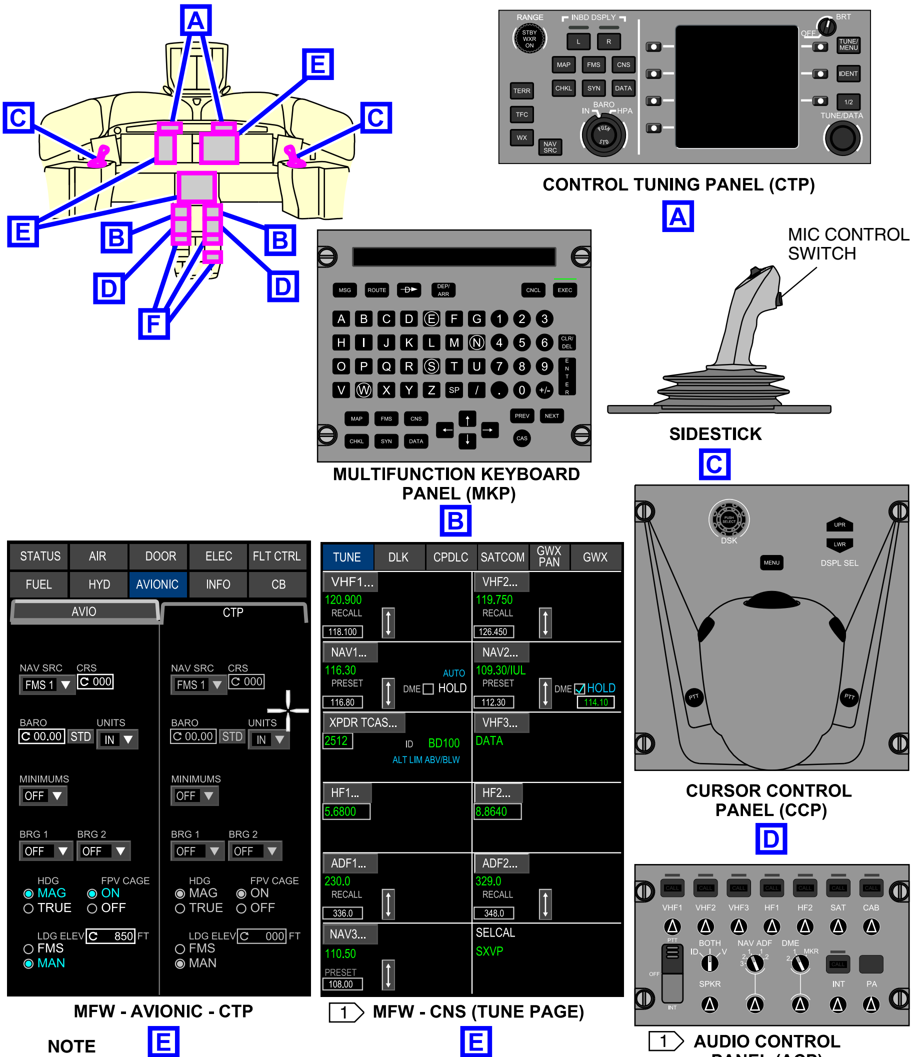
Communication system antennas
Figure 05–01–3

Control of the communication system is provided by the:

- Control Tuning Panels (CTPs),
- TUNE page – Radio Tuning System Application (RTSA),
- Multifunction Keyboard Panels (MKPs),
- Cursor Control Panels (CCPs),
- CTP tab on the AVIONIC page (CTP inhibiting only),
- Push-To-Talk (PTT) switches, and
- Audio Control Panels (ACPs).

Figure 05–01–4 shows the controls for the communication system.

Figure 05–01–5 shows the CTP tab on the AVIONIC page.



NOTE

1 This view shows options that may not be installed on your aircraft.

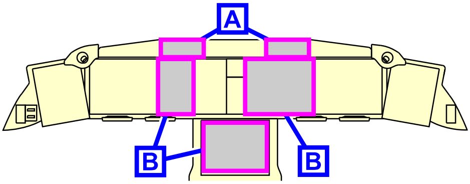
Communication system controls
Figure 05–01–4

AVIONIC synoptic page – CTP tab
Figure 05–01–5

The communication indications are shown on the:

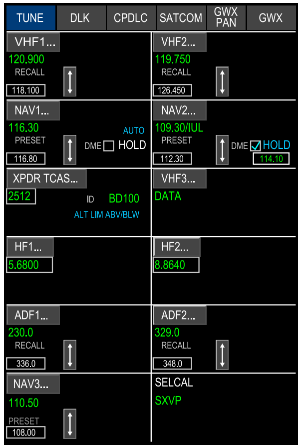
- CTP display,
- CNS (TUNE page),
- MAP page, and
- EICAS page.

Figure 05–01–6 shows the displays for the communication system.



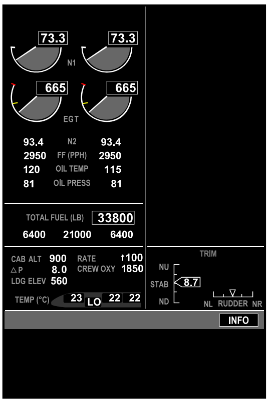
CTP

A



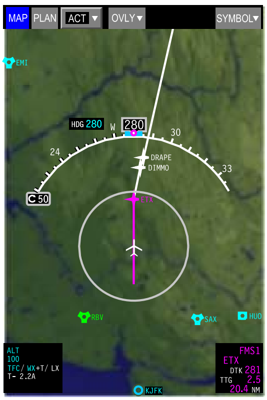
1 MFW - CNS (TUNE PAGE)

B



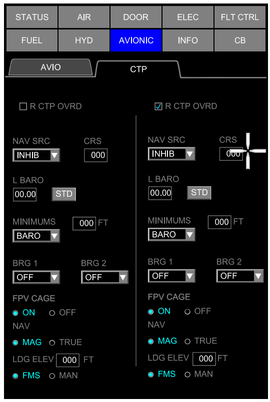
EICAS

B



MFW - MAP PAGE

B



MFW - AVIONIC - CTP

B

NOTE

1 This view shows options that may not be installed on your aircraft.

Communication system displays
Figure 05–01–6

B. Radio Interface Unit (RIU)

Communication is managed by two Radio Interface Units (RIUs).

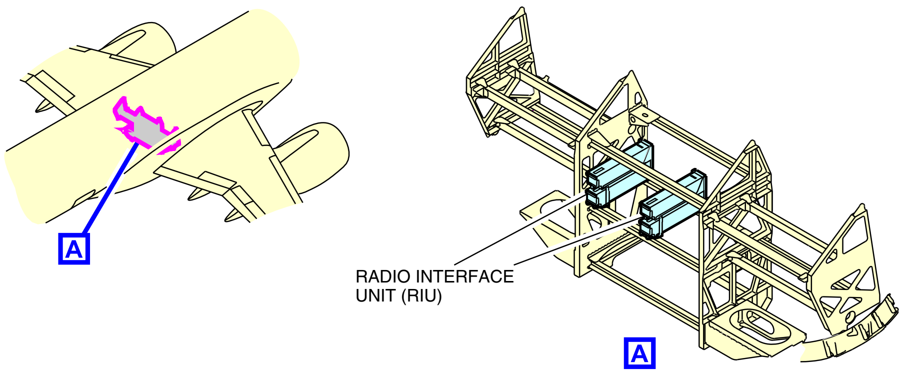
The RIUs are located in the mid equipment bay and manage audio for the communication system (refer to Figure 05–01–7). Both RIUs are independent.

Within each RIU, two independent data paths are provided for radio data concentration.

The two RIUs can be tuned from the CTPs and the RTSA.

The RIUs convert all analog signals to digital data. Both RIUs have optional SELCAL capabilities and support dual audio management of the ACPs. RIU 1 has an airborne router and data link to support the Aircraft Communications Addressing and Reporting System (ACARS). This enables message traffic for Air Traffic Services (ATS), Airline Operational Communication (AOC), and Controller–Pilot Data Link Communications (CPDLC).

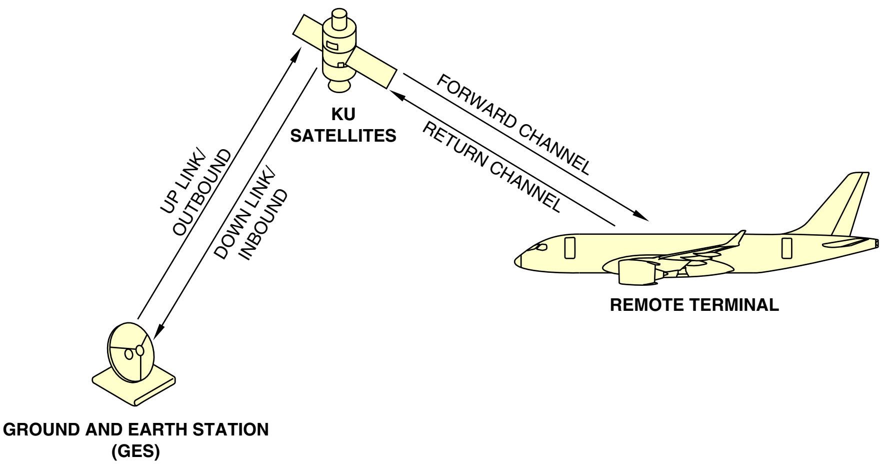
The RIUs also provide the aural alerts for the Traffic Alert and Collision Avoidance System (TCAS) and transponder, EICAS, and Terrain Awareness and Warning System (TAWS).



Radio Interface Unit (RIU) locations
Figure 05–01–7

C. Ku-band connectivity system (Panasonic eXConnect) <44309212C>

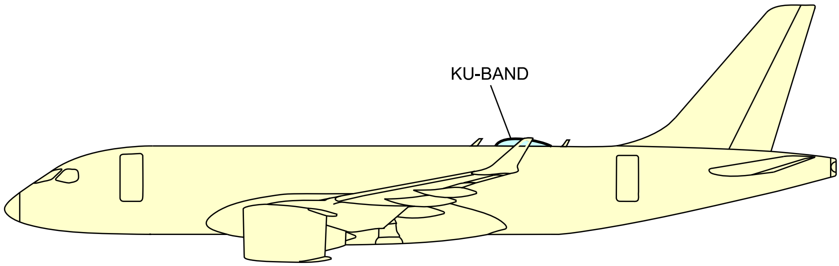
The Panasonic eXConnect system uses the Ku-band aeronautical network to deliver broadband connectivity. This connectivity service enables passengers to access the internet on personal electronic devices (refer to Figure 05–01–8).



Ku–band satellite link
Figure 05–01–8

(1) Antenna

The antenna receives and transmits Ku-band signals from a satellite network for communication to a ground system network. The low-profile antenna is installed on the upper fuselage (refer to Figure 05–01–9).



KU-BAND ANTENNA

Ku–band connectivity antenna
Figure 05–01–9

The INLET switch is located on the EQUIP COOLING panel (refer to Figure 05–01–10). It lets the flight crew control the transmission to prevent the high energy signal from being transmitted from the antenna while maintenance personnel are de-icing the aircraft.

When the INLET switch is selected OFF, if Ku–band transmission stays powered or status is unknown while on the ground, the caution message **KU BAND ON** is displayed on the EICAS page.

EQUIP COOLING panel – INLET switch
Figure 05–01–10

RADIO COMMUNICATION – OVERVIEW

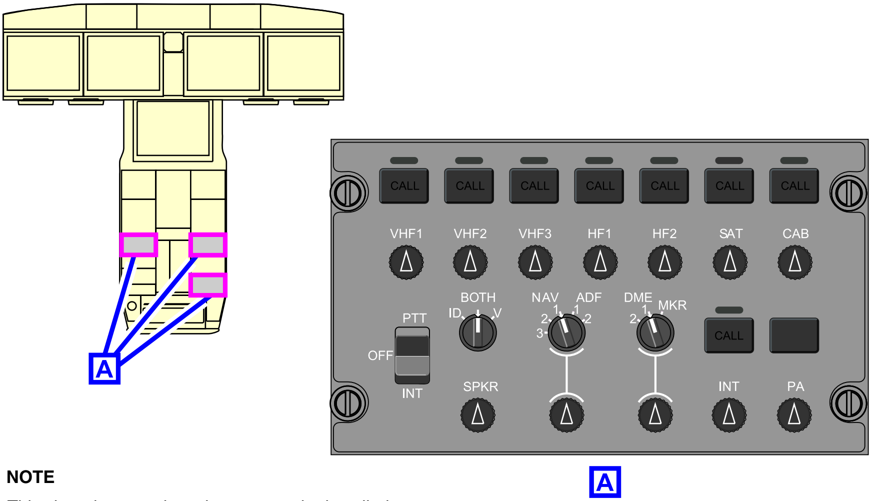
The radio communication system includes the equipment that follows:

- HF1 communication radio, <23129001C>
- HF1 and HF2 communication radios, <23120003C>
- A satellite communication (SATCOM) system, <23150006C>
- The Selective Calling (SELCAL) system, and <23210004C>
- Three VHF communication radios.

The third VHF communication radio and the SATCOM system provide data links for the optional Controller-Pilot Data Link Communications (CPDLC). <23240001C>

A. Audio Control Panel (ACP)

Three Audio Control Panels (ACPs) are installed on the central pedestal. The ACPs receive, process, and distribute audio and keying data (refer to Figure 05–02–1).



NOTE

This view shows options that may not be installed on your aircraft.

Audio Control Panel (ACP)
Figure 05–02–1

The ACP controls the aural VHF and HF communication in the flight compartment through the speakers, the headsets, or the flight crew oxygen masks. Every member of the flight crew can monitor as many VHF communications as required. <23129001C>

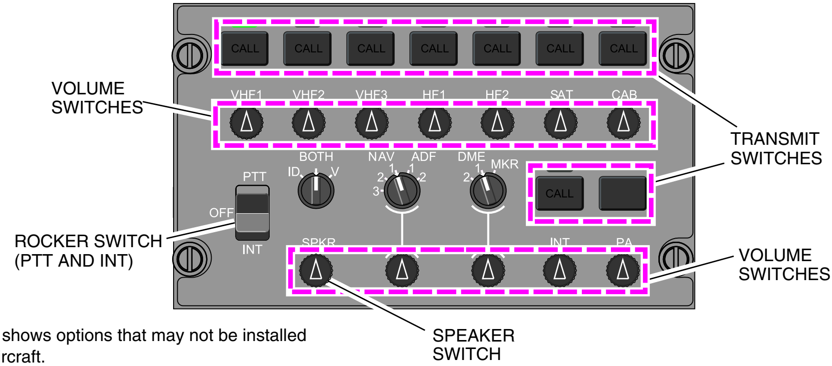
Each ACP has the VHF and HF functions that follow: <23129001C>

- Volume adjustment,
- Transmit channel selection, and
- Push-To-Talk (PTT) selection.

Each ACP has the controls and switches that follow:

- Microphone selector (transmit) rocker switch (PTT, OFF, INT),
- Communication transmission selection transmit switches,
- Communication audio on/off and volume switches, and
- Speaker volume switch (SPKR).

Figure 05–02–2 shows the ACP volume and transmit switch locations.



NOTE

This view shows options that may not be installed on your aircraft.

ACP – Volume and transmit switch locations
Figure 05–02–2

(1) Transmit switches

Transmit switches are used to broadcast to:

- SAT (SATCOM), <23150006C>
- HF radio (HF1), <23120001C> or <23120005C>
- HF radios (HF1 and HF2), <23120003C>
- VHF radios (VHF1, VHF2, and VHF3),
- CAB (Cabin communication),
- INT (Intercom), and
- PA (Passenger Address).

When a transmit switch is pushed, the light above it comes on to indicate that the transceiver is selected. Audio is automatically enabled for the selected transceiver. Only one transmit switch can be selected at a time.

(2) Audio on/off volume switches

The on/off volume switches control the volume of the communication systems as follows:

- Off – The volume switch is latched (pushed in).
- On – The volume switch is unlatched (in the raised position), and it becomes visible.

When selected on, the volume is adjusted by rotating the switch.

When a communication radio is selected to transmit, the radio audio is activated and the volume can be adjusted without unlatching the switch.

The SPKR volume switch controls the speakers on each side of the overhead panel as follows:

- Off – When the SPKR switch is latched (pushed in), the speakers are off.
- On – When the SPKR switch is unlatched (in the raised position), the speakers are on.

When selected on, the volume is adjusted by rotating the switch.

NOTE

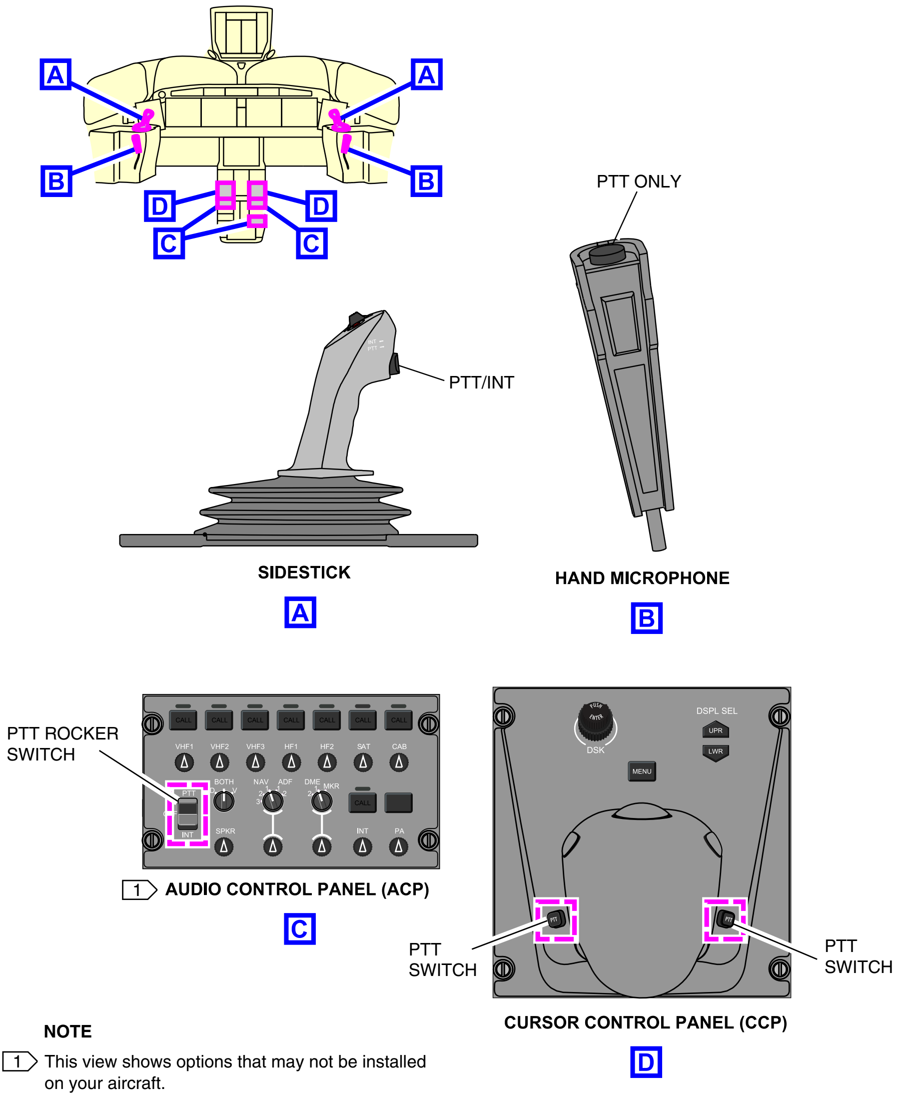
ACP 3 SPKR volume knob is inactive.

B. Push-To-Talk (PTT) switches

The flight compartment is equipped with 11 PTT switches.

Their locations are as follows (refer to Figure 05–02–3):

- ACPs – Three PTT switches (one rocker switch on each ACP),
- CCPs – Four PTT switches (two on each CCP),
- Sidesticks – Two PTT switches (one on each sidestick), and
- Hand-held microphones – Two PTT switches (one on each).



PTT (Push–To–Talk) locations
Figure 05–02–3

(1) PTT/INT and PTT rocker switches – INT position

The INT position is used for internal aircraft communication between the pilots, and for external aircraft communication between the flight compartment and designated ground crew positions.

The HOT MIC function is initiated when the PTT rocker switch on either ACP or the PTT switch on either sidestick is permanently set to the INT position.

(2) PTT switch

The PTT switch is used for external voice communication, either air-to-air or air-to-ground.

The PTT switch has open microphone protection that becomes active after 30 continuous seconds of VHF radio transmission. When the switch has been activated for 30 continuous seconds, the VHF transmission is automatically terminated accompanied by two beeps. To continue transmission after automatic termination of VHF transmission, the PTT switch must be released and keyed again.

The open microphone protection is also activated after 2 continuous minutes of transmitting on the communication systems that follow:

- HF communication, <23129001C>
- SATCOM communication, <23150006C>
- Passenger Address (PA) communication, and
- Cabin crew communication.

C. VHF communication radio

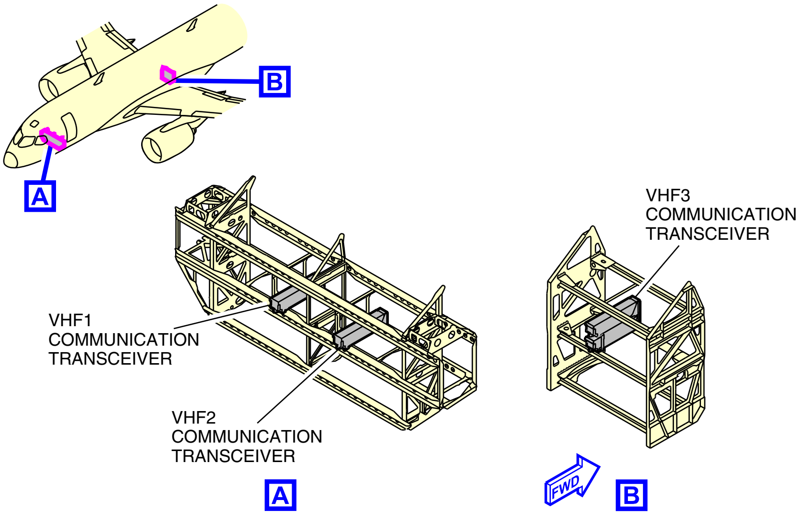
The VHF communication system includes the transceivers/transmitters that follow:

- Two Radio Interface Units (RIUs),
- Three transceivers (VHF1, VHF2, and VHF3), and
- Three antennas (VHF1, VHF2, and VHF3).

VHF1, VHF2, and VHF3 provide voice communications with SELCAL capability.

Only VHF3 can operate in voice or data mode. When the data is selected, the radio provides VHF Data Link (VDL) communication mode A and mode 2.

The VHF1 and VHF2 transceivers are located in the forward equipment bay. The VHF3 transceiver is located in the mid equipment bay. Refer to Figure 05–02–4.



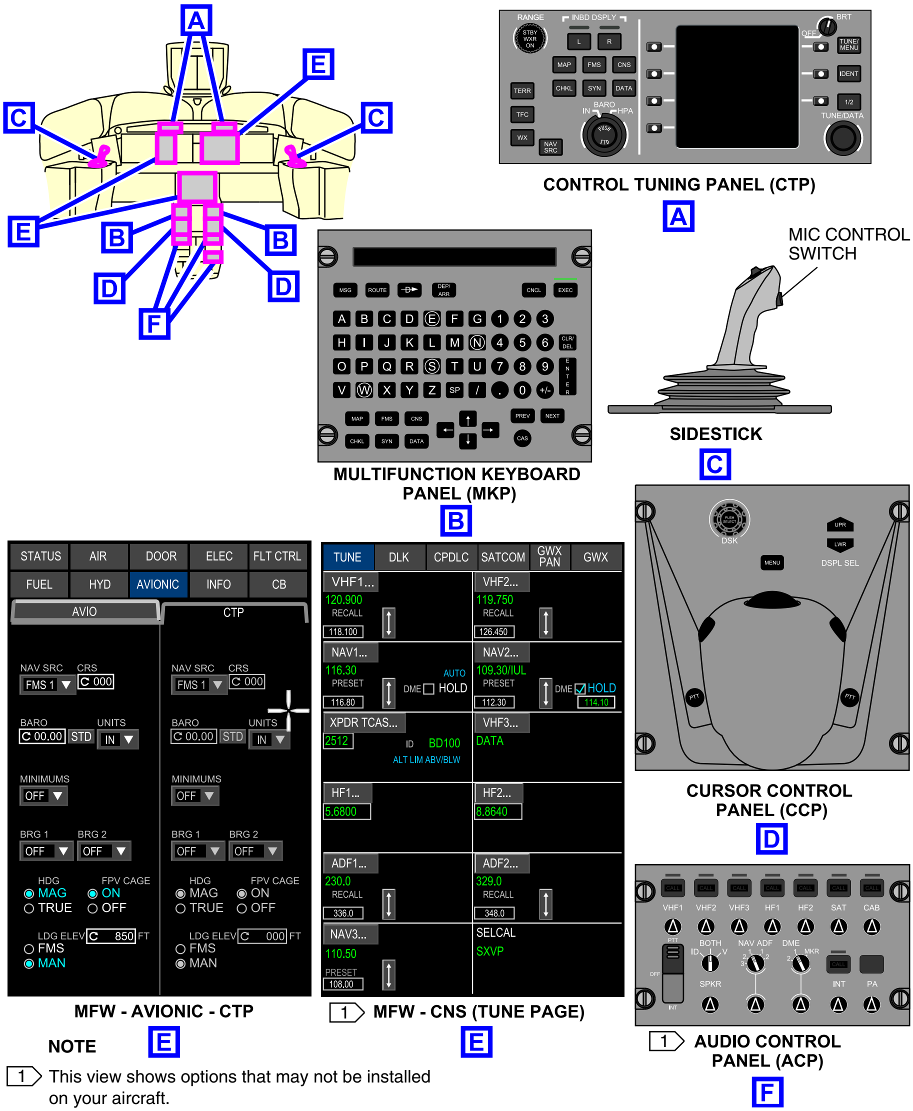
VHF1, VHF2, and VHF3 transceiver locations
Figure 05–02–4

Radio Interface Units 1 and 2 (RIU 1 and RIU 2) are the main components of VHF communication radios. Each RIU receives audio inputs from the radio antenna and ACPs. The RIU data shows on the CTP display and on the TUNE page of a Multifunction Window (MFW).

The VHF controls are provided by (refer to Figure 05–02–5):

- Three Audio Control Panels (ACPs),
- Two Cursor Control Panels (CCPs),
- Two Multifunction Keyboard Panels (MKPs),

- Two Control Tuning Panels (CTPs),
- The AVIONIC page, and
- The TUNE page.



NOTE

1 This view shows options that may not be installed on your aircraft.

Communication system controls
Figure 05–02–5

D. HF communication radio <23129001C>

The HF communication system transmits and receives in HF band. Communication is possible in simplex or half-duplex, in Upper Sideband (USB), Lower Sideband (LSB), or Amplitude Modulation (AM).

The HF communication system includes one transceiver and one antenna. <23120001C> or <23120005C>

The HF communication system includes two transceivers and one antenna. <23120003C>

The HF controls are provided by:

- Three Audio Control Panels (ACPs),
- Two Control Tuning Panels (CTPs), and
- The TUNE page.

Tuning of the HF is done when the flight crew uses a microphone, followed by a selection of a new frequency.

Initially, there is a 6-second delay associated with an aural alert to prevent transmitting on both HFs at the same time. <23120003C>

The HF1 transceiver is located in the aft equipment bay. <23120001C> or <23120005C>

The HF1 and HF2 transceivers are located in the aft equipment bay. <23120003C>

E. SELCAL <23210004C>

The Selective Calling (SELCAL) is used to alert the flight crew when a ground radio station wants to communicate with the aircraft.

The SELCAL function monitors the VHF and the HF radio frequencies for aircraft-specific four-digit codes. The SELCAL system uses all the VHF and the HF components. <23129001C>

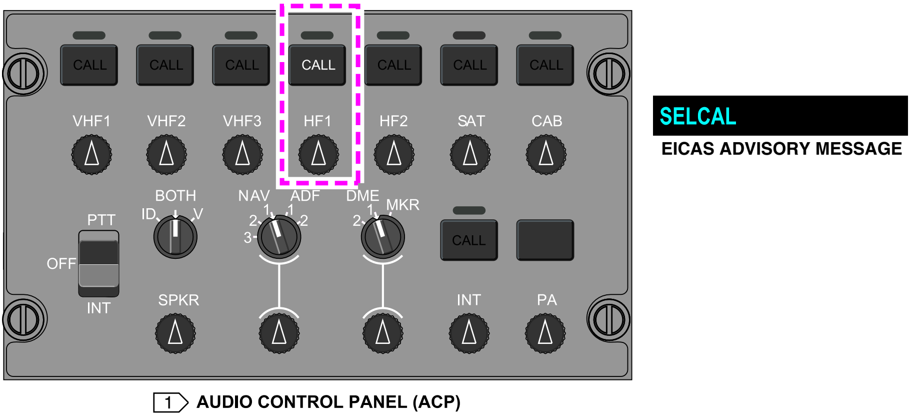
The SELCAL controls and indications are provided by:

- Three Audio Control Panels (ACPs),
- Two Control Tuning Panels (CTPs),

- The TUNE page, and
- The EICAS page.

Radio Interface Unit 1 (RIU 1) and RIU 2 are the main components for SELCAL radio communication. Each RIU receives audio inputs from all the VHF and HF radio antennas and Audio Control Panels (ACPs). <23129001C>

To alert the flight crew of incoming SELCAL calls, there is a SELCAL aural message and a SELCAL EICAS advisory message. Also, the CALL label is illuminated on the corresponding transmit switch of the ACP (refer to Figure 05–02–6).



NOTE

1 This view shows options that may not be installed on your aircraft.

ACP and SELCAL EICAS advisory message
Figure 05–02–6

When the radio transmit switch is pushed and the PTT switch is keyed, the SELCAL advisory message and the CALL legend go off.

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RADIO AND CONTROL TUNING PANEL (CTP) – DESCRIPTION AND OPERATION

Radio control and tuning can be done by:

- Control Tuning Panel (CTP),
- Display tuning, and
- Graphical tuning.

CTP

A. Overview

There are two CTPs located on the glareshield. Both CTPs are equipped with a display screen and provide centralized controls, frequency tuning, and mode selection for:

- VHF1 and VHF2 communication,
- VHF1 and VHF2 navigation,
- VHF3 (VOICE/DATA),
- HF1, <23120001C> or <23120005C>
- HF1 and HF2, <23120003C>
- Transponders and TCAS control,
- SELCAL, <23210004C>
- CPDLC, and <23249001C>
- Data Link (DLK).

The left CTP (CTP1) controls:

- VHF1,
- Transponder 1,
- HF1, <23120001C> or <23120005C>
- VHF3.

The right CTP (CTP2) controls:

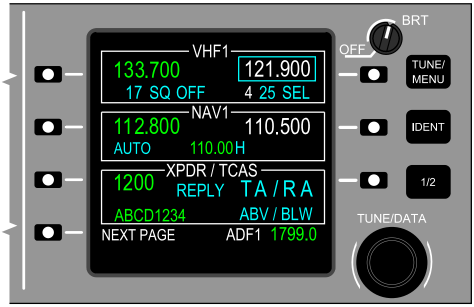
- VHF2,
- Transponder 2,
- HF2, and <23120003C>
- VHF3.

NOTE

Each CTP can tune the cross-side radios.

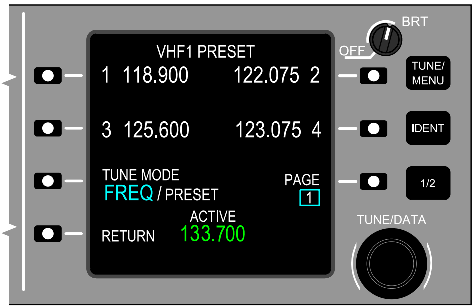
B. CTP display

The frequencies of the radios, codes, and modes are shown on the CTP display. The general structure of a CTP display is the top level page, the control page, and the preset page. Refer to Figure 05–03–1.



TOP LEVEL PAGE

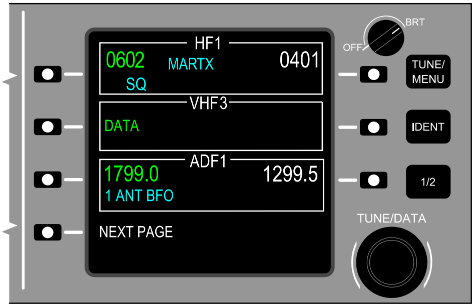
CONTROL PAGE



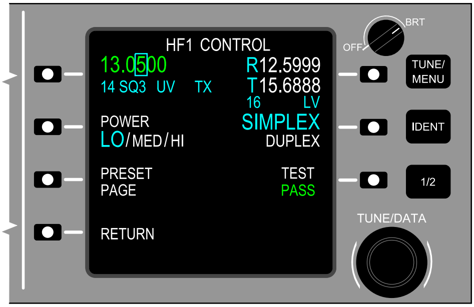
PRESET PAGE

CTP pages
Figure 05–03–1

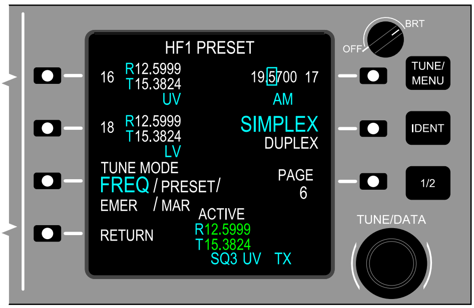
Figure 05–03–2 shows the CTP – HF – Pages <23129001C>



HF1 SECOND TOP LEVEL PAGE



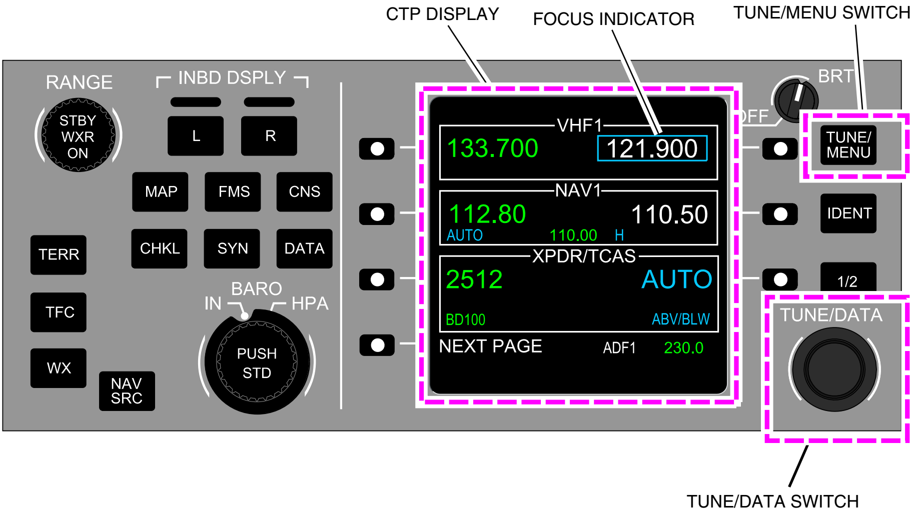
HF1 CONTROL PAGE



HF1 PRESET PAGE

CTP – HF pages <23129001C>
Figure 05–03–2

The top level tuning page is the default CTP page. It is accessed when the TUNE/MENU switch is pushed. Refer to Figure 05–03–3.

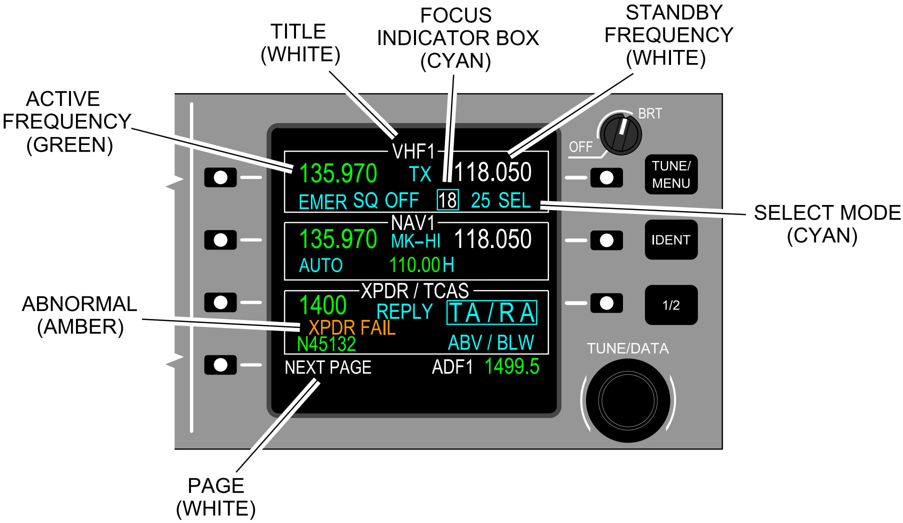


Control Tuning Panel (CTP)
Figure 05–03–3

Active frequencies are normally displayed in green and standby frequencies are displayed in white. If the active frequency is invalid, missing or failed, or the radio has failed, the active frequency is displayed in amber.

A focus indicator is displayed as a cyan box surrounding the frequency, code, or mode currently controlled by the TUNE/DATA switch.

Figure 05–03–4 shows the color logic of the CTP display.



CTP color logic
Figure 05–03–4

The system window titles are shown in white for the on-side systems. For example, VHF1 is shown in white when viewed on CTP1. The titles are shown in amber when the CTP is showing the cross-side radios. For example, VHF2 is shown in amber if CTP1 is showing cross-side data. Refer to Figure 05–03–5.

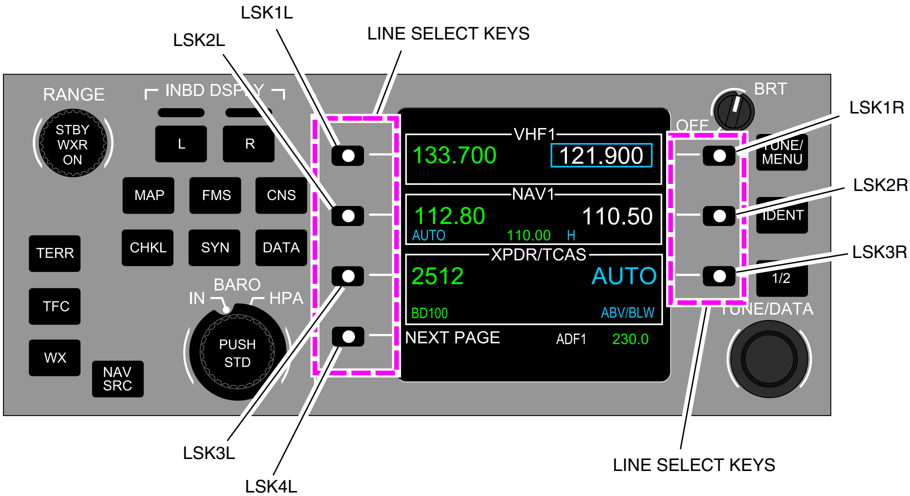
Left Control Tuning Panel (CTP1) – Cross–side view
Figure 05–03–5

The table that follows is a summary of the CTP color logic.

Color	Description
Green	Active frequency
White	Inactive frequency, title and page
Cyan	Focus indicator box or selected mode
Amber	Cross-side information or malfunction

C. CTP – Line Select Keys (LSK)

The CTP has four LSKs on the left side (L) of the display and three on the right side (R). These LSKs can be used as frequency selectors, mode selectors, or page selectors. They are related to the data shown beside them on the CTP display. They are identified as 1L, 2L, 3L, and 4L for the left side, and 1R, 2R, and 3R for the right side (refer to Figure 05–03–6).



CTP – Line Select Key (LSK) locations
Figure 05–03–6

D. CTP – TUNE/DATA switch

The TUNE/DATA switch is used to modify the data in the focus indicator, such as:

- Frequency,
- Code,
- Operating mode, or
- Page number.

To tune a frequency, the outer ring of the TUNE/DATA switch is turned to change the digits before the decimal, and the inner ring of the TUNE/DATA switch is turned to change the digits after the decimal.

Figure 05–03–7 shows the TUNE/DATA switch.

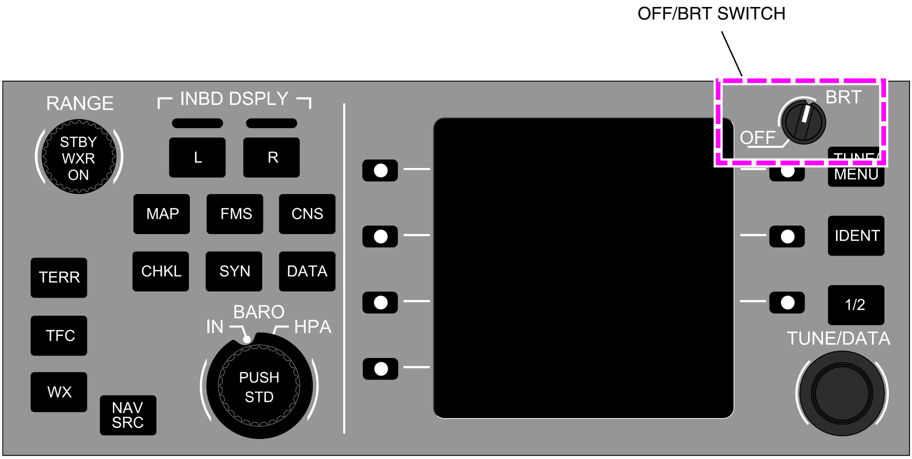
CTP – TUNE/DATA switch
Figure 05–03–7

E. CTP – OFF/BRT switch

The OFF/BRT switch controls the CTP display brightness. When the OFF position is selected, the CTP radio tuning is inhibited and the messages that follow are displayed on the EICAS page (refer to Figure 05–03–8):

- EICAS caution message – L CTP TUNING FAIL (for the CTP on the left side), or
- EICAS caution message – R CTP TUNING FAIL (for the CTP on the right side), and
- EICAS status message – CTP OVERRIDE.

Each CTP can tune both onside and cross-side radios.



L CTP TUNING FAIL

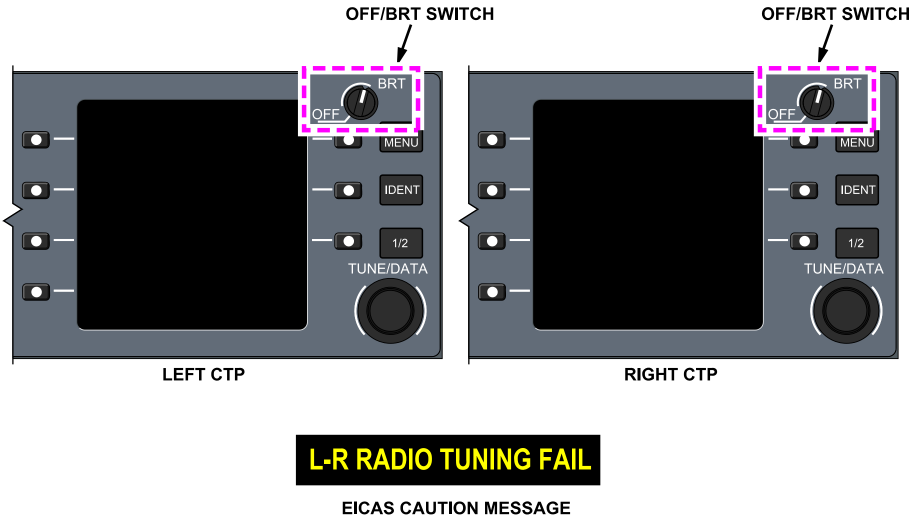
EICAS CAUTION MESSAGE

CTP OVERRIDE

EICAS STATUS MESSAGE

CTP OFF/BRT switch
Figure 05–03–8

When both CTPs are inhibited, the L-R RADIO TUNING FAIL caution message is displayed on the EICAS page. Refer to Figure 05–03–9.



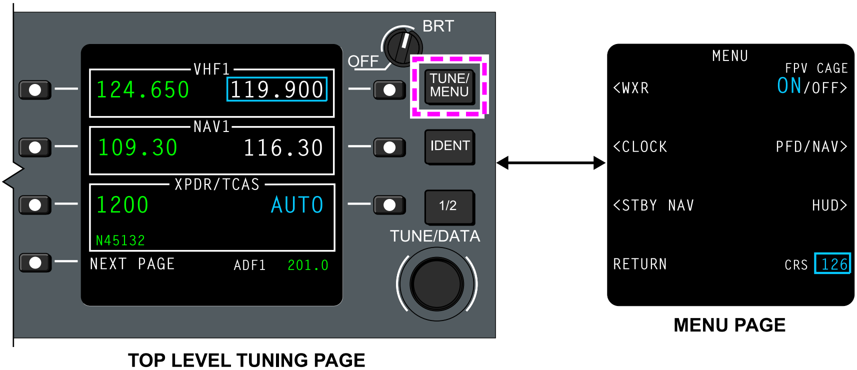
Dual CTP inoperative
Figure 05–03–9

NOTE

The switches on the left side of the CTP and the BARO rotary switch are operational when the OFF/BRT switch is at OFF.

F. CTP – TUNE/MENU switch

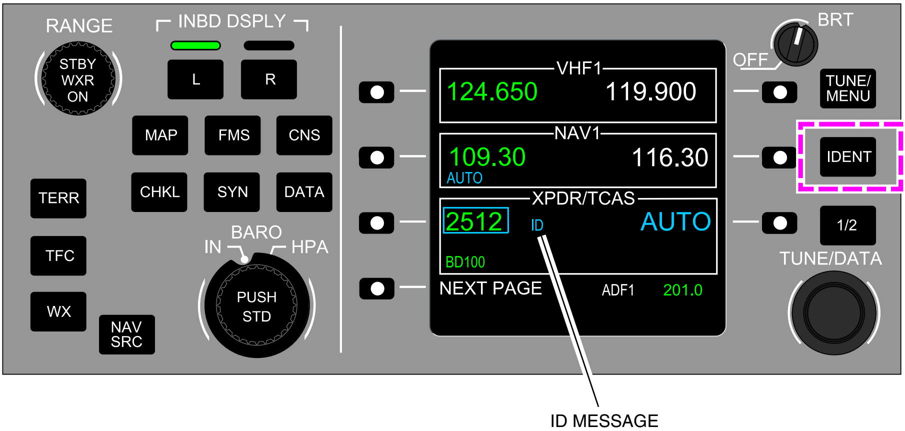
When the TUNE/MENU switch is pushed, the CTP display toggles between the top level tuning page and the MENU page. Refer to Figure 05–03–10.



CTP – VHF1 top level page and TUNE/MENU switch
Figure 05–03–10

G. CTP – IDENT switch

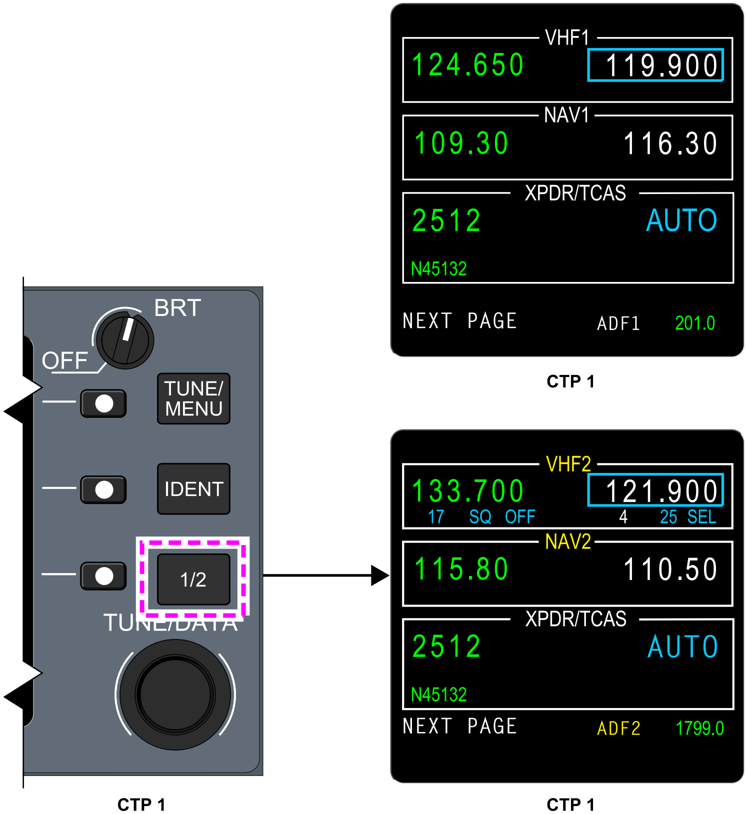
The IDENT switch is used when an ATC squawk identification is required. When the IDENT switch is pushed, ID is displayed in cyan. Refer to Figure 05–03–11.



CTP – IDENT switch
Figure 05–03–11

H. CTP – 1/2 switch

The 1/2 switch is used to tune the cross-side radios. When the 1/2 switch is pushed, the cross-side radio legends are displayed in amber. When the 1/2 switch is pushed a second time, the CTP reverts to normal onside radio tuning. Refer to Figure 05–03–12.



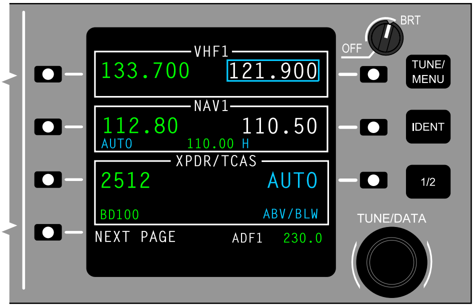
CTP – 1/2 switch
Figure 05–03–12

I. CTP – Power-up test

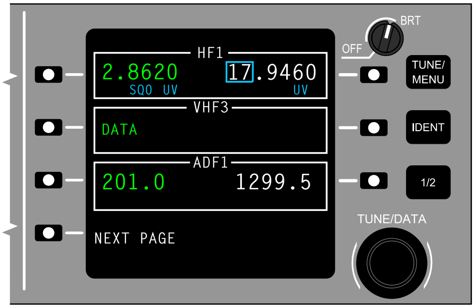
On the ground at system power-up, the CTP does a unit self-test. During the test, the CTP displays the TUNE top level page and a Rockwell Collins copyright notice is shown for 20 seconds at the bottom of the page. If the unit is powered up while the aircraft is in the air, the copyright notice is not shown. If there is an individual radio system failure, the active frequency or code is shown in amber.

CTP RADIO TUNING

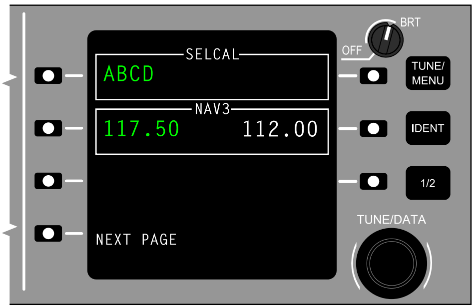
The radio tuning is done from the top level page. The top level page can have up to three pages (refer to Figure 05–03–13). The first top level tuning page is the default page. To have direct access to the default top level page, the TUNE/MENU switch on the right side of the CTP is pushed.



VHF1 TOP LEVEL PAGE



SECOND TOP LEVEL PAGE



THIRD TOP LEVEL PAGE

CTP – Top level pages
Figure 05–03–13

The CTP uses the top level tuning pages to show indications and allows the selections that follow:

- Direct and standby tuning,
- Shows the frequency selection (25 SEL) label,
- Shows the frequency selection (8.33 SEL) label, <31000008C>
- Gives access to other top level pages (NEXT PAGE), and
- Shows the EMER (Emergency), SQ OFF (Squelch Off), TX (Transmission), and numbered preset frequency (1 to 19) labels.

These actions can also be accomplished from the VHF2 CONTROL page.

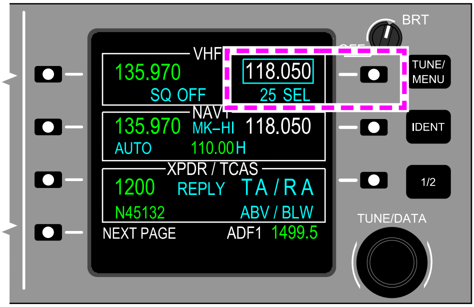
The names of the second and the third top level pages depend on the communication option selections. To swap between the pages, the LSK 4L (adjacent to NEXT PAGE) is pushed.

A. CTP – VHF standby tuning

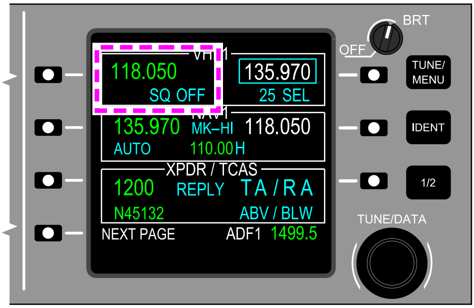
Tuning and swapping a standby VHF frequency (white) can be done from the top level page. When LSK 1R is pushed, a focus indicator box (cyan) surrounds the VHF1 standby frequency. Then it can be tuned by rotating the inner ring of the TUNE/DATA switch. Finally, to swap the standby frequency to active, LSK 1R is pushed a second time.

These actions swap the standby and the active frequencies.

Figure 05–03–14 shows the VHF standby tuning.



VHF1 TOP LEVEL PAGE



VHF1 TOP LEVEL PAGE

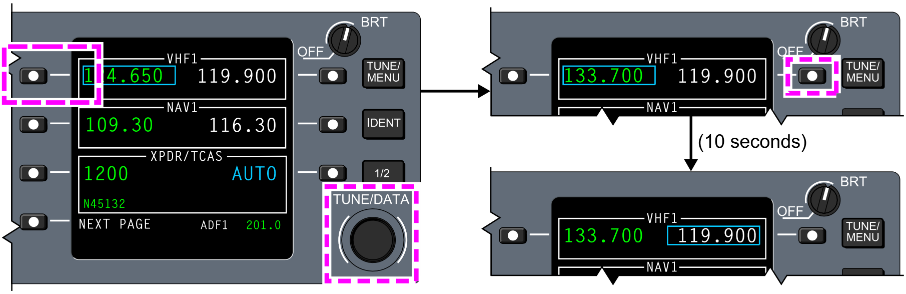
CTP – VHF standby frequency swapped to active frequency
Figure 05–03–14

The same information is applicable to the VHF CONTROL pages.

B. CTP – VHF active tuning

Direct tuning of the VHF active frequency (green) is done when LSK 1L on the top level page is pushed. This causes the focus indicator box (cyan) to surround the VHF1 active frequency (green). Direct tuning can be done by rotating the inner ring of the TUNE/DATA switch (refer to Figure 05–03–15). The focus indicator box (cyan) returns to the standby frequency (white) position 10 seconds after the last action on the TUNE/DATA switch or when LSK 1R is pushed again.

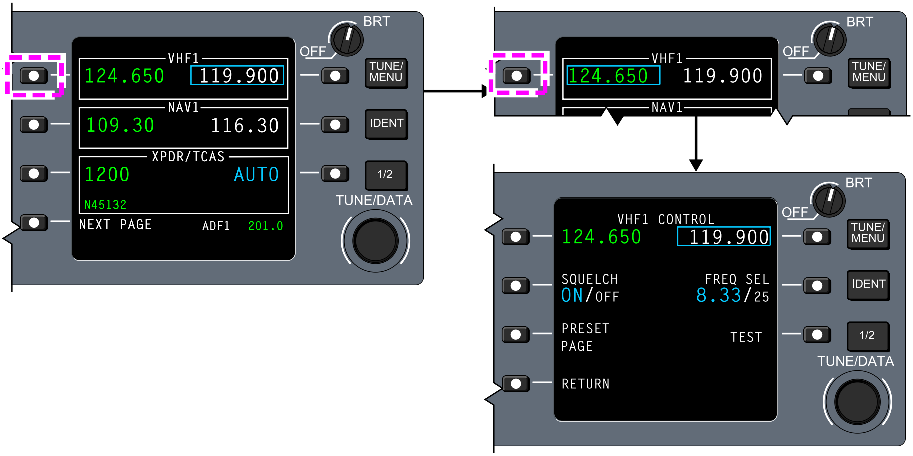
The same information is applicable to the VHF CONTROL page.



CTP – VHF direct tuning
Figure 05–03–15

C. CTP – VHF CONTROL pages

The VHF CONTROL pages are accessed from the top level tuning page when the associated LSK is pushed twice. The first time the LSK is pushed, the focus indicator box (cyan) will move to the active frequency (green). Pressing the LSK a second time shows the VHF CONTROL page. Refer to Figure 05–03–16.



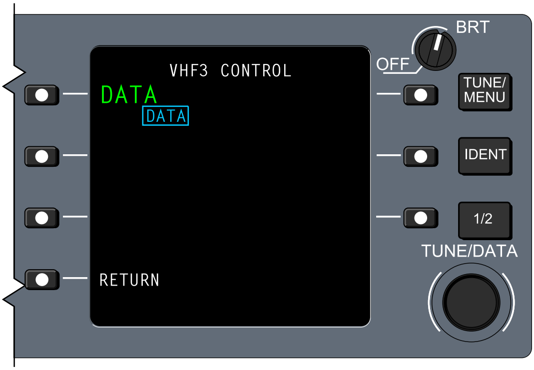
CTP – Access to VHF1 CONTROL page
Figure 05–03–16

The VHF CONTROL pages allow the selections and functions that follow:

- Direct and standby tuning,
- Selection of voice or data mode (VOICE/DATA) for VHF3 only,
- Selection of the frequency select (FREQ SEL) channel spacing,
- Access to the PRESET PAGE,
- Display of the active preset indication,
- Selection of the squelch ON or OFF, and
- Selection of the test mode.

The same selections and functions are applicable to the VHF2 CONTROL page.

The VHF3 CONTROL page allows only VOICE/DATA selection (refer to Figure 05–03–17). The LSK 1L and the TUNE/DATA switches are used to toggle between VOICE and DATA mode.



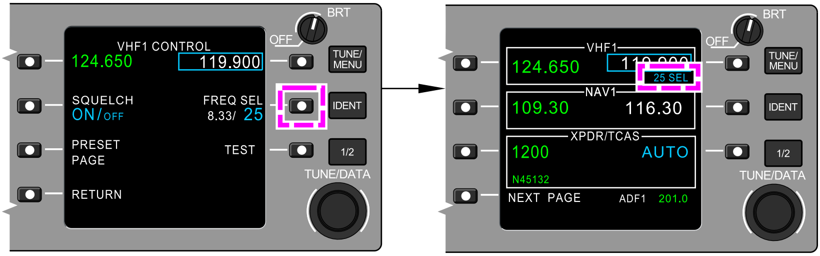
CTP – VHF3 CONTROL page
Figure 05–03–17

(1) CTP – VHF frequency select (FREQ SEL)

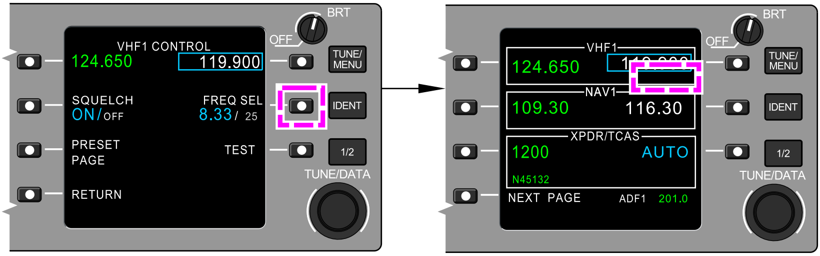
On the VHF CONTROL page, the channel spacing is set at 25 kHz. It is shown in a large, cyan font. Refer to Figure 05–03–18.

On the VHF CONTROL page, pushing LSK 2R alternates between 8.33 kHz and 25 kHz channel spacing. The selection is confirmed when 8.33 or 25 appears in a large, cyan font. Refer to Figure 05–03–19. <31000008C>

The selection spacing (FREQ SEL, cyan) is also shown below the standby VHF1 frequency on the TUNE top level page and above the active VHF1 frequency on the VHF PRESET page.



CTP – Spacing selection on the VHF1 CONTROL or VHF2 CONTROL pages
Figure 05–03–18

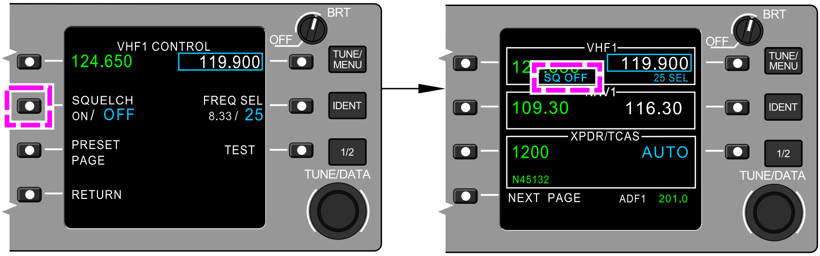


CTP – Channel spacing selection on the VHF1 or VHF2 CONTROL pages <31000008C>
Figure 05–03–19

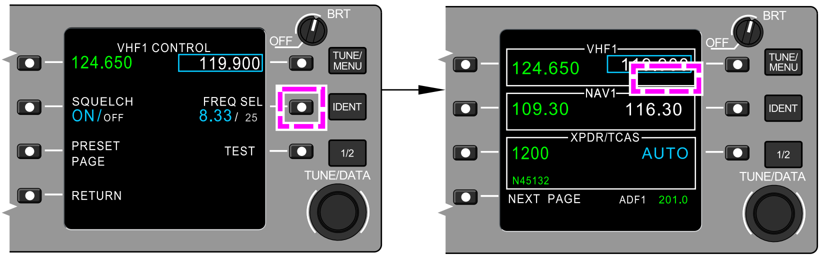
(2) CTP – VHF SQUELCH

Pushing LSK 2L toggles the SQUELCH mode (large font, cyan) between ON (default) and OFF. When selected to OFF, SQ OFF is shown in cyan below the active frequency on the top level page and the VHF PRESET page.

Figure 05–03–21 <31000008C>, or Figure 05–03–20 shows the SQUELCH indication on the VHF1 CONTROL page.



CTP – VHF1 CONTROL page – SQUELCH
Figure 05–03–20



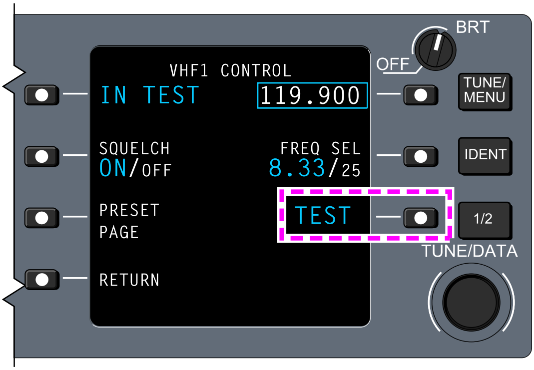
CTP – VHF1 CONTROL page – SQUELCH <31000008C>
Figure 05–03–21

(3) CTP – VHF TEST

On the VHF CONTROL page, pushing LSK 3R puts the VHF communication in test mode for approximately 10 seconds. The TEST indication changes to a larger font, and becomes cyan while the test mode is active.

An amber active frequency indicates that the test has failed.

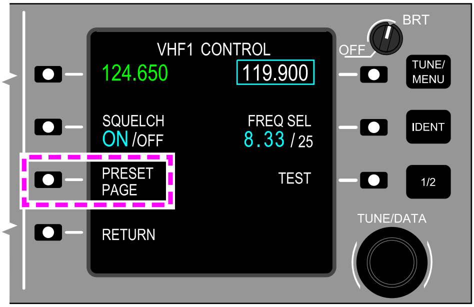
Figure 05–03–22 shows the VHF1 CONTROL page in test.



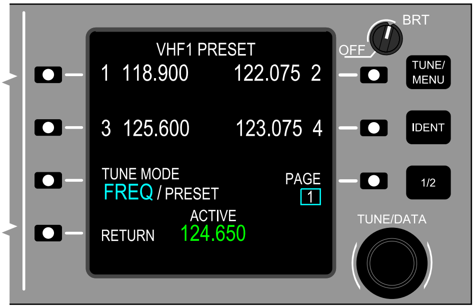
CTP – VHF1 CONTROL page – TEST
Figure 05–03–22

(4) CTP – PRESET PAGE

Pushing the LSK 3L adjacent to PRESET PAGE will display the VHF1, VHF2, or VHF3 PRESET page. On the selected CONTROL page, pressing the LSK adjacent to PRESET PAGE will cause the focus indicator box (cyan) to surround the number below PAGE. Then, the TUNE/DATA switch can be used to cycle through the PRESET pages. The PRESET pages give access to preset frequencies programmed in memory. Refer to Figure 05–03–23.



VHF1 CONTROL PAGE



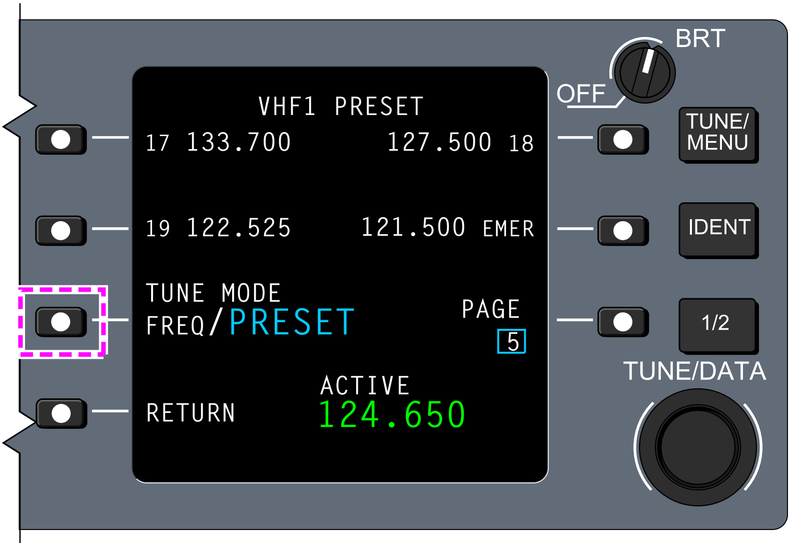
VHF1 PRESET PAGE

CTP – Access to VHF1 PRESET page from VHF1 CONTROL page
Figure 05–03–23

D. CTP – VHF preset tuning

There are 20 preset frequencies available for each VHF radio. Each preset programmable frequency has an assigned number (1 to 20). The last preset frequency is permanently assigned to the emergency frequency, 121.500 MHz. The EMER indication replaces the number 20. The preset frequencies are synchronized between the two CTPs.

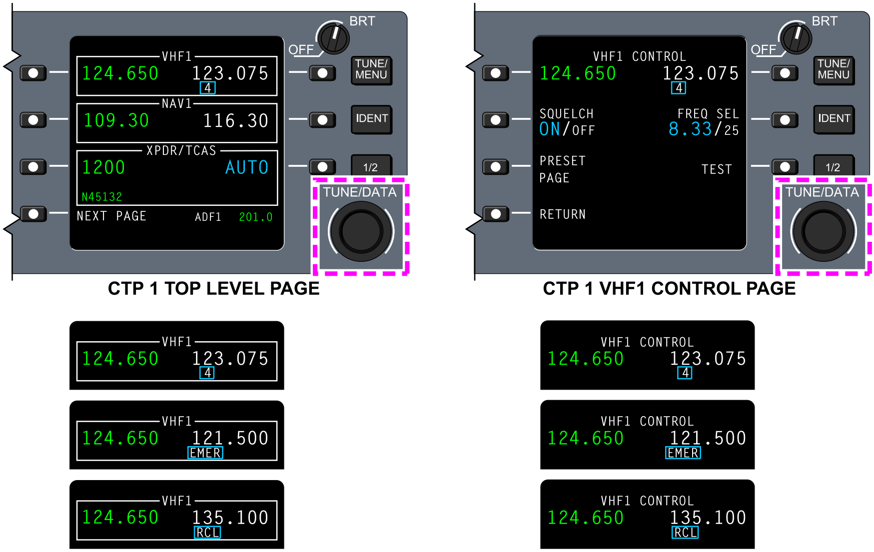
To enable preset tuning, LSK 3L (adjacent to TUNE MODE) is used to toggle between the default FREQ tune mode and the PRESET tune mode. The enabled mode is displayed in a large, cyan font. Refer to Figure 05–03–24.



CTP – VHF PRESET page
Figure 05–03–24

When the PRESET tuning mode is selected (large font, cyan), the standby frequency and preset indication are surrounded by the focus indicator box (cyan) on the VHF top level page, and the VHF1 CONTROL pages revert to the last values displayed when preset tuning was previously active. To change the standby frequency, either TUNE/DATA switch can be used to cycle the preset frequencies through presets 1 to 19, EMER, and RCL (recall). Refer to Figure 05–03–25.

RCL (Recall) is displayed when the active frequency is not a preset frequency.

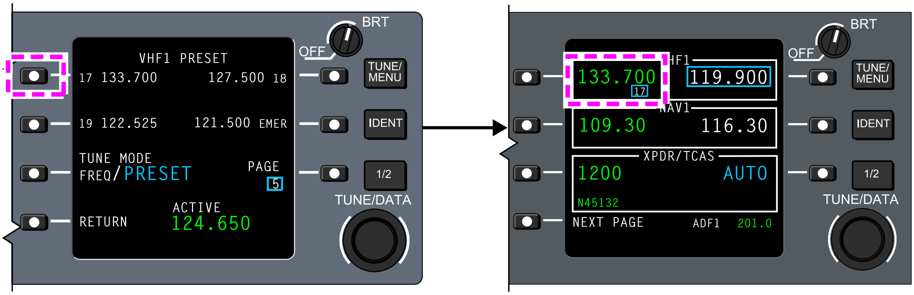


CTP – VHF PRESET tuning (part 1)
Figure 05–03–25

The active VHF frequency (green) can be direct-tuned from the VHF PRESET page. Pushing LSK 1L causes the focus indicator box (cyan) to surround that frequency only. Pushing LSK 1L again transfers the preset frequency to the active window and automatically displays the top level tuning page. If the frequency is saved in the PRESET page, a number (1 to 19) (cyan) is displayed automatically under the frequency. If it is the emergency frequency, the label EMER (cyan) is displayed.

Preset frequencies can be directly tuned in FREQ and PRESET tuning modes.

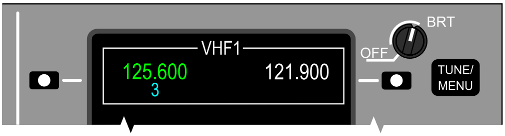
Figure 05–03–26 shows the VHF PRESET tuning.



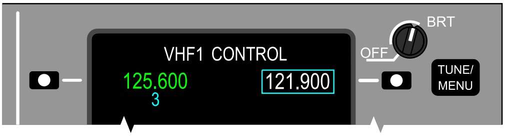
CTP – VHF PRESET tuning (part 2)
Figure 05–03–26

When an active frequency (green) is selected and it is numbered as a preset frequency, a number (1 to 19) (cyan) appears below it. These indications are displayed on the top level page and on the VHF CONTROL page. On the VHF PRESET page, the preset frequency number is displayed in white on the corresponding side and in cyan at the bottom of the page.

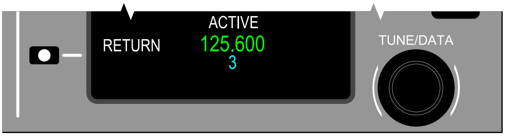
Figure 05–03–27 shows the active frequency indications on the CTP.



VHF1 TOP LEVEL PAGE



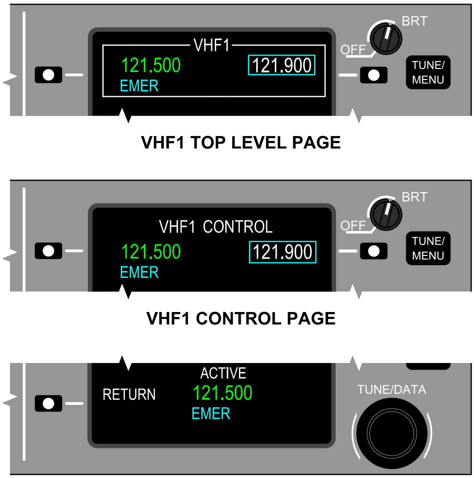
VHF1 CONTROL PAGE



VHF1 PRESET PAGE

CTP – Active frequency indications
Figure 05–03–27

When an emergency frequency is active (green), an EMER label (cyan) appears below the frequency. Refer to Figure 05–03–28.



VHF1 PRESET PAGE

CTP – Active frequency EMER (Emergency) indications
Figure 05–03–28

(1) CTP – VHF automatic emergency tuning

The VHFs automatically tune to 121.5 MHz (EMER) on VHF1 and VHF2, and display the **VHF COM 121.5 ENABLE** EICAS status message when:

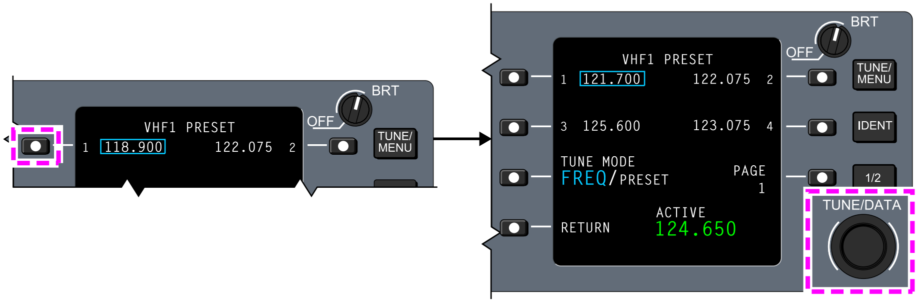
- The left and right CTPs are selected to OFF, or
- The left and right CTPs failed, or
- The left and right CTP OVRD is selected on the AVIONIC page.

Each condition can generate other EICAS caution and advisory messages. For detailed information, refer to Chap 08 – Section 8 – Communication – EICAS MESSAGES.

E. CTP – VHF preset frequency setting

Setting (programming) a preset frequency in one of the 19 preset locations is done on the VHF PRESET page. Pushing the LSK beside the preset frequency (white) causes the focus indicator box (cyan) to surround it. Rotating the DATA/TUNE switch changes the preset frequency and keeps it in memory. The new frequency replaces the previous one in the selected location. The focus indicator box (cyan) returns to the default position 10 seconds after the last action on the TUNE/DATA switch, or when LSK 3R is pushed.

Figure 05–03–29 shows the VHF PRESET frequency setting.

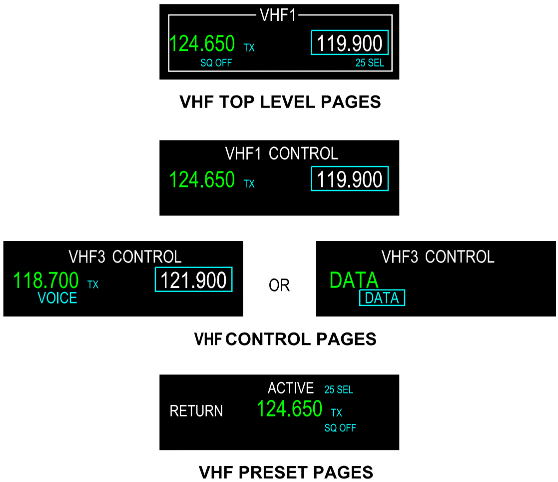


CTP – VHF PRESET frequency setting
Figure 05–03–29

F. CTP – VHF radio messages

The CTP displays the VHF radio messages that follow (refer to Figure 05–03–30):

- TX is displayed in cyan when the VHF COM radio is transmitting,
- SQ OFF is displayed in cyan when squelch is selected off,
- 25 SEL is displayed in cyan when 25 kHz channel spacing is selected,
- VOICE is displayed in cyan when VHF3 is in voice mode, and
- DATA is displayed in cyan when VHF3 is in data mode.



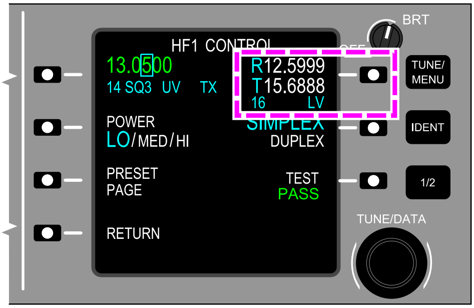
CTP – VHF radio messages
Figure 05–03–30

G. CTP – HF standby tuning <23129001C>

HF radio tuning and control is accessed from the CTP tuning page 2.

Tuning and swapping of an HF standby frequency (white) to an HF active frequency (green) is done by pushing LSK 1R, on the second top level page or on the HF1 CONTROL page. Pushing LSK 1R once causes the focus indicator box (cyan) to surround the digits before the decimal of the HF standby frequency (white). Pushing LSK 1R a second time swaps the standby frequency (white) to the active frequency (green).

Figure 05–03–31 shows the HF standby tuning on the CTP.

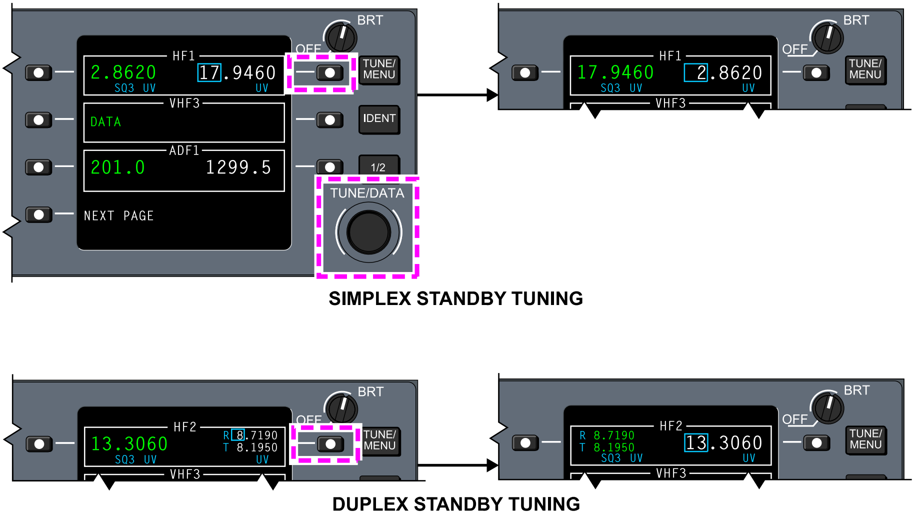


CTP – HF1 CONTROL page – Preset frequency selection to active <23129001C>
Figure 05–03–31

Rotation of the outer TUNE/DATA switch changes the position of the focus indicator box (cyan), and the inner TUNE/DATA switch changes the standby frequency (white).

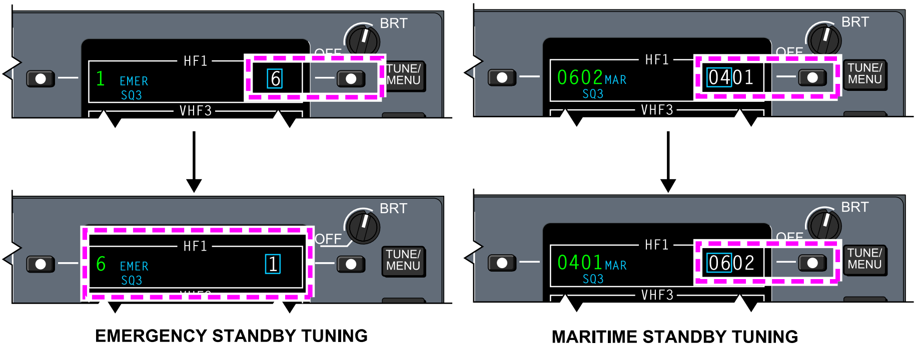
The focus indicator box (cyan) returns to the standby frequency (white) position 10 seconds after the last action done on the TUNE/DATA switch or by pushing LSK 1R.

Figure 05–03–32 shows the simplex and duplex standby tuning on the CTP.



CTP – HF simplex and duplex standby tuning to active <23129001C>
Figure 05–03–32

Figure 05–03–33 shows the HF EMER (Emergency) and MAR (Maritime) standby tuning on the CTP.

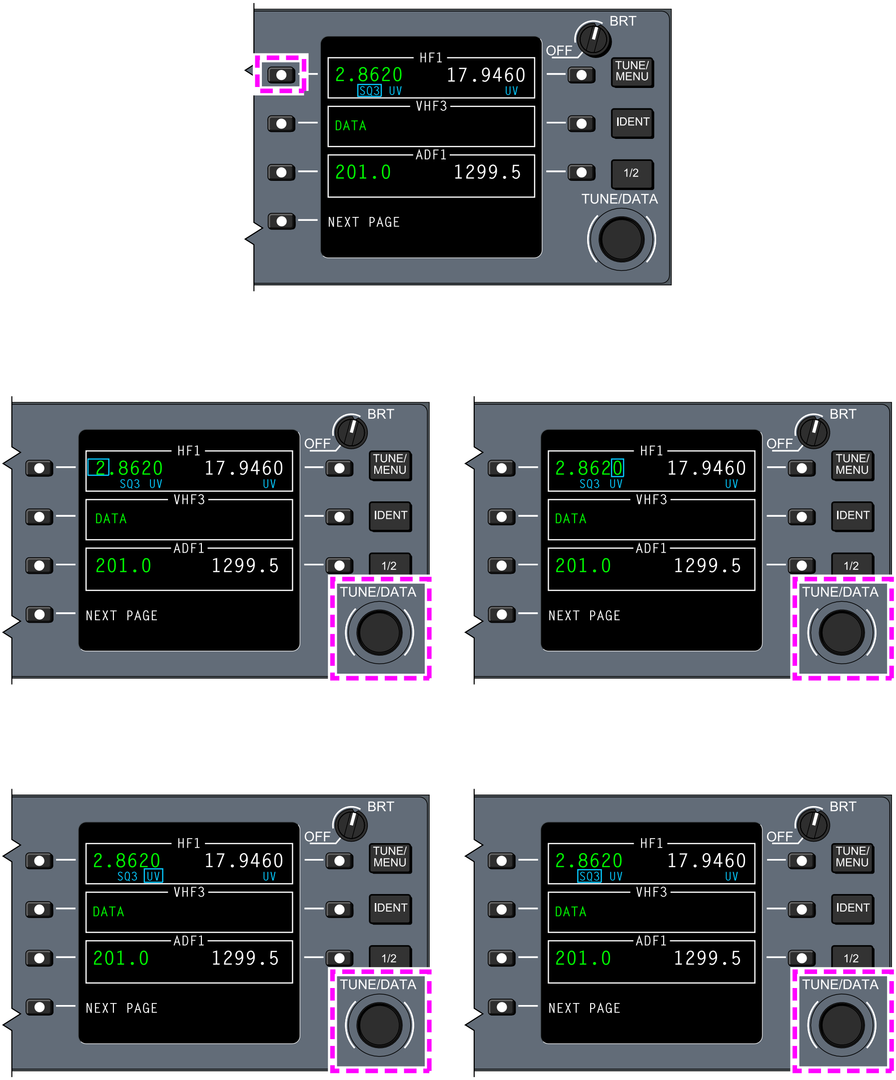


CTP – HF EMER (Emergency) and MAR (Maritime) standby tuning <23129001C>
Figure 05–03–33

H. CTP – HF direct tuning <23129001C>

The direct (active) tuning of the HF active frequency (green) is done by pushing LSK 1L on the second top level page. This action causes the focus indicator box (cyan) to surround the squelch level (SQ0, SQ1, SQ2, or SQ3) in all four tune modes. Rotation of the outer TUNE/DATA switch positions the focus indicator box (cyan). When the active frequency is surrounded, direct tuning can be done with the inner TUNE/DATA switch. The focus indicator box (cyan) returns to the standby frequency (white) position 10 seconds after the last action on the TUNE/DATA switch, or by pushing LSK 1R. Refer to Figure 05–03–34.

Rotation of the outer TUNE/DATA switch places the focus indicator around the frequency digits, the emission mode, or the squelch level. Rotation of the inner TUNE/DATA switch changes the frequency digits, the emission mode or the squelch level.

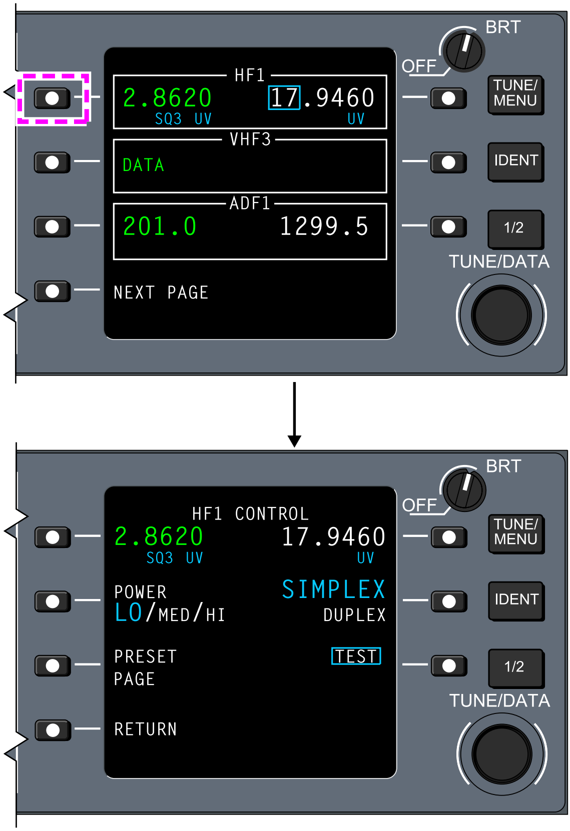


CTP – HF direct tuning <23129001C>
Figure 05–03–34

I. CTP – HF CONTROL pages <23129001C>

The HF CONTROL pages are accessed from the second top level page by pushing LSK 1L. Pushing the LSK once transfers the focus indicator box (cyan) to the squelch level. Pushing the LSK a second time shows the selected HF CONTROL page.

Figure 05–03–35 shows the second top level page and the HF1 CONTROL page.

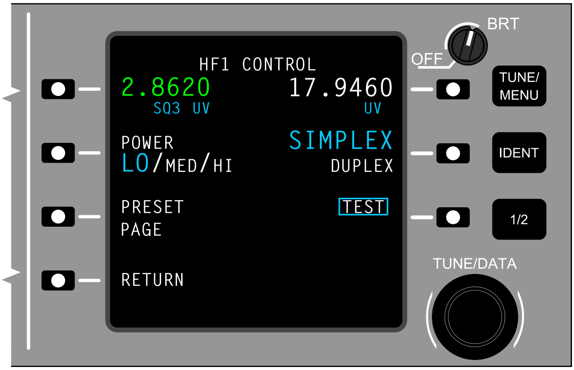


CTP – Access to HF1 CONTROL page <23129001C>
Figure 05–03–35

The HF CONTROL pages (refer to Figure 05–03–36) allow the selections that follow:

- Direct and standby tuning,
- Selection of the emission mode (UV, LV, or AM),
- Selection of the SIMPLEX or DUPLEX frequency tuning,
- Selection of the transmission POWER level,
- Selection of the PRESET PAGE,
- Selection of squelch (SQ) level (SQ0, SQ1, SQ2, or SQ3), and
- Selection of the test (TEST) mode.

The same information is applicable to HF2. <23120003C>



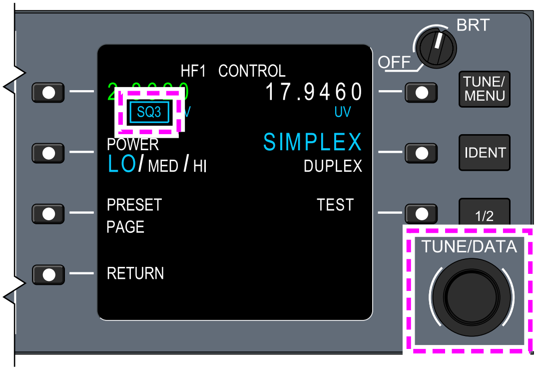
CTP – HF1 CONTROL page <23129001C>
Figure 05–03–36

(1) CTP – HF squelch (SQ) level selection

The HF radio operates in one of the four squelch levels that follow:

- Level 1 (SQ1),
- Level 2 (SQ2),
- Level 3 (SQ3) – default and maximum setting, or
- Level 0 (SQ0) – squelch off.

The squelch (SQ) level is shown in cyan, under the active frequency (green), on the second top level page and the HF CONTROL page. Refer to Figure 05–03–37.



CTP – HF squelch (SQ) level selection <23129001C>
Figure 05–03–37

Pushing LSK 1L on the second top level page causes the focus indicator box (cyan) to surround the squelch (SQ) level. When the squelch level is surrounded by the focus indicator box (cyan), the inner TUNE/DATA switch is used to change the selection of the squelch level.

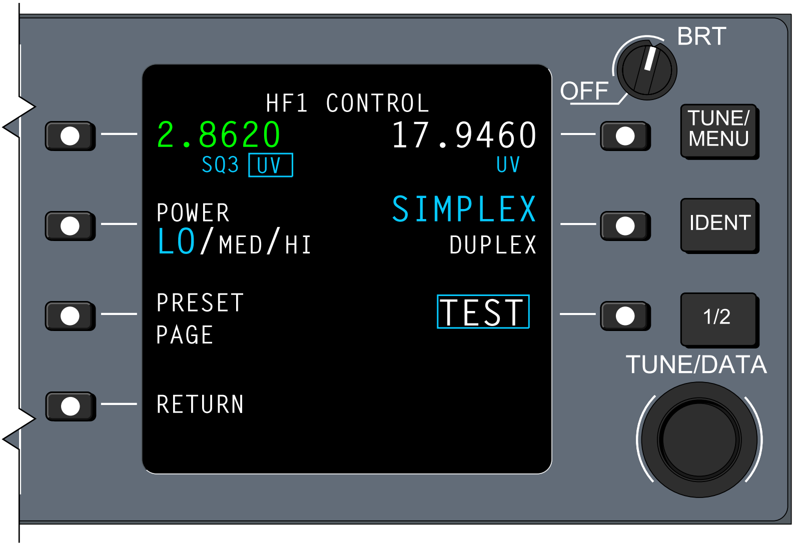
The same information applies to the HF2 CONTROL page. <23120003C>

(2) CTP – HF emission mode selection

The HF radio operates in one of the three emission modes that follow:

- Upper sideband Voice (UV),
- Lower sideband Voice (LV), or
- Amplitude Modulation (AM).

The emission mode indicator is shown in cyan under the active and standby frequencies (refer to Figure 05–03–38). When the emission mode is surrounded by the focus indicator box (cyan), the inner TUNE/DATA switch is used to change the selection of the emission mode. The emission mode selection can be set from the second top level page, HF CONTROL page, or HF PRESET page.



CTP – HF emission mode selection <23129001C>
Figure 05–03–38

NOTE

In TUNE MODE – PRESET, the emission mode cannot be set for the standby frequency on the second top level or HF CONTROL pages.

(3) CTP – HF POWER level selection

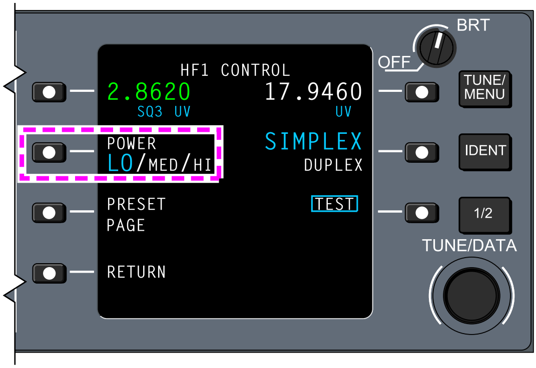
The HF radio operates in one of the three power levels that follow:

- LO (Low), default setting,
- MED (Medium), or

- HI (High).

On the HF CONTROL page, pushing LSK 2L changes the POWER level selection. A POWER level selection is active when it is in large, cyan font.

Figure 05–03–39 shows where to select the power level.

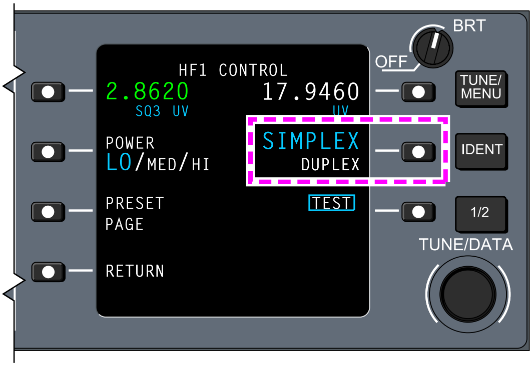


CTP – HF1 CONTROL page – Power level selection <23129001C>
Figure 05–03–39

(4) CTP – SIMPLEX DUPLEX selection

The SIMPLEX or DUPLEX selection is associated with the standby or active frequency and can be done on the HF CONTROL page or the HF PRESET page. Pushing LSK 2R toggles the selection (large font, cyan) between SIMPLEX and DUPLEX. When SIMPLEX is selected, one frequency is shown. When DUPLEX is selected, two frequencies are shown.

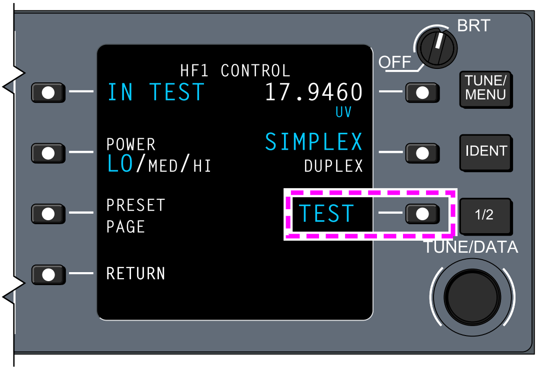
Figure 05–03–40 shows the SIMPLEX or DUPLEX selection on the HF1 PRESET page.



CTP – HF SIMPLEX or DUPLEX selection <23129001C>
Figure 05–03–40

(5) CTP – HF TEST

On the HF1 CONTROL page, pushing LSK 3R (refer to Figure 05–03–41) puts the HF communication in test mode for approximately 10 seconds. During the test mode, TEST is displayed in large, cyan letters and the active frequency is replaced by a cyan IN TEST message.

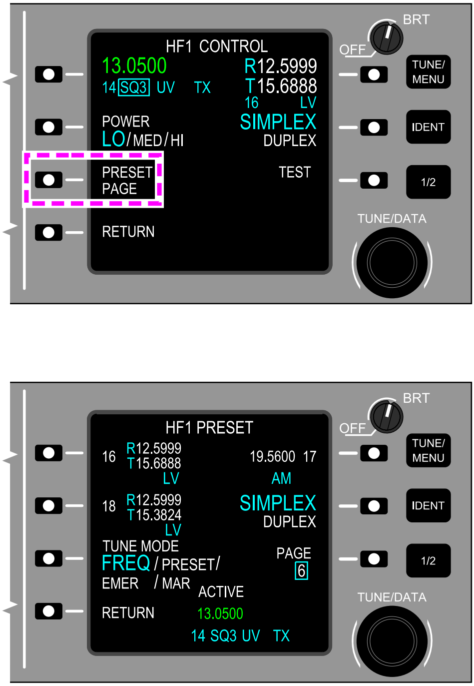


CTP – HF1 CONTROL page – HF test <23129001C>
Figure 05–03–41

(6) CTP – PRESET page

Pushing LSK 3L on the HF1 CONTROL page shows the HF1 PRESET page. On the selected CONTROL page, pushing the LSK adjacent to PRESET PAGE will cause the focus indicator box (cyan) to surround the number below PAGE. Then, the TUNE/DATA switch can be used to cycle through the PRESET pages. The pages provide access to preset frequencies programmed in memory. <23129001C>

Figure 05–03–42 shows the HF1 PRESET page menu selection from the HF1 CONTROL page on the CTP.



CTP – Access to HF1 PRESET page <23129001C>
Figure 05–03–42

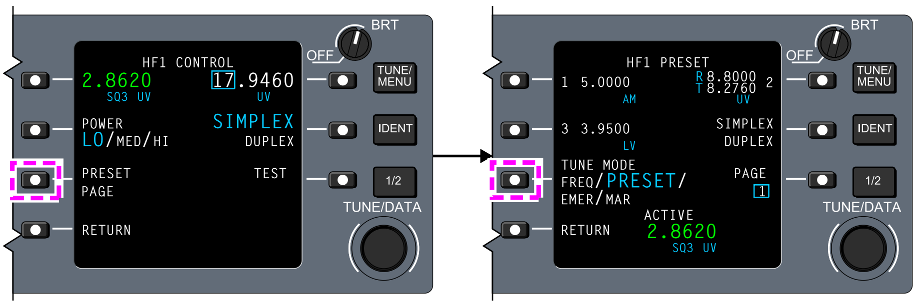
J. CTP – HF tuning modes <23129001C>

The HF operates in one of the four tune modes that follow:

- FREQ (Frequency) – The default mode (standby and direct) using SIMPLEX or DUPLEX frequencies,
- PRESET – Numbered preset frequencies stored in memory (SIMPLEX or DUPLEX),

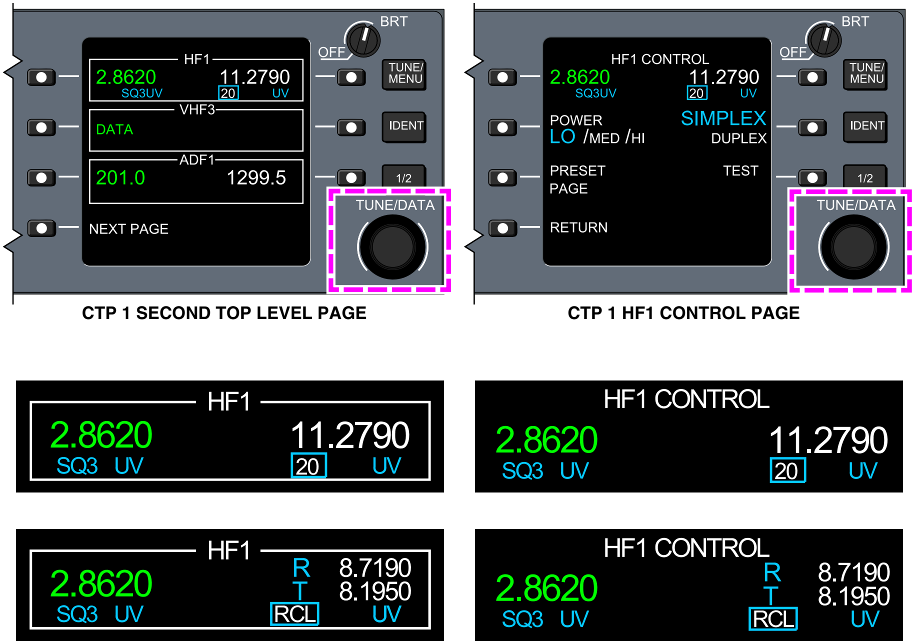
- EMER (Emergency) – Predefined emergency international distress frequencies (six):
  - Channel 1 (2182 kHz),
  - Channel 2 (4125 kHz),
  - Channel 3 (6215 kHz),
  - Channel 4 (8291 kHz),
  - Channel 5 (12290 kHz), and
  - Channel 6 (16420 kHz).
- MAR (Maritime) – All 249 International Telecommunication Union (ITU) numbered, four-digit channels operating on predefined frequencies.

On the HF PRESET page, pushing LSK 3L changes the TUNE MODE selection. A TUNE MODE selection is active when it is in large, cyan font (refer to Figure 05–03–43).



CTP – HF1 PRESET page – TUNE mode selection <23129001C>
Figure 05–03–43

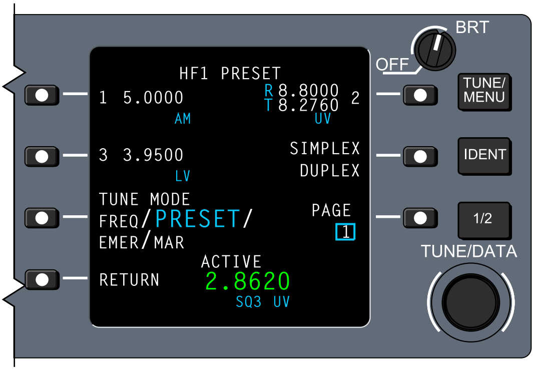
In the PRESET tuning mode, the focus indicator is located below the standby frequency surrounding preset frequency numbers from 1 to 20, or RCL (Recall). The TUNE/DATA switch is used to cycle through the preset frequencies. Refer to Figure 05–03–44.



CTP – HF preset tuning <23129001C>
Figure 05–03–44

K. CTP – HF preset tuning <23129001C>

There are 20 preset frequencies available for each HF. Each preset programmable frequency has an assigned number (1 to 20). They can be programmed as SIMPLEX or DUPLEX frequencies. Presets for emergency and maritime tuning are not available. The preset frequencies are synchronized between the two CTPs. Refer to Figure 05–03–45.



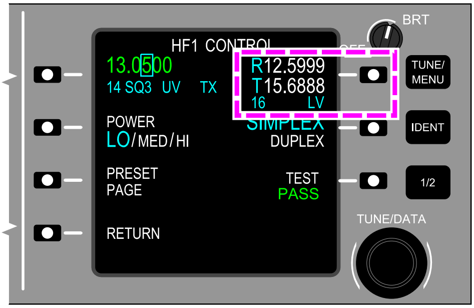
CTP – HF1 PRESET page <23129001C>
Figure 05–03–45

There are seven HF1 PRESET pages with three preset frequencies on each page, except for page 7, which shows only two preset frequencies (19 and 20). The HF active frequency (green) is shown at the bottom center of the HF1 PRESET page.

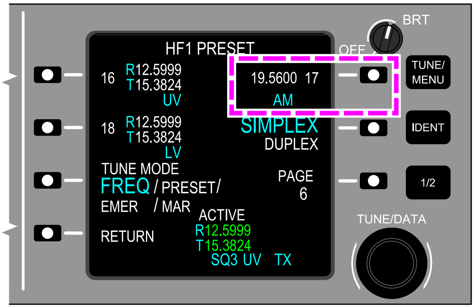
The HF preset frequency can be selected to active from the HF second top level pages, the HF CONTROL page, and the HF PRESET page. From any of these pages, pushing LSK 1R causes the focus indicator box (cyan) to surround the digits before the decimal. Pushing LSK 1R again changes the numbered preset frequency (white) to the active frequency (green). The active frequency is then shown on the top left side of the HF selected page with the associated number (1 to 20), or the recall (RCL) label (for second level page only).

Figure 05–03–46 shows the preset selection to active on the HF1 CONTROL page.

Figure 05–03–47 shows the preset selection to active on the HF1 PRESET page



CTP – HF1 CONTROL page – Preset frequency selection to active <23129001C>
Figure 05–03–46



CTP – HF1 PRESET page – Preset frequency selection to active <23129001C>
Figure 05–03–47

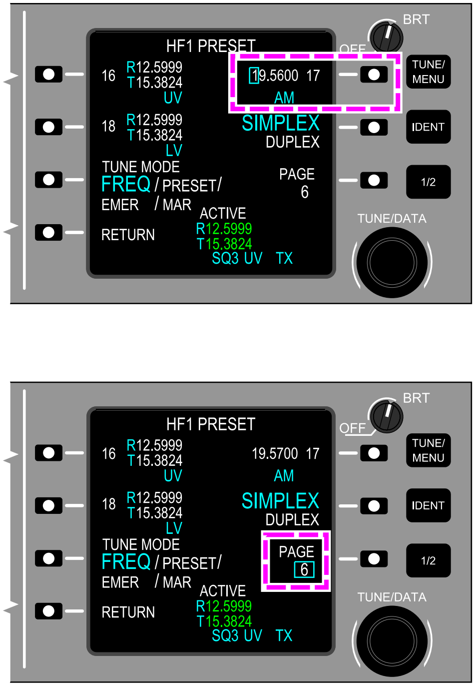
L. CTP – HF preset frequency setting <23129001C>

To program (set) an HF preset frequency, the TUNE MODE must be selected to PRESET on the HF PRESET page. Refer to Figure 05–03–48.

CTP – HF1 PRESET page <23129001C>
Figure 05–03–48

Programming (setting) an HF preset frequency is done on the HF PRESET page. Pushing the LSK beside the preset frequency (white) causes the focus indicator box (cyan) to surround the digits before the decimal. Rotation of the outer TUNE/DATA switch changes the position of the focus indicator box (cyan). Rotation of the inner TUNE/DATA switch changes the preset frequency (white). The focus indicator box (cyan) returns to the default position 10 seconds after the last action on the TUNE/DATA switch, or when LSK 3R is pushed.

Figure 05–03–49 shows the frequency programming on the HF PRESET page.



CTP – HF1 PRESET – Frequency programming <23129001C>
Figure 05–03–49

M. CTP – HF radio messages <23129001C>

The HF radio messages that follow are displayed on tuning page 2, HF CONTROL, or HF PRESET pages (refer to Figure 05–03–50):

- TX is displayed in cyan when the HF radio is transmitting, and
- IN TEST is displayed in cyan when the test mode is active.

TUNING PAGE 2

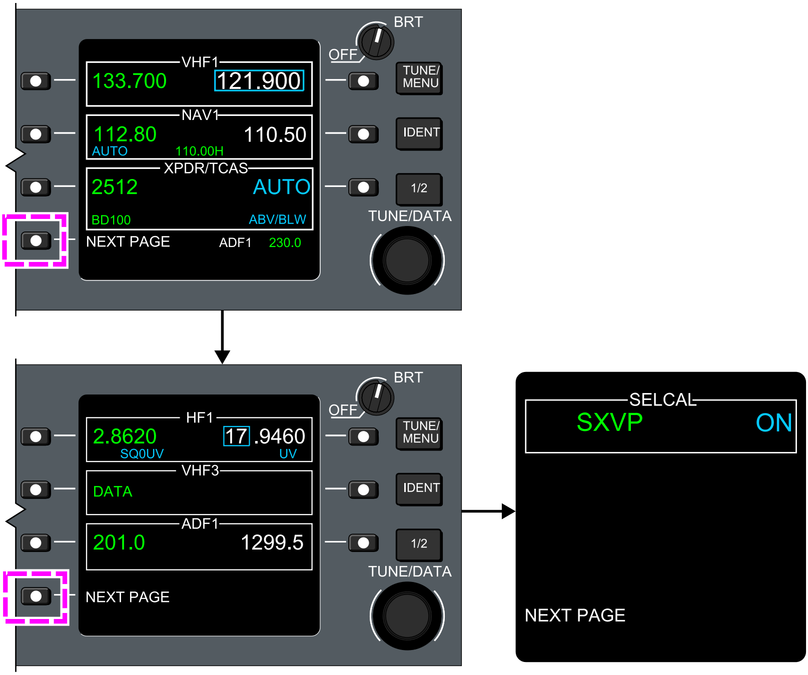
HF CONTROL PAGES

HF PRESET PAGES

CTP – HF radio messages <23129001C>
Figure 05–03–50

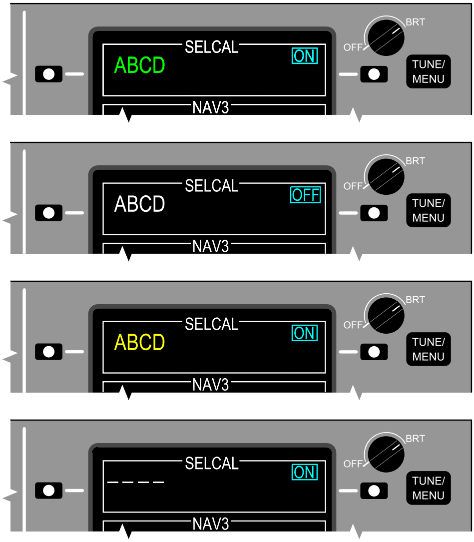
N. CTP – SELCAL detection status <23210004C>

The SELCAL detection status can be set from the third top level page. When the LSK adjacent to the status is pushed, SELCAL detection status ON or OFF can be selected with the inner TUNE/DATA switch. Refer to Figure 05–03–51.



CTP – SELCAL control <23210004C>
Figure 05–03–51

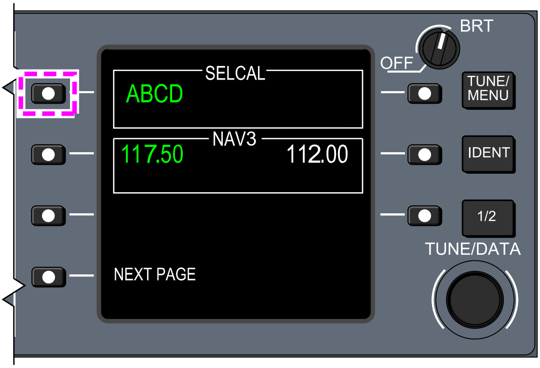
The SELCAL detection status (ON/OFF) is shown in cyan. The SELCAL code is normally displayed in green with detection ON. When the detection is selected to OFF, the SELCAL code is displayed in white. For invalid SELCAL codes, invalid code feedback (echo) and configuration errors, the SELCAL code is displayed in amber. If the SELCAL code feedback (echo) is missing, the code is displayed as white dashes. Refer to Figure 05–03–52.



CTP – SELCAL color logic <23210004C>
Figure 05–03–52

(1) SELCAL CONTROL page

The SELCAL CONTROL page is accessed from the third top level page by pushing LSK 1L. Pushing LSK 1L the first time transfers the focus indicator box (cyan) to the SELCAL code. Pushing LSK 1L a second time shows the SELCAL CONTROL page on the CTP. Refer to Figure 05–03–53.



THIRD TOP LEVEL PAGE

SELCAL CONTROL PAGE

CTP – Access to SELCAL CONTROL page <23210004C>
Figure 05–03–53

The SELCAL CONTROL page shows the indications that follow:

- Display of the SELCAL codes, and
- Selection of the SELCAL detection status (ON or OFF).

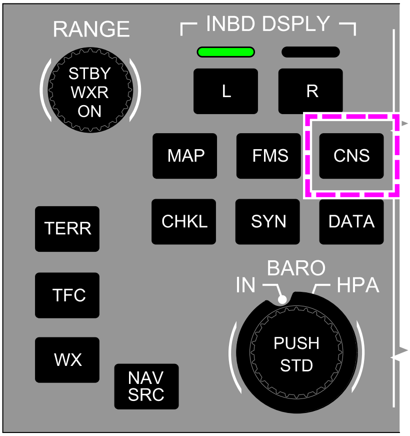
DISPLAY TUNING

A. Overview

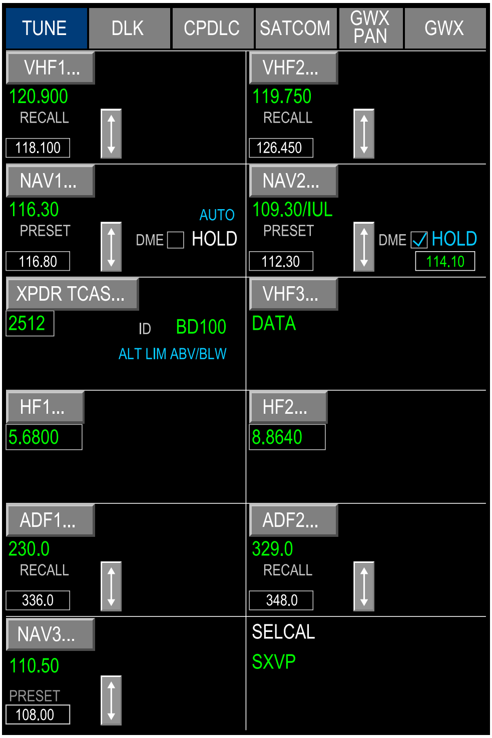
The display tuning provides radio tuning and control similar to the CTP, but uses the Communication Navigation and Surveillance (CNS) page on the MFW.

The CNS page can be displayed by (refer to Figure 05–03–54):

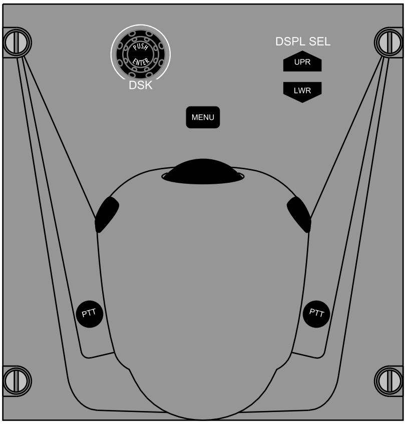
- Pushing the CNS switch on the CTP,
- Pushing the CNS switch on the MKP, or
- Selecting the CNS soft switch using the CCP.



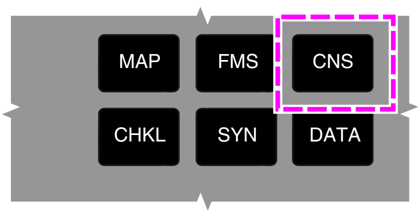
CONTROL TUNING PANEL (CTP)



1 CNS PAGE



CURSOR CONTROL PANEL (CCP)



MULTIFUNCTION KEYBOARD PANEL (MKP)

NOTE

1 This view shows options that may not be installed on your aircraft.

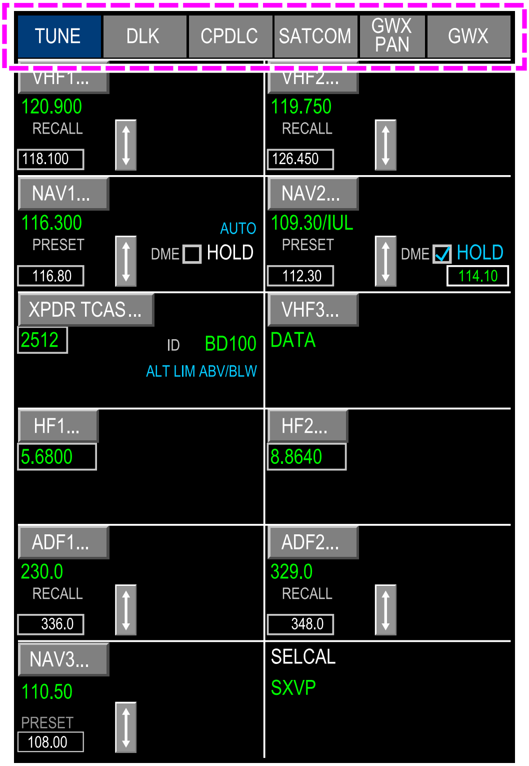
TUNE page and controls
Figure 05–03–54

B. Communication Navigation and Surveillance (CNS) page

The CNS page includes soft tile switches that give access to the pages that follow (refer to Figure 05–03–55):

- TUNE – For tuning and control of the communication and navigation radios,
- DLK – To control and set data link (DLK) communications,
- CPDLC – To use and control Controller–Pilot Direct Link Communication (CPDLC), <23249001C>
- SATCOM – To manage satellite communications, and <23150004C>
- GWX – To manage graphical weather reception and settings.

These pages can be accessed by selecting the dedicated soft switches located at the top of the page depending on the available options.



NOTE

This view shows options that may not be installed on your aircraft.

CNS – TUNE page overview
Figure 05–03–55

C. CNS – TUNE page – Overview

The TUNE page is the default page, and is linked to the CTP. It provides control, frequency tuning, and mode selection for (refer to Figure 05–03–56):

- HF1, <23120001C> or <23120005C>
- HF1 and HF2, <23120003C>
- SELCAL, <23210004C>

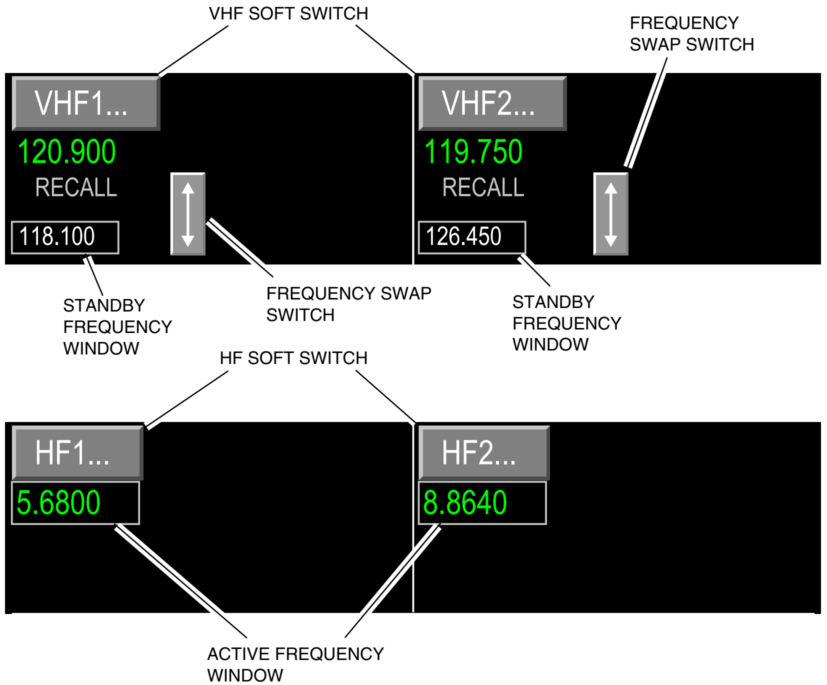
- VHF1 and VHF2, and
- VHF3.

NOTE

This view shows options that may not be installed on your aircraft.

CNS – Tune page
Figure 05–03–56

On the TUNE page, the frequency and control soft switches of each communication radio are displayed and are selectable with the CCP cursors. Refer to Figure 05–03–57.



CNS – Tune page – VHF and HF radio frequencies
Figure 05–03–57

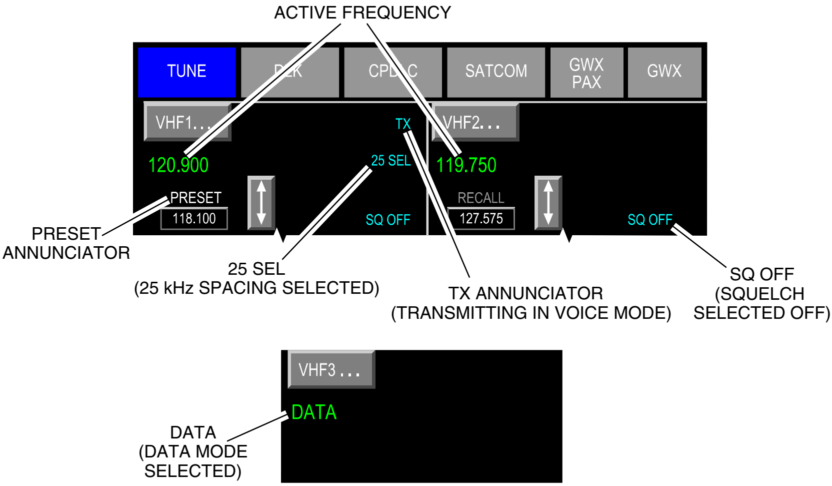
Active frequencies are displayed in green or in amber. The frequency is displayed in amber when there is a system fault or a mismatch between the selected tuning and the radio.

The information shown on the TUNE page for VHF1, VHF2, and VHF3 is:

- VHF1, VHF2, and VHF3 soft switches,
- Active frequency indication,
- DATA indication when VHF3 is in data mode,

- PRESET annunciator,
- RECALL annunciator,
- TX annunciator (radio transmission),
- 8.33 SEL annunciator, <31000008C>
- 25 SEL annunciator, and
- SQ OFF annunciator.

Figure 05–03–58 shows the VHF main display indications on the TUNE page.



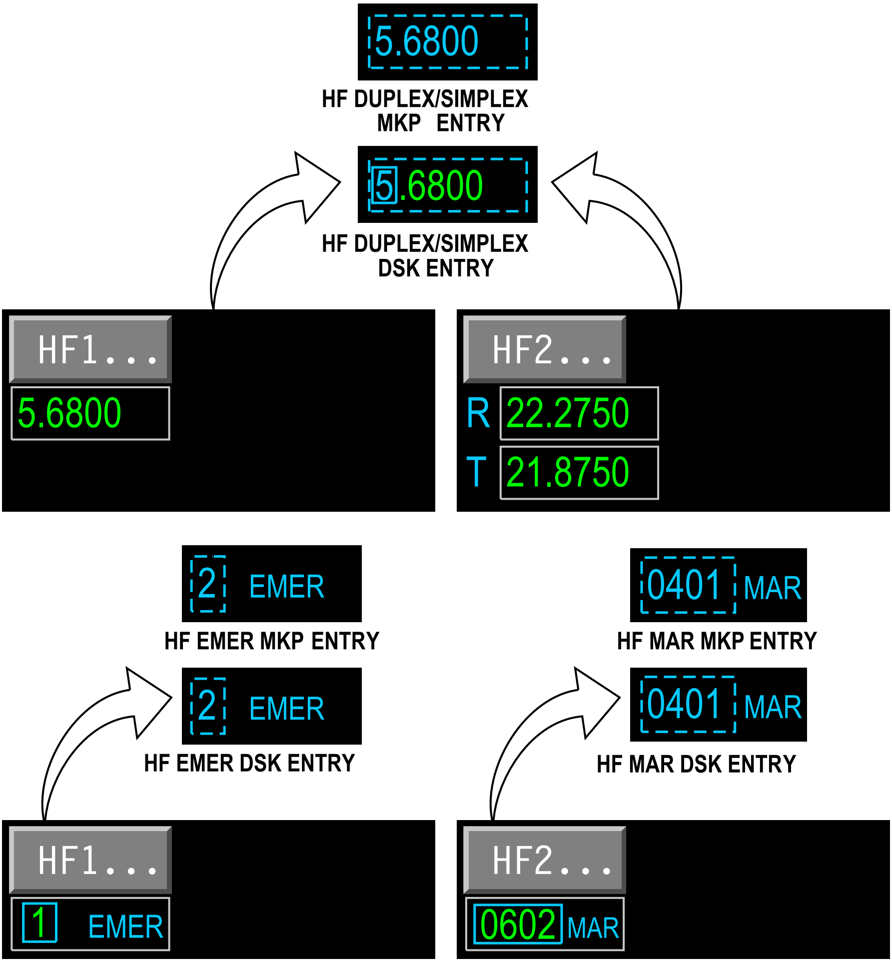
TUNE page – VHF main display indications
Figure 05–03–58

The information on the TUNE page for HF1 (refer to Figure 05–03–59) is: <23120001C> or <23120005C>

The information on the TUNE page for HF1 and HF2 (refer to Figure 05–03–59) is: <23120003C>

- Active frequency indication,

- HF1 soft switch, <23129001C>
- HF2 soft switch, <23129001C>
- Simplex mode,
- Duplex mode,
- EMER (Emergency) mode,
- MAR (Maritime) mode,
- EM (Emission) (LV, UV, or AM) mode,
- TX annunciator (radio transmission), and
- SQ (Squelch) level.



TUNE page – HF direct tuning <23129001C>
Figure 05–03–59

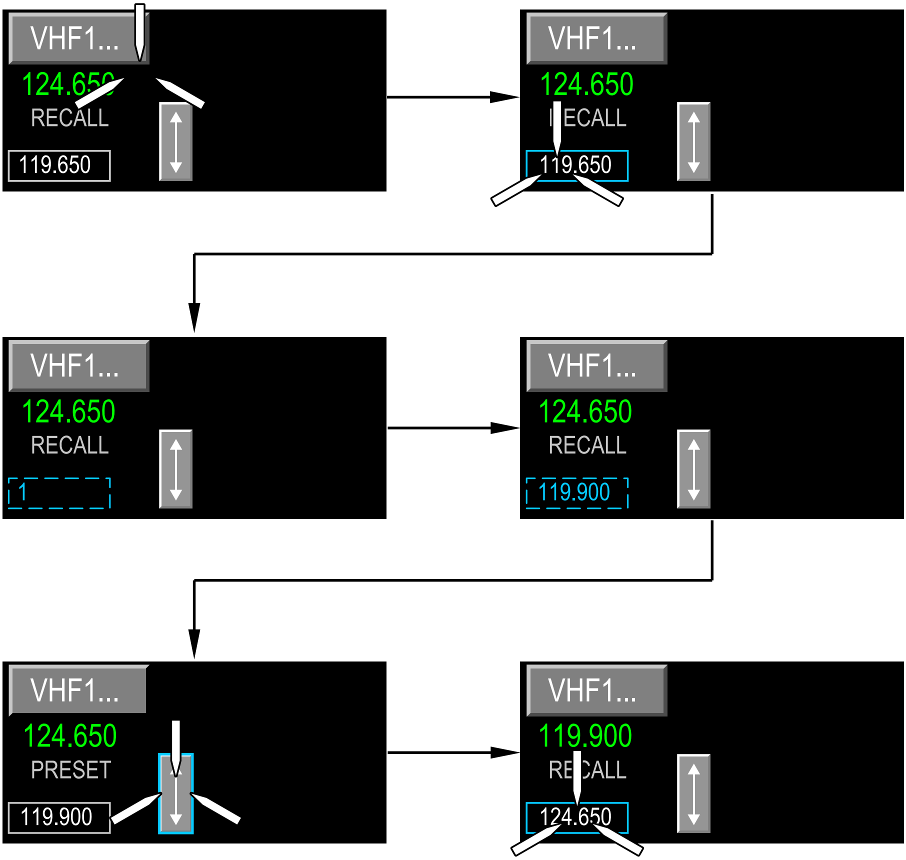
D. CNS – TUNE page – VHF tuning

Standby tuning of VHF1, VHF2, and VHF3 can be set on the TUNE page using the MKP or the CCP.

(1) Standby frequency tuning with the MKP

Direct tuning for the standby frequency can be done by moving the cursor over the standby frequency, and typing the frequency on the MKP as follows (refer to Figure 05–03–60):

- The cursor is moved in the applicable communication radio display (VHF1 is used as an example) using the MKP.
- When the standby frequency is selected (cyan), a new frequency can be typed on the MKP. During the digit entry, the frequency is cleared and a cyan dashed line box is displayed. Up to six frequency digits can be typed into the MKP scratchpad.
- When all the frequency digits are entered, the ENTER switch on the MKP must be pressed. The new standby frequency is shown in white, and the frequency swap soft switch is surrounded by a cyan border.
- When the frequency swap soft switch is selected, using the MKP controls, the standby and active frequencies are swapped. The PRESET/RECALL annunciator changes to RECALL and the cursor defaults to a standby window.

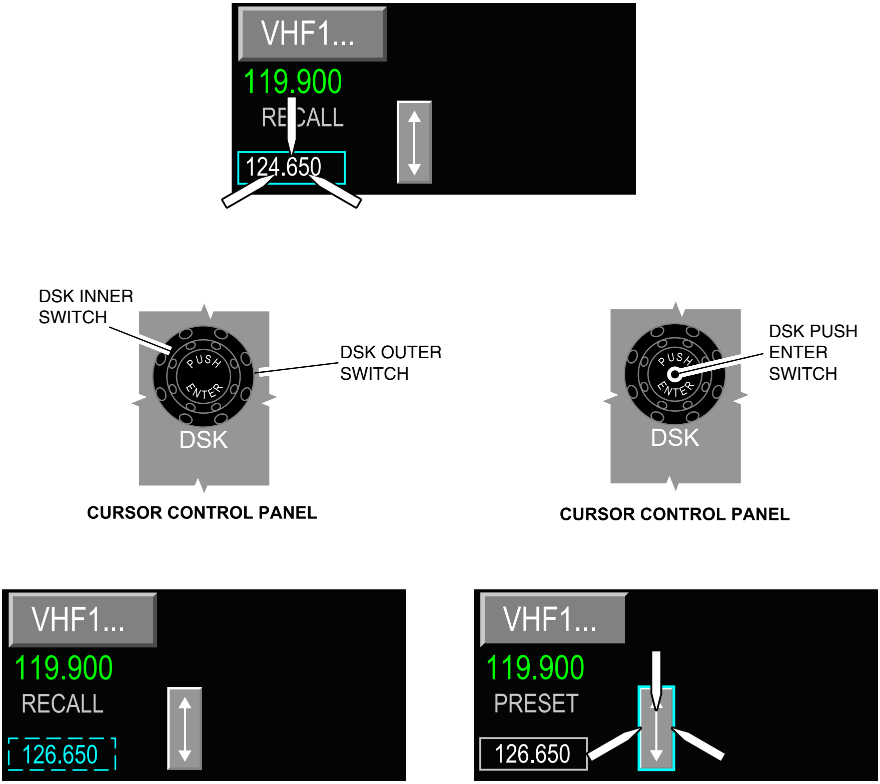


CNS – TUNE page – VHF standby window tuning (MKP frequency entry)
Figure 05–03–60

(2) Standby frequency tuning with the CCP

Direct tuning for the standby frequency can also be done by moving the cursor over the standby frequency and using the DSK to enter the frequency, as follows (refer to Figure 05–03–61):

- The cursor is moved to the applicable communication radio display (VHF1 is used as an example) using the CCP.
- The standby frequency, shown in white, is selected with the CCP, which will change the white box to a cyan box.
- When the standby frequency is selected (cyan), a new frequency can be entered with the DSK switch. The outer ring of the DSK switch changes the MHz digits (before the decimal) and the inner ring changes the KHz digits (after the decimal). During the rotation of the DSK switch, a cyan dashed–line box is displayed.
- When the frequency is set, the PUSH ENTER switch on the CCP is pushed. The new standby frequency is shown in white, and the frequency swap soft switch is surrounded by a cyan border.
- When the frequency swap soft switch is selected, using the CCP, the standby and active frequencies are swapped. It changes the PRESET/RECALL annunciator to RECALL and the cursor defaults to a standby window.



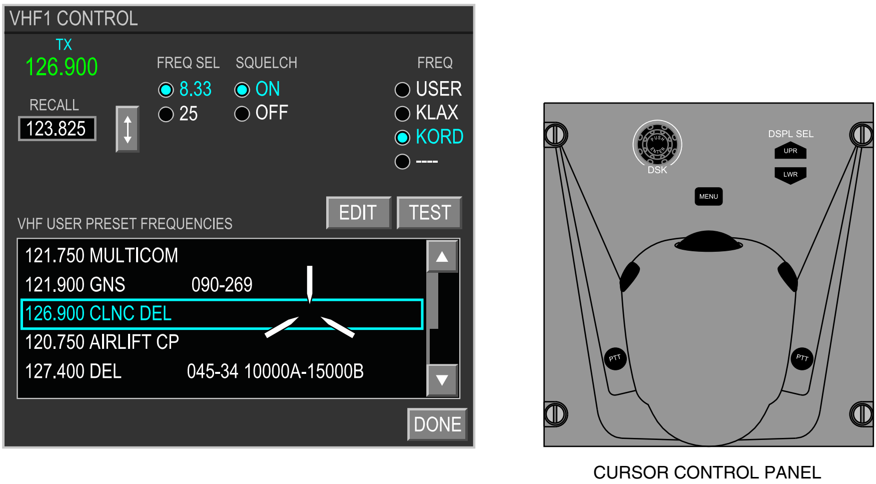
TUNE page – VHF standby window tuning (CCP frequency entry)
Figure 05–03–61

(3) Standby frequency tuning (shortcut)

To accelerate standby frequency tuning on the TUNE page or the VHF CONTROL window, the flight crew can leave out (omit) the first digit and the decimal point of the VHF frequency (e.g. type 18 for a frequency of 118.000, or type 183 for the frequency of 118.300).

When the last digit is a 5 and the second-to-last digit is a 2 or 7, the flight crew does not need to enter the last digits (e.g. type 1812 for a frequency of 118.125, or 1817 for a frequency of 118.175).

Figure 05–03–62 shows the VHF1 CONTROL window preset selection.



TUNE page – VHF1 CONTROL window preset selection
Figure 05–03–62

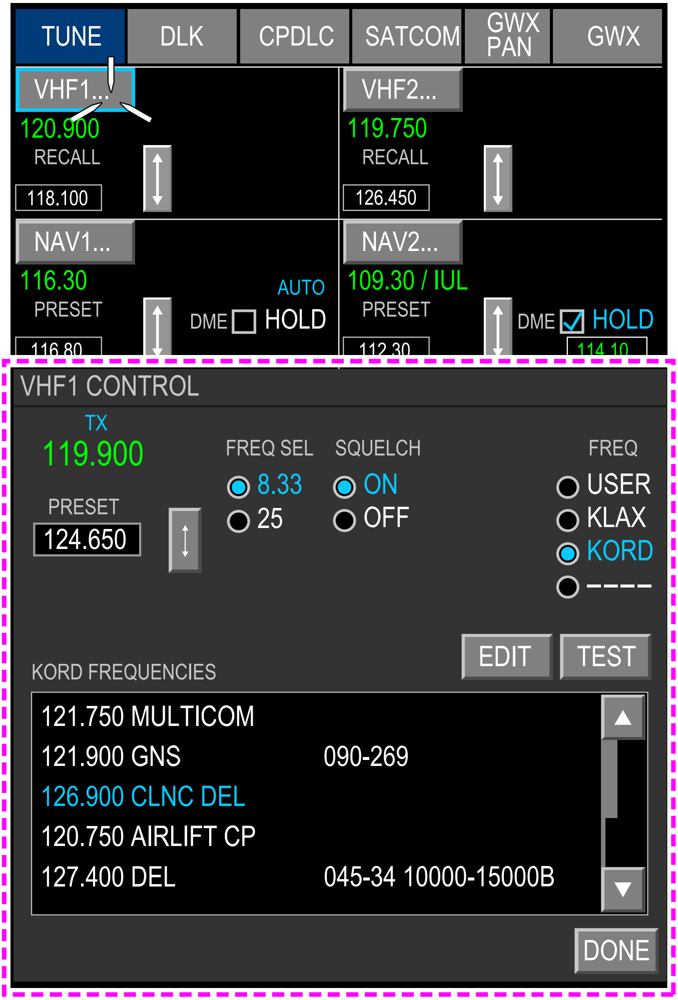
E. CNS – TUNE page – VHF CONTROL window

The VHF1, VHF2, and VHF3 CONTROL windows are accessed by selecting the VHF1, VHF2, or VHF3 soft switches on the TUNE page. The VHF CONTROL windows are synchronized with the CTP.

The VHF CONTROL windows include (refer to Figure 05–03–63):

- Active frequency indication,
- Standby frequency window,
- Standby frequency preset/recall annunciator,

- Frequency swap soft switch,
- TX (transmission) indication,
- VHF channel spacing control,
- SQUELCH control,
- VOICE/DATA mode control (VHF3 only),
- PRESET FREQUENCIES list selection and EDIT soft switch, and
- TEST soft switch.

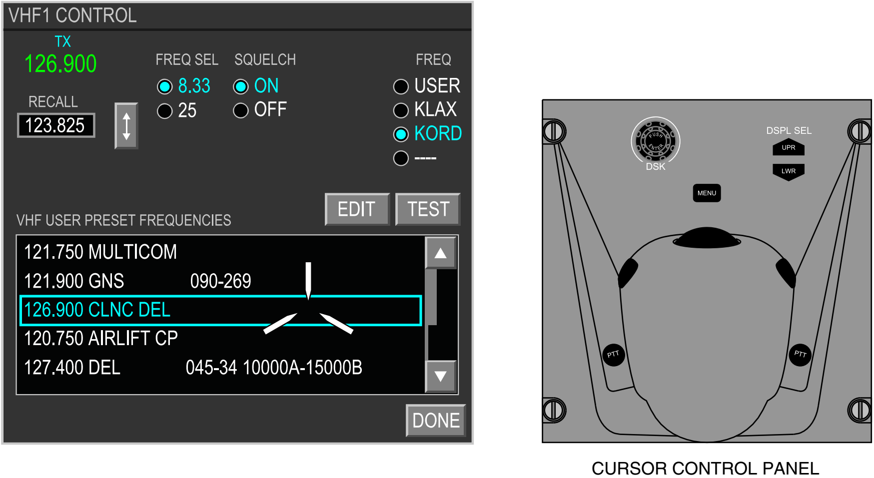


NOTE

This view shows options that may not be installed on your aircraft.

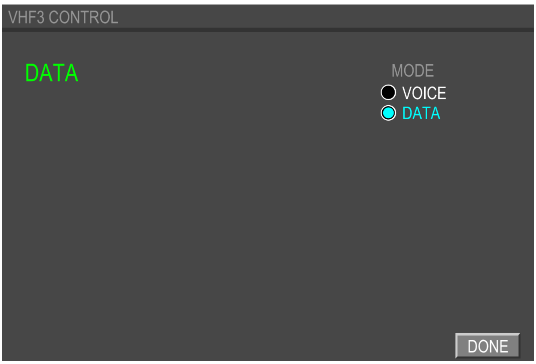
TUNE page – VHF1 CONTROL window
Figure 05–03–63

[Figure 05–03–64](#) shows the VHF1 CONTROL window preset selection.



TUNE page – VHF1 CONTROL window preset selection
Figure 05–03–64

Figure 05–03–65 shows the VHF3 CONTROL window.



TUNE page – VHF3 CONTROL window
Figure 05–03–65

(1) VHF radio setting

The frequency selections (FREQ SEL), SQUELCH, tune mode (MODE), and preset frequencies (PRESETS) are accessible from the VHF CONTROL window.

It allows the selections that follow:

- FREQ SEL – Selects 25 kHz VHF channel spacing.
- FREQ SEL – Selects 8.33 kHz VHF channel spacing. <31000008C>
- SQUELCH – Selects the squelch ON or OFF.
- MODE – Selects VOICE or DATA operating mode (for VHF3 only).
- FREQ – There are four VHF preset frequencies lists that can be selected to show in the VHF PRESET FREQUENCIES window. They include USER defined frequencies, followed in order by the origin, destination, and alternate airport ICAO identifiers defined in the FMS active flight plan. The airport VHF communication frequency lists are derived from the FMS navigation database and cannot be modified. The ICAO airport identifiers are replaced by gray dashes if they are not in the active flight plan.

Each title (FREQ SEL, SQUELCH, MODE, and FREQ) is labeled in gray capital letters. Each selection has its own column. Under the column, each selected state is shown with a cyan radio button beside it.

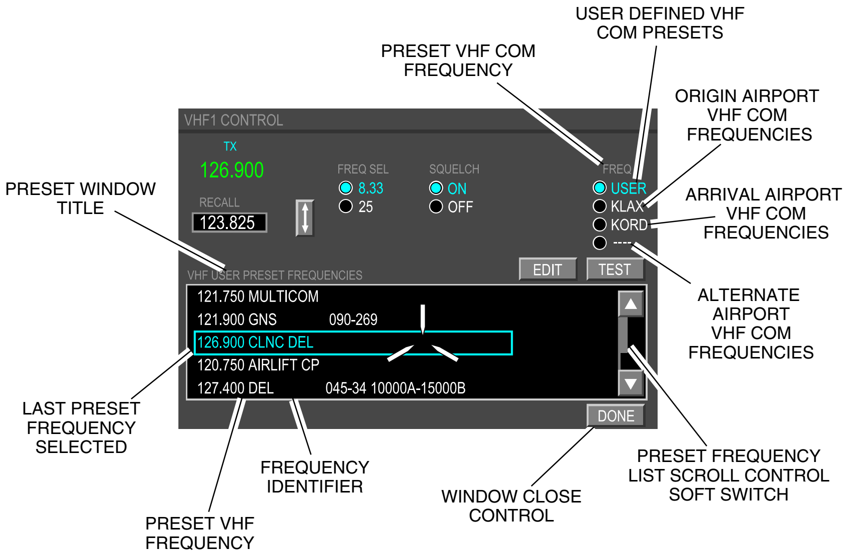
When a cursor is placed over a selection in the VHF PRESET FREQUENCIES list, a focus indicator box (cyan) surrounds the item and the CCP or MKP is used to select it. An active selected state is indicated when the radio button and label are cyan. When deselected, the radio button is black and the label is white. Only one item in a group can be selected and active (cyan).

NOTE

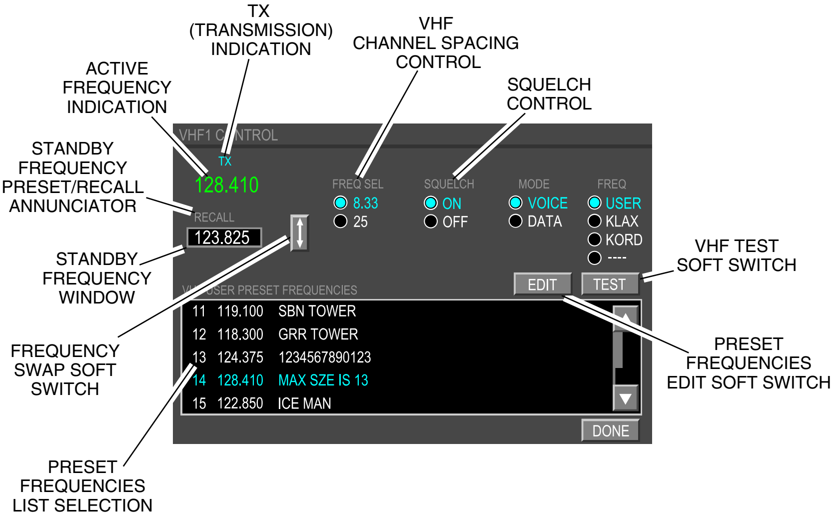
1. For the SQUELCH selection, only SQ OFF will be shown in cyan on the TUNE page.
2. When VHF3 is selected in VOICE, an EICAS status message **VHF3 IN VOICE** appears on the EICAS page.

Figure 05–03–66 shows the VHF1 CONTROL window indications.

Figure 05–03–67 shows the VHF1 CONTROL window general indications.



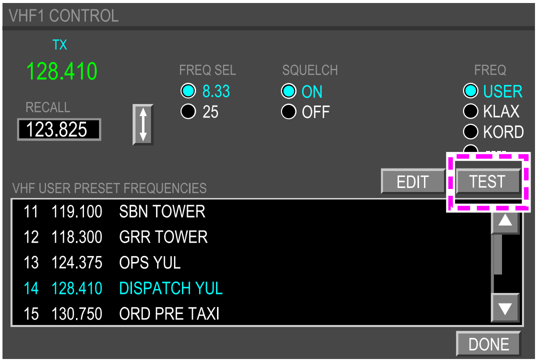
TUNE page – VHF1 CONTROL window indications
Figure 05–03–66



TUNE page – VHF1 CONTROL window general indications
Figure 05–03–67

(2) CNS – TUNE page – VHF CONTROL window – TEST soft switch

The TEST soft switch is available on the VHF CONTROL windows (refer to Figure 05–03–68). The VHF CONTROL windows are accessed through their related VHF soft switches on the TUNE page. Selection of the TEST soft switch starts the VHF communication test for 10 seconds. At the end of the test sequence, the flight crew should hear a single audio beep for a successful test or two audio beeps if the test fails. To hear the audio beeps, a volume switch (VHF1, VHF2, VHF3, or SPKR) must be selected on the ACP.

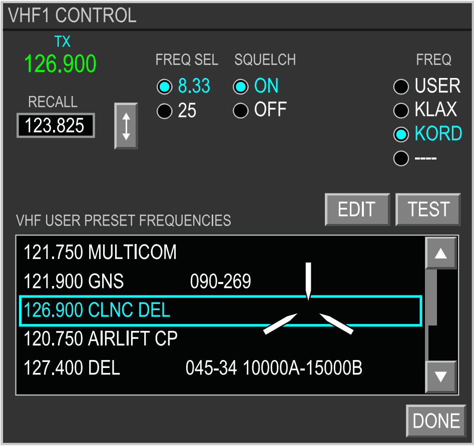


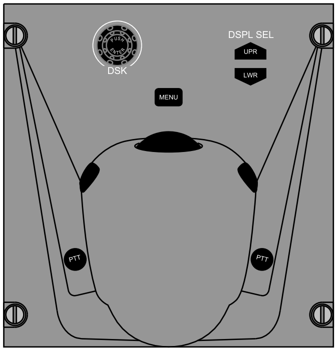
TUNE page – VHF1 CONTROL window – TEST soft switch
Figure 05–03–68

(3) CNS – TUNE page – VHF preset tuning

The VHF USER PRESET FREQUENCIES list is accessible from the VHF CONTROL window.

To change a preset frequency (white) to an active frequency (green) from the VHF CONTROL window, the user must select the desired frequency on the list with the CCP. Placing the cursor over the preset frequency line highlights it (refer to Figure 05–03–69). When the preset frequency is highlighted, pushing the ENTER switch on the MKP, or PUSH ENTER on the DSK switch of the CCP, changes the frequencies. The selected preset frequency is shown in cyan in the VHF USER PRESET FREQUENCIES list and appears as an active frequency (green).





CURSOR CONTROL PANEL

TUNE page – VHF1 CONTROL window preset selection
Figure 05–03–69

The active frequency can be directly tuned from a preset frequency as follows:

- The cursor is moved on the active frequency window,
- P and the applicable preset number (e.g. P1, P2, to P20) is typed in the scratchpad, and
- The ENTER switch on the MKP is pushed.

On the VHF CONTROL window, four selections are available. These four selections are listed under the frequency (FREQ) column as follows:

- USER,
- Departure airport,
- Arrival airport, and
- Alternate airport.

NOTE

Only the USER preset frequencies are numbered.

The departure, arrival, and alternate frequencies are taken from the Flight Management System (FMS) navigation database.

When a selection from the four preset frequencies is made:

- The selection changes to cyan,
- The preset frequencies list related to the selection appears, and
- The name of the selection appears at the top of the list.

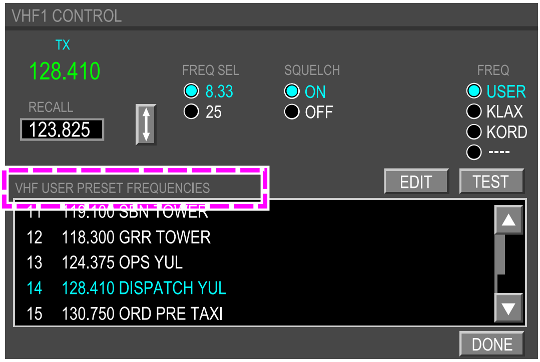
The list can be scrolled line-by-line using the momentary arrow soft switch, or continuously line-scrolled using the DSK inner ring switch. The preset frequencies list title is determined by the FREQ selection on the VHF CONTROL window:

- The VHF USER PRESET FREQUENCIES share a total of 20 user preset frequencies.
- Frequency 20 is permanently programmed to the emergency frequency 121.500 with an EMER label.
- The USER PRESET FREQUENCIES list is not synchronized with the CTPs.

NOTE

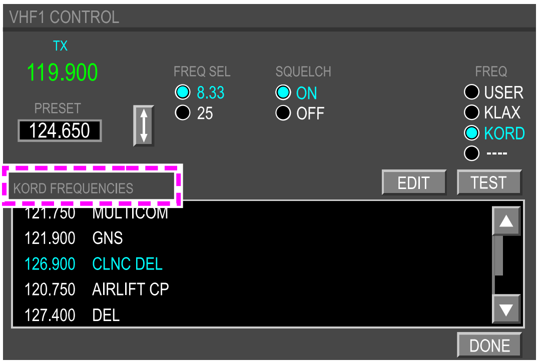
The VHF USER PRESET FREQUENCIES list shows the frequencies that can be edited by the pilots.

Figure 05–03–70 shows the VHF USER PRESET FREQUENCIES selection.



TUNE page – VHF1 CONTROL window – VHF USER PRESET FREQUENCIES
Figure 05–03–70

The origin, destination, and alternate airports have their own preset frequency lists. There is a maximum of 20 frequencies available from the active flight plan (entered in the FMS). Refer to Figure 05–03–71.



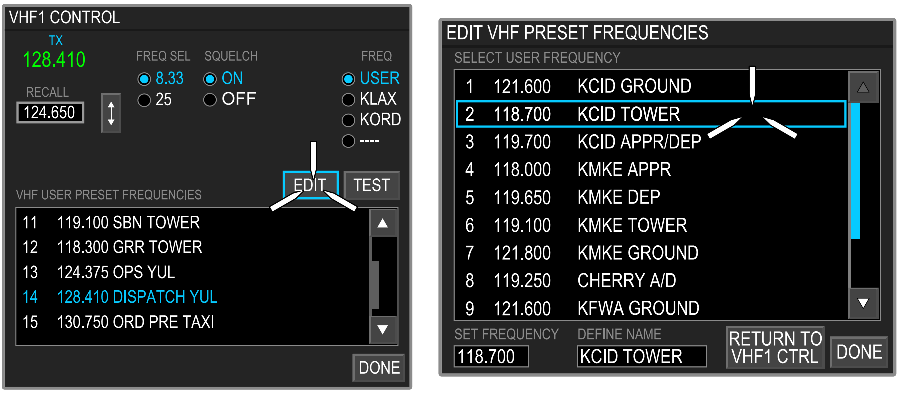
TUNE page – VHF1 CONTROL window – KORD (arrival airport) FREQUENCIES
Figure 05–03–71

NOTE

The flight plan airport communication frequencies cannot be edited.

(4) VHF preset frequencies editing

The USER preset frequencies are edited in the EDIT VHF PRESET FREQUENCIES window. When the EDIT soft switch in the VHF CONTROL window is selected, the EDIT VHF PRESET FREQUENCIES window is displayed. Refer to Figure 05–03–72.



TUNE page – EDIT VHF1 USER PRESET FREQUENCIES
Figure 05–03–72

On the EDIT VHF PRESET FREQUENCIES window, the preset frequency is edited as follows:

- The desired preset frequency (white) is selected using the CCP or MKP directional arrows to scroll the list.

- When the desired preset frequency is highlighted, the preset frequency data is shown in the SET FREQUENCY data entry field at the bottom of the page.
- The preset frequency is changed using the MKP readout line or the DSK.
- The new preset frequency can be named on the DEFINE NAME data entry field using the MKP readout line (scratchpad) or the DSK.

  A maximum of 13 characters can be used to identify the new preset frequency.
- The new preset frequency is entered by pushing the ENTER switch on the MKP, or PUSH ENTER on the DSK switch of the CCP. The DONE soft switch on the TUNE page can also be used.

(5) VHF preset standby frequency (shortcut)

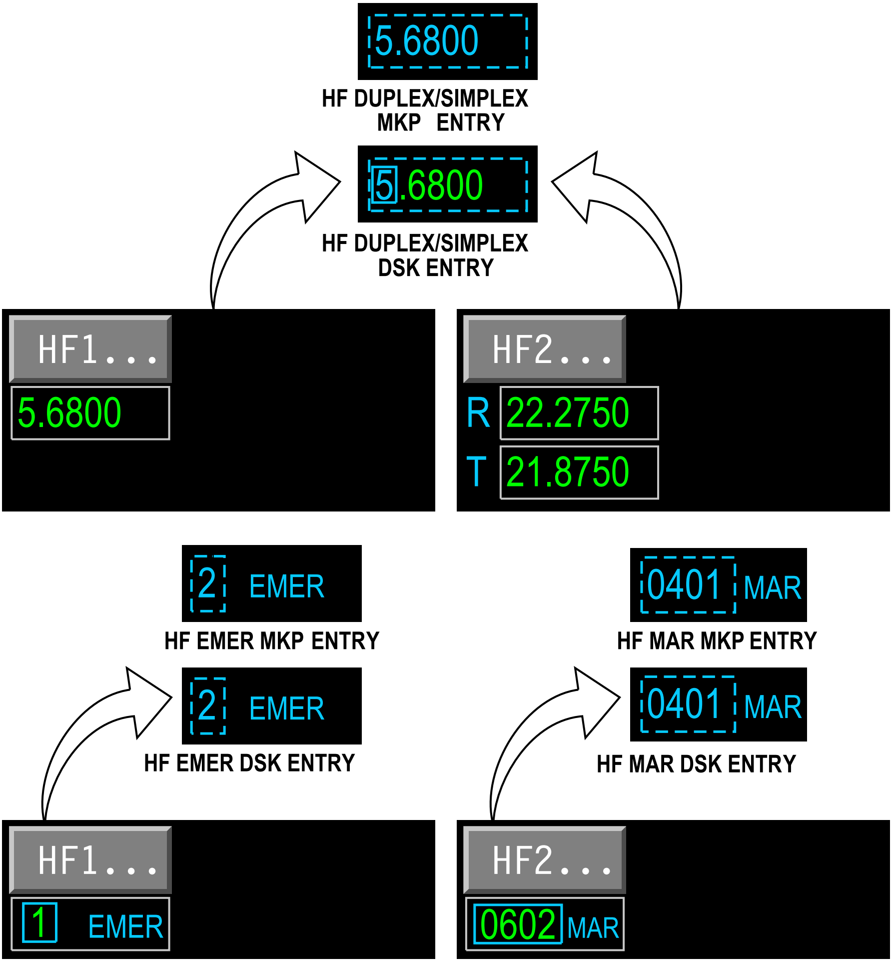
The preset frequency can be entered as a standby frequency by selecting it with the CCP. To enter the preset frequency, the flight crew can type the letter P, followed by the desired preset frequency number (e.g. P1, P2, to P19) on the MKP. The selection is entered by pushing the ENTER switch.

F. CNS – TUNE page – HF tuning <23129001C>

(1) HF direct tuning

The HF can be tuned directly from the TUNE page or from the HF CONTROL window by selecting the active frequency (green) with the CCP. When the active frequency is selected, a new frequency can be entered on the MKP and confirmed by pushing the ENTER switch. Then the new active frequency (green) is shown (refer to Figure 05–03–73).

There is no standby frequency tuning window and no swap soft switch.



TUNE page – HF direct tuning <23129001C>
Figure 05–03–73

When the DSK switch is used to change a SIMPLEX or DUPLEX frequency, the outer DSK switch moves the focus indicator box (cyan) around the digit(s) of the frequency. The inner DSK switch changes the digit(s) surrounded by the focus indicator box (cyan).

When the DSK is used to change an EMER (Emergency) channel, either DSK switch (outer or inner) can be used to change the channel. The active frequency (green) is shown on the TUNE page and the HF CONTROL page.

When the DSK is used to change a MAR (Maritime) channel, the outer DSK switch changes the first pair of digits. The inner DSK switch changes the second pair of digits. The active frequency (green) is shown on the TUNE page and the HF CONTROL page.

(2) HF direct tuning (shortcut)

The HF active frequency can be tuned by typing the frequency shortcut in the MKP readout window (scratchpad) and entering it in the active frequency field on the TUNE page or HF CONTROL window. When an HF frequency is entered in the MKP without a decimal point and with fewer than six digits, the decimal is assumed to be at the lowest valid frequency. For example, entering 21, 210, 2100, or 21000 results in a frequency of 2.1000. Entering six or more digits results in a frequency of two digits before the decimal (e.g. entering 210000 results in a frequency of 21.0000).

G. CNS – TUNE page – HF CONTROL window <23129001C>

The HF CONTROL windows are accessed by selecting the HF soft switch on the TUNE page. The HF CONTROL windows are synchronized with the CTPs.

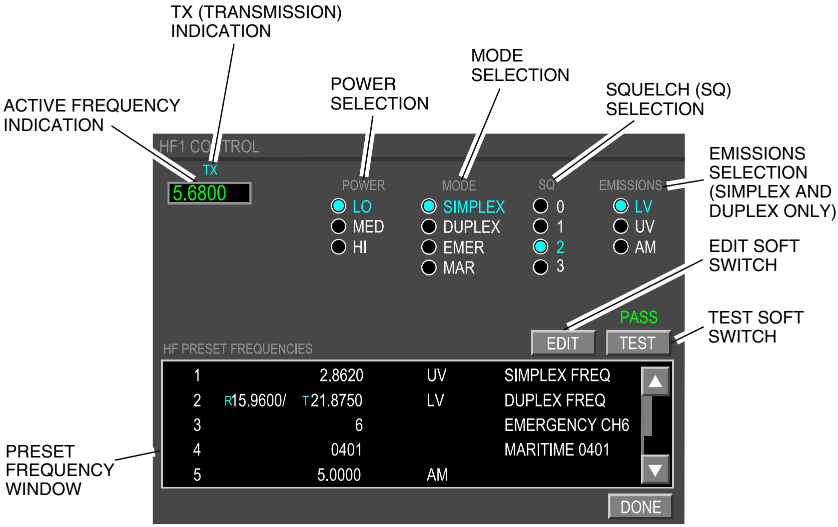
The HF CONTROL window shows:

- TX (Transmission) indication,
- Active frequency indication,
- POWER list selection,
- MODE list selection,
- SQ (Squelch) list selection,

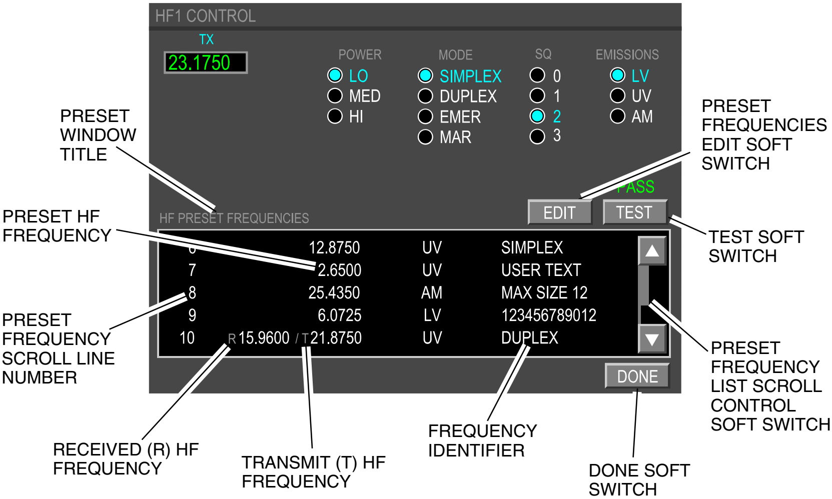
- EMISSIONS list selection,
- PRESET FREQUENCIES list selection,
- EDIT soft switch, and
- TEST soft switch.

Figure 05–03–74 shows and describes the HF1 CONTROL window.

Figure 05–03–75 shows and describes the HF1 CONTROL window indications.



TUNE page – HF1 CONTROL window – General <23129001C>
Figure 05–03–74



TUNE page – HF1 CONTROL window indications <23129001C>
Figure 05–03–75

Each title (POWER, MODE, SQ and EMISSIONS) is labeled in grey capital letters. Each selection has its own column. Under the column, each selection has a radio button on its left side.

When a cursor is placed over the selection, a focus indicator box (cyan) surrounds the item and the CCP or MKP are used to select it. An active selected state is indicated by a cyan radio button adjacent to the selection and a cyan label. When deselected, radio buttons are black and the labels are white.

(1) POWER level

The POWER level enables one of the three selections that follow:

- LO (Low), the default setting,
- MED (Medium), or
- HI (High).

(2) MODE selection

MODE enables one of the four selections that follow:

- SIMPLEX – The default mode, it displays simplex band frequencies for standby and active frequencies.
- DUPLEX – Duplex band frequencies for standby and active frequencies.
- EMER (Emergency) – Predefined emergency international distress frequencies (six):
  - Channel 1 (2.182 MHz),
  - Channel 2 (4.125 MHz),
  - Channel 3 (6.215 MHz),
  - Channel 4 (8.291 MHz),
  - Channel 5 (12.290 MHz), and
  - Channel 6 (16.420 MHz).
- MAR (Maritime) – All 249 International Telecommunication Union (ITU) numbered, four-digit channels operating on predefined frequencies.

The selected MODE is shown on the TUNE page in cyan.

(3) SQ (Squelch) level

The SQ level enables one of the four selections that follow:

- Level 0 (off),
- Level 1,
- Level 2 (default setting), or
- Level 3 (maximum setting).

The SQ level selection is shown on the TUNE page in cyan.

(4) EMISSIONS selection

There are three EMISSIONS selections:

- Lower sideband Voice (LV),
- Upper sideband Voice (UV), or
- Amplitude Modulation (AM).

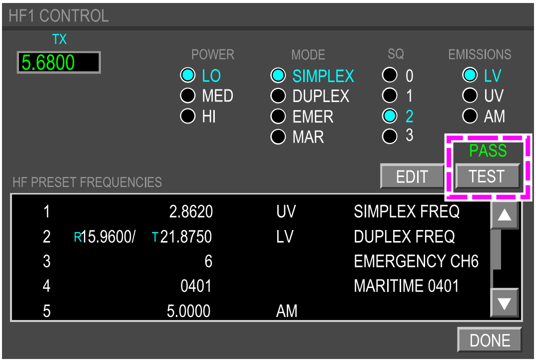
The EMISSIONS selection is shown on the TUNE page in cyan.

NOTE

In EMER mode and MAR mode, the EMISSIONS selections are not available.

(5) CNS – TUNE page – HF CONTROL window – TEST soft switch

There is a TEST soft switch on the HF CONTROL window (refer to Figure 05–03–76), which is accessed with the HF soft switch on the TUNE page. The TEST soft switch starts a 10-second HF communication test. During the test, a white IN TEST indication replaces the active frequency. At the end of the test sequence, the flight crew should hear a single audio beep for a successful test or two audio beeps if the test fails. After the test, a green PASS or amber FAIL is shown above the TEST soft switch. The PASS or FAIL indication remains in view until the HF CONTROL window is closed.



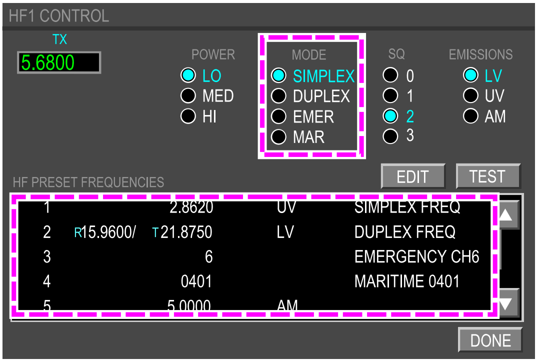
TUNE page – HF1 CONTROL window – TEST soft switch <23129001C>
Figure 05–03–76

(6) CNS – TUNE page – HF PRESET FREQUENCIES window

The HF PRESET FREQUENCIES list is accessible from the HF CONTROL window. Four selections are available under the MODE column, as follows:

- SIMPLEX,
- DUPLEX,
- EMER (Emergency), and
- MAR (Maritime).

When a mode is selected, the selection changes to cyan and the preset frequencies list related to that selection appears. Refer to Figure 05–03–77.



TUNE page – HF1 CONTROL window – MODE selection <23129001C>
Figure 05–03–77

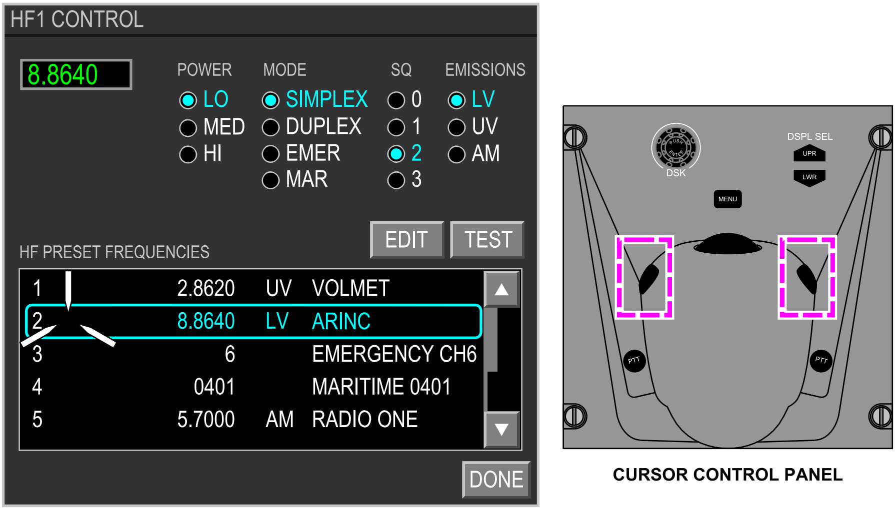
The list can be scrolled line-by-line using the momentary arrow soft switch, or continuously line-scrolled using the DSK inner ring switch. The PRESET FREQUENCIES list title is determined by the mode selection on the HF CONTROL window. The HF PRESET FREQUENCIES share a total of 20 preset frequencies (SIMPLEX or DUPLEX). The HF PRESET FREQUENCIES list is not synchronized with the CTPs.

NOTE

Only the HF PRESET FREQUENCIES can be edited by the pilots.

(7) HF preset frequency change to active

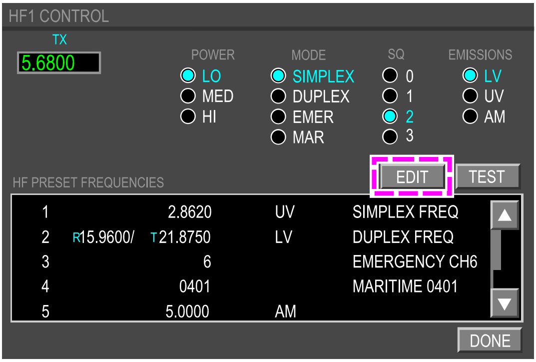
To change a preset frequency (white) to an active frequency (green) from the HF CONTROL window, the user must select the desired frequency from the HF PRESET FREQUENCIES list on the CCP. Placing the cursor over the preset frequency line highlights it. When the preset frequency is highlighted, pushing the ENTER switch on the MKP or the PUSH ENTER switch on the DSK switch of the CCP changes the frequencies. The selected preset frequency shows in cyan in the preset frequencies list and appears as an active frequency (green). Refer to Figure 05–03–78.



TUNE page – HF1 CONTROL preset tuning <23129001C>
Figure 05–03–78

(8) TUNE page – HF preset frequency editing

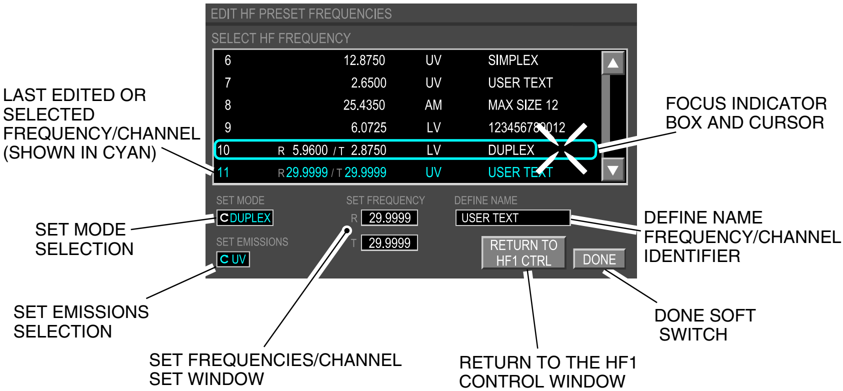
The HF PRESET FREQUENCIES are edited in the EDIT HF PRESET FREQUENCIES window. This is accessed through the HF CONTROL window by selecting the EDIT soft switch with the CCP or MKP (refer to Figure 05–03–79).



TUNE page – HF1 CONTROL window – EDIT <23129001C>
Figure 05–03–79

On the EDIT HF PRESET FREQUENCIES window (refer to Figure 05–03–80), the desired preset frequency (white) is selected using the CCP or MKP directional arrows to scroll the list. When the desired preset frequency is highlighted, the preset frequency data is shown in the data entry fields at the bottom of the page. The data entry fields are:

- SET MODE,
- SET EMISSIONS,
- SET FREQUENCY, and
- DEFINE NAME.



EDIT HF PRESET FREQUENCIES – Indications <23129001C>
Figure 05–03–80

The tune mode of the new preset frequency can be changed in the SET MODE data entry field using the DSK switch. The cursor and the DSK inner ring switch can be used to set one of the four tune modes:

- SIMPLEX,
- DUPLEX,
- EMER (Emergency), or
- MAR (Maritime).

The emission mode of the new preset frequency can be changed in the SET EMISSIONS data entry field using the DSK switch. The cursor and the DSK inner switch can be used to set one of the three tune modes:

- UV,
- LV, or

- AM.

UV, LV, and AM emission modes are available for the SIMPLEX and DUPLEX tune modes only.

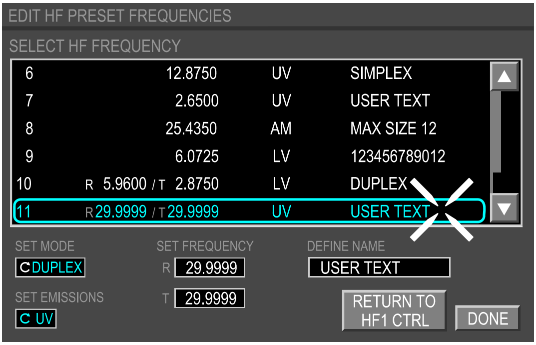
The new preset frequency can be changed in the SET FREQUENCY data entry field using the MKP readout line (scratchpad) or the DSK switch.

The name of the new preset frequency can be entered in the DEFINE NAME data entry field using the MKP readout line (scratchpad). A maximum of 13 alphanumeric characters can be entered in this field.

The new preset frequency is confirmed by pushing the ENTER switch on the MKP or PUSH ENTER on the DSK switch of the CCP. The DONE soft switch can also be used.

(9) HF preset frequency (shortcut)

The HF preset frequency (white) can be tuned directly to an active frequency (green) on the TUNE page or HF CONTROL window (refer to Figure 05–03–81). To tune an HF preset frequency using a shortcut, the flight crew selects the HF active frequency with the CCP. In the MKP readout window (scratchpad), the letter P is typed followed by the desired preset frequency number (e.g. P1, P2,... P20). The selection is confirmed by pushing the ENTER switch on the MKP.



EDIT HF PRESET FREQUENCIES – Frequency programming <23129001C>
Figure 05–03–81

(10) CNS – TUNE page – MODE (shortcut)

The mode selection can be changed directly (shortcut) from the TUNE page or the HF CONTROL window with the active frequency.

The shortcuts for direct MODE tuning are applicable for:

- SIMPLEX,
- DUPLEX,
- EMER (Emergency), and
- MAR (Maritime).

The shortcut for MODE selection is done by selecting the HF active frequency (green) with the CCP. When the HF active frequency is selected, a new frequency can be entered with a specific letter on the MKP and confirmed by pushing the EXEC switch.

When the HF active frequency is not in SIMPLEX mode, entering a valid HF frequency followed by an S or F changes the tune mode to SIMPLEX. For example, entering 2.8620S or 2.8620F changes the tune mode and shows SIMPLEX with a frequency of 2.8602.

NOTE

The letter F is included to support other legacy HF installations.

When the HF active frequency is not in DUPLEX mode, entering a combination of valid HF frequencies preceded by an R and a T changes the tune mode to DUPLEX. For example, entering R2.8620 T2.8800 changes the tune mode and shows DUPLEX with a receive frequency of 2.8620 and transmit frequency of 2.8800.

NOTE

A space is required between the last digit of the receive frequency and the first letter of the transmit frequency.

If the receive and transmit frequencies are entered when the tune mode is SIMPLEX, the tune mode changes to DUPLEX.

When the HF active frequency is not in EMER mode, entering a valid emergency channel number (from 1 to 6) followed by the letter E, changes the tune mode to EMER. For example, entering 2E changes the tune mode and shows EMER with emergency channel 2.

When the HF active frequency is not in MAR mode, entering a valid maritime channel followed by the letter M changes the tune mode to MAR. For example, entering 0401M changes the tune mode and shows MAR with maritime channel 0401.

(11) CNS – TUNE page – EMISSIONS (shortcut)

When the active HF tune mode is SIMPLEX or DUPLEX, the EMISSIONS selection can be changed by entering LV, UV, or AM at the end of the frequency entry. For example, entering 5.0000S AM or R2.8620 T2.8800 LV changes the EMISSIONS mode to the entered value.

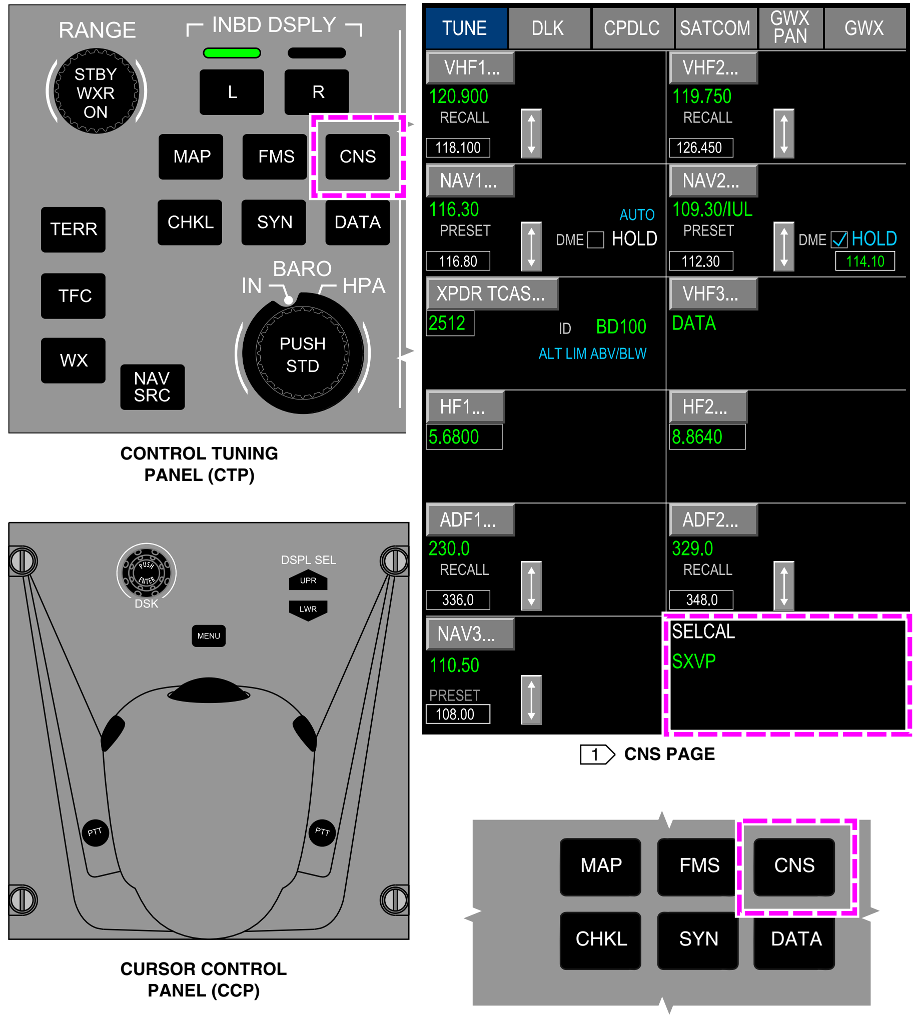
H. CNS – TUNE page – SELCAL <23210004C>

The TUNE window displays the four-character aircraft assigned SELCAL code. The SELCAL code can only be changed from the Aircraft Personality Module (APM).

When the CTP is inhibited, all SELCAL main display indications and controls are removed and replaced with an amber SELCAL DISABLED message.

Figure 05–03–82 shows the control switches that are necessary to access the TUNE page that shows the CNS – TUNE page – SELCAL display.

Figure 05–03–83 shows the CNS – TUNE page – SELCAL display.

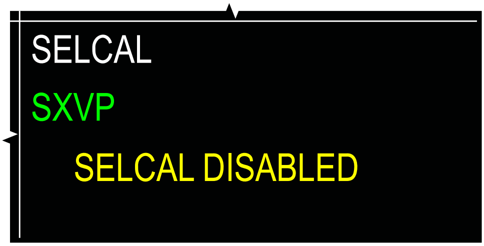


MULTIFUNCTION KEYBOARD PANEL (MKP)

NOTE

1 This view shows options that may not be installed on your aircraft.

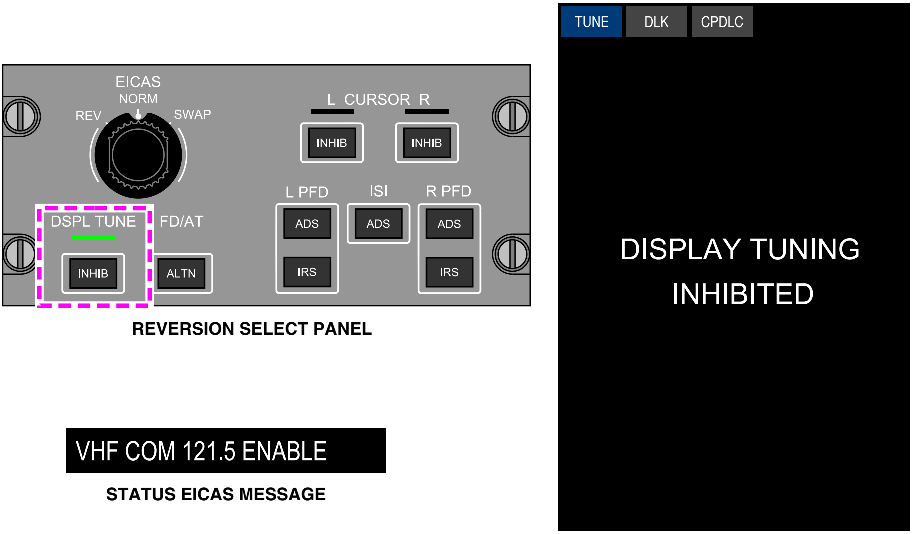
CNS – TUNE page – SELCAL <23210004C>
Figure 05–03–82



TUNE page – Tuning window SELCAL display <23210004C>
Figure 05–03–83

I. CNS – TUNE pages – Display tuning inhibit

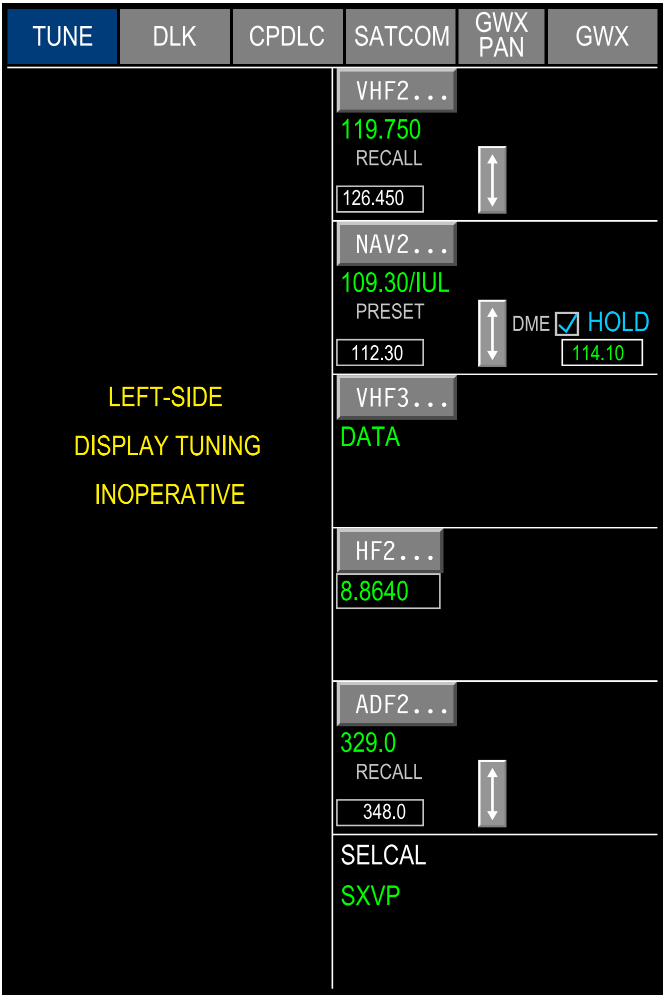
The DSPL TUNE INHIB switch, located on the Reversion Select Panel (RSP), inhibits the display tuning. When pushed, it will cause a white DISPLAY TUNING INHIBITED EICAS status message to be displayed (refer to Figure 05–03–84). When display tuning is inhibited and both CTPs are turned off (with their respective OFF/BRT switch), VHF1 and VHF2 are automaticity tuned to 121.5 MHz for emergency communication, and the status message **VHF COM 121.5 ENABLE** is displayed on the EICAS page.



TUNE page – Display tuning inhibited
Figure 05–03–84

J. CNS – TUNE pages – Display tuning fail

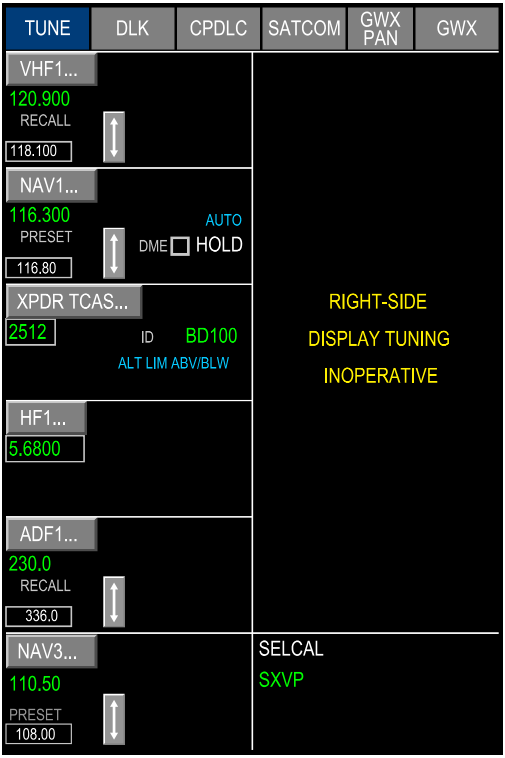
When tuning capability of the left-side or right-side radio is lost, the associated VHF, NAV, HF (if installed), and ADF areas are blanked out and an amber LEFT-SIDE (RIGHT-SIDE) DISPLAY TUNING INOPERATIVE message is displayed (refer to Figure 05–03–85 and Figure 05–03–86).



NOTE

This view shows options that may not be installed on your aircraft.

CNS – TUNE page – Tuning capability lost (left–side)
Figure 05–03–85



NOTE

This view shows options that may not be installed on your aircraft.

CNS – TUNE page – Tuning capability lost (right–side)
Figure 05–03–86

The loss of display tuning capability for all radio systems is indicated by the removal of all radio main displays and an amber DISPLAY TUNING INOPERATIVE message displayed on the tuning window (refer to Figure 05–03–87).

NOTE

This view shows options that may not be installed on your aircraft.

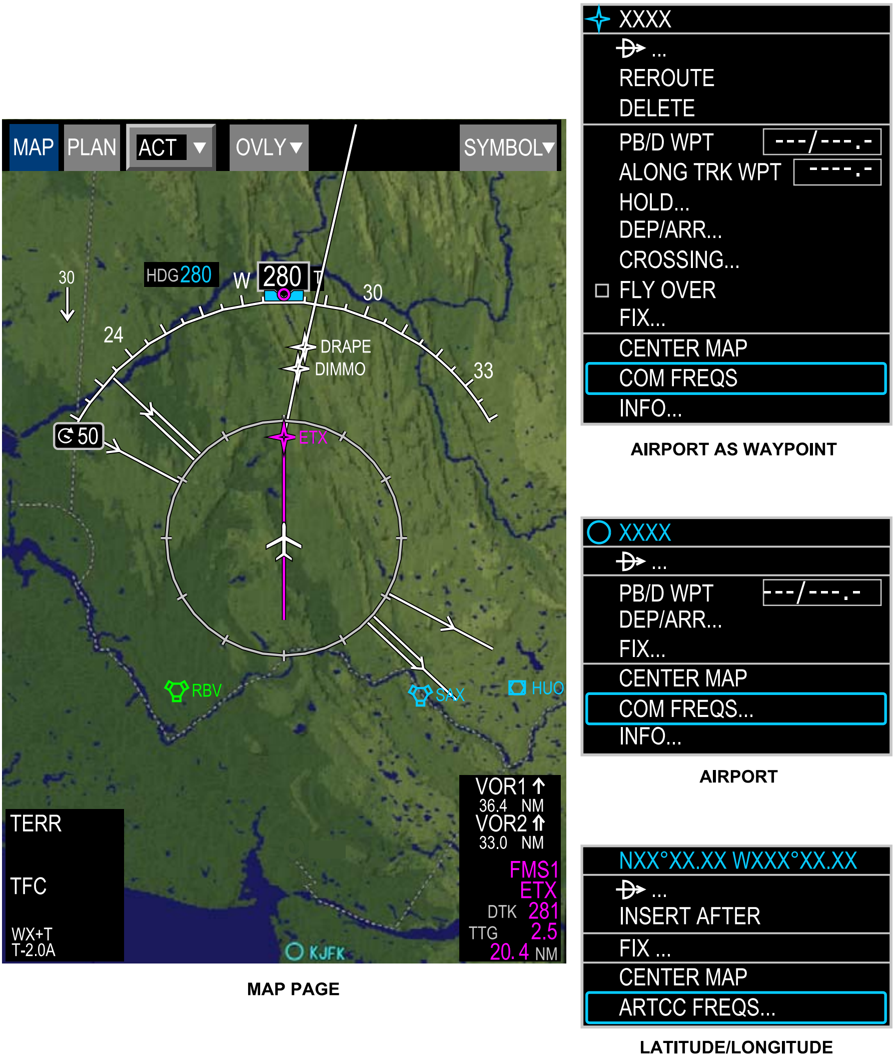
TUNE page – DISPLAY TUNING INOPERATIVE message
Figure 05–03–87

GRAPHICAL TUNING

The FMS graphical tuning function allows tuning of the VHF COM radios for Airport or Air Route Traffic Control Center (ARTCC) frequencies. The tuning can be done from any MFW set to a MAP or PLAN page that contains the selectable icons that follow (Refer to Figure 05–03–88):

- Airports,
- Airports as flight plan waypoints, and

- Latitude/longitude selections.



CNS– TUNE page – Graphical menus
Figure 05–03–88

The CCP or the MKP can be used to select these icons. When selected, a drop-down menu is displayed with one of the items that follow:

- COM FREQS (airports/runways), or
- ARTCC FREQS (LAT/LONG).

When the COM FREQS or ARTCC FREQS item is selected, the selected airport VHF or ARTCC VHF dialog box displays.

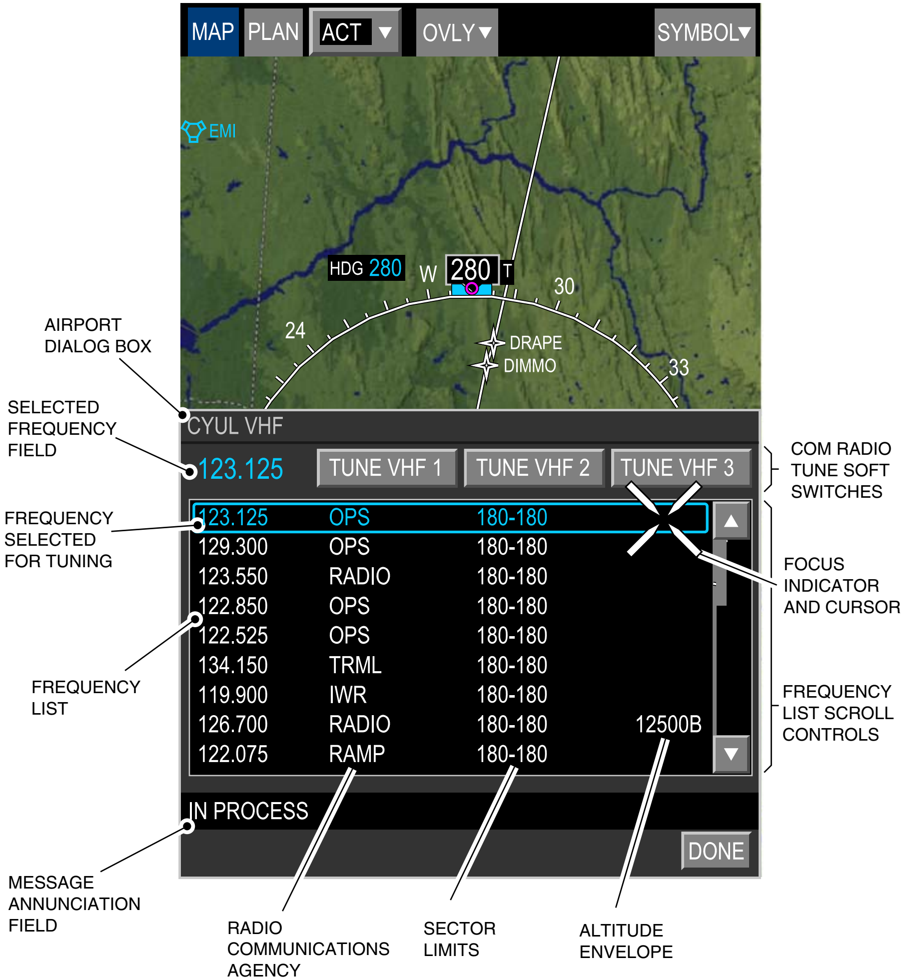
When an empty location is selected on the graphical map display (MAP or PLAN), the LAT/LONG menu that contains the ARTCC FREQS item is displayed.

The airport and ARTCC frequencies are derived from the FMS navigation database.

A. COM FREQS dialog box

Selecting the COM FREQS item displays the selected airport VHF dialog box. The dialog box includes (refer to Figure 05–03–89):

- VHF frequency list associated with the selected airport. Each list item includes:
  - Selectable VHF frequency,
  - Radio communication agency,
  - Frequency sector limits, and
  - Altitude envelope.
- Scrolling control if the list contains more than 10 frequencies,
- Selected frequency field,
- Tune control soft switches for each VHF radio, and
- System message annunciation field.



COM FREQS dialog box
Figure 05–03–89

The CCP or MKP controls are used to position the focus indicator around the desired frequency for selection. The selected frequency is displayed in cyan in the selected frequency field and in the frequency list.

A message at the bottom of the dialog box indicates the communication status with the NAV database. These messages are displayed in white and are as follows:

- IN PROCESS (during retrieval of frequency data),
- ERROR READING NAV DB (failed connection to NAV database), or
- NO FREQUENCIES AVAILABLE (no data available in the NAV DB for the selected airport).

B. ARTCC FREQS dialog box

Selecting the ARTCC task item displays the ARTCC VHF dialog box. The dialog box displays up to five ARTCC frequencies within a 200 nm area from the cursor selected latitude/longitude position on the FMS graphical map. The dialog box includes the information and controls that follow (refer to Figure 05–03–90):

- VHF frequency list associated with the selected latitude/longitude waypoint. Each list item includes:
  - VHF frequency,
  - Call sign (up to 30 characters),
  - Remote site name (up to 25 characters), and
  - Altitude envelope (if applicable).
- Selected frequency field,
- Tune control soft switches for each VHF radio, and
- System message field.

ARTCC FREQS dialog box
Figure 05–03–90

The ARTCC frequencies are listed in the order of the nearest to the farthest from the selected latitude/longitude waypoint. The ARTCC VHF dialog box functions like the airport VHF dialog box for frequency selection, indications, and tuning control.

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CABIN AND GROUND CREW COMMUNICATION – OVERVIEW

The intercom system, also called the cabin and ground crew communication system, includes the flight compartment intercom and the service and maintenance intercom.

The flight compartment intercom system is for communication between the external service panel, refuel/defuel service panel, and the flight compartment.

The service intercom system is for communication between all the service and maintenance areas and the flight compartment.

During ground operations, the intercom system supplies HOT MIC communication (voice is automatically transmitted when detected).

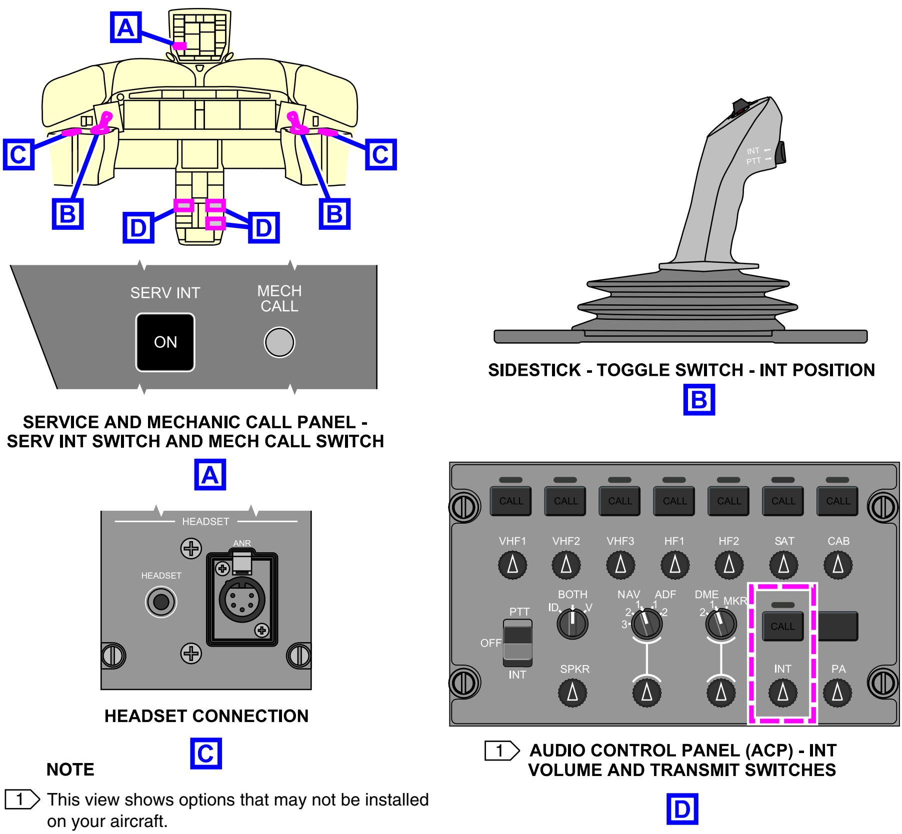
The intercom transmissions are done from:

- The microphones on the headsets,
- The microphones in the flight crew oxygen masks, or
- The flight compartment interphone.

The flight compartment intercom system controls are located on the:

- Audio Control Panel (ACP),
- Sidestick (toggle switch), and
- Service and mechanic call panel.

Refer to Figure 05–04–1 for the locations of the internal intercom switches and the headset jack. <23410001D>



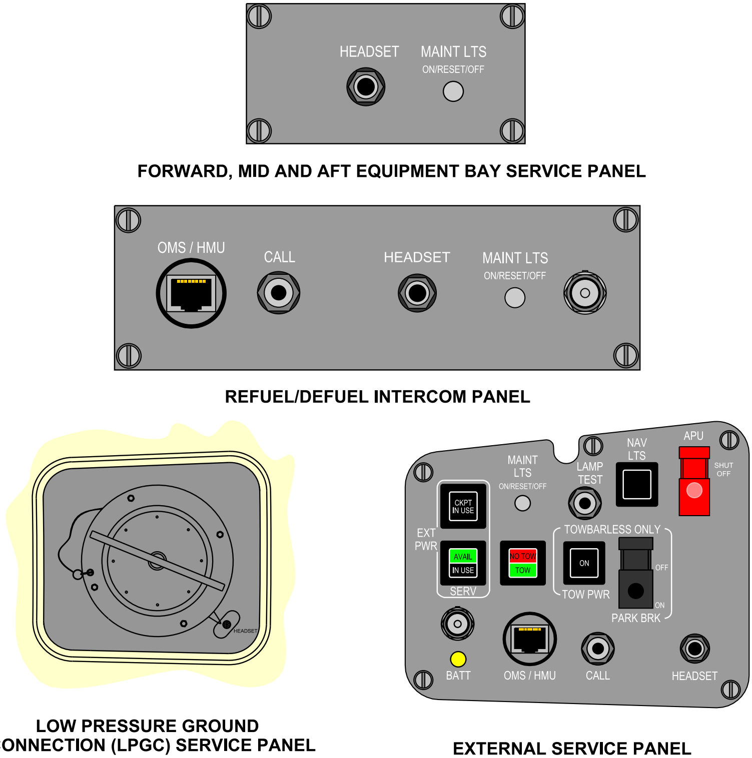
INT (Intercom) – Internal intercom switch and headset jack locations – Single jack <23410001D>
Figure 05–04–1

The service and maintenance intercom system controls are located on the:

- External service panel,
- Forward equipment bay service panel,
- Mid equipment bay service panel,
- Aft equipment bay service panel,
- Refuel/defuel intercom panel, and

- Low Pressure Ground Connection (LPGC) service panel.

Refer to Figure 05–04–2 for the locations of the external service panels and headset jack. <23410001D>



INT (Intercom) – External service panel locations – Single jack <23410001D>
Figure 05–04–2

A. Cabin crew communication

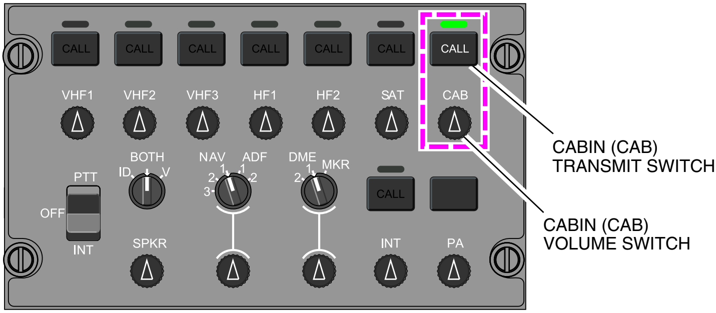
The cabin communication system allows the flight crew to communicate with the flight attendants in the cabin.

(1) Cabin call – Audio Control Panel (ACP)

The cabin communication system controls are located on the Audio Control Panels (ACPs) and the Cabin Management System (CMS).

Each ACP (refer to Figure 05–04–3) has the cabin communication system functions that follow:

- Transmit selection (CAB transmit switch),
- Volume adjustment (CAB volume switch), and
- Push-To-Talk (PTT) switch.



NOTE

This view shows options that may not be installed on your aircraft.

ACP – Cabin Communication (CAB) switches
Figure 05–04–3

The CAB volume switch adjusts the volume of the cabin communication. It is activated when it is pushed out. This raises the switch (unlatches it) and a white band is visible around the switch. The volume is adjusted by rotating the CAB volume switch.

When the flight crew wants to communicate with a flight attendant, the CAB transmit switch is pushed. It causes the actions that follow:

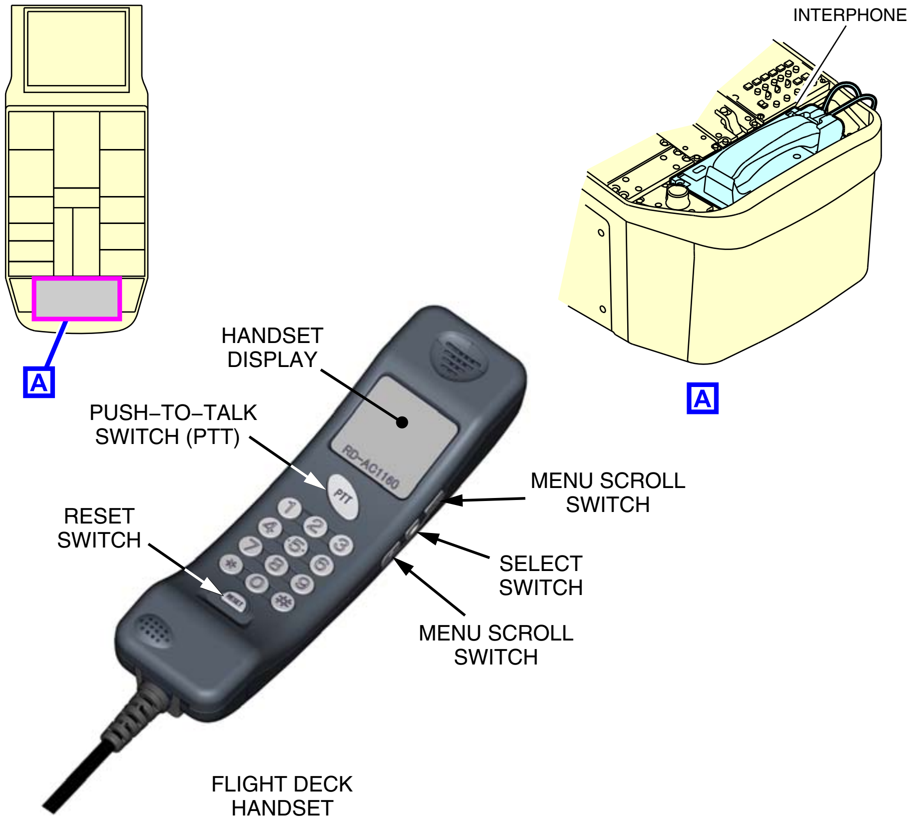
- A chime is heard in the cabin,

- The red cabin call light comes on, and
- The green light above the CAB transmit switch comes on.

Pushing the CAB transmit switch for more than 3 seconds generates a priority call for the cabin. A triple chime is heard and the red call light flashes in the cabin.

(2) Cabin call – Interphone

The flight compartment interphone can also be used for cabin communication. It is located at the bottom of the center pedestal (refer to Figure 05–04–4).



Interphone
Figure 05–04–4

To call the cabin crew, the handset is used as follows:

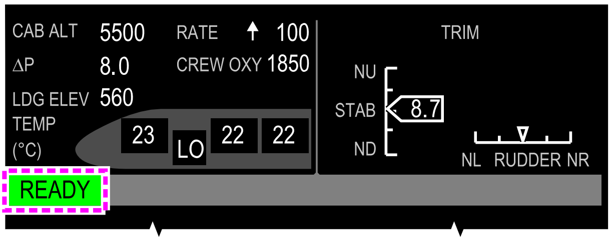
- The cabin station is selected on the handset display with the menu scroll and the select switches on the side of the handset, or
- The station number is manually entered with the handset keyboard,

- When the communication is finished, the call is ended by putting the handset back in its cradle or by pushing the reset switch on the handset.

To answer a normal or a priority cabin call, the handset is lifted from the cradle.

(3) Cabin messages

When the cabin is secured for takeoff or landing, a flight attendant sends a notification. The flight crew will then see an illuminated **READY** (green) communication flag at the bottom of the EICAS page (refer to Figure 05–04–5). The flag flashes for 5 seconds and then remain steady.



EICAS PAGE

READY – Communication flag
Figure 05–04–5

When a flight attendant contacts the flight crew, the indications are:

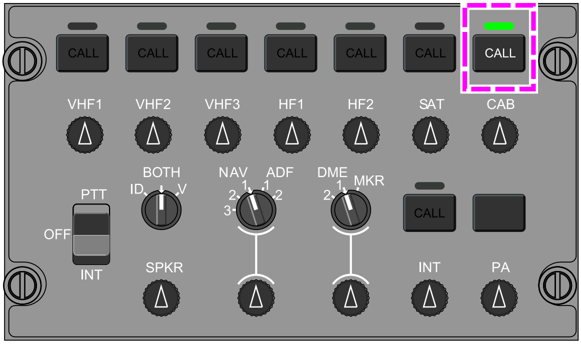
- The **CABIN** communication flag is illuminated (cyan) on the EICAS page,
- A tone is heard, and
- The CALL label on the CAB transmit switch is illuminated.

When a flight attendant contacts the flight crew for a priority call, the indications are:

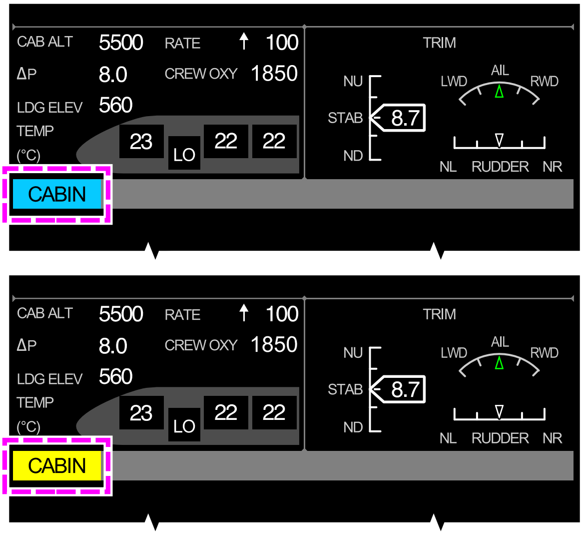
- The CABIN communication flag is illuminated (amber) on the EICAS page,
- An associated tone is heard, and
- The CALL label on the CAB transmit switch flashes.

A priority call overrides a normal cabin call at all times.

Figure 05–04–6 shows the cabin associated EICAS communication flags.



1 AUDIO CONTROL PANEL (ACP)



NOTE

1 This view shows options that may not be installed on your aircraft.

CABIN – Communication flags
Figure 05–04–6

NOTE

If the EICAS page is compressed, the EICAS communication flags are changed to EICAS communication messages.

(4) Compressed EICAS messages

When the EICAS page is compressed, the messages display as shown in Figure 05–04–7.

COMMUNICATION FLAGS		
Symbol	**Color**	**Description**
READY	Black writings on green background	Cabin is ready for takeoff or landing (no aural).
CABIN	Black writings on cyan background	Cabin is calling (normal situation).
CABIN	Black writings on amber background	Cabin is calling for a priority event.

Cabin calls – Communication flags
Figure 05–04–7

B. Passenger Address (PA)

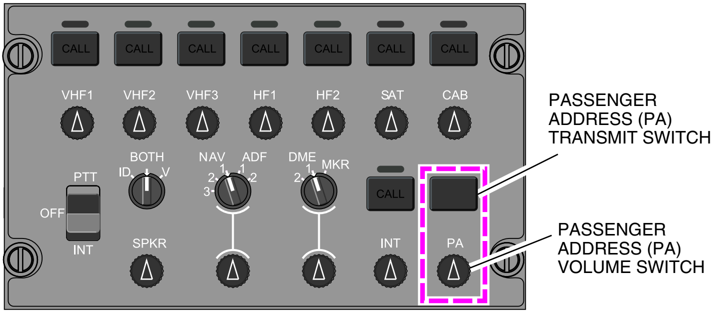
The PA system allows the flight crew to broadcast information to the passengers in the cabin.

It includes the components that follow:

- Audio Control Panel (ACP),
- Cabin Management System (CMS),
- Amplifier, and
- Speakers.

Each Audio Control Panel (ACP) (refer to Figure 05–04–8) has the PA functions that follow:

- Volume adjustment (PA volume switch),
- Transmit selection (PA transmit switch), and
- Push-To-Talk (PTT) switch.



NOTE

This view shows options that may not be installed on your aircraft.

ACP – Passenger Address (PA) switches
Figure 05–04–8

NOTE

There is no green light above the PA transmit switch.

The PA volume switch adjusts the volume of the PA. It is activated when it is pushed out. This raises the switch (unlatches it) and a white band is visible around the switch. The volume is adjusted by rotating the switch. The PA volume switch allows the flight crew to listen before broadcasting over the PA system so that they do not interrupt the flight attendants or pre-recorded messages.

NOTE

Aural alerts cannot be inhibited or attenuated.

Pushing the PA switch momentarily selects the PA function. The PA transmit switch has its own Push-To-Talk (PTT) function. It must be pushed during the entire communication. When the PA is done with the hand-held microphone, the PTT switch on the microphone and the PA transmit switch must be pushed at the same time. Releasing the PA transmit switch returns the audio system to its previous communication transmission selections.

NOTE

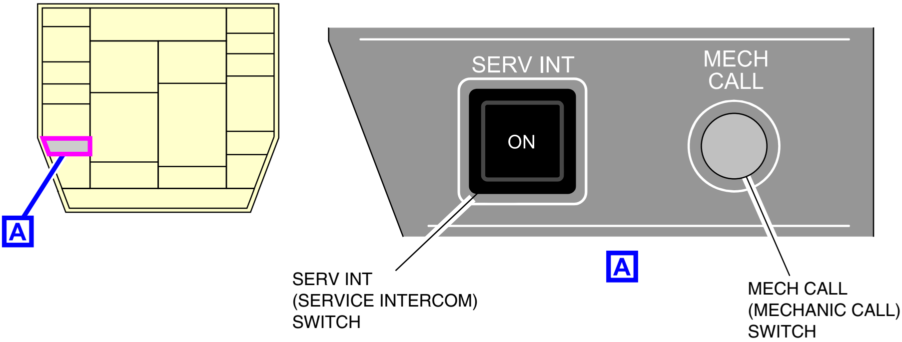
When the flight crew broadcasts a PA, it will override a simultaneous PA from the cabin.

The PA can be done with any of the microphones that follow:

- The headset microphones,
- The microphones in the flight crew oxygen masks,
- The hand-held microphones, or
- The flight compartment interphone.

C. Ground crew communication

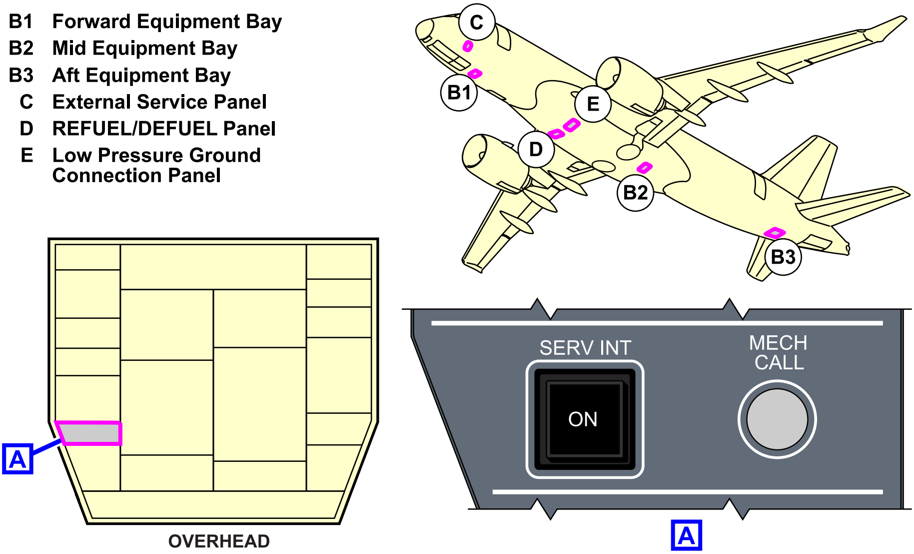
The service and mechanic call panel is located on the overhead panel, and has a SERV INT switch and a MECH CALL switch (refer to Figure 05–04–9).



Service and mechanic call panel
Figure 05–04–9

During normal ground operations, when the SERV INT switch on the service and mechanic call panel is not pushed, the intercom is active only between the areas that follow (refer to Figure 05–04–10):

- The three flight deck stations,
- The external service panel, and
- The external REFUEL/DEFUEL panel.



Service intercom
Figure 05–04–10

When the SERV INT switch is selected, the ON label is illuminated. Communication is open between all the maintenance and service areas and the flight compartment.

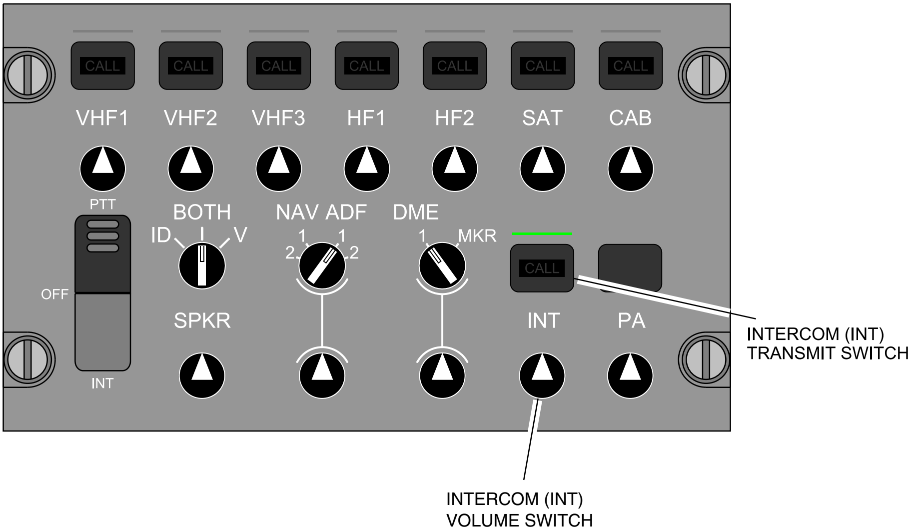
When the MECH CALL switch is pressed, it generates a horn sound in the external service panel areas.

The controls for the communication between the flight compartment and the service and maintenances area are available on the items that follow:

- The ACPs, and
- The sidestick toggle switch.

The ground crew communication controls from the ACPs are (refer to Figure 05–04–11):

- INT volume switch,
- INT transmit switch, and
- Rocker switch (PTT, OFF, and INT).



ACP – INT (Intercom) volume and speaker switches
Figure 05–04–11

The green light above the INT transmit switch comes on when the switch is pushed. A tone is heard in the flight compartment when there is a new incoming call from the service and maintenance crews.

The ACP permits transmission on only one communication channel at a time.

When there is an incoming mechanic call from the external service panel of the refuel/defuel intercom panel, the CALL labels are illuminated on the INT transmit switches on all ACPs. Pushing the INT transmit switch when the CALL label is illuminated opens the associated channel of communication and causes the green light above the INT transmit switch to come on.

NOTE

When the INT transmit switch is used, the flight crew must select the PTT switch to communicate.

NOTE

If there is a power failure, there is no intercom capability.

The rocker switch has three positions:

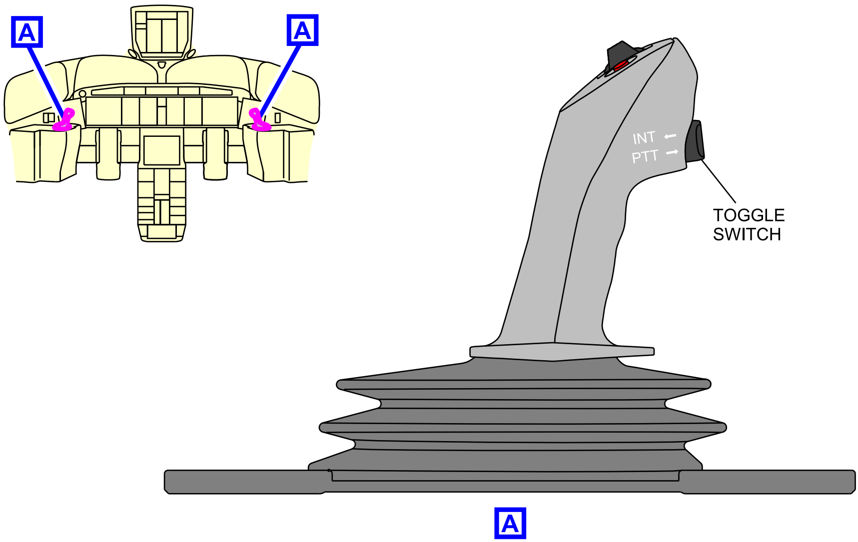
- PTT – Allows transmission through one channel. It is used for the intercom system only when the INT transmit switch is selected.
- OFF – The intercom function of the ACP is disabled.
- INT – Activates the HOT MIC function (voice is automatically transmitted when detected). It is used primarily for communication between the flight crew.

When selected to the PTT position, the rocker switch is spring-loaded to the OFF position.

The sidestick toggle switch (refer to Figure 05–04–12) has two positions:

- PTT (Push-To-Talk), and
- INT.

The toggle switch is spring-loaded to the OFF position only when selected to PTT. It has the same function as the rocker switch on the ACP but they are independent.



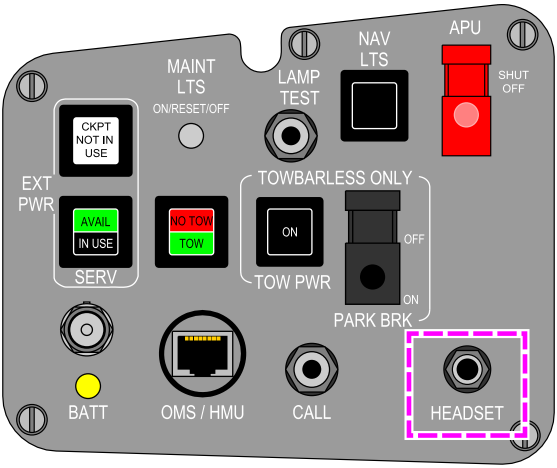
Sidestick – Toggle switch location
Figure 05–04–12

<Mod 240006> or <Post–SB BD500–240006>

(1) External service panel

The external service panel is located on the left side of the forward fuselage (refer to Figure 05–04–13). It has a single jack and a CALL switch. <23410001D>

The CALL switch is used to get the attention of the flight crew to initiate a conversation. When the CALL switch is pushed, the CALL label is illuminated on all ACPs and a chime is heard in the flight compartment.

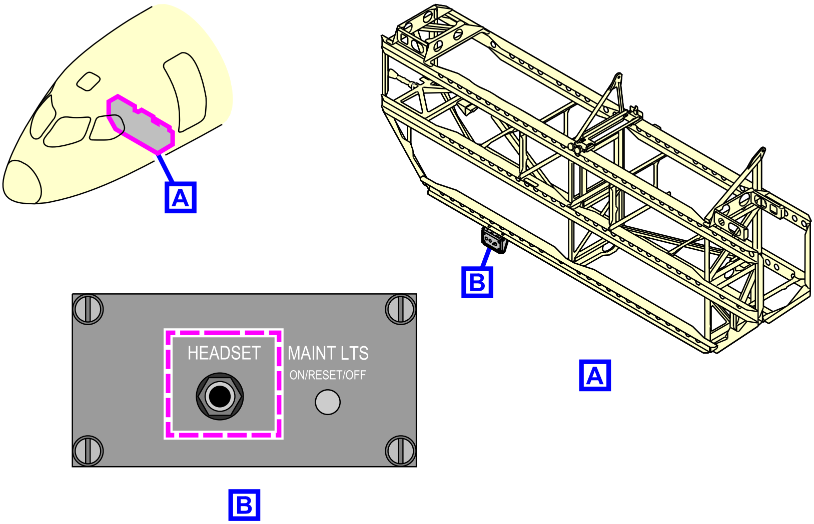


Electrical/towing service panel – Single jack <23410001D>
Figure 05–04–13

(2) Equipment bay service panels

The forward equipment bay intercom panel is located at the bottom of the rack, adjacent to the maintenance light switch.

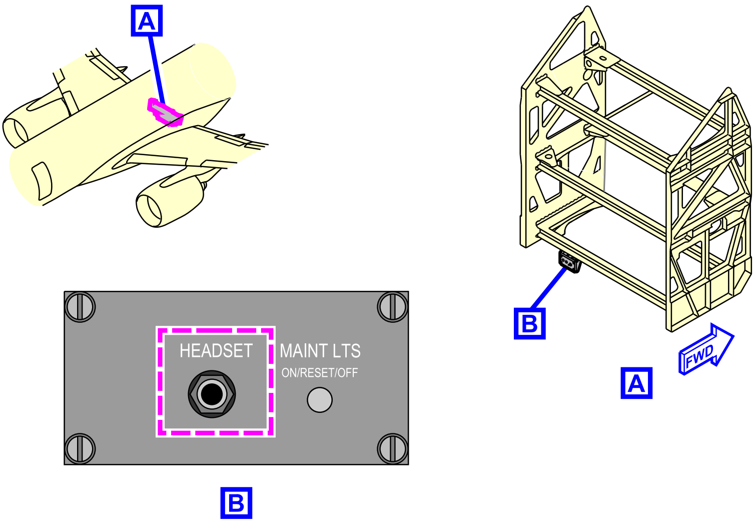
Refer to Figure 05–04–14 for the location of the forward equipment bay service panel with a single jack. <23410001D>



Forward equipment bay – Service panel location – Single jack <23410001D>
Figure 05–04–14

The mid equipment bay service intercom panel is located at the bottom of the rack, adjacent to the maintenance light switch.

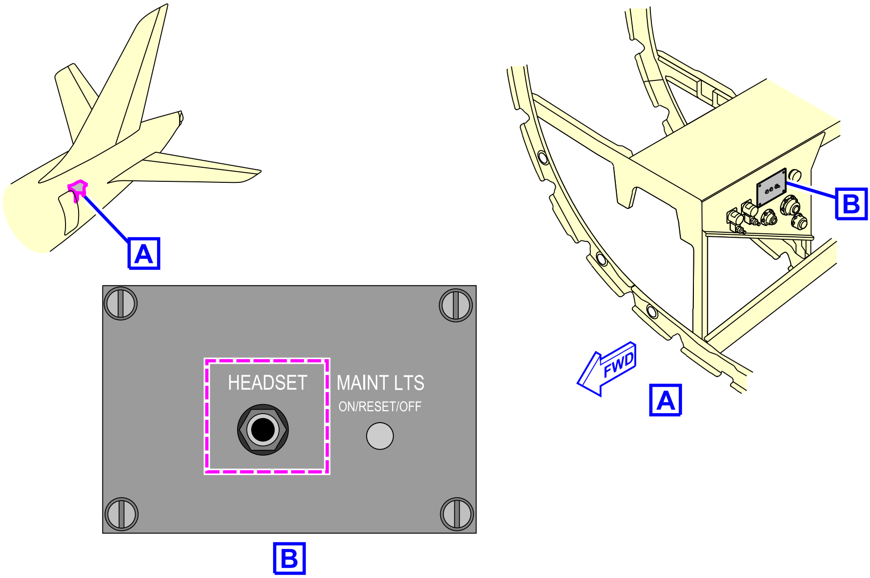
Refer to Figure 05–04–15 for the location of the mid equipment bay service panel with a single jack. <23410001D>



Mid equipment bay – Service panel location – Single jack <23410001D>
Figure 05–04–15

There is a service intercom panel in the aft equipment bay.

Refer to Figure 05–04–16 for the location of the aft equipment bay service panel with a single jack. <23410001D>



Aft equipment bay – Service panel location – Single jack <23410001D>
Figure 05–04–16

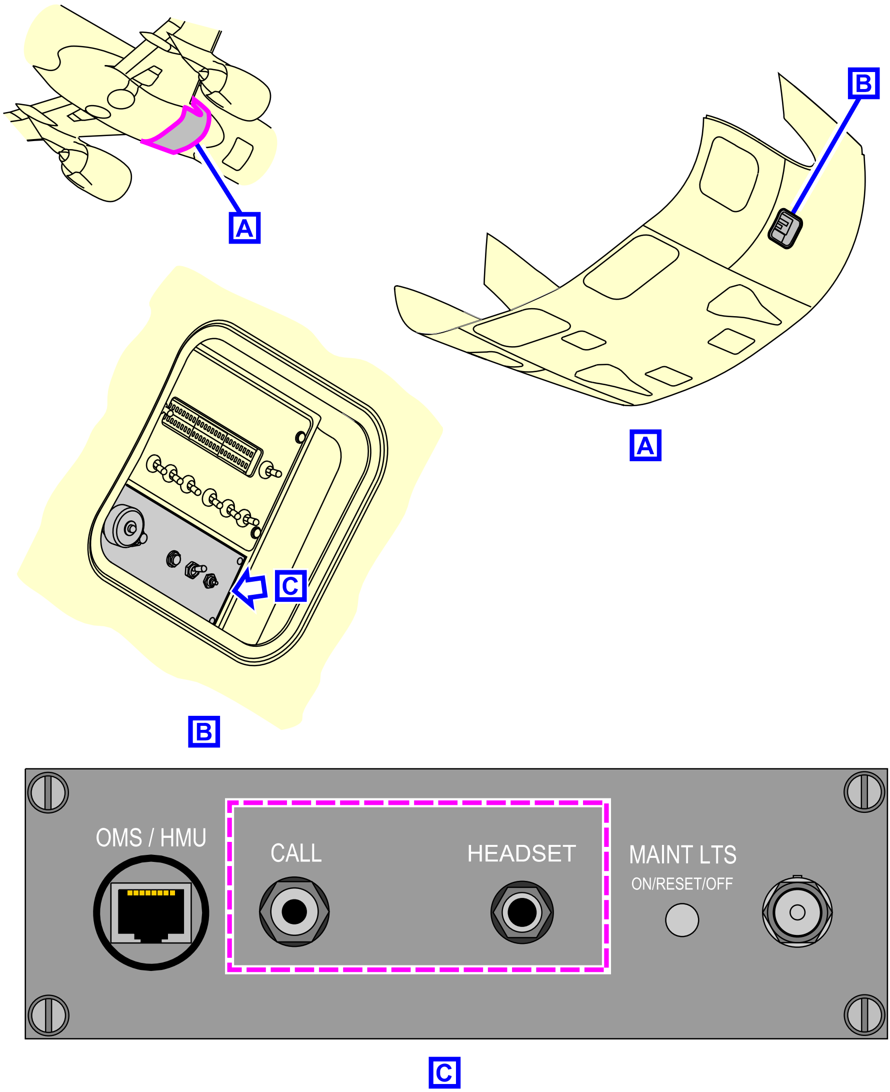
(3) Refuel/defuel intercom panel

The refuel/defuel intercom panel is located on the right side of the wing-to-body fairing, below the refuel/defuel panel.

It has a single jack and a CALL switch. <23410001D>

The CALL switch is used to get the attention of the flight crew to initiate a conversation. When the CALL switch is pushed, the CALL label on all ACPs is illuminated and a chime is heard in the flight compartment.

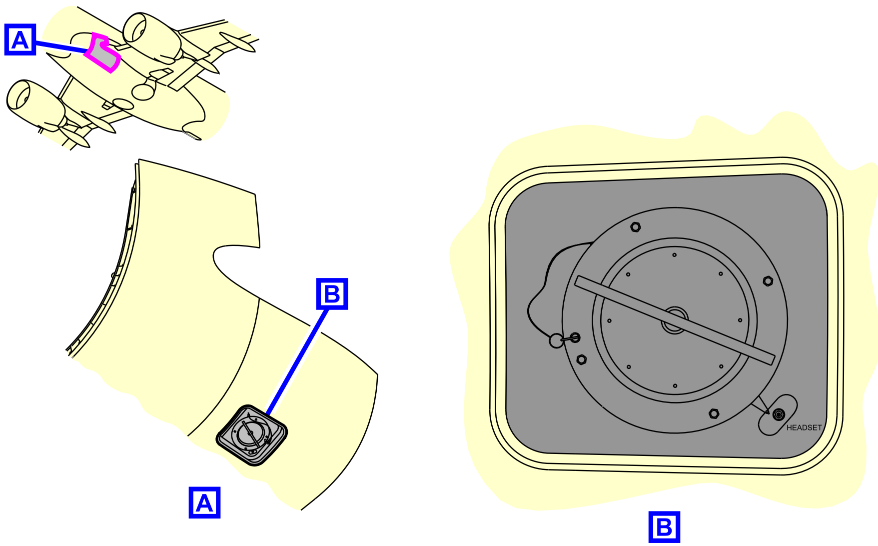
Refer to Figure 05–04–17 for the location of the refuel/defuel intercom panel with a single jack. <23410001D>



Refuel/defuel intercom panel location – Single jack <23410001D>
Figure 05–04–17

(4) Low Pressure Ground Connection (LPGC) service panel

The LPGC service panel is located on the left side of the wing-to-body fairing. Refer to Figure 05–04–18 for the location of the LPGC service panel with a single jack. <23410001D> or <23411001C>



Low Pressure Ground Connection (LPGC) service panel location – Single Jack <23410001D> or <23411001C>
Figure 05–04–18

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SATCOM – GENERAL

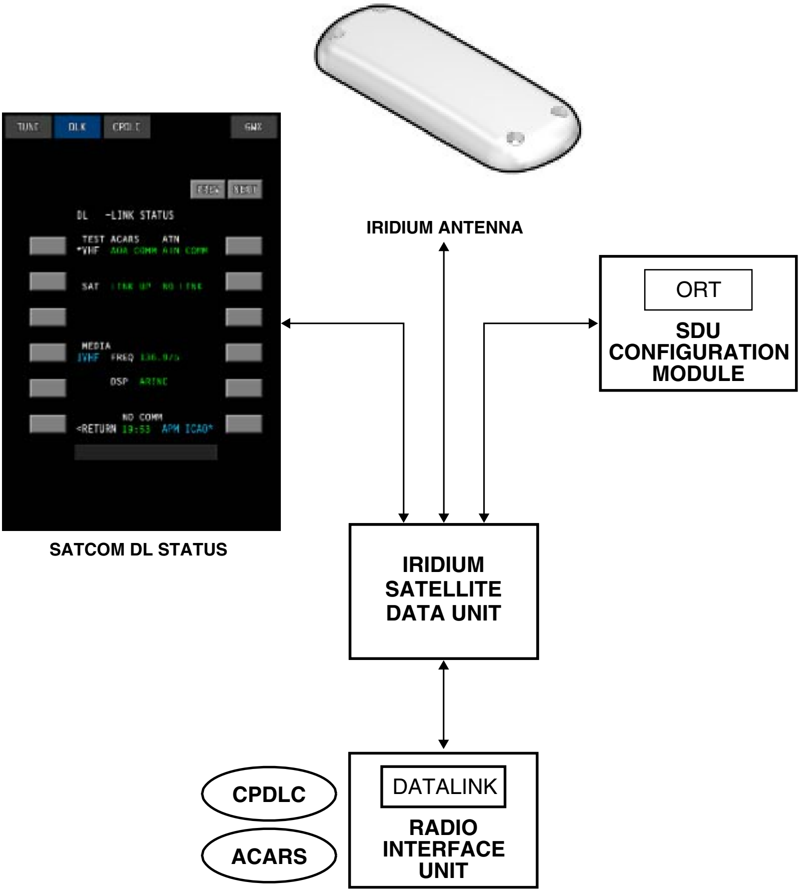
A. Overview

The SATCOM system supplies communication through global satellite and ground communication networks.

The SATCOM network includes the Iridium satellites, Ground Earth Stations (GES), and the aircraft equipment. Iridium satellite constellation uses 66 satellites for worldwide coverage, which includes the polar regions (refer to Figure 05–05–1).

The SATCOM system includes:

- One Satellite Data Unit (SDU),
- One SATCOM configuration module, and
- One SATCOM antenna (high gain).



SATCOM system
Figure 05–05–1

B. SATCOM Satellite Data Unit (SDU)

The SATCOM SDU controls SATCOM operation and is responsible to establish the connection between the aircraft and the Iridium network. The SDU supplies one channel of data service.

The SDU configuration module stores the Owner Requirements Table (ORT). The ORT stores the configuration data for the SATCOM system.

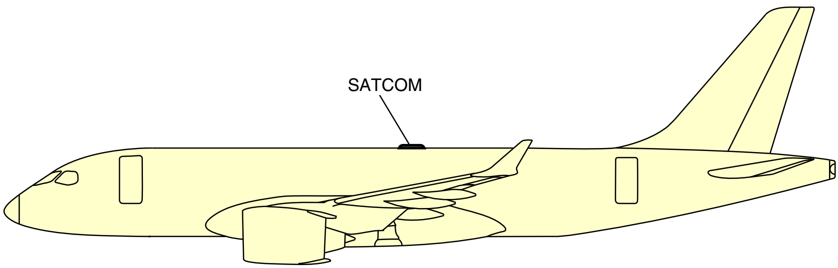
The SATCOM SDU is located in the mid equipment bay.

The SDU interfaces with the Radio Interface Unit (RIU) for data link communications that support the functions that follow:

- ACARS
- FANS CPDLC

C. SATCOM antenna

The SATCOM antenna is a low-profile antenna installed on the upper fuselage (refer to Figure 05–05–2).

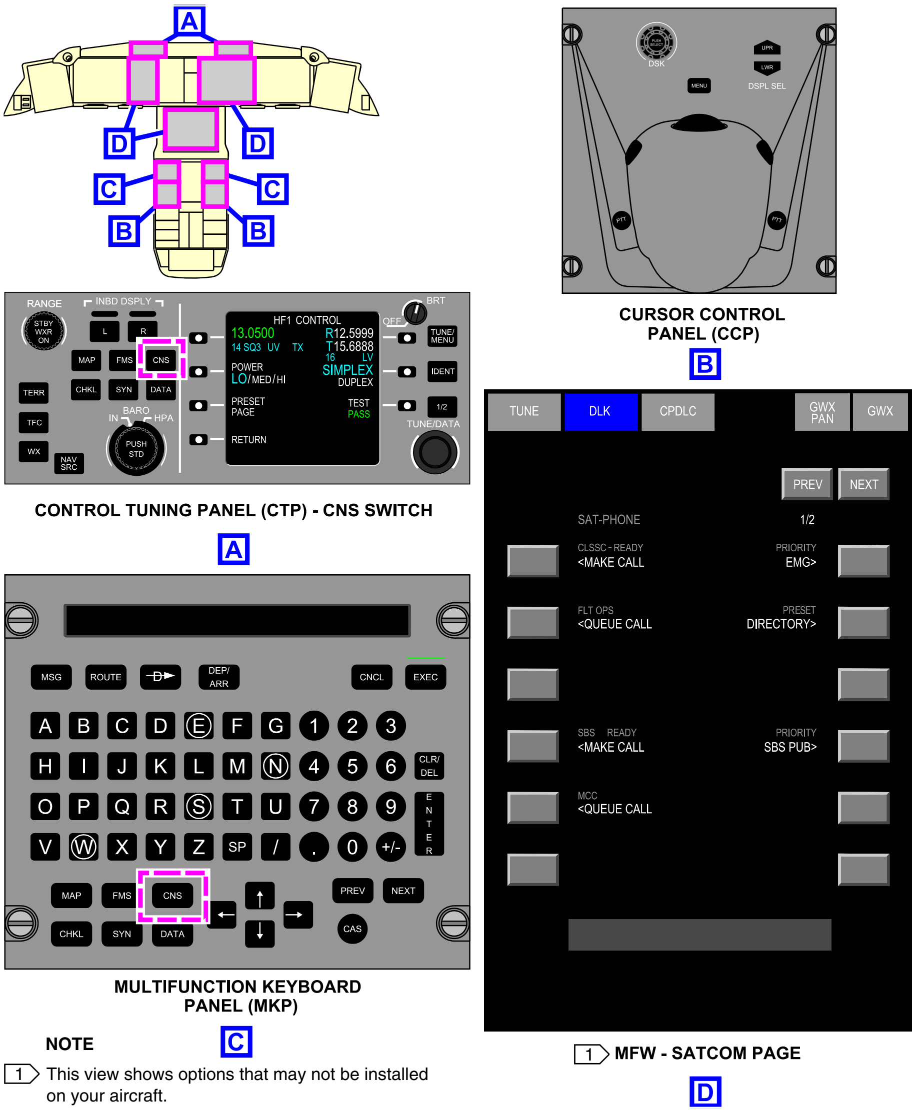


SATCOM antenna <23150004C>
Figure 05–05–2

SATCOM – DESCRIPTION AND OPERATION

A. SATCOM operation

The SATCOM status page is accessible with the CNS switch on the Control Tuning Panel (CTP) or on the Multifunction Keyboard Panel (MKP), and with the Cursor Control Panel (CCP) (refer to Figure 05–05–3).



NOTE

1 This view shows options that may not be installed on your aircraft.

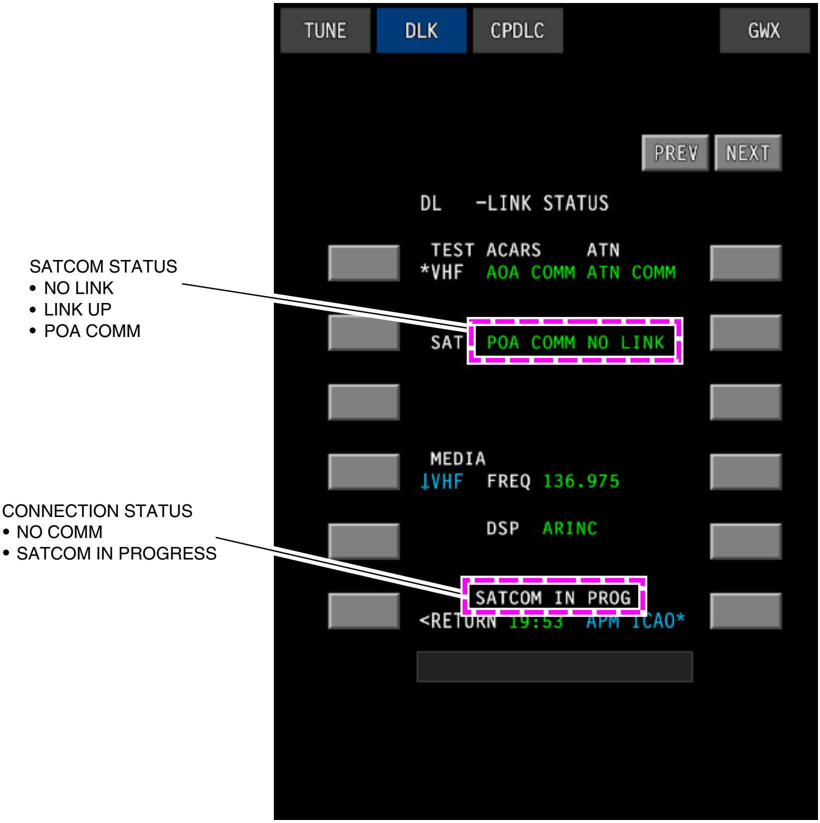
Access to SATCOM pages
Figure 05–05–3

Initial system logon is automatic and happens immediately on system power–up with no crew input required. If line of sight to satellites is available, the SATCOM connects to the ACARS data services. During the connection process, SATCOM CAS messages and NO COMM are removed and SATCOM IN PROG is displayed (refer to Figure 05–05–4).

When logon is complete, the status of the channel changes from NO COMM to POA COMM. The system logs on to the Short Burst Data (SBD) channel and attaches the SBD to the network.

NOTE

To log on to the Iridium network, the aircraft antenna must have unobstructed access to a satellite.



SATCOM DLK STATUS page
Figure 05–05–4

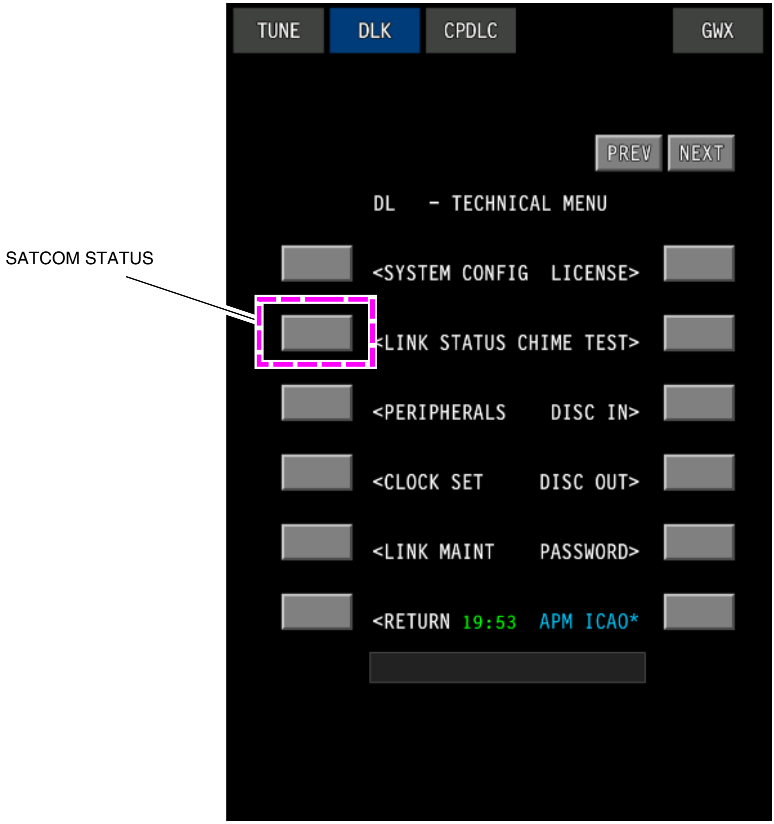
B. TECHNICAL MENU page

The TECHNICAL MENU page has selections to see the status of the data link systems (SATCOM) and to do tests (refer to Figure 05–05–5).

The primary use of the TECHNICAL MENU is for maintenance. The flight crew can make the selections that follow:

- LICENSE – Verifies the installation of licenses.

- LINK STATUS – Confirms that the communication systems are available.
- LINK MAINT – Provides an alternative way to verify the communication systems.
- CHIME TEST – Tests audio notification of incoming messages.



SATCOM TECHNICAL MENU page
Figure 05–05–5

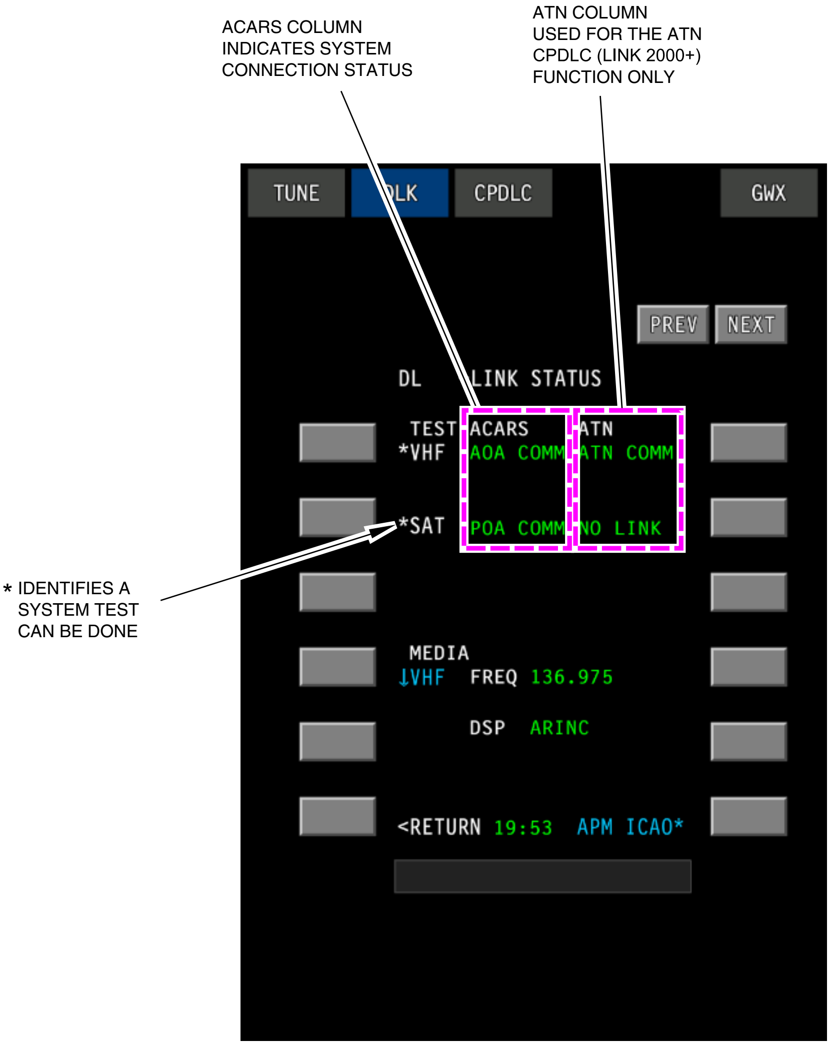
C. LINK STATUS page

The LINK STATUS page gives information on the current status of each communication system (refer to Figure 05–05–6).

The status is displayed beside the system name with the related activity displayed at the bottom of the page.

The three columns indicate the status as follows:

- Test – Identifies when a system test can be done.
- ACARS – Indicates the connection status of the system used for FANS, AOC CORP, and ATS services.
- ATN – Indicates the connection status of systems used for the ATN CPDLC (LINK 2000+) function. Only VHF data link can be used for ATN CPDLC. The TECHNICAL MENU page has selections to view data link systems (SATCOM) status and to do tests.



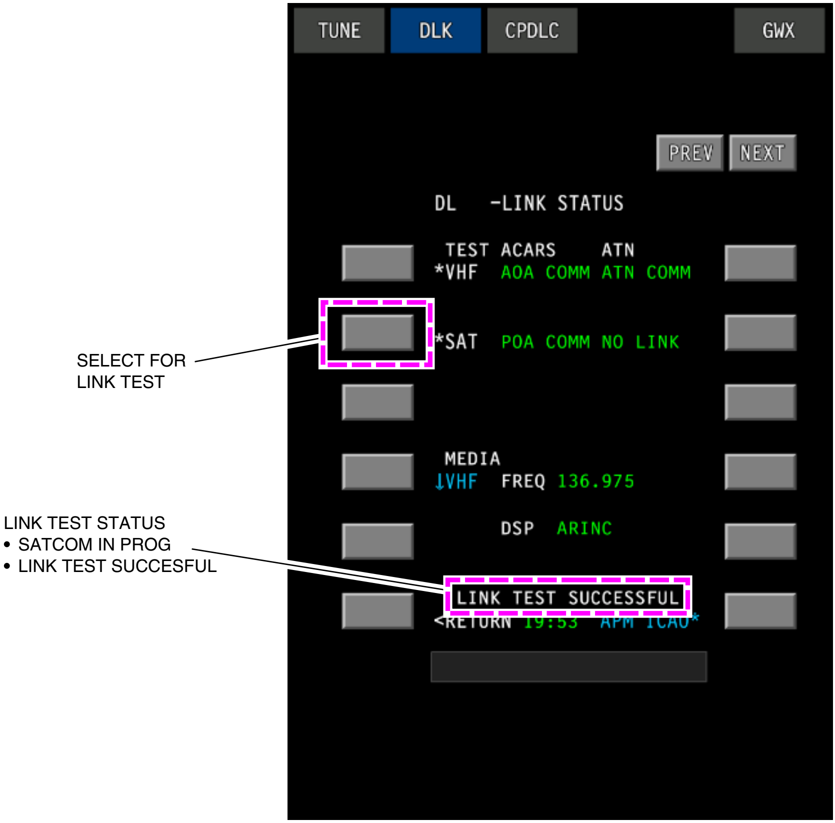
LINK STATUS page
Figure 05–05–6

D. LINK STATUS TEST

A test can be done on the SATCOM system when an asterisk (*) is displayed adjacent to SAT in the TEST column (refer to Figure 05–05–7).

The line select key initiates the link test with a SATCOM IN PROG displayed at the bottom of the page.

A LINK TEST SUCCESSFUL message is displayed when the test is successful. If the message does not appear, contact the maintenance crew. The LINK STATUS page gives information about the current status of each communication system.



LINK STATUS TEST
Figure 05–05–7

E. SATCOM status

The SAT line ACARS column will display one of the statuses that follow:

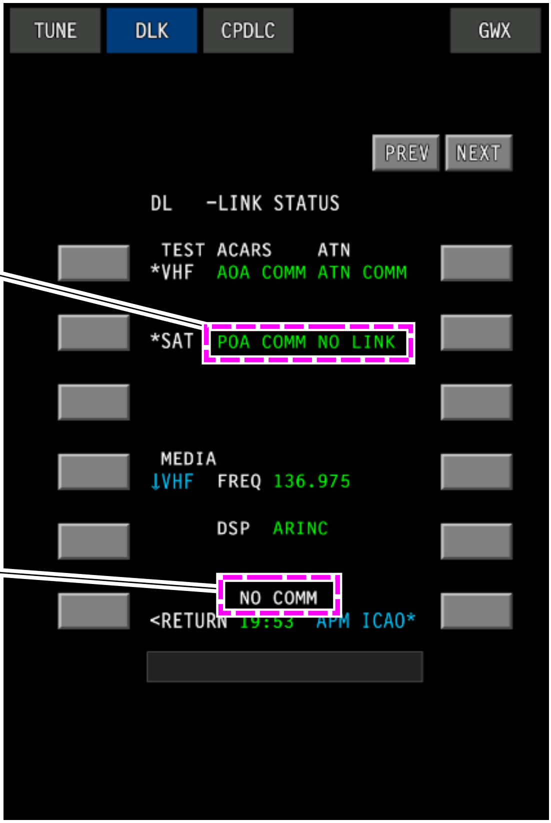
- NO LINK – Indicates no SATCOM data link is available. One or more of the SATCOM Crew Alerting System (CAS) messages will be displayed.
- LINK UP – Displayed when a SATCOM start a data link connection. SATCOM IN PROG is displayed at various times while the signal is being established.
- POA COMM – POA (plain old ACARS) is displayed when a data link connection is established.

When a system is unavailable, NO LINK is displayed in the ACARS or ATN columns. When no systems are available, the NO COMM message is displayed on the Connection Status line. When a system becomes active and communicates with the DSP, the NO COMM message is removed (refer to Figure 05–05–8).

SATCOM CONNECTION STATUS
- NO LINK
- LINK UP
- POA COMM

WHEN A SATCOM SYSTEM IS NOT AVAILABLE, NO LINK IS DISPLAYED IN THE ACARS AND ATN COLUMNS

CONNECTION STATUS WHEN NO SYSTEMS ARE AVAILABLE NO COMM MESSAGE SHOWN



SATCOM STATUS
Figure 05–05–8

SATCOM – GENERAL

A. Overview

The Automated Flight Information Reporting System (AFIRS™) SATCOM is a two-way voice and data communication system. It provides global coverage through the Iridium satellite network.

The AFIRS™ system has the capabilities that follow:

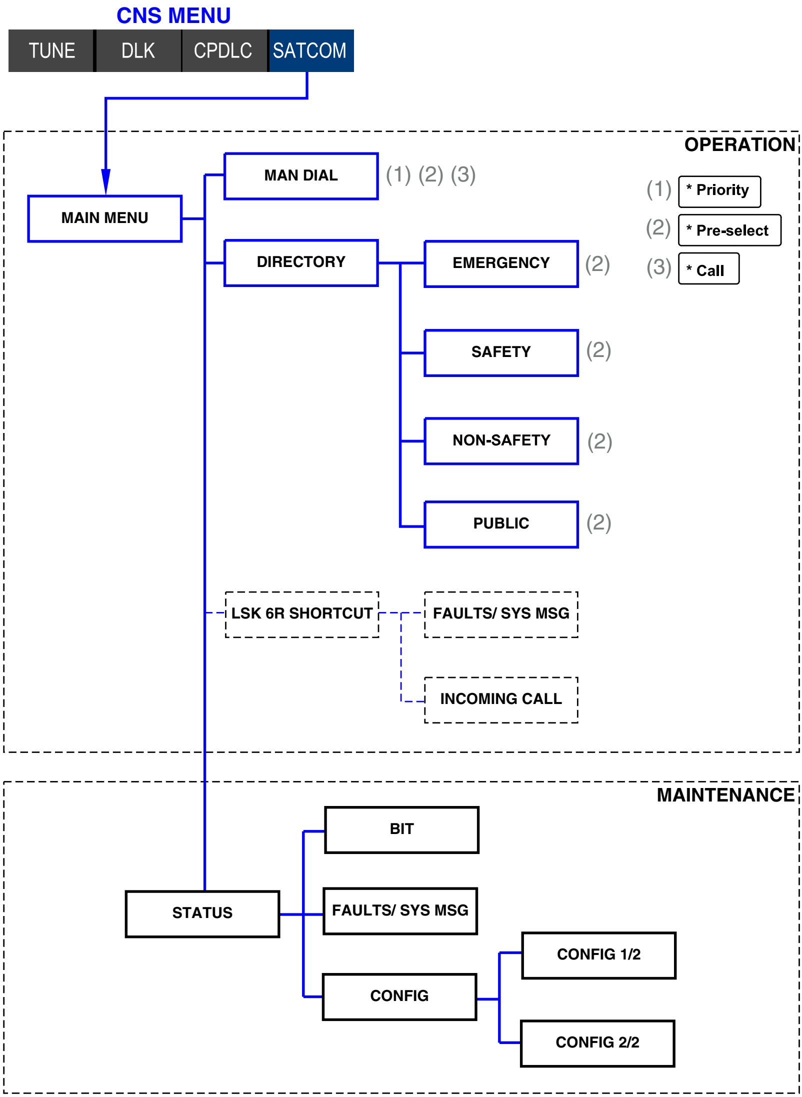
- Aircraft Communications Addressing and Reporting System (ACARS) over Iridium SATCOM.
- Future Air Navigation Systems (FANS–1/A+) over Iridium SATCOM.
- Long Range Communication System (LRCS) for Air Traffic Services (ATS) safety services communication.

It has a Satellite Communication (SATCOM) link with the Public Switched Telephone Network (PSTN) via the Iridium satellite network. The system uses a standard ARINC SATCOM interface with the Audio Integrating System, the Radio Interface Unit, and ARINC Emulated Control Display Unit (ECDU) in the flight compartment.

The AFIRS™ Iridium SATCOM system provides a dedicated safety-services data channel with the capability to send and receive standard ACARS messages between the aircraft Communications Management Unit (CMU) and a safety-services certified terrestrial service provider. Refer to Figure 05–05–1.

SATCOM system operational concept
Figure 05–05–1

The AFIRS™ primary control and display interface is the aircraft ECDU. It is used to control the voice functions and to display various system parameters (refer to Figure 05–05–2).



SATCOM tree structure
Figure 05–05–2

B. System components

The AFIRS™ system consists of the three core components that follow:

- One Satellite Data Unit (SDU),
- One SDU Configuration Module (SCM), and
- One Iridium antenna.

It interfaces with the systems that follow:

- Audio management – The flight crew controls voice from the Audio Control Panel (ACP). The MIC selection, push-to-talk and, audio levels are controlled on the ACP.
- Radio management – Provides the capability to send and receive standard ACARS messages between the aircraft Communications Management Unit (CMU), which resides in the Radio Interface Unit (RIU), and a safety-services certified terrestrial service provider. These consist of:
  – Air Traffic Services (ATS),
  – Aeronautical Operational Control (AOC),
  – Future Air Navigation System (FANS), Controller–Pilot Data Link Communications (CPDLC) including Automatic Dependent Surveillance Contract (ADS–C) capability.
- ECDU application.

C. SATCOM Satellite Data Unit (SDU) and SDU Configuration Module (SCM)

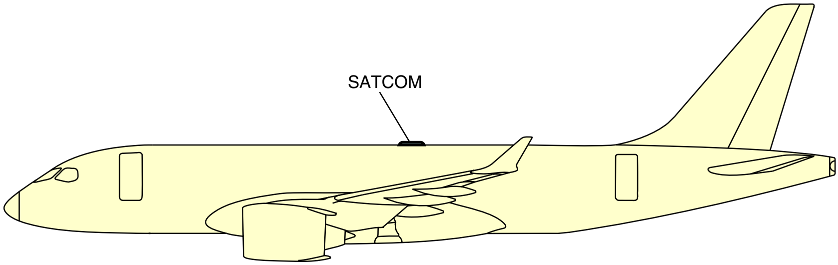
The SATCOM SDU controls SATCOM operation and is responsible to establish the connection between the aircraft and the Iridium network. The SDU provides air-to-ground and ground-to-air voice and digital ACARS data communications.

The SDU configuration module stores the Installation Configuration Table (ICT) and the Owner Requirements Table (ORT). These tables provide the configuration data for the SATCOM system. The SCM hosts the Iridium Subscriber Identification Module (SIM) card, which identifies the aircraft on the Iridium SATCOM network.

The SATCOM SDU and SCM are located in the mid equipment bay.

D. Antenna

The SATCOM antenna is a low-profile antenna installed on the upper fuselage (refer to Figure 05–05–3).



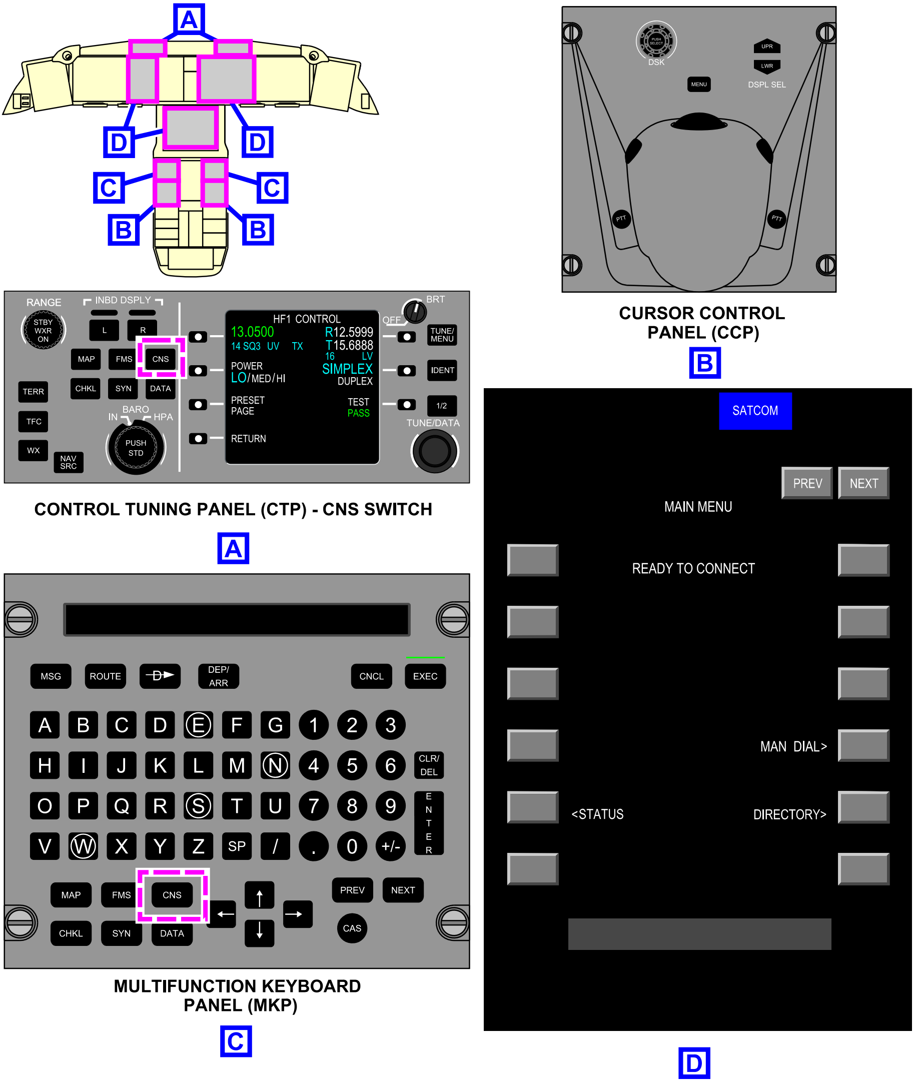
SATCOM antenna
Figure 05–05–3

SATCOM – DESCRIPTION AND OPERATION

A. SATCOM operation

The SATCOM page is accessible with the CNS switch on the Control Tuning Panel (CTP) or the Multifunction Keyboard Panel (MKP), and with the Cursor Control Panel (CCP) (refer to Figure 05–05–4).

The ECDU SATCOM main menu is displayed.



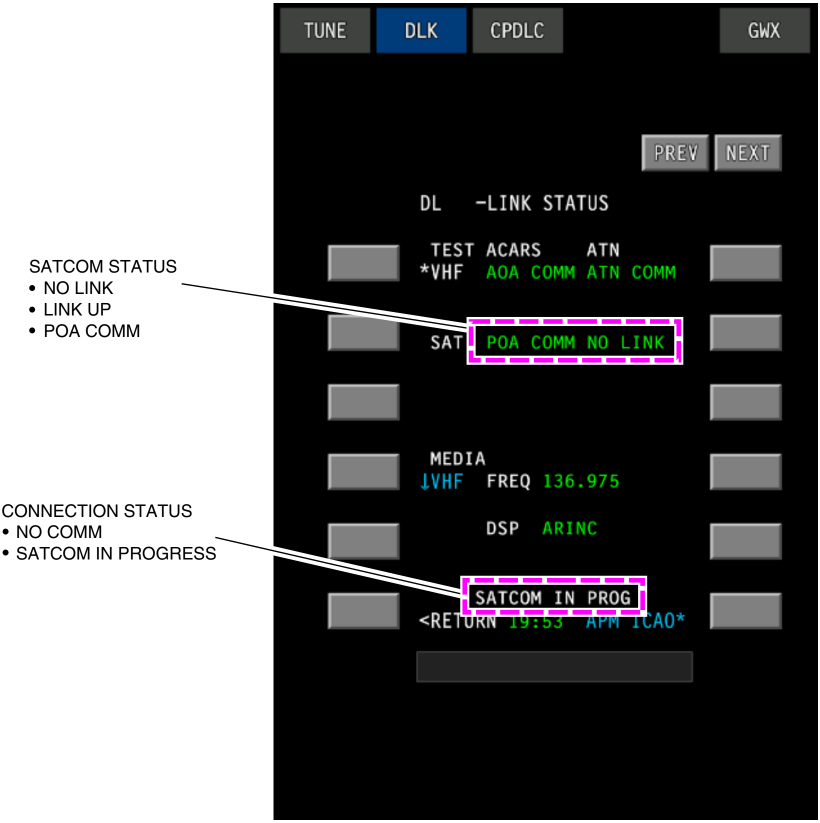
Access to SATCOM pages
Figure 05–05–4

If line of sight to satellites is available, initial system logon is automatic and happens immediately on system power-up with no crew input required, and the SATCOM also connects to the ACARS data services. During the connection process, SATCOM CAS messages and NO COMM are removed and SATCOM IN PROG is displayed (refer to Figure 05–05–5).

When logon is complete, the status of the channel changes from NO LINK to POA COMM.

NOTE

To log on to the Iridium network, the aircraft antenna must have unobstructed access to a satellite.



SATCOM DLK STATUS page
Figure 05–05–5

B. SATCOM MAIN MENU page

The MAIN MENU page provides access to the functions that follow:

- STATUS – System status and fault pages.
- MAIN DIAL – Manual dialing, which allows direct dial or phone number preselection (on the MAIN MENU page), and call priority adjustment.

- DIRECTORY – Directory pages, which provide access to preloaded Emergency, ATS, and AOC contacts.
- Scratchpad readout – Used to show status, action feedback, delete functions, and provides editable data to the flight crew. The scratchpad messages are independent on each ECDU display unit.

The satellite link status on LSK 1 can display the status messages that follow:

- NOT AVAILABLE – The satellite link is unavailable. Voice function is inoperative. Data may still be operative.
- READY TO CONNECT – The satellite link is available and data functions are operable. Voice calls can be initiated or received.
- INCOMING CALL – Incoming ground-to-air voice call (unanswered).
- DIALING – Outgoing air-to-ground voice call in the flight compartment.
- CONNECTED – Flight compartment voice call established and in progress.

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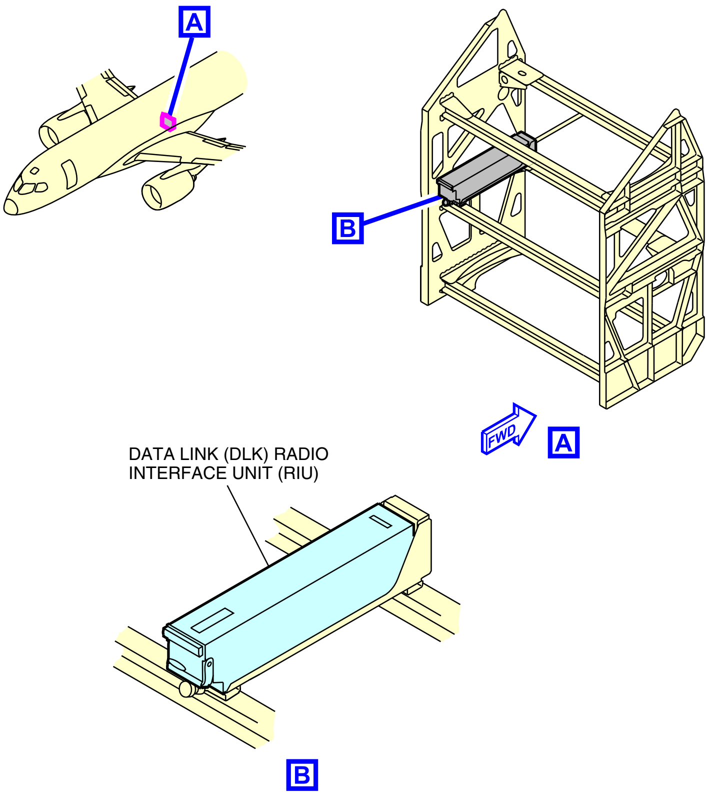
DLK – OVERVIEW

The Data Link (DLK) communication system transmits and receives digital data through the Aircraft Communications Addressing and Reporting System (ACARS) network. The DLK–enabled Radio Interface Unit (RIU) contains airborne router and data link technical applications. The operator must subscribe to the DLK service provider for DLK capabilities (refer to Figure 05–06–1).



Data Link (DLK) Radio Interface Unit (RIU)
Figure 05–06–1

The system combines with the Flight Management System (FMS) for direct uploading of flight plan and Weather (WX) data and enables message traffic for the following:

- Controller Pilot Data Link Communications (CPDLC), <23249001C>
- Air Traffic Services (ATS),
- Airline Operational Communication (AOC), and
- Technical communications.

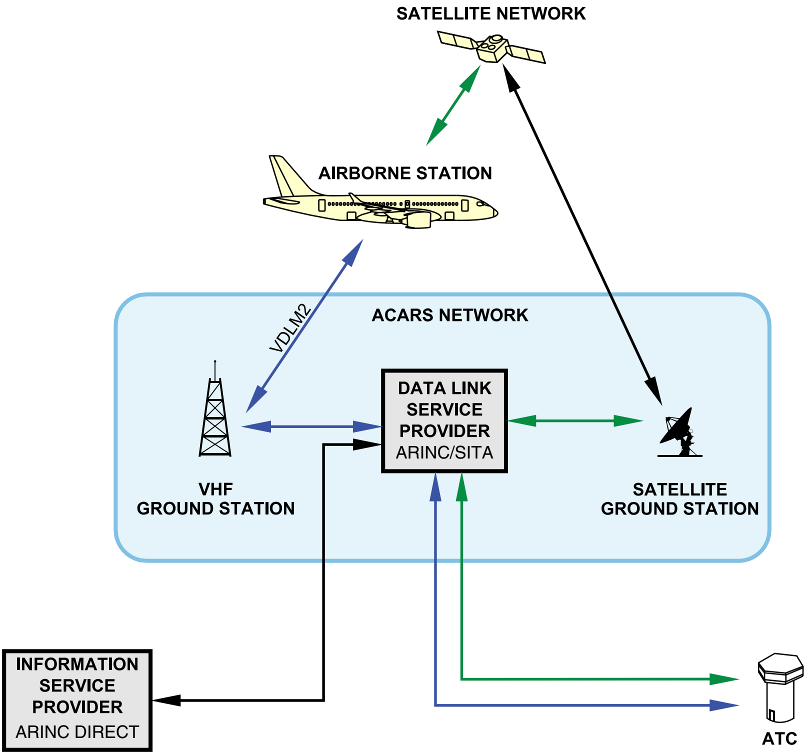
The data link permits the transmittal of routine information without voice communication.

DLK activation requires the aircraft operator to subscribe to a data link service provider for basic ACARS operation.

The DLK system uses the transmission methods that follow (refer to Figure 05–06–2):

- SATCOM (uses satellite to transmit data in areas where the VHF data link network is not available), <23150004C>
- VHF3 (to receive and transmit data on a VHF data link ground network), or
- VHF2 (secondary).

The transmission selection method is automatic, but the flight crew can select or disable a transmission method through the DLK page – TECHNICAL MENU page on the Multifunction Window (MFW).



Data link network architecture
Figure 05–06–2

The DLK system controls are located on:

- The Control Tuning Panel (CTP),
- The Multifunction Keyboard Panel (MKP), and
- The CNS – DLK page.

The system indications are provided by the CNS pages, and the EICAS advisory message **DLK** is displayed on the EICAS page.

The DLK system status is shown on the EICAS communication flag section at the bottom of the EICAS page.

Messages that are sent (downlink) and the ones that are received (uplink) through the data link system are recorded in the Cockpit Voice Recorder (CVR).

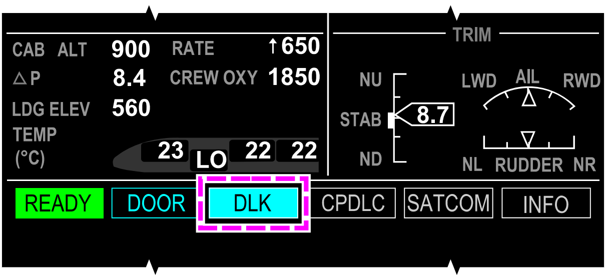
The messages and the reports can be printed on the flight deck printer. <23220001C>

DLK – DESCRIPTION AND OPERATION

A. DLK – Communication flag

The DLK communication flag is illuminated on the EICAS page to annunciate incoming communications from AOC and ATS (refer to Figure 05–06–3).

When a DLK communication is received, initially the DLK communication flag flashes for 5 seconds and then becomes steady. A tone is also heard in the flight compartment.



EICAS PAGE

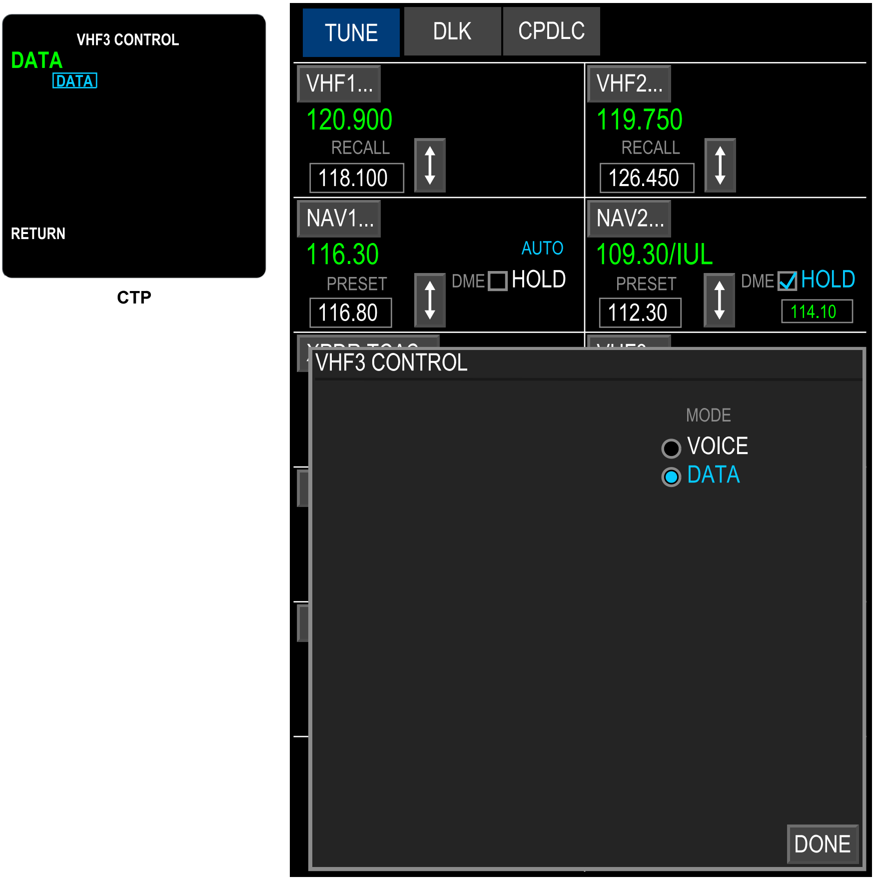
DLK – Communication flag
Figure 05–06–3

Unless it is a departure or oceanic ACARS clearance that is received, the DLK EICAS communication flag resets when the AOC page or the ATS page is selected to receive the communication. If a departure or oceanic ACARS clearance is received, the DLK flag resets when the clearance is accepted.

B. VHF Data link setup

VHF3 is used for data link communications when network services are available. VHF3 must be set to DATA mode.

VHF3 is set to DATA mode by accessing the VHF3 CONTROL page on the CTP and selecting DATA. When selected, DATA is displayed in green on the CTP. Refer to Figure 05–06–4.



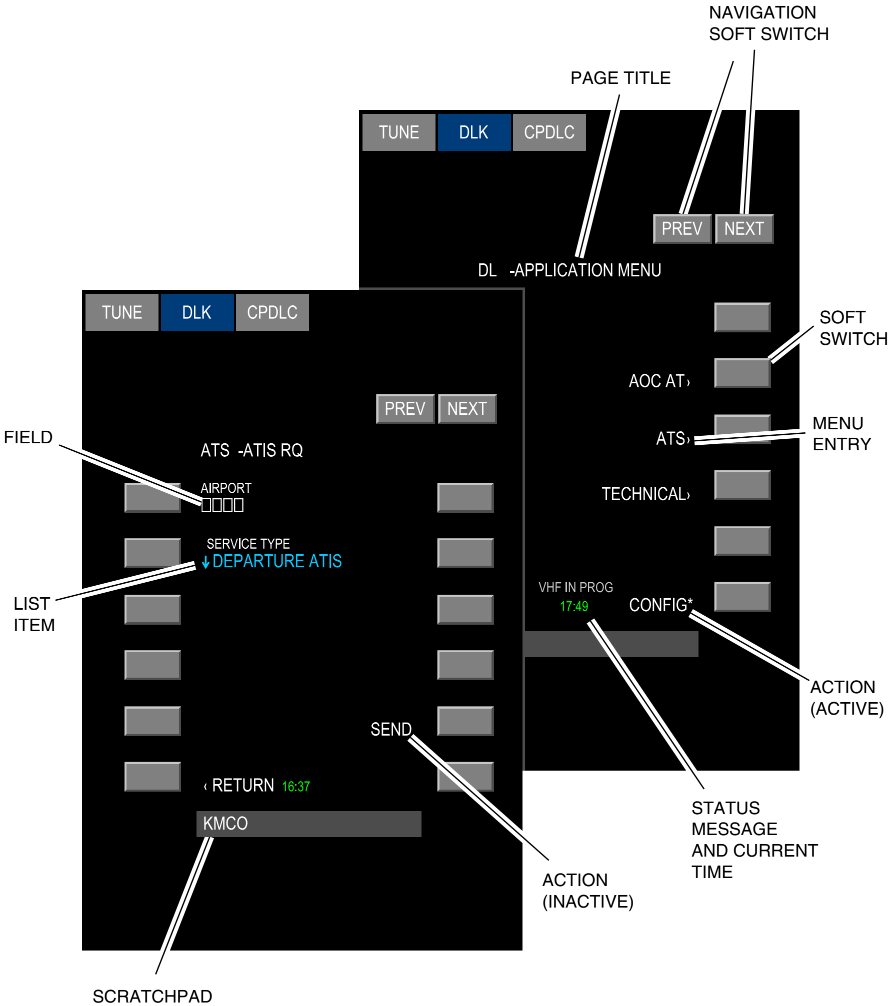
Data link setup
Figure 05–06–4

VHF3 DATA mode can also be accessed from the CNS page by selecting the VHF3 soft switch. When the VHF3 CONTROL window is displayed, the MODE selection can be set to DATA.

C. CNS – DLK pages

The DLK page is accessed with the CNS switch on the Multifunction Keyboard Panel (MKP) or Control Tuning Panel (CTP).

Pushing the CNS switch shows the CNS page on the MFW. The DLK page is accessible from the top menu of the CNS. On the DLK page, the cursor can be moved using the CCP or the MKP tab keys. The data entries that are done with the keyboard of the MKP are shown in the readout window (scratchpad) of the MKP and on the scratchpad at the bottom the DLK page display (refer to Figure 05–06–5). The scratch pad also displays error messages. The soft switches PREV and NEXT are used to navigate inside the DLK pages.

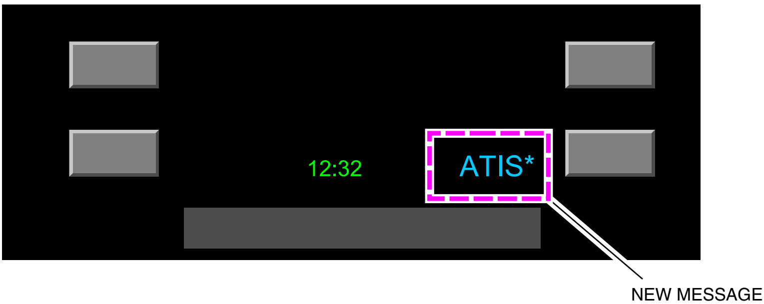


DLK page
Figure 05–06–5

There are two columns of soft switches that allow the selections that follow:

- Menus with an angle bracket (< or >) beside them display a new page applicable to the menu.
- Data entry fields (small empty boxes) transfer the data entries from the scratchpad to the applicable fields.
- List items with a down arrow (↓) beside them cycle through the values in the list, and/or
- Actions that are active when an asterisk (*) is shown beside them execute the action.

When a new message is received, an aural alert sounds and the DLK EICAS annunciation flashes. On the DLK page, the bottom right soft switch becomes active (refer to Figure 05–06–6). When the active soft switch is selected, the received message is displayed and the DLK EICAS annunciation is reset.



DLK – New message
Figure 05–06–6

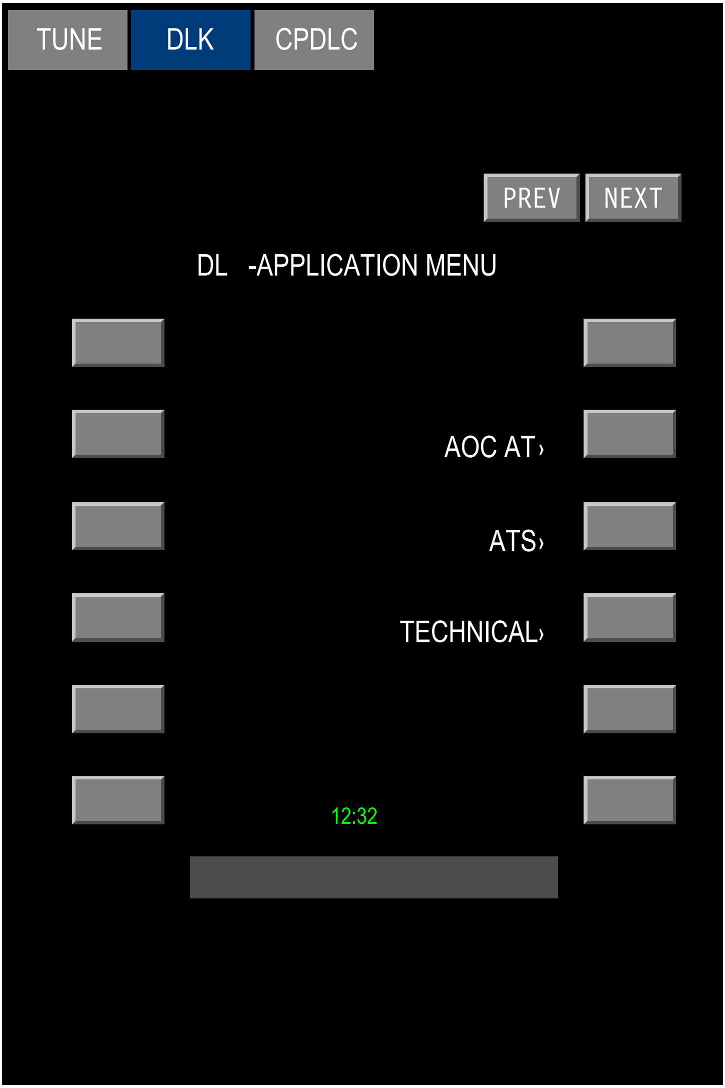
D. DLK – APPLICATION MENU Page

The APPLICABLE MENU page is the default page. It displays the entries that follow (refer to Figure 05–06–7):

- AOC AT〉 – Displays the AOC MENU page,

- ATS〉 – Displays the ATS MENU page, and
- TECHNICAL〉 – Displays the TECHNICAL MENU page.

Each menu is accessible with its associated soft switch.



CNS – DLK – APPLICATION MENU page
Figure 05–06–7

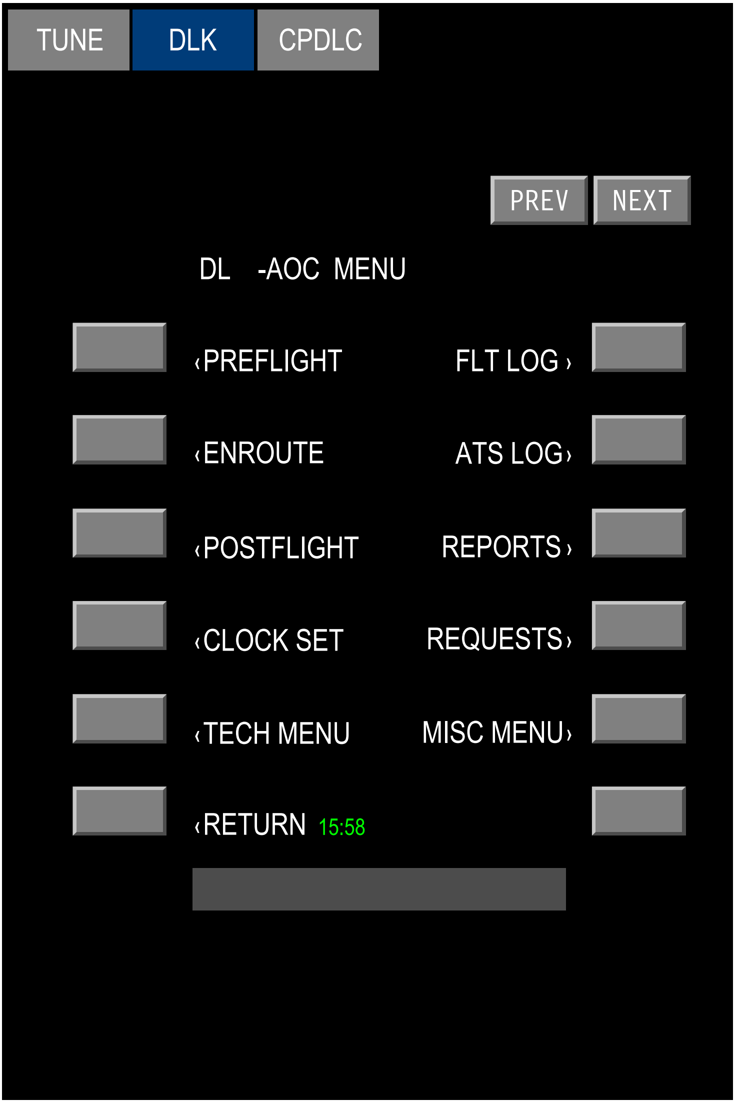
E. DLK – AOC MENU page

The AOC MENU page (refer to Figure 05–06–8) allows the exchange of Airline Operational Communication (AOC) messages between the aircraft and the airline operation center through the ACARS network. AOC messages are automatically sent when:

- Forward passenger door is closed (prior to pushback),
- Weigh-Off-Wheels (WOFFW),
- Weigh-On-Wheels (WOW) touchdown, and
- Forward passenger door is opened (at the gate).

A log of the reports is accessed through the REPORTS menu. Other messages can also be initiated by the flight crew or received from the ground, including text messages. The AOC application can be fully customized by the operator through a ground base station tool, which permits the operator to adapt the data link exchanges for operations. Typical functions include:

- Clearances,
- Delays and diversions,
- Weight and balance,
- Flight planning,
- Position reports ETA,
- Engine, snags, and maintenance reports,
- Flight log, flight summary, and Out-Off-On-In (OOOI) reports,
- Crew, stations, and dispatch reports, and
- Weather requests.



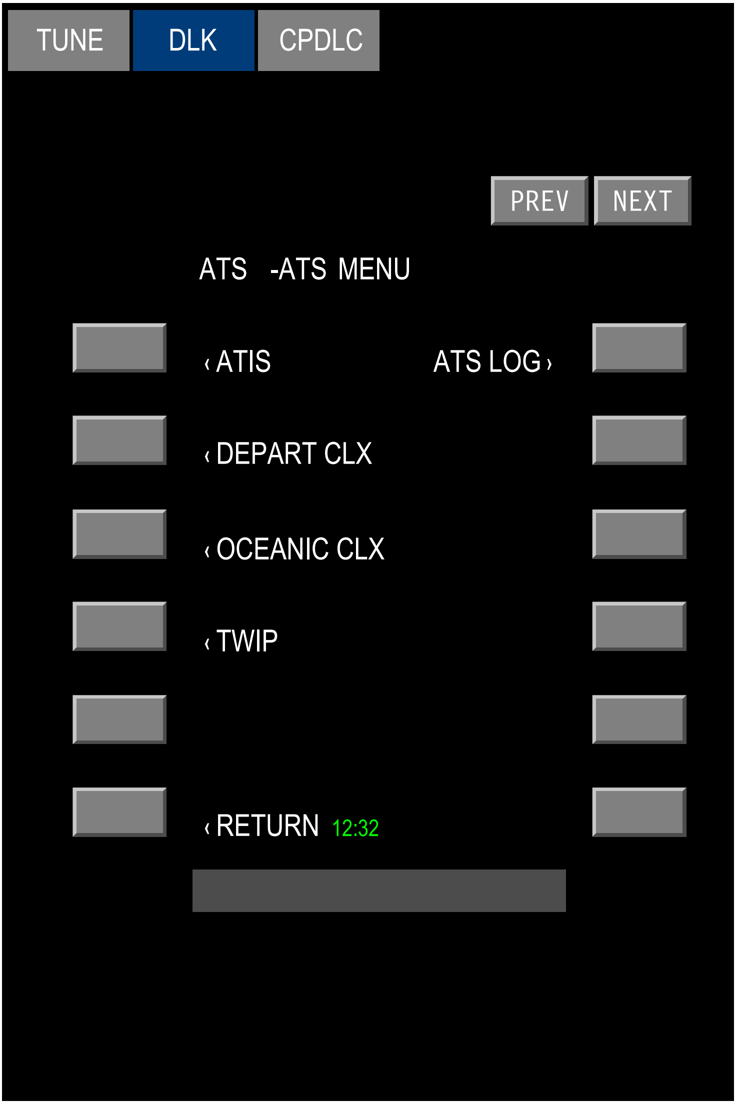
DLK – AOC MENU page
Figure 05–06–8

F. DLK – ATS MENU page

The Air Traffic Services (ATS) soft switch allows the exchange of messages related to air traffic services. The ATS pages are also intermixed with the AOC MENU structure in the standard AOC database when no customizing is applied.

The ATS MENU page has the ATS functions that follow (refer to Figure 05–06–9):

- ⟨ATIS (Airport Traffic Information System) – Displays the ATIS RQ page,
- ⟨TWIP (Terminal Weather Information for Pilot) – Displays the TWIP RQ page,
- ⟨DEPART CLX (Departure Clearance) – Displays the DEPART CLX RQ page,
- ⟨OCEANIC CLX (Oceanic clearance) – Displays the OCEANIC CLX RQ page, and
- ATS LOG⟩ – Displays the ATS LOG page.



DLK – ATS MENU page
Figure 05–06–9

(1) ATIS RQ page

The ATIS RQ page is used to request ATIS for a specific airport. Refer to Figure 05–06–10.

DLK – ATIS RQ page
Figure 05–06–10

In the AIRPORT field, the airport ICAO code can be entered.

The SERVICE TYPE has the three options that follow:

- ↓DEPARTURE ATIS – Requests the ATIS for a departure airport,

- ↓ENROUTE INFO SERVICE – Requests the ATIS for an enroute airport, and
- ↓ARRIVAL ATIS – Requests the ATIS for the arrival airport.

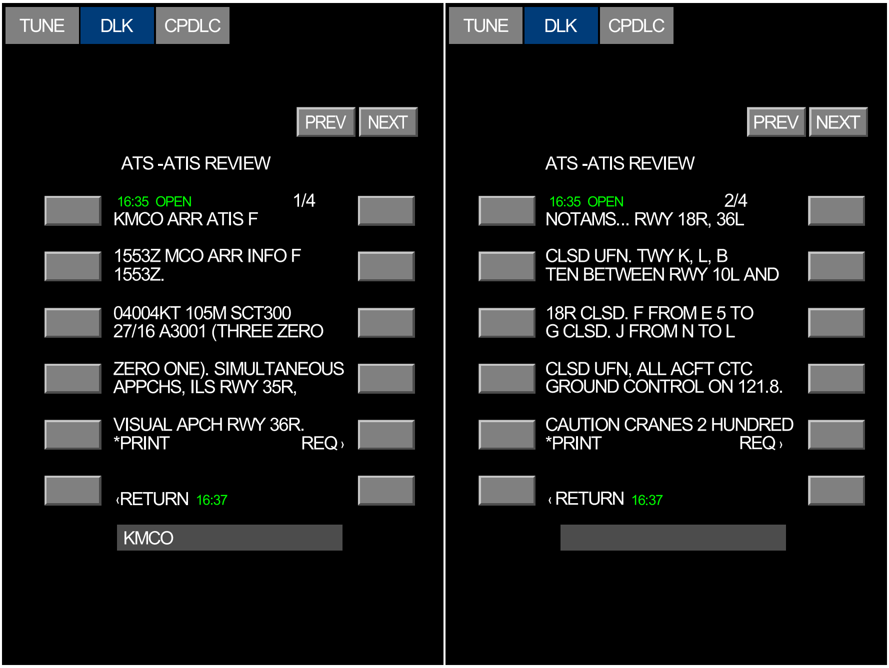
The REPORTING MODE is available only for an ARRIVAL ATIS and has the three options that follow:

- ↓SINGLE REPORT – Requests only one report,
- ↓START AUTO-UPDATES – Requests automatic updates of the ATIS, and
- ↓STOP AUTO-UPDATES – Stops automatic updates.

When SEND* is selected, the request is sent and the ATS MENU page is displayed.

When an ATIS is received, ATIS* is displayed adjacent to the bottom right soft switch on the DLK page.

Selecting the ATIS* soft switch displays the ATIS REVIEW page with the details of the ATIS. Refer to Figure 05–06–11.



DLK – ATIS REVIEW page
Figure 05–06–11

On the ATIS REVIEW page, selecting REQ⟩ displays the ATIS RQ page and selecting ⟨RETURN displays the previous page.

Also, on the ATIS REVIEW page, selecting *PRINT prints the message on the flight deck printer. <23220001C>

(2) TWIP RQ page

The TWIP RQ page is used to request Terminal Weather Information for Pilots (TWIP). Refer to Figure 05–06–12.

DLK – TWIP RQ page
Figure 05–06–12

The AIRPORT field accepts the ICAO station identifier.

The REPORTING MODE has three options:

- ↓SINGLE REPORT – Requests only one report,
- ↓START AUTO-UPDATES – Requests automatic updates, and

- ↓STOP AUTO-UPDATES – Stops automatic updates.

PRESENTATION requests the TWIP report in ↓TEXT or ↓GRAPHICS format.

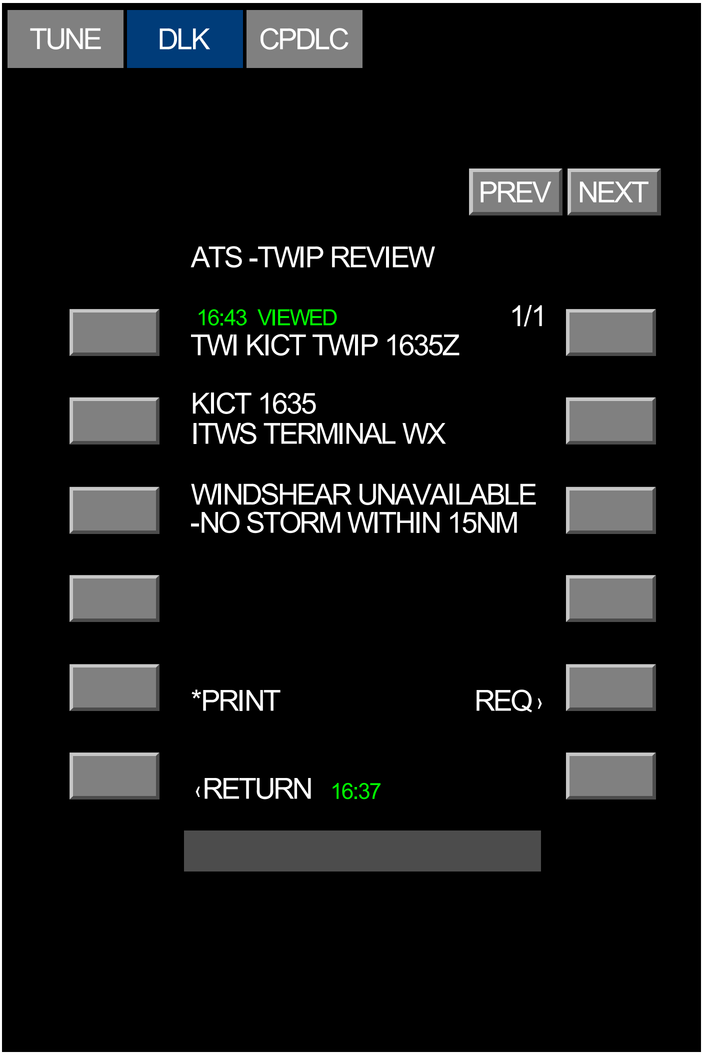
When SEND* is selected, the request is sent and the ATS MENU page is displayed.

When a TWIP message is received, TWIP* is displayed adjacent to the bottom right soft switch on the DLK page.

Selecting the TWIP* soft switch displays the TWIP REVIEW page with the details of the TWIP message.

On the TWIP REVIEW page, selecting REQ〉 displays the TWIP RQ page and selecting 〈RETURN displays the previous page.

Also, on the TWIP REVIEW page, selecting *PRINT prints the message on the flight deck printer. Refer to Figure 05–06–13. <23220001C>



DLK – TWIP REVIEW page
Figure 05–06–13

(3) DEPART CLX RQ page

The DEPART CLX RQ page is used to create a departure clearance request (refer to Figure 05–06–14):

- ATS FLT ID field accepts the flight identifier,
- A/C TYPE accepts the type identifier for the aircraft,
- ORIG STA accepts the ICAO identifier of the origin airport,
- GATE accepts a gate number,
- FACILITY accepts the identifier of the ATC facility where the flight plan was filed,
- ATIS accepts the ATIS letter, and
- DEST STA accepts the ICAO identifier of the destination airport.

A second page accepts remarks.

DLK – DEPART CLX RQ page
Figure 05–06–14

When SEND* is selected, the request is sent and the ATS MENU page is displayed.

When the departure clearance is received, DEP CLX* is displayed adjacent to the bottom right soft switch on the DLK page. Refer to Figure 05–06–15.

DLK – DEPART CLX REVIEW page
Figure 05–06–15

Selecting the DEP CLX* soft switch displays the DEPART CLX REVIEW page with the details of the clearance.

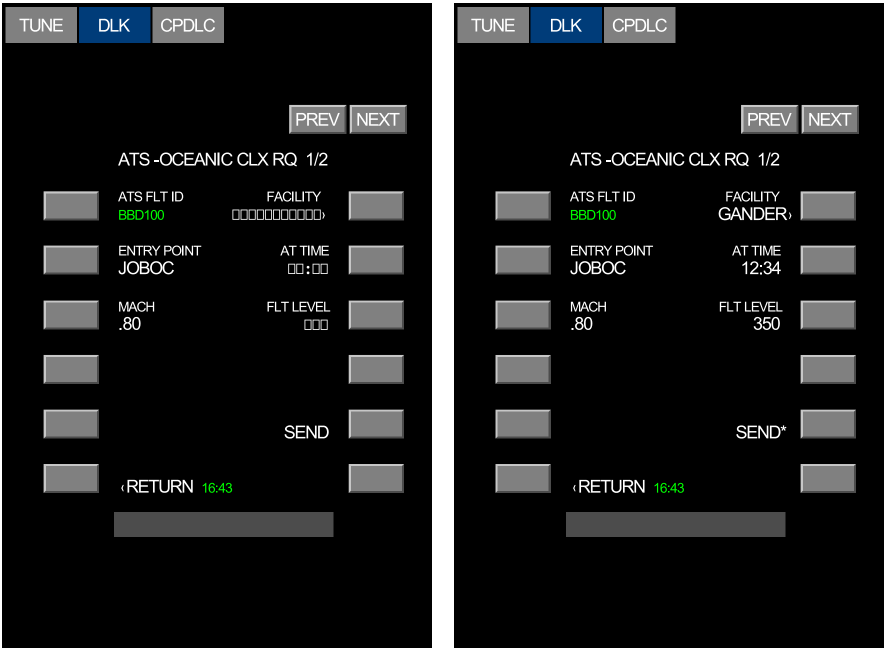
Selecting ACCEPT* on the last DEPART CLX REVIEW page sends a message to ATC to accept the clearance.

Selecting the REQ> soft switch displays the DEPART CLX RQ page.

(4) OCEANIC CLX RQ page

The OCEANIC CLX RQ page is used to request an oceanic clearance, as follows (refer to Figure 05–06–16):

- ATS FLT ID accepts the flight identifier,
- ENTRY POINT accepts the entry fix identifier for the oceanic route,
- FACILITY displays the FACILITY page where the oceanic facility is selected,
- MACH accepts the planned cruise airspeed,
- AT TIME accepts the estimated time the entry fix will be reached, and
- FLT LEVEL accepts the flight level requested at the entry fix.

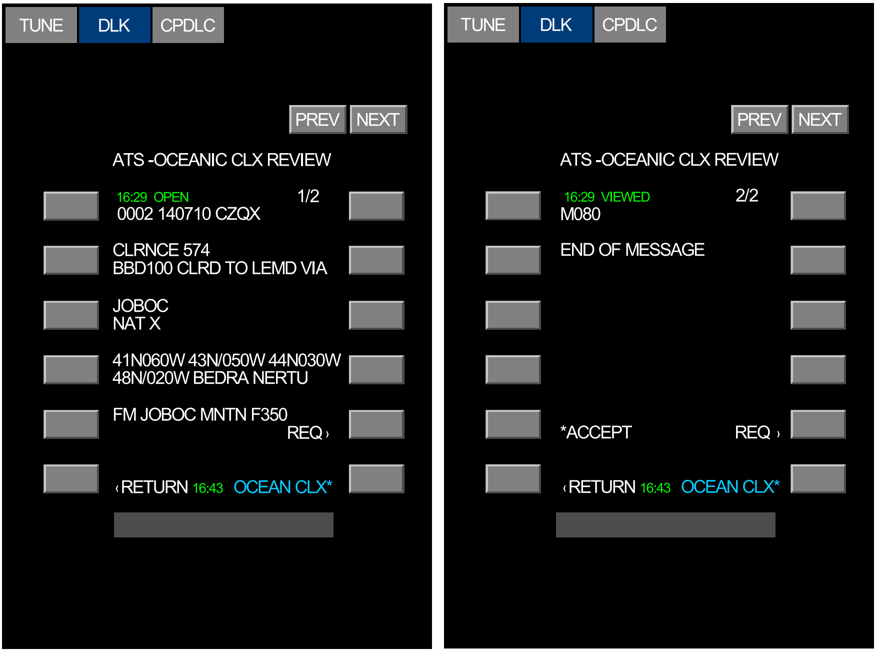


DLK – OCEANIC CLX RQ page
Figure 05–06–16

A second page accepts remarks.

When SEND* is selected, the request is sent and the ATS MENU page is displayed.

When an oceanic clearance is received, OCEAN CLX* is displayed adjacent to the bottom right soft switch on the DLK page. Refer to Figure 05–06–17.



DLK – OCEANIC CLX REVIEW page
Figure 05–06–17

Selecting the OCEAN CLX* soft switch displays the OCEANIC CLX REVIEW page with the details of the clearance.

Selecting ACCEPT* on the last OCEANIC CLX REVIEW page sends a message to ATC to accept the clearance. Selecting REQ〉 displays the OCEANIC CLX RQ page.

(5) ATS LOG page

The ATS LOG page is used to review received messages.

The messages are displayed in the order they are received, with the most recent at the top. Up to 25 message (5 pages) can be kept. When the limit is reached and a new message is received, the oldest message is discarded.

When a message is received, the ATS LOG page displays the time it was received and one of the statuses that follow (refer to Figure 05–06–18):

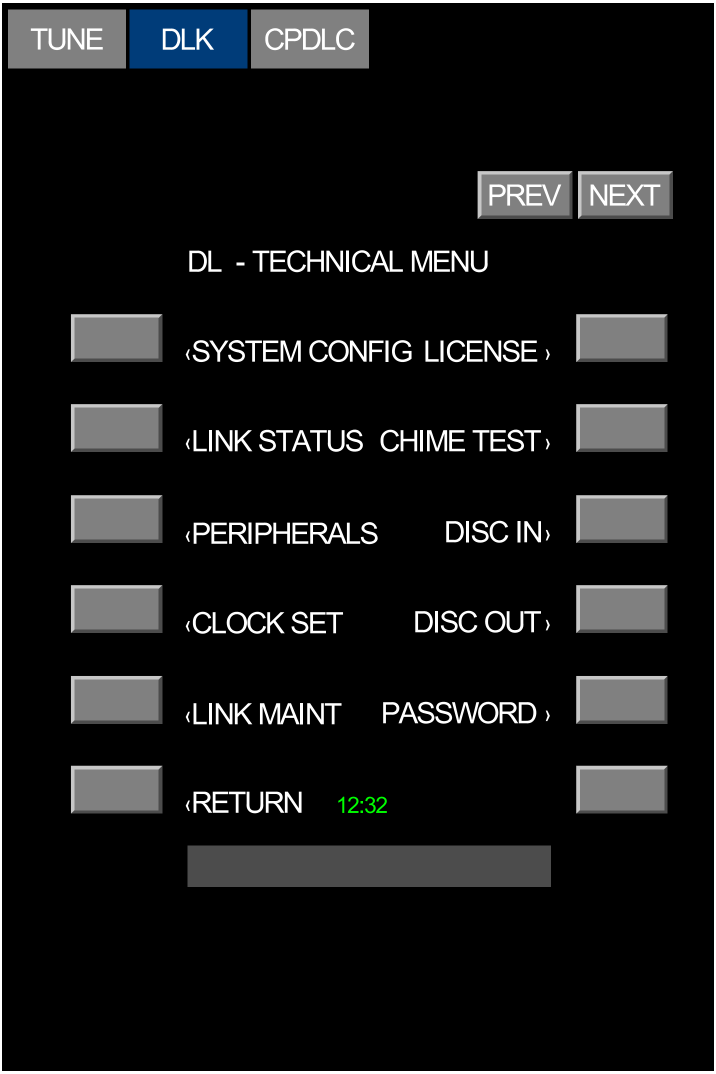
- NEW – No part of the message has been displayed,
- OPEN – At least one page of the message has been displayed,
- VIEWED – All pages of the message have been displayed, and
- ACCEPTED – When applicable, the clearance has been accepted.

DLK – ATS LOG page
Figure 05–06–18

G. DLK – TECHNICAL MENU page

The technical applications from the TECHNICAL MENU page provide interfaces that are used to view system status, update system parameters, and test certain functions or limits. The TECHNICAL MENU page application can show the information that follows (refer to Figure 05–06–19):

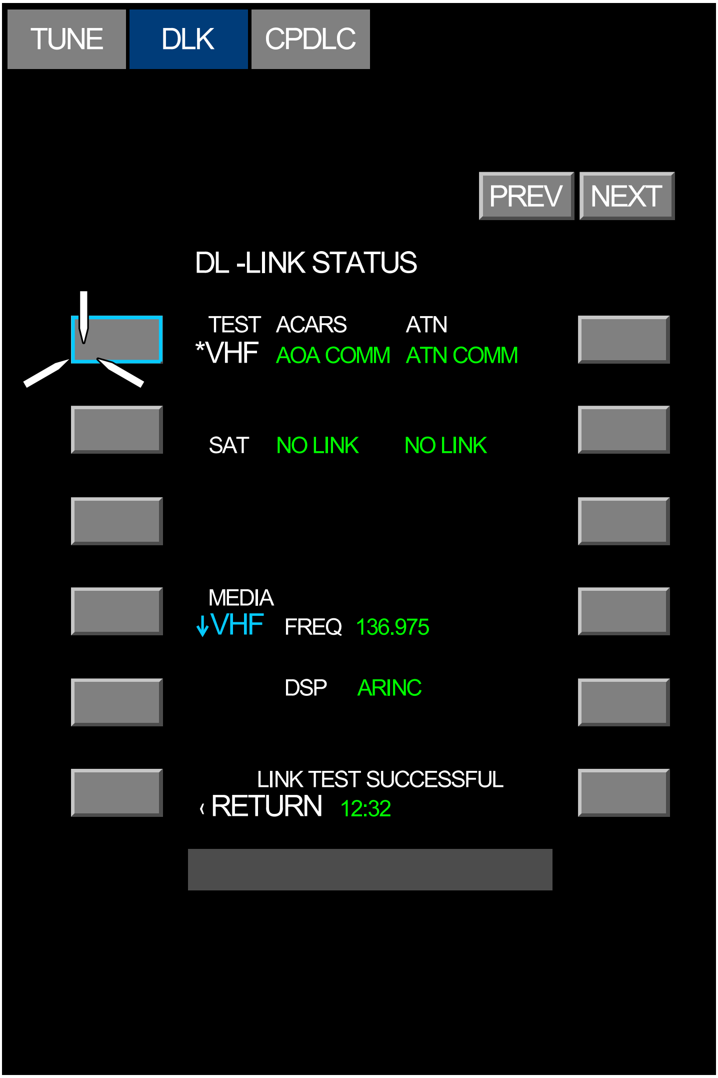
- SYSTEM CONFIG – Gives information about the hardware and software configuration, and prints a system configuration report.
- LINK STATUS – Displays the LINK STATUS page.
- PERIPHERALS – Gives information about interface link and interface health status. The interface link displays either ABSENT or PRESENT and the interface health status displays either OK or INOP when an interface issue is detected.
- CLOCK SET – Gives information and access to configure the system clock and request updates from the ground network system time.
- LICENSE – Gives access to the software licenses (maintenance function).
- CHIME TEST – Displays the CHIME TEST page.
- LINK MAINT - Gives access to the link status and maintenance pages for SATCOM. <23150004C>
- DISC IN – Gives a summary of the current discrete inputs status.
- DISC OUT – Gives a summary of the current discrete outputs status.
- PASSWORD – Gives access to the password protected menu.



DLK – TECHNICAL MENU page
Figure 05–06–19

(1) The LINK STATUS page

The LINK STATUS page provides information about the current status of each VHF and SATCOM channel, as well as the ability to perform tests (refer to Figure 05–06–20). <23150004C>



DLK – LINK STATUS page
Figure 05–06–20

While the system is unavailable, the NO COMM status is displayed at the bottom of the page.

On power-up, the data link system scans the channels and attempts communication with the preferred Data link Service Providers (DSPs). While the system is scanning, POA SCAN or VDL SCAN is displayed in both the ACARS and ATN columns.

Once communication with a DSP is established on a channel, the appropriate POA COMM, AOA COMM, or ATN COMM is displayed.

When a channel is unavailable, NO LINK is displayed. When the system is operational, the NO COMM status is removed.

The VHF ACARS statuses shown adjacent to soft switch L1 are as follows (refer to Figure 05–06–20):

- NO LINK – Data link service is not available or data unit is not responding.
- POA SCAN – POA frequency search is in progress.
- VDL SCAN – Frequency search is in progress for VDL service.
- VDL LINK – VDL service is established for AOA link support.
- POA COMM – ACARS is established and using POA service.
- AOA COMM – ACARS is established and using AOA service.
- VOICE – VHF is in voice mode.

The SAT ACARS statuses shown adjacent to soft switch L2 are as follows (refer to Figure 05–06–20):

- NO LINK – Data unit is logged off.
- LINK UP – Data unit is logged on.
- POA COMM: ACARS is established using POA service.

The VHF ATN statuses shown adjacent to soft switch R1 are as follows (refer to Figure 05–06–20):

- NO LINK – ATN data link service is not available. Data unit does not respond.

- VDL SCAN – Frequency search is in progress for VDL service.
- VDL LINK – VDL service is established for ATN link support.
- ATN COMM – ATN routes are established with VDL service.
- VOICE – VHF is in voice mode.

The SAT ATN status shown adjacent to soft switch R2 are as follows (refer to Figure 05–06–20):

- NO LINK – ATN data link service is not available.

MEDIA* is used to manually select between ↓VHF and ↓SATCOM (if installed). FREQ displays the link frequency and DSP displays the service provider name. <23150004C>

Selecting the VHF* soft switch initiates a test of the system. If successful, the **LINK TEST SUCCESSFUL** advisory message is displayed at the bottom of the page.

The table that follows summarizes the advisory messages that can be displayed at the bottom of the DLK sub-pages:

DLK page advisory messages	
LINK TEST SUCCESSFUL	This advisory is displayed after a successful completion of a VHF or SATCOM link test.
NO COMM	This advisory is displayed to indicate no media (VHF, SATCOM) are available to downlink a message. The advisory clears when the VHF, SATCOM, or medium becomes available to downlink a message.
VHF IN PROGRESS	This advisory is displayed to indicate the system has sent a downlink message through VHF but the downlink has not yet been acknowledged. The advisory clears when the acknowledgement is received or the link is declared NO COMM.
VOICE MODE	This advisory is displayed to indicate that VHF3 is in voice mode. The advisory clears when VHF3 radio is in data mode.

A MANUAL VHF TUNE prompt is displayed on soft switch R5 when the VHF ACARS status is POA SCAN, POA COMM or VDL SCAN, and when a VDL link is established but ATN services are not available and VHF ATN status do not reflect ATN COMM. The MANUAL VHF TUNE selection is removed when ATN service is available. When MANUAL VHF TUNE is selected, the associated page opens.

This page gives access to Plain Old ACARS (POA) Data Link Service Providers (DSP) included in the scan algorithm, and the ability to manually tune VDL Mode 2. Multiple pages are used when more than eight POA DSP are enabled in the scan list (refer to Figure 05–06–21).

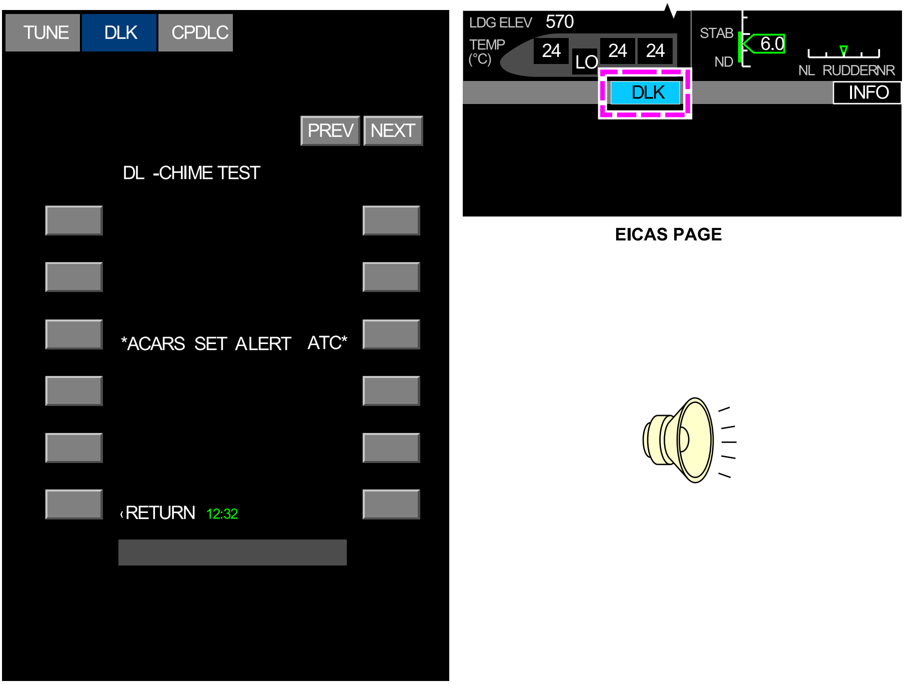
Selection of any soft switch (L1 to L4 & R1 to R4) will place the CMU in POA mode, select that DSP to be scanned and display the LINK STATUS page. Selection of the VDL MODE 2 will cause the CMU to try VDL Mode 2 and display the LINK STATUS page.

MANUAL VHF TUNE page
Figure 05–06–21

(2) The CHIME TEST page

The CHIME TEST page is used to test the ACARS aural alert.

Selecting the ACARS* soft switch triggers the DLK annunciation on the EICAS page and the associated aural alert. Selecting ATC* sends a test request through the ATC system. The answer received from ATC triggers the DLK annunciation and associated aural alert (refer to Figure 05–06–22).



DLK – CHIME TEST page
Figure 05–06–22

H. SELCAL message <23210004C>

When a SELCAL message is received, SELCAL* is displayed adjacent to the bottom right soft switch on the DLK page.

When SELCAL* is selected, the SELCAL page displays the frequency requested by ATC for voice operation. Refer to Figure 05–06–23.

DLK – SELCAL Page <23210004C>
Figure 05–06–23

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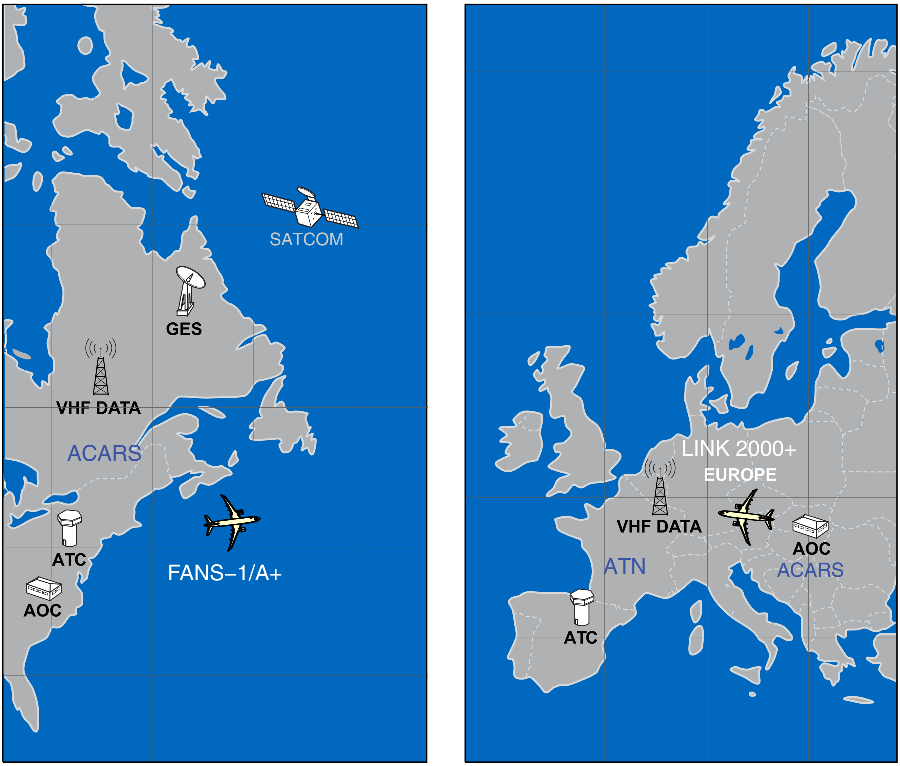
CPDLC – OVERVIEW

The CPDLC is a non-verbal communication system created to supplement voice communication between Air Traffic Control (ATC) and the flight crew.

It can use either the LINK 2000+ (ATN B1) for European airspace above FL285 or the FANS-1/A+ for oceanic or remote areas. The network protocols of FANS-1/A+ and LINK 2000+ are significantly different therefore they are not compatible. The network is automatically selected based on the ground station the user is connecting to.

Regular data link services, such as Airline Operations Center (AOC) communications, continue to use the ACARS network.



FANS–1/A+ and LINK 2000+ coverage
Figure 05–08–1

The CPDLC system controls are located on:

- The Control Tuning Panel (CTP) (CNS switch),
- The Multifunction Keyboard Panel (MKP),
- The EICAS page (Communication section for CPDLC messages only),
- The quick-response panel, and
- The quick-response soft switches, (located in the communication inbox).

The CPDLC indications are located on the communication section and on the MFW (CNS – CPDLC pages).

When a CPDLC message is received, the CPDLC communication flag flashes and then the message is shown in the communication inbox below the communication flag.

The messages are referred to as call uplink messages when they come from the ATC, and as call downlink messages when they are generated from the aircraft.

The communication inbox can show a maximum of five lines of an uplink message plus the header. It can have multiple pages. If the CPDLC is not available, the communication inbox is completely black.

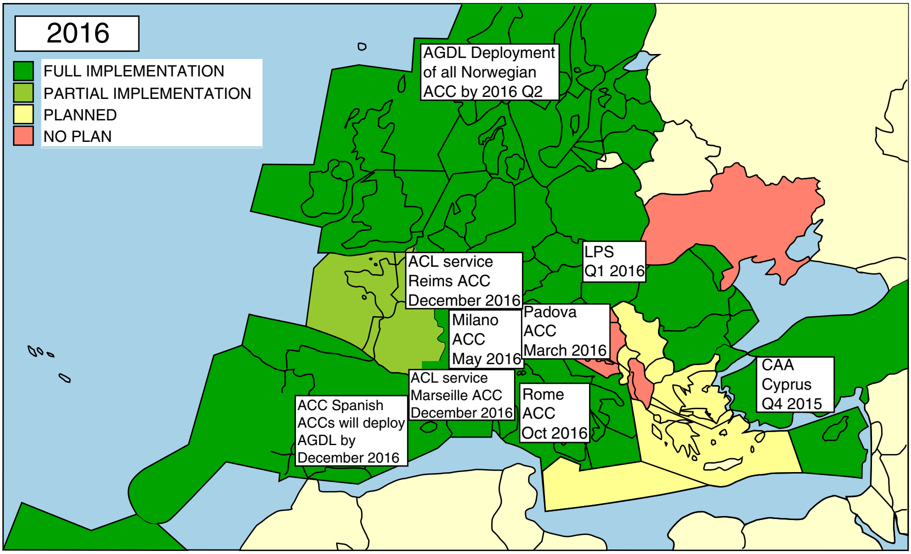
A. CPDLC – ATN LINK 2000+

The CPDLC system sends and receives messages supported by the EUROCONTROL LINK 2000+ program over the VHF Digital Link (VDL) mode 2.

The LINK 2000+ system is also referred to as ATN B1 CPDLC. On the aircraft, the ATN CPDLC function is identified as LINK 2000+.

The services offered within European airspace (refer to Figure 05–08–2) are:

- Data link initiation capability,
- ATC communications management,
- ATC clearances, and
- ATC microphone check.



Introduction to CPDLC – Link 2000+ <23240001C>
Figure 05–08–2

LINK 2000+ is a data link communication standard introduced in anticipation of increased air traffic over Europe. Its use is limited to European airspace above FL285.

LINK 2000+ uses an air-to-ground CPDLC service to supplement Air Traffic Control (ATC) voice communications. CPDLC message sets are pre-formatted text messages, consistent with radiotelephony phraseology.

The CPDLC ATN LINK 2000+ has the three functions that follow:

- Message log,
- Log on, and
- Request.

The message log function stores all the message exchanges between the flight crew and ATC. The flight crew can retrieve any clearance from ATC.

The log on function allows the flight crew to notify ATC that they intend to use the CPDLC function to communicate. After reception by ATC and acknowledgment, the connection is established.

The request function allows the flight crew to request a clearance from ATC. This function requires the flight crew to log on first and have the connection established with the current ATC authority.

B. CPDLC – Aeronautical Telecommunications Network (ATN)

The network protocol for LINK 2000+ is the ATN, which defines the architecture for air-to-ground digital data links. Refer to Figure 05–08–3.

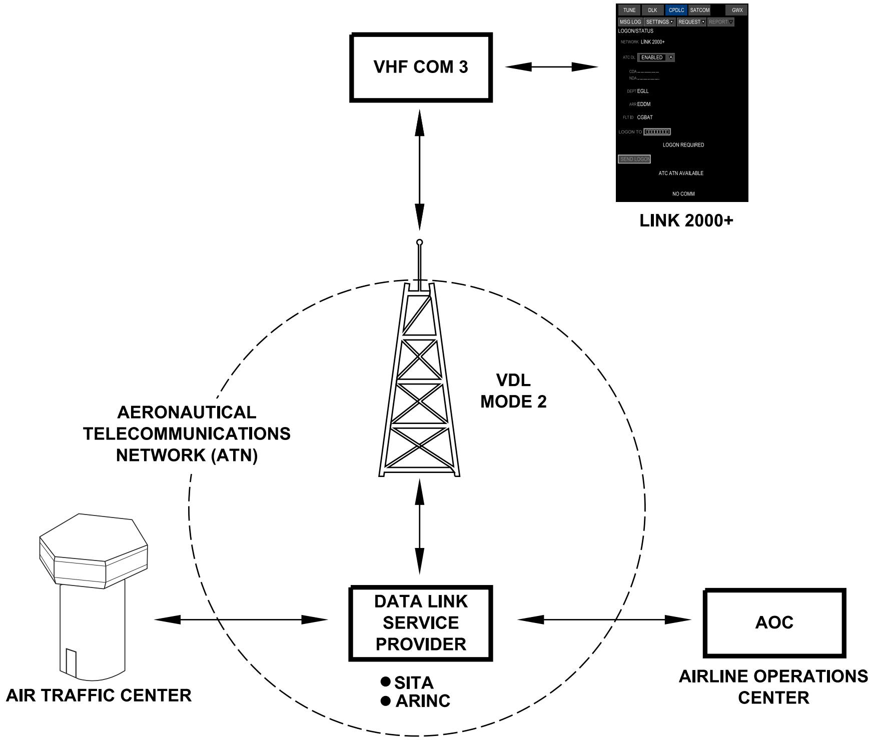
The ATN is part of a larger telecommunications network established by European Air Navigation Service Providers (ANSPs) in support of Eurocontrol (European Organization for the Safety of Air Navigation) to expand and improve the air traffic management system.

Aeronautical Telecommunication Network (ATN) <23240001C>
Figure 05–08–3

C. CPDLC – Network overview

The ATN uses VHF data link (VDL) mode 2 for communication between the aircraft LINK 2000+ system and the ground network (refer to Figure 05–08–4). VHF COM 3 is used for data link communication with the ATN.

The data link service provider, such as Societe Internationale Telecommunique Aeronautique (the French society SITA) or Aeronautical Radio Incorporated (ARINC), operates the ground infrastructure to route CPDLC messages to and from ATC and the Airline Operations Center (AOC).



LEGEND

VDL VHF data link

Network overview <23240001C>
Figure 05–08–4

D. CPDLC – Flight crew interface

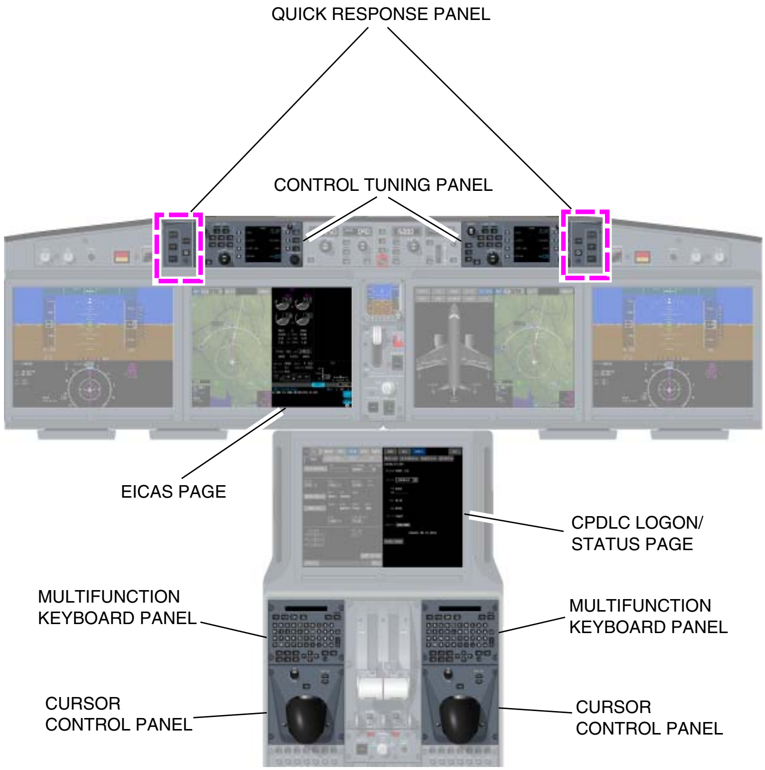
To use LINK 2000+, the flight crews use the displays that follow (refer to Figure 05–08–5):

- The CPDLC tab on a Multifunction Window (MFW),
- The quick-response panels, located on both sides of the glareshield,
- The Multifunction Keyboard Panels (MKPs) and Cursor Control Panels (CCPs), located on the center pedestal,

- The Control Tuning Panels (CTPs), located on the glareshield, and
- The CPDLC inbox, displayed on the lower part of the EICAS page.

To access the CPDLC page, use one of the methods that follow:

- Select the CNS Quick Access Key (QAK) on the CTP to cycle through the available CNS applications on the associated Display Unit (DU).
- Select the CNS QAK on the MKP to display the available CNS applications on the lower display unit. Continue to push the QAK to cycle through the applications.
- Push the MENU switch on the CCP to display a drop-down menu. Use the cursor to select CNS from the drop-down menu.

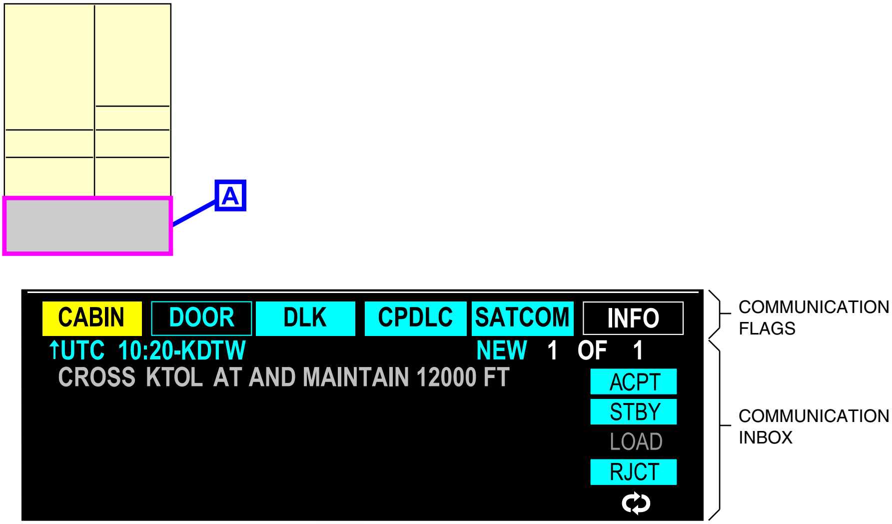


CPDLC and associated controls <23240001C>
Figure 05–08–5

CPDLC – DESCRIPTION

A. CPDLC – Communication section

The communication section is located at the bottom of the EICAS page (refer to Figure 05–08–6). It has two sections, the communication flags and the communication inbox.



Communication section <23240001C>
Figure 05–08–6

The communication inbox has the capabilities that follow:

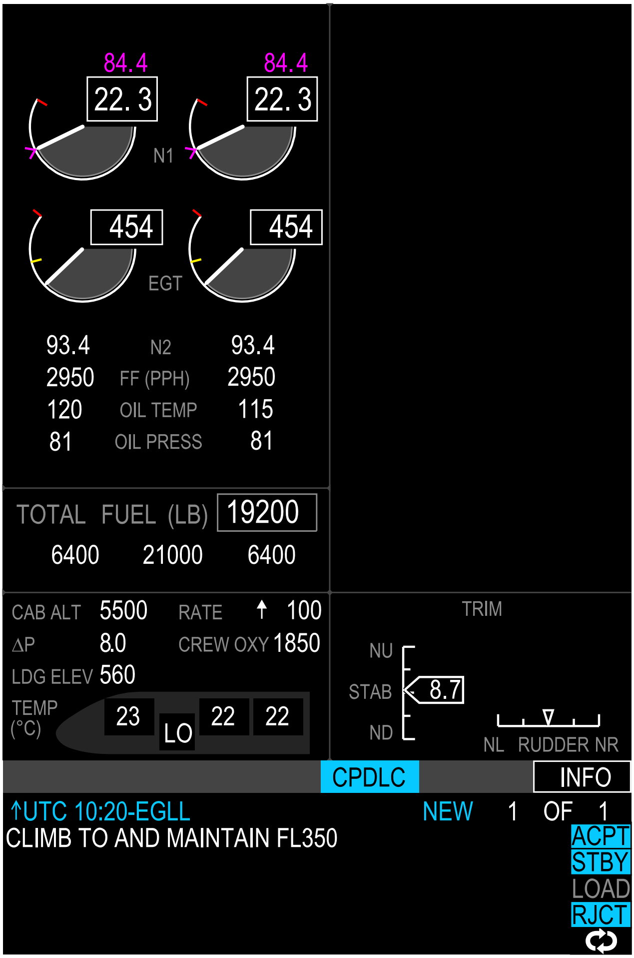
- Show the time a message has been received,
- Show the four-letter code of the current authority (ATC),
- Uplink messages (five maximum),
- Show the available answers linked to a received message,
- Give flight crews the ability to answer quickly from the quick-response panel, (for detailed information, refer to Chap 05 – Communication – Controls and Indications – Communication inbox),
- Give feedback when a received message is loadable,
- Update the status of the received messages,
- Remove closed messages when the ACCEPT or REJECT reply is selected,
- Show the most important message at the top of the list,

- Give feedback when an answer has been sent,
- Give feedback to go to the appropriate application when a multi-element message cannot be shown, and
- Show the management messages.

For more details, refer to Chap 05 – Communication – Controls and Indications – Communication inbox.

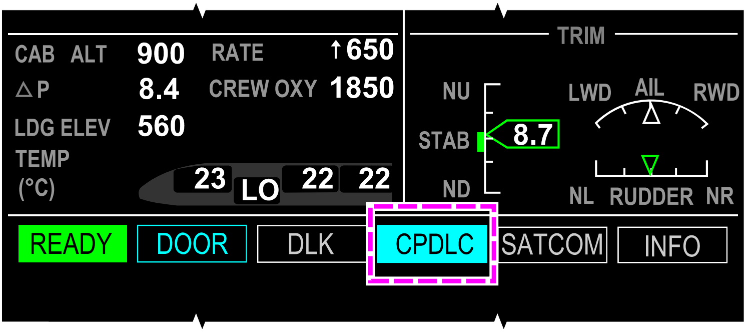
B. CPDLC – Communication flag

The CPDLC communication flag is displayed at the bottom of the EICAS page when a new ATC uplink message is received and has been reviewed or acknowledged (refer to Figure 05–08–7).



EICAS page <23240001C>
Figure 05–08–7

When a message is received, the CPDLC communication flag (refer to Figure 05–08–8) flashes for 5 seconds, accompanied by a data link aural alert. The CPDLC communication flag stays visible until the message is viewed or a response is sent. CPDLC messages have priority over ACARS messages.



EICAS PAGE

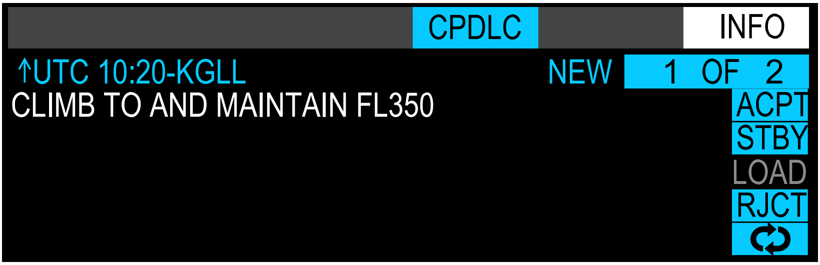
CPDLC – Communication flag <23240001C>
Figure 05–08–8

The CPDLC communication flag (refer to Figure 05–08–9) and the data link aural alert are inhibited during the flight phases that follow:

- Takeoff,
- Landing, and
- Go around.

NOTE

If the EICAS page is compressed, a CPDLC EICAS advisory message will be shown only if a message is received.



COMMUNICATION SECTION

Communication inbox <23240001C>
Figure 05–08–9

(1) CPDLC communication flag – Reset

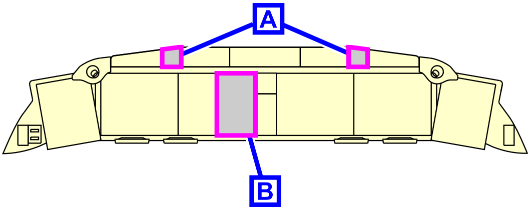
The CPDLC communication flag resets after the selection of any of the soft switches in the communication inbox or the switches on the quick-response panel (refer to Figure 05–08–10).

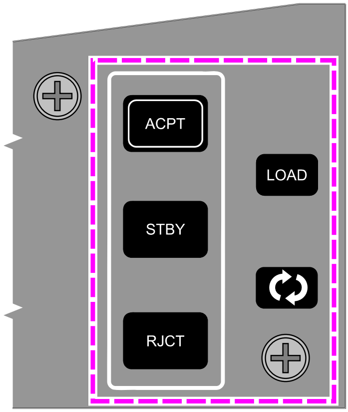
The switches on the quick-response panel and the soft switches on the EICAS page are identical, and include:

- ACPT (accept),
- RJCT (reject),
- STBY (standby),
- LOAD (two circular arrows), and
- Refresh.

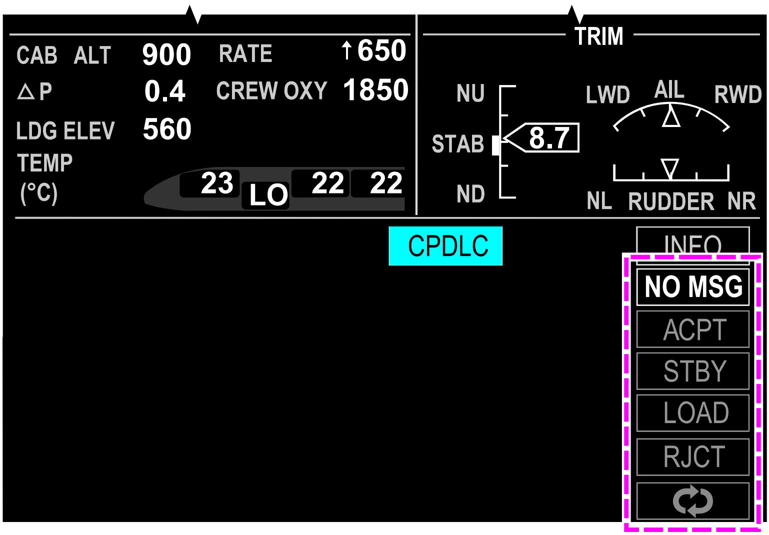
NOTE

The LOAD switch or soft switch is not functional with LINK 2000+.





QUICK-RESPONSE PANEL
A



COMMUNICATION INBOX SOFT SWITCHES
B

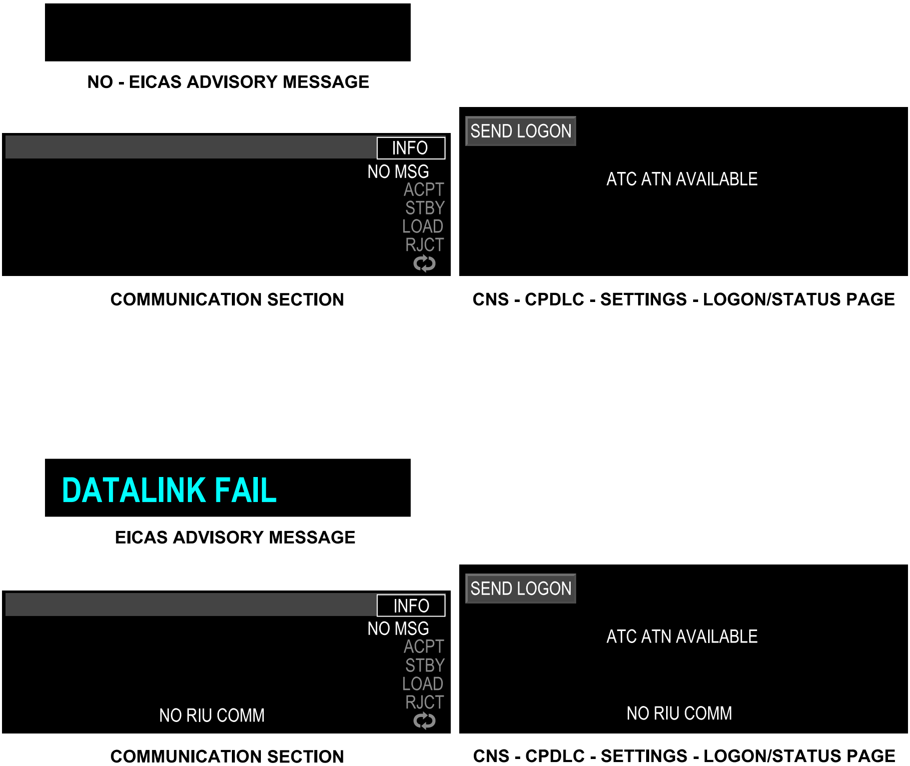
CPDLC – EICAS communicating flag – Reset <23240001C>
Figure 05–08–10

C. ATN service availability

The ATN verifies aircraft identification and CPDLC capability to determine that there is a valid connection between the two. When available, the CPDLC automatically connects to the ATN and an ATC ATN AVAILABLE message is displayed on the CPDLC – SETTINGS – LOGON/STATUS page (refer to Figure 05–08–11). The flight crew can log on and establish a CPDLC connection only when the message is displayed.

NOTE

Flight crew connection to the ATN is also known as Data Link Initiation Capability (DLIC).



ATN service availability <23240001C>
Figure 05–08–11

D. Communication system status

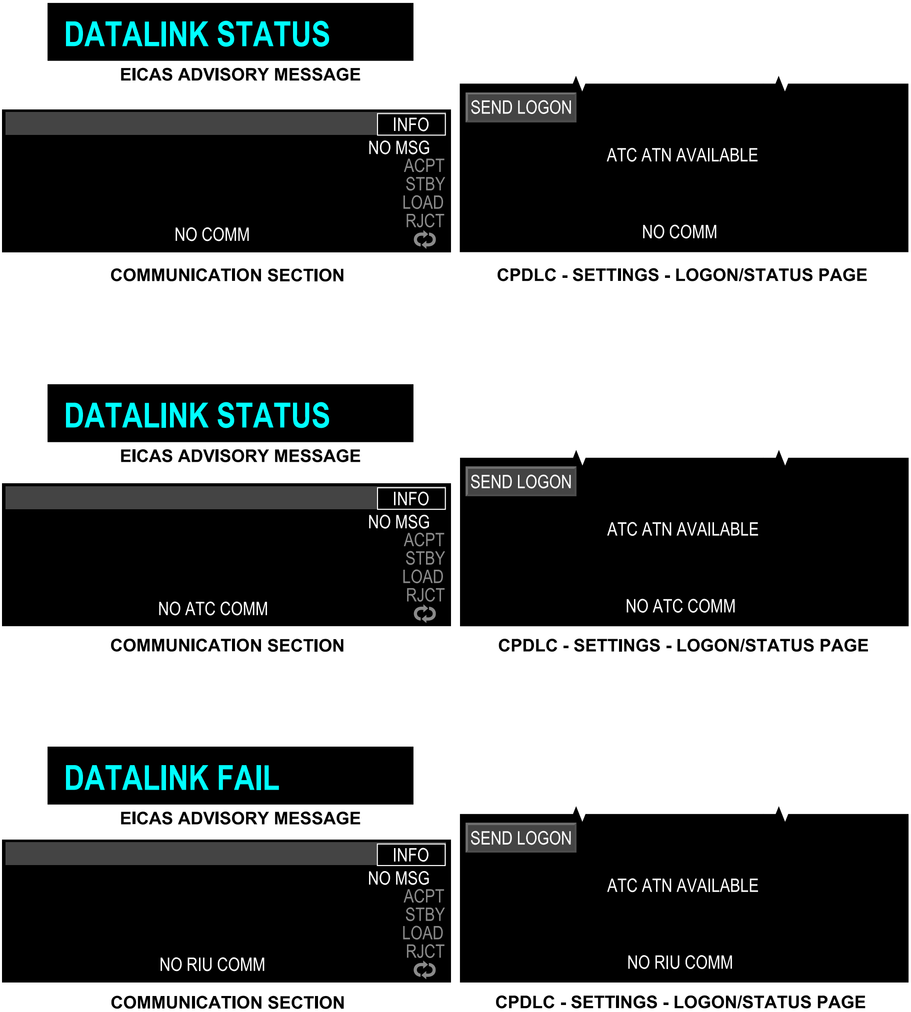
LINK 2000+ uses the Data Link (DLK) system to communicate with ATC.

The status of the DLK communication system is displayed at the bottom of the communication inbox and on the CPDLC – SETTINGS – LOGON/STATUS page.

If a NO COMM message is displayed at the bottom of the communication inbox on the EICAS page, the DLK system is inoperative. A **DATALINK STATUS** advisory message is displayed on the EICAS page. COM 3 must be in DATA mode for DLK communication to occur. Refer to Figure 05–08–12.

If a NO ATC COMM message is displayed, the communication system is operational, however no connection between CPDLC and ATC has been established. A **DATALINK STATUS** advisory message is displayed on the EICAS page. To remove the NO ATC COMM message, the flight crew must log on and establish the connection.

A **DATALINK FAIL** EICAS advisory message indicates a failure of the DLK system. When a failure occurs, a NO RIU CONN message is displayed in the communication inbox and on the CPDLC – SETTINGS – LOGON/STATUS page.



Communication system status <23240001C>
Figure 05–08–12

E. CPDLC pages – General

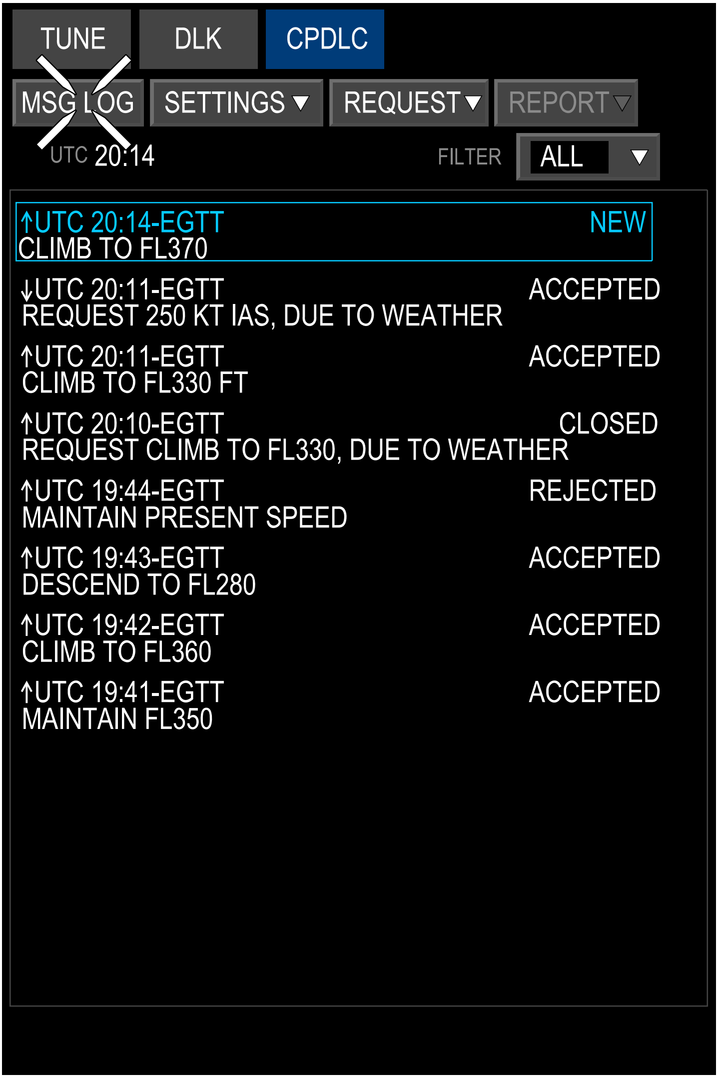
The CPDLC page is accessed with the CNS switch on the Multifunction Keyboard Panel (MKP) or Control Tuning Panel (CTP).

When there are no CPDLC received messages in the communication inbox of the EICAS page, pushing the CNS switch for the first time will show the CNS – TUNE page. When the CNS switch is pushed again, it navigates through the CNS pages.

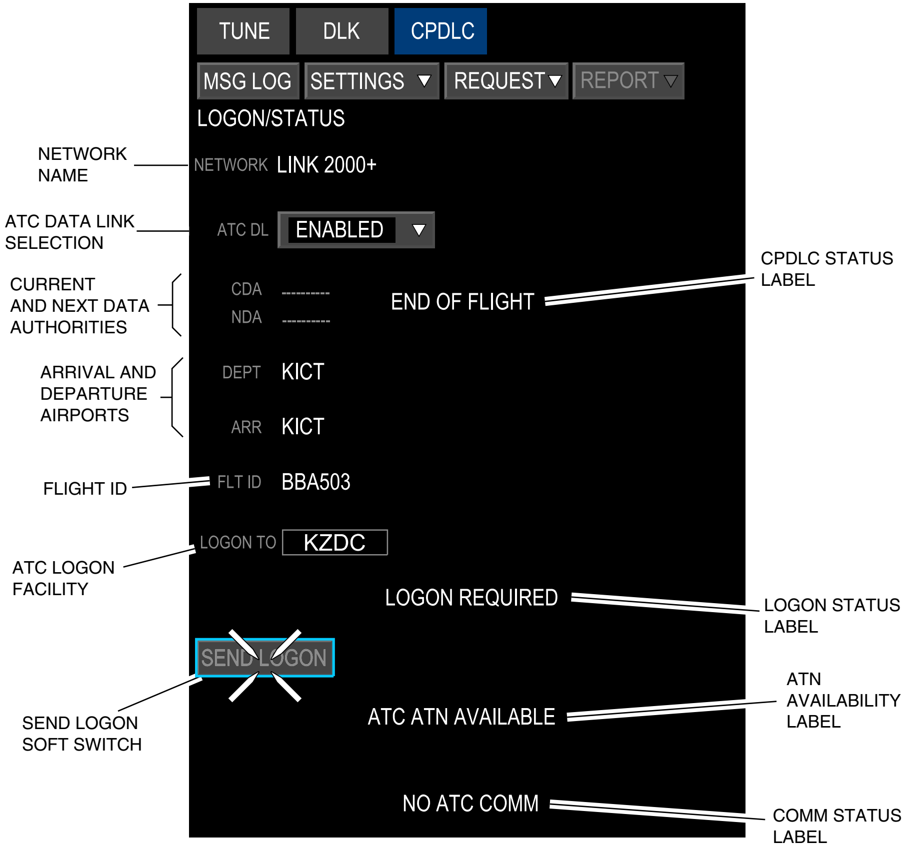
When a CPDLC message is received in the communication inbox of the EICAS page, pushing the CNS switch for the first time will show the CPDLC page directly on the Multifunction Window (MFW).

The menus that follow are accessible from the CPDLC page with soft switches:

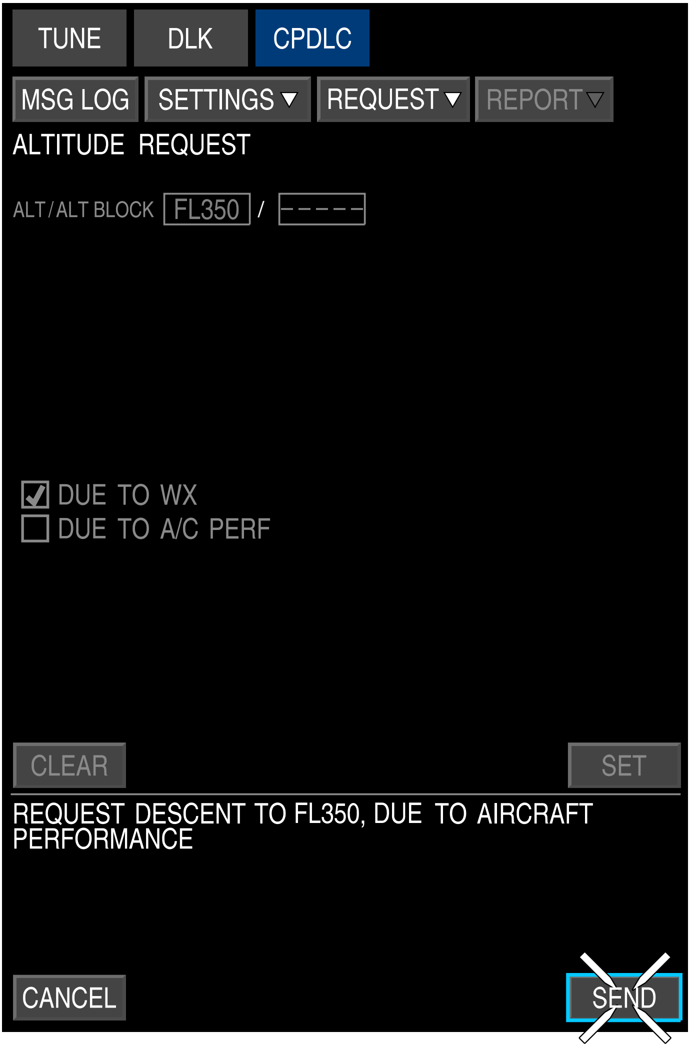
- MSG LOG (refer to Figure 05–08–13): Displays the CPDLC message history.
- SETTINGS (refer to Figure 05–08–14): The SETTINGS soft switch has a drop-down menu with the selections of LOGON or SYSTEM INFO.
- REQUEST (refer to Figure 05–08–15): The REQUEST soft switch has a drop-down menu with the selections that follow:
  - ALTITUDE,
  - OFFSET,
  - SPEED,
  - ROUTE, and
  - MONITORING.
- The REPORT soft switch is disabled. This function is only available with FANS-1/A+.



CPDLC tile – MSG LOG page <23240001C>
Figure 05–08–13



CPDLC tile – SETTINGS – LOGON/STATUS page – labels <23240001C>
Figure 05–08–14



CPDLC – REQUEST – ALTITUDE REQUEST PAGE

CNS – CPDLC tile – REQUEST – ALTITUDE REQUEST <23240001C>
Figure 05–08–15

F. CPDLC tile – MSG LOG page

The MSG LOG page gives access to the history of all the CPDLC communications made during the flight between the flight crew and ATC. The messages are received or sent with the time recorded in UTC HH:MM. The complete messages are shown on the message log page with time and status. A page can show up to 12 messages per page, up to a maximum of 75 messages, and has a scroll bar to navigate (refer to Figure 05–08–16). If the maximum capacity is reached, closed messages will be deleted to allow new messages to be inserted.

CNS – CPDLC tile – MSG LOG page <23240001C>
Figure 05–08–16

The header and the status of the closed (inactive) messages that follow are shown in white:

- CONN ENDED,
- TIMED OUT,
- ACCEPTED, and
- REJECTED.

The closed messages are all recorded and shown in chronological order.

The message log is cleared and set to the default state in the conditions that follow:

- A new flight identification (ID) is entered in the SETTINGS – LOGON/STATUS page,
- The LINK2000+ application is powered down or reset, and
- A new logon has been established after an END OF FLIGHT event has occurred.

The header and the status of the opened (active) messages that follow are shown in cyan:

- NEW,
- STBY,
- ACPT/OPEN, and
- OPEN.

The open messages are shown on top.

The messages can be filtered to display either ALL messages or only OPEN messages that require action.

The message log remains at its current position upon exit (which enables a quick return to the same message).

The MSG LOG page displays the current system time. Each message also has the information that follows:

- Message type arrow (uplink or downlink),
- Time message was sent,
- Air traffic services unit,
- Message status, and
- Message.

For long messages, only the first line is visible.

When the uplink or downlink message is open, the message header is displayed in cyan. When the message is closed, it changes to white.

G. CPDLC tile – SYSTEM INFO page

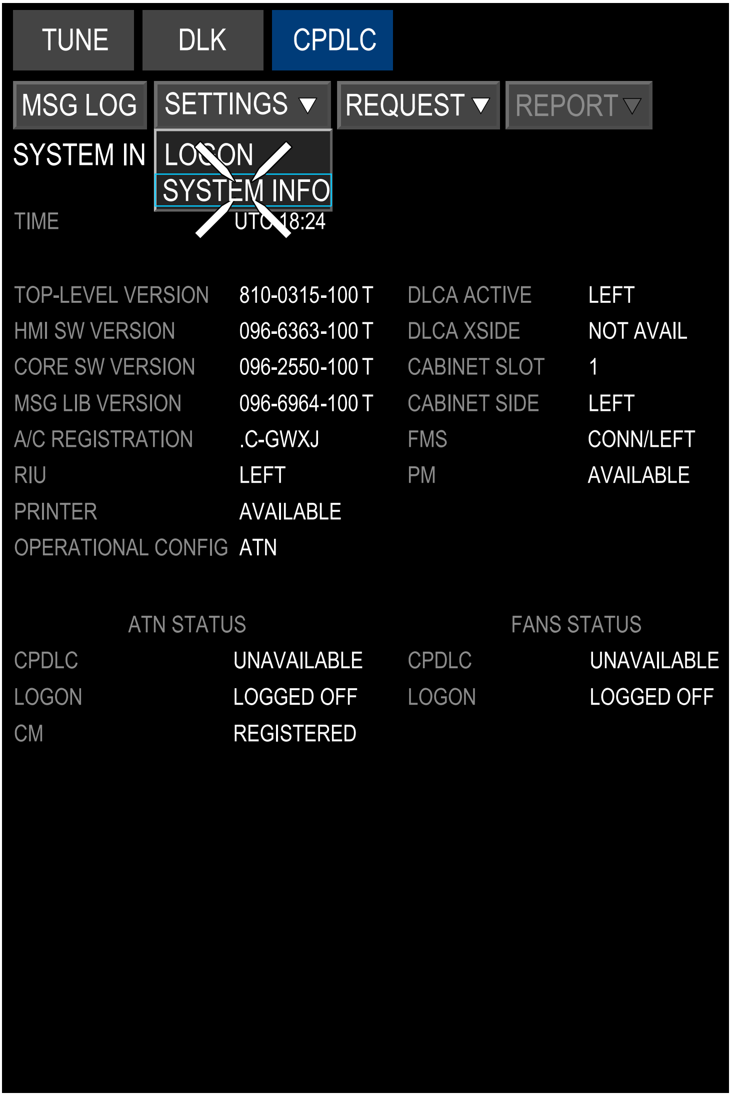
The SYSTEM INFO page (refer to Figure 05–08–17) gives information about the status of the CPDLC system.

Although this page is not normally accessed during system operation, it can be used to determine system status.

The OPERATIONAL CONFIG field identifies the network in use (ATN).

The ATN STATUS fields provide status of the:

- CPDLC the availability of CPDLC communication with ATC,
- LOGON system logon, and
- CM (context management) ATN aircraft registration and identification.



CPDLC tile – SETTINGS – SYSTEM INFO page <23240001C>
Figure 05–08–17

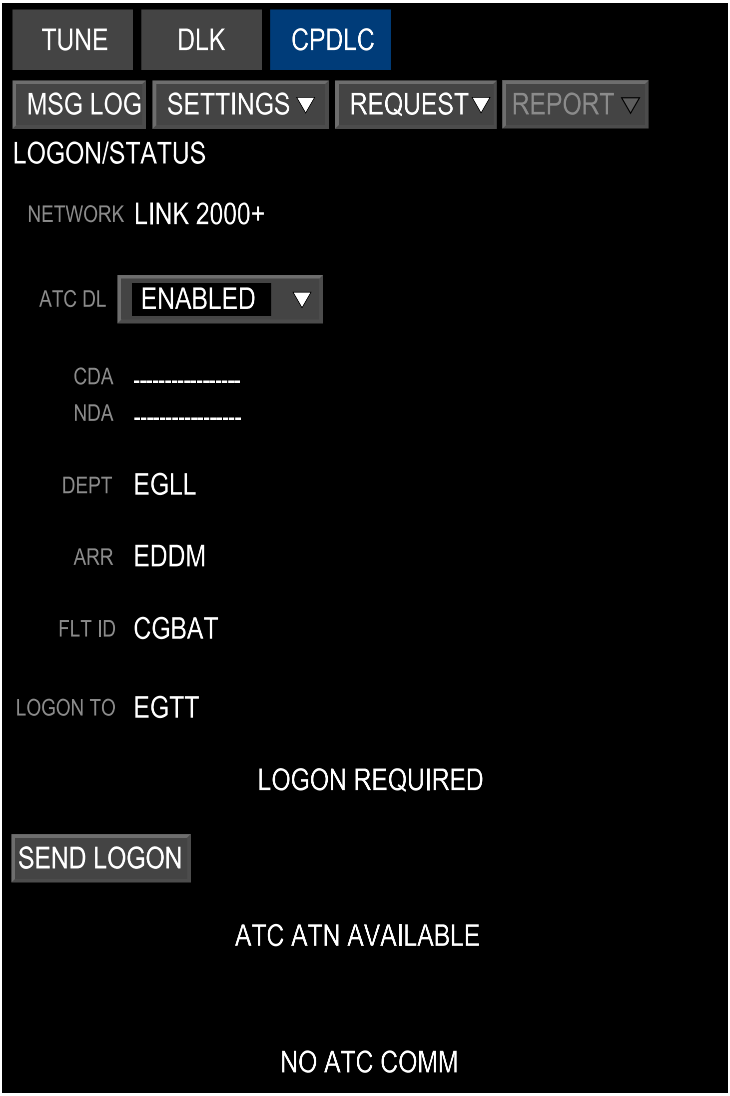
H. CPDLC tile – SETTINGS – LOGON/STATUS page

The SETTINGS soft switch gives access to the LOGON/STATUS page from a drop-down menu (refer to Figure 05–08–18).

To use LINK 2000+ CPDLC, the flight crew must log on from the LOGON/STATUS page.

The LOGON/STATUS page displays the items that follow:

- Network name,
- ATC Data Link (DLK) selection,
- Current and next data authorities,
- Arrival and departure airports,
- Flight Identification (ID),
- ATC logon facility,
- SEND LOGON soft switch,
- CPDLC status label,
- Logon status label,
- ATN availability label, and
- COMM status label.



CPDLC tile – SETTINGS – LOGON/STATUS page <23240001C>
Figure 05–08–18

The LOGON/STATUS page allows the flight crew to select the data link communications (ATN Link2000+) to initiate the communication link with Air Traffic Control (ATC).

The initialization of the ATC communication link is done by selecting the ATC identifier (LOGON TO) and entering the information that follows:

- DEPT (departure airport),
- ARR (arrival airport), and
- Flight identification (FLT ID).

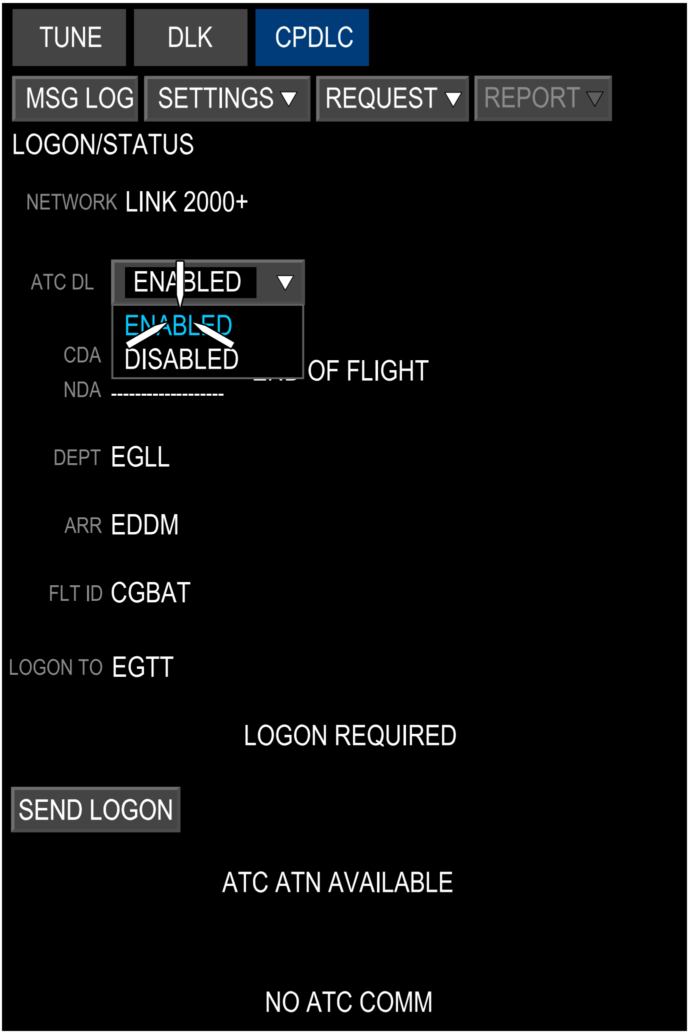
The information is linked from the active flight plan but can also be entered manually by the flight crew.

When all the information is completed, pushing the SEND LOGON soft switch sends the request. The flight crew can terminate the connection at any time.

I. CPDLC tile – SETTINGS – Enable/disable ATC Data link

LINK 2000+ operation can be enabled and disabled by selection of the ATC DL.

When selected to DISABLED (refer to Figure 05–08–19), the flight crew cannot log on or use the CPDLC function.



CNS - CPDLC - SETTINGS - LOGON/STATUS PAGE

ATC Datalink ENABLED <23240001C>
Figure 05–08–19

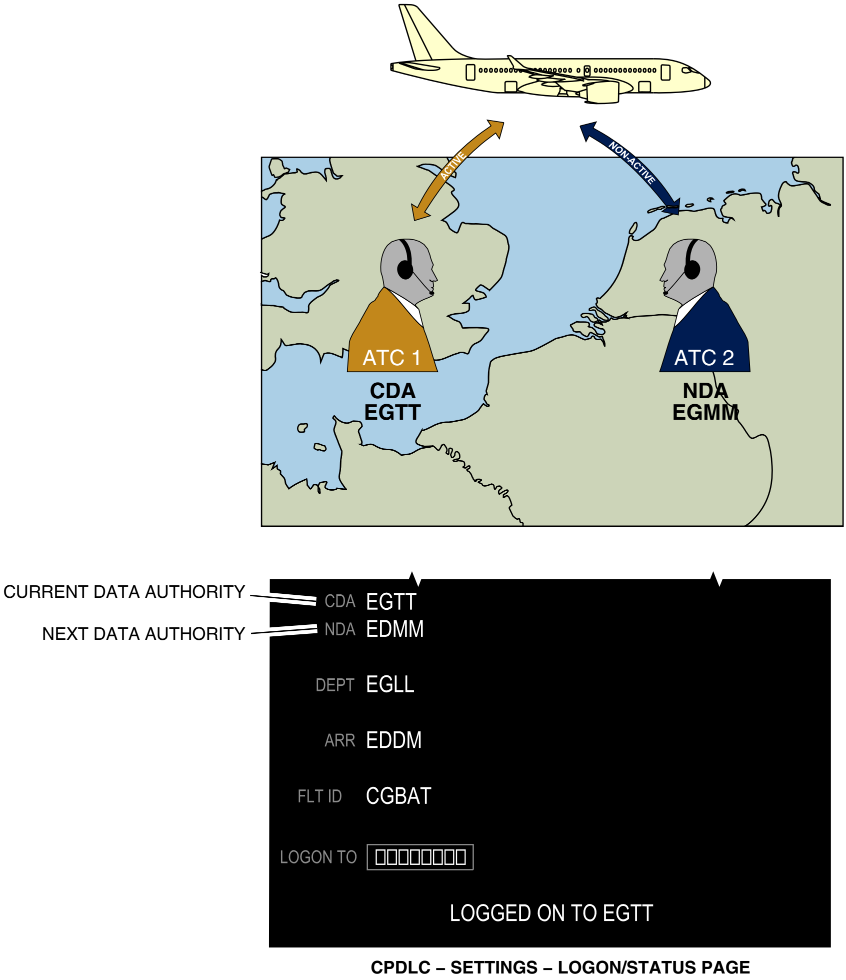
J. CPDLC tile – SETTINGS – Controller connections

In ATN airspace, an aircraft can have two controller connections with only one active at a time. The active connection is known as the Current Data Authority (CDA). The non-active connection is known as the Next Data Authority (NDA).

The CDA and NDA are displayed on the SETTINGS – LOGON/STATUS page (refer to Figure 05–08–20).

The transfer from one controller to another is initiated by the CDA and is largely transparent to the flight crew.

If the transfer is not successful, the controller sends data link instructions to the pilot to manually disconnect from the CDA and log on to the NDA.



Controller connections <23240001C>
Figure 05–08–20

K. CPDLC tile – SETTINGS – ATC logon

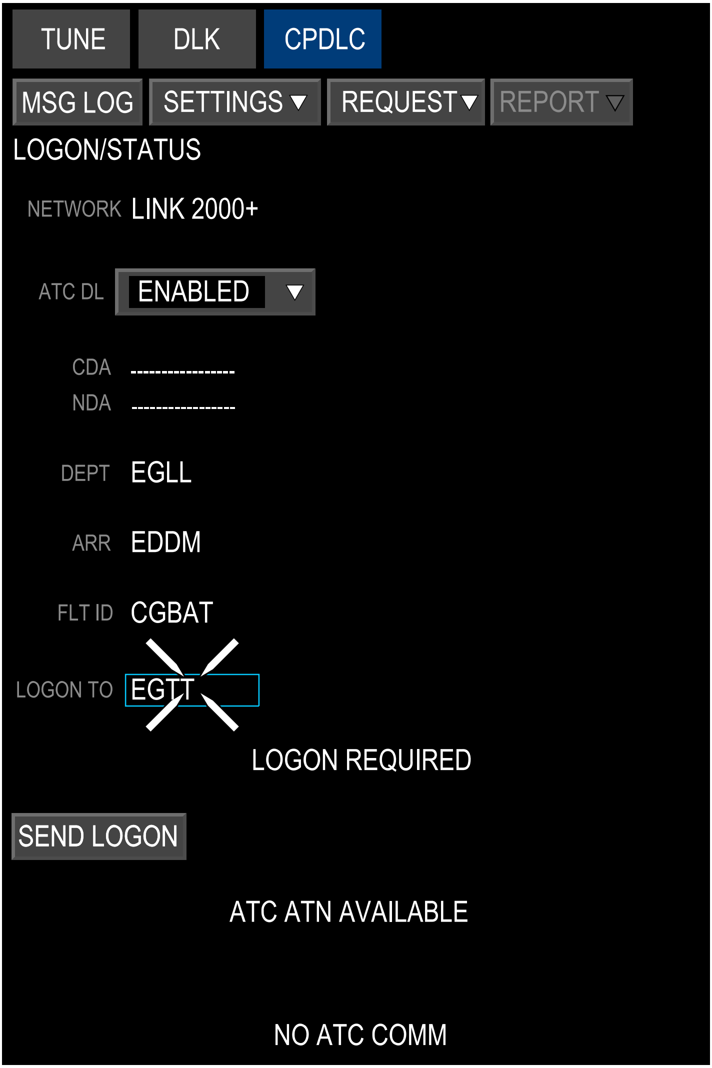
Logging on is the initial function that enables CPDLC communication. Before attempting to log on, verify that the ATC ATN AVAILABLE label and the NO ATC COMM labels are displayed (refer to Figure 05–08–21).

The flight plan data that follows must be verified:

- Departure (DEPT) airport,
- Arrival (ARR) airport, and
- Flight identification (ID).

This data must be identical to the filed flight plan. If it is not, the logon attempt will fail.

The ICAO airport code of the ATC facility is entered in the LOGON TO field. The selection of the SEND LOGON soft switch establishes a connection with ATC and the LOGGED ON TO XXXX label is displayed. The ATC facility airport code is displayed as the Current Data Authority (CDA). The NO ATC COMM label is removed.



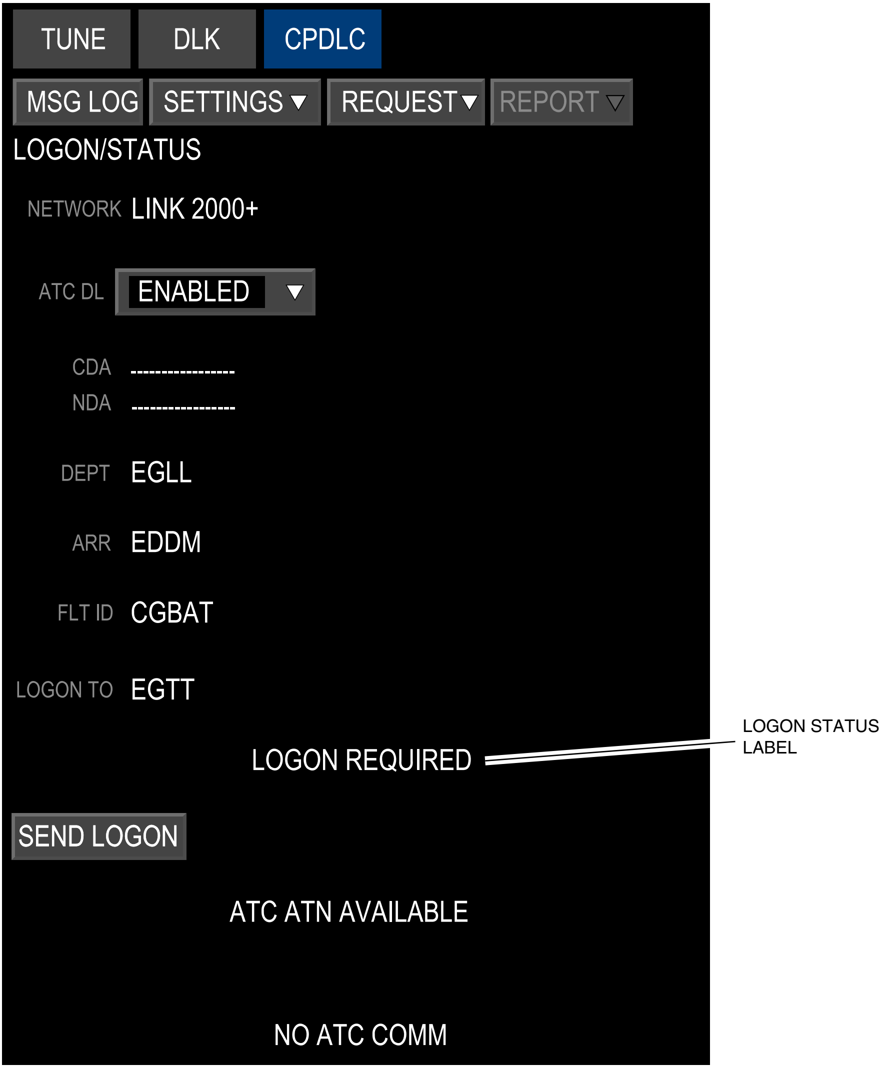
CPDLC – SETTINGS – LOGON/STATUS PAGE

ATC logon <23240001C>
Figure 05–08–21

L. CPDLC tile – SETTINGS – LOGON status label

The LOGON status label (refer to Figure 05–08–22) indicates the current connection status or attempted connection with the ground network. The LOGON status labels are:

- LOGON REQUIRED – The system is not logged on.
- CONTACTING XXXX – The SEND LOGON soft switch has been pushed and a response from the ATC center has not yet been received.
- LOGGED ON TO XXXX – A successful LOGON with the ATC center has been established.
- REJECTED BY XXXX – The ATC center has rejected the logon request or was unable to connect.
- TIMED OUT – The SEND LOGON soft switch was selected but there was no response from the ATC center before the 90 seconds timer expired.



CPDLC - SETTINGS - LOGON/STATUS PAGE

LOGON status label <23240001C>
Figure 05–08–22

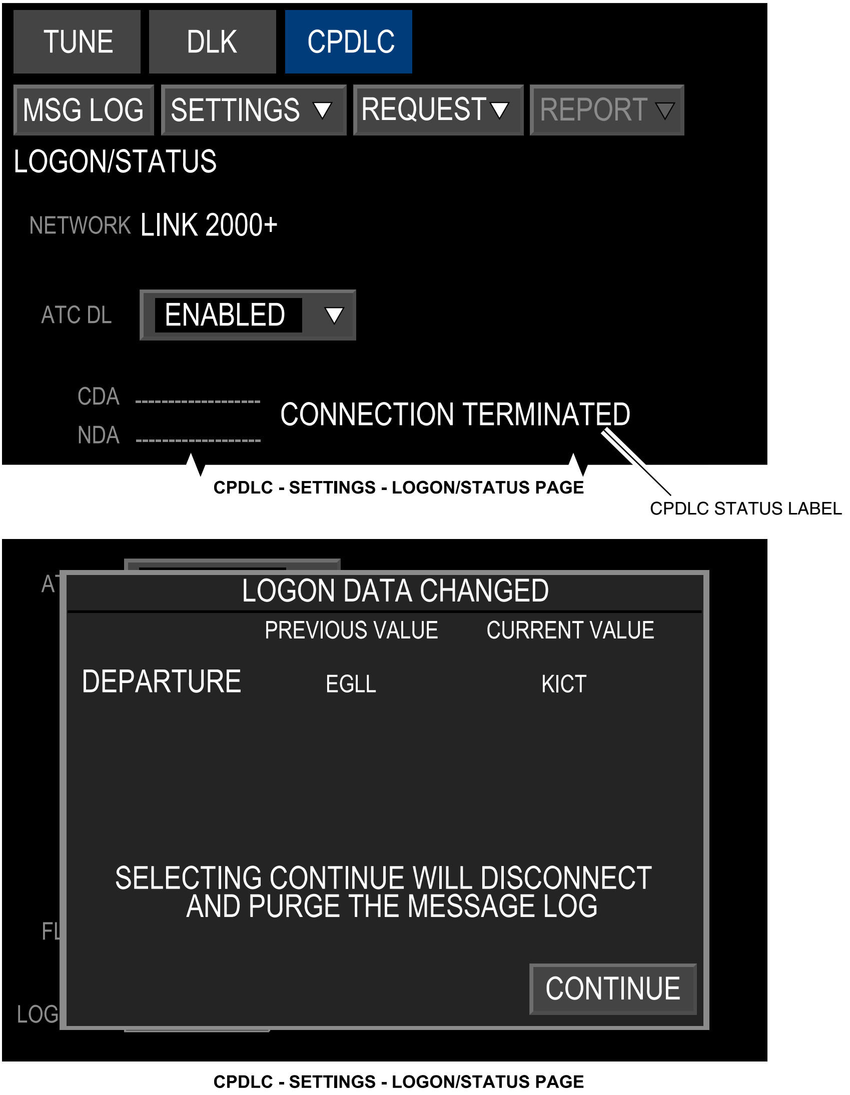
M. CPDLC status label

The CPDLC status label alerts the flight crew to changes in the status of the CPDLC connection. When there is a change in status, the **DATALINK STATUS** advisory message is displayed on the EICAS page.

The CONNECTION TERMINATED label is displayed (refer to Figure 05–08–23) when ATC sends an uplink end service message or the connection is terminated due to a loss of the ATN network.

The END OF FLIGHT label is displayed when the FMS signals the end-of-flight event.

If the DEST or ARR airport, or if the FLT ID has changed since a CPDLC logon occurred, a dialog box appears to advise the flight crew. Selecting the CONTINUE soft switch will disconnect the existing CPDLC logon and all messages in the message log will be erased. The LOGON DATA CHANGED label is displayed and a new logon is required.



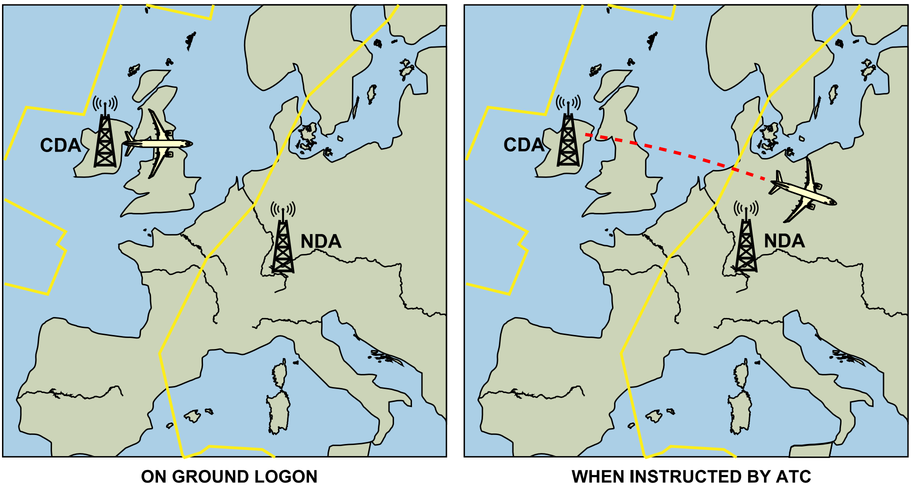
CPDLC status label <23240001C>
Figure 05–08–23

N. CPDLC page – ATC logon conditions

ATC logon is done by the flight crew on the ground before departure, or under certain operating conditions when airborne. Timing guidelines and operating conditions for manually-initiated ATC logons are as follows:

- On the ground, for aircraft departing from airports below or in close proximity to the concerned Area Control Center (ACC),
- Airborne, 10 to 30 minutes before entering the airspace of a Flight Information Region (FIR), or
- When instructed by ATC for situations such as an unsuccessful automatic data link transfer.

When the aircraft transitions from one ATC unit (CDA) to another (NDA), no logon is required and transfer is done automatically by ATC. Refer to Figure 05–08–24.



ATC logon conditions <23240001C>
Figure 05–08–24

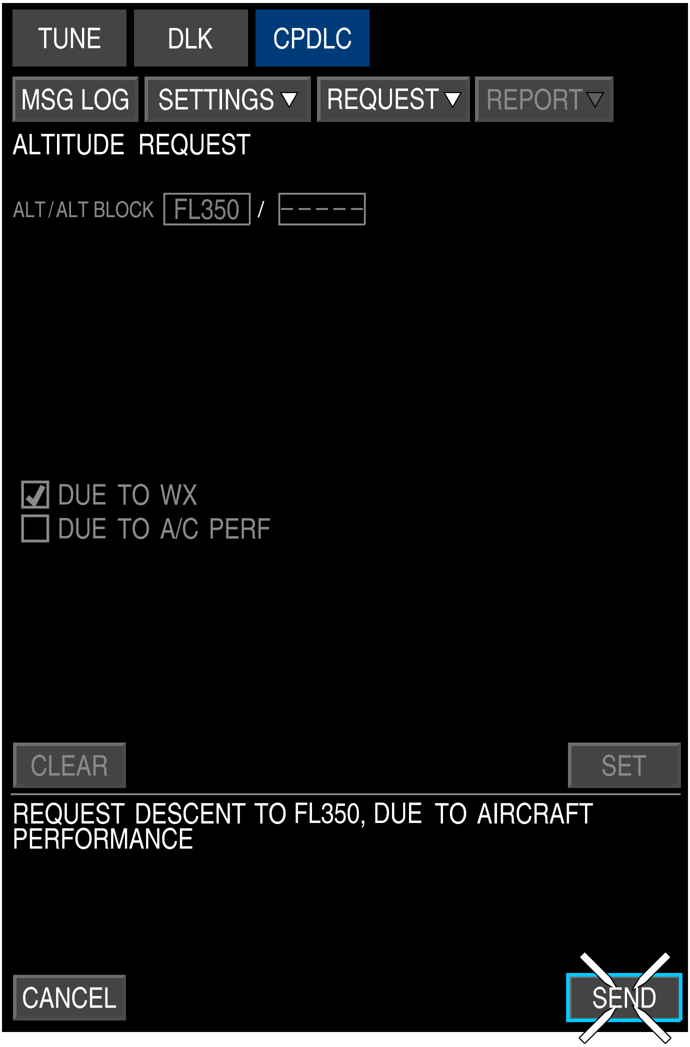
O. CPDLC tile – REQUEST menu

The REQUEST drop-down menu soft switch gives access to the aircraft requests that follow:

- Vertical request,
- Lateral request,
- Speed request,
- Negotiation request, and
- Route modification request.

When a selection is made, the parameters of the request can be entered in sequence from the MKP readout window (scratchpad), then reviewed and sent.

Refer to Figure 05–08–25.



CPDLC – REQUEST – ALTITUDE REQUEST PAGE

CNS – CPDLC tile – REQUEST – ALTITUDE REQUEST <23240001C>
Figure 05–08–25

CPDLC – OPERATION

A. CPDLC messages

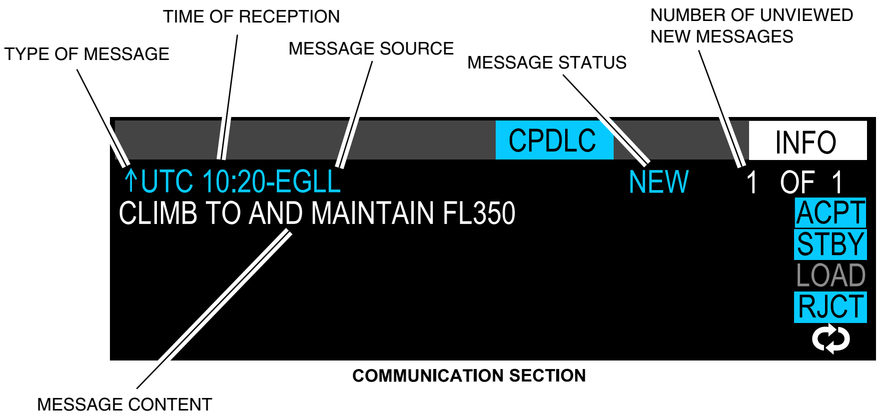
CPDLC messages are pre-formatted and are selected from a pre-defined set. This set of text messages covers a broad spectrum of commands, responses, and requests.

Uplink messages are sent from ATC to the flight crew. Downlink messages are sent from the flight crew to ATC.

B. Uplink messages

When an uplink message is received, a CPDLC communication flag on the communication section flashes (refer to Figure 05–08–26) and the data link aural alert sounds. The communication inbox displays the:

- Type of message, uplink or downlink, represented by an arrow,
- Time of message reception,
- Message source (ATC center),
- Message status,
- Number of unviewed new messages, and
- Message content.



Uplink messages <23240001C>
Figure 05–08–26

(1) Uplink message responses

When an uplink message is received from ATC, the flight crew determines whether they can respond with a quick response or if more information needs to be added to the response.

For a quick response, the flight crew reviews the message on the communication inbox then selects the appropriate switch on the quick-response panel or the appropriate soft switch on the communication inbox (refer to Figure 05–08–27).

NOTE

If there is an unanswered uplink message in the EICAS inbox and the EICAS inbox is switched to a different DU, use the CPDLC page to respond. Use of the quick-response panel after an EICAS display switch can cause a reset of the Datalink application. If this occurs, the flight crew may re-logon to the Datalink network and re-establish ground contacts.

NOTE

The EICAS communication inbox does not show the full content of all incoming messages. For more details, refer to Chapter 5 – Communication – Controls and Indications – Communication inbox.

If a more detailed response to an uplink message is required the CPDLC page must be used.

To respond to an uplink message using the quick-response panel, the flight crew has three options:

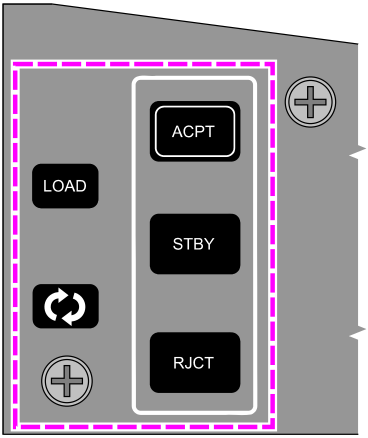
- ACPT (accept),
- STBY (standby), or
- RJCT (reject).

When the ACPT switch is pushed, ATC is advised that the flight crew have accepted the uplink message. The message is removed from view.

When the STBY switch is pushed, ATC is advised that the message has been read but a further response is expected. The message status changes to STANDBY. The response timer is paused but an ACPT or RJCT response is still required to close the uplink message.

When the RJCT switch is pushed, ATC is advised that the flight crew is unable to comply with the uplink request. The message is then removed from view. To include a reason for the rejection (aircraft performance or weather), the flight crew must use the CPDLC page.

The flight crew can also respond to an uplink message using the cyan soft switches in the communication inbox. The soft switches on the CPDLC page have the same functions as the switches on the quick-response panel.



COPILOT QUICK - RESPONSE PANEL

COMMUNICATION SECTION

Uplink message quick responses <23240001C>
Figure 05–08–27

(2) Uplink messages that do not require a response

Some uplink messages do not require a response and are immediately closed when received. Since there is no quick response available, the message is only displayed on the MSG LOG page (refer to Figure 05–08–28). The pilots are advised to check the MSG LOG page by the data link aural alert and the flashing CPDLC communication flag on the EICAS page.

One example of this is the CHECK STUCK MICROPHONE message. ATC can choose to send this broadcast message to all CPDLC users within the airspace to verify that aircraft are not blocking a voice channel. To avoid multiple simultaneous replies, the message is immediately closed. No response is possible.

CPDLC - SETTINGS - LOGON/STATUS PAGE

Uplink messages that do not require a response <23240001C>
Figure 05–08–28

C. Message log sort order

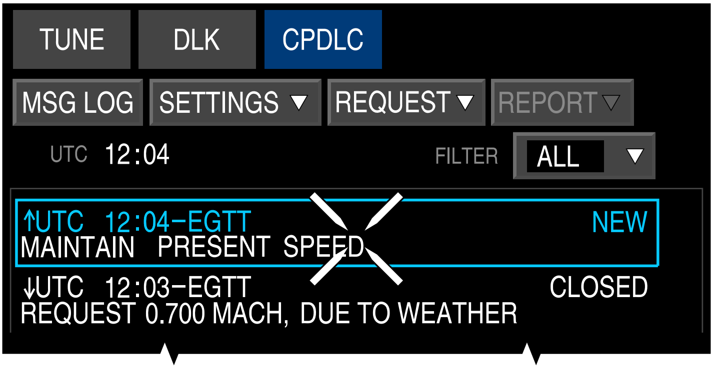
Messages in the message log are displayed according to their priority status and chronological order. The table that follows shows the possible uplink messages and their priority:

Priority	Message	Description
1	NEW	A new uplink message that has not been viewed and requires pilot action.
2	OPEN	An uplink message that has been viewed but no response has been sent.
	STANDBY	An open uplink message that has been responded to with STANDBY, but still requires an ACCEPT or REJECT response.
3	CLOSED/ UNVIEWED	An uplink message that is closed but has not been viewed.
	REJECTED/ UNVIEWED	An uplink message that has been rejected but has not been viewed.
	ACCEPTED/ UNVIEWED	An uplink message that has been accepted but has not been viewed
	ACCEPTED/ OPEN	An uplink message that has been accepted but further action, such as a confirmation, is still required.
4	ACCEPTED	An uplink message that has been responded to with an ACCEPT response.
	REJECTED	An uplink message that has been responded to with a REJECT response.
	CLOSED	No further response is required.
	TIMED OUT	An uplink message that has not been responded to in the allotted amount of time. ATC is automatically advised that the message timed out before the user was able to respond. The original message cannot be responded to.

Priority	Message	Description
	CONN ENDED	The CPDLC connection with the ground network has ended. The message is considered closed and the user can no longer respond to any messages.

D. Message response page

When a new message arrives and the flight crew does not want to respond using the quick-response panel, the new message is selected from the MSG LOG page. Refer to Figure 05–08–29.



CPDLC MSG LOG PAGE

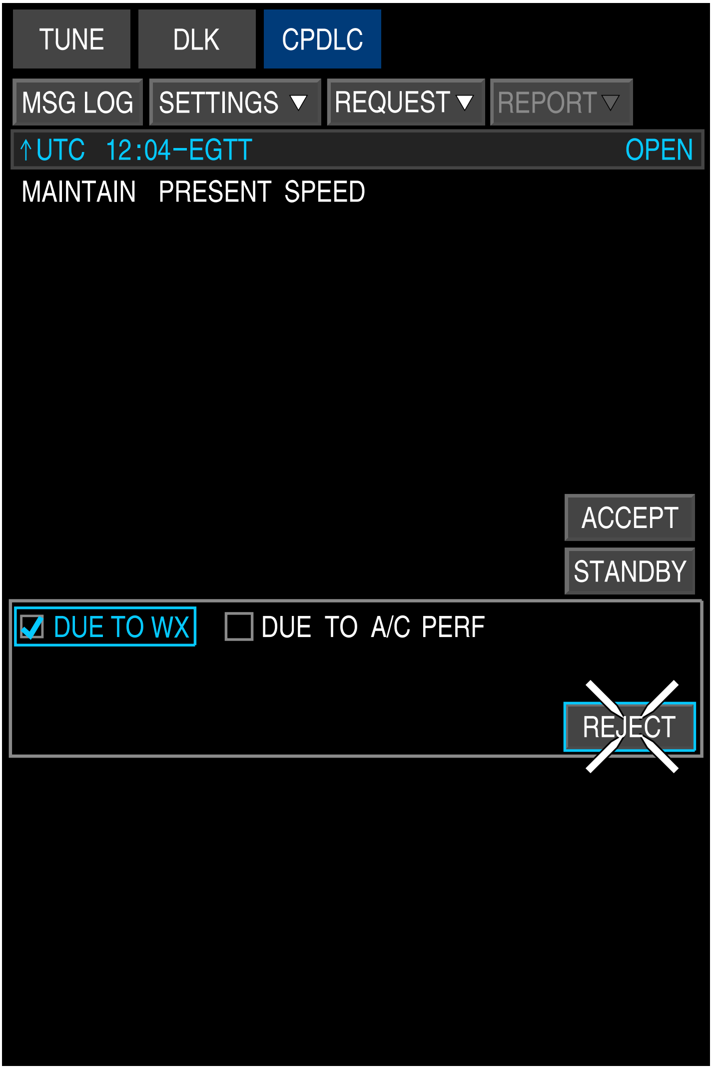
Message response page (part 1) <23240001C>
Figure 05–08–29

When a message is selected, the message response page is displayed. Responses are either:

- ACCEPT,
- STANDBY, or

- REJECT.

When a message is rejected, a reason can be selected but is not required. The selections available are DUE TO WX or DUE TO A/C PERF. Refer to Figure 05–08–30.



CPDLC MESSAGE RESPONSE PAGE

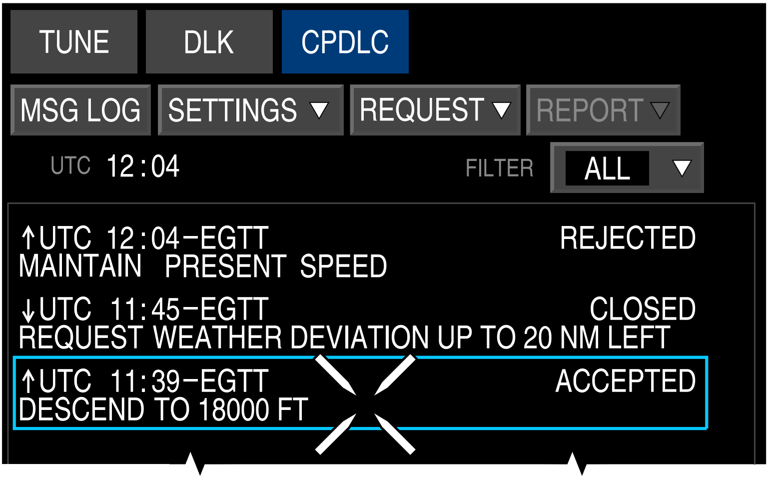
Message response page (part 2) <23240001C>
Figure 05–08–30

If a reason has been selected, the reason is included in the response to ATC. It is also present on the message history page with the uplink message, its current status, and the response that was sent to ATC.

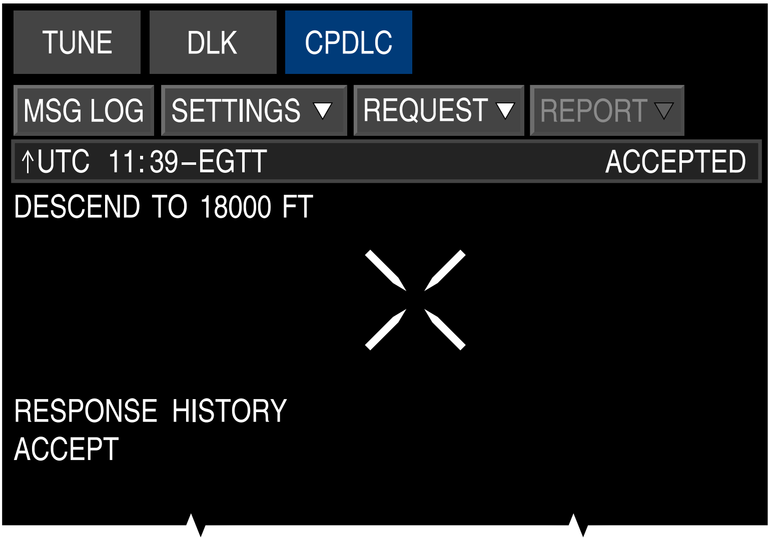
E. Message history page

Details of older messages can be reviewed on the message history page. To view details, select the message on the MSG LOG page. Refer to Figure 05–08–31.

A PRINT soft switch, if enabled, allows printing of the message on the flight deck printer.



CPDLC - SETTINGS - LOGON/STATUS PAGE



CPDLC - MESSAGE HISTORY PAGE

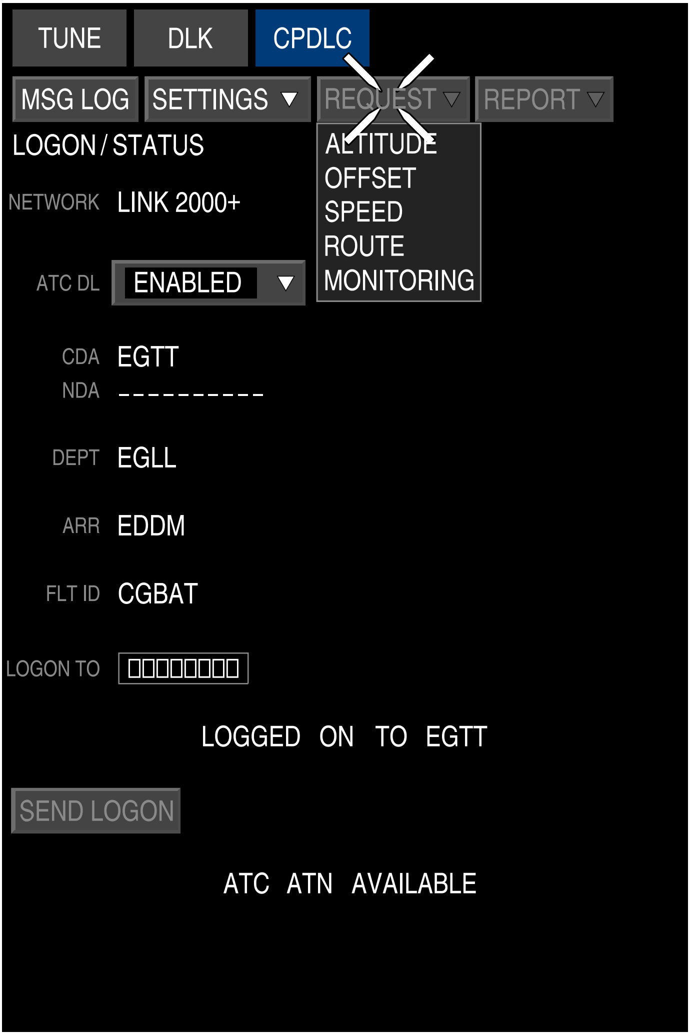
Message history page <23240001C>
Figure 05–08–31

F. Downlink messages

The flight crew can use the REQUEST soft switch to send requests to ATC.

When the REQUEST soft switch is selected (refer to Figure 05–08–32), a drop-down menu is displayed with the selections that follow:

- ALTITUDE,
- OFFSET,
- SPEED,
- ROUTE, and
- MONITORING.



CPDLC- SETTINGS - LOGON/STATUS PAGE

Downlink messages <23240001C>
Figure 05–08–32

G. Sending downlink messages

To make a request, the flight crew selects the type of request from the REQUEST drop-down menu soft switch (e.g. ALTITUDE). Refer to Figure 05–08–33.

The request is constructed from the available elements in the request area.

The CLEAR soft switch returns the page to its default condition.

When the SET soft switch is selected, the compiled messages are put into the verify message area. This lets the flight crew review the messages before they are sent.

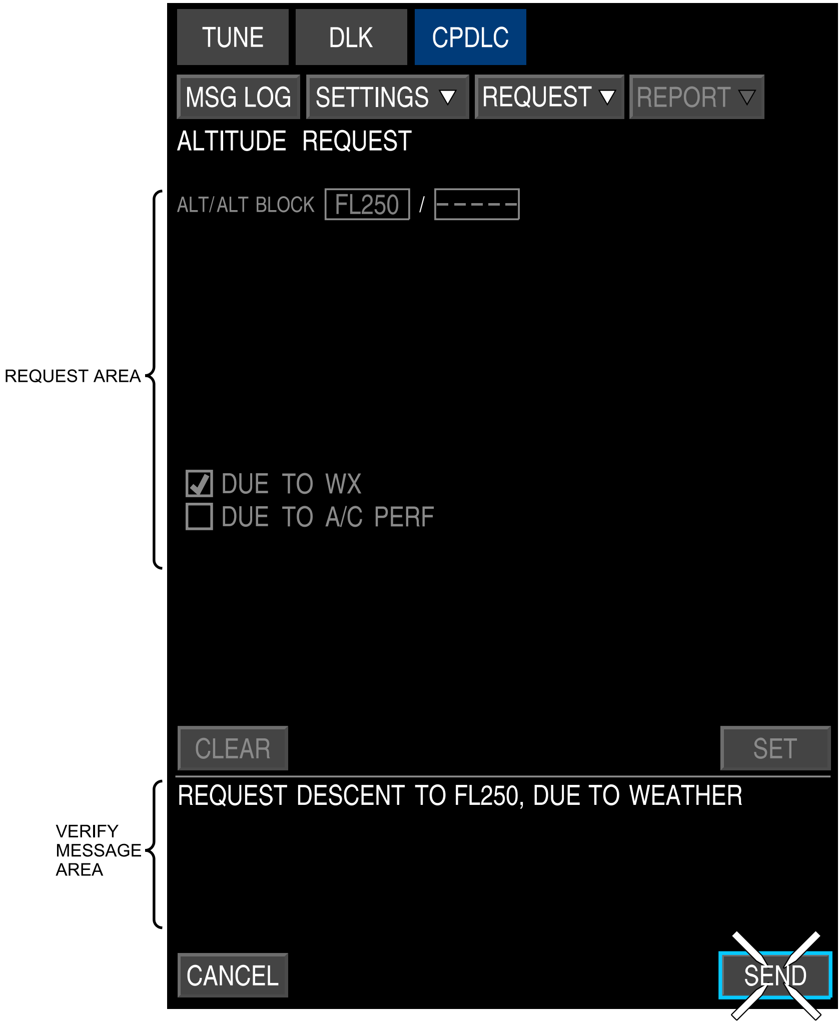
The CANCEL soft switch terminates the request and returns to the MSG LOG page.

The SEND soft switch is enabled when the data link system determines that the conditions for successful transmission have been met. When the SEND soft switch is selected, the message is sent to ATC and returns to the MSG LOG page.

All CPDLC messages must be viewed before they are sent to the ground. When there is more data than can be displayed on the verify message area, a scroll bar will be present. The scroll bar must be scrolled all the way to the bottom before CPDLC SEND functionality becomes available.

NOTE

Some pages could contain blank data while scrolling.



CPDLC – REQUEST – ALTITUDE REQUEST PAGE

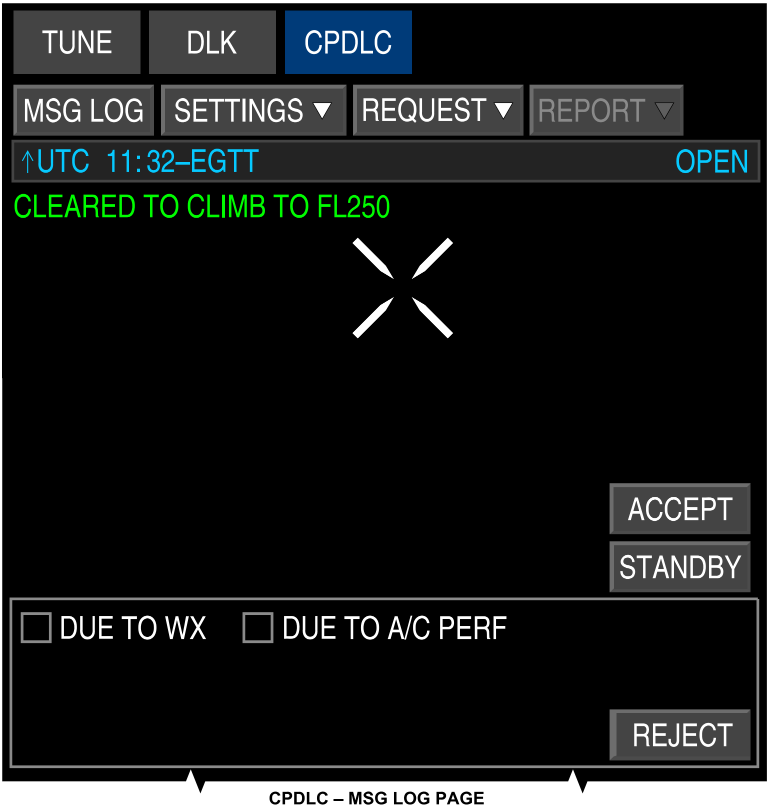
Sending downlink messages <23240001C>
Figure 05–08–33

H. ATC response to downlink messages

The response from ATC to the downlink message request is displayed in the communication inbox and on the MSG LOG page. Refer to Figure 05–08–34.

ATC requires acknowledgment of the response. Selecting the NEW message on the MSG LOG page opens the response page. The flight crew can select the desired response from this page or use the quick-response panel for a simple reply.

Selecting the MSG LOG page shows the status of the original downlink message and the status of the reply from ATC.



CPDLC – MSG LOG PAGE

COMMUNICATION SECTION

ATC response to downlink message <23240001C>
Figure 05–08–34

I. Downlink message

The status of downlink messages is displayed on the MSG LOG page.

The downlink message with the highest priority, and the most recent message within that priority category, is displayed at the top of the MSG LOG page.

The table that follows shows the possible downlink messages and their priority:

Priority	Message	Description
1	PENDING	A downlink message that has been transmitted from the aircraft but has not received a network acknowledgment from the ground system.
	OPEN	A downlink message that requires a response from ATC but no response has been received.
	STANDBY	A downlink message that has been responded to with a STANDBY response, but still requires a further response from ATC.
2	ACCEPTED/ UNVIEWED	A downlink message that has been responded to with an ACCEPTED response that has not yet been viewed by the crew. When viewed, ACCEPTED is displayed.
	REJECTED/ UNVIEWED	A downlink message that has been rejected but has not been viewed. When viewed, REJECTED is displayed.
3	ACCEPTED	A downlink message that has been responded to with an ACCEPTED response and no further ATC action is required in response to the downlink.
	REJECTED	A downlink message that has been responded to with a REJECTED response. The message is considered closed.

Priority	Message	Description
	CLOSED	A downlink message that requires no further response. The message does not necessarily mean that it has been viewed by ATC however.
	CONN ENDED	The CPDLC connection with the ground network has ended. The message is considered closed and the user can no longer respond to any messages.
	TIMED OUT	A downlink message that has not been responded to in the allotted amount of time. The original message cannot be responded to.
4	ERROR	A downlink message that caused an ERROR message to be sent in response.

J. Altitude requests

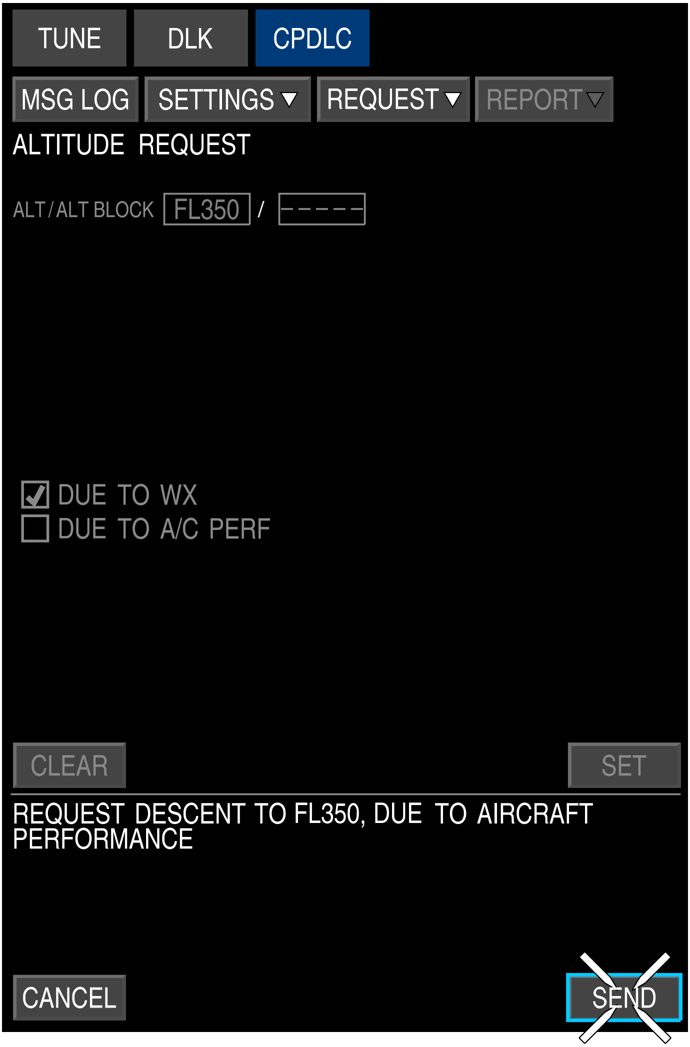
The flight crew can make requests for a specific altitude. The altitude request can be in feet or flight level (FL). The request can be accompanied with a DUE TO WX and/or DUE TO A/C PERF reason (refer to Figure 05–08–35), but a reason is not required.

If the request is for an altitude (or FL) within ±150 ft of the current altitude (and the ALT BLOCK is empty), a request will be sent for that specific altitude. If the request is for an altitude greater than 150 ft above the current altitude, the message will read REQUEST CLIMB TO (altitude). Likewise, if the request is for a lower altitude (greater than 150 ft below the current altitude) the message will read REQUEST DESCENT TO (altitude).

After sending the request to ATC, ATC will uplink the clearance to which the crew must respond.

NOTE

The system has provisions for the selection of an altitude block. However, the ATN cannot currently support altitude block requests. If an altitude block request is made, the ATN will return an error message.



CPDLC – REQUEST – ALTITUDE REQUEST PAGE

CNS – CPDLC tile – REQUEST – ALTITUDE REQUEST <23240001C>
Figure 05–08–35

K. Offset requests

The OFFSET REQUEST page is used for a lateral deviation request.

The requested direction (L or R) and distance are entered in the OFFSET field. An offset of up to 121 nm can be entered. The DUE TO WX is automatically selected and cannot be deselected. However, an additional reason can be added to the request. Refer to Figure 05–08–36.

NOTE

Strategic Lateral Offset Procedures (SLOP) are limited to 1 or 2 nm left or right of centerline.

CPDLC OFFSET REQUEST PAGE

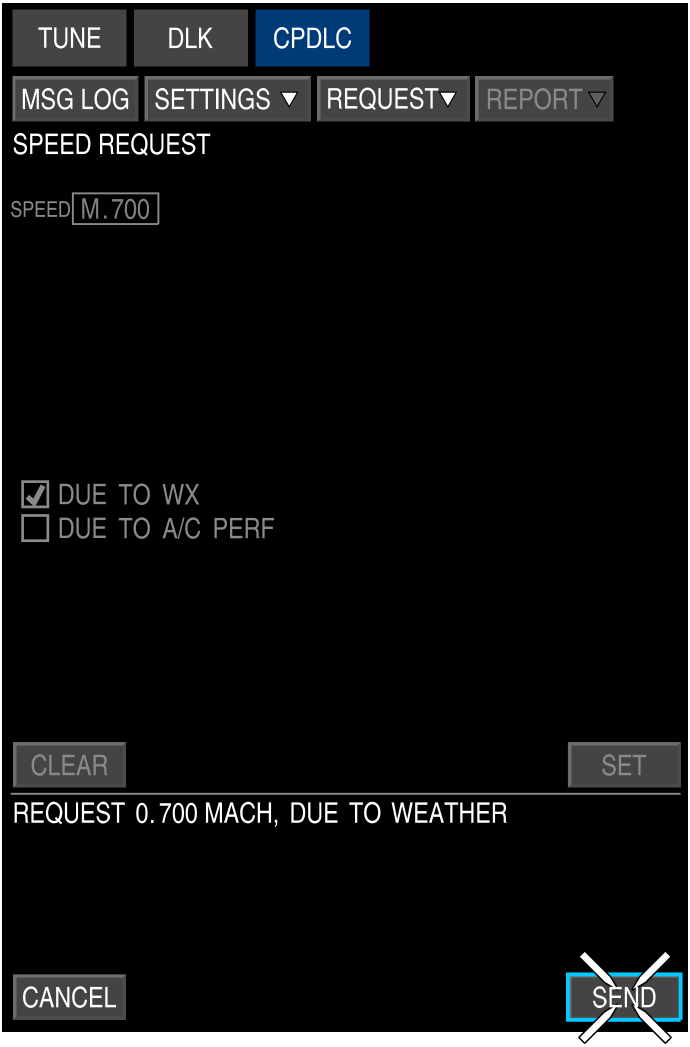
CNS – CPDLC tile – REQUEST – OFFSET REQUEST <23240001C>
Figure 05–08–36

L. Speed requests

Similar to the offset request, the crew can also request specific speeds. The speed requested can either be a Mach number or IAS.

The speed request can also include a reason for the request (refer to Figure 05–08–37).

In this scenario, the crew wanted to slow down due to weather but ATC wants them to maintain their current speed due to heavy traffic. However, the crew insists on slowing down due to considerable turbulence in the area and rejects the ATC request. Subsequently, ATC gives clearance for a reduced Mach number.



CPDLC – REQUEST – SPEED REQUEST PAGE

CNS – CPDLC tile – REQUEST – SPEED REQUEST <23240001C>
Figure 05–08–37

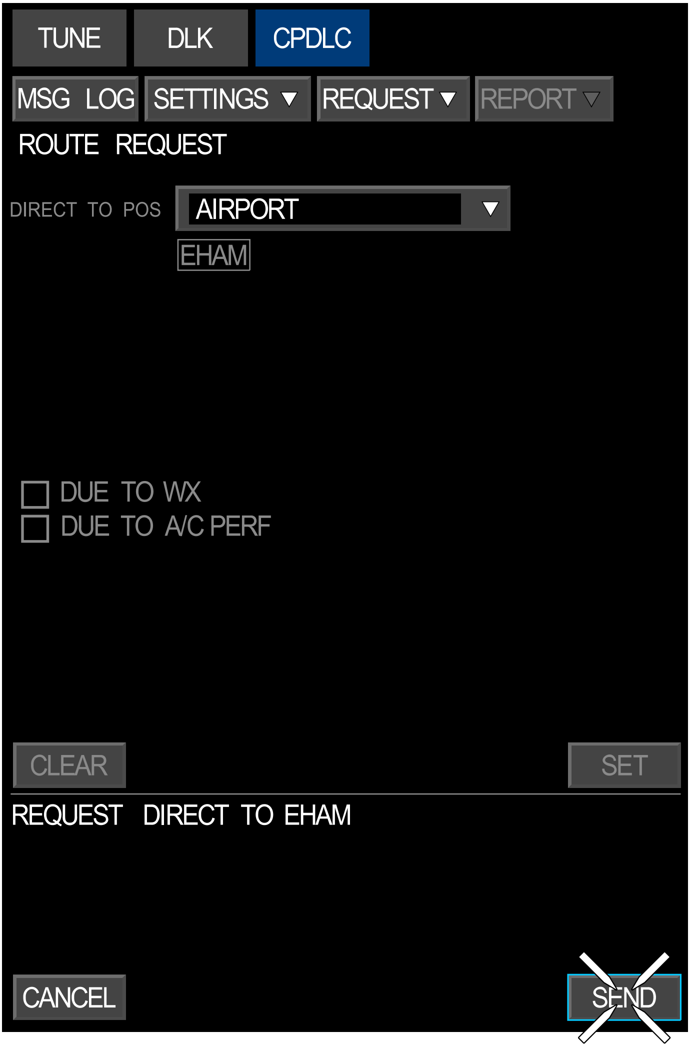
M. Route requests

The crew can request clearance to a specific position using the ROUTE REQUEST page (refer to Figure 05–08–38).

The DIRECT TO POS drop-down menu soft switch has the selections that follow:

- NAVAID,
- AIRPORT,
- FIX,
- LAT/LON, and
- PLACE/BEARING/DIST.

The crew can also select the DUE TO WX or DUE TO A/C PERF reasons.



CPDLC REQUEST PAGE

CNS – CPDLC tile – REQUEST – ROUTE REQUEST <23240001C>
Figure 05–08–38

N. Request – MONITORING

Although MONITORING appears under the REQUEST drop-down menu soft switch, no request is actually being made of ATC. Instead, MONITORING allows the crew to notify ATC of the facility they are monitoring using VHF communications.

If all of the fields have been populated (refer to Figure 05–08–39), selecting SET puts the compiled message in the verify message area. Selecting SEND routes the message to ATC.

Since no response is expected from ATC, the message is immediately closed.

CPDLC REQUEST PAGE

CNS – CPDLC tile – REQUEST – MONITORING <23240001C>
Figure 05–08–39

O. Conditional clearances – Special considerations

Pay special attention to the meaning of uplink vertical clearance message elements that contain the words AT or BY.

The table that follows clarifies the intended meaning of these message elements:

Message	Message intent
AT [time] CLIMB TO AND MAINTAIN [altitude]	Instruction that **AT** or **AFTER** the specified time, a climb to the specified level is to commence, and once reached, the specified level is to be maintained.
AT [position] CLIMB TO AND MAINTAIN [altitude]	Instruction that **AFTER PASSING** the specified position, a climb to the specified level is to commence, and once reached, the specified level is to be maintained.
AT [time] DESCEND TO AND MAINTAIN [altitude]	Instruction that **AT** or **AFTER** the specified time, a descent to the specified level is to commence, and once reached, the specified level is to be maintained.
AT [position] DESCEND TO AND MAINTAIN [altitude]	Instruction that **AFTER PASSING** the specified position, a descent to the specified level is to commence, and once reached, the specified level is to be maintained.
CLIMB TO REACH [altitude] **BY** [time]	Instruction that a climb is to commence at a rate such that the specified level is reached **AT** or **BEFORE** the specified time.
CLIMB TO REACH [altitude] **BY** [position]	Instruction that a climb is to commence at a rate such that the specified level is reached **BEFORE PASSING** the specified position.
DESCEND TO REACH [altitude] **BY** [time]	Instruction that a descent is to commence at a rate such that the specified level is reached **AT** or **BEFORE** the specified time.

Message	Message intent
DESCEND TO REACH [altitude] **BY** [position]	Instruction that a descent is to commence at a rate such that the specified level is reached **BEFORE PASSING** the specified position.

ABNORMAL OPERATION

A. DATALINK STATUS message

The **DATALINK STATUS** advisory message indicates a change in the status of the data link system.

Specifically, this message displays for any of the conditions that follow:

- Logon timeout,
- Logon data mismatch (e.g. flight ID),
- ATN transition (e.g. not available to available),
- ATN disconnect,
- CPDLC connection established or terminated, or
- Data link system status change (e.g. standby to active).

This message can indicate that the LINK 2000+ system is inoperative. The crew should refer to the CPDLC LOGON/STATUS page to determine the current system status.

B. DATALINK FAIL message

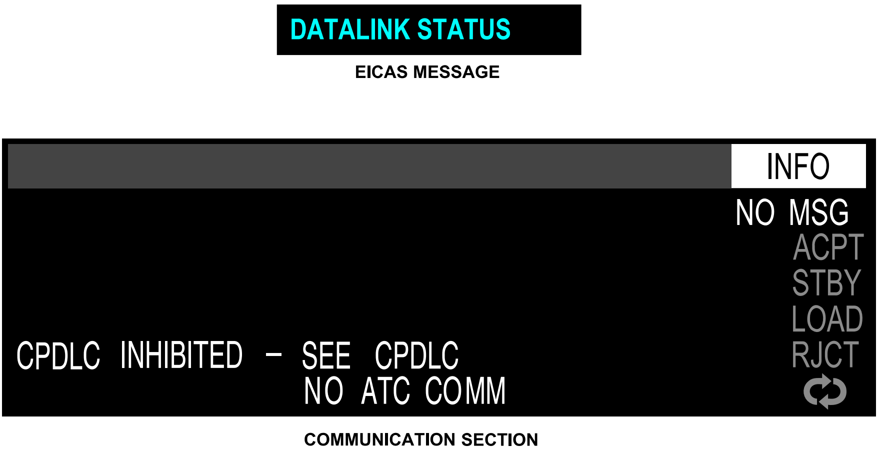
The **DATALINK FAIL** advisory message alerts the crew to an onboard equipment failure. This message indicates that the data link system has detected a failure that renders all data link systems inoperative (LINK 2000+, ACARS, and FANS-1/A+). LINK 2000+ operation is inhibited until this failure has been corrected.

The flight crew and controller must use voice communication.

C. CPDLC INHIBITED – SEE CPDLC message

After an initial logon, if the LINK 2000+ system is disabled, the CPDLC INHIBITED – SEE CPDLC message is displayed in the communication inbox (refer to Figure 05–08–40).

This message directs the user to the CPDLC LOGON/STATUS page to attempt another logon.

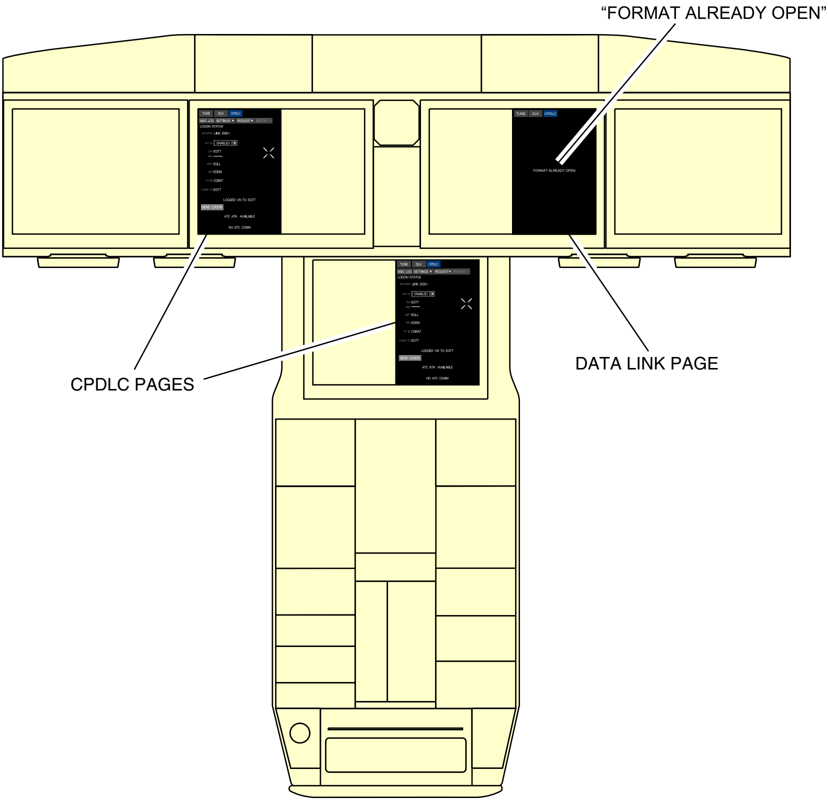


CPDLC INHIBITED – SEE CPDLC message
Figure 05–08–40

D. FORMAT ALREADY OPEN message

Only one CPDLC page can be open on the pilot or copilot side of the flight deck (refer to Figure 05–08–41). A single page can be displayed on both sides at the same time, but any changes made in one will immediately be reflected in the other.

If an attempt is made to display two CPDLC pages on the same side, the FORMAT ALREADY OPEN message will be displayed.



FORMAT ALREADY OPEN message
Figure 05–08–41

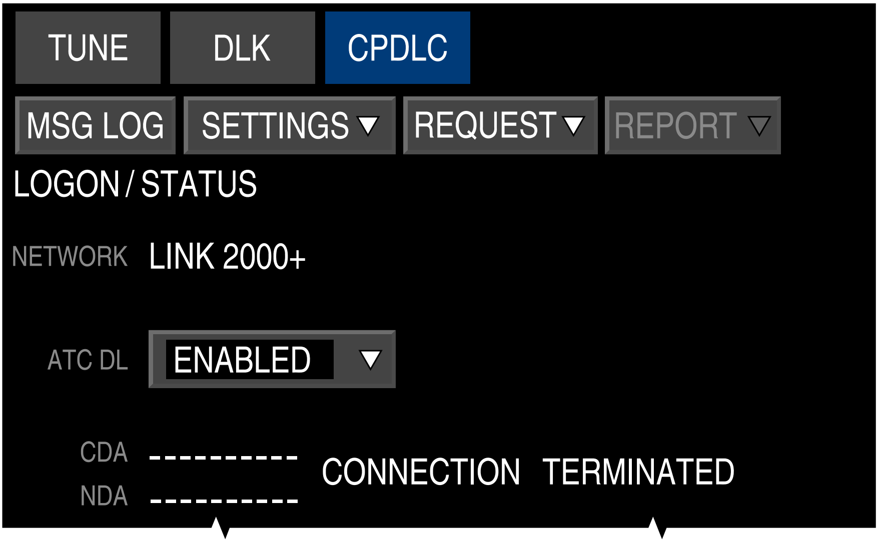
E. CONNECTION TERMINATED message

The CONNECTION TERMINATED message is displayed on the CPDLC status label when an uplink end service message is received, or when a CPDLC connection has been terminated due to loss of the ATN network (refer to Figure 05–08–42).

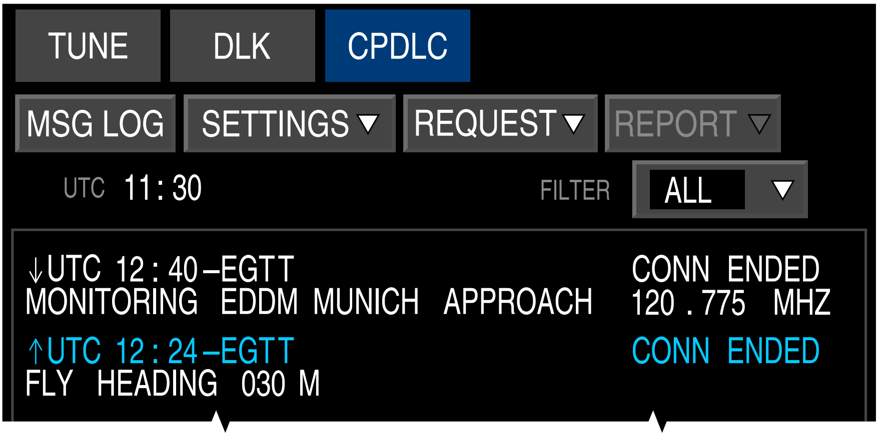
The communication inbox displays a CPDLC INHIBITED – SEE CPDLC message to advise the crew that CPDLC communication has ended and can only resume after a new successful logon.

In this situation, all OPEN messages revert to CONN ENDED.

When the CONNECTION TERMINATED message is displayed, the crew and controller must use voice communication.



CPDLC MSG LOG PAGE



CPDLC MSG LOG PAGE

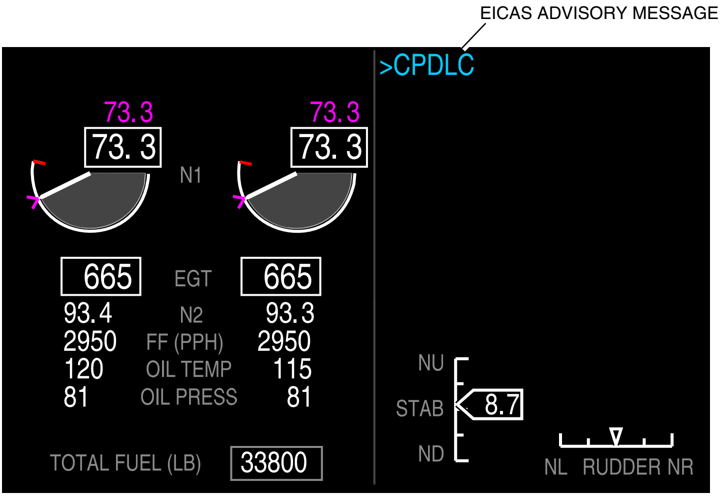
CONNECTION TERMINATED – message
Figure 05–08–42

F. CPDLC – EICAS compressed mode

When in the EICAS compressed mode (refer to Figure 05–08–43), the communication inbox and the CPDLC tile are not available. In this case, the **>CPDLC** advisory message is displayed on the EICAS page when an uplink message is received. It is accompanied by a data link aural alert. The crew must go to the CPDLC page to view the message.

NOTE

The **>CPDLC** EICAS advisory message and aural tone are inhibited during takeoff and landing.



EICAS compressed mode – CPDLC
Figure 05–08–43

G. Timeout error messages

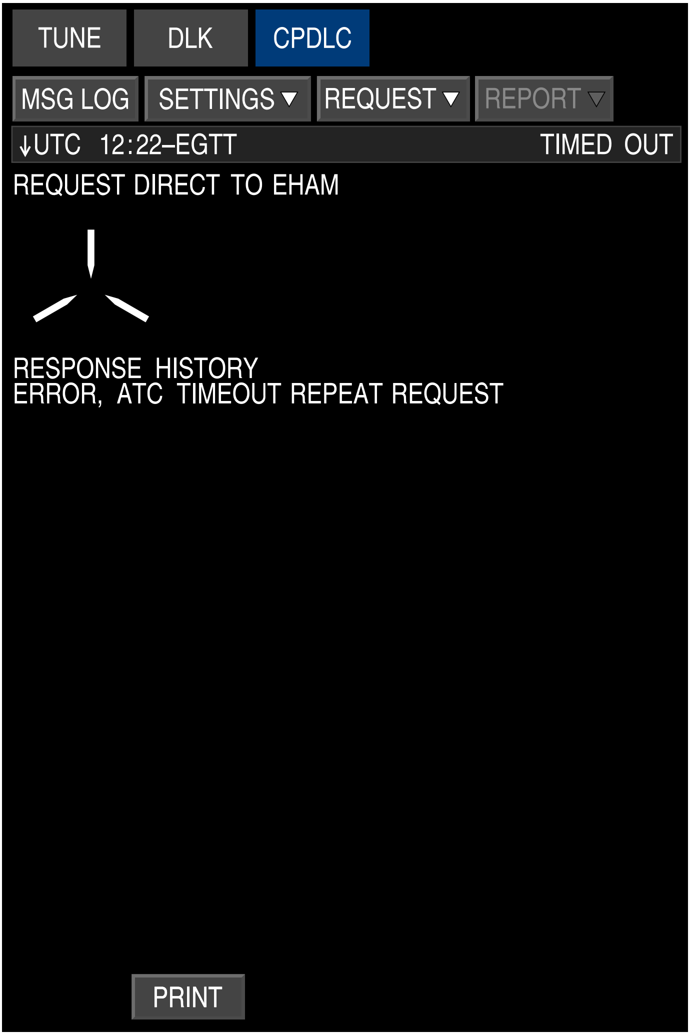
When an uplink or downlink message is not responded to in the allotted time, a timeout message is automatically generated (refer to Figure 05–08–44).

There are two common timeout error messages.

The AIR SYSTEM TIMED OUT message is automatically sent when the flight crew has failed to respond to an ATC uplink message.

The ATC TIMEOUT REPEAT REQUEST is also automatically sent when the controller fails to respond to a flight crew downlink request.

When a timeout error message is received, the flight crew or controller can resend the original message.



CPDLC MSG LOG PAGE

Timeout error message
Figure 05–08–44

COMMUNICATION – CONTROLS

The communication system controls are located on:

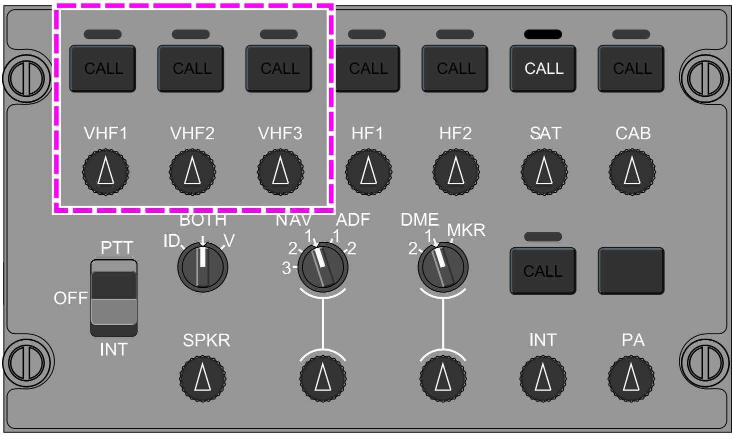
- The Audio Control Panel (ACP),
- The sidestick (toggle switch),
- The Control Tuning Panel (CTP),
- The MFW controls,
- The quick response panel,
- The interphone,
- The service and mechanic call panel,
- The refuel/defuel intercom panel, and
- The external service panel.

A. Audio Control Panel (ACP)

The flight deck is equipped with three ACPs located on the center pedestal. Each ACP (refer to Figure 05–09–1) includes the controls that follow:

- VHF1, VHF2, and VHF3 transmit and volume switches,
- HF1 transmit and volume switches, <23120001C> or <23120005C>
- HF1 and HF2 transmit and volume switches, <23120003C>
- SAT (SATCOM) transmit and volume switches, <23150006C>
- CAB (Cabin Communication) transmit and volume switches,
- PTT/OFF/INT rocker switch,
- NAVAID VOICE/ID three-position rotary switch,
- SPKR (Speaker) volume switches,
- NAV/ADF three-position rotary switch and volume switch,
- DME MKR three-position rotary switch and volume switch,
- INT (Intercom) transmit and volume switches, and

- PA (Passenger Address) transmit and volume switches.



NOTE
This view shows options that may not be installed on your aircraft.

Audio Control Panel (ACP)
Figure 05–09–1

NOTE

The ACP control panels are standard and include switches that will be inoperative if the option is not available (not purchased). In such cases, a red INOP label will identify the switches of non-purchased options that are not functioning.

(1) Volume switch

- Off – The volume switch is latched (pushed in).
- On – The volume switch is unlatched (in the raised position), and it becomes visible.

When selected on, the volume is adjusted by rotating the switch.

(2) Transmit switch

- On – When the transmit switch is pushed, the green light above it comes on and the communication channel is open.
- Off – When the transmit switch is pushed again, the green light above it goes off and the communication channel is closed.

When there is an incoming call on a channel, the CALL label on the corresponding transmit switch is illuminated on all ACPs.

NOTE

The PA does not have a CALL label light.

(a) SELCAL <23210004C>

When there is an incoming SELCAL, a tone is heard in the flight compartment, and a **SELCAL** advisory message is shown on the EICAS page.

(b) SATCOM <23150006C>

When there is an incoming SATCOM call, the SATCOM EICAS communication flag will flash for 5 seconds and stay highlighted on the EICAS page until the call is taken. A tone is heard in the flight compartment, and the **SATCOM** advisory message is shown on the EICAS page.

The SATCOM has priority levels and a precedence service which defines the order in which priorities are processed. Emergency is the highest level and public is the lowest level. The priority levels are defined as follows:

- Priority 1 – Emergency, reserved for emergency call.
- Priority 2 – Safety, ATC call with high priority.
- Priority 3 – Non-safety, ATC call with low priority or AOC call.
- Priority 4 – Public, calls not covered by priority 1 to 3.

When a SATCOM call is in progress and a higher priority call is received, the current call is preempted (cut), a tone is heard in the flight compartment and alerts for the new call are triggered after a few seconds.

NOTE

The SATCOM allows the flight crew to be notified of incoming communications even when the aircraft radios are muted.

(3) PTT/OFF/INT rocker switch

There is a rocker switch on each ACP. It has three positions:

- PTT – Allows transmission through one channel.
- OFF – Disables the intercom function of the ACP.
- INT – Activates the HOT MIC function (voice is automatically transmitted when detected).

(4) NAVAID VOICE/ID rotary switch

There is a NAVAID VOICE/ID rotary switch on each ACP. It has three positions:

- BOTH – Allows the crew to hear voice and ID.
- V – Allows the crew to listen to voice only.
- ID – Allows the crew to hear ID only.

(5) NAV/ADF rotary switch

Allows the selection of NAV1, NAV2, NAV3 (if installed), ADF1 (if installed), or ADF2 (if installed).

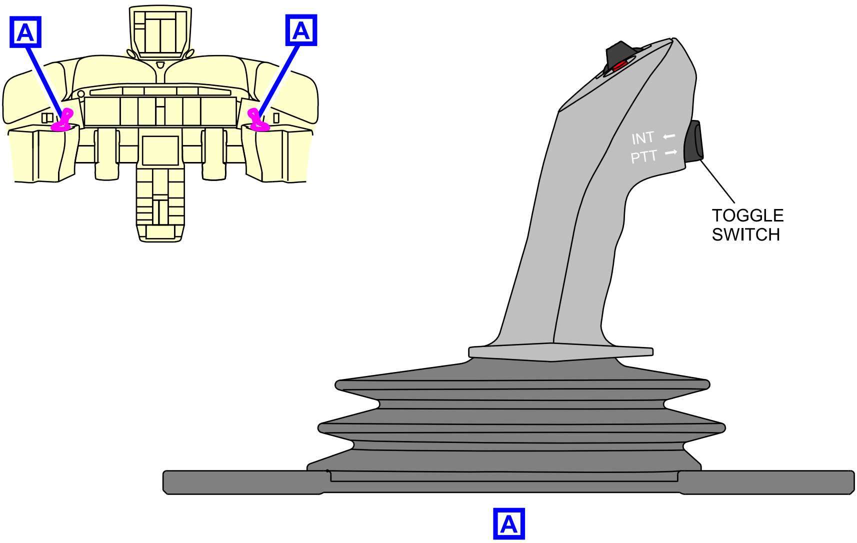
(6) DME rotary switch

Allows the selection of DME1, DME2 or MKR (Marker).

B. Sidestick (toggle switch)

The sidesticks are located on the left and right side consoles. The toggle switch (refer to Figure 05–09–2) has two positions:

- PTT – Allows transmission through one radio channel. It can be used for the intercom system only when the INT transmit switch is selected.
- INT – Activates the HOT MIC. It is used primarily for communication between the flight crew.



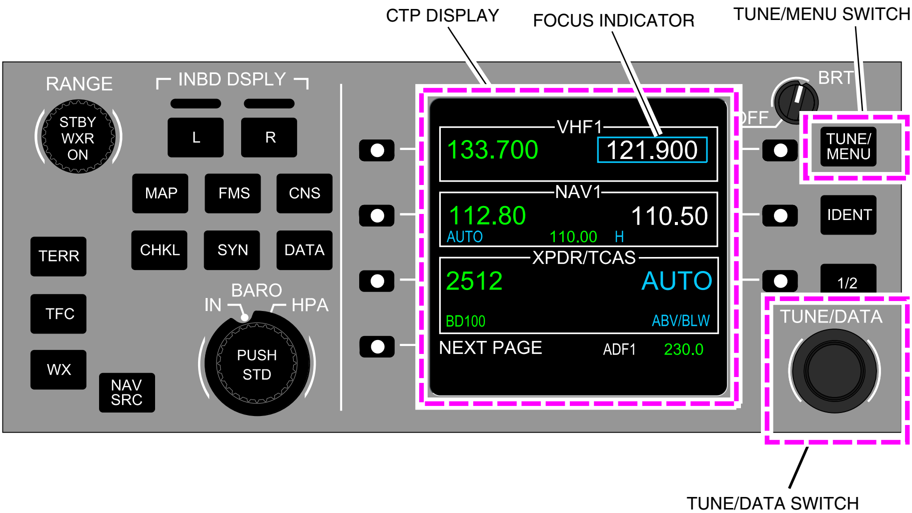
Sidestick – Toggle switch location
Figure 05–09–2

C. Control Tuning Panel (CTP) – Overview

There are two CTPs located on the glareshield. Both CTPs (refer to Figure 05–09–3) provide centralized controls, display frequency tuning, and mode selection for:

- VHF1 and VHF2 communication,
- VHF1 and VHF2 navigation,

- VHF3,
- HF1, <23120001C> or <23120005C>
- HF2, <23120003C>
- Transponder and TCAS control,
- SELCAL, <23210004C>
- CPDLC, and <23249001C>
- Data link (if installed).



Control Tuning Panel (CTP)
Figure 05–09–3

The CTP includes the communication controls that follow:

- Seven LSKs that control individual radio frequencies,
- One OFF/BRT switch,
- One TUNE/MENU switch that allows selection of the radio tuning pages,

- One IDENT switch that commands the transponder to transmit the aircraft identifier,
- One 1/2 switch, which allows cross-side radio tuning,
- One double-stack TUNE/DATA switch that allows selection/modification of the frequencies, and
- One CNS switch that displays CNS pages on the MFW.

D. Communication Navigation, and Surveillance (CNS) – TUNE page controls

The CNS – TUNE page uses the controls that follow:

- Cursor Control Panel (CCP),
- Multifunction Keyboard Panel (MKP), and
- Reversion Switch Panel (RSP).

For detailed information about these control panels, refer to Chapter 08 – Section 02 – Display system.

E. Quick-response panel <23249001C>

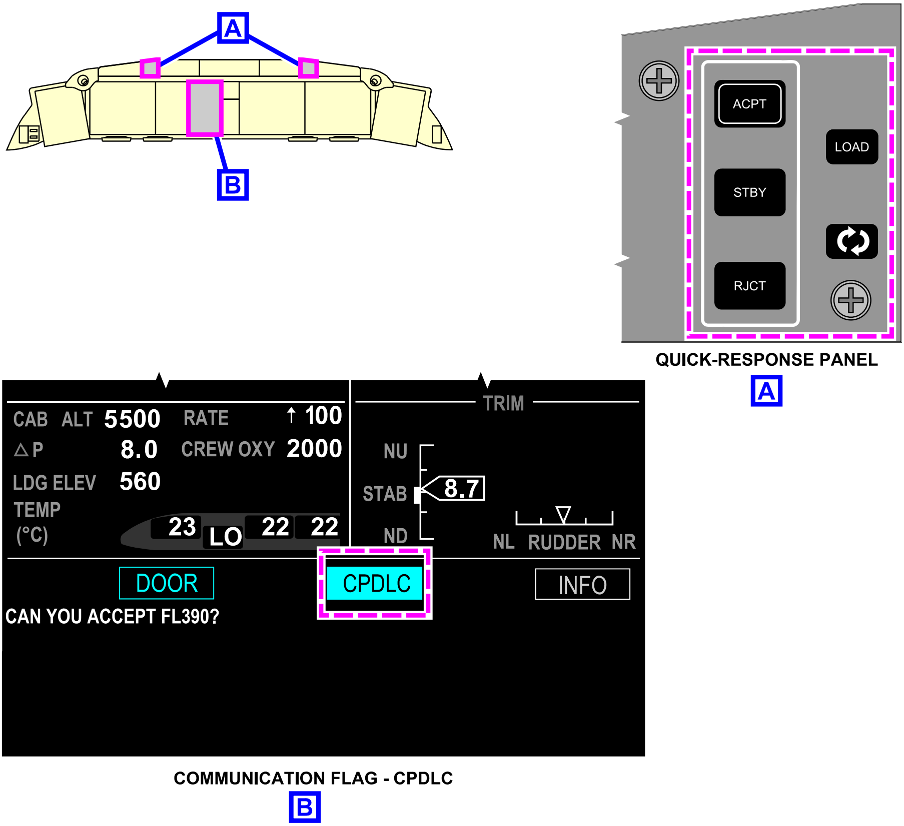
The quick-response panel (refer to Figure 05–09–4) is located on the glareshield. The switches associated with the quick-response panel are:

- ACPT – Sends responses to accept the request.
- STBY – Sends response to wait, with response to be formulated at a later time.
- RJCT – Sends response to reject the request.
- LOAD – Used to insert a loadable message (cyan) into the Flight Management System (FMS).

NOTE

When the aircraft is on ground, if a clearance message includes an origin, some FMS data will be cleared when the message is loaded in the FMS. It will be necessary for the flight crew to enter the data again. This applies for performance, fuel, wind, route and route constraints data.

- Refresh – Used to clear the inbox.

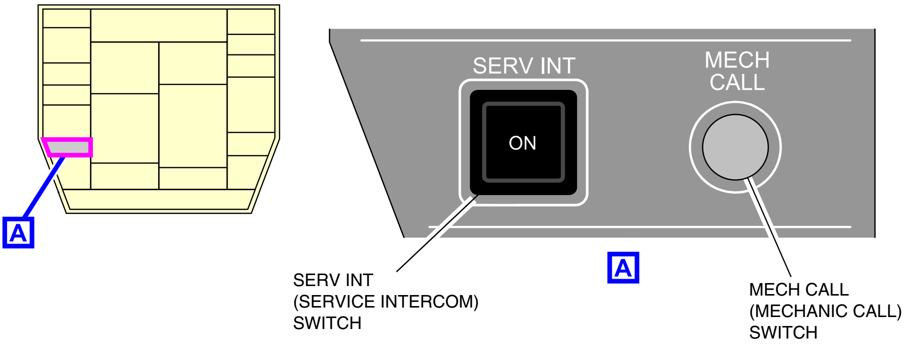


Quick–response panel <23249001C>
Figure 05–09–4

F. Service and mechanic call panel

The service and mechanic call panel (refer to Figure 05–09–5) is located on the overhead panel. It includes the controls that follow:

- SERV INT switch:
  - ON – When the SERV INT switch is pushed in, the label ON is illuminated on the switch and the flight compartment intercom and all the service and maintenance intercom systems are opened (HOT MIC).
  - Off – The SERV INT switch is black when it is not selected and only the flight compartment, the external panel, and the refuel/defuel intercom systems are open.
- MECH CALL switch – Initiates a call horn in the external service panel area.



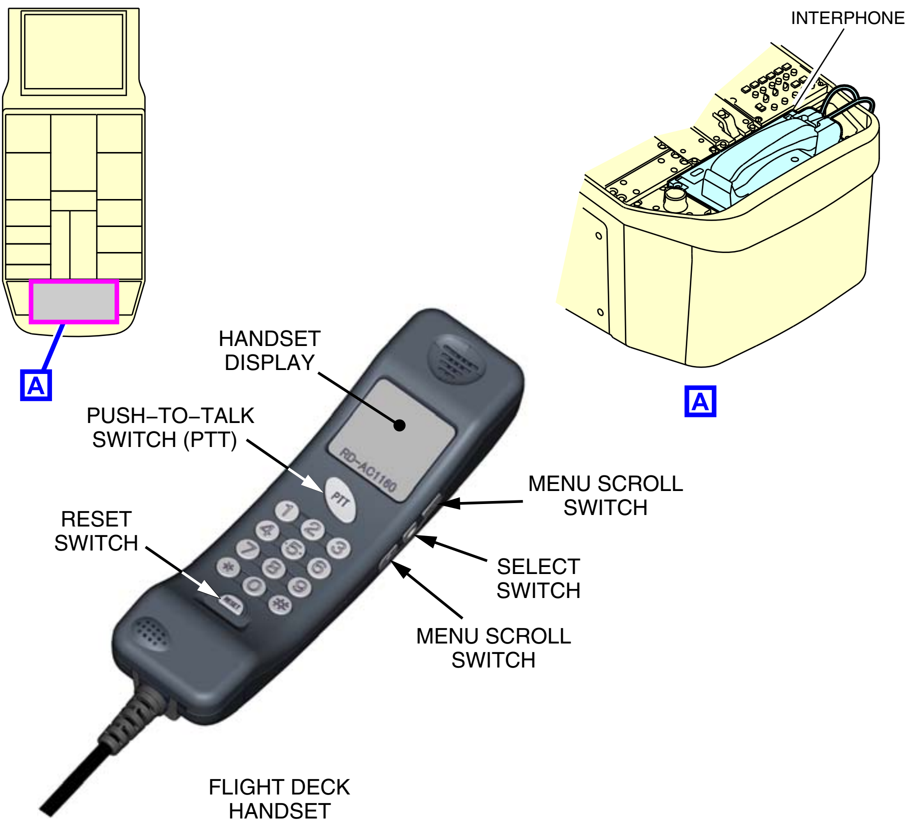
Service and mechanic call panel
Figure 05–09–5

G. Interphone

The flight compartment interphone is located at the end of the center pedestal (refer to Figure 05–09–6). It can be used for:

- Cabin communication,
- Intercom, and

- PA.



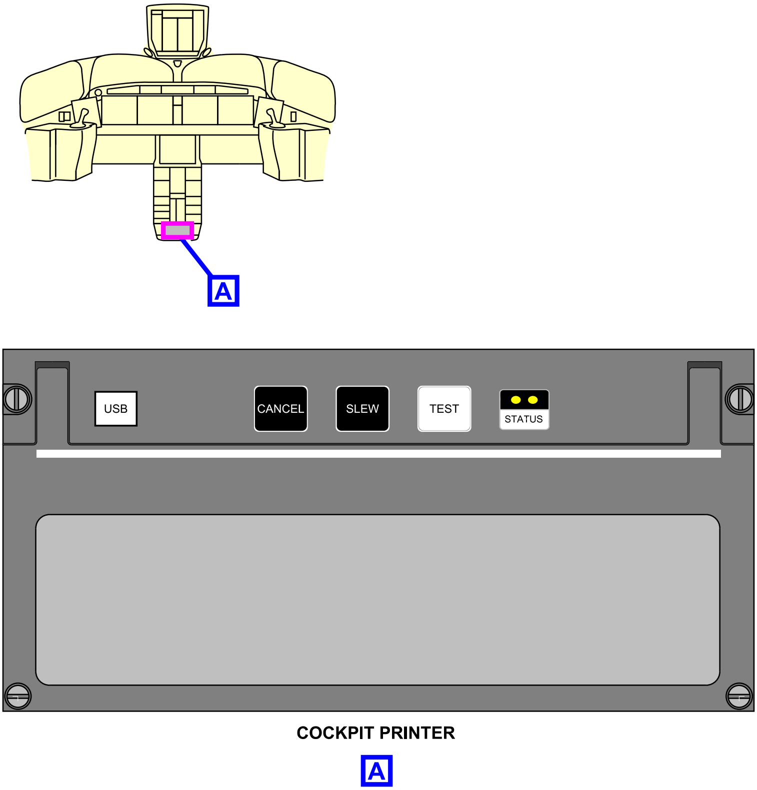
Interphone
Figure 05–09–6

H. Flight deck printer <23220001C>

The flight deck printer is a thermal printer that prints on 215.90 mm (8.50 in.) wide paper. It is located at the end of the center pedestal (refer to Figure 05–09–7). It has a USB port, and the four switches that follow:

- CANCEL,

- SLEW,
- TEST, and
- Status.



Flight deck printer <23220001C>
Figure 05–09–7

The Printer Server Application (PSA) provides printing capability for the flight compartment.

The flight deck printer prints from the sources that follow:

- Very High Frequency (VHF) transceiver for DLK messages,

- Onboard Maintenance System (OMS) for maintenance data, and
- Integrated Flight Information System (IFIS) for charts.

COMMUNICATION – INDICATIONS

A. Indications – Overview

The communication system indications are located on:

- The Control Tuning Panels (CTP),
- The Multifunction Windows (MFW and TUNE page), and
- The EICAS page.

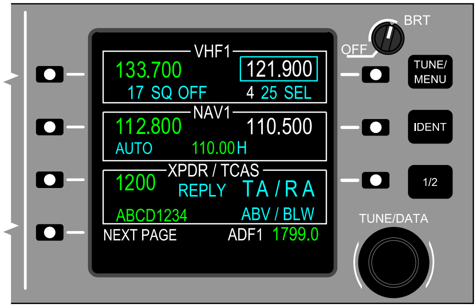
B. Control Tuning Panel (CTP)

There are two CTPs located on the glareshield. Each CTP includes a display that provides the communication information that follows:

- VHF1 and VHF2 communication,
- VHF1 and VHF2 navigation,
- VHF3,
- HF1, <23120001C> or <23120005C>
- HF1 and HF2, <23120003C>
- SELCAL, <23210004C>
- CPDLC, <23249001C>
- Transponder and TCAS control, and
- Data link.

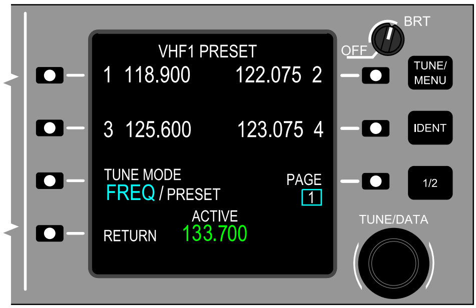
The CTP communication indications have a three-level structure and use the pages (refer to Figure 05–09–8) that follow:

- Top level pages,
- Control pages, and
- Preset pages.



TOP LEVEL PAGE

CONTROL PAGE



PRESET PAGE

CTP pages
Figure 05–09–8

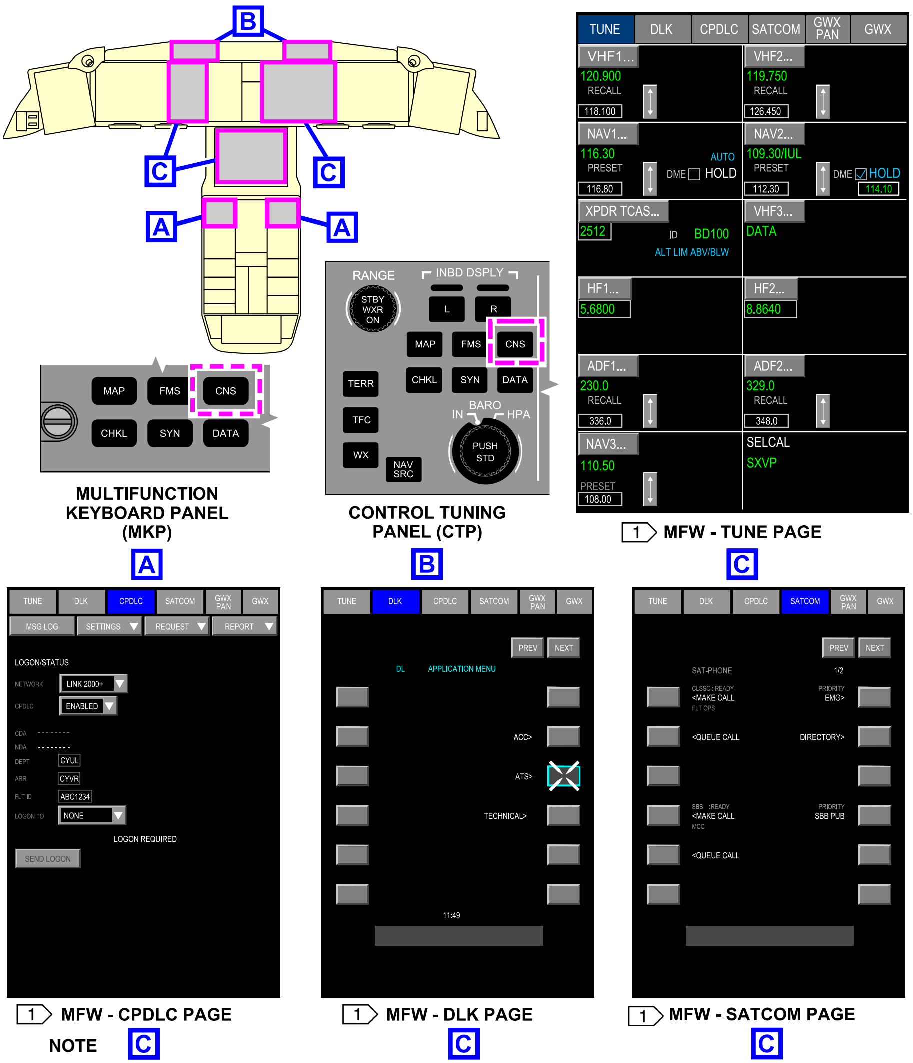
For detailed information about CTP tuning, refer to Chapter 05 – Section 03 – Radio tuning.

C. MFW – CNS – TUNE pages

The Multifunction Windows (MFWs) include the communication pages (refer to Figure 05–09–9) that follow.

- TUNE,
- DLK,
- CPDLC, <23249001C>
- SATCOM, <23150006C>
- GWX.

They are accessible by pushing the CNS switch on the CTP or the MKP. Successive pushes of the CNS switch allow navigation through the CNS pages.



NOTE

1 This view shows options that may not be installed on your aircraft.

CNS switch with TUNE, DLK, CPDLC, and SATCOM pages
Figure 05–09–9

When a CPDLC message is received in the inbox of the EICAS page, the first push of the CNS switch shows the CPDLC page directly on the MFW. <23249001C>

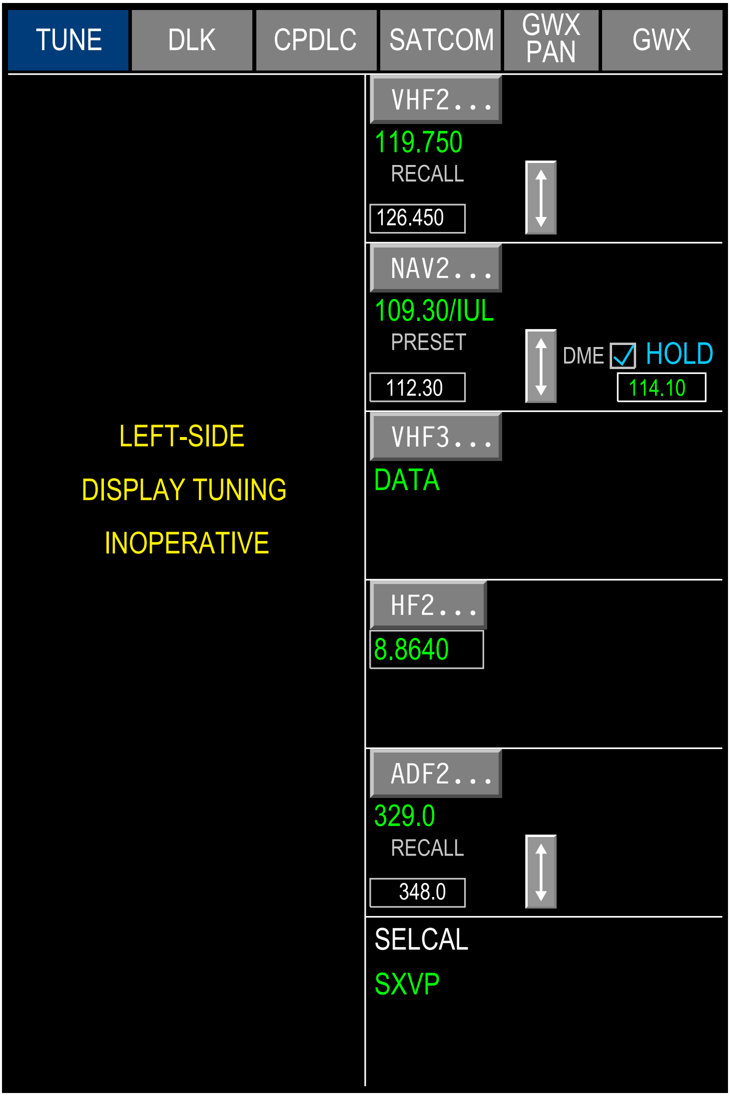
The loss of display tuning capability for all radio systems is indicated by the removal of all radio main displays and an amber DISPLAY TUNING INOPERATIVE message is displayed on the tuning quarter window (refer to Figure 05–09–10).

NOTE

This view shows options that may not be installed on your aircraft.

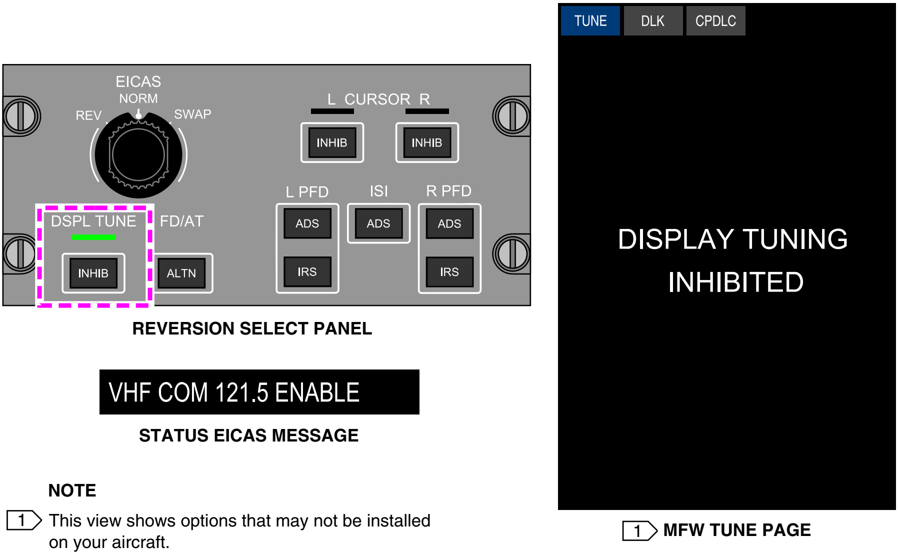
TUNE page – DISPLAY TUNING INOPERATIVE message
Figure 05–09–10

When tuning capability of the left-side or right-side radio is lost, the associated VHF, NAV, HF, and ADF areas are blanked out and an amber LEFT-SIDE (RIGHT-SIDE) DISPLAY TUNING INOPERATIVE message is displayed (refer to Figure 05–09–11). <23129001C>



CNS – TUNE page – Tuning capability lost (left–side)
Figure 05–09–11

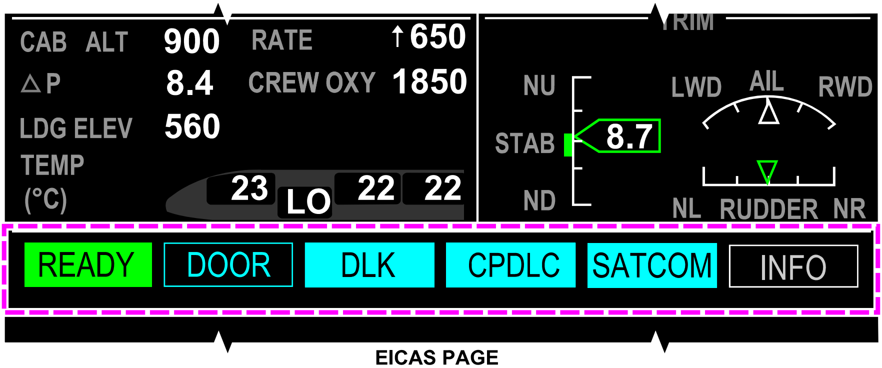
The DSPL TUNE INHIB switch, located on the Reversion Select Panel (RSP), inhibits the display tuning. When pushed, it will cause a white DISPLAY TUNING INHIBITED message to be displayed (refer to Figure 05–09–12). When display tuning is inhibited and both CTPs are turned off (with their respective OFF/BRT switch), VHF1 and VHF2 are automaticity tuned to 121.5 MHz for emergency communication, and the status message **VHF COM 121.5 ENABLE** is displayed on the EICAS page.



TUNE page – Display tuning inhibited
Figure 05–09–12

D. Communication flags

The communication flags appear at the bottom of the EICAS page (refer to Figure 05–09–13).



EICAS PAGE

Communication flags
Figure 05–09–13

The table that follows describes the possible communication flag displays.

COMMUNICATION FLAGS	
SYMBOL	**DESCRIPTION**
READY (green)	Cabin is ready for takeoff or landing (no sound).
CABIN (cyan)	Cabin is calling in normal situation. A tone is heard in the flight compartment and the CALL label is illuminated on the CAB transmit switch.
CABIN (amber)	Cabin is calling for a priority situation. An associated tone is heard in the flight compartment and the CALL label flashes on the CAB transmit switch.

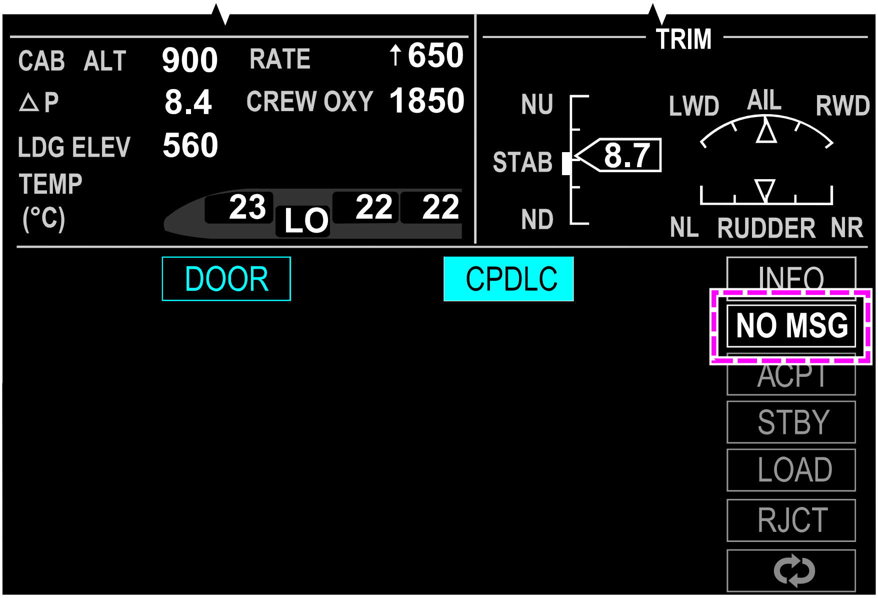
COMMUNICATION FLAGS	
SYMBOL	**DESCRIPTION**
DLK (cyan)	Signals a new Airline Operational Communication (AOC) message. It flashes for 5 seconds, and then becomes steady. A tone is heard in the flight compartment.
CPDLC (cyan) <23249001C>	Signals an incoming Controller–Pilot Data Link Communications (CPDLC). It flashes for 5 seconds, and then becomes steady to announce an incoming CPDLC uplink message from ATC. A tone is heard in the flight compartment 10 seconds after the CPDLC message has been received if no action have been taken.
SATCOM (cyan) <23150006C>	Signals an incoming ground-to-air voice call. It flashes for 5 seconds, and then becomes steady. An aural alert is heard in the flight compartment.
SATCOM (cyan text in full cyan box) <23150006C>	Ongoing SATCOM call from ground to air or air to ground (no sound).
SATCOM (cyan text in doted cyan box) <23150006C>	On-hold SATCOM call from ground to air or air to ground (no sound).

E. Communication inbox <23249001C>

The Controller–Pilot Data Link Communications (CPDLC) system uses the communication inbox to show received messages. The inbox is completely black when no CPDLC messages are available.

The communication inbox is at the bottom of the EICAS page (refer to Figure 05–09–14), and can show the generic messages that follow:

- NO MSG,
- CPDLC INHIBITED – SEE CPDLC,
- PRIOR OPEN MESSAGE – SEE CPDLC, and
- NO ATC COMM.



EICAS PAGE

Communication inbox – NO MSG
Figure 05–09–14

The PRIOR OPEN MESSAGE – SEE CPDLC message is shown when the flight crew has not replied to messages received before the one displayed.

The RESPONSE NOT SUPPORTED – SEE CPDLC message is shown on the fourth line in the EICAS communication inbox when the received CPDLC uplink message is too long to be displayed in the area. The first three lines in the inbox show the beginning of the message. The contents of the full message is available from the Message Log page.

The NO ATC COMM message is shown when communication with ATC is lost.

The flight crew is able to quickly answer a request or a clearance from the quick-response panel located on the glareshield or on the CPDLC pages.

NOTE

The EICAS communication inbox provides an overview of incoming messages. It does not indicate all crew required actions. Some messages are excluded from the inbox display logic. The crew is required to process all messages from the CPDLC pages and must not use the quick-response panel until the Message Log in the CPDLC pages has been viewed.

F. CPDLC – Description of specific messages <23249001C>

(1) **DATALINK STATUS** EICAS advisory message

The **DATALINK STATUS** EICAS advisory message indicates a change in the status of the Data Link (DLK) system.

Specifically, this message is displayed for the conditions that follow:

- Logon timeout,
- Logon data update (e.g. flight ID),
- ATN transition (e.g. not available to available), <23240001C>
- ATN disconnect, <23240001C>
- CPDLC connection established or terminated, and
- DLK system status change (e.g. standby to active).

This message may indicate that the LINK 2000+ system is inoperative. The crew should refer to the CPDLC LOGON/STATUS page to determine the current system status. <23240001C>

(2) **DATALINK FAIL** EICAS advisory message

The **DATALINK FAIL** EICAS advisory message alerts the flight crew to an onboard equipment failure.

This message indicates that the DLK system has detected a failure that makes all data link systems inoperative (Link 2000+, ACARS, and FANS-1/A+).

LINK 2000+ operation is inhibited until this failure has been corrected. <23240001C>

The flight crew and controller must use voice communication.

(3) CPDLC INHIBITED – SEE CPDLC message

After an initial logon, if the LINK 2000+ system is disabled the CPDLC INHIBITED message is displayed. <23240001C>

The CPDLC INHIBITED – SEE CPDLC message is displayed in the communication inbox. Refer to Figure 05–09–15.

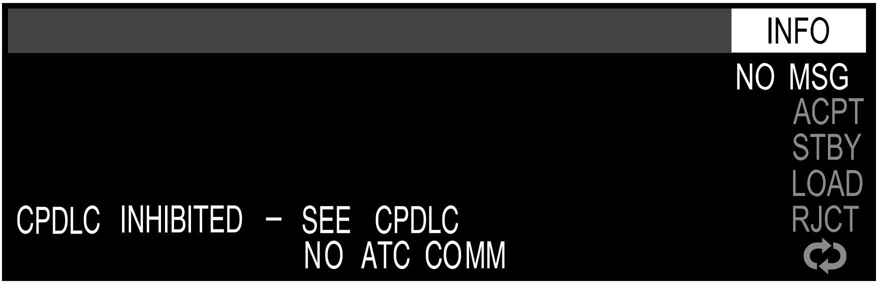
This message directs the user to the CPDLC LOGON/STATUS page to try another logon.

This message is also posted when downlink actions are disabled due to any of the conditions that follow:

- A communication is in progress (when waiting for a network acknowledgement after a downlink message is sent).
- A transfer of communication (CDA/NDA) message is in progress.
- The logon data is updated. The **DATALINK STATUS** EICAS advisory message is also displayed.

While CPDLC is inhibited, the keys on the quick-response panel are disabled, and, if a downlink is composed, the SEND button is disabled.

EICAS MESSAGE



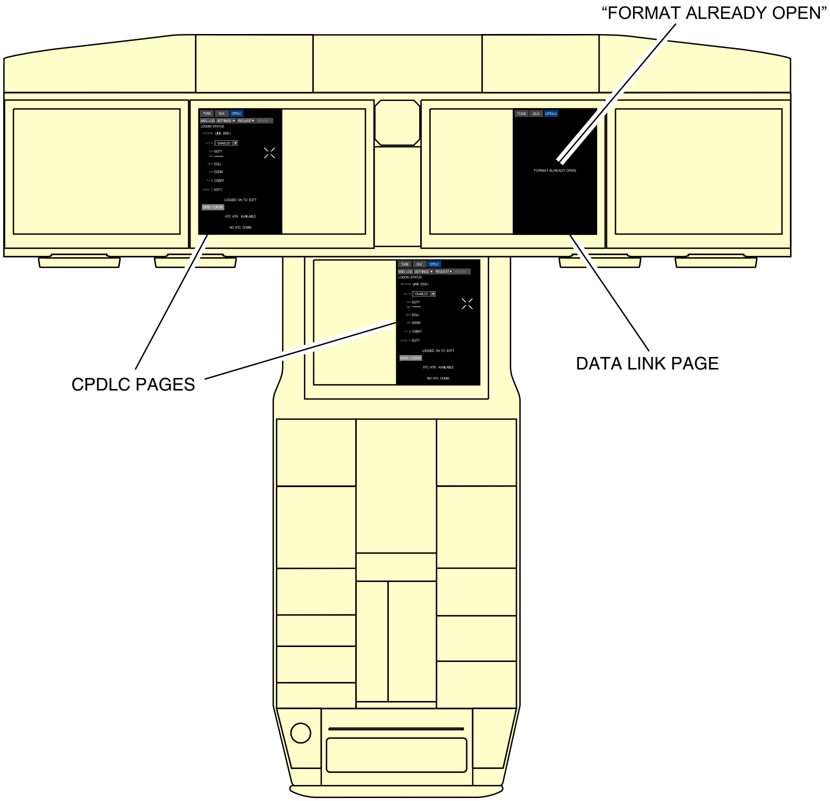
COMMUNICATION SECTION

CPDLC INHIBITED – SEE CPDLC message <23249001C>
Figure 05–09–15

(4) FORMAT ALREADY OPEN message

Only one CPDLC page can be open on the pilot or copilot side of the flight deck. A single page can be displayed on both sides at the same time, but any changes made in one will immediately be reflected in the other.

If an attempt is made to display two CPDLC pages on the same side, the FORMAT ALREADY OPEN message will be displayed on the Multifunction Window (MFW). Refer to Figure 05–09–16.



FORMAT ALREADY OPEN message <23249001C>
Figure 05–09–16

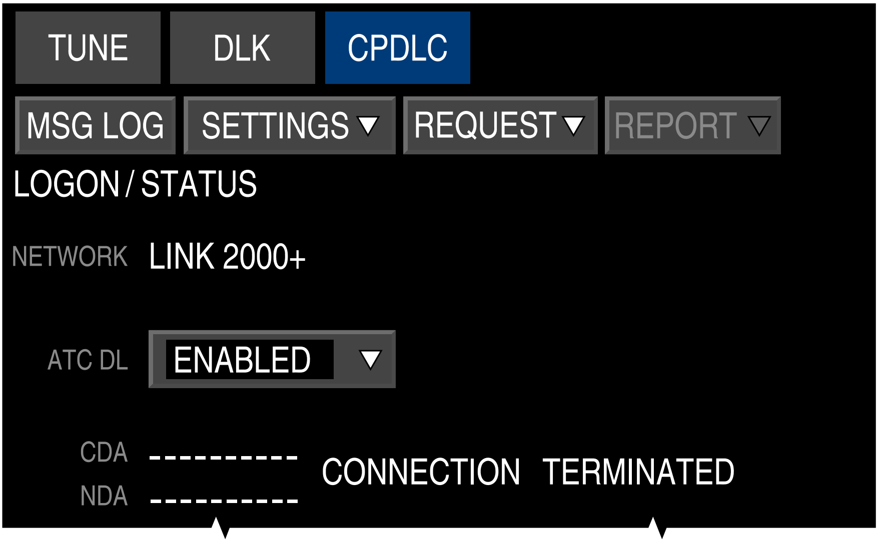
(5) CONNECTION TERMINATED message

The CONNECTION TERMINATED message is displayed on the CPDLC status label when an uplink end service message is received or a CPDLC connection has been terminated due to loss of the ATN network. <23240001C>

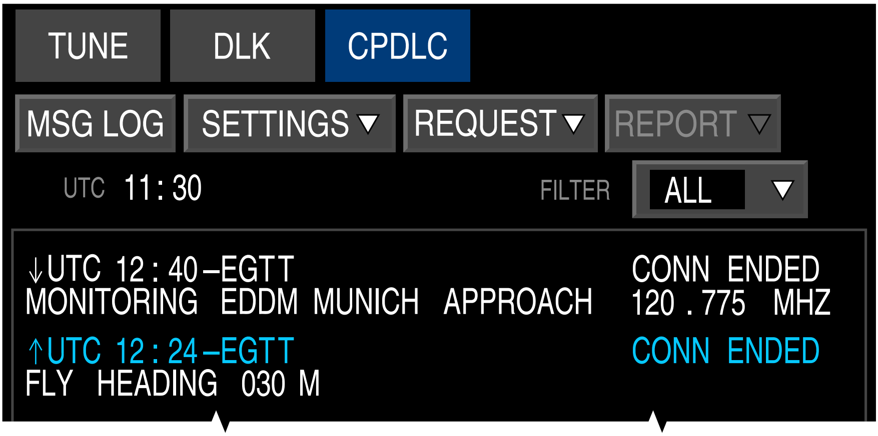
The communication inbox displays a CPDLC INHIBITED–SEE CPDLC message to advise the flight crew that CPDLC communication has ended and can only resume after a new successful logon.

In this situation, all OPEN messages revert to CONN ENDED.

When the CONNECTION TERMINATED message is displayed (refer to Figure 05–09–17), the crew and controller must use voice communication.



CPDLC MSG LOG PAGE



CPDLC MSG LOG PAGE

CONNECTION TERMINATED – message <23249001C>
Figure 05–09–17

(6) Timeout error messages

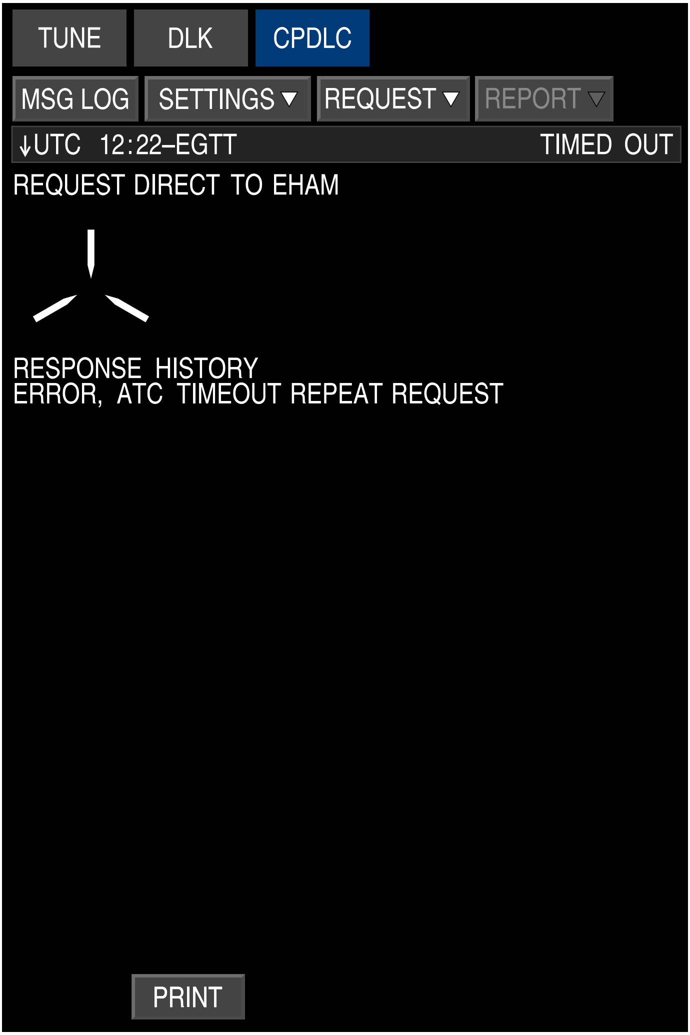
When there has been no response to an uplink or downlink message in the allotted time, a timeout message is automatically generated.

There are two common timeout error messages.

The AIR SYSTEM TIME-OUT message is automatically sent when the flight crew has failed to respond to an ATC uplink message.

The ATC TIMEOUT REPEAT REQUEST message (refer to Figure 05–09–18) is also automatically sent when the controller fails to respond to a flight crew downlink request.

When a timeout error message is received, the flight crew or controller can resend the original message.



CPDLC MSG LOG PAGE

Timeout error message <23249001C>
Figure 05–09–18

G. CNS – CPDLC page – Soft switches <23249001C>

Which soft switches are shown depends on the selected CPDLC page (MSG LOG, SETTINGS, REQUEST, or REPORT).

The soft switches are:

(1) SET soft switch

When the SET soft switch is selected for the first time, the system displays the message to be sent to ATC for confirmation. Subsequent selections will update the text.

(2) CLEAR soft switch

When the CLEAR soft switch is selected, it erases the message or a part of the message that needs to be deleted.

(3) SEND soft switch

When the SEND soft switch is selected for a downlink message, it transmits the message and moves it to the MSG LOG page. When the SEND soft switch is selected for an uplink message, it starts the transmission of the message, which stays on the response page.

(4) CANCEL soft switch

When the CANCEL soft switch is selected, it stops the message composition and moves it to the MSG LOG page. The cursor is automatically positioned on the topmost message of the MSG LOG page. If a canceled message is opened, its default values are reset.

(5) ACCEPT soft switch

When the ACCEPT soft switch is selected, it sends an acceptance notice to ATC. It also changes the status of the message to CLOSED.

(6) REJECT soft switch

When the REJECT soft switch is selected, it rejects the message with a rejection reason entered (if required) and the message status is changed to CLOSED.

(7) STANDBY soft switch

When the STANDBY soft switch is selected, it sends a standby response to ATC and changes the status message to STANDBY. If the transmission message is already started, it puts it on hold.

(8) LOAD soft switch

When the LOAD soft switch is selected, the highlighted parameters in the message body are loaded to the FMS. Feedback is provided whether the parameters are loaded correctly or not.

NOTE

When the aircraft is on ground, if a clearance message includes an origin, some FMS data will be cleared when the message is loaded in the FMS. It will be necessary for the flight crew to enter the data again. This applies for performance, fuel, wind, route and route constraints data.

(9) EXPAND soft switch

The EXPAND soft switch allows the flight crew to alternate between the expansion and the contraction of the message log shown. When the EXPAND soft switch is selected for the first time, it expands each message fully. Selecting it a second time contracts each message to show only the first line.

(10) PRINT soft switch <23220001C>

When the PRINT soft switch is selected, it prints the complete contents of the associated page on the flight deck printer. The printed content for each message includes the header and all conversations related to the message at the time the PRINT soft switch is selected.

COMMUNICATION – EICAS MESSAGES

A. Warning messages

None

B. Caution messages

Message	Description	Inhibit
AURAL WARN FAIL	Channel B on both RIUs failed.	TO, LDG
KU BAND ON <44309210C>	The INLET switch is selected to OFF and the Ku-band system is powered or status is unknown while on the ground.	TO, LDG
L CTP TUNING FAIL	L RIU channel B failure leading to L CTP not capable of tuning left side radio.	TO, LDG
L-R RADIO TUNING FAIL	Four channels of RIU failed, leading to only emergency audio available.	TO, LDG
R CTP TUNING FAIL	R RIU channel B failure leading to L CTP not capable of tuning left side radio.	TO, LDG

C. Advisory messages

Message	Description	Inhibit
AUDIO PNL 1 FAIL	ACP1 failed.	TO, LDG
AUDIO PNL 2 FAIL	ACP2 failed.	TO, LDG
>CPDLC <23249001C>	CPDLC message received (only in compressed mode).	TO, LDG
DATALINK FAIL <23249001C>	Datalink system (CMU) failed.	TO, LDG
DATALINK STATUS <23249001C>	No communication currently available to send/receive data.	TO, LDG
>DLK	DLK message received (only in compressed mode).	TO, LDG

Message	Description	Inhibit
SATCOM FAIL <23150004C>	SATCOM system failed (data).	TO, LDG
SATCOM NO SIGNAL <23150004C>	SATCOM coverage lost (data).	TO, LDG
SATCOM DATA FAIL <23150006C>	SATCOM data function failed.	TO, LDG
SATCOM FAIL <23150006C>	SATCOM system failed (voice and data).	TO, LDG
SATCOM NO SIGNAL <23150006C>	SATCOM signal is not available for voice and data.	TO, LDG
SATCOM VOICE FAIL <23150006C>	SATCOM voice function failed.	TO, LDG
SAT VOICE NO SIGNAL <23150006C>	SATCOM signal is not available for voice or Iridium SIM card issue.	TO, LDG
SELCAL <23210004C>	SELCAL incoming audio request received on either VHF or HF radios.	TO, LDG
CABIN COM FAULT	Loss of either PA/intercom through audio control panel or loss of PA/intercom through handset	TO, LDG

D. Status messages

Message	Description	Inhibit
AURAL WARN INHIBIT	Aural warning system has been disabled by the flight crew.	None
CTP OVERRIDE	L or R CTP override through Avionics synoptic page.	None
DSPL TUNE INHIB	Left or right display tune inhibited.	None

Message	Description	Inhibit
VHF COM 121.5 ENABLE	VHF operating in emergency mode.	None
VHF3 IN VOICE	VHF3 selected in voice mode by flight crew.	None

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CHAPTER 6 – DOORS

GENERAL

MAIN DOORS

EMERGENCY EXIT DOORS

CARGO DOORS

List of figures

DOORS – INDICATIONS

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DOORS – OVERVIEW

There are 12 external doors (refer to Figure 06–01–1) on the aircraft: <52201001D>

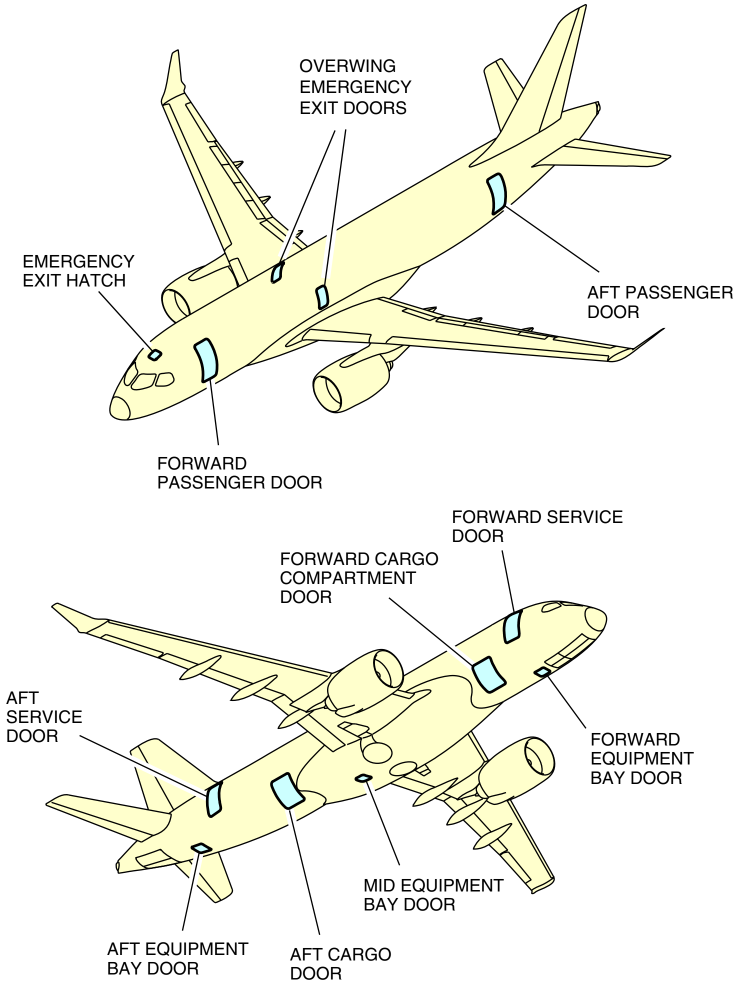
- Four main doors (two passenger and two service doors),
- One flight crew emergency exit hatch,
- Two overwing emergency exit doors, <52201001D>
- Two cargo doors, and
- Three equipment bay doors.

Additionally, there is one reinforced flight compartment door (with a surveillance camera, if installed).

All doors are equipped with operating mechanisms. Designated doors are equipped with proximity sensors.

The proximity sensors are monitored and evaluated by the Landing Gear Steering Control Units (LGSCUs). The LGSCUs provide the flight crew with door status on the DOOR synoptic page and EICAS messages.

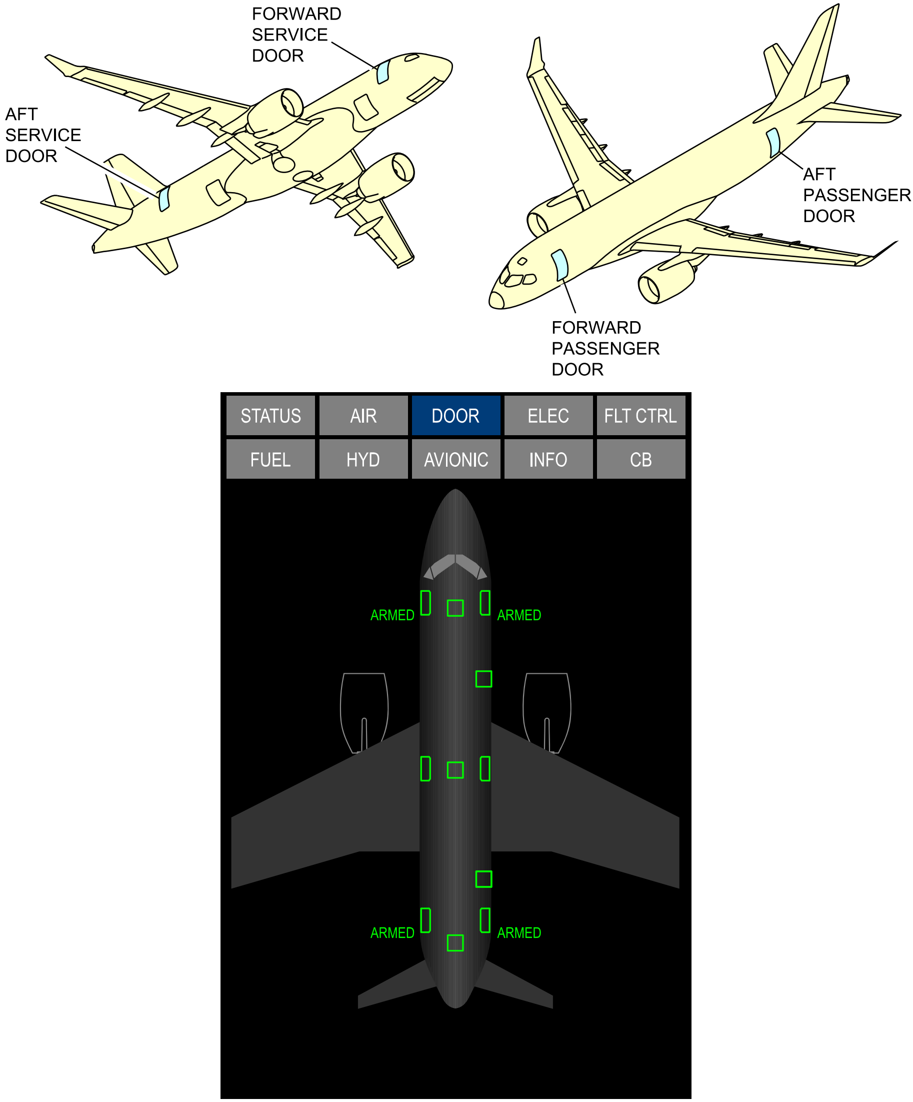
With the exception of the flight crew emergency exit hatch and the reinforced flight compartment door, all door status indications are displayed on the DOOR synoptic page. Status and fault messages are reported on the EICAS page.



Door locations <52201001D>
Figure 06–01–1

MAIN DOORS – OVERVIEW

There are four plug-type main doors: two passenger doors on the left side (FWD and AFT) and two service doors on the right side (FWD and AFT) (refer to Figure 06–02–1 <52201001D>). They are qualified as emergency exits. Each door structure has a pressure and aerodynamic seal to keep internal pressure and to close the gap between the doors and the fuselage.



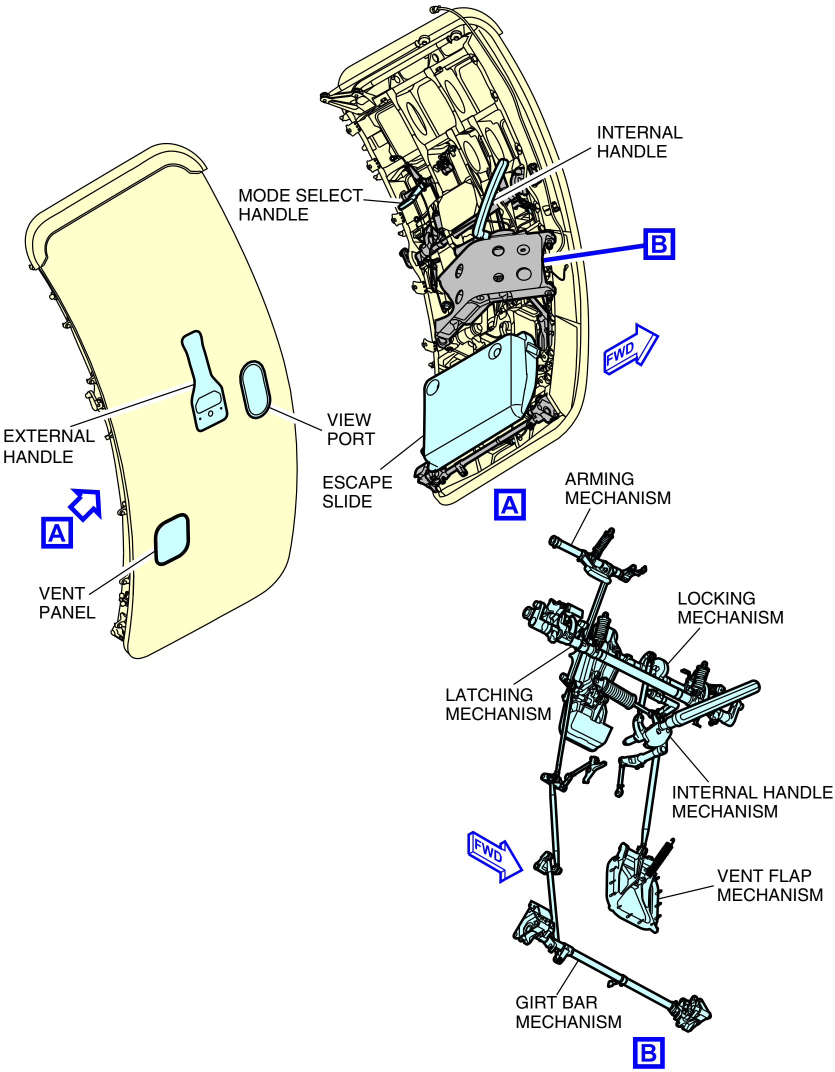
Passenger and service door locations <52201001D>
Figure 06–02–1

The passenger and service doors are Type C and can be operated from inside or outside the aircraft. Normal operation is done manually.

The four main doors have similar mechanisms and operating principles but have different geometries and sizes (refer to Figure 06–02–2).

Each door is equipped with the mechanisms that follow:

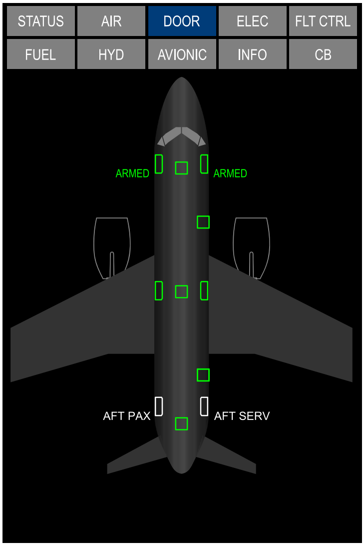
- Locking mechanism,
- Arming mechanism,
- Latching mechanism,
- Vent flap mechanism,
- Internal and external handle mechanism,
- Damper actuator (opening assist mechanism),
- Girt bar mechanism, and
- Three visual indicators.



Passenger and service door mechanisms
Figure 06–02–2

Each door is equipped with proximity sensors to monitor its position. The sensors are monitored and evaluated by the Landing Gear Steering Control Units (LGSCUs) for status and fault indications on the DOOR synoptic page, EICAS page, and Cabin Management System (CMS) refer to Figure 06–02–3 <52201001D>.

EICAS ADVISORY MESSAGES



DOOR SYNOPTIC PAGE

CMS

Doors and slide status <52201001D>
Figure 06–02–3

MAIN DOORS – DESCRIPTION AND OPERATION

A. Visual indicator

Each passenger and service door is equipped with the three visual indicators that follow:

- A door mechanical locking indicator,
- A differential pressure indicator (overpressure light), and
- A slide mechanical arming indicator.

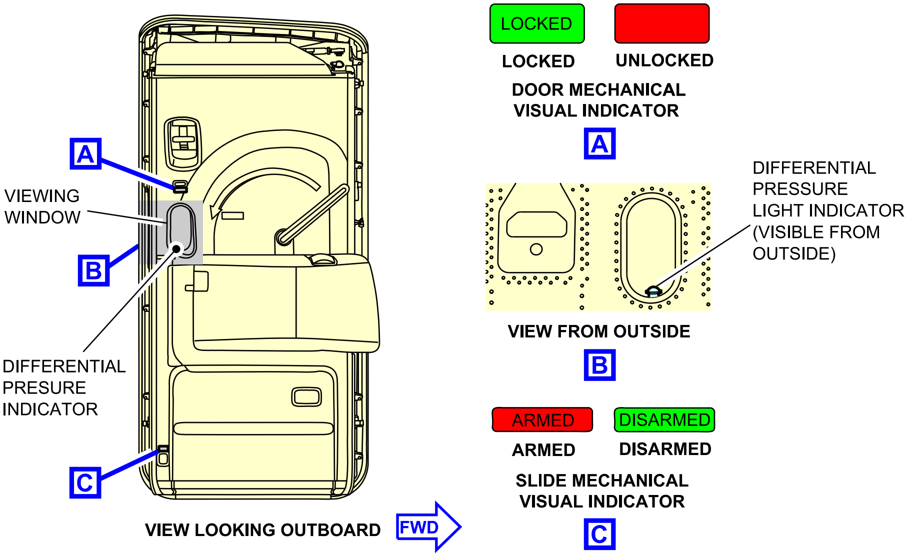
The door mechanical locking indicator is located under the mode select handle. It shows if the door is LOCKED (green) or UNLOCKED (red).

The differential pressure indicator is located at the bottom of the door viewport, and can be seen from inside and outside the aircraft. When the light flashes, it indicates that the differential pressure between the inside and the outside of the aircraft is too high.

The slide mechanical indicator is located at the bottom of the door. When the mode select handle is in the disarmed position (handle up), the DISARMED label (green) shows. The girt bar mechanism and the slide will remain stowed if the door is opened.

When the mode select handle is in the armed position (handle down), the ARMED label (red) shows. If the door is opened, the evacuation slide will deploy.

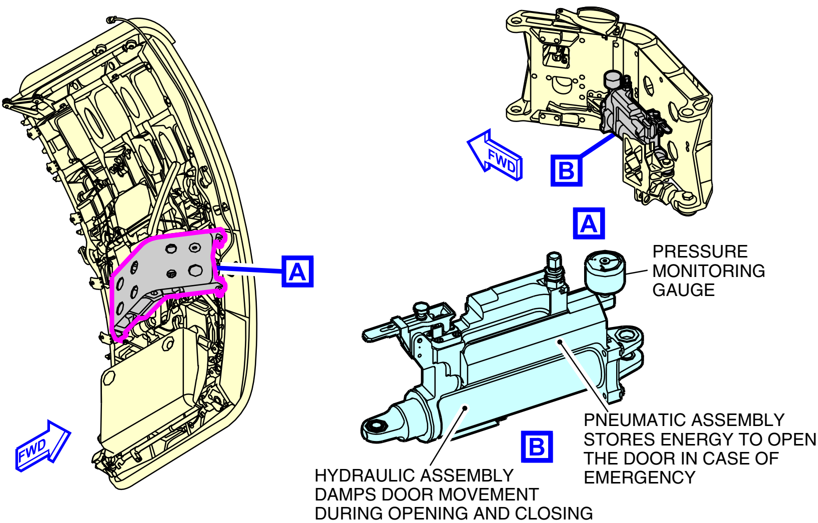
Figure 06–02–4 shows the visual indicator locations on the main doors.



Service and passenger door visual indicator
Figure 06–02–4

B. Opening assist mechanism

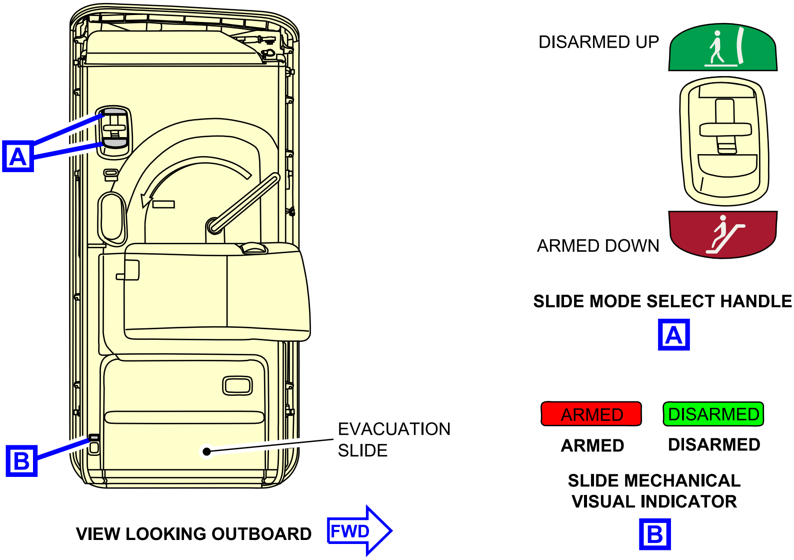
The opening assist mechanism is installed in the hinge arm of each main door (refer to Figure 06–02–5). When the door is disarmed, a hydraulic actuator limits the door speed during normal opening and closing to protect the crew and passengers from door acceleration and to prevent damage to the structure. When the door is armed, a pneumatic actuator opens the door to deploy the evacuation slide during emergency situations.



Main door opening assist mechanism location
Figure 06–02–5

C. Mode select handle

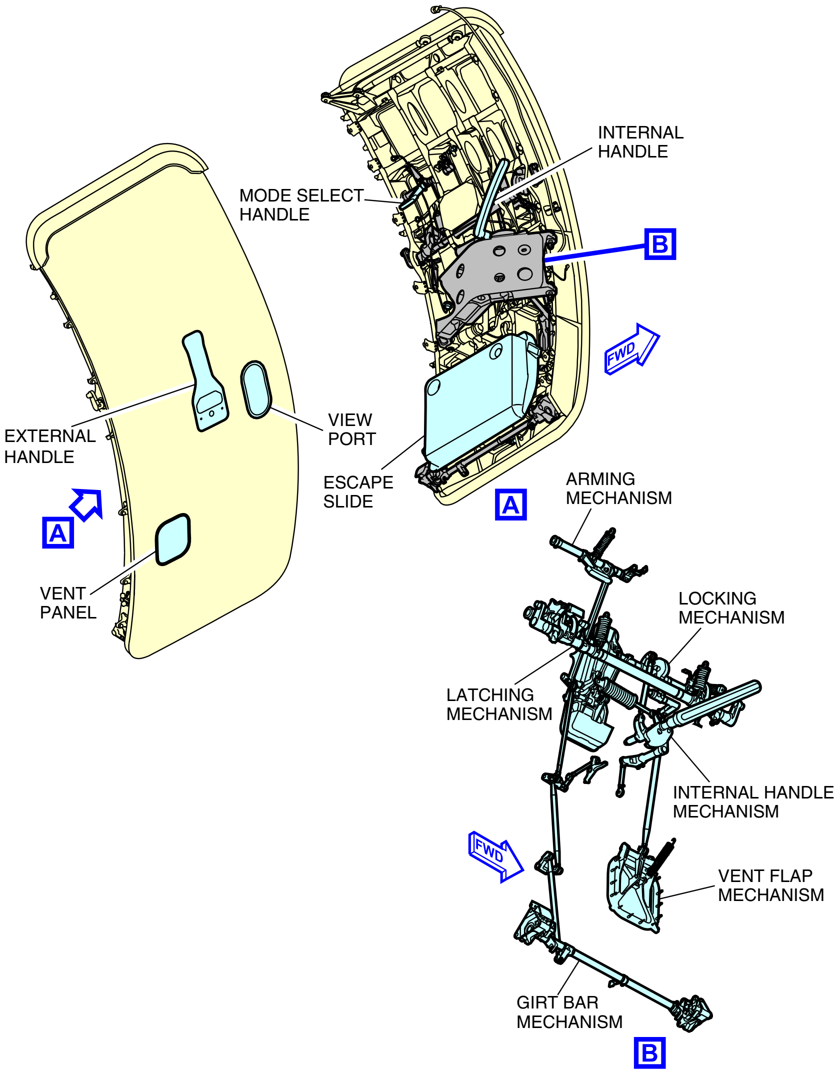
The mode select handle is used to arm and disarm the main door escape slides (refer to Figure 06–02–6). When the handle is in the disarmed position, it deactivates the escape slide and allows the door to open normally. When the handle is in the armed position, it arms the escape slide deployment mechanism. If the door is opened when the mechanism is armed, the evacuation slide deploys automatically.



Mode select handle and interior handle
Figure 06–02–6

D. Girt bar mechanism

The girt bar mechanism is used to arm or disarm and to deploy the escape slide. The mechanism is disarmed when the girt bar is retracted from the fuselage and armed when it is connected to the fuselage. The slides are automatically disengaged from the girt bar when the door opens from the outside (refer to Figure 06–02–7).

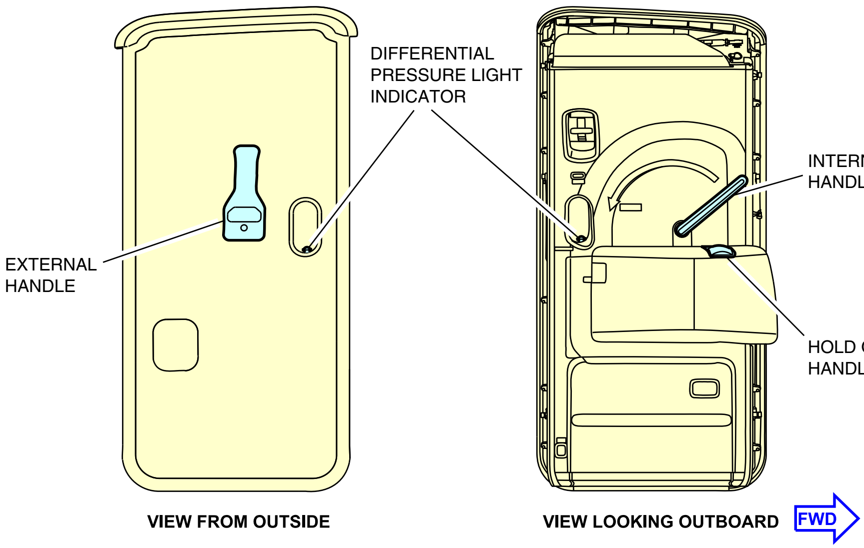


Passenger and service door mechanisms
Figure 06–02–7

E. Internal and external handles

The main door handles are used to open and close the passenger and service doors, from inside and outside the aircraft (refer to Figure 06–02–8). Each main door includes:

- One external handle,
- One internal handle, and
- One hold open handle.



Main door opening motion
Figure 06–02–8

WARNING

Before the door is opened, the differential pressure indicator should be checked. If the light flashes red and the door is opened, it may open quickly and cause injury to personnel.

(1) Opening from inside

When the internal handle is selected to the OPEN position (internal handle rotated towards OPEN), the vent flap opens, and the door unlocks and unlatches. Once pushed, the door will move outward and forward. The hinge arm provides guidance for the door and limits the door opening speed. The hold open handle latches, and the door is locked parallel to the fuselage, in the open position.

If the internal handle is turned and the door is not disarmed, the emergency opening assist mechanism will fully open the door and the evacuation slide will deploy.

To operate the main doors from inside:

- Look through the viewing window to assess the outside conditions,
- Make sure that the cabin differential pressure indicator is not flashing,
- Set the slide mode select lever to its appropriate setting,
- Confirm that the slide mechanical indicator status corresponds to the mode select lever position,
- Push the door lever to the UNLOCKED position, and
- Open the door outward until it locks against the fuselage.

(2) Opening from outside

When the external handle is selected to the open position (external handle pulled up), the door slide is disarmed, the vent flap opens, and the door unlocks and unlatches. Once pushed, the door will move outward and forward. The hinge arm provides guidance to the door and limits the door opening speed. The hold open handle latches, and the door is locked parallel to the fuselage in the open position.

NOTE

From the outside, the closed vent flap panel indicates if the door is in the closed/latched/locked position.

(3) Door closing

Pulling the hold open handle unlocks the door, which can then be pulled back. When the door reaches the door stop, it is closed, latched and locked by rotating the door operating handle. The door mechanical indicator turns green and visually confirms that the door is locked. The door status is displayed on the DOOR synoptic page. For detailed information, refer to Chap 06 – DOORS – Section 07 – Doors – Indications.

MAIN DOOR EVACUATION SLIDES

A. Main door evacuation slides – Overview

The four main doors are qualified as primary emergency exits. They are equipped with door-mounted evacuation slide assemblies with similar design but different lengths (between forward and aft). Each slide assembly includes:

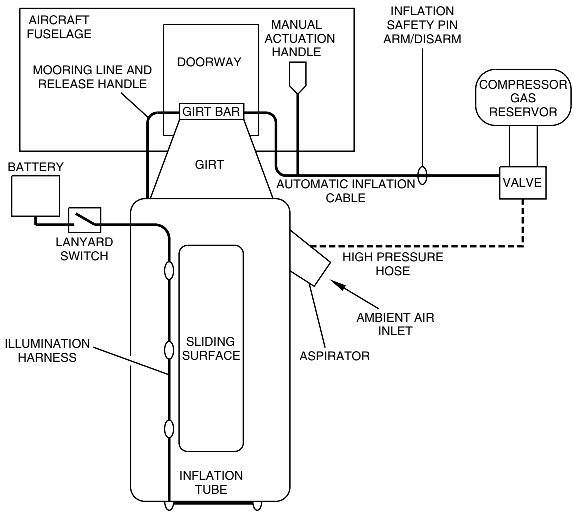
- A packing assembly,
- An inflatable assembly,
- A girt bar, and
- An inflation assembly.

The packing assembly contains the evacuation slide system. The inflatable assembly includes the sliding surface, an inflated tube and an illumination harness. The girt bar is the attachment point of the slides to the airplane structure.

Each inflation assembly includes:

- A reservoir that stores a compressed gas mixture,
- A regulator that regulates the inflating gas flow,
- A pressure gauge that indicates the reservoir pressure,
- An aspirator that mixes stored compressed gas with ambient air, and
- An integral battery.

Figure 06–03–1 shows a schematic of the evacuation slides.



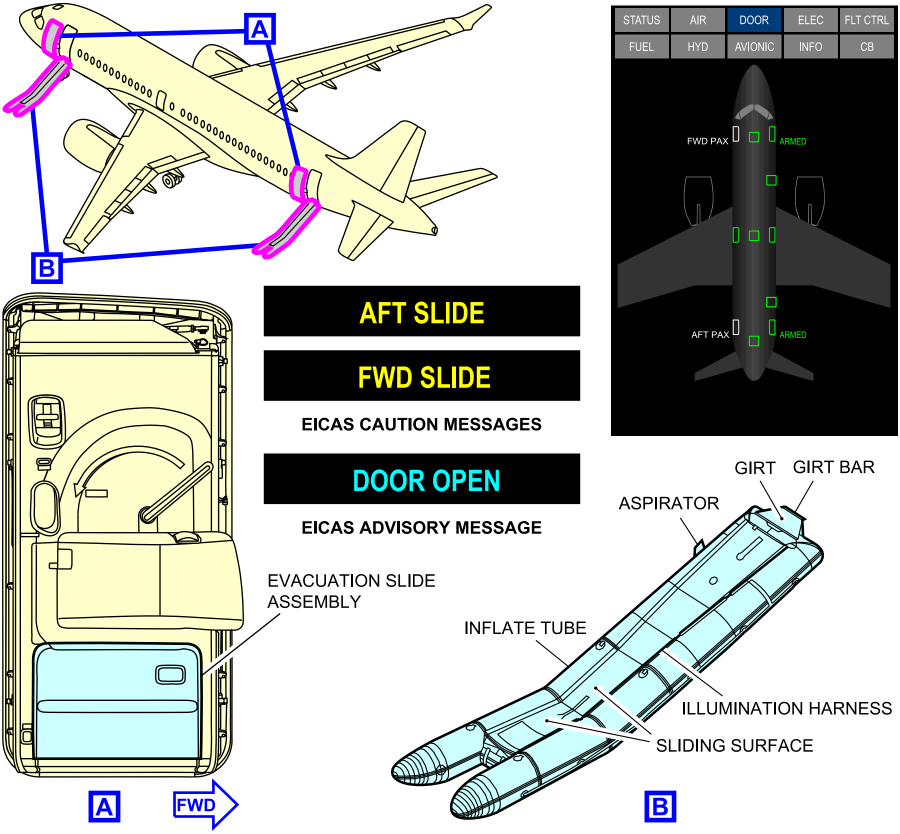
Main door slide deployment mechanism schematic
Figure 06–03–1

B. Main door evacuation slides – Operation

When the main door opens in an armed condition, a tension cable releases the slide from the packing assembly. The packed slide falls and is suspended by frangible links from the girt bar in a semi-extended position. At the same time, the inflation cable automatically activates the inflation of the sliding tube. When full pressure is reached, the slide is extended, and ready for use.

If the automatic activation fails, the crew can pull the manual actuation handle to start the inflation manually. The handle is located on the right side of the door. It is a red colored metallic handle with a white PULL label on it.

Figure 06–03–2 <52201001D> shows the evacuation slide assembly location on the main door and when it is extended.



Main door slide deployment mechanism <52201001D>
Figure 06–03–2

OVERWING EMERGENCY EXIT DOORS

A. Overwing emergency exit doors – Overview

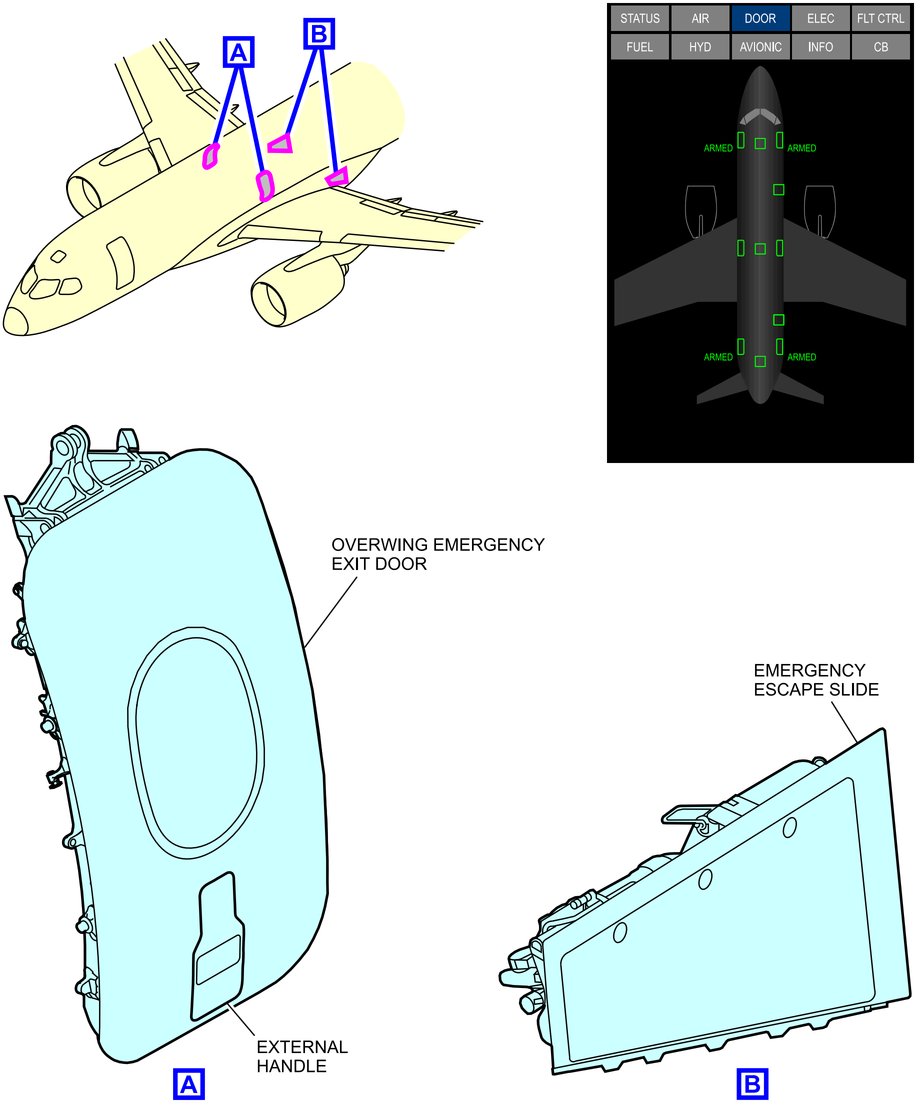
There are two, type III overwing emergency exit doors. . One is located on the left and one on the right side of the aircraft. Each door is mechanically linked to an escape slide to assist passengers and crew during emergency evacuation. The slides are installed on each side of the aircraft fuselage in a compartment at the wing trailing edges. Each overwing emergency exit door is equipped with the mechanisms that follow: <52201001D>

- A self-opening mechanism,
- An internal and an external handle mechanism to unlatch the door, and
- A deployment mechanism to deploy the slides during the opening.

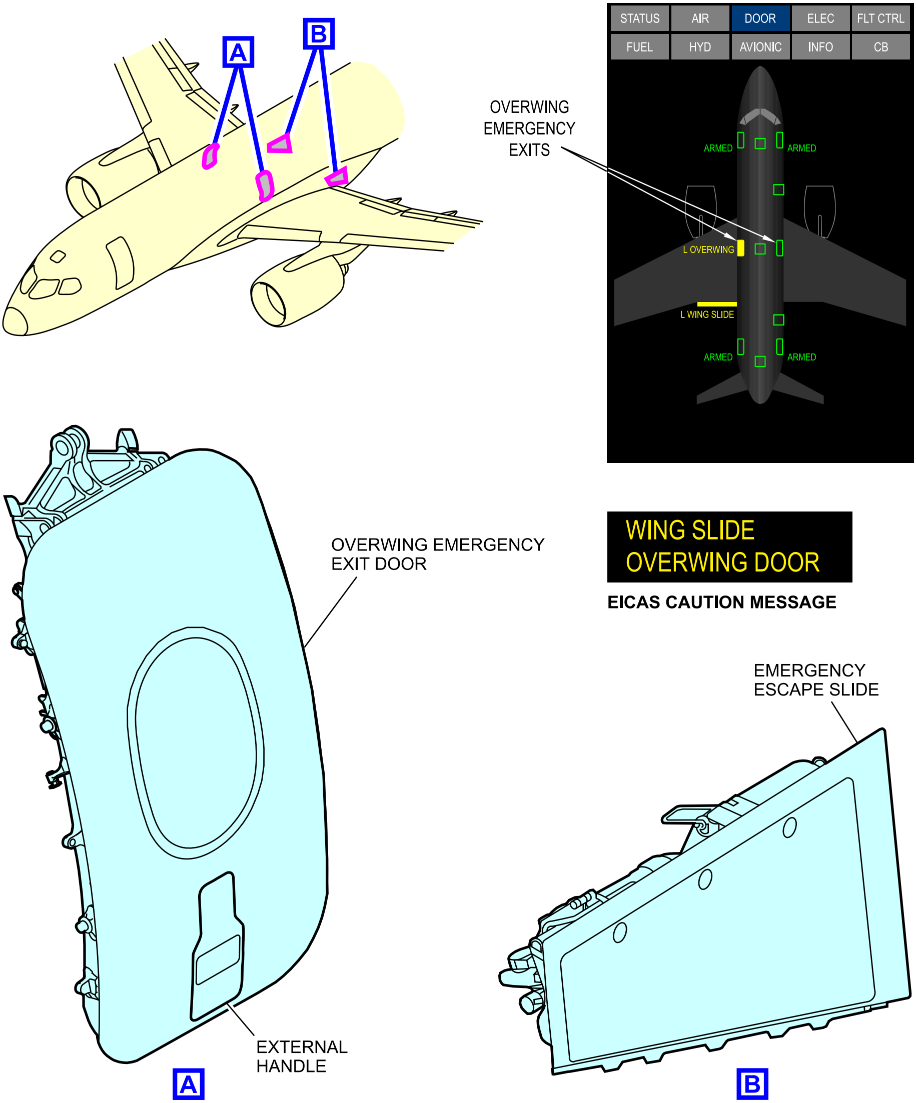
The DOOR synoptic page shows the overwing emergency exit doors status and faults. The slides are always armed, and will show green on the synoptic page. Faults (deployed or low pressure) will be shown on the DOOR synoptic page and on the EICAS page.

Each active overwing emergency exit door has proximity sensors that are monitored and evaluated by the Landing Gear Steering Control Units (LGSCUs) for status and fault indications on the DOOR synoptic page, EICAS page, and Cabin Management System (CMS).

Figure 06–03–3 and Figure 06–03–4 show the overwing emergency exit door locations and indications. <52201001D>



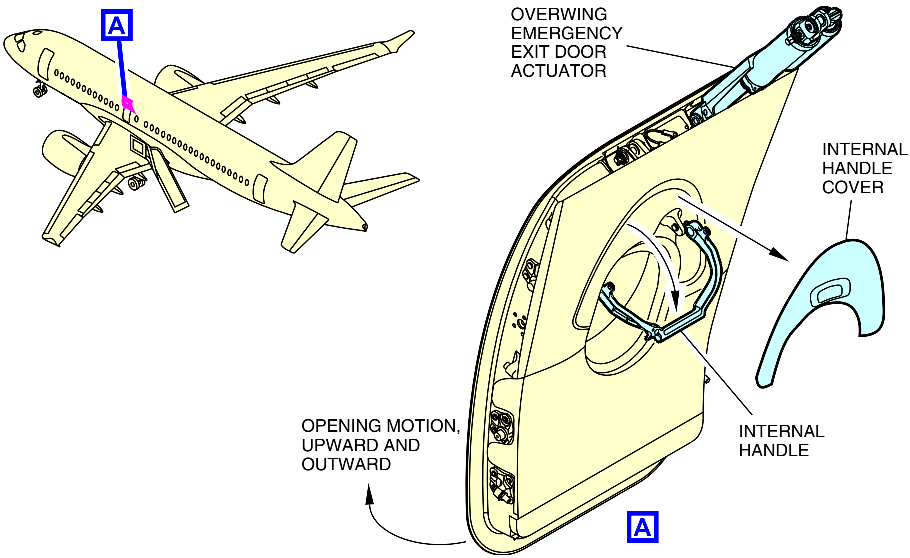
Overwing emergency exit door locations <52201001D>
Figure 06–03–3



Overwing emergency exit door indications <52201001D>
Figure 06–03–4

B. Overwing emergency exit doors – Operation

When the internal handle is pulled down, it unlatches, unlocks, and opens the door (refer to Figure 06–03–5 <52201001D>). The door actuator takes over the sequence and opens the door automatically until maximum travel. The door opens with an upward and outward motion.



Overwing emergency exit doors – Opening sequence <52201001D>
Figure 06–03–5

To open the overwing emergency exits doors from inside:

- Remove the internal panel to expose the handle, and
- Pull the handle (the door will open automatically).

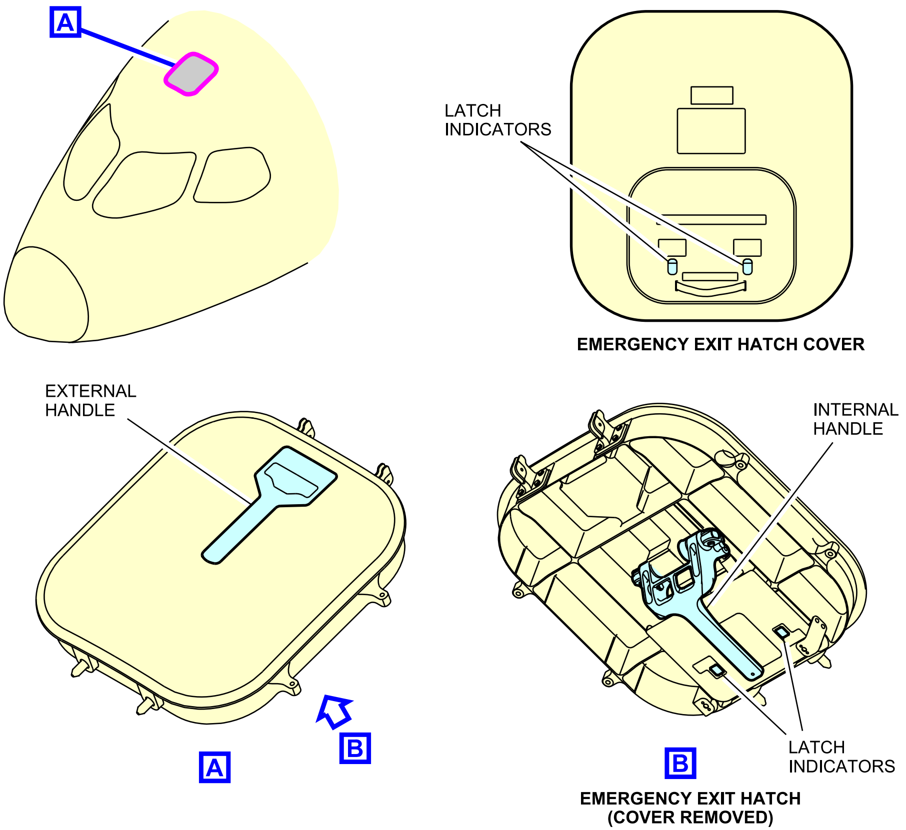
Slide inflation is mechanically and automatically activated when the overwing emergency exit doors are opened. If the automatic activation mechanism fails, the cabin crew can pull the manual actuation handle to inflate the evacuation slide.

NOTE

When the overwing emergency exit doors are closed, the evacuation slide deployment mechanism is always armed.

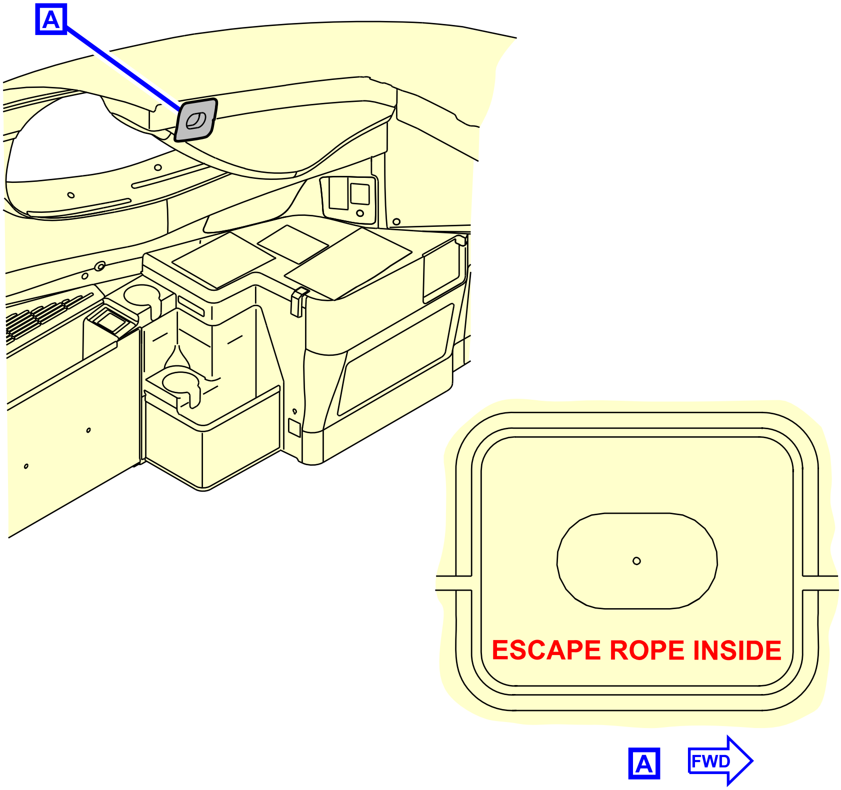
FLIGHT CREW EMERGENCY EXIT HATCH

The flight crew emergency exit hatch (refer to Figure 06–03–6) is a plug-type door used by the flight crew in emergency situations. The hatch is located on the top of the flight compartment and it is opened with either an internal or an external handle. To open the hatch from inside, the flight crew has to remove the cover and pull the internal handle to unlatch. Once the hatch is unlatched, the flight crew has to pull it down to clear the opening. The hatch hangs on its aft fitting.



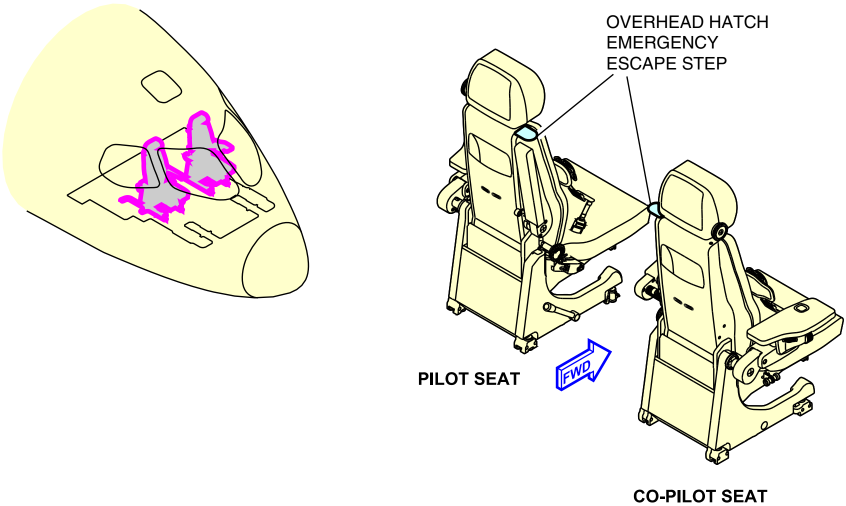
Flight crew emergency exit hatch
Figure 06–03–6

An escape rope (escape line) is located on the left side of the emergency exit hatch for the flight crew to lower themselves to the ground (refer to Figure 06–03–7).



Flight crew escape line location
Figure 06–03–7

The flight crew emergency exit hatch can be reached by using the emergency escape step located on the inboard top side of both flight deck seats (refer to Figure 06–03–8).



Emergency exit hatch step
Figure 06–03–8

The flight crew emergency exit hatch has no proximity sensors and therefore there are no indications on the DOOR synoptic page and no related EICAS messages.

The hatch has two mechanical latch indicators that must be visually checked to see whether the hatch is locked (green) or unlocked (red) (refer to Figure 06–03–6).

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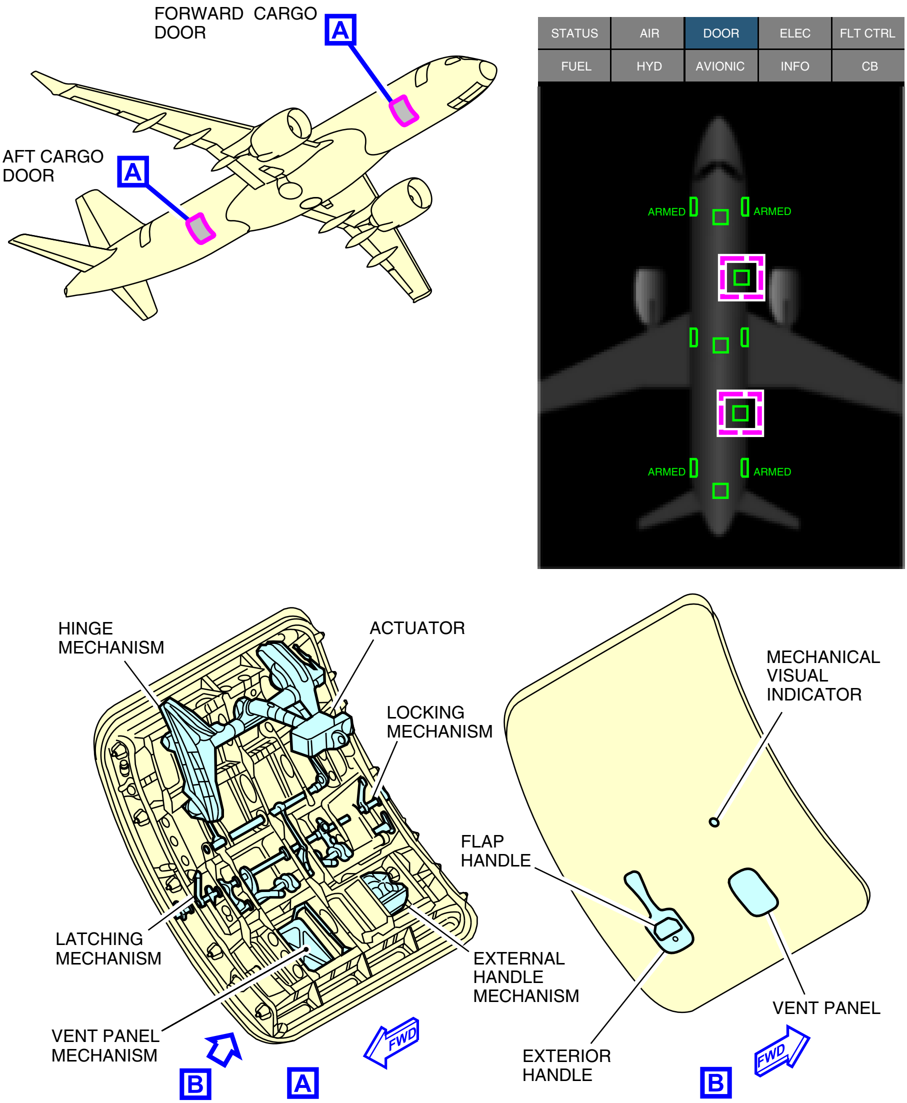
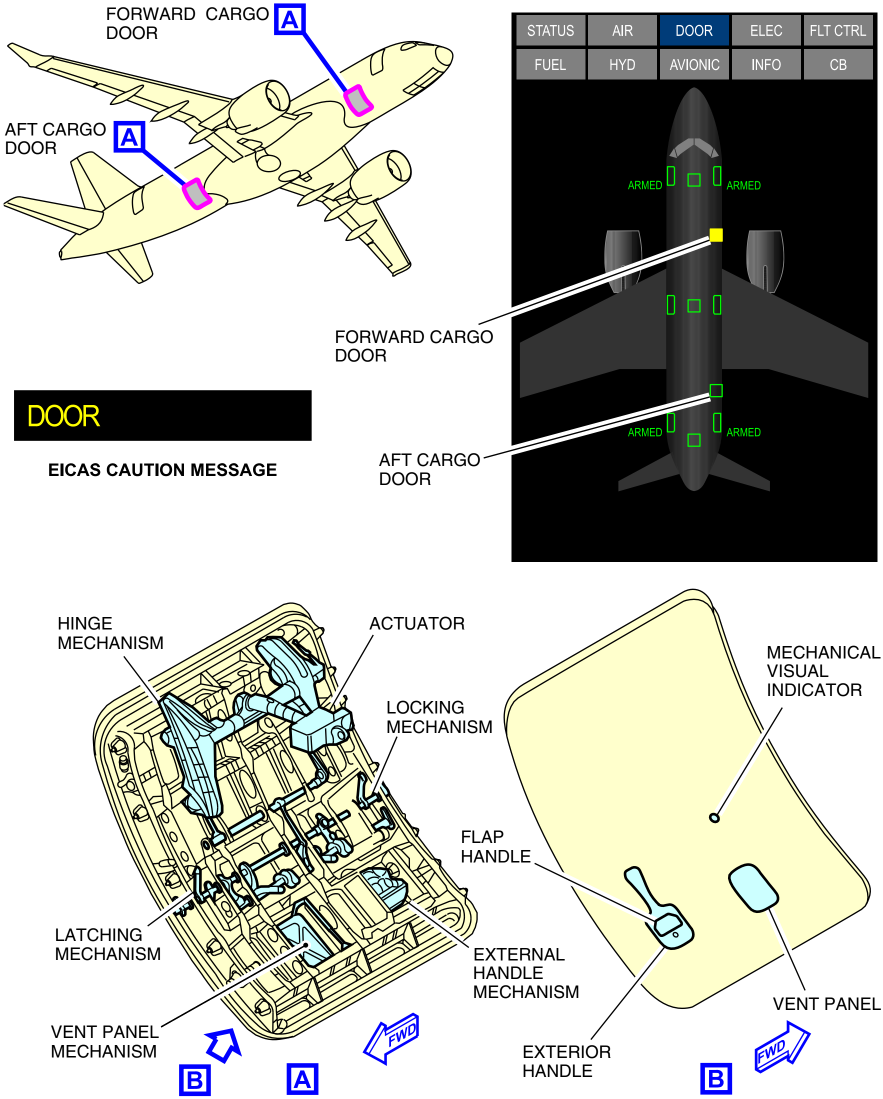
CARGO DOORS – OVERVIEW

There are two cargo doors. One is located in the right forward side and one in the right aft side of the aircraft. The doors are identical in size and have the same mechanism (refer to Figure 06–04–1 <52201001D>, or Figure 06–04–2 <52201001D>). They are opened and closed with a single handle and a control panel.



Cargo door locations and mechanism <52201001D>
Figure 06–04–1



Cargo door indications and mechanisms <52201001D>
Figure 06–04–2

The forward cargo door actuator is powered by BATT DIRECT BUS 1, while the aft cargo door actuator is powered by BATT DIRECT BUS 2.

Each door has proximity sensors, one visual indicator and is equipped with:

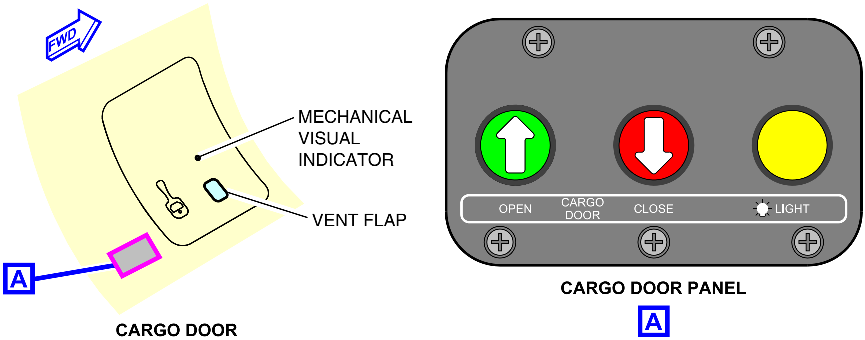
- One electric actuator,
- One handle mechanism, and
- One vent flap mechanism.

The proximity sensors are monitored and evaluated by the Landing Gear Steering Control Units (LGSCUs) for status and fault indications on the DOORS synoptic page and EICAS page.

Each cargo door is equipped with a visual indicator to show a locked or an unlocked condition. The indicator is visible from outside through a small viewport located above the vent panel. Green indicates a locked door and red indicates an unlocked door.

CARGO DOORS – DESCRIPTION AND OPERATION

Each cargo door is operated with a handle and a control panel, which is located on the fuselage beside the lower left corner of the cargo door (refer to Figure 06–04–3).



Cargo door panel
Figure 06–04–3

The control panel has three switches:

- One OPEN switch to raise the door,
- One CLOSE switch to lower the door, and
- One LIGHT switch to turn on the internal lights.

When the handle is pulled up, the vent flap opens and the cargo door unlocks, unlatches, and lifts away from the fuselage. Once lifted, the door is opened by an electrical actuator when the OPEN switch on the control panel is pressed. When the CLOSE switch is pressed in, the door closes. The handle must then be pulled down to lock and latch the door.

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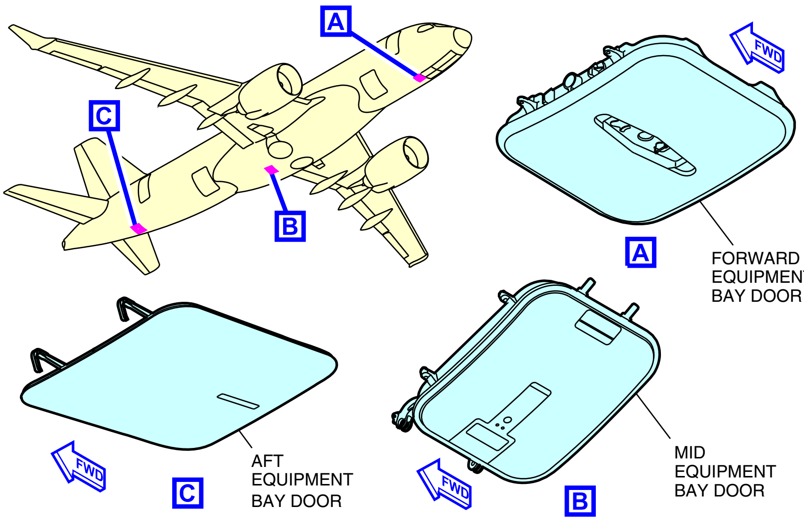
EQUIPMENT BAY DOORS – OVERVIEW

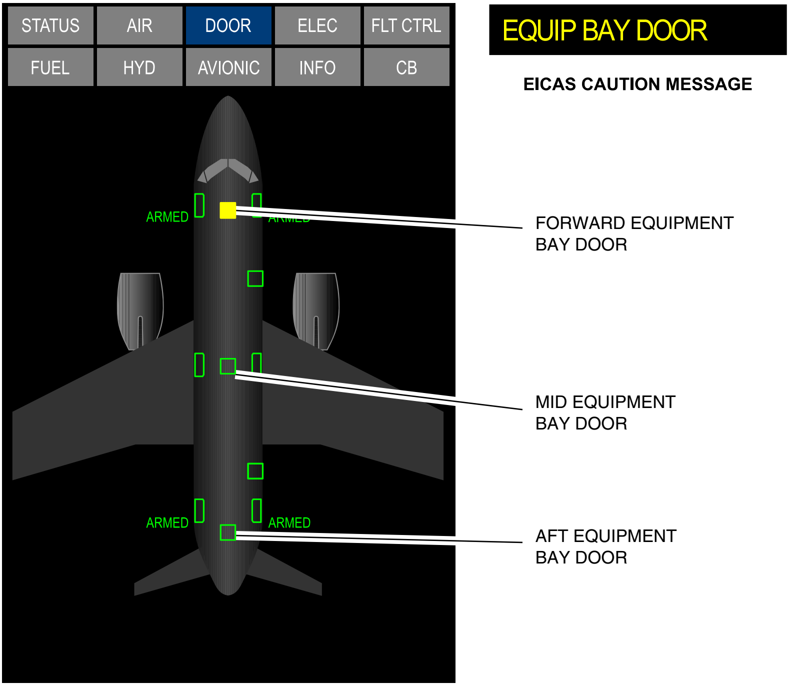
The aircraft is equipped with three equipment bay doors (forward, mid, and aft) (refer to Figure 06–05–1). They provide access to the avionics equipment for maintenance.

The forward and mid equipment bay doors are plug-type, pressure doors.



Equipment compartment doors location
Figure 06–05–1

The equipment bay door status and faults are reported on the DOOR synoptic page (refer to Figure 06–05–2).



SYNOPTIC PAGE – DOOR

Equipment bay doors
Figure 06–05–2

(1) Forward equipment bay door

The forward equipment bay door gives access to the forward avionics equipment. It is a sliding door that is opened and closed with an external handle. To open the door, a trigger has to be pushed to release the handle. Once released, the handle has to be turned counter-clockwise to unlatch the door. Then it has to be pushed up (inward) and the handle turned clockwise and pushed into the door. The door then slides aft on the rails to clear the opening.

To close the door, it has to slide forward on the rails and the trigger has to be pushed to release the handle. Once the handle is released, it has to be turned counter-clockwise and the door has to be pulled down to align with the surrounding structure. Once pulled down, the handle has to be turned clockwise to latch the door and pushed up to be stowed.

(2) Mid equipment bay door

The mid equipment bay door gives access to the mid avionics equipment. Access to the mid equipment bay door is from an access panel on the wing-to-body fairing. To open the door, the flap has to be pushed, and the handle has to be pulled to unlatch the door. To clear the opening, the door is pushed up with the additional handle until it touches the stop pad.

The door is closed by pulling the door down into position and pushing the handle closed while making sure the flap is flush. The access panel will then have to be closed and latched.

(3) Aft equipment bay door

A push-to-release latch is used to open and close the aft equipment bay door. The door unlatches, rotates downward and remains suspended by its hinges in open position. To close the door, just reverse the process.

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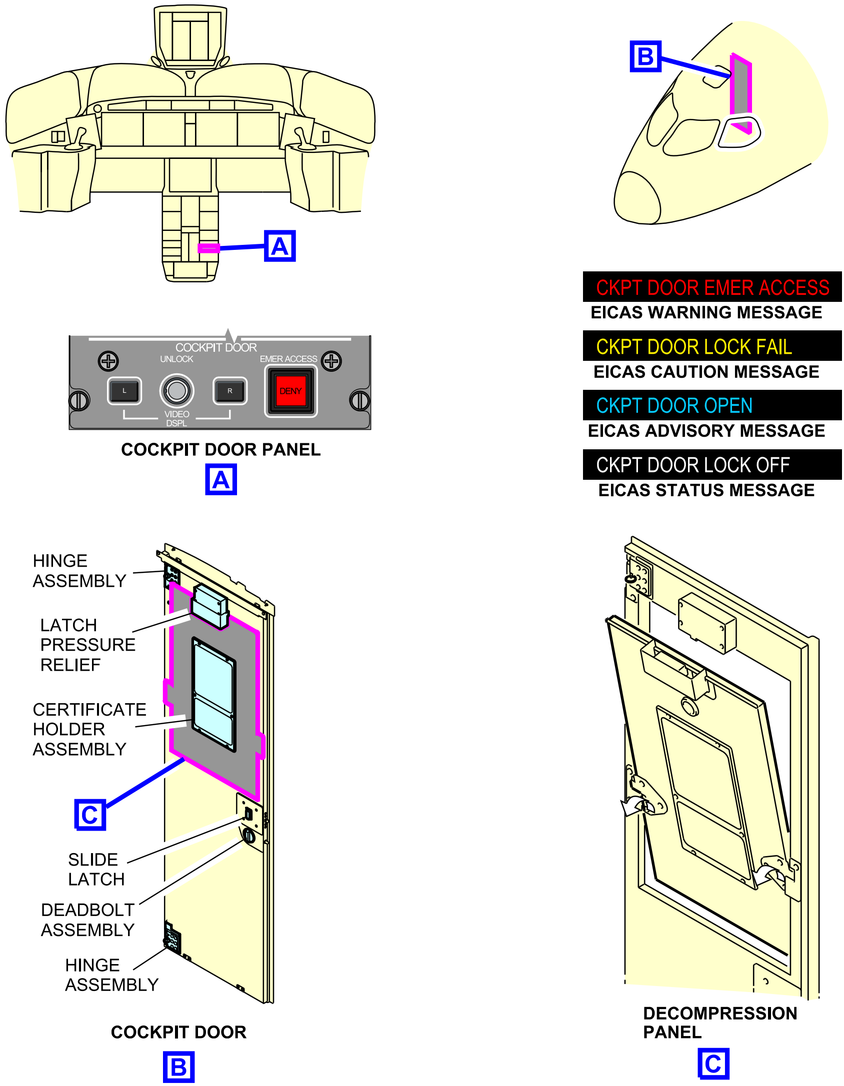
REINFORCED FLIGHT DECK DOOR – OVERVIEW

The reinforced flight deck door allows the flight crew to control the access to the flight compartment under a normal or an emergency request from the cabin.

The door is bulletproof and can resist forcible intrusion by unauthorized personnel. In addition, the door is equipped with a decompression panel that opens when the pressure differential between the cabin and the flight compartment exceeds 0.8 psi.

The COCKPIT DOOR panel comes with two video control switches, allowing the crew to view the perimeter of the flight deck entrance door (refer to Figure 06–06–1). <23730002C>

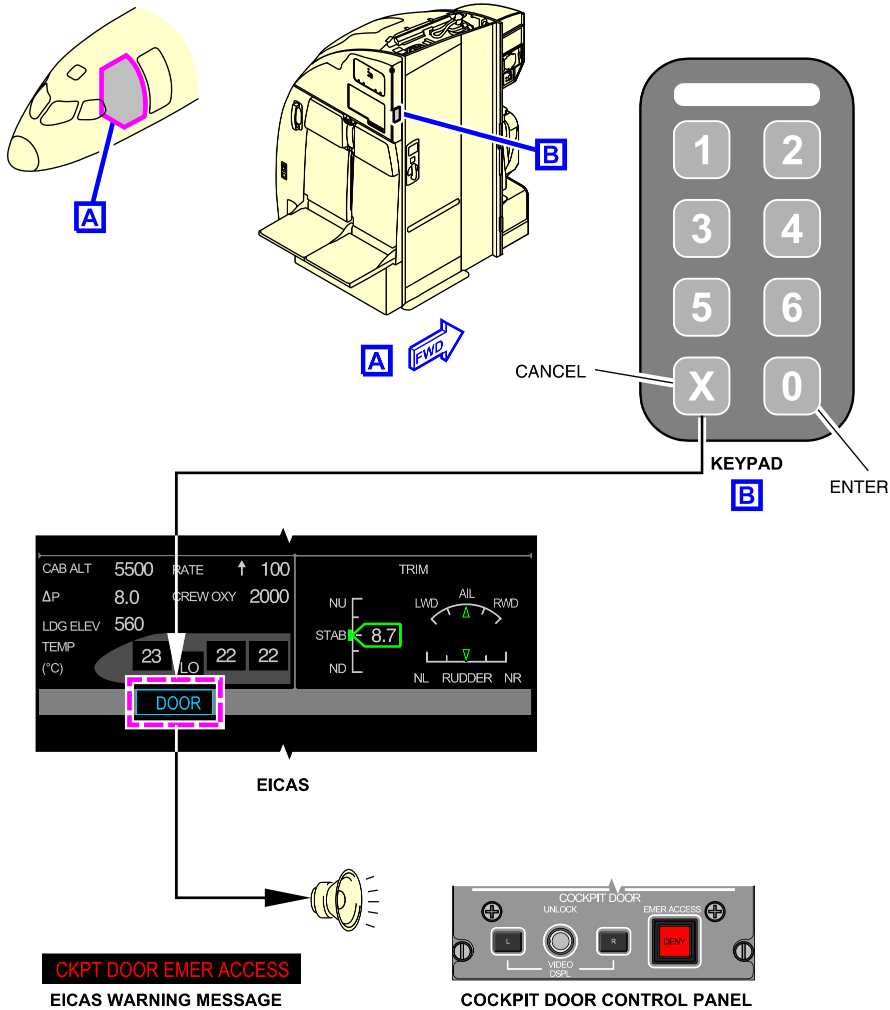


Reinforce flight deck door with surveillance system <23730002C>
Figure 06–06–1

REINFORCED FLIGHT DECK DOOR – DESCRIPTION AND OPERATION

A. Normal and emergency access

A normal request is made by pressing any of the numeric switches on the keypad in the cabin followed by the ENTER switch. This request triggers an audible doorbell tone in the flight compartment for 5 seconds. The flight crew can then press the UNLOCK switch on the COCKPIT DOOR panel to allow access. The door will remain unlocked for 5 seconds after the UNLOCK switch is pressed. The flight crew can refuse access by ignoring the request (refer to Figure 06–06–2 <23730002C>).



Keypad and COCKPIT DOOR panel <23730002C>
Figure 06–06–2

If the cabin crew suspects that the flight crew may be incapacitated, an emergency request is made with a special code entered on the keyboard. The special code triggers audio and visual signals in the flight compartment:

- Tone alert between 30 – 60 seconds,
- **CKPT DOOR EMER ACCESS** warning message displays on the EICAS page and an associated aural warning "COCKPIT DOOR" sounds
- EMER ACCESS DENY switch on the COCKPIT DOOR panel illuminates red.

The flight crew can accept or refuse the emergency access request by pressing the UNLOCK switch or the EMER ACCESS switch on the COCKPIT DOOR panel.

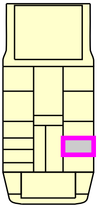
If the flight crew gives no response within the reaction time (30 seconds) after the emergency access request, the door unlocks automatically for 5 seconds.

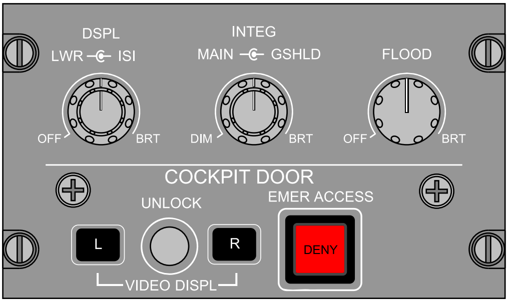
To deny an emergency request, the flight crew presses the EMER ACCESS DENY switch. The switch extinguishes and the door remains locked.

If the access is denied within the reaction time (30 seconds), any subsequent emergency access request will be inhibited for the next 30 minutes.

B. Reinforced flight deck door surveillance camera <23730002C> or <23730003C>

The flight deck door surveillance system provides a video display of the area outside the flight deck door and the surrounding area. The video can be displayed on a Multifunction Window (MFW) of Display Unit (DU) 3 or DU5 through the COCKPIT DOOR panel (refer to Figure 06–06–3).





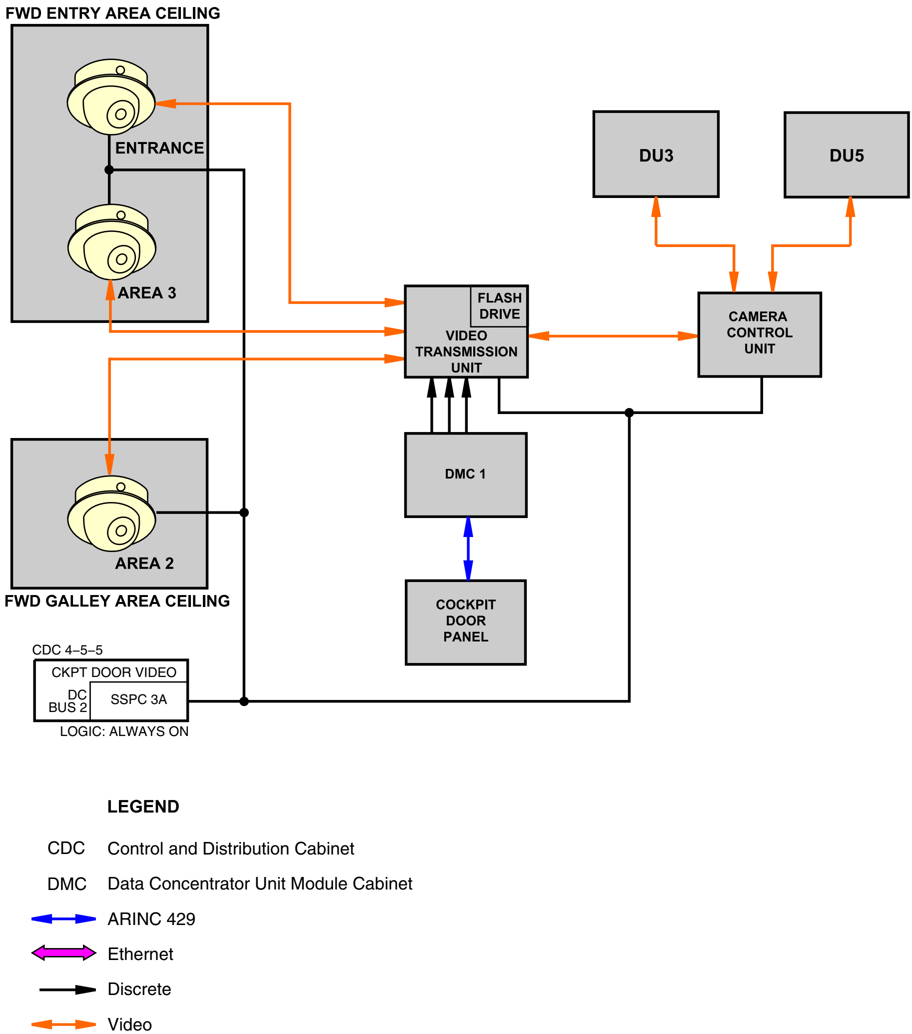
Cockpit door Panel <23730002C> or <23730003C>
Figure 06–06–3

The flight deck door surveillance system uses the following cameras:

- Entrance,
- Area 2, and
- Area 3.

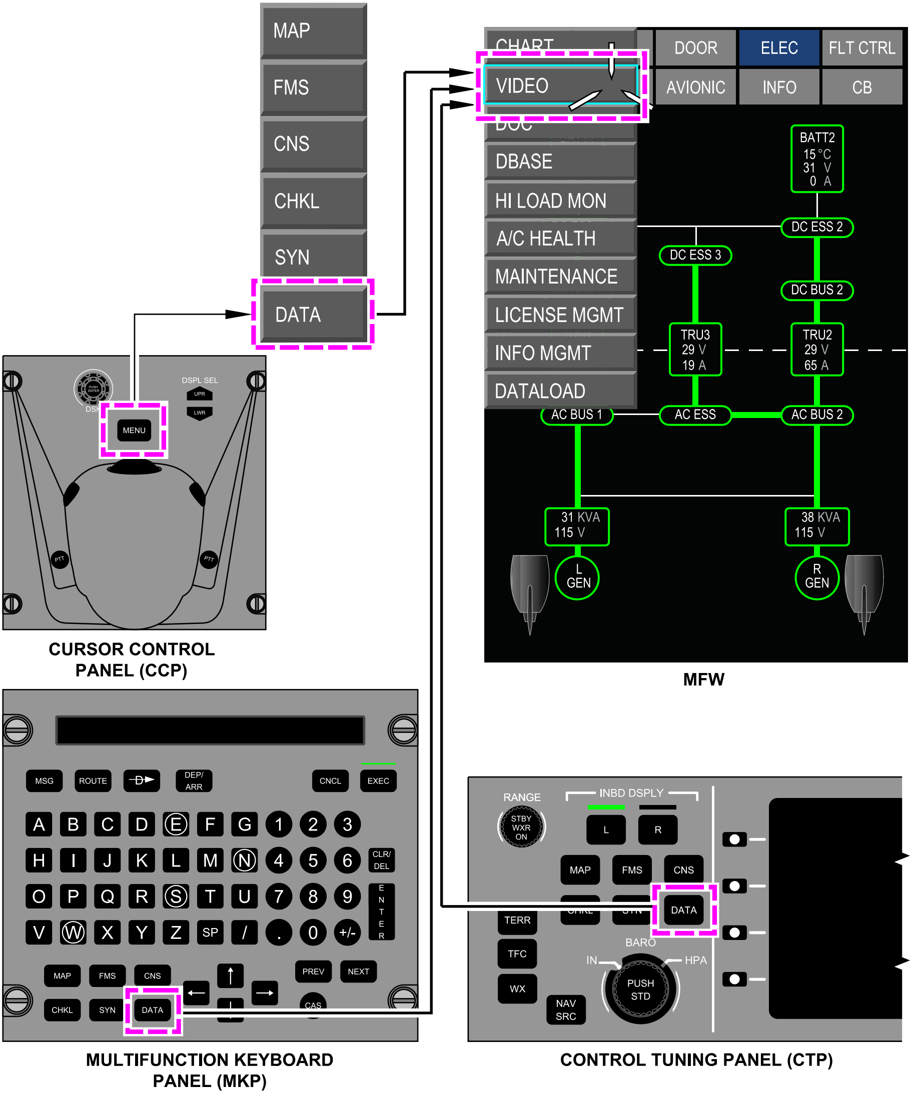
They are located in the forward galley and provide coverage of the outside of the flight deck door. Each camera feeds the Video Transmission Unit (VTU) that distributes the video signals to a Camera Control Unit (CCU) which provides video to the DUs.

Refer to Figure 06–06–4. <23730002C>



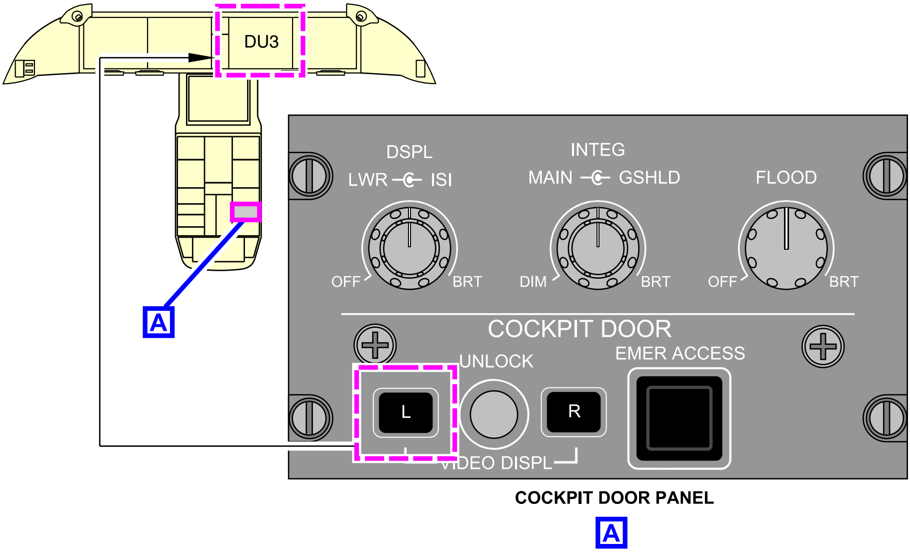
Flight deck door surveillance system diagram <23730002C>
Figure 06–06–4

The video display is accessed through the normal MFW drop-down menu or can be accessed from the COCKPIT DOOR panel (refer to Figure 06–06–5).

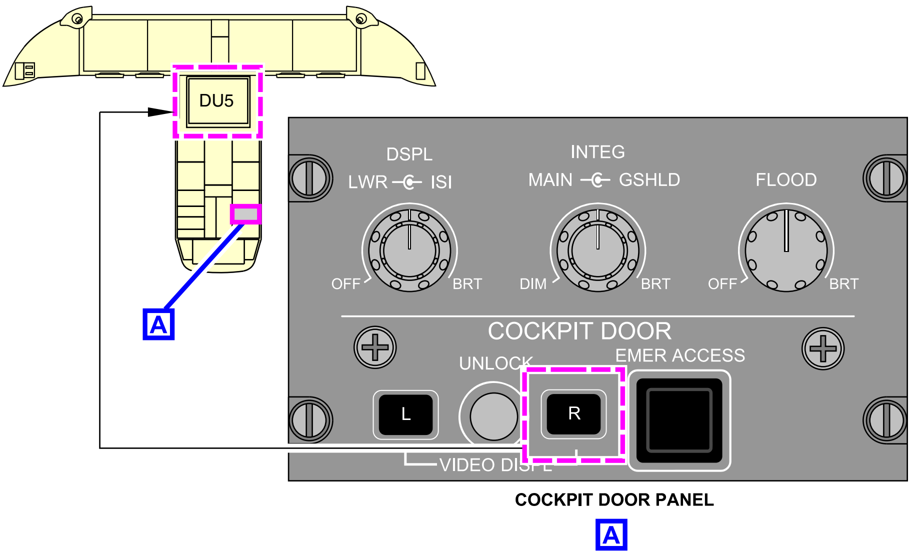


Flight deck door surveillance system – Video access
Figure 06–06–5

When the VIDEO DSPL L switch is pressed, the video is shown on the DU 3 (refer to Figure 06–06–6). Pressing VIDEO DSPL R moves the display to DU 5 (refer to Figure 06–06–7). The VIDEO DSPL L (R) switches can be used to cycle through the video display from each camera.



COCKPIT DOOR panel – VIDEO DSPL L switch <23730002C> or <23730003C>
Figure 06–06–6



COCKPIT DOOR panel – VIDEO DSPL R switch <23730002C> or <23730003C>
Figure 06–06–7

Each camera is installed to provide a different field of view. The cameras are capable of operating in low light conditions. They feed the VTU individually. A removable flash drive, installed in the VTU, records the video. When the memory is full, the oldest information is overwritten.

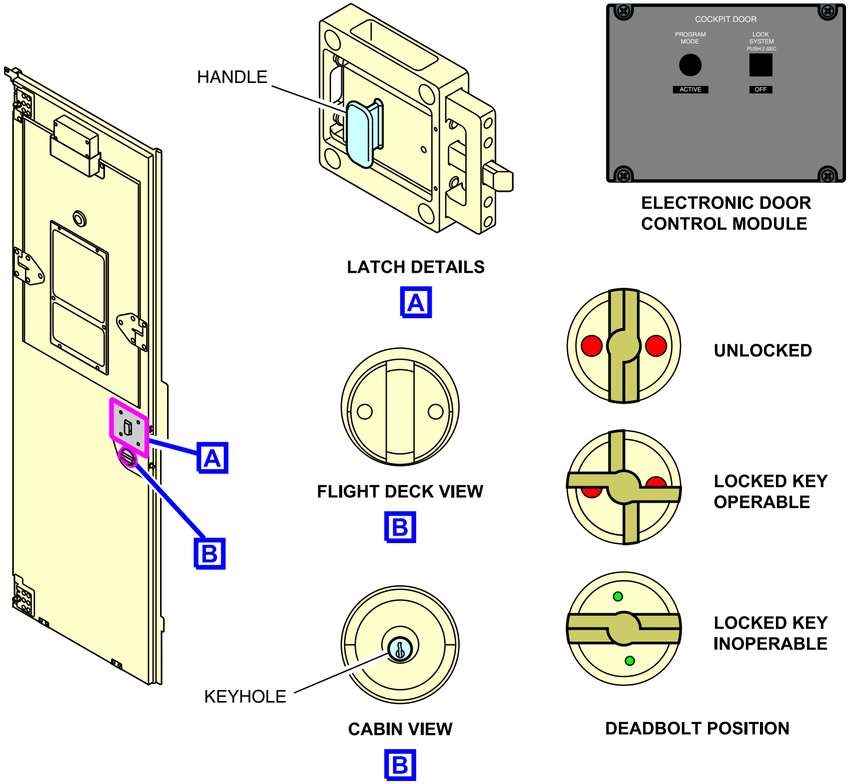
C. Remote access system

The door is locked/unlocked by the flight deck remote access system that provides access to the flight compartment (refer to Figure 06–06–8).

The keypad, located outside the flight deck door to the left of the lavatory, is used to access and signal the flight compartment.

The flight deck door handle slides sideways to unlatch the door. A deadbolt can be used to lock the door, if the flight deck remote access system fails.

The electronic door control module, located on the observer bulkhead, controls the door locking features.



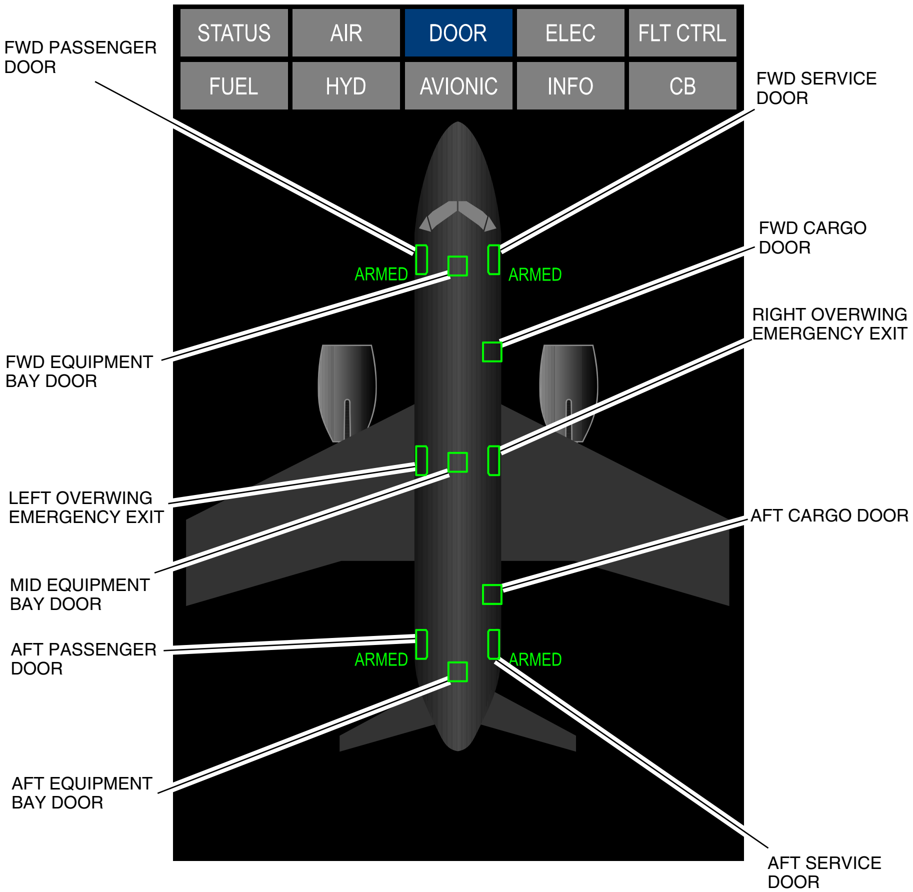
Electronic door control module – latch and deadbolt
Figure 06–06–8

DOOR SYNOPTIC PAGE

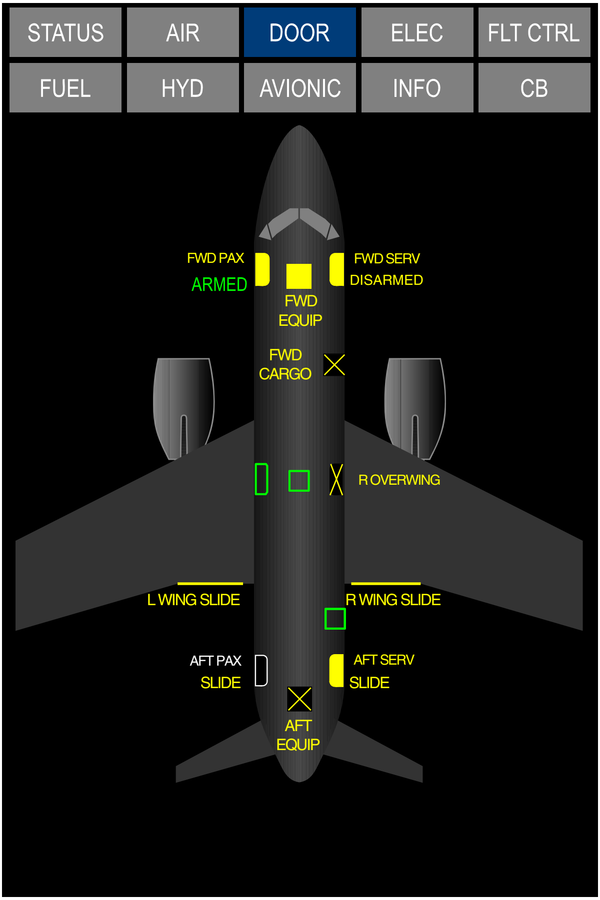
A. DOOR synoptic page

The DOOR synoptic page (refer to Figure 06–07–1 <52201001D>) gives the flight crew the status of the doors and evacuation slides. The information is received by the Landing Gear Steering Control Units (LGSCUs), which collect all signals from the door proximity sensors.

Figure 06–07–2 <52201001D> displays an overview of the DOOR synoptic page and Figure 06–07–3 gives the description.



DOOR synoptic page <52201001D>
Figure 06–07–1



DOOR synoptic page – Overview <52201001D>
Figure 06–07–2

ENGINES (MANAGED BY FADEC)	
	Running.
	Not running.
	Invalid.

DOOR SLIDE STATUS	
DISARMED	Door closed/latched/locked, but slide lever disarmed (removed when door opened).
ARMED	Door closed/latched/locked and door slide lever armed.
SLIDE	Door slide fault detected (electrical or mechanical failures, invalid or failed LGSCU).

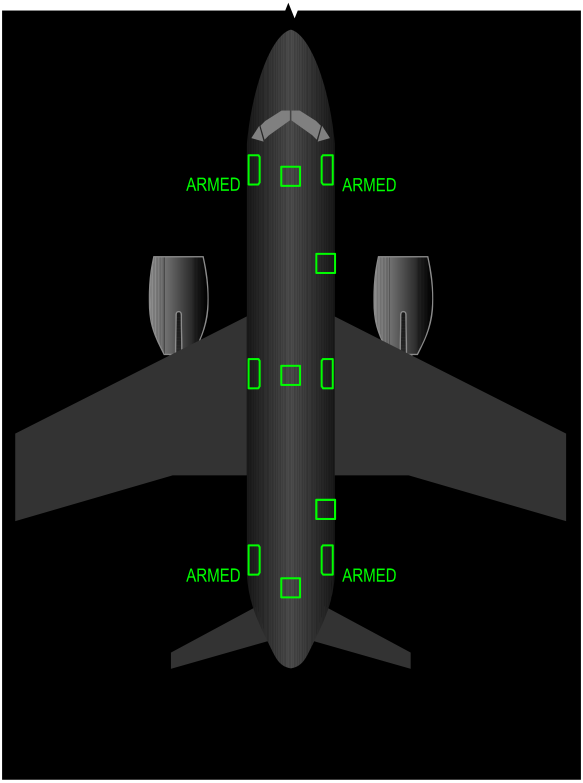
WING SLIDE STATUS (ALWAYS ARMED)	
SLIDE	Wing slide fault detected (low–pressure or deployed).

DOOR STATUS	
Symbol	Condition
FWD PAX	At least one engine running and the door is not closed/latched/locked. **OR** Door fault. Note: Label of door is shown in amber.
	Door closed/latched/locked. Note: Label of door is not shown.
FWD PAX	Door open on ground, engine is not running. Note: Label of door is shown in white.
FWD PAX	Invalid or failed LGSCU or invalid door sensor. Note: Label of door is shown in amber.
FWD CARGO	At least 1 engine running and door not closed, or not latched or not locked. **OR** Door fault. Note: Label of door is shown in yellow.
	Door closed,lactched, locked. Note: Label of door is not shown.
FWD CARGO	Door open on ground, engine not running. Note: Label of door is shown in white.
FWD CARGO	Invalid or failed LGSCU or invalid door sensor. Note: Label of door is shown in yellow.

DOOR synoptic page – Description
Figure 06–07–3

B. DOOR synoptic page – Both engines running and doors closed and locked

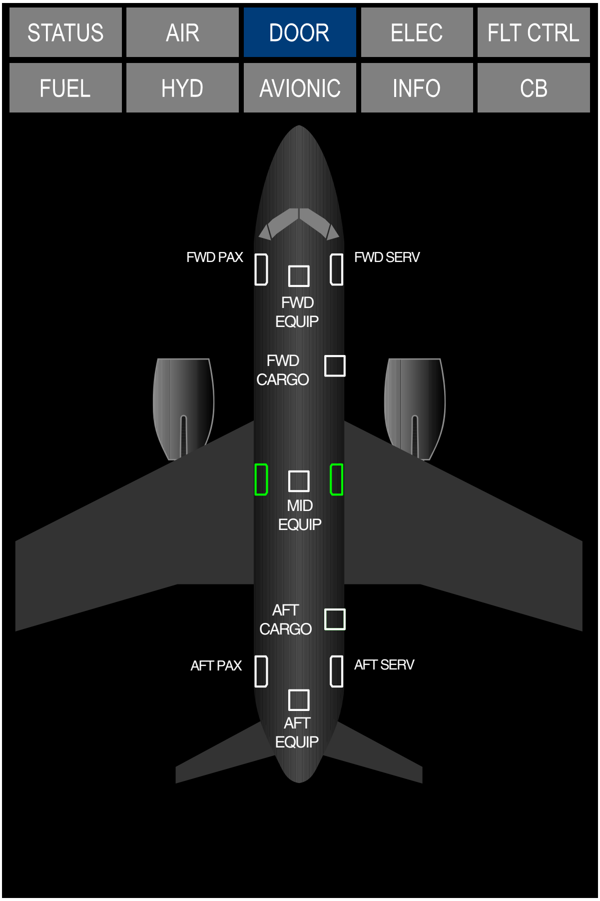
Figure 06–07–4 <52201001D> shows the DOOR synoptic page when both engines are running (on ground or in flight), and all doors are closed, latched.



DOOR synoptic page – On ground or in flight – All doors are latched and locked <52201001D>
Figure 06–07–4

C. DOOR synoptic page – Both engines not running

Figure 06–07–5 <52201001D> shows the DOOR synoptic page when aircraft is on the ground, engines are not running and all doors are opened except the overwing emergency exit doors.



EICAS ADVISORY MESSAGES

DOOR synoptic page – On ground – Engine not running <52201001D>
Figure 06–07–5

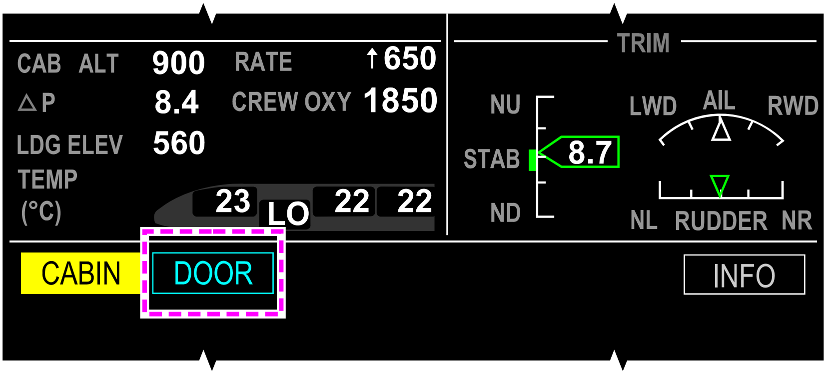
D. DOOR – Communication flag

The communication flags are used to annunciate incoming communications. They have associated aural alerts (tone or voice messages).

The communication flag (refer to Figure 06–07–6) designated as DOOR appears when a person requests to enter the flight compartment. When the doorbell is pressed the following actions occur:

- A tone is generated in the flight deck,
- The DOOR flag flashes for 5 seconds and then becomes steady, and
- The DOOR flag resets 8 seconds after the last push of the doorbell.

When the EICAS page is compressed, the DOOR flag is not replaced by an EICAS message.



EICAS PAGE

COMM Flag	Aural	Description
READY	No	Signals that the cabin crew is ready for takeoff or landing. (Reset is customizable).
CABIN	Yes	Signals that a cabin call is pending. (Resets after the call is taken).
CABIN	Yes	Signals an incoming priority communication from the cabin. (Resets after the call is taken).
DOOR	Yes	Signals a doorbell event. (Resets eight seconds after the last doorbell button command).

DOOR – Communication flag
Figure 06–07–6

DOORS – EICAS MESSAGES

A. Warning messages

Message	Description	Aural	Inhibit
CKPT DOOR EMER ACCESS	Emergency request from cabin.	COCKPIT DOOR	None

B. Caution messages

Message	Description	Inhibit
AFT DOOR	Aft passenger or service door failed or opened with at least one engine running.	TO, LDG
AFT SLIDE	Aft passenger or service door slide is faulty with at least one engine running.	TO, LDG
CARGO DOOR	Forward or aft cargo door failed or opened with at least one engine running.	TO, LDG
CKPT DOOR LOCK FAIL	Failure of the FDRAS to lock door or loss of communication to DMC.	TO, LDG
DOOR SLIDE DISARMED	Any access door slide is still disarmed in flight or with one engine running.	TO, LDG
EQUIP BAY DOOR	Forward, mid, or aft equipment bay door failed or opened with at least one engine running.	TO, LDG
FWD DOOR	Forward passenger or service door failed or opened with at least one engine running.	TO, LDG
FWD SLIDE	Forward passenger or service door evacuation slide is faulty with at least one engine running.	TO, LDG
OVERWING DOOR	Left or right overwing emergency exit door failed or opened with at least one engine running.	TO, LDG

Message	Description	Inhibit
WING SLIDE	Left or right overwing evacuation slide faulty or deployed.	TO, LDG

C. Advisory messages

Message	Description	Inhibit
CKPT DOOR OPEN	Flight compartment door open.	TO, LDG
DOOR FAULT	Any electrical or mechanical failure of any door while on ground and no engine running.	TO, LDG
DOOR OPEN	Any door opened while on ground and no engine running.	TO, LDG
DOOR SLIDE DISARMED	Any door slide disarmed while on ground and no engine running.	TO, LDG
DOOR SLIDE FAULT	Any electrical or mechanical failure of any door slide while on ground and no engine running.	TO, LDG

D. Status messages

Message	Description	Inhibit
CKPT DOOR LOCK OFF	Flight compartment door system is in maintenance mode or when associated SSPC is PULL and LOCK.	None

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CHAPTER 7 – ELECTRICAL

List of figures

DC POWER DISTRIBUTION

PRIMARY POWER DISTRIBUTION

SECONDARY POWER DISTRIBUTION

ELECTRICAL – CONTROLS AND INDICATIONS

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ELECTRICAL SYSTEM – OVERVIEW

The aircraft uses both 115 VAC and 28 VDC electrical power.

Two engine-driven Variable Frequency Generators (VFGs) are the primary source of AC power. An Auxiliary Power Unit (APU) generator supplies auxiliary power. A Ram Air Turbine (RAT) supplies emergency AC power. AC ground power is supplied through an electrical power connection on the left side of the forward fuselage.

Three Transformer Rectifier Units (TRUs) and two Nickel Cadmium (NiCad) batteries supply the required DC power.

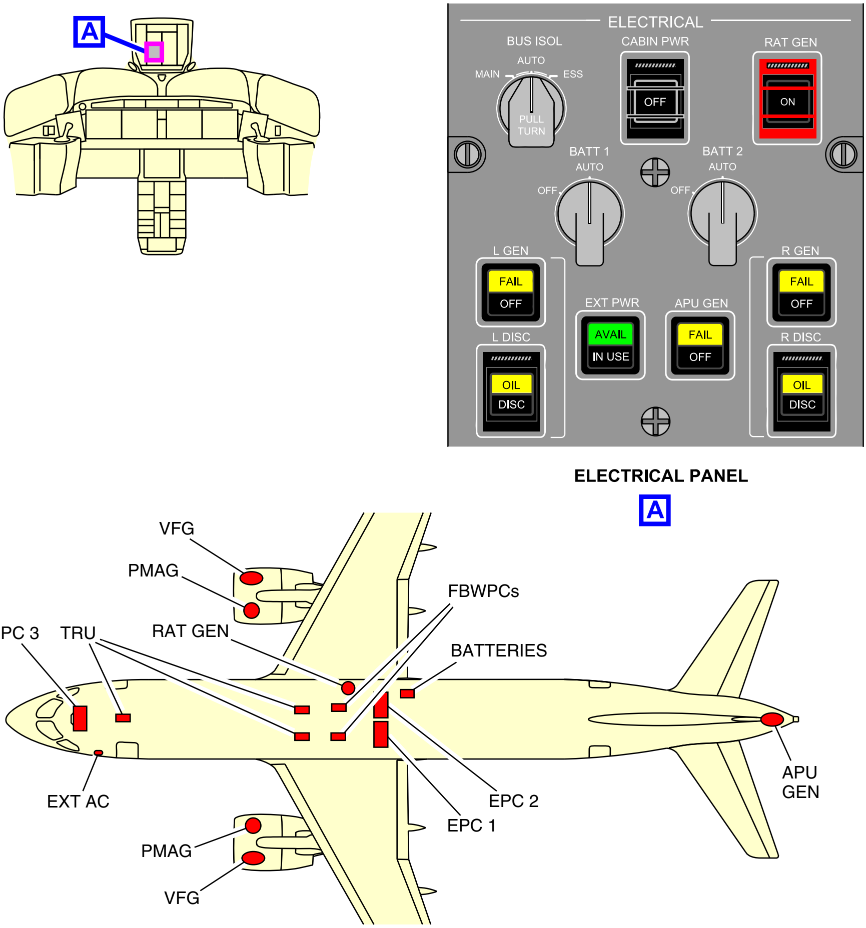
Two dedicated Permanent Magnet Alternator/Generators (PMAGs) supply power to two Fly-By-Wire Power Converters (FBWPCs) for the fly-by-wire components.

The electrical control and distribution system is divided into three Electrical Power Centers (EPCs) that are managed by Bus Power Control Units (BPCUs) and an Emergency Power Control (EMPC).

The ELEC synoptic page displays the system distribution architecture and status of the system components. The EICAS gives system fault and status information. The ELECTRICAL panel is part of the overhead panel.

Figure 07–01–1 shows the electrical overview and the location of the ELECTRICAL panel.

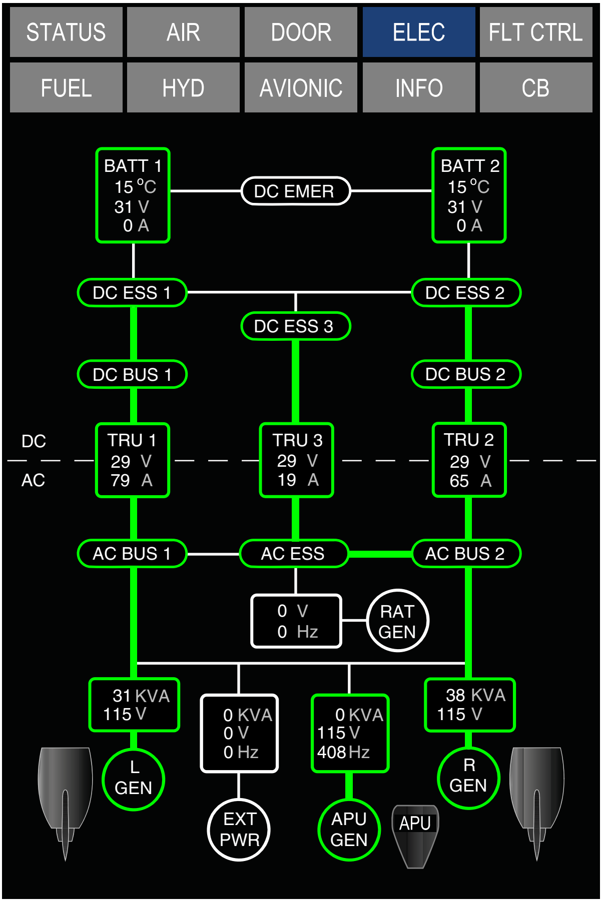
Figure 07–01–2 shows the electrical system architecture.



LEGEND

EPC	Electric Power Center
FBWPC	Fly–By–Wire Power Converter
PMAG	Permanent Magnet Alternator/Generator
RAT	Ram Air Turbine
VFG	Variable Frequency Generator
TRU	Transformer Rectifier Unit

Electrical overview and ELECTRICAL panel location
Figure 07–01–1



ELEC synoptic page – Electrical system architecture
Figure 07–01–2

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AC POWER GENERATION – OVERVIEW

The aircraft can receive AC power from four sources:

- Variable Frequency Generators (VFGs),
- APU Generator,
- External AC Power, and
- Ram Air Turbine (RAT).

AC POWER GENERATION – DESCRIPTION AND OPERATION

A. Variable Frequency Generator (VFG)

Two Variable Frequency Generators (VFGs), one mounted on each engine accessory gearbox, supply 115 VAC. Each VFG is rated to 75 kVA for continuous operation and up to 112.5 kVA for 5 minutes and 150 kVA for 5 seconds. Power fluctuations of ±5 to 6 kVA are normal when the windshield and window heaters are on. The VFGs contain a Permanent Magnet Generator (PMG), which supplies power to a Generator Control Unit (GCU) and an Overvoltage Protection Unit (OPU). Both the GCU and the OPU are located in the mid equipment bay.

NOTE

The PMG inside the Variable Frequency Generator (VFG) is not the same component as the Permanent Magnet Alternator/Generator (PMAG) associated with the Fly-By-Wire Power Converters (FBWPCs) and the Electronic Engine Control (EEC). The PMAG will be discussed later in this chapter.

Lubricating oil for the VFG is cooled by a dedicated air/oil cooler on the engine.

The VFGs are controlled by the L GEN or R GEN switch respectively. The L GEN and R GEN switches are located on the overhead ELECTRICAL panel and operate through a GCU.

(1) Generator Control Unit (GCU)

The Generator Control Unit (GCU) does the functions that follow:

- Regulates VFG voltage,
- Electrically connects or disconnects the VFG to the main AC busses,
- Protects the electrical circuits from generator faults, and
- Supplies status information to the Bus Power Control Units (BPCUs).

Primary power for the GCU is the associated PMG, backed up by aircraft DC power.

(2) Overvoltage Protection Unit (OPU)

The Overvoltage Protection Unit (OPU) is an additional independent backup to the GCU overvoltage protection. The OPU electrically disconnects the VFG if it produces excessive voltage and the GCU has not acted. The PMG powers the OPU.

B. APU generator

A 115 VAC, Variable Frequency Generator (VFG) is mounted on the APU accessory gearbox. The generator is rated to 75 kVA for continuous operation up to FL 365. The output decreases linearly with altitude to 58 kVA at FL 410. The APU may support loads in excess of 58 kVA (up to 75 kVA) at altitudes between FL 365 and FL 410. Power fluctuations of ±5 to 6 kVA are normal when the windshield and window heaters are on.

The APU generator contains its own Permanent Magnet Generator (PMG), which supplies power to the APU generator control unit as well as the APU Overvoltage Protection Unit (OPU). The APU engine and generator share oil for lubrication and cooling.

The APU GEN switch, operating through the APU Generator Control Unit (GCU), controls the APU generator function. It is located on the overhead ELECTRICAL panel.

(1) APU Generator Control Unit (AGCU)

The APU Generator Control Unit (AGCU) does the functions that follow:

- Regulates the APU generator voltage,
- Connects or disconnects the APU generator to the aircraft busses,
- Protects the electrical channel from APU generator faults, and
- Supplies status information to the Bus Power Control Units (BPCUs).

Primary power for the AGCU is the APU PMG, backed up by aircraft DC power.

(2) Overvoltage Protection Unit (OPU)

The Overvoltage Protection Unit (OPU) is an additional, independent backup to the AGCU overvoltage protection. The OPU electrically disconnects the APU generator if it produces excessive voltage and the AGCU has not been tripped. The APU PMG powers the OPU.

C. External AC power

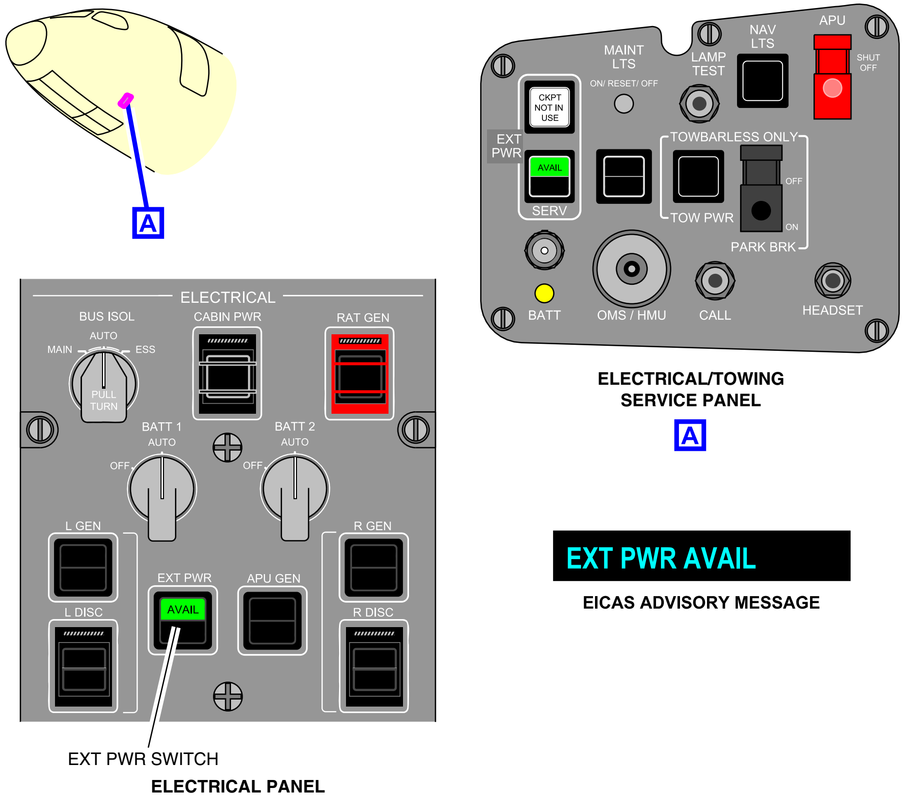
External power can be used to supply AC power in two different modes:

- Ground service mode, and
- External power mode.

When connected, external power is checked for frequency, voltage, and phase. If power is suitable, the top half of the EXT PWR switch (on the overhead ELECTRICAL panel) and the EXT PWR SERV switch (on the external electrical/towing service panel) are illuminated with AVAIL in black text on a green background, along with an **EXT PWR AVAIL** EICAS advisory message (refer to Figure 07–02–1).

<Mod 240006> or <Post–SB BD500–240006>

When the external power mode is not in operation, the EXT PWR CKPT NOT IN USE light (on the external electrical/towing service panel) is illuminated in black text on a white background.



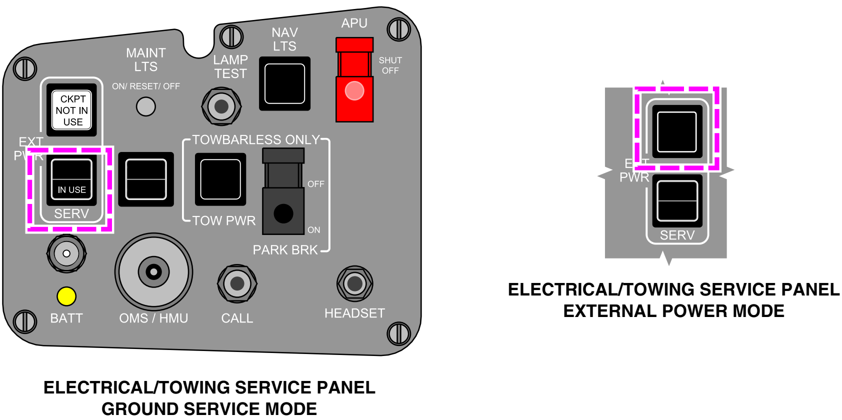
Electrical/towing service panel (external) and ELECTRICAL panel (flight compartment) indications
Figure 07–02–1

(1) Ground service mode

When the EXT PWR SERV switch on the electrical/towing service panel is pushed, the ground service mode is in operation. In the EXT PWR SERV switch, the AVAIL with a green background goes off and IN USE in white text comes on (refer to Figure 07–02–2). In ground service mode, AC BUS 1, AC BUS 2, and DC BUS 1 are powered.

When the EXT PWR switch in the flight compartment is selected, the CKPT NOT IN USE light on the electrical/towing service panel is off.

<Mod 240006> or <Post–SB BD500–240006>



Electrical/towing service panel – Ground service mode
Figure 07–02–2

(1) External power mode

When the EXT PWR switch on the ELECTRICAL panel is pushed, the external power mode is in operation. In external mode, all of the electrical system is powered (refer to Figure 07–02–3).

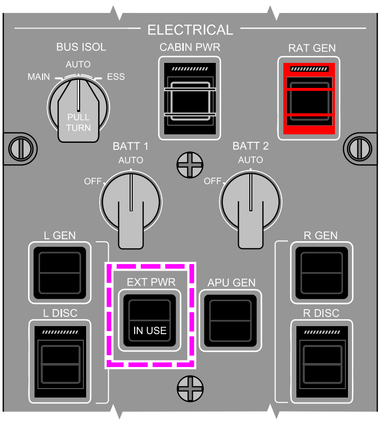
NOTE

The DC EMER bus and the BATT DIR busses are always powered.

The BATT DIR busses are not displayed on the ELEC synoptic page.

The DC EMER bus is displayed in amber if there is a malfunction on the bus.

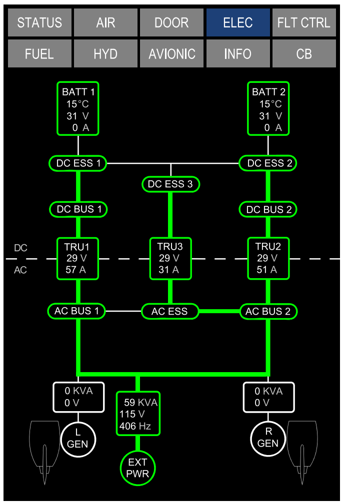
When ground power is available, shutting down the engine and APU VFGs automatically connects the external power mode.



EXTERNAL POWER IN USE

EXT PWR IN USE

EICAS STATUS MESSAGE

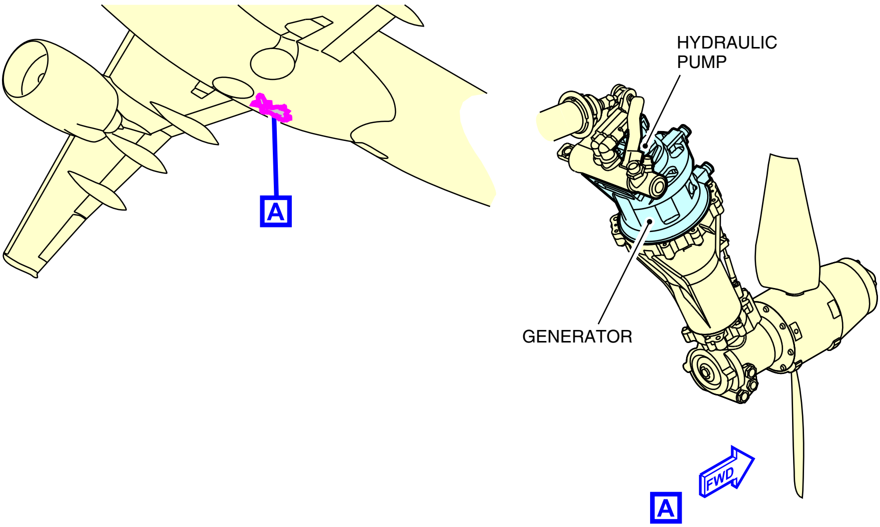


SYNOPTIC PAGE - ELEC

External power mode
Figure 07–02–3

D. Ram Air Turbine (RAT)

If there is full loss of AC power, a Ram Air Turbine (RAT) supplies emergency AC power and hydraulics. The RAT is stored in the right side of the wing-to-body fairing near the right main landing gear (refer to Figure 07–02–4). It is a two-bladed, wind-driven turbine that powers a 115 VAC, air-cooled generator, rated at 10 kVA. It also drives a hydraulic pump.



Ram air turbine
Figure 07–02–4

If there is a full loss of AC power in-flight, the RAT deploys automatically. The flight crew can also manually deploy the RAT with the guarded RAT GEN switch on the overhead ELECTRICAL panel. For more information, refer to Section 06 – Controls and indications.

When the RAT is deployed, the advisory message **RAT DPLY** is displayed on the EICAS page.

Electrical power from the RAT generator supplies the AC ESS bus, which powers Electrical Power Center 3 (EPC 3) and DC ESS 3 bus through TRU 3. Refer to Section 04 — Primary power distribution in this chapter.

The RAT supplies electrical power at aircraft speeds of 148 KIAS or more, and hydraulic power at speeds as low as 115 KIAS. Refer to Figure 07–02–5.

The batteries connect to the DC ESS 1 and DC ESS 2 busses, and all three DC ESS busses are connected in parallel.

The RAT cannot be stowed in flight.

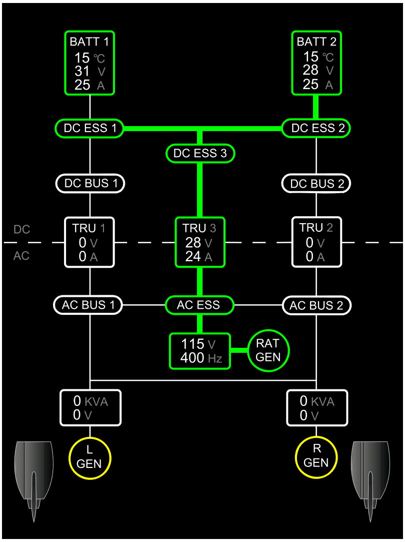
(1) Ram Air Turbine Generator Control (RGC)

The RAT Generator Control (RGC) and the Emergency Power Control (EMPC) unit monitor and control the generation and distribution of electrical power supplied to EPC 3.

During all phases of flight, the EMPC receives power from DC ESS 2 bus, DC ESS 3 bus, and DC EMER bus. It supplies 28 VDC to the RGC during power-up Built-In-Test (BIT), executes RAT auto-deploy logic, gives redundant overvoltage protection and manages emergency power distribution when the RAT is deployed.

When AC power is supplied by the RAT only, the messages that follow will be displayed on the EICAS pages:

- **EMER PWR ONLY** EICAS warning message, and
- **RAT GEN ON** EICAS advisory message.



EMER PWR ONLY

EICAS WARNING MESSAGE

RAT GEN ON

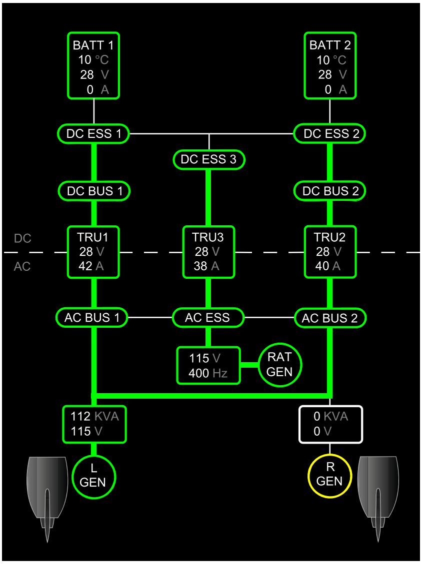
EICAS ADVISORY MESSAGE

Ram Air Turbine (RAT) generator control
Figure 07–02–5

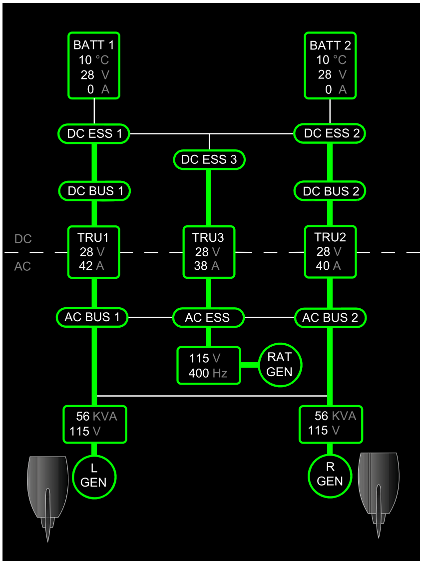
If a single VFG is recovered while the RAT is deployed, the VFG supplies the entire electrical system except for the AC ESS and DC ESS 3 busses. The RAT continues to supply these two busses.

The **RAT DPLY** advisory message replaces the **EMER PWR ONLY** warning message on the EICAS page (refer to Figure 07–02–6).

If a second VFG is recovered, the electrical system is powered normally, with the exception that the RAT continues to supply the AC ESS bus and DC ESS 3 bus.



SINGLE VFG WITH RAT



TWO VFGs WITH RAT

RAT DPLY

RAT GEN ON

EICAS ADVISORY MESSAGE

VFGs with RAT
Figure 07–02–6

DC POWER GENERATION – OVERVIEW

DC power for the aircraft is supplied by:

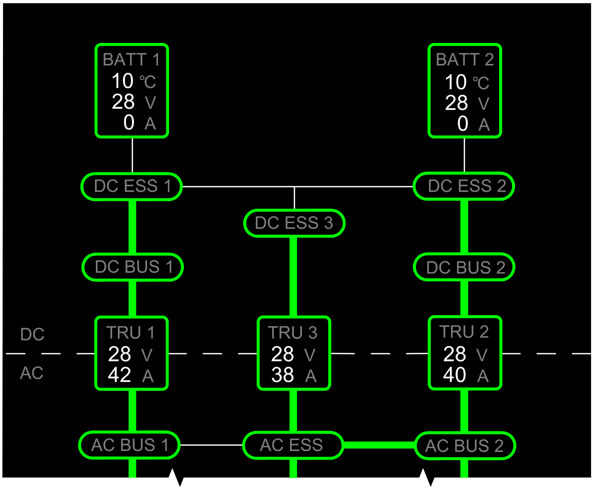
- Transformer Rectifier Units (TRUs),
- Nickel-cadmium (NiCad) batteries, and
- Battery Chargers.

DC power, generated by two Fly-By-Wire Power Converters (FBWPCs), is supplied to the Electronic Flight Control System (EFCS) and engine Full Authority Digital Engine Controller (FADEC).

DC POWER GENERATION – DESCRIPTION AND OPERATION

A. Transformer Rectifier Units (TRUs)

Three Transformer Rectifier Units (TRUs) are the primary source of DC power, and are each rated at 350 amperes. The TRUs receive 115 VAC power from the AC busses, convert it to 28 VDC, and distribute it to the DC busses. Refer to Figure 07–03–1.



DC power generation
Figure 07–03–1

AC SOURCE	TRU	POWERS	MONITORED BY	LOCATION
AC BUS 1	TRU1	DC BUS 1	BPCU 1	EPC 1
AC BUS 2	TRU2	DC BUS 2	BPCU 2	EPC 2
AC ESS BUS	TRU3	DC ESS 3	EMPC	EPC 3

B. Batteries

Two 24 VDC NiCad batteries, each rated at 42 ampere-hours (Ah), are located on the right side of the wing-to-body fairing. They supply power for the components that follow:

- BATT DIR busses at all times,
- DC EMER bus at all times,

- DC ESS busses when BATT selector is in AUTO and TRUs are not functioning, and
- Electric brakes when all other DC sources are not available.

During ground operations, the batteries are used for operations such as refueling and APU start. They also make it possible for maintenance personnel to open and reset electronic circuit breakers. If the aircraft is not powered by an external AC source, both batteries are needed to start the APU. Battery 1 powers the APU ECU, and Battery 2 powers the APU starter.

If only batteries supply the power for more than 5 minutes, the **BATT DISCHARGING** caution message is displayed on the EICAS page. A horn also sounds until AC power is available, or batteries are switched off.

C. Battery chargers

There are two identical AC battery chargers in the mid equipment bay. Battery charger 1 charges BATT 1 and battery charger 2 charges BATT 2 through their respective BATT DIR busses.

Battery charger 1 receives power from AC BUS 1 and battery charger 2 receives power from AC BUS 2.

Each battery charger monitors battery temperature to determine the appropriate charging threshold and inhibits charging if the battery temperature exceeds this threshold.

The battery chargers function when the BATT 1 (2) switches are set to AUTO, and the corresponding AC BUS 1 (2) is powered. Regardless of the position of the BATT switches, the battery chargers are turned on during external power ground service mode operation.

In emergency power conditions, AC BUS 2 is not available, and battery charger 2 is powered from the AC ESS bus. Battery charger 1 is not powered in this case.

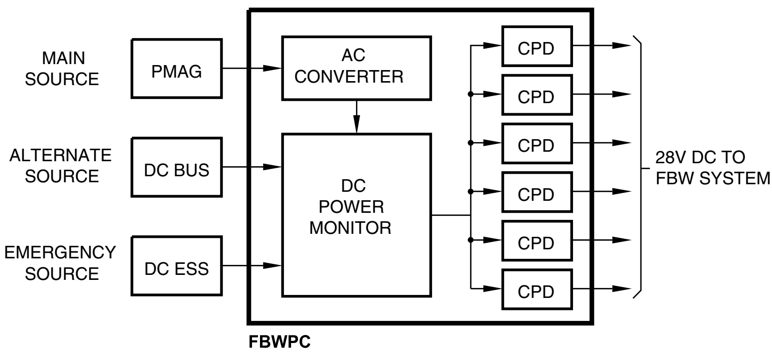
D. Fly-by-wire power generation and FADEC power

The two Permanent Magnet Alternator/Generators (PMAGs), one on each engine accessory gearbox, supply dedicated AC power to two FBWPCs and the Electronic Engine Control (EEC) of each FADEC.

NOTE

These PMAGs are not the PMGs associated with the engine-driven variable frequency generators or the APU generator. They are separate and independent of the aircraft electrical system.

Each PMAG converter changes AC to DC and supplies dedicated DC power to the Fly-By-Wire (FBW) system through Circuit Protection Devices (CPDs). An alternate and emergency source of DC power also feeds into the FBWPC. A power monitor selects the source of DC power based on availability from the TRUs or the DC ESS busses. Refer to Figure 07–03–2.



LEGEND

CPD	Circuit Protection Device
FBW	Fly–By–Wire
FBWPC	Fly–By–Wire Power Converter
PMAG	Permanent Magnet Alternator/Generator

Fly–By–Wire power converter
Figure 07–03–2

PRIMARY POWER – OVERVIEW

The primary power distribution system distributes AC and DC power from the electrical sources to the Electrical Power Centers (EPCs).

The components of the primary power distribution system are:

- AC busses,
- DC busses,
- Electrical Power Centers (EPCs),
- Bus Power Control Units (BPCUs), and
- Emergency Power Control (EMPC).

PRIMARY POWER – DESCRIPTION AND OPERATION

A. AC busses

The aircraft has three AC busses:

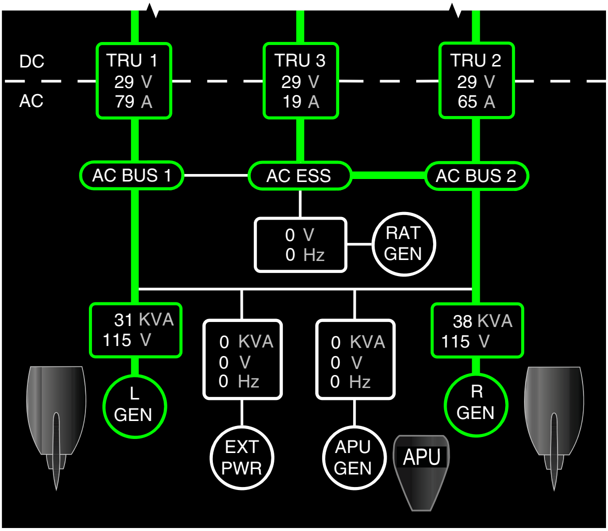
- AC BUS 1,
- AC BUS 2, and
- AC ESS bus.

AC BUS 1 and AC BUS 2 are the main AC busses. They receive power from the Variable Frequency Generator (VFG), the APU generator, or from external AC power.

The AC Essential (AC ESS) bus supplies power to the AC equipment required for flight. The AC ESS is normally powered by AC BUS 2 but can be powered by AC BUS 1 or the RAT.

Each AC bus powers a Transformer Rectifier Unit (TRU), which supplies the primary source of DC power.

Figure 07–04–1 shows the AC BUS architecture.



ELEC synoptic page – AC BUS architecture
Figure 07–04–1

B. AC BUS priority

The AC busses are automatically powered depending on the availability of power from the priority source.

The chart that follows shows the priority of main AC BUS power sources.

BUS	1st PRIORITY	2nd PRIORITY	3rd PRIORITY	4th PRIORITY
AC BUS 1	L GEN	EXT PWR	APU GEN	R GEN
AC BUS 2	R GEN	APU GEN	EXT PWR	L GEN

C. DC busses

There are eight DC busses:

- DC BUS 1 and DC BUS 2,

- DC ESS 1, DC ESS 2 and DC ESS 3,
- BATT DIR 1 and BATT DIR 2, and
- DC EMER bus.

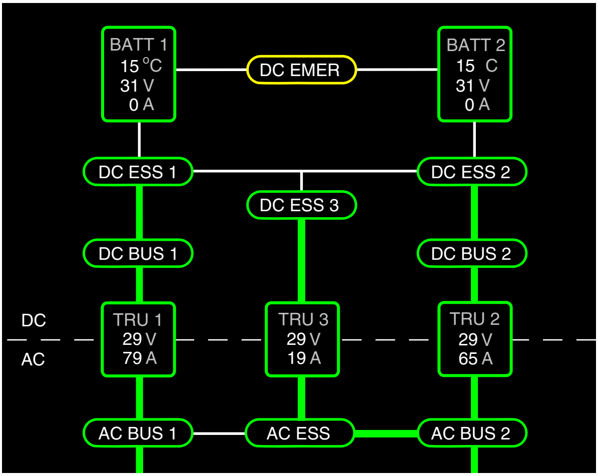
DC BUS 1 and DC BUS 2 are the main DC busses and normally receive power from their respective TRUs.

The DC ESS busses supply power to the DC equipment necessary for flight. DC ESS 1 and DC ESS 2 normally receive power from their respective main DC bus. DC ESS 3 normally receives power from TRU3.

BATT DIR 1 and BATT DIR 2 are not shown on the ELEC synoptic page. They are powered by their respective battery.

The DC EMER bus only shows on the ELEC synoptic page when not powered. It receives power from both batteries.

Figure 07–04–2 shows the DC BUS architecture.

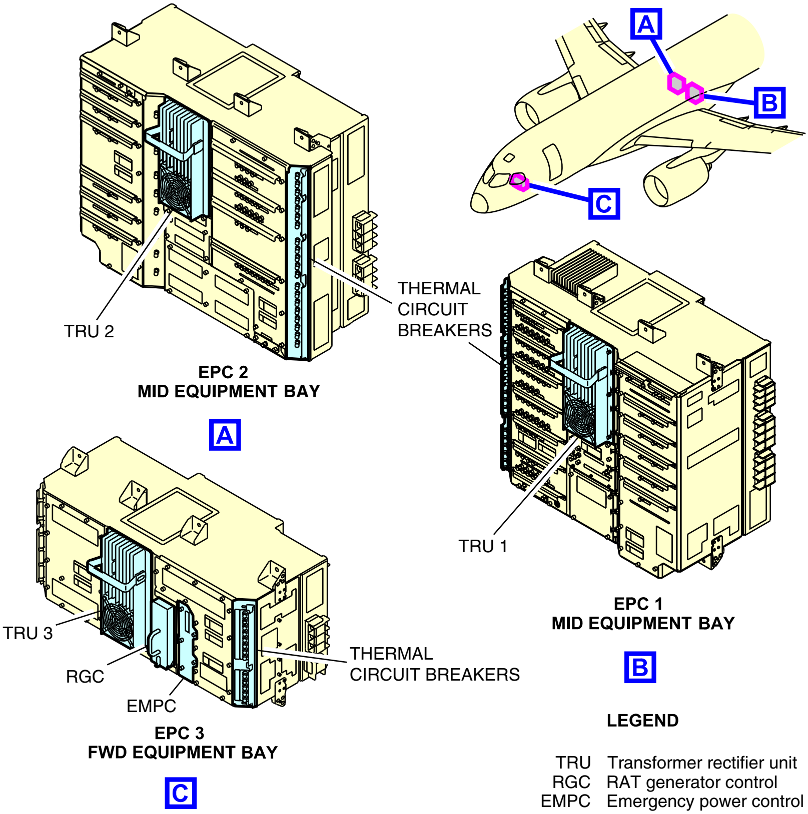


ELEC synoptic page – DC BUS architecture
Figure 07–04–2

D. Electrical Power Centers (EPCs)

Power isolation and distribution for the electrical system is managed by three Electrical Power Centers (EPCs). The EPCs contain the AC and DC busses, the TRUs, the line and bus tie contactors, and most of thermal circuit breakers on the aircraft. The two flight deck Circuit Breaker (CB) panels will be discussed in the secondary power distribution section.

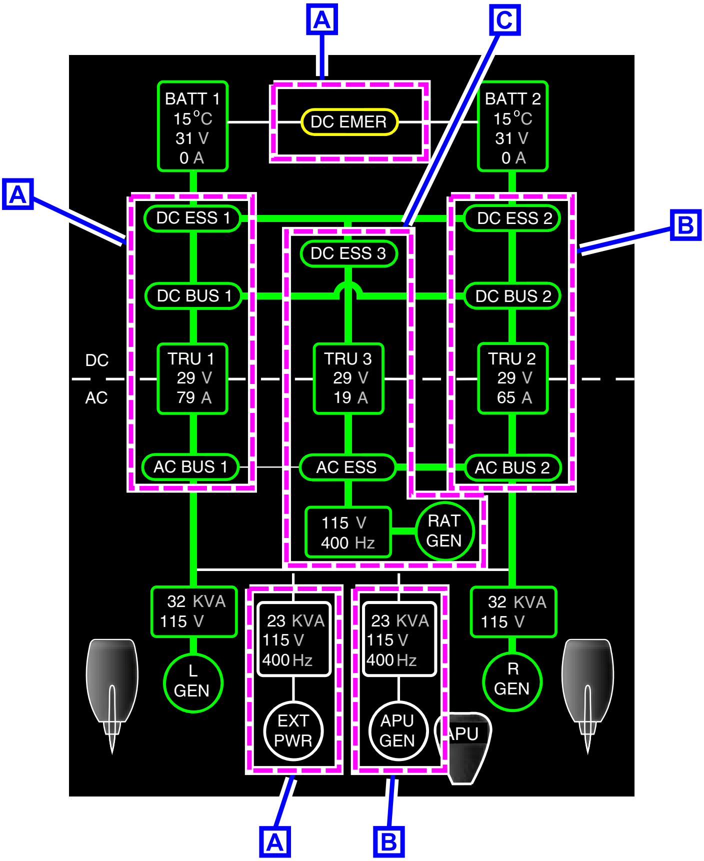
EPC 1 is located in the left mid equipment bay (aft shelf). It contains the distribution infrastructure for the left power channel and external power. EPC 2 is located in the right mid equipment bay (aft shelf). It contains the distribution infrastructure for the right power channel and APU generator. EPC 3 is located in the forward equipment bay. It contains the primary power distribution infrastructure for the essential/emergency power channel. Refer to Figure 07–04–3.



EPCs locations
Figure 07–04–3

E. Bus Power Control Units (BPCUs)

Two Bus Power Control Units (BPCUs) and the Emergency Power Control (EMPC) manage the EPCs (refer to Figure 07–04–4).



A EPC 1: CONTROLLED BY BUS POWER CONTROL UNIT 1 (BPCU 1)

B EPC 2: CONTROLLED BY BUS POWER CONTROL UNIT 2 (BPCU 2)

C EPC 3: CONTROLLED BY EMERGENCY POWER CONTROL (EMPC)

EPCs and control units
Figure 07–04–4

BPCU 1 manages EPC 1, BPCU 2 manages EPC 2, and the EMPC manages EPC 3.

The BPCUs route AC power from the available power sources (VFG, APU or EXT PWR) to their respective AC busses, TRUs, and DC busses. The BPCUs control AC and DC line contactors and bus tie contactors. This allows the control units to automatically reconfigure electrical power along alternate paths if there is a component failure.

If a BPCU fails, the remaining one takes control of the entire electrical system.

Control of the line and bus tie contactors is completely automatic, unless inhibited by the crew through the Bus Isolation (BUS ISOL) switch.

Both BPCU 1 and BPCU 2 can receive power from DC ESS BUS 1 and DC ESS BUS 2. They receive backup power from the DC EMER bus when the other power sources are not available.

F. Emergency Power Control (EMPC)

The Emergency Power Control (EMPC) unit performs the same function for EPC 3 as the BPCUs do for EPC 1 and EPC 2. In addition, the EMPC controls the RAT.

The EMPC performs the functions that follow:

- Monitors and controls the primary power distribution within EPC 3,
- Executes RAT auto-deploy logic,
- Provides a redundant overvoltage protection function for the RAT, and
- Manages emergency power distribution when the RAT is deployed.

During all phases of flight, the EMPC is powered by the DC ESS 2, DC ESS 3 and the DC EMER busses. During power-up Built-in-Test (BIT), the EMPC provides 28 VDC to the RAT Generator Control (RGC).

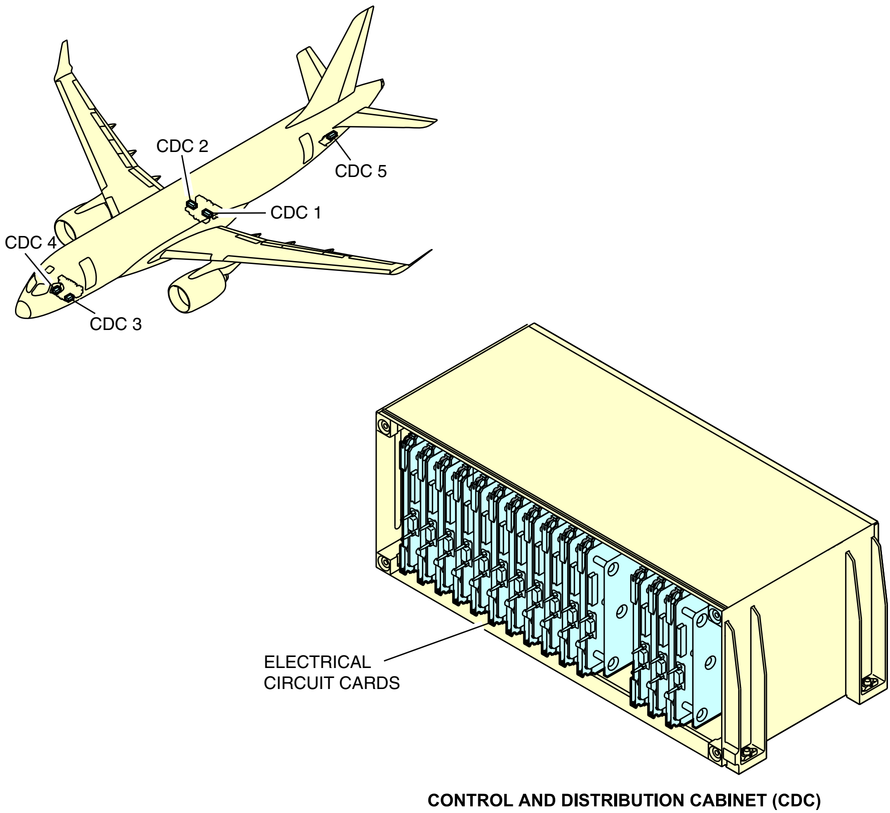
SECONDARY POWER – OVERVIEW

The secondary power distribution system consists of five Control and Distribution Cabinets (CDCs) and two thermal circuit breaker panels.

SECONDARY POWER – DESCRIPTION AND OPERATION

A. Control and Distribution Cabinets (CDCs)

Five Control and Distribution Cabinets (CDCs) receive AC and DC power from the EPCs and redistribute that power to components that are not essential for flight. CDC 1 and CDC 2, located in the mid equipment bay, are master CDCs, while CDC 3 and CDC 4, located in the forward equipment bay, and CDC 5, located in the aft equipment bay, are slaves (refer to Figure 07–05–1).



CDC and location
Figure 07–05–1

The major functions of the CDCs are to:

- Distribute power to aircraft components through Solid State Power Controllers (SSPCs),
- Manage electrical load shedding (master CDCs), and
- Monitor and report the status of all aircraft circuit breakers to the CB synoptic page (master CDCs).

B. Solid State Power Controllers (SSPCs)

Solid State Power Controllers (SSPCs) provide the function of a circuit breaker and a switch. Since they are solid state, SSPCs are considered virtual devices. Some SSPCs are always on and show as IN (in green) on the CB synoptic page. Other SSPCs may also show as IN (in green) on the CB synoptic page, but may not be activated.

SSPC logic only activates circuit breakers when specific conditions are met. A green IN on the CB synoptic page means power is available.

C. Load shedding

If a BPCU detects excessive demand on a VFG or a TRU, it requests load shedding from the master CDCs. Seven predefined groups of SSPCs are identified for electrical load shedding in the event of single generator operations. These groups are not required for continued safe flight or landing the aircraft. The master CDCs will load shed one or more of the seven groups of SSPCs based on the severity of the demand on the generator.

The first three SSPC groups are AC load and the remaining four are DC:

- Groups 1 and 2 are primarily galley equipment,
- Group 3 is mostly in-flight entertainment,
- Group 4 is lighting, and
- Groups 5, 6 and 7 are DC circuit breakers designed to unload the TRUs.

APU load shedding is requested by the APU Electronic Control Unit (ECU). On the ground, the ECU uses logic similar to that of the BPCU to request load shedding from the master CDCs. Additionally, on main engine starts the ECU may request load shedding in order to provide sufficient pneumatic power to the starter.

NOTE

At FL 410, the ECU lowers its maximum output to 58 kVA. Earlier load shedding than normal should be expected if the APU is the only source of AC power above FL 365.

D. Circuit Breaker (CB) monitoring

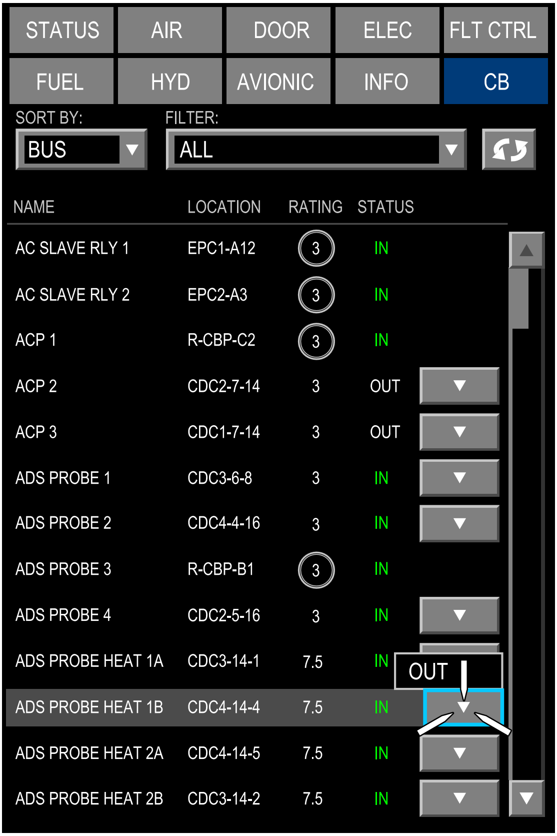
Information on Thermal Circuit Breakers (TCBs), Solid–State Power Controllers (SSPCs), and other Electronic Circuit Breakers (ECBs) displays on the CB synoptic page (refer to Figure 07–05–2).

Information is listed in columns as follows:

- The name of the TCB or ECB,
- Its physical location,
- The rating in amperes (A) of the device. TCBs are further identified with a double–line circle in the rating column, and
- The status of the device.

TCBs and ECBs may have the following status:

- IN indicates the breaker is in and its load may be powered,
- OUT indicates the breaker is out,
- TRIP indicates that the breaker has tripped due to an overload and the status has not been acknowledged. The **CB TRIP** advisory message displays on the EICAS,
- LOCK indicates the breaker has been locked offline by maintenance and is equivalent to a TCB collar,
- SHED indicates the breaker has turned off to limit electrical load, and
- INVALID indicates the breaker state is unknown.



Electronic circuit breaker page
Figure 07–05–2

E. Circuit Breaker (CB) commands

The rightmost column on the CB synoptic page permits interaction with the ECBs using the cursor. A circuit breaker or ECB that has failed is identified in this column. The TRIP acknowledgment soft switch displays when a TCB or ECB has tripped. Selecting the TRIP acknowledgment soft switch:

- Confirms the breaker tripped state,
- Changes the state to OUT, and
- Removes the CB TRIP message from the EICAS if no other TRIP acknowledgment soft switches are active.

A command soft switch displays opposite SSPCs only. Selecting it opens a command menu enabling a change of state between in or out. TCBs are accessed from the CB panels in the flight deck.

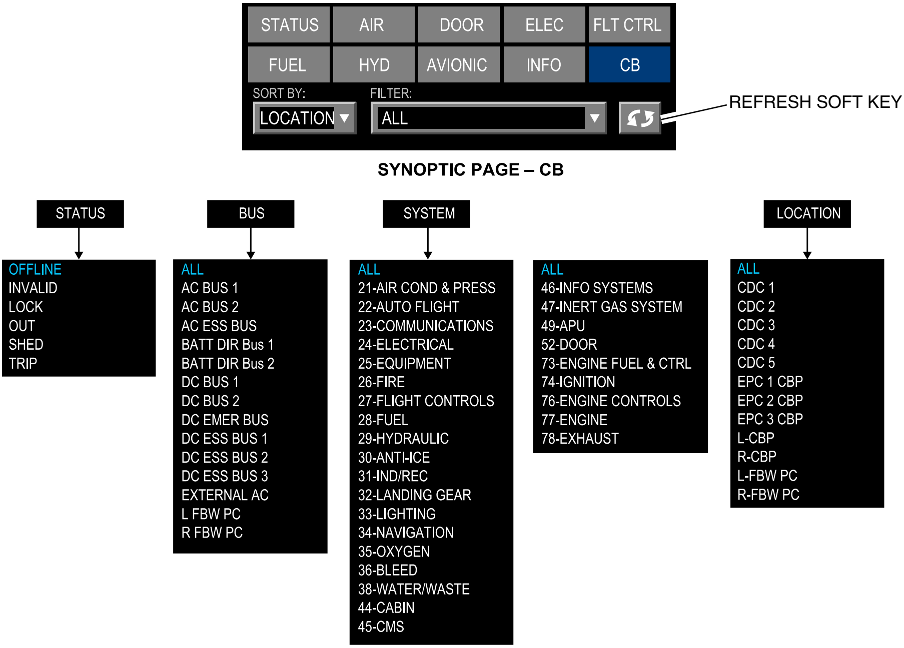
Selecting the arrow soft switches on the scroll bar displays more pages of a long CB list.

F. Circuit Breaker (CB) sorting

Sorting of displayed CB information is achieved through two combo box lists. The SORT BY box offers four selections, each of which may be organized by the FILTER box offers four selections, each of which may be organized by the FILTER box as follows:

- STATUS is filtered by six CB states (offline, invalid, lock, out, shed, trip),
- BUS is filtered by any of the AC and DC buses,
- SYSTEM is filtered by ATA number, and
- LOCATION is filtered by EPCs, CDCs, TCBs, or FBWPCs.

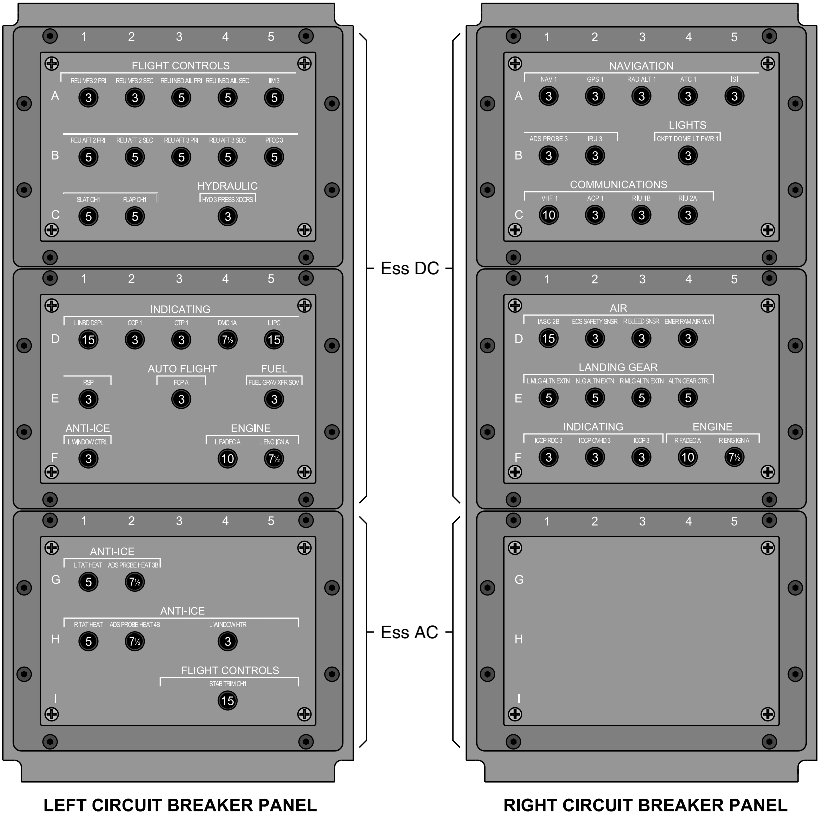
Selecting the REFRESH soft switch, which becomes visible when a new sort is required, lists the breakers according to the sort box parameters.



Circuit breaker sorting
Figure 07–05–3

G. Flight deck Circuit Breakers (CBs)

Two circuit breaker panels containing conventional thermal circuit breakers are located in the flight deck aft of the pilot seats on the left and right side walls (refer to Figure 07–05–4) . Each panel is divided into three modules. The top two modules of each panel contain selected DC essential thermal circuit breakers and the bottom module contains selected AC essential thermal circuit breakers. These are the only circuit breaker panels in the flight deck.



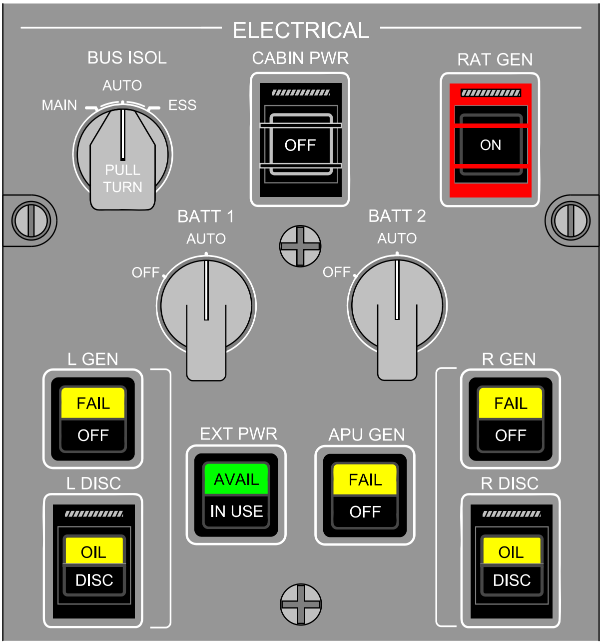
Flight deck circuit breaker panels
Figure 07–05–4

ELECTRICAL – CONTROLS

A. ELECTRICAL panel

The overhead ELECTRICAL panel has the switches that follow (refer to Figure 07–06–1):

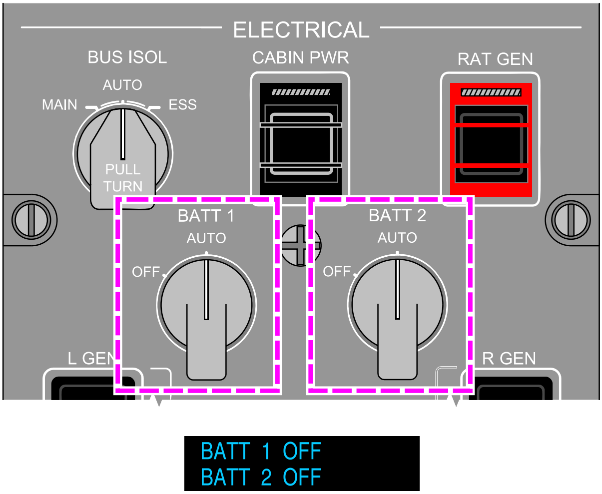
- BATT 1 and BATT 2,
- APU GEN,
- L GEN and R GEN,
- EXT PWR,
- BUS ISOL,
- CABIN PWR,
- RAT GEN, and
- L DISC and R DISC.



Overhead ELECTRICAL panel
Figure 07–06–1

B. BATT 1 and BATT 2 switches

The BATT 1 and BATT 2 switches allow the BPCU to connect the BATT DIR bus to its corresponding DC ESS (refer to Figure 07–06–2). They also allow the battery charger to operate if AC power is available.



EICAS ADVISORY MESSAGES

Battery switches
Figure 07–06–2

The BATT 1 and BATT 2 switches have two positions:

OFF: Disconnects the BATT DIR bus from its corresponding DC ESS bus. The **BATT 1 OFF** and **BATT 2 OFF** advisory messages are displayed on the EICAS page.

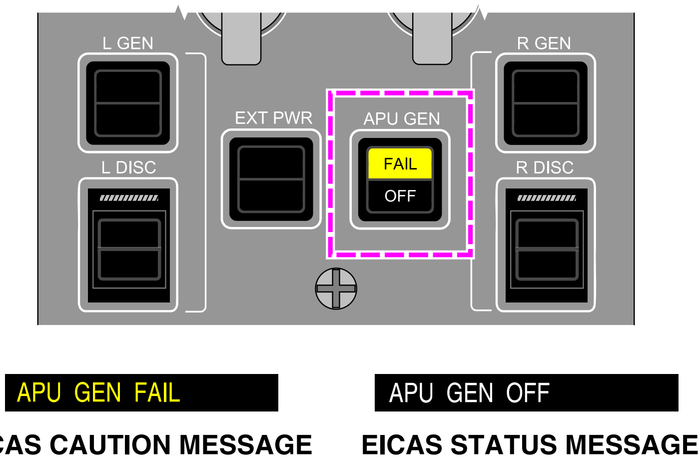
AUTO: Allows the BPCU to connect the BATT DIR bus to its corresponding DC ESS bus when necessary. In AUTO, the BATT DIR bus will power the corresponding DC ESS bus until the DC ESS bus receives power from a TRU.

NOTE

The BATT DIR busses and the DC EMER bus are always powered regardless of the BATT switch position.

C. APU GEN switch

The APU GEN switch allows the crew to connect or disconnect the APU generator (refer to Figure 07–06–3):



APU GEN switch
Figure 07–06–3

The APU GEN switch has the indications that follow:

FAIL: Is illuminated in black text on an amber background when the APU Generator Control Unit (GCU) removes the generator from the bus due to a fault. The **APU GEN FAIL** caution message is displayed on the EICAS page.

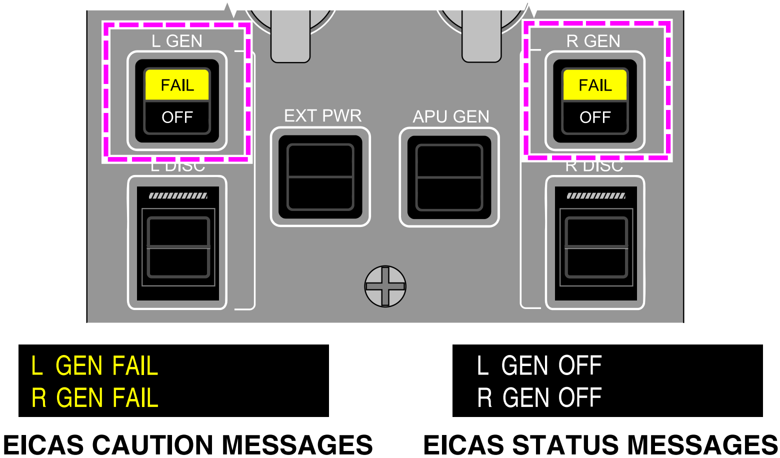
OFF: Is illuminated with white text on a black background when the generator is selected OFF while the APU is running. The **APU GEN OFF** status message is displayed on the EICAS page.

NOTE

When the APU is shut down, the OFF label in the APU GEN SWITCH will not be illuminated when the APU VFG is disconnected. The OFF light and **APU GEN OFF** EICAS status message are displayed only when the APU is in operation.

D. L GEN and R GEN switches

The L GEN and R GEN switches allow the crew to connect or disconnect the associated Variable Frequency Generator (VFG). An amber fail light indicates generator fault or failure. Refer to Figure 07–06–4.



L GEN and R GEN switches
Figure 07–06–4

The L GEN and R GEN switches have the indications that follow:

FAIL: Is illuminated with black text on an amber background when a GCU takes the VFG offline due to a fault or failure. The **L GEN FAIL** and **R GEN FAIL** caution messages are displayed on the EICAS page.

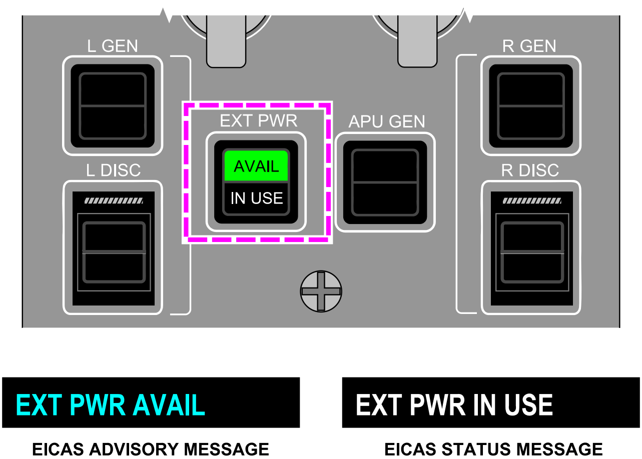
OFF: Is illuminated with white text on a black background when the GEN switch is selected OFF while the engine is running. The **L GEN OFF** and **R GEN OFF** status messages are displayed on the EICAS page.

NOTE

When the L (R) engine is shut down, the OFF label in the L (R) GEN switch will not be illuminated when the L (R) generator is disconnected. The OFF light and **L (R) GEN OFF** EICAS status message are displayed only when the engine is in operation.

E. EXT PWR switch

The EXT PWR switch allows the flight crew to connect or disconnect the external AC power. Refer to Figure 07–06–5.



EXT PWR switch
Figure 07–06–5

AVAIL: Is illuminated with black text on a green background when suitable external AC power is connected to the aircraft. The **EXT PWR AVAIL** advisory message is displayed on the EICAS page.

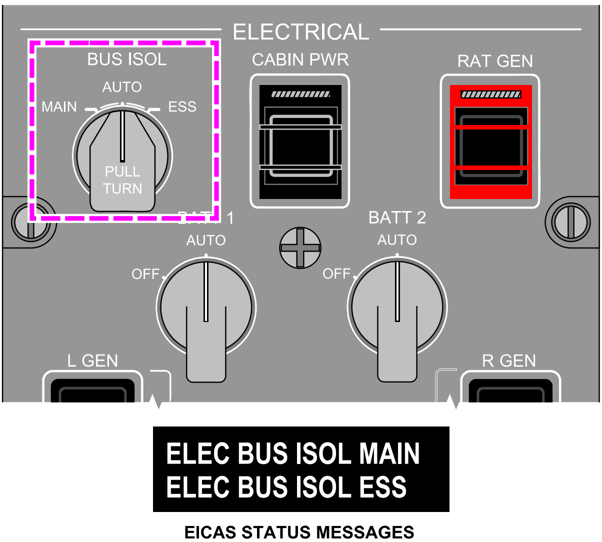
IN USE: Is illuminated with white text on a black background when external power is in use. The **EXT PWR IN USE** status message is displayed on the EICAS page.

NOTE

If an engine VFG or the APU generator is available when EXT PWR is selected, the aircraft electrical load will be shared.

F. BUS ISOL switch

The BUS ISOL switch controls automatic EPC reconfiguration of line and bus tie contactors, such as during smoke isolation procedures. Refer to Figure 07–06–6.



BUS ISOL switch
Figure 07–06–6

The BUS ISOL switch has three positions:

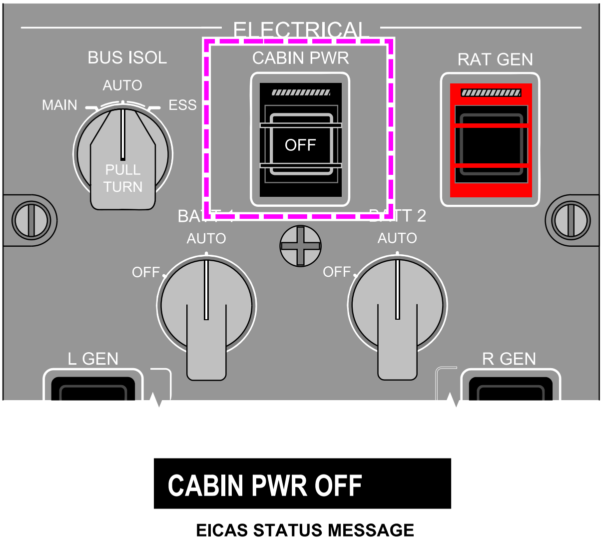
AUTO: Allows the BPCUs and EMPC to reconfigure electrical routing as needed.

MAIN: Inhibits automatic reconfiguration in EPC 1 and EPC 2. When the BUS ISOL switch is selected to MAIN, AC busses can only be powered by their on-side VFG. The **ELEC BUS ISOL MAIN** status message is displayed on the EICAS page.

ESS: Inhibits automatic reconfiguration in EPC 3. When the BUS ISOL switch is selected to ESS, only the RAT can power the AC ESS bus. The **RAT GEN ON** advisory and **ELEC BUS ISOL ESS** status messages are displayed on the EICAS page.

G. CABIN PWR guarded switch

The CABIN PWR guarded switch is used to deactivate electrical loads from flight compartment outlets and selected cabin systems to isolate sources of smoke in the cabin, such as the forward and/or aft galleys and in-flight entertainment systems. Refer to Figure 07–06–7.



CABIN PWR switch
Figure 07–06–7

NOTE

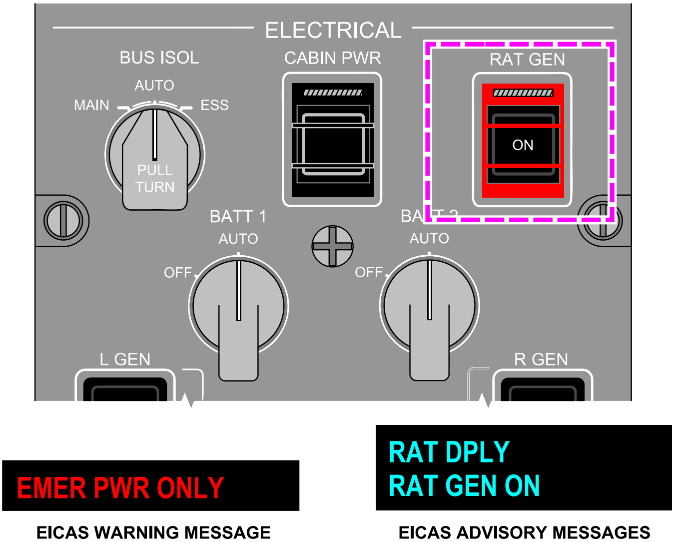
To prevent confusion or inadvertent activation during smoke isolation procedures, the CABIN PWR switch is protected with a transparent plastic guard for tactile differentiation.

The cabin PWR switch has the indication that follows:

OFF: Is illuminated with white text on a black background when CABIN PWR is selected off. The **CABIN PWR OFF** status message is displayed on the EICAS page.

H. RAT GEN guarded switch

The RAT GEN guarded switch allows the flight crew to manually deploy the RAT (the RAT is normally automatically deployed when AC power is lost in-flight). Refer to Figure 07–06–8.



RAT GEN switch
Figure 07–06–8

The RAT GEN switch has the indication that follows:

ON: Is illuminated with white text on a black background to indicate that the RAT is deployed and is supplying electrical power.

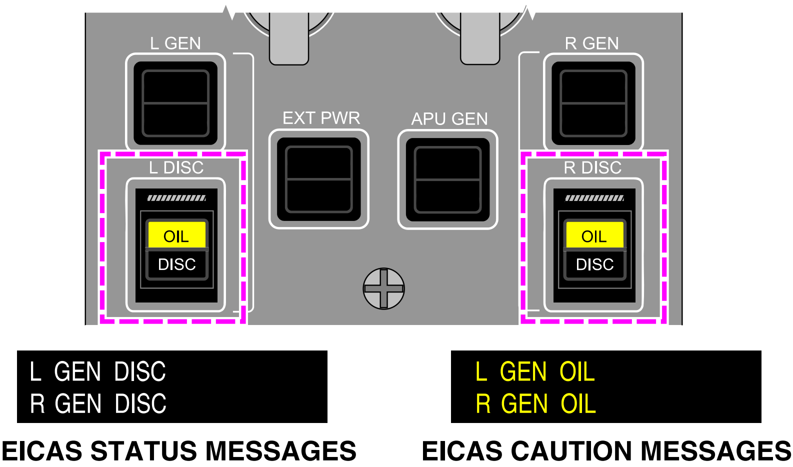
The **EMER PWR ONLY** warning message is displayed on the EICAS page and, after the generator supplies power, the **RAT GEN ON** advisory message is also displayed. If a VFG is recovered, the **RAT DPLY** advisory message replaces the **EMER PWR ONLY** warning message.

NOTE

If the RAT GEN switch is pushed when the RAT is deployed, the RAT GCU will reset.

I. L DISC and R DISC guarded switches

The L DISC and R DISC guarded switches allow the crew to disconnect the respective generator shaft from the engine gearbox (refer to Figure 07–06–9).



L DISC and R DISC switches
Figure 07–06–9

NOTE

When the L DISC or R DISC guarded switch is pushed, the corresponding VFG disconnects from the gearbox. The generator cannot be reconnected in flight.

The L DISC and R DISC switches have the indications that follow:

OIL: Is illuminated with black text on an amber background when low oil pressure or high oil temperature conditions exist. The **L GEN OIL** and **R GEN OIL** caution messages are displayed on the EICAS page.

DISC: Is illuminated with white text on a black background (only when the engine is running) to indicate that the associated generator is disconnected from the engine gearbox. The **L GEN DISC** and **R GEN DISC** status messages are displayed on the EICAS page.

NOTE

Engine VFG high oil temperature has two thresholds. When the temperature reaches the first threshold, the amber OIL light comes on in the corresponding switch. When the temperature is at the higher limit threshold, the engine VFG automatically disconnects from the engine accessory gearbox.

ELECTRICAL – INDICATIONS

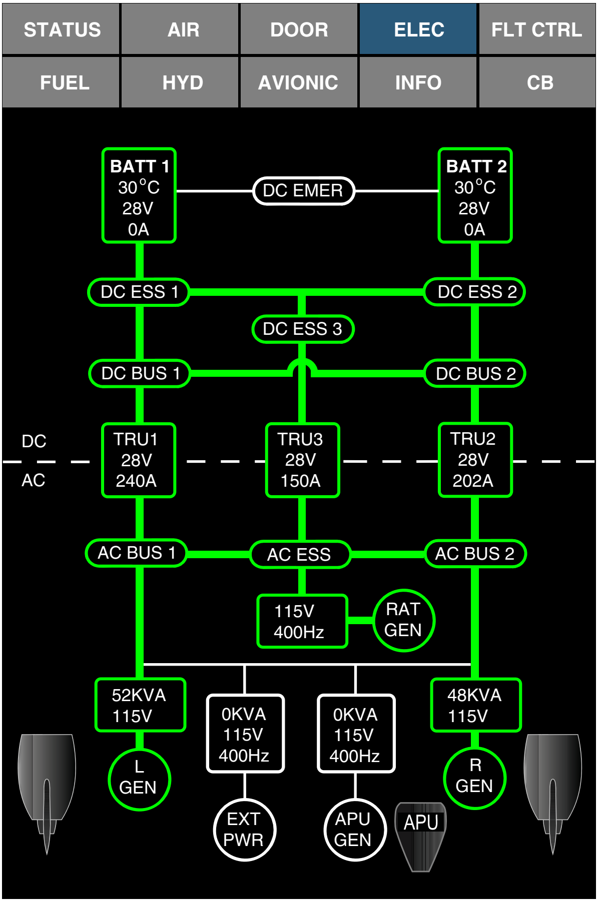
A. ELEC synoptic page

The ELECT synoptic page shows the different states of operation of the electrical components to give the flight crew situational awareness (refer to Figure 07–06–10).

NOTE

The indications shown on the ELEC synoptic page in Figure 07–06–10 are not representative of any particular configuration.

Figure 07–06–11 shows the legend for the ELEC synoptic page.



ELEC synoptic page
Figure 07–06–10

ENGINE REPRESENTATION (MANAGED BY FADEC AND APU)

SYMBOL	CONDITION
APU	RUNNING
APU	NOT RUNNING
APU	INVALID

FLOW LINES

SYMBOL	CONDITION
	POWERED
	NOT POWERED
	INVALID

GEN STATUS AND ASSOCIATED BOXOUT

SYMBOL	CONDITION
0 KVA 115V 400Hz, L GEN / L GEN DISC	–NOT OPERATING –DISCONNECT
0 KVA 115V 400Hz, APU GEN	FAILED
0 KVA 115V 400Hz, EXT GEN	INVALID
0 KVA 115V 400Hz, R GEN	OPERATING

BUS STATUS

SYMBOL	CONDITION
DC ESS 3	POWERED
AC ESS	FAILED
DC EMER	DISCONNECTED
AC BUS 1	INVALID

DECLUTTERED SYMBOLOGY LOGIC

SYMBOL	CONDITION
73KVA 115V 400Hz, APU GEN, APU	SHOWN ONLY WHEN APU IS RUNNING OR CONTROL IS INVALID

DECLUTTERED SYMBOLOGY LOGIC

SYMBOL	CONDITION
73KVA 115V 400Hz, EXT PWR	SHOWN ONLY WHEN EXTERNAL AC FREQUENCY IS DETECTED OR CONTROL LOGIC IS INVALID

TRU/BATT STATUS

SYMBOL	CONDITION
TRU1 28 V 0 A	NOT ONLINE NORMAL DISCONNECT
BATT1 30 °C 28 V 20 A	NORMAL OPERATION
BATT2 30 °C 150 V 200 A	FAIL
TRU3 32 V 11 A	INVALID

CURRENT, VOLTAGE, FREQUENCY, PWR RATING READOUTS

SYMBOL	CONDITION
44 A	ABNORMAL
28 V	NORMAL
-- KVA	INVALID

TEMPERATURE READOUT

SYMBOL	CONDITION
72 °C	OVERTEMP
32 °C	NORMAL
-- °C	INVALID

DECLUTTERED SYMBOLOGY LOGIC

SYMBOL	CONDITION
115V 400Hz, RAT GEN	SHOWN ONLY WHEN RAT IS DEPLOYED OR RAT LINE CONTACTOR CLSD OR CONTROL LOGIC IS INVALID

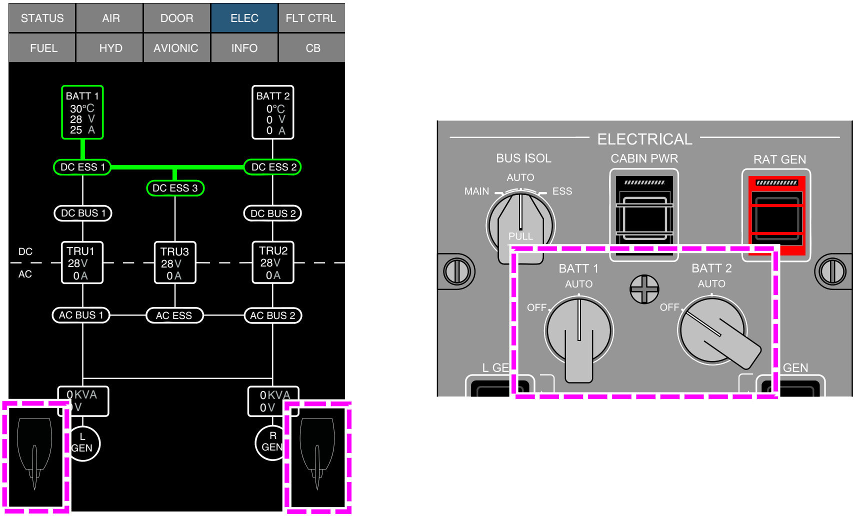
DECLUTTERED SYMBOLOGY LOGIC

SYMBOL	CONDITION
	INTERCONNECT DC BUS 1 AND DC BUS 2 FLOW LINES SHOWN ONLY WHEN ENERGIZED OR CONTROL LOGIC IS INVALID

ELEC synoptic page – Legend
Figure 07–06–11

B. ELEC synoptic page – BATT 1 AUTO and BATT 2 OFF

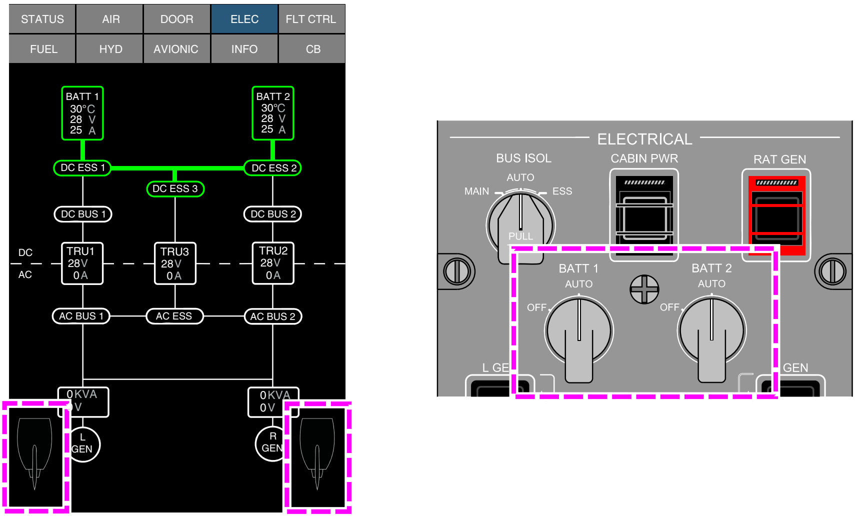
Figure 07–06–12 shows the ELEC synoptic page with the BATT 1 switch set to AUTO and the BATT 2 switch set to OFF. Only the DC ESS 1, DC ESS 2, and DC ESS 3 busses are powered. The aircraft is on the ground without external AC power applied.



ELEC synoptic page – BATT 1 switch at AUTO and BATT 2 switch at OFF
Figure 07–06–12

C. ELEC synoptic page – BATT 1 AUTO and BATT 2 AUTO

Figure 07–06–13 shows the ELEC synoptic page with the BATT 1 switch set to AUTO and the BATT 2 switch set to AUTO. Only the DC ESS 1, DC ESS 2, and DC ESS 3 busses are powered. The aircraft is on the ground without external AC power.

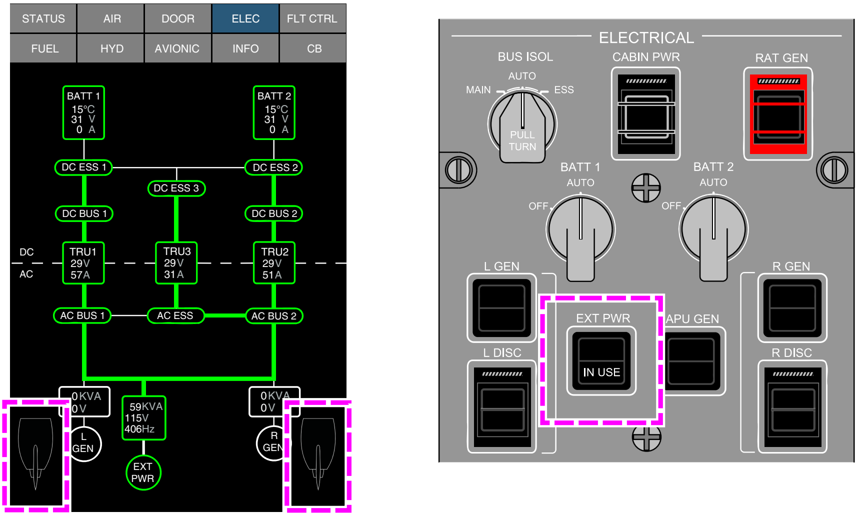


ELEC synoptic page – BATT 1 and BATT 2 switches at AUTO
Figure 07–06–13

D. ELEC synoptic page – EXT PWR IN USE

Figure 07–06–14 shows the ELEC synoptic page with the EXT PWR switch set to IN USE. All the AC and DC busses are powered.

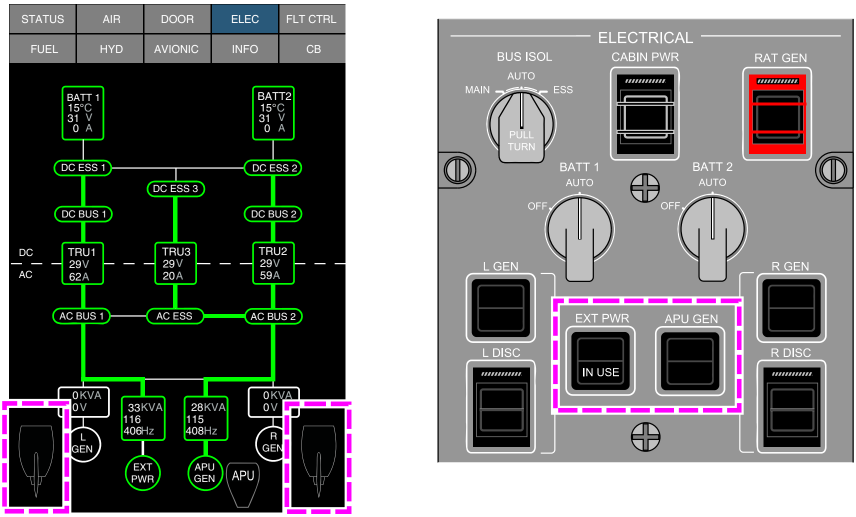
The aircraft is on the ground with only the external AC power applied.



ELEC synoptic page – EXT PWR IN USE
Figure 07–06–14

E. ELEC synoptic page – EXT PWR IN USE and APU GEN online

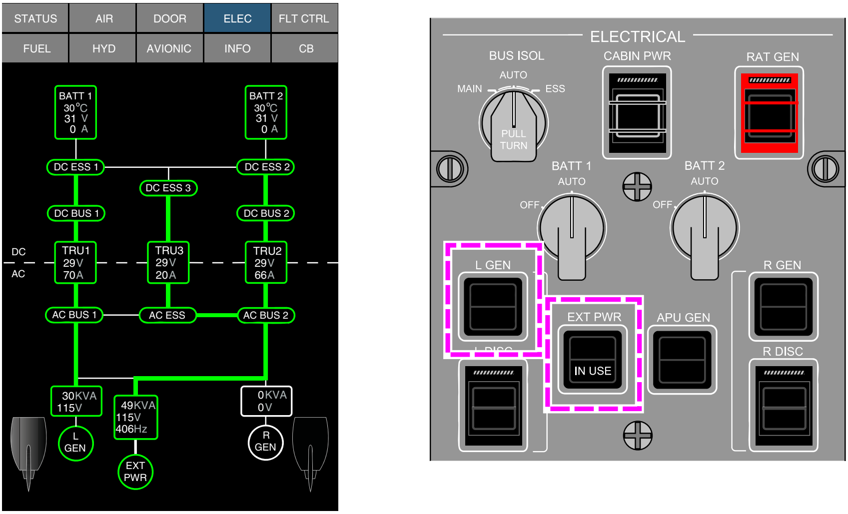
Figure 07–06–15 shows the ELEC synoptic page with EXT PWR in use and the APU GEN online (APU running). All the AC and DC busses are powered. The aircraft is on the ground using external AC power with the APU GEN online.



ELEC synoptic page – EXT PWR IN USE and APU ON
Figure 07–06–15

F. ELEC synoptic page – EXT PWR IN USE and L GEN online

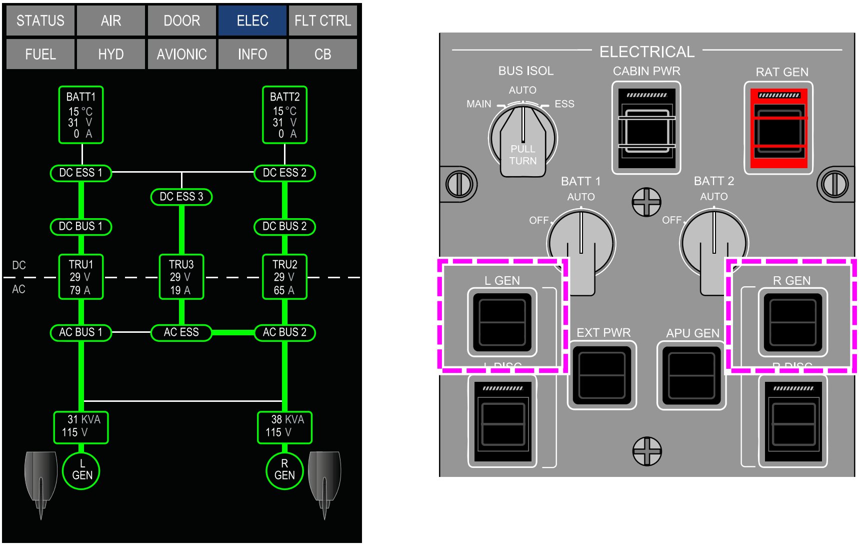
Figure 07–06–16 shows the ELEC synoptic page with the EXT PWR switch set to IN USE and the L GEN online (L ENG running). All the AC and DC busses are powered. The aircraft is on the ground with external AC power applied and the left engine running.



ELEC synoptic page – EXT PWR IN USE and L GEN ON
Figure 07–06–16

G. ELEC synoptic page – L GEN online and R GEN online

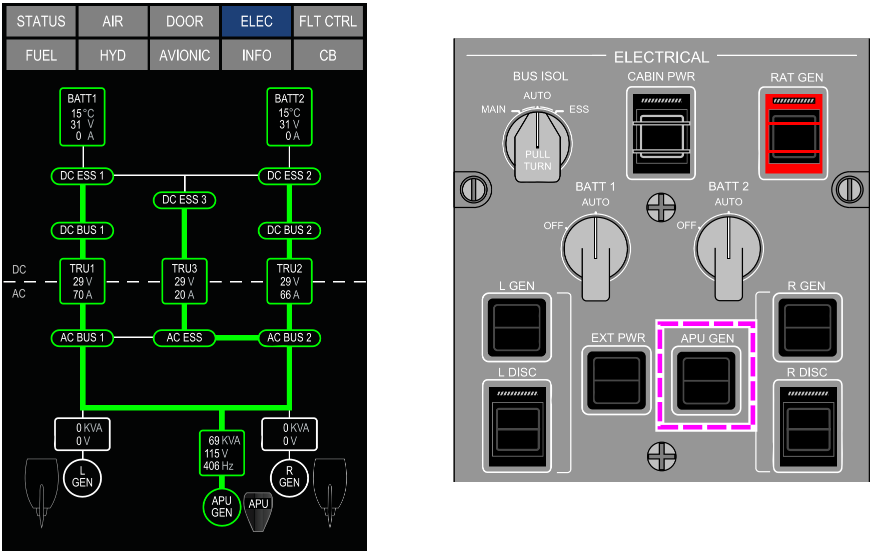
Figure 07–06–17 shows the ELEC synoptic page with both the L GEN and the R GEN online (both engines running). All the AC and DC busses are powered. The aircraft can be on the ground or in the air with both engines running.



ELEC synoptic page – L GEN and R GEN ON
Figure 07–06–17

H. ELEC synoptic page – APU GEN online

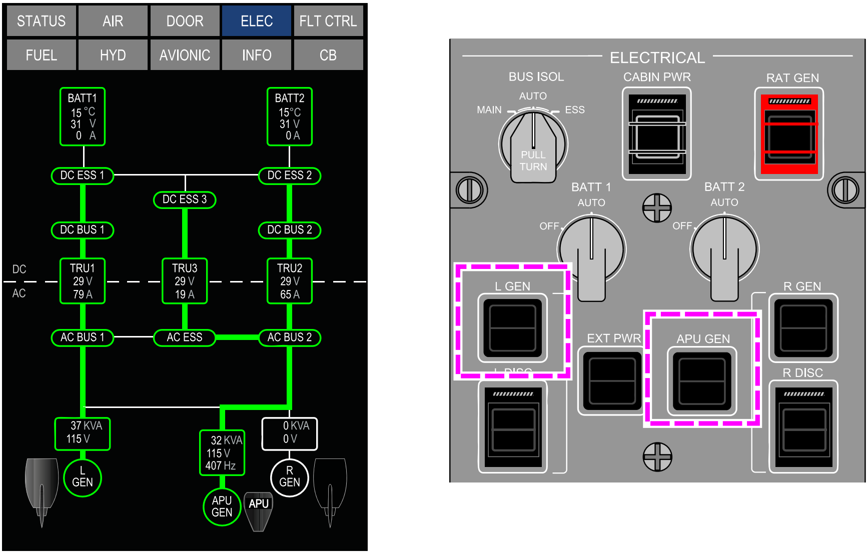
Figure 07–06–18 shows the ELEC synoptic page with only the APU GEN online. All the AC and DC busses are powered. The aircraft is on the ground with only the APU running.



ELEC synoptic page – APU ON
Figure 07–06–18

I. ELEC synoptic page – APU GEN online and L GEN online

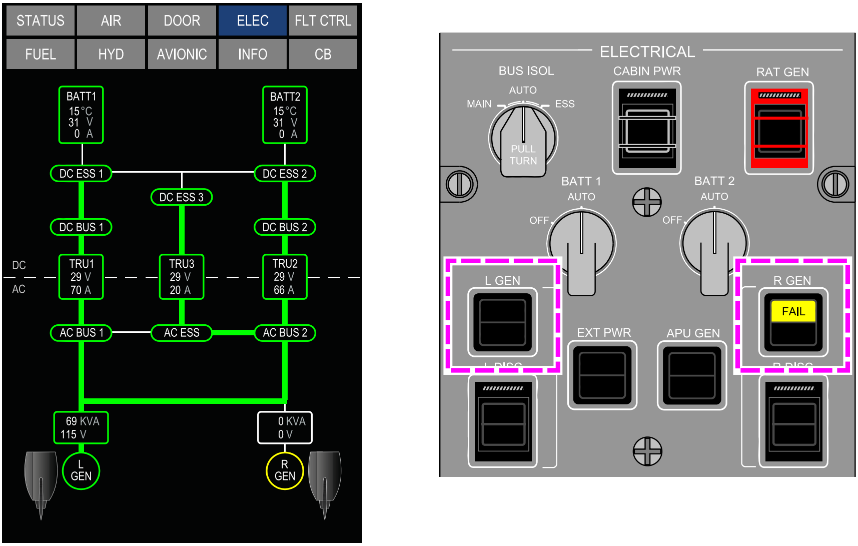
Figure 07–06–19 shows the ELEC synoptic page with the APU GEN online (APU running) and the L GEN online (L engine running). All the AC and DC busses are powered. The aircraft is on the ground with the APU and the left engine running.



ELEC synoptic page – APU and L GEN ON
Figure 07–06–19

J. ELEC synoptic page – R GEN failed

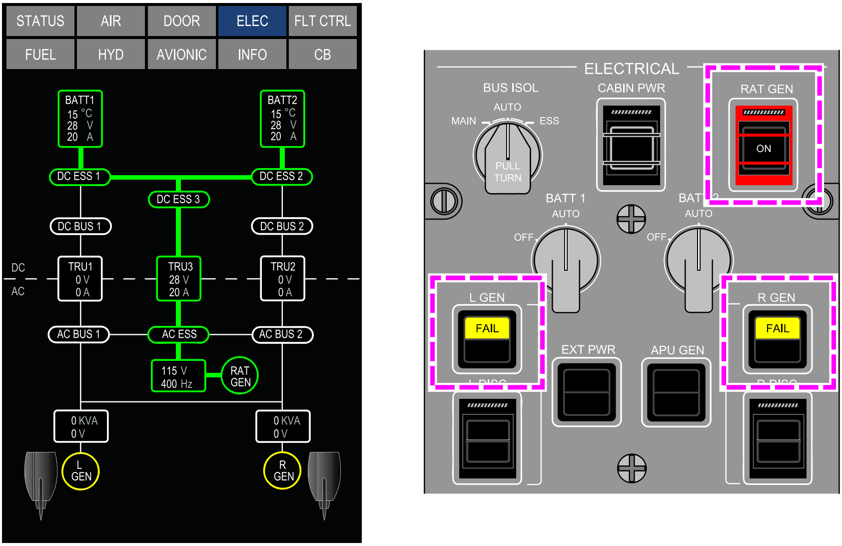
Figure 07–06–20 shows the ELEC synoptic page with the L GEN online and the R GEN failed (both engines running). All the AC and DC busses are powered. The aircraft is on the ground or in the air with both engines running and only the left generator available.



ELEC synoptic page – R GEN FAIL
Figure 07–06–20

K. ELEC synoptic page – L GEN failed and R GEN failed

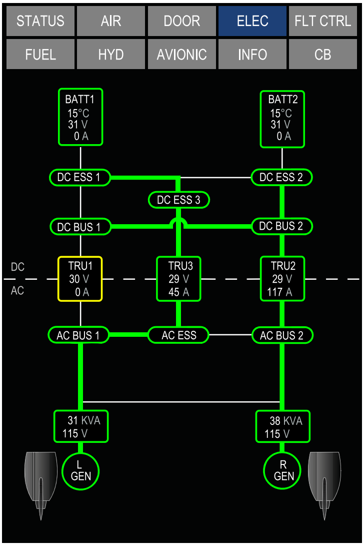
Figure 07–06–21 shows the ELEC synoptic page with both L GEN and R GEN failed (both engines running) and the RAT GEN online (RAT deployed). Only the AC ESS, DC ESS 3, DC ESS 1, and DC ESS 2 busses are powered. The aircraft is in the air on emergency power with both engines running with failed generators.

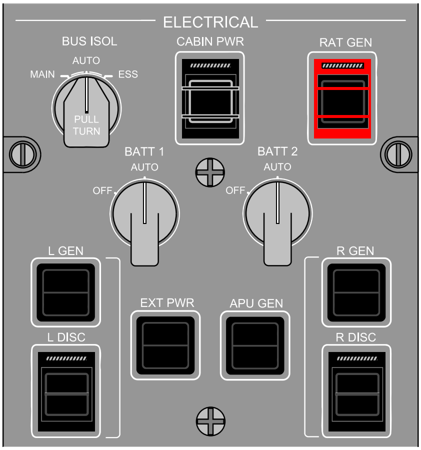


ELEC synoptic page – L GEN and R GEN FAIL
Figure 07–06–21

L. ELEC synoptic page – Single TRU failure

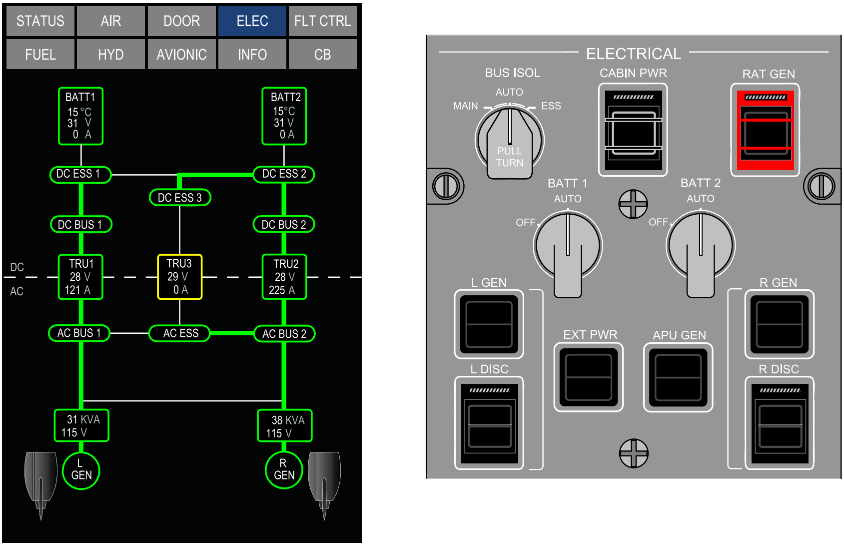
Figure 07–06–22 shows the ELEC synoptic page with TRU 1 failed. All the AC and DC busses are powered. The aircraft is on the ground or in the air with both engines running and both generators on.





ELEC synoptic page – TRU 1 failure
Figure 07–06–22

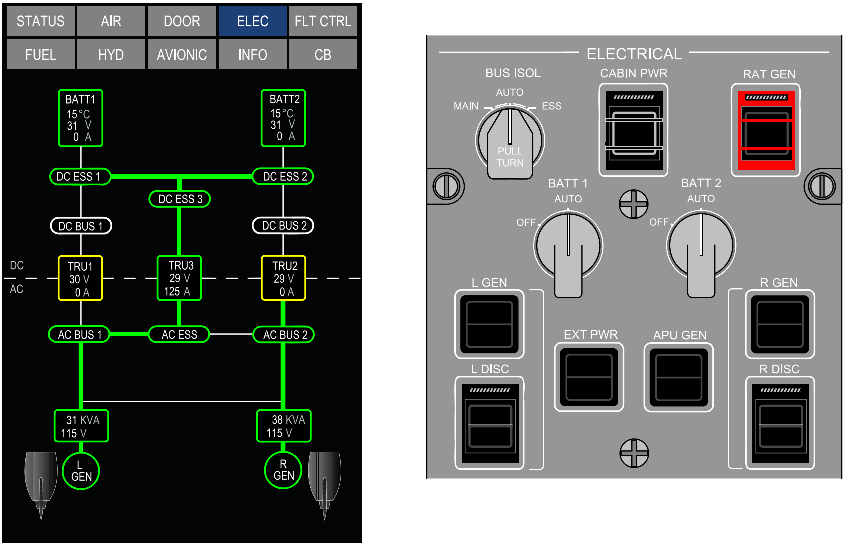
Figure 07–06–23 shows the ELEC synoptic page with TRU 3 failed. All the AC and DC busses are powered. The aircraft is on the ground or in the air with both engines running and both generators on.



ELEC synoptic page – TRU 3 failure
Figure 07–06–23

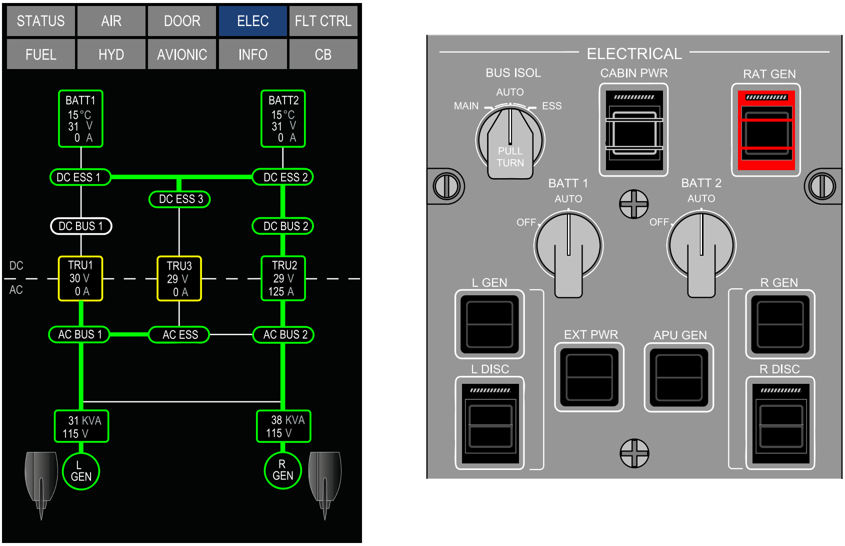
M. ELEC synoptic page – Multiple TRU failures

Figure 07–06–24 shows the ELEC synoptic page with TRU1 and TRU2 failed. All the AC busses are powered. Only the DC ESS 1, DC ESS 2, and DC ESS 3 busses are powered. The aircraft is on the ground or in the air with both engines running and both generators online.



ELEC synoptic page – TRU 1 and TRU 2 failures
Figure 07–06–24

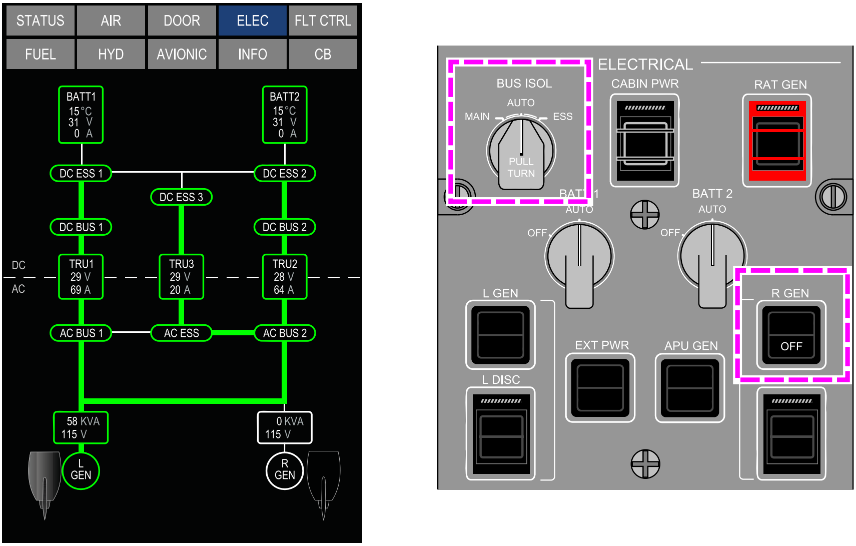
Figure 07–06–25 shows the ELEC synoptic page with TRU1 and TRU3 failed. All the AC busses are powered. Only the DC ESS 1, DC ESS 2, DC ESS 3, and DC BUS 2 are powered. The aircraft is on the ground or in the air with both engines running and both generators online.



ELEC synoptic page – TRU 1 and TRU 3 failures
Figure 07–06–25

N. ELEC synoptic page – BUS ISOL at AUTO and R GEN OFF

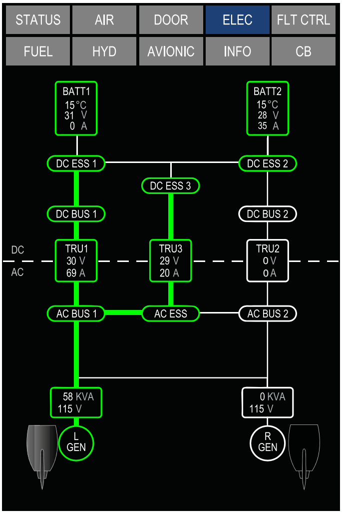
Figure 07–06–26 shows the ELEC synoptic page with the BUS ISOL switch set to AUTO and the R GEN set to OFF. All the AC and DC busses are powered. The aircraft is on the ground or in the air with only the left engine running and the left generator online.

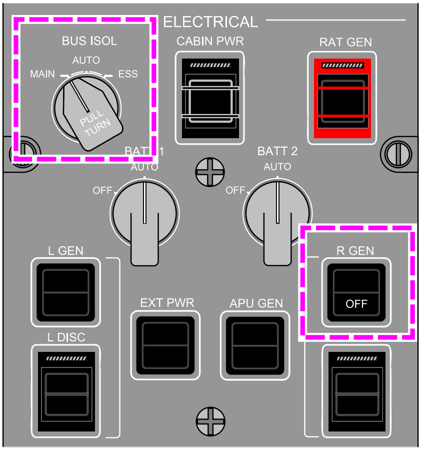


ELEC synoptic page – BUS ISOL switch at AUTO and R GEN OFF
Figure 07–06–26

O. ELEC synoptic page – BUS ISOL at MAIN and R GEN OFF

Figure 07–06–27 shows the ELEC synoptic page with the BUS ISOL switch set to MAIN and the R GEN switch set to OFF. Only AC BUS 1 and AC ESS are powered. All DC busses remain powered except DC BUS 2. The aircraft is on the ground or in the air with the left engine running and the left generator online.

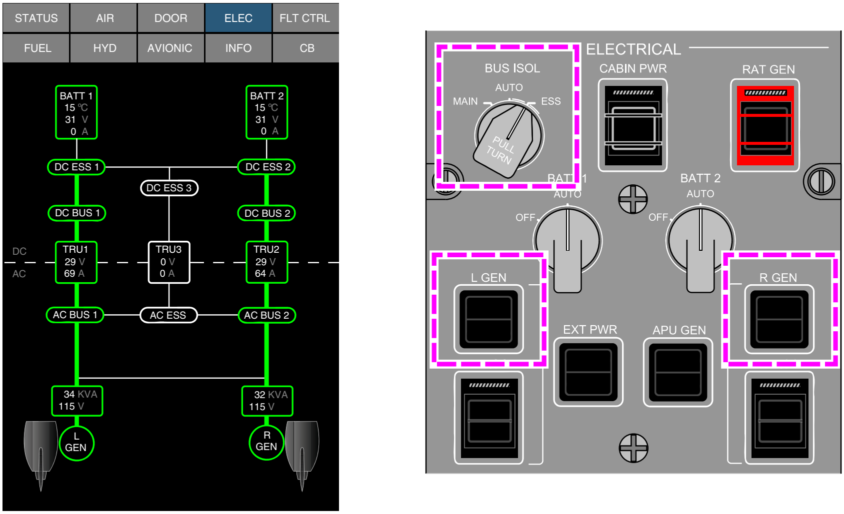




ELEC synoptic page – BUS ISOL switch at MAIN and R GEN OFF
Figure 07–06–27

P. ELEC synoptic page – BUS ISOL at ESS, L GEN online and R GEN online

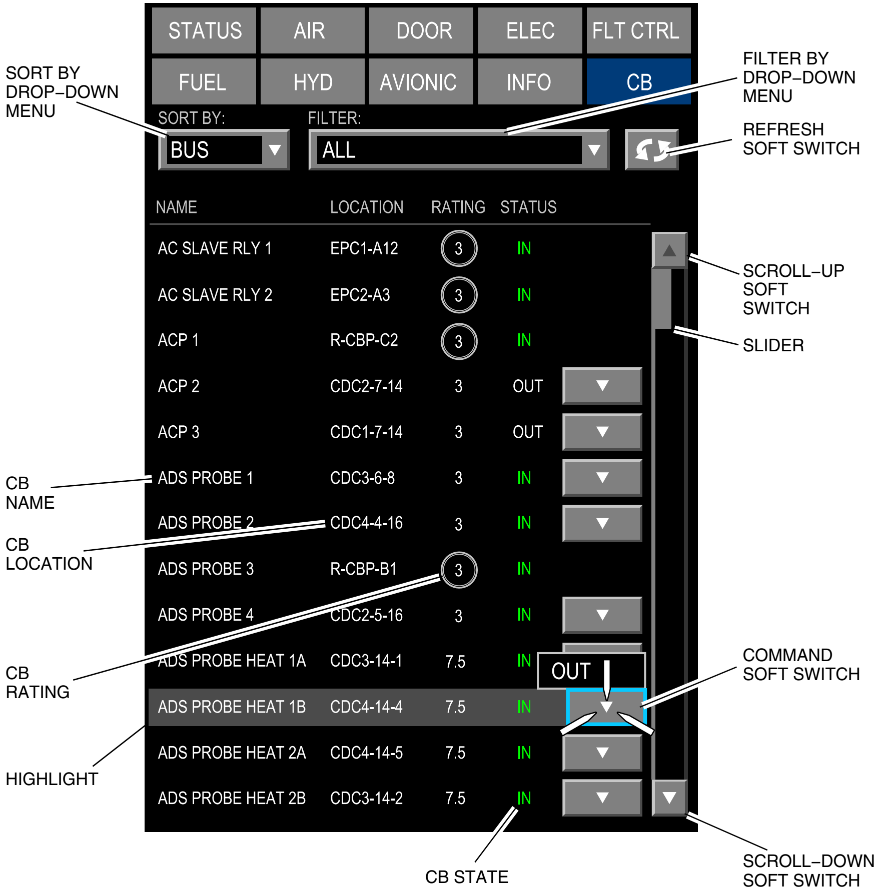
Figure 07–06–28 shows the ELEC synoptic page with the BUS ISOL switch set to ESS and both L GEN and R GEN online (both engines running). All AC busses are powered except for AC ESS. All DC busses are powered except for DC ESS 3. The aircraft is on the ground or in the air with both engines and generators running.



ELEC synoptic page – BUS ISOL switch at ESS, L GEN ON and R GEN ON
Figure 07–06–28

Q. CB synoptic page

Refer to Figure 07–06–29 for description of the CB synoptic page.



CB synoptic page – Electronic Circuit Breaker (ECB) page description
Figure 07–06–29

ELECTRICAL – EICAS MESSAGES

A. Warning messages

Message	Description	Aural	Inhibit
EMER PWR ONLY	Loss of the main power generation in flight.	None	None

B. Caution messages

Message	Description	Inhibit
AC BUS 1	AC BUS 1 not powered with at least one AC primary power source available.	TO, LDG
AC BUS 2	AC BUS 2 not powered with at least one AC primary power source available.	TO, LDG
AC ESS BUS	AC ESS bus not powered with at least one AC primary power source available or in emergency mode.	TO, LDG
APU GEN FAIL	APU GEN not online, with APU running and APU GEN switch selected to AUTO, or total loss of TTP communication from AGCU.	TO, LDG
BATT 1 FAIL	Battery 1 not connected to DC ESS 1 bus when required or battery fault from battery charger.	TO, LDG
BATT 2 FAIL	Battery 2 not connected to DC ESS 2 bus when required or battery fault from battery charger.	TO, LDG
BATT 1 OVERTEMP	Battery 1 temperature greater or equal to 71°C and appears as long as it is above 65°C.	TO, LDG

Message	Description	Inhibit
BATT 2 OVERTEMP	Battery 2 temperature greater or equal to 71°C and appears as long as it is above 65°C.	TO, LDG
BATT DISCHARGING	Battery 1 or 2 (or both) discharging for 5 minutes or more on ground.	TO, LDG
DC BUS 1	DC BUS 1 not powered with at least one AC primary power source available.	TO, LDG
DC BUS 2	DC BUS 2 not powered with at least one AC primary power source available.	TO, LDG
DC EMER BUS	DC EMER bus not powered.	TO, LDG
DC ESS BUS 1	DC ESS 1 bus not powered.	TO, LDG
DC ESS BUS 2	DC ESS 2 bus not powered.	TO, LDG
DC ESS BUS 3	DC ESS 3 bus not powered.	TO, LDG
L GEN FAIL	L GEN not online and control switch set to AUTO, or total loss of TTP communication from LGCU.	TO, LDG
R GEN FAIL	R GEN not online and control switch set to AUTO, or total loss of TTP communication from RGCU.	TO, LDG
L GEN OIL	L GEN low oil pressure or high oil temperature detected.	TO, LDG
R GEN OIL	R GEN low oil pressure or high oil temperature detected.	TO, LDG
RAT GEN FAIL	RAT generator not online in flight when RAT is deployed or fault detected during BIT or RAT is not supplying power as demanded.	TO, LDG

C. Advisory messages

Message	Description	Inhibit
BATT CHARGER FAULT	Battery charger 1 or 2 inoperative.	TO, LDG
BATT EMER PWR ON	Loss of all AC power sources in flight and the only power source is the battery system.	TO, LDG
CB TRIP	Thermal CB, SSPC, or FUSE open and not acknowledged.	TO, LDG
ELECTRICAL FAULT	Loss of redundant or non-critical function for the electrical system.	TO, LDG
EXT PWR AVAIL	External power connected and ready to be used.	TO, LDG
LOAD SHED	Automatic load shed commanded.	TO, LDG
RAT GEN ON	RAT generator online.	TO, LDG
RAT DPLY	RAT deployed in flight or on ground.	TO, LDG
TRU FAULT	TRU1, TRU2 or TRU3 failure or not connected to their respective DC BUS.	TO, LDG

D. Status messages

Message	Description	Inhibit
APU GEN OFF	APU GEN OFF while APU is running with APU GEN switch selected to OFF.	None
BATT 1 OFF	BATT 1 selected and confirmed OFF.	None
BATT 2 OFF	BATT 2 selected and confirmed OFF.	None
BATT PWR CONFIG	ELEC switch on maintenance panel selected to DC ESS 3.	None

Message	Description	Inhibit
CABIN PWR OFF	CABIN PWR switch selected to OFF on ELECTRICAL panel.	None
ELEC BUS ISOL ESS	AC ESS and DC ESS 3 busses cross feeding manually inhibited.	None
ELEC BUS ISOL MAIN	AC BUS 1, AC BUS 2, DC BUS 1, DC BUS 2, DC ESS 1, DC ESS 2 busses cross feeding manually inhibited.	None
EXT PWR IN USE	External power connected and online.	None
L GEN DISC	L GEN disconnected manually.	None
R GEN DISC	R GEN disconnected manually.	None
L GEN OFF	L GEN OFF while left engine running with L GEN switch selected to OFF.	None
R GEN OFF	R GEN OFF while right engine running with R GEN switch selected to OFF.	None

CHAPTER 8 – ELECTRONIC DISPLAY

GENERAL

DISPLAY SYSTEM

MULTIFUNCTION WINDOW (MFW)

EICAS

AIR DATA SYSTEM (ADS)

List of figures

PRIMARY FLIGHT DISPLAY (PFD)

MULTIFUNCTION WINDOW (MFW)

EICAS

AIR DATA SYSTEM (ADS)

INTEGRATED STANDBY INSTRUMENT (ISI)

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ELECTRONIC DISPLAY – OVERVIEW

The flight deck is equipped with five Display Units (DUs) that show high resolution displays of flight, navigation, communication, engine, and system data.

The electronic display chapter covers the operation of the flight deck displays for the systems that follow:

- Display system,
- Primary Flight Display (PFD),
- Multifunction Window (MFW),
- EICAS,
- Air Data System (ADS),
- Integrated Standby Instrument (ISI),
- Electronic Display System (EDS) – Indications.

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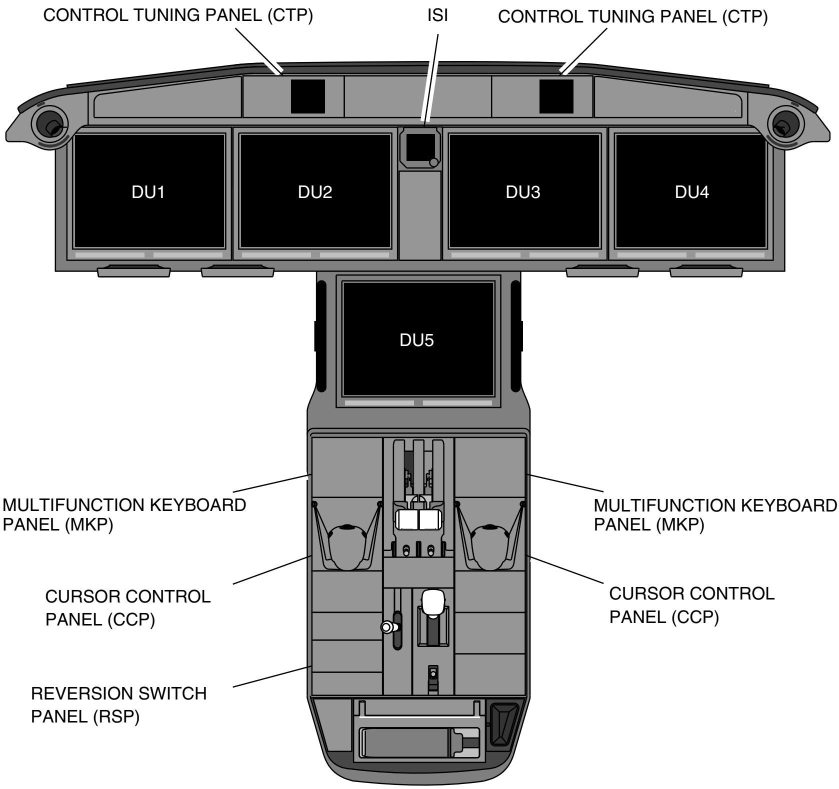
DISPLAY SYSTEM – OVERVIEW

A. Display Unit (DU)

The display system uses five Display Units (DUs). Four DUs are located across the flight instrument panel and one DU is on the center pedestal (refer to Figure 08–02–1).



Display unit/control panel overview
Figure 08–02–1

They are identified as:

- DU 1 (left outboard),

- DU 2 (left inboard),
- DU 3 (right inboard),
- DU 4 (right outboard), and
- DU 5 (center pedestal).

The DUs are high-resolution, Liquid Crystal Display (LCD) screens, with an integrated microprocessor, and are interchangeable. They display:

- Flight parameters,
- Navigation information,
- Communication information,
- Approach and weather charts,
- System synoptic pages,
- Electronic Checklist (ECL), and
- Maintenance data.

To select and control a display, and to enter data, each pilot can use one of the panels that follow:

- Control Tuning Panel (CTP), or
- Multifunction Keyboard Panels (MKP), or
- Cursor Control Panel (CCP).

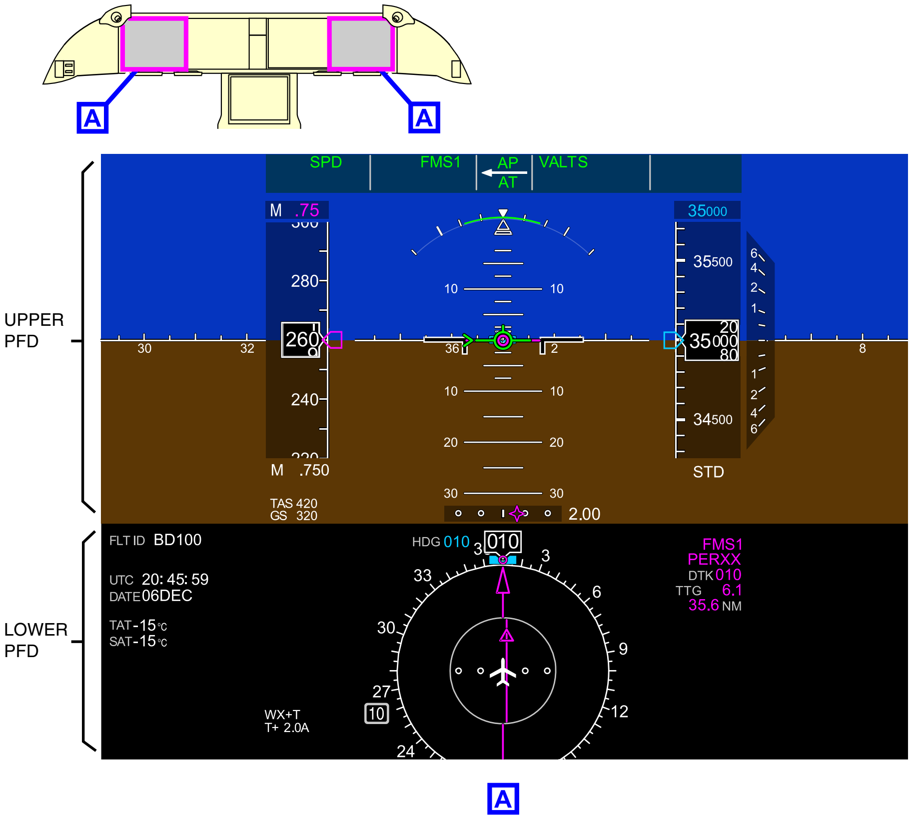
Automatic and manual reversion capabilities ensure that critical flight data stays in view if there is a DU failure.

The information displayed on the DUs is grouped into three specific areas:

- Primary Flight Display (PFD),
- Engine Indication and Crew Alerting System (EICAS), and
- Multifunction Window (MFW).

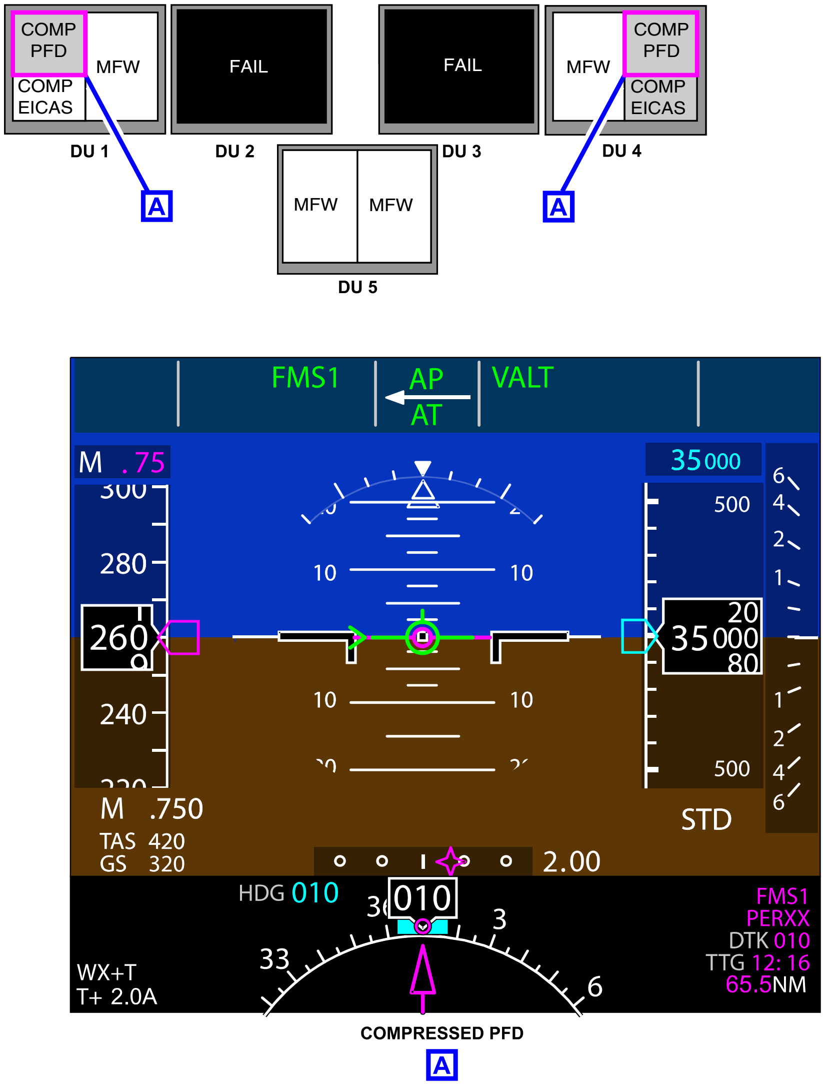
B. Primary Flight Display (PFD)

The Primary Flight Display (PFD) includes the Attitude Direction Indicator (ADI) and the Horizontal Situation Indicator (HSI). It displays the airspeed, altitude, Flight Director (FD) commands, and the Flight Mode Annunciator (FMA) and navigation information (refer to Figure 08–02–2).



Primary Flight Display (PFD)
Figure 08–02–2

The PFDs are displayed on DU 1 and DU 4. They occupy the full surface of the DU screen. During multiple DU failures or during reversion mode, a compressed version of the PFDs will be displayed on a quarter of the screen surface (refer to Figure 08–02–3).



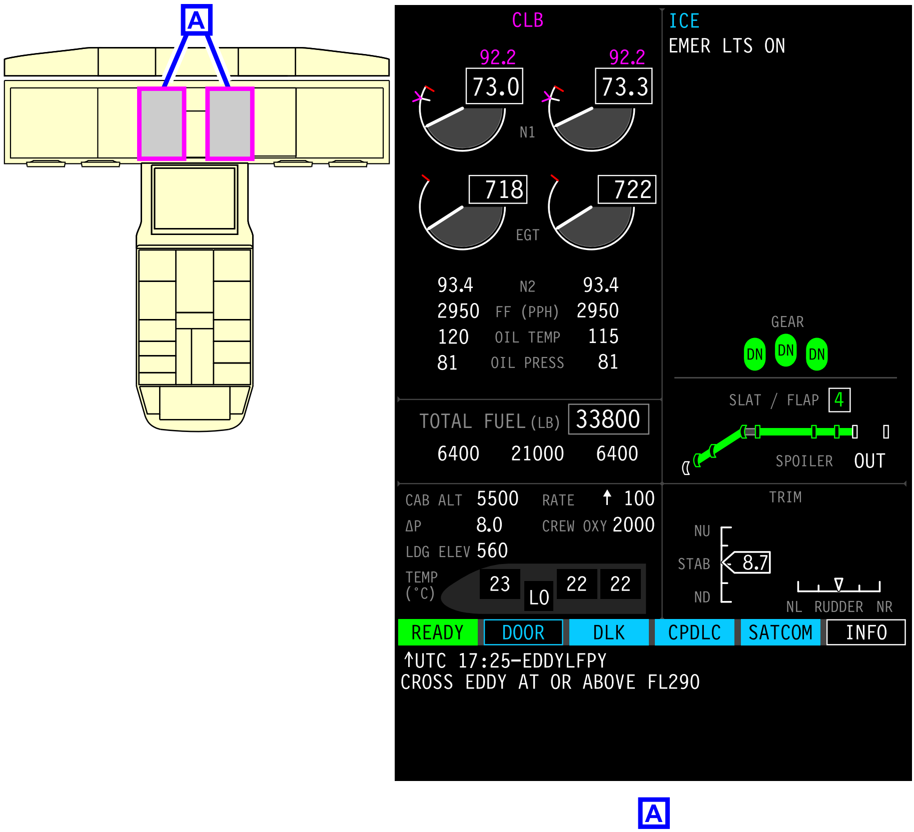
Compressed PFD
Figure 08–02–3

C. Engine Indication and Crew Alerting System (EICAS)

The Engine Indication and Crew Alerting System (EICAS) displays:

- All the engine indications: N_1, Exhaust Gas Temperature (EGT), N_2, Fuel Flow (FF), oil pressure (OIL PRESS), and oil temperature (OIL TEMP),
- Total fuel,
- Landing gear position,
- Flap and spoiler positions,
- AIL trim, RUDDER trim, and STAB trim position,
- Flight deck, cabin, and forward cargo bay temperatures,
- Cabin altitude (CAB ALT), differential pressure (ΔP), and climb or descent rate (RATE),
- Landing elevation (LDG ELEV),
- Crew oxygen indication (CREW OXY),
- EICAS messages (warning, caution, advisory and status), and
- Communication flags and messages.

The default position of the EICAS page display is the right half of DU 2. If there is a malfunction of DU 2, the EICAS page is displayed on the left half of DU 3 (refer to Figure 08–02–4).



EICAS page
Figure 08–02–4

D. Multifunction Window (MFW)

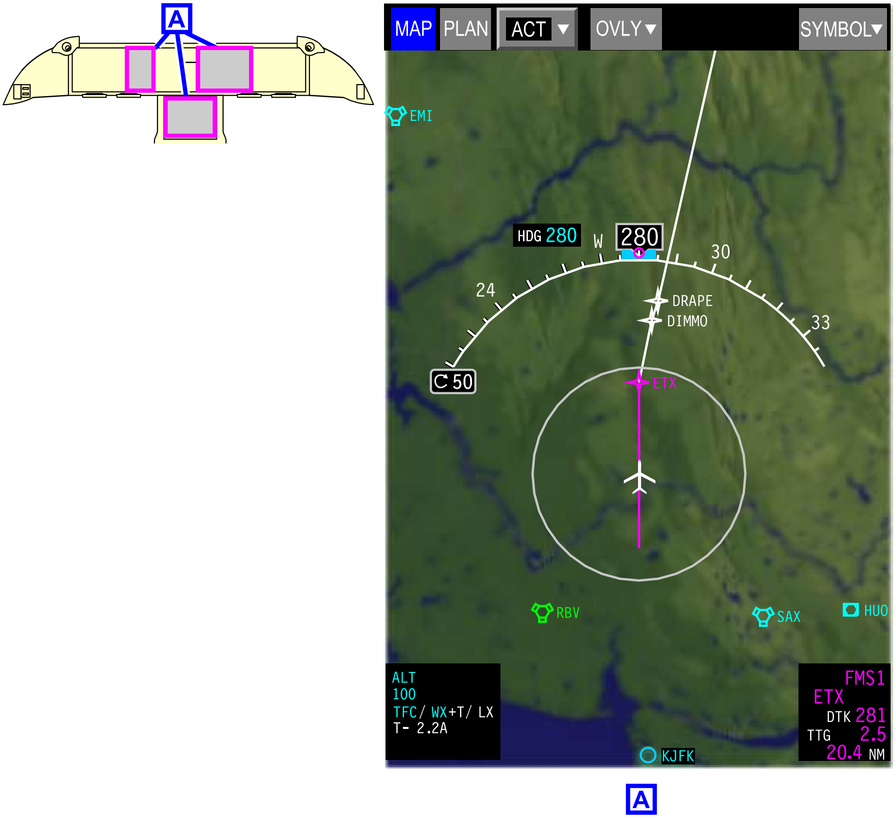
Each Multifunction Window (MFW) occupies half a screen or the full screen when the MFW map is displayed. There are five MFW displays. They are displayed on DU 2, DU 3, and DU 5 (half of DU 2 or DU 3 displays the EICAS page) (refer to Figure 08–02–5). The MFWs can display different types of aircraft system and flight information that includes:

- MFW maps and associated overlays, including airport moving map,

- Vertical Situation Display (VSD) can be selected on the lower one-third of the MAP format,
- Synoptic pages,
- Electronic Checklist (ECL),
- Flight Management System (FMS) interface: Initiation, route planning, performance, etc.,
- Radio Tuning: Communication, Navigation and Surveillance (CNS) page,
- Controller–Pilot Data Link Communications (CPDLC), <23249001C>
- Satellite Communication (SATCOM), <23150006C>
- Data Link (DLK): AOC and ATS,
- Graphical Weather (GWX) charts: DLK or satellite,
- Approach charts (if installed),
- En route charts (if installed),
- Video (if installed),
- Document reader (if installed),
- Maintenance, and
- Database status.

NOTE

The MFWs can be displayed on DU 1 and DU 4 if multiple DUs fail or during reversion mode.



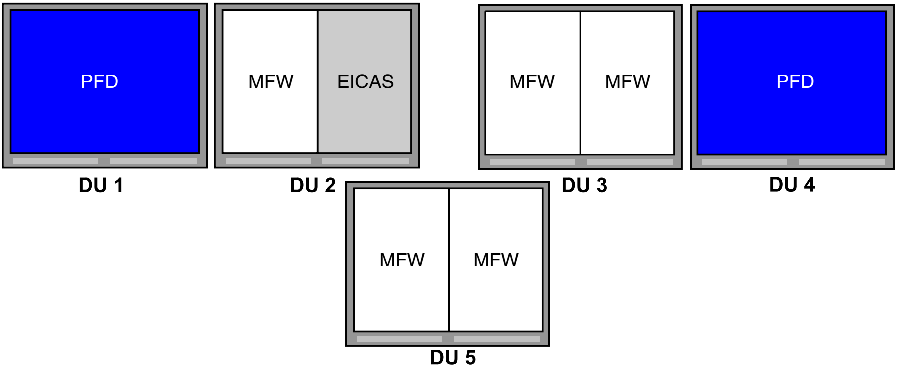
Multifunction Window (MFW) – MAP
Figure 08–02–5

E. Normal display configuration

In normal configuration (refer to Figure 08–02–6):

- DU 1 and DU 4 display the Primary Flight Displays (PFDs),
- DU 2 displays a MFW on the left side, and the EICAS page on the right side,
- DU 3 displays two MFWs, and

- DU 5 displays two MFWs.



Normal display configuration
Figure 08–02–6

NOTE

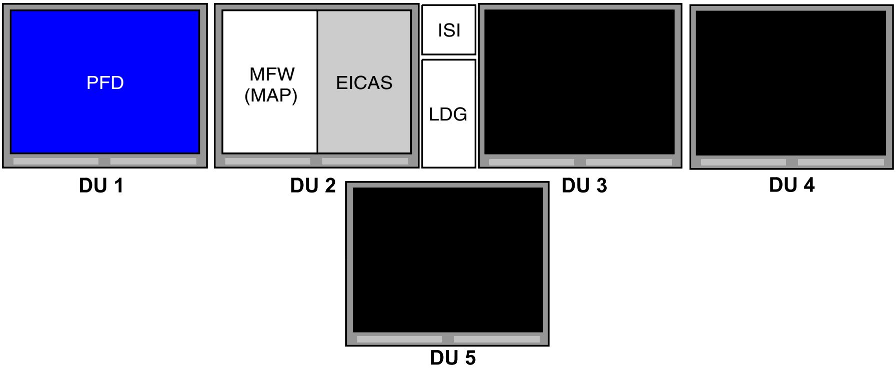
If the copilot is the pilot flying, DU 2 will show two MFWs and DU 3 will show the EICAS page (left half) and a MFW (right half).

The MFWs can be configured by the flight crew to show FMS, route and map displays, synoptic pages, tuning windows, charts, documents, video, or Electronic Checklist (ECL).

F. Configuration on emergency or battery power

When operating on emergency power (ESS BUS powered by RAT or batteries) or battery power only, DU 1 and DU 2 are always powered, which allows the left side to be fully operational.

The PFD is on DU 1, and the MAP and EICAS pages are on DU 2 (refer to Figure 08–02–7). In this case, the right side Cursor Control Panel provides cross-side management.



Display configuration on essential or battery power
Figure 08–02–7

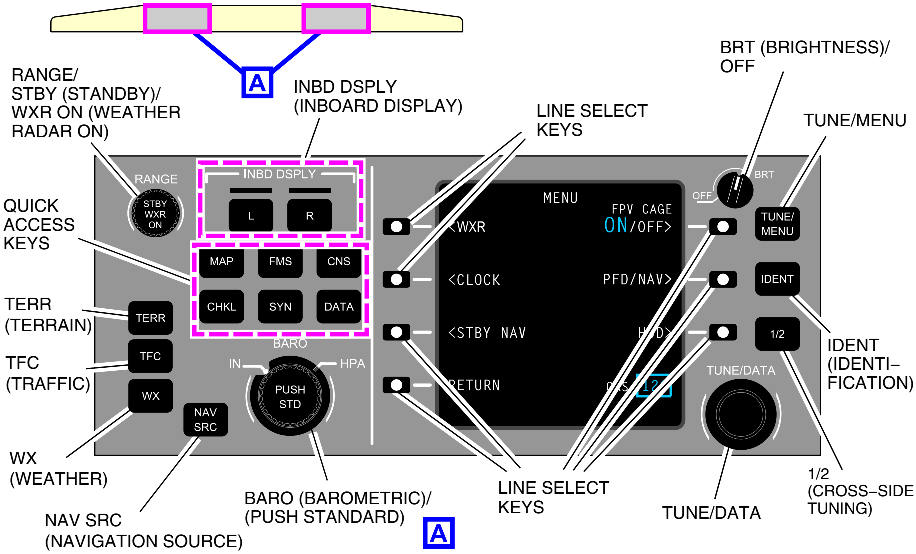
DISPLAY CONTROLS

A. Control Tuning Panel (CTP)

The left and right Control Tuning Panels (CTPs), located on the glareshield, are used to select:

- PFD formats,
- Overlays,
- Navigation sources,
- Range (weather and radar),
- Communication (COM) tuning,
- Minimums,
- Bearing pointers,
- Transponder, and
- Navigation (NAV) tuning.

The CTP includes a Liquid Crystal Display (LCD) screen with Line Select Keys (LSKs) and specific switches (refer to Figure 08–02–8).



Control Tuning Panel (CTP)
Figure 08–02–8

The BRT/OFF switch adjusts the CTP display brightness when turned. When selected OFF, it turns off the associated CTP.

The CTP display has specific switches:

- TUNE/MENU – Selects the radio tuning top level page. If the radio tuning page is already displayed, the TUNE/MENU switch displays the CTP main menu page.
- IDENT – Activates transponder identification transmission to Air Traffic Control (ATC) for 18 seconds (ID annunciated in cyan on the CTP display and ATC main page).
- 1/2 (cross–side tuning) – Allows cross–side radio tuning (cross–side tuning is displayed in amber).
- TUNE/DATA – Controls the items on the CTP display.

For detailed information about the radio tuning functions, refer to Chapter 05 — Communication.

The CTP MENU display has the soft switches that follow:

- <WXR (Weather Radar) – Provides control of the weather radar.
- <CLOCK – Display and entry of UTC time and date. Also displays flight time, FMS origin airport departure time, and arrival airport time.
- <STBY NAV (Standby Navigation) – Displays the compass with course pointer/deviation/direction, present position and source, source block data (desired track and distance), ground speed, and bearing pointer display.
- FPV CAGE ON/OFF – Turns the Flight Path Vector (FPV) caging OFF or ON on the PFD.
- PFD/NAV> – Selects Barometric (BARO), radio (RADIO) minimum altitude, or OFF.

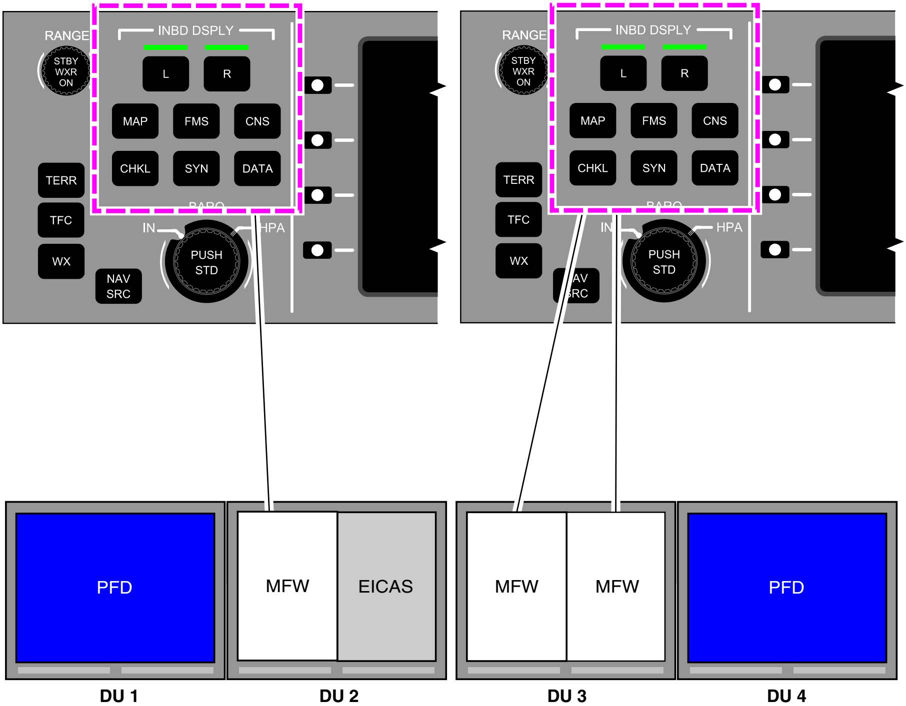
The RANGE switch adjusts the range on the MAP page. The range steps are: 2, 5, 10, 20, 40, 80, 160, 320 and 640 nm. The STBY WXR ON inset switch allows selection of the weather radar to on or standby.

The BARO (barometric) switch sets the barometric pressure on the Attitude Direction Indicator (ADI) to either inches of mercury (inHg) or Hectopascals (HPA). The inset PUSH STD (push standard) switch sets the barometric pressure to the standard atmosphere setting.

The TERR (Terrain), TFC (Traffic), and WX (Weather) switches respectively control the terrain, Traffic Alert and Collision Avoidance System (TCAS), and weather overlays in the target windows.

For detailed information about navigation-related functions, refer to Chapter 16 – Navigation.

The left and right CTPs have dedicated switches to control the selection on DU 2 and DU 3. Once selected, the L INBD DSPL and R INBD DSPL switches allow the selection of the desired side of the target window (refer to Figure 08–02–9).



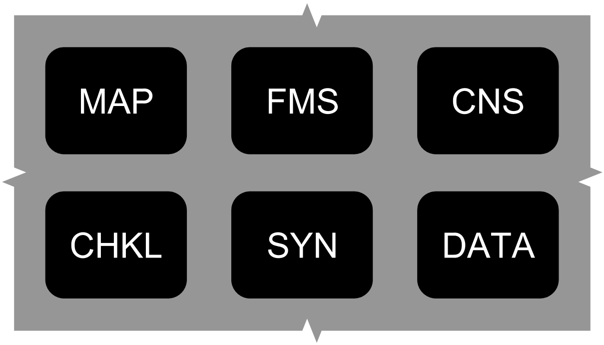
CTP DU selection
Figure 08–02–9

The CTP has the Quick Access Keys (QAKs) that follow:

- MAP,
- FMS,
- CNS,
- CHKL,
- SYN, and

- DATA.

They allow selection of the desired page in the target window (refer to Figure 08–02–10).



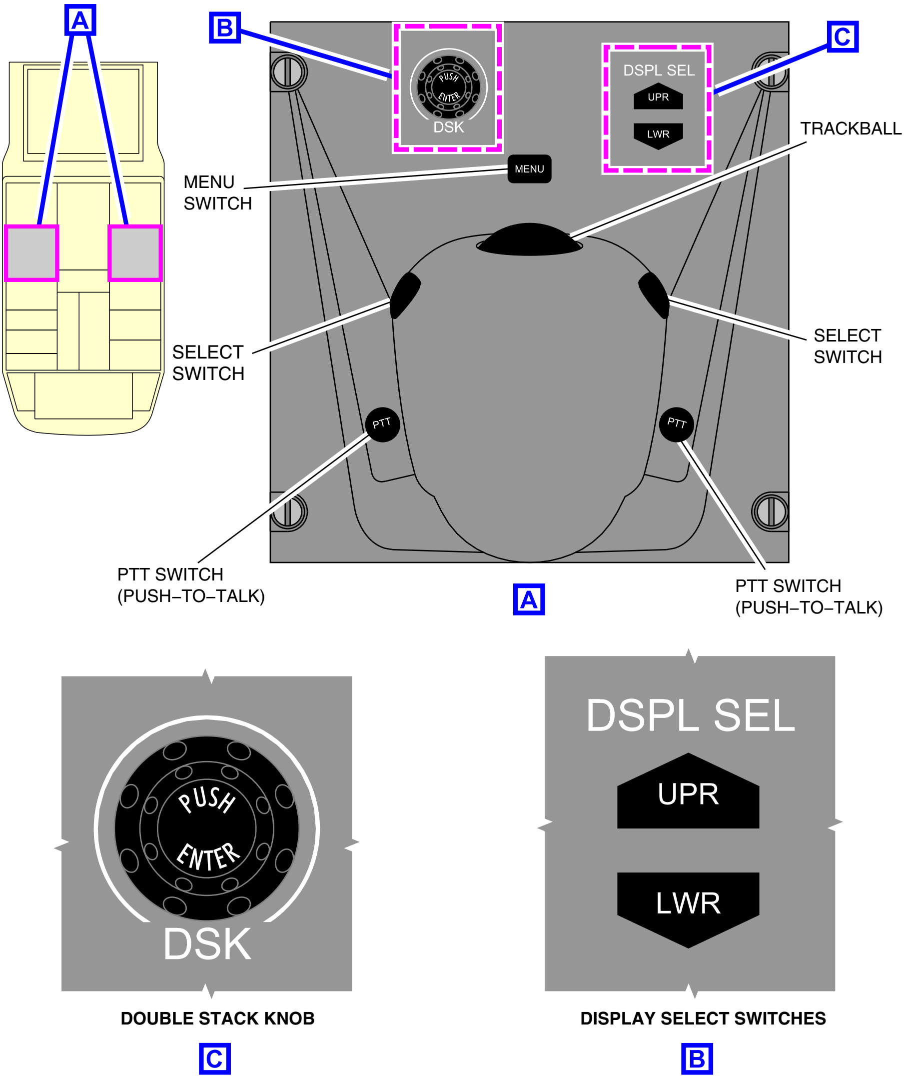
CTP – Quick Access Keys (QAKs)
Figure 08–02–10

- MAP: Displays the last selected MAP page. Subsequent pushes of the MAP QAK cycles through the map formats (MAP, PLAN).
- FMS: Opens the last selected FMS page displayed, or opens the DBAS/STATUS page when first selected. Multiple pushes will cycle through the FMS page (DBASE (Database), POS (Position), FPLN (Flight Plan), PERF (Performance), and ROUTE).
- CNS (Communication, Navigation and Surveillance): Opens the TUNE page. Multiple pushes will cycle through the CNS formats (TUNE, DLK (Data Link), CPDLC, SATCOM and GWX). If there are any CPDLC messages in the inbox, the CPDLC page will open when the CNS switch is pushed.
- CHKL: Opens the checklist on the queue page. If there is only one warning or caution message in the EICAS list, the associated message checklist opens.
- SYN: Opens the synoptic page. Multiple presses cycle through the synoptic pages and follow the synoptic page menu order (STATUS, AIR, DOOR, ELEC, FLT CTRL, FUEL, HYD, AVIONIC, INFO and CB).

- DATA: Opens the last displayed application, depending on the options installed (DBASE, CHART, VIDEO, DOC).

B. Cursor Control Panel (CCP)

Two Cursor Control Panels (CCPs) located on the center pedestal (refer to Figure 08–02–11), below each Multifunction Keyboard Panel (MKP), provide the control interface for the display cursor and allow item selection from the on-screen menus. In normal mode, the left CCP interacts with the Multifunction Windows (MFW) located on DU 2 and DU 5. The right CCP interacts with the MFWs on DU 3 and DU 5.



Cursor Control Panel (CCP)
Figure 08–02–11

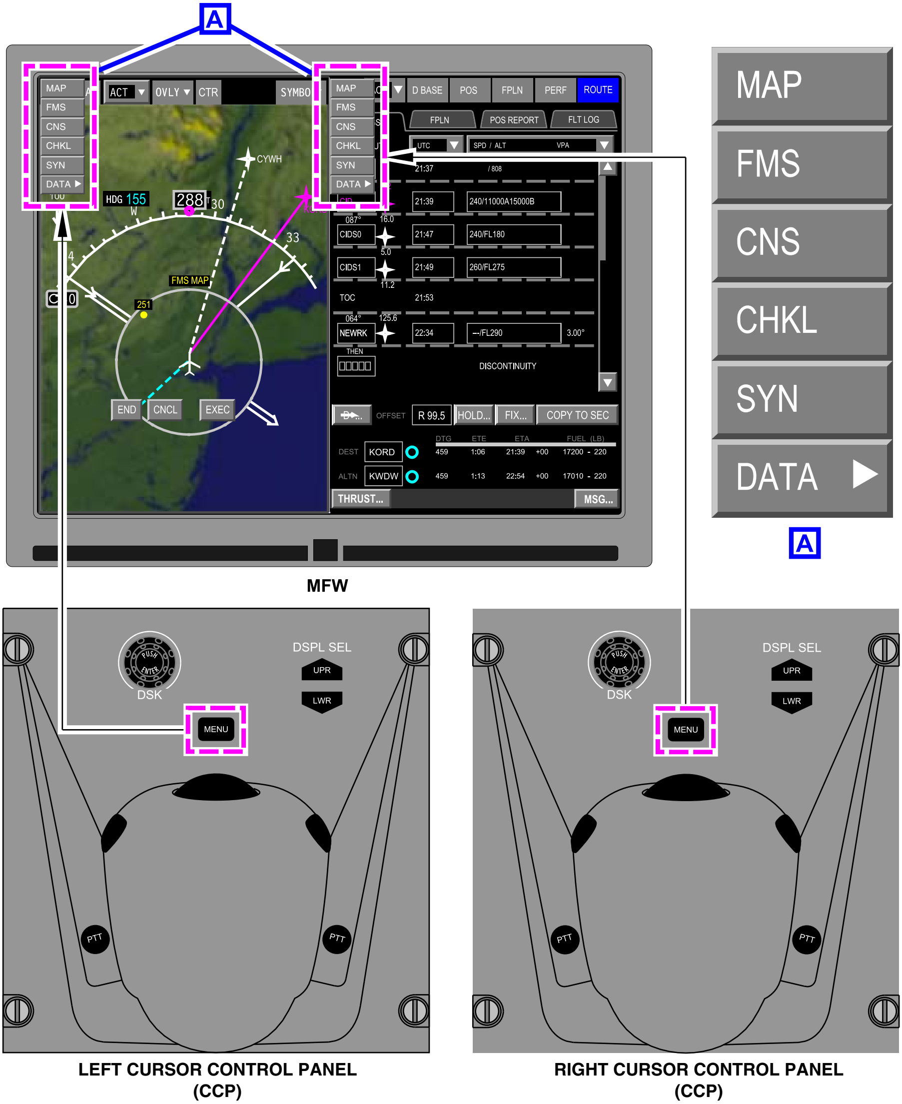
Each CCP includes:

- Trackball to maneuver the display cursor.
- Double Stack Knob (DSK), which includes an inner and an outer knob to navigate and a PUSH ENTER switch.
- MENU switch to display the menu list in the MFW where the cursor is positioned.
- Display Select (DSPL SEL) – UPR/LWR switches, which are used to assign the on-side cursor to the home position of the upper/lower display.
- Select switches, which are used to validate data entry fields or allow selection of interactive elements.
- Push-To-Talk (PTT) switches, which are used to open communication on the selected transmit channels.

The outer knob of the DSK is used to position scroll list content, position the data entry cursor, or change the value of various display items or selection boxes. The inner knob is a rotary control used to position the scroll list content or change the value of various display items or selection boxes.

The DSPL SEL activates the cursor on the selected display unit. The trackball can also be used to navigate from one DU to the next. The left and right CCP DSPL SEL – UPR switch respectively positions the cursor on the home position of DU 2 and DU 3. The DSPL SEL – LWR switch positions the cursor of the selected CCP side on the DU 5 corresponding side.

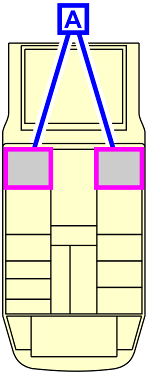
The MENU switch on the CCP opens the on-screen page menu (refer to Figure 08–02–12). The menu list appears in the partition where the cursor is positioned. The menu list has the same functions as the Quick Access Keys (QAKs) on the MKP and CTP.

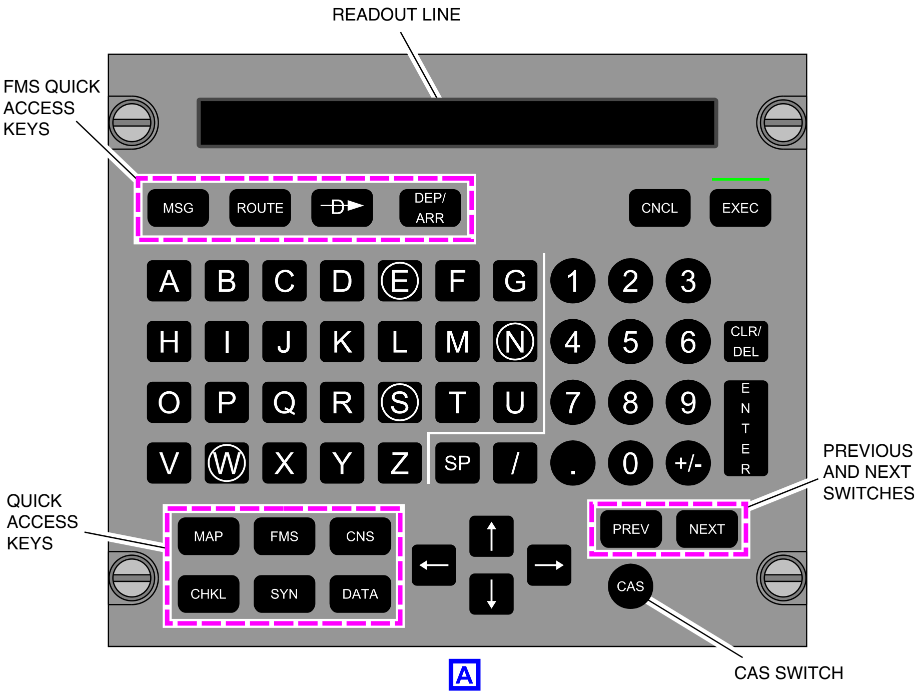


Control of MFWs from the CCP
Figure 08–02–12

C. Multifunction Keyboard Panel (MKP)

The MKP provides alphanumeric keyboard entry with a readout line (scratchpad) and FMS quick access keys to interact with the FMS Multifunction Windows (MFWs). It is also a backup for the CCP. The left and right MKPs are located on the center pedestal (refer to Figure 08–02–13). In normal operation, the left MKP will be used by the pilot to interact with DU 2 and DU 5 and the right MKP will be used by the copilot to interact with DU 3 and DU 5.

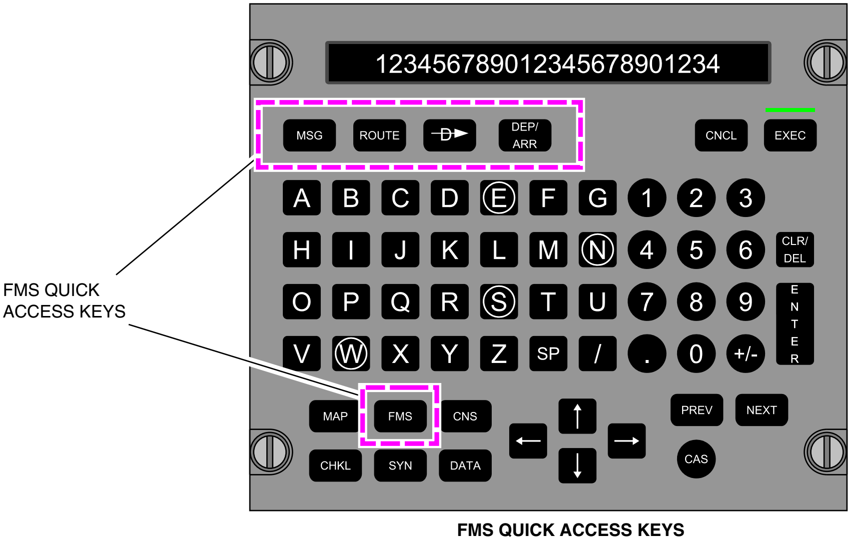




Multifunction Keyboard Panel (MKP)
Figure 08–02–13

The MKP has five FMS quick access keys (refer to Figure 08–02–14):

- MSG: Opens the FMS MSG (message) dialog box window on DU 5,
- ROUTE: Opens the FMS route window on DU 5,
- Direct to (symbol): Opens the direct to dialog box,
- DEP/ARR: Opens the DEPARTURE or ARRIVAL dialog box (depending on the phase of flight), and
- FMS: Opens an FMS page.



FMS quick access keys
Figure 08–02–14

The left MKP Quick Access Keys (QAKs) control the content that is displayed on the left half of DU 5 (left MFW). The right MKP QAKs control the content that is displayed on the right half of DU 5 (right MFW).

The MKP has the six QAKs that follow:

- MAP,

- FMS,
- CNS,
- CHKL,
- SYN, and
- DATA.

Each one opens the respective page in a MFW.

The QAKs of the MKP and the CTP allow the selection of specific MFW formats without the requirement to use the Cursor Control Panel (CCP) trackball.

The FMS uses two additional switches, CNCL and EXEC, to cancel or execute a modified flight plan. For detailed information, refer to Chapter 22 – Flight Management System.

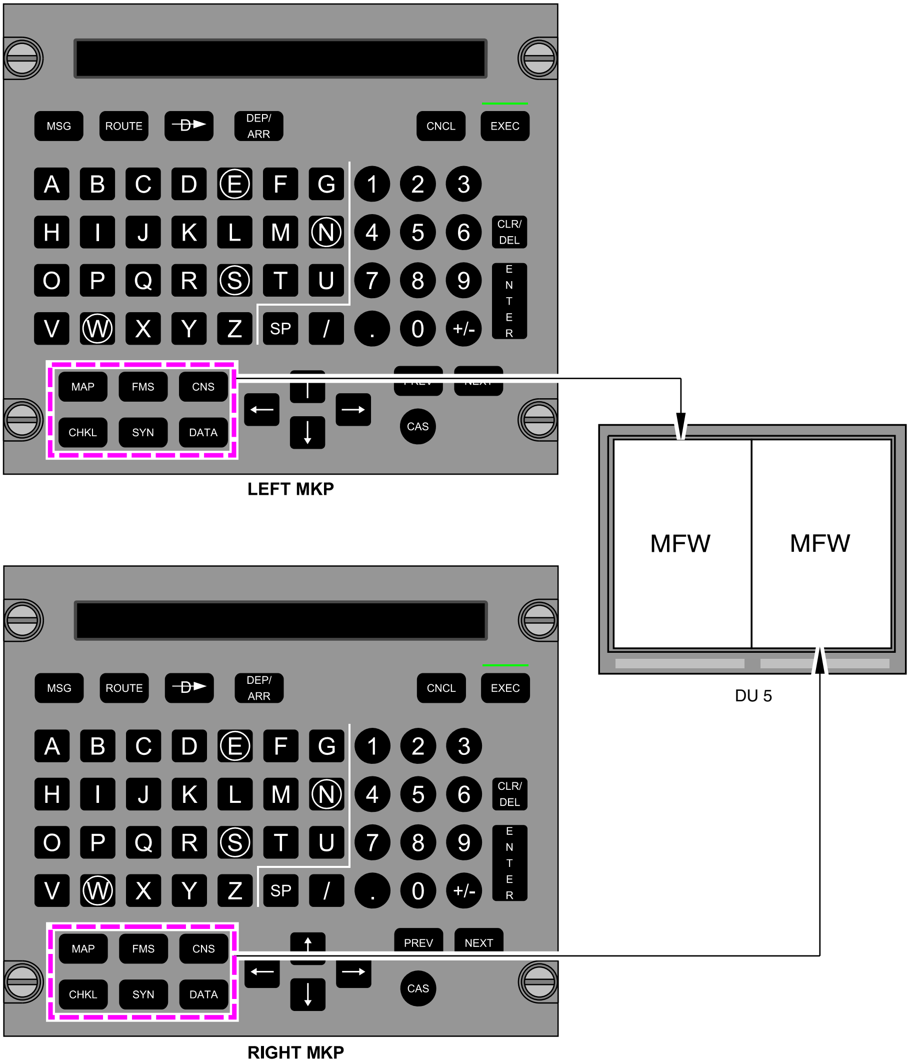
The readout line displays the text entered from the MKP keyboard. When the ENTER switch is pushed, the text entered in the readout line is uploaded to the selected field. If the readout line is empty and the ENTER switch is pushed, the content of the selected field is copied to the readout line.

Directional arrows used with the ENTER key (to confirm selection), can manage display format and menu item selection (backup to the CCP).

The CAS switch is used to cycle through the EICAS message pages. When the last page is reached, the next push of the CAS switch collapses the CAS stack and hides active caution, advisory, and status messages. In EICAS compressed mode, both EICAS stacks are synchronized.

The PREV and NEXT switches are used to navigate to the previous or next page of the selected page sequence. In PLAN format, NEXT or PREV respectively position the MAP center on the next or the previous waypoint in the waypoint list.

The MKP QAKs allow MFW selection on DU 5, without the use of the CCP trackball. The CTP and the MKP QAKs have the same functions (refer to Figure 08–02–15).



MKP DU selection
Figure 08–02–15

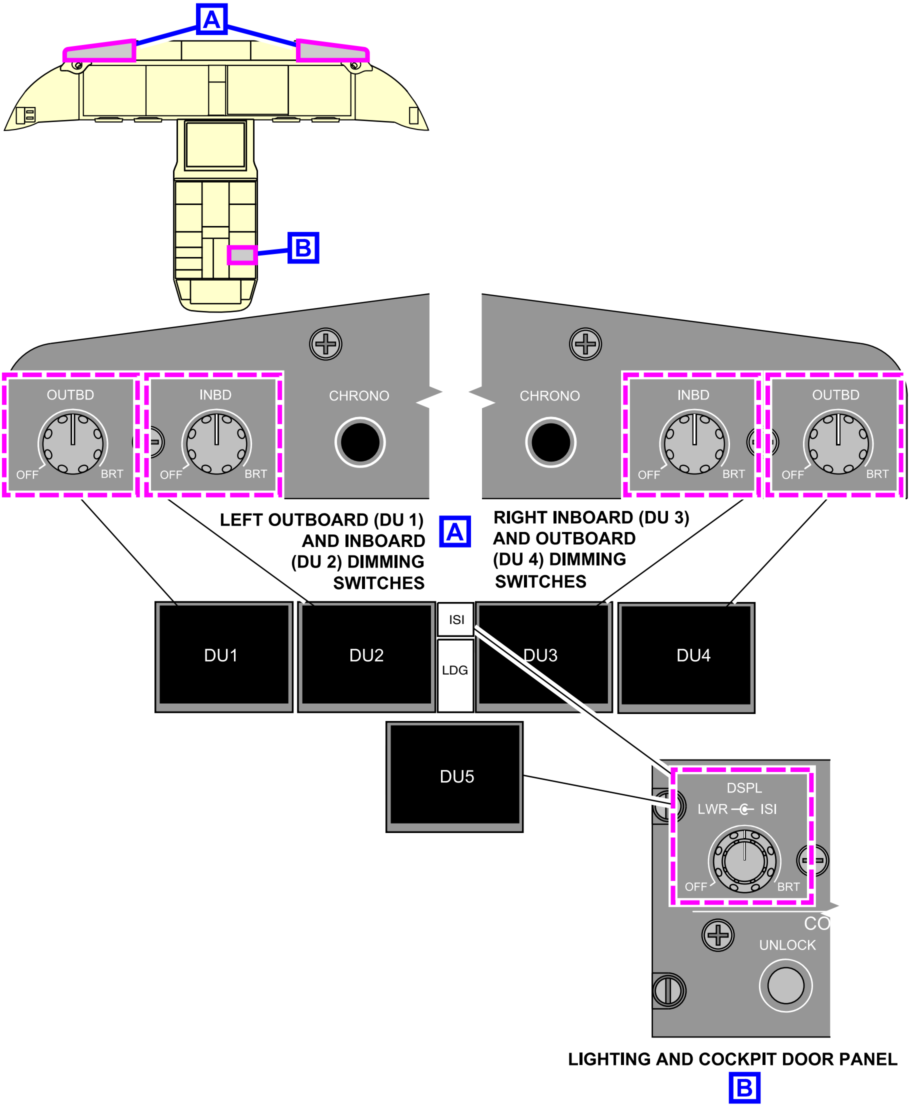
D. Display dimming

Each DU has an associated control dimming switch, located on each side of the glareshield (for DU 1, DU 2, DU 3 and DU 4), and on the lights and cockpit door panel (for DU 5) (refer to Figure 08–02–16).

The left glareshield panel has two dimming control switches. The OUTBD switch adjusts the brightness of DU 1 and the INBD switch adjusts the brightness of DU 2. The brightness of DU 3 and DU 4 are respectively adjusted with the INBD and OUTBD dimming switches on the right glareshield panel.

Each switch turns from the OFF position (counterclockwise) to the BRT (brightest) position (clockwise). If there is a switch failure, the display will automatically adjust to 80% brightness.

The DSPL LWR/ISI switch, located on the lights and cockpit door panel, adjusts the brightness of both the Integrated Standby Instrument (ISI) and DU 5. The outer knob controls the brightness of DU 5 and the inner adjusts the ISI display. The inner and outer switches rotate from the OFF position (counterclockwise) to the BRT (brightest) position (clockwise). If there is a switch failure, the display will automatically adjust to 80% brightness.

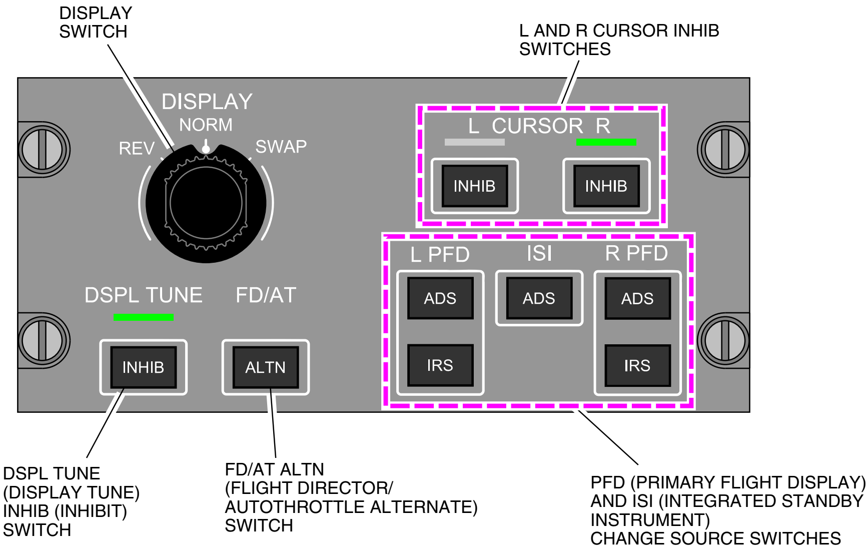


Display dimming switches
Figure 08–02–16

E. Reversion Switch Panel (RSP)

The Reversion Switch Panel (RSP), located on the center pedestal (refer to Figure 08–02–17), allows:

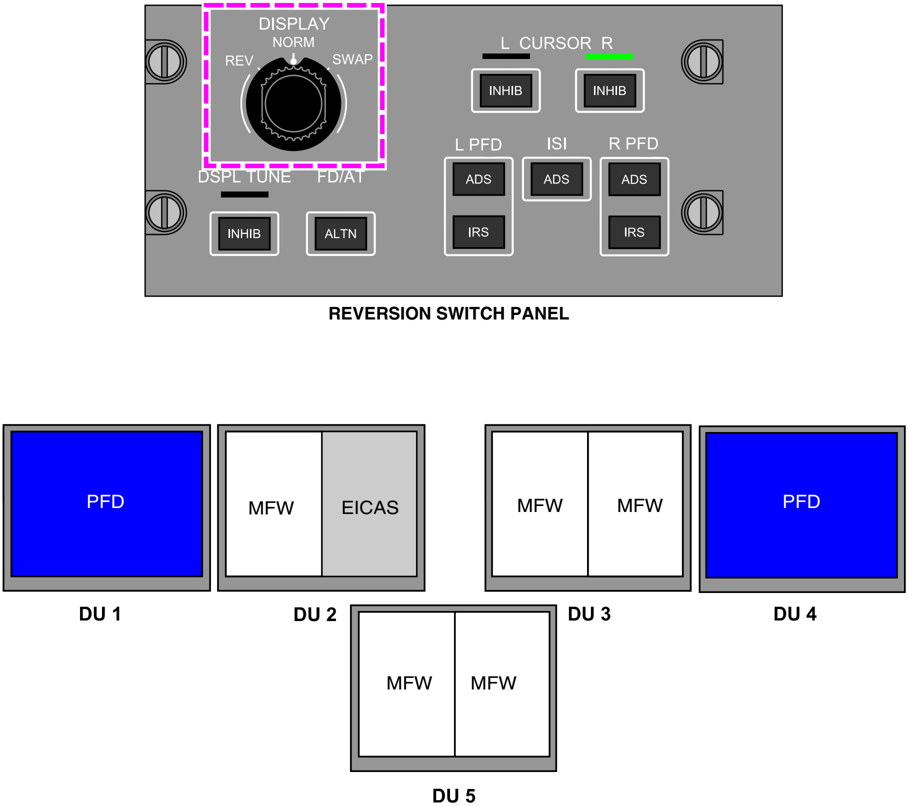
- DISPLAY page swap (in normal conditions),
- PFD and EICAS page compressed mode selection (if there is a DU failure),
- DU tuning and cursor inhibit,
- Flight Director and Autothrottle (FD/AT) source channel selection,
- Inertial Reference System (IRS) source selection (for PFDs) and
- Air Data System (ADS) source selection (for PFDs, and ISI)



Reversion Switch Panel (RSP)
Figure 08–02–17

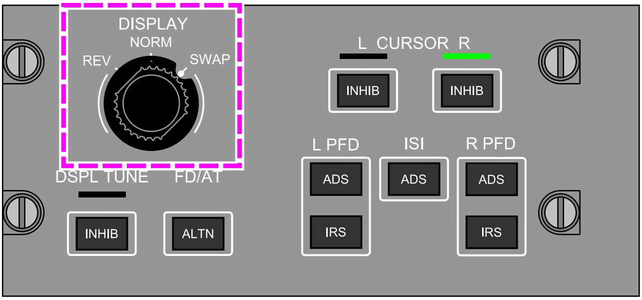
One EICAS page can be displayed in the flight deck, in all configurations. The default location for the EICAS page is the right side of DU 2. The three-position DISPLAY switch (REV, NORM and SWAP), located on the RSP, is used to change the position of the EICAS page in different DU.

When the NORM (normal) position is selected, the EICAS page is displayed on DU 2. The NORM position also allows automatic reversion when one or more DU(s) fail(s). Refer to Figure 08–02–18.

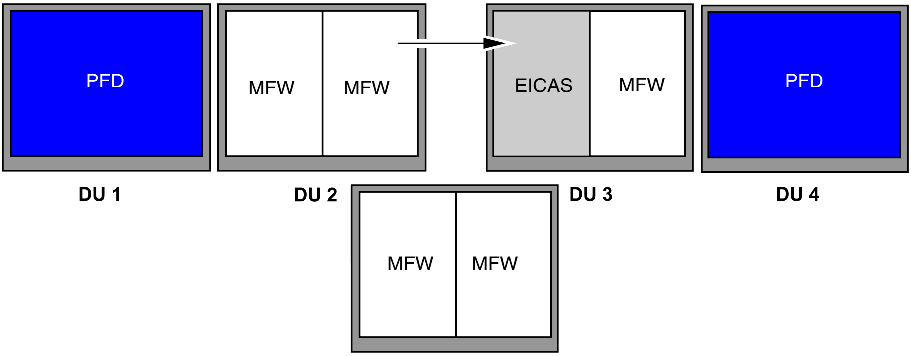


EICAS page swap to DU 3 (left side) part 1
Figure 08–02–18

When the SWAP position is selected, DU 2 displays two MFWs, and DU 3 displays the EICAS page on the left side (refer to Figure 08–02–19). The EICAS swapping function is available when all DUs are functioning, or if DU 5 is failed (refer to MMEL).



REVERSION SWITCH PANEL



EICAS page swap to DU 3 (left side) part 2
Figure 08–02–19

When the REV position is selected, the manual reversion mode is activated only when two or three DUs have failed.

When the DSPL TUNE — INHIB switch is selected, the bar above the switch is illuminated green to indicate that the display tuning is disabled. If the DSPL TUNE — INHIB switch is pushed a second time, the display tuning function will be restored.

NOTE

When the display tuning is inhibited and both CTPs are inhibited from tuning, the left and right VHF COM radios tune to 121.5 MHz for emergency communication.

The FD/AT – ALTN switch allows the transfer of the Flight Director (FD) and the Autothrottle (AT) source to the alternate channel (the default channel changes every day at power-up).

The L/R CURSOR INHIB switches disable the trackball of the associated CCP. In this situation, the cursor is moved using the directional arrows on the Multifunction Keyboard Panel (MKP).

The ADS and IRS switches allow manual selection of an alternate source for the selected display. If there is a case of failure of any ADS or IRS source, the system automatically changes the ADS or IRS source on the affected display (L PFD, R PFD or ISI).

For detailed information about the ADS/IRS, refer to Chapter 10 – Flight Controls and Chapter 16 – Navigation.

DISPLAY UNIT REVERSION

A. Automatic reversion

If a DU fails, the system automatically reconfigures the remaining DUs to show the critical flight parameters. Setting the OFF/BRT switch to OFF can also cause automatic reversion.

B. Display unit automatic reversion

When a DU failure occurs, a DU is selected OFF, or when reversion is manually selected, the remaining DUs automatically reconfigure to show a half PFD and the EICAS page.

The resulting DU reconfiguration is based on where the failure occurs and how many DUs are inoperative:

- One inoperative DU,
- Two inoperative DUs,

- Three inoperative DUs, or
- Four inoperative DUs.

(1) Half PFD format

In a half PFD format, the ADI field of view, and the lateral and vertical scaling remain unchanged. However, as the space between the altitude and speed tapes is reduced, the FPV lateral travel (conformal) boundary is reduced from ±22.5 degrees to ±13.2 degrees. This results in an increased possibility that the FPV will become non-conformal (ghosted) in certain crosswind conditions.

In a half PFD format, the HSI displays compass and navigation information. The information is presented differently depending on the information displayed in the adjacent DU partition.

When a MFW (MAP) is displayed in the partition adjacent to the half PFD on the same DU, there is no change in the compass and navigation information displayed. Refer to Figure 08–02–20.

(2) HSI Mini-Map

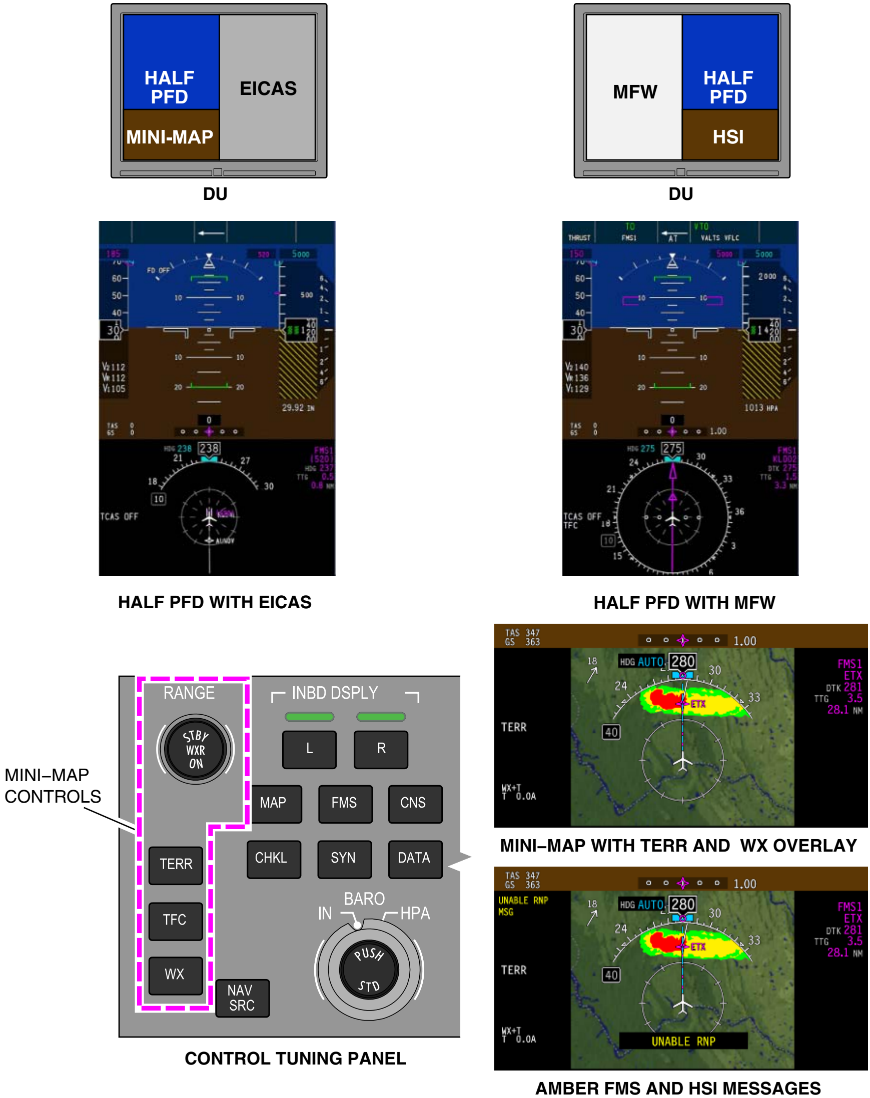
In a half PFD format, when the EICAS page, synoptic page, ECL, or FMS are displayed adjacent to the half PFD on the same DU, the HSI compass changes to a mini-map.

The mini-map displays navigation source, FMS route and way points, and TCAS traffic. Map range, and TERRAIN and WXR overlays are selectable from the associated CTP, as required. TERR is automatically displayed during a TAWS event. Cursor control on the mini-map is not possible.

FMS/HSI messages are displayed on the HSI mini-map. However, because of the reduced capability of the half PFD, it is not always possible to open the dialogue box to acknowledge the messages. To clear the messages, pilots may have to interchange the MFW and EICAS page displays.

(3) The EICAS display

As a result of the half PFD format, the EICAS information layout and content is not affected by DU failures. The EICAS page will always remain in view. Flight deck, cabin, and cargo temperatures and pressurization continue to be displayed.

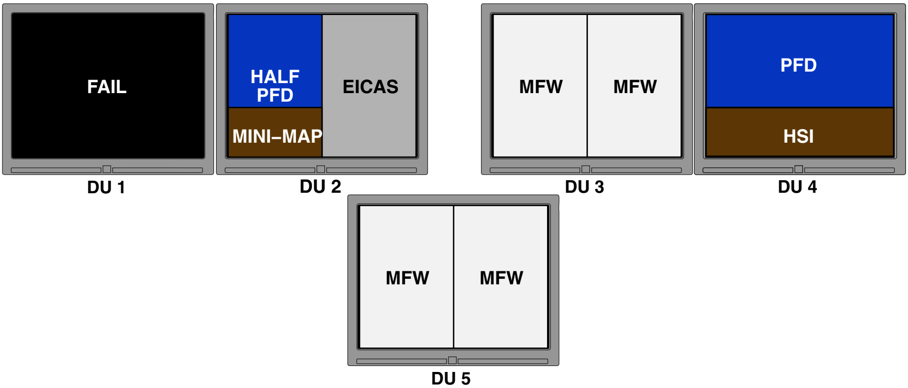


Half PFD HSI formats
Figure 08–02–20

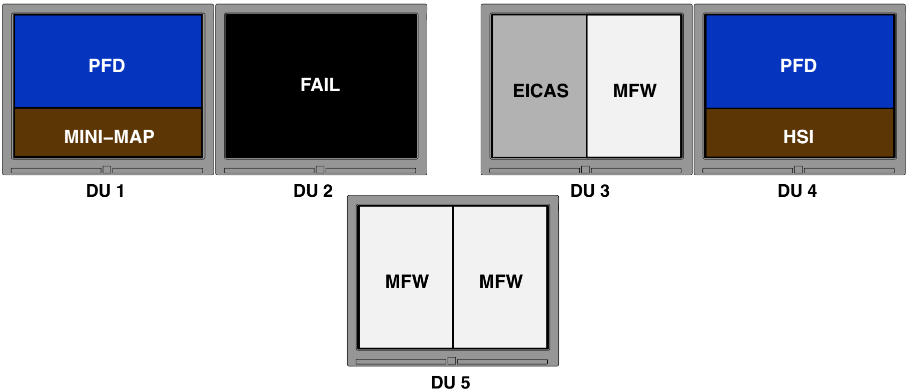
C. One display unit inoperative

When one outboard DU fails (DU 1 or DU 4), the remaining operating PFD moves inboard in half PFD format.

When one of the inboard DU (DU 2 or DU 3) is inoperative, the full PFD with a mini-map is shown on the outboard DU (DU 1 or DU 4). Because a MAP is not available on the adjacent DU, the full PFD with mini-map includes MAP overlays to improve situational awareness. Refer to Figure 08–02–21.



DU 1 FAILED



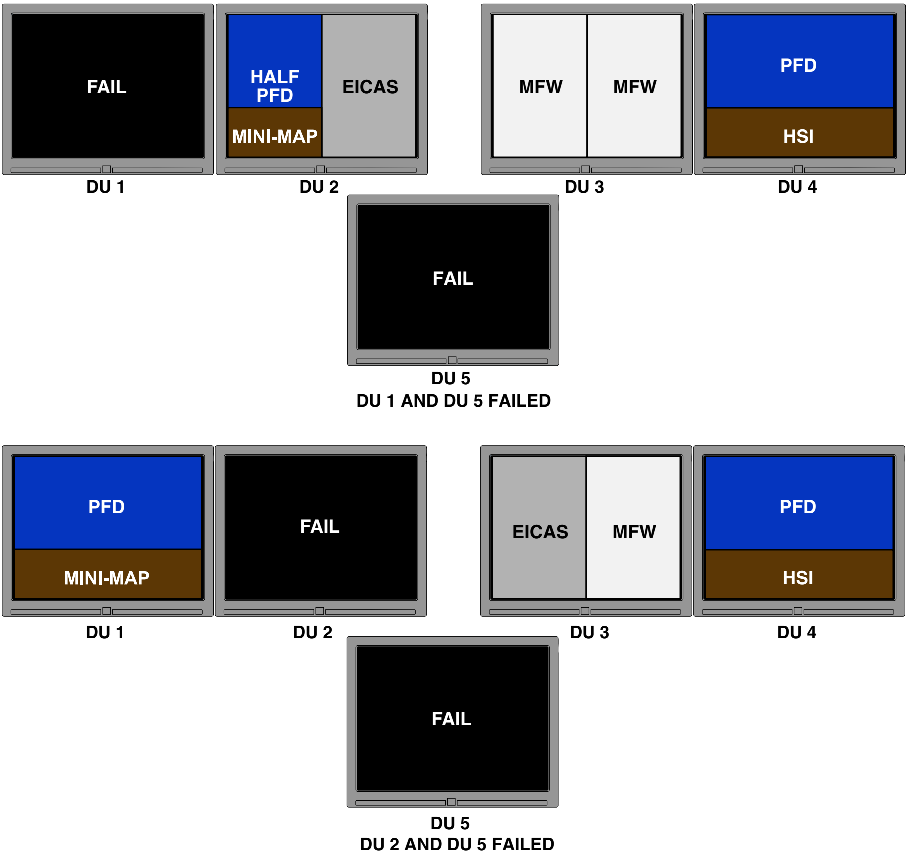
DU 2 FAILED

One DU inoperative
Figure 08–02–21

D. Two display units inoperative

When two inoperative DUs are not paired, the remaining DUs reconfigure to show a half or full PFD, MFW and EICAS page (refer to Figure 08–02–22).

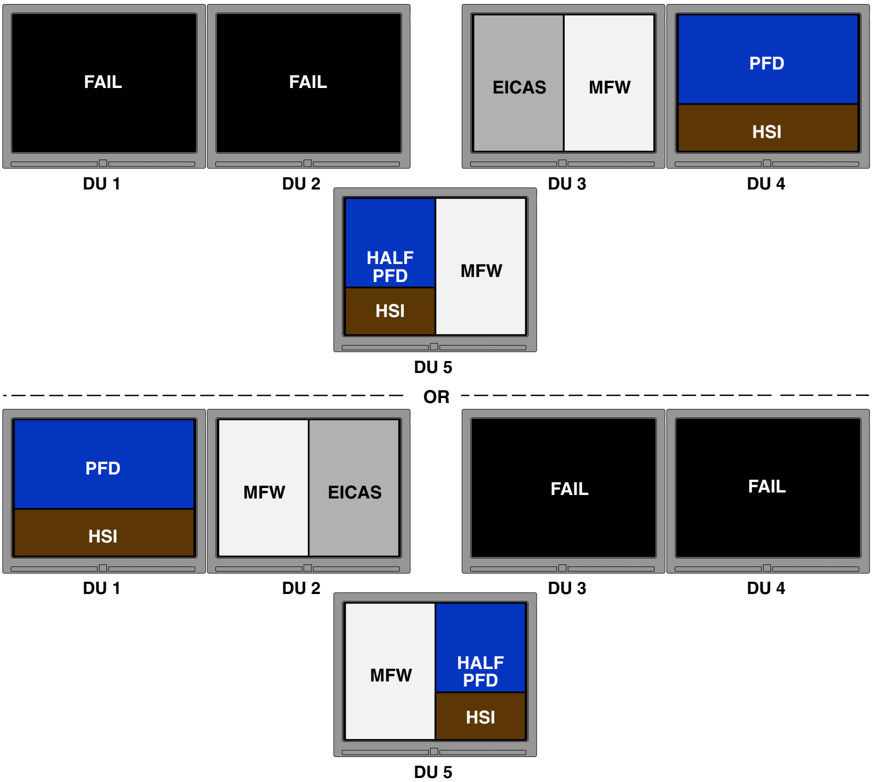
If a MFW (MAP) is not available on the adjacent DU, the PFD, full or half, is displayed with a mini-map.



Two unpaired DUs inoperative
Figure 08–02–22

When a pair of DUs (DU 1 and DU 2, or DU 3 and DU 4) fail (refer to Figure 08–02–23):

- The PFD is shown on the outboard DU, and the EICAS page and MFW are shown on the inboard DU.
- A half PFD and MFW are shown on DU 5.

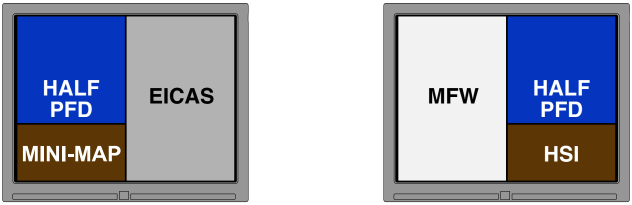


Two paired DUs inoperative
Figure 08–02–23

E. Three display units inoperative

When the two operating DUs are not paired, a half PFD, the EICAS page, and the MFW are shown. The location of the MFW and the EICAS page depends on which DUs have failed.

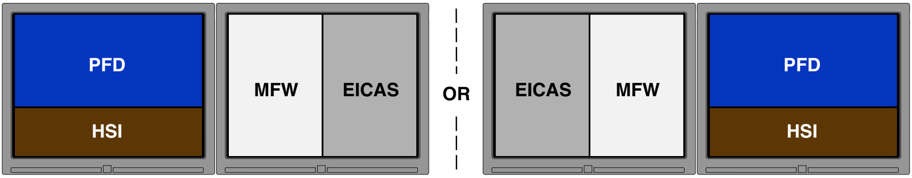
With unpaired operating DUs, if a MFW (MAP) is not available on the adjacent DU, the half PFD is displayed with a mini-map. Refer to Figure 08–02–24.



Operating display units not paired
Figure 08–02–24

When the operating DUs are on the pilot side, the full PFD is shown on DU 1, and the EICAS page and MFW are shown on DU 2.

When the operating DUs are on the copilot side, the full PFD is shown on DU 4, and the EICAS page and MFW are shown on DU 3. Refer to Figure 08–02–25.



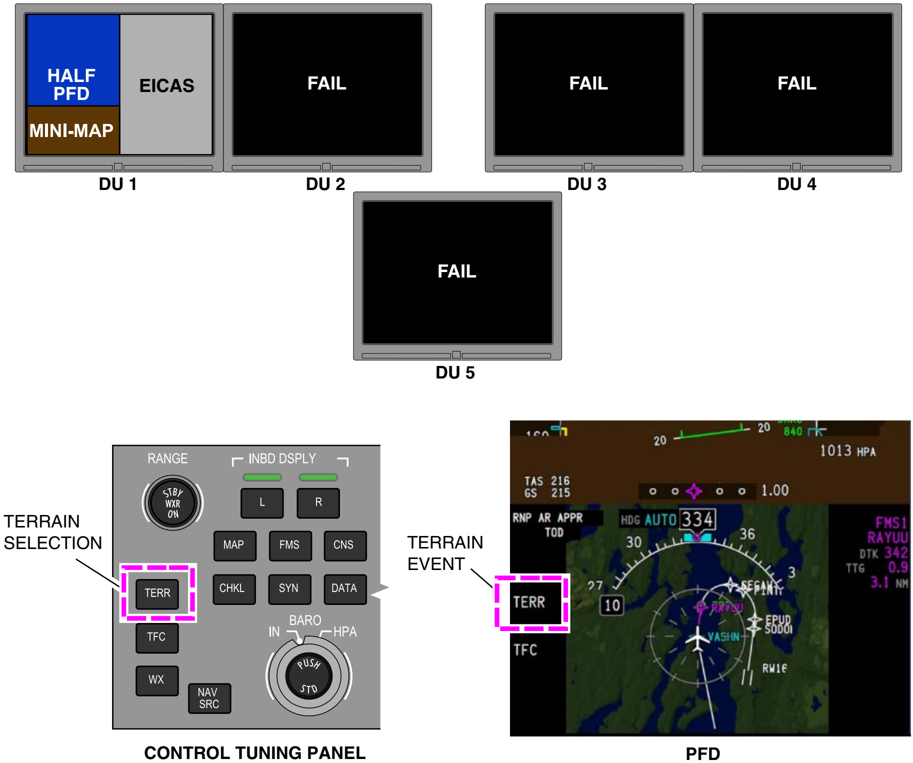
Operating display units paired
Figure 08–02–25

F. Four display units inoperative

If four DUs are inoperative, the remaining DU displays the PFD in half format, mini-map, and the EICAS page (refer to Figure 08–02–26).

The HSI terrain is not displayed by default. Terrain can be selected using the TERR overlay pushbutton on the CTP. TERR is automatically displayed when a terrain warning occurs.

With four DUs inoperative, the reversion switch and menu choices (MAP, FMS, CNS, CHKL, SYN and DATA) are all unavailable, and the SELECTION INVALID message appears on the PFD. The TERR, TFC and WX switches are available for display selections.

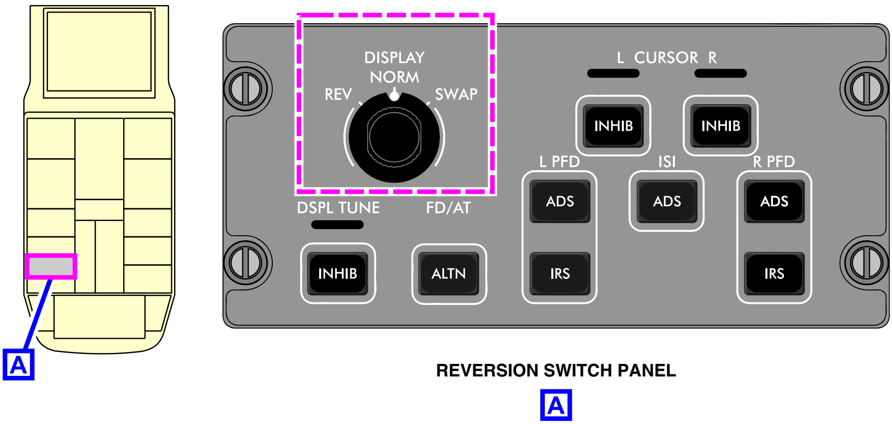


Four display units inoperative
Figure 08–02–26

G. Display reversion mode

The DISPLAY reversion mode causes any DU that shows a full PFD to display a half PFD and either the EICAS page or the MFW on the other half of the DU.

The DISPLAY manual reversion mode, selected when the DISPLAY switch is set to REV (refer to Figure 08–02–27), is available if:



Reversion Switch Panel (RSP) DISPLAY switch
Figure 08–02–27

- Automatic reversion is triggered and two DUs are inoperative, or
- Only DU 1 and DU 2 are operative, and one or two PFDs display in full.

When DU 1 and DU 4 fail, manual reversion mode is not available.

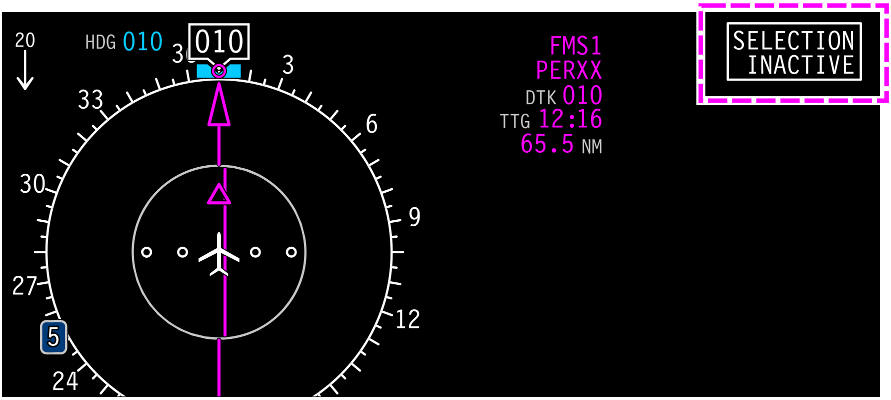
(1) Reversion mode message

When the DISPLAY switch is set to REV and the reversion function is unavailable, the DISPLAY REV MISCONFIG status message is shown on the EICAS page and the SELECTION INACTIVE message on the PFD, on the top right portion of the HSI. Refer to Figure 08–02–28.

If the DISPLAY switch is set to SWAP and the swap function is not available (no DU 2, DU 3, DU 5 failures), the SELECTION INACTIVE message is displayed on the PFD, on the top right of the HSI.

DISPLAY REV MISCONFIG

EICAS

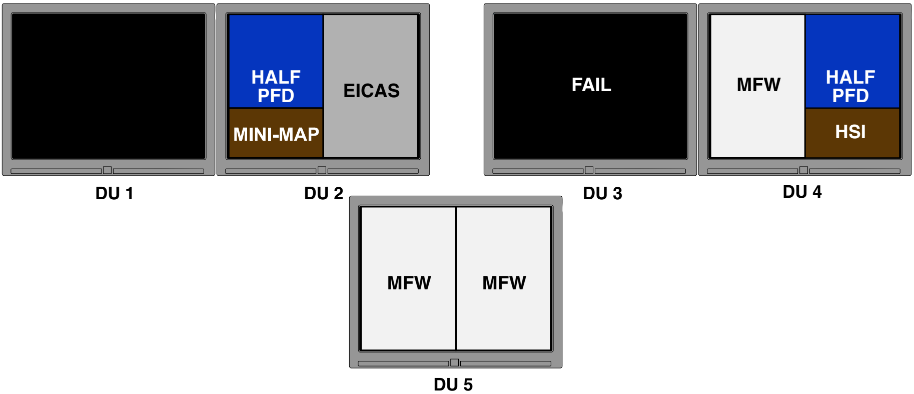


SELECTION INACTIVE message
Figure 08–02–28

H. Two display units inoperative

When two DUs are inoperative, if the DISPLAY switch is set to the REV position, any full PFD is replaced with a half PFD and either the EICAS page or the MFW (refer to Figure 08–02–29).

The pilot and copilot cursors operate in the MFWs located on their respective side (DU 1 and DU 2 for pilot, DU 3 and DU 4 for copilot). Both cursors operate either MFW located in DU 5.



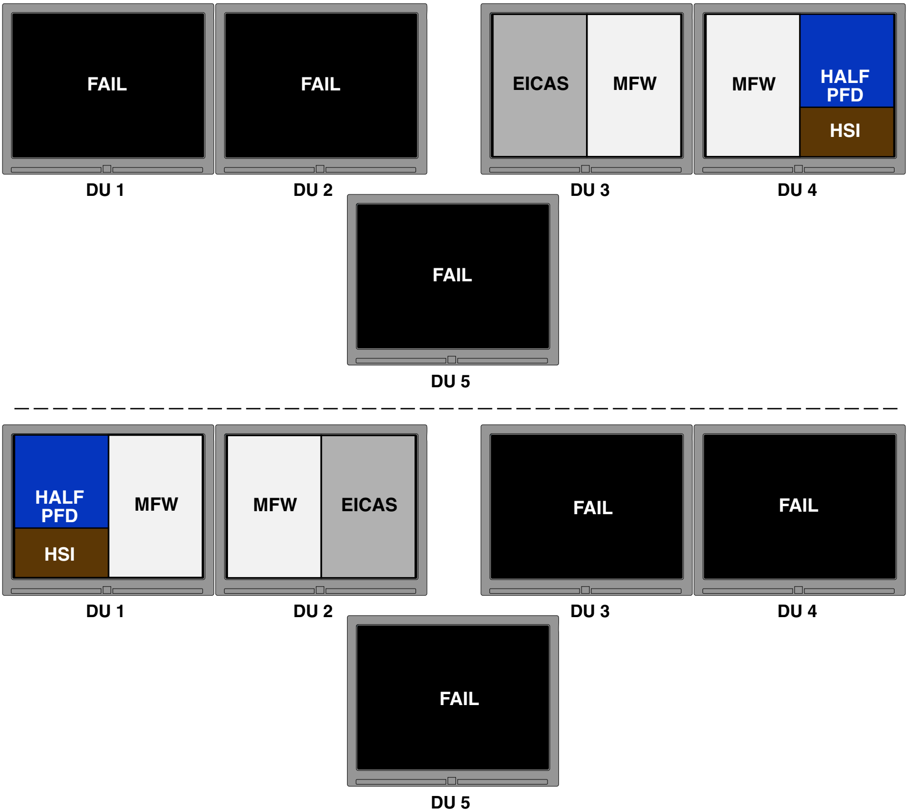
Two display units inoperative – DISPLAY reversion mode selected
Figure 08–02–29

I. Three display units inoperative

When three DUs are inoperative, if the DISPLAY switch is set to the REV position (refer to Figure 08–02–30):

- The outboard operating DU (DU 1 or DU 4) displays a half PFD and the MFW.
- The inboard operating DU (DU 2 or DU 3) displays the EICAS page and the MFW.

The pilot and the copilot cursors operate the MFW located on their respective side (DU 1 for pilot, DU 4 for copilot), and both cursors operate in the MFWs on DU 2 or DU 3.



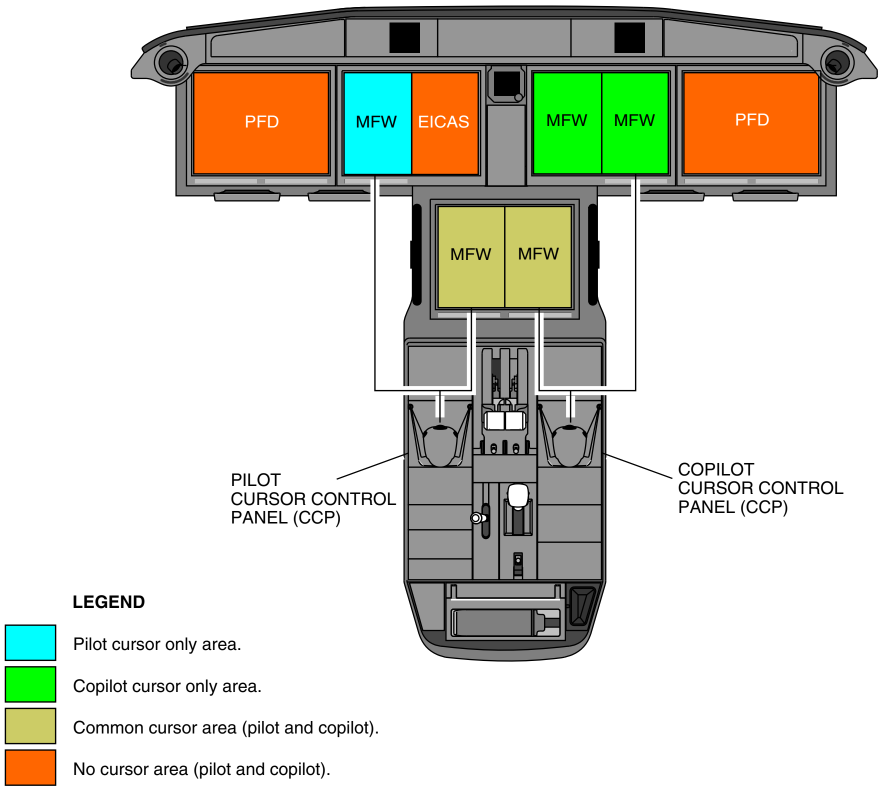
Three display units inoperative – DISPLAY reversion mode selected
Figure 08–02–30

CURSOR CONTROL AND OPERATION

A. Cursor overview

The cursor is controlled by rotating the trackball of the CCP. Cursor movements are horizontal, vertical, or diagonal.

The pilot-side cursor moves within DU 2 and DU 5 and the copilot cursor moves within DU 3 and DU 5. Cursor movement is possible in the MFWs only. The cursor cannot be moved in the EICAS page area or in the PFDs (refer to Figure 08–02–31).



Normal cursor operation
Figure 08–02–31

Cursor movement within a MFW is unrestricted once positioned in the window. The cursor may be used to select items from the:

- MFW menus,
- Drop-down lists,
- Label keys,
- Toggle controls,
- Dialog boxes, and
- Graphic map objects in the MFW page.

B. Cursor display

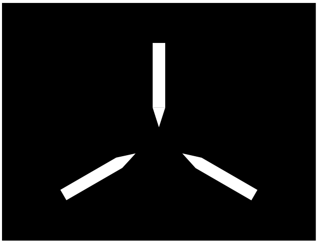
The two cursors are similar in dimensions, but the left side cursor is displayed as a white inverted Y symbol (refer to Figure 08–02–32) while the right side cursor is displayed as a white X symbol (refer to Figure 08–02–33).

The cursor fades after 3 minutes of inaction to prevent hiding information and to declutter the display.

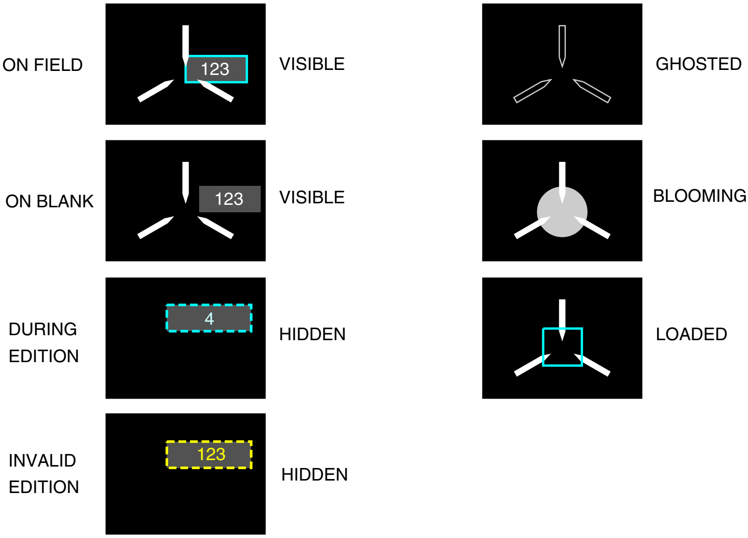
The other possible cursor statuses are:

- Loaded,
- Blooming,
- Ghosted,
- On field,
- On blank, and
- Hidden.

Figure 08–02–32 and Figure 08–02–33 show the different types of cursor.

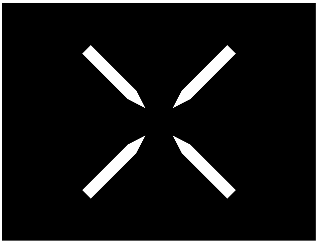


LEFT SIDE CURSOR (PILOT)

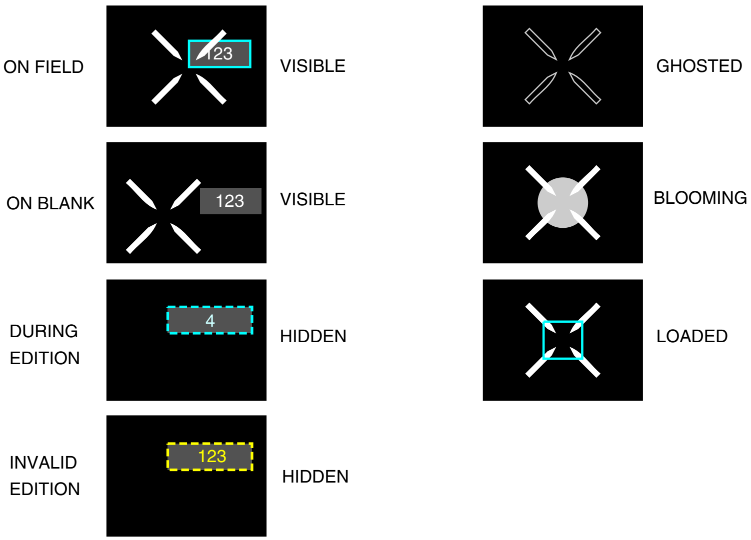


CURSOR STATUS DEPENDING ON SELECTION

Pilot cursor status
Figure 08–02–32



RIGHT SIDE CURSOR (COPILOT)



CURSOR STATUS DEPENDING ON SELECTION

Copilot cursor status
Figure 08–02–33

C. Cursor home position

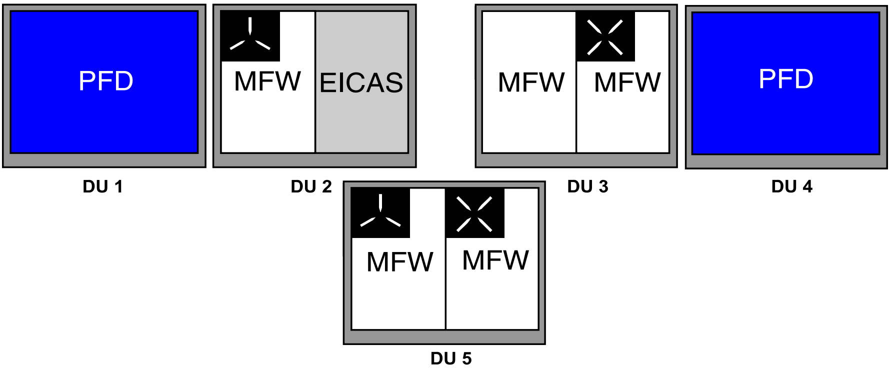
The DSPL SEL switches (UPR and LWR) on each Cursor Control Panel (CCP) are used to move the cursor to the home positions.

On the pilot side CCP, when the UPR switch is pushed the cursor moves to the UPR home position located in the upper left corner of DU 2. And when the LWR switch is pushed, the cursor moves to the LWR home position located in the upper left corner of the left MFW on DU 5.

On the copilot side CCP, when the UPR switch is pushed the cursor moves to the UPR home position located in the upper left corner of the right Multifunction Window (MFW) of DU 3. And when the LWR switch is pushed, the cursor moves to the LWR home position located in the upper left corner of the right MFW on DU5.

In normal operation, cross-side cursor is not enabled on DU 2 and DU 3. The left cursor cannot be enabled to DU 3 and the right cursor cannot be enabled to DU 2.

Figure 08–02–34 shows the cursor home position.



Cursor home positions
Figure 08–02–34

NOTE

When only one MFW is accessible (three or more DU failure, or battery power only), both pilots can access the MFW sequentially (one at a time).

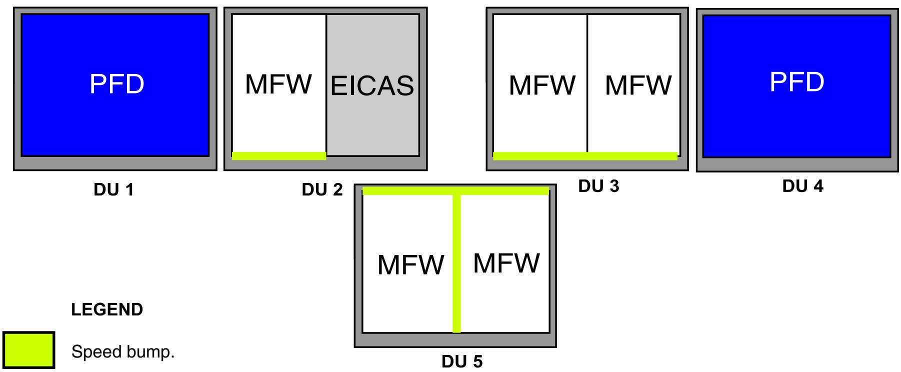
D. Cursor bumping/speed bumps

The pilot and copilot cursors may simultaneously occupy DU 5, but not on the same MFW. If a cursor enters a MFW where the other cursor is already located, the first cursor is bumped back to its MFW home position, giving the arriving cursor priority.

A cursor is also bumped when the MFW is changed to a page that does not support cursor operation.

A cursor delay, referred to as a speed bump, is used to momentarily stop the movement of the cursor when it is at the edge of a display. To cross the speed bump, the trackball must be rolled in the intended direction of travel. The speed bump prevents the inadvertent movement of the cursor to the adjacent DU when working at the edge of a display.

Figure 08–02–35 shows the locations of the cursor speed bumps.

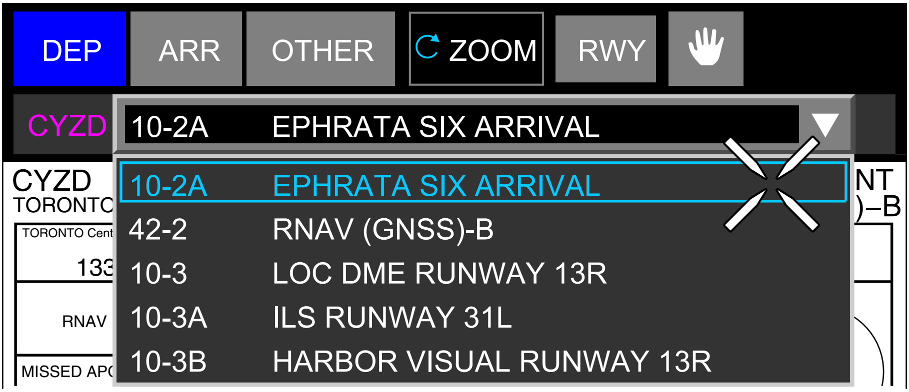


Speed bumps
Figure 08–02–35

E. Drop-down list

The cursor is used to select items listed on drop-down lists.

The movement of the cursor to individual items causes a cyan box to highlight the associated items. When selected, by pressing the select switch on the CCP, the listed items are displayed in cyan text (refer to Figure 08–02–36).



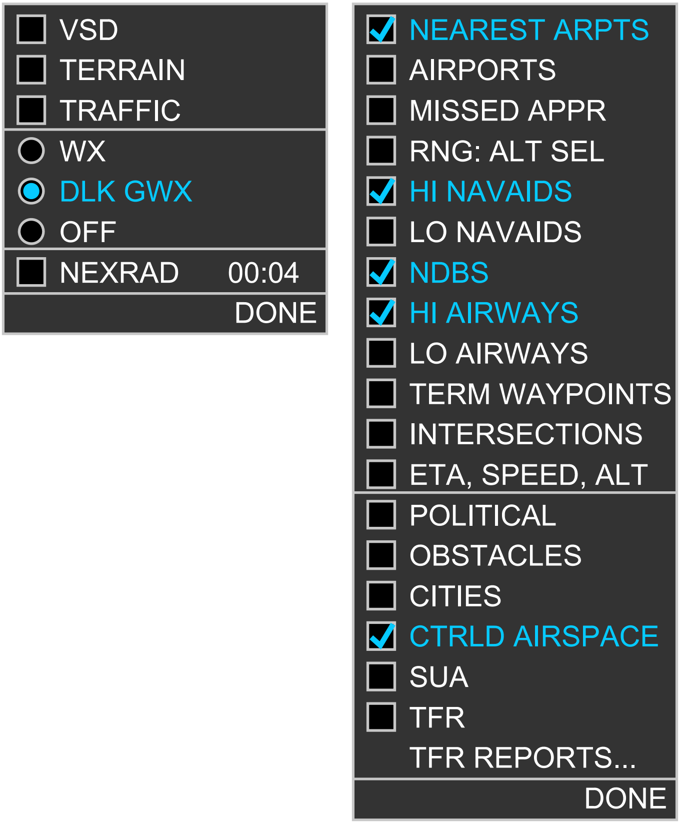
Drop–down list
Figure 08–02–36

Several drop-down lists and menus have single and multiple selection items. Single-selection items are indicated by a circle that becomes cyan when selected. Single-selection items automatically disable the previous selection.

Multiple-selection items are indicated by a check box next to each listed item. Selected items are shown in cyan with a check-mark in the box next to each item. Certain menu items may not always be selectable, depending on format and display configuration.

Disabled or non-selectable items appear as shaded text.

Figure 08–02–37 shows the single and multiple menu selection.

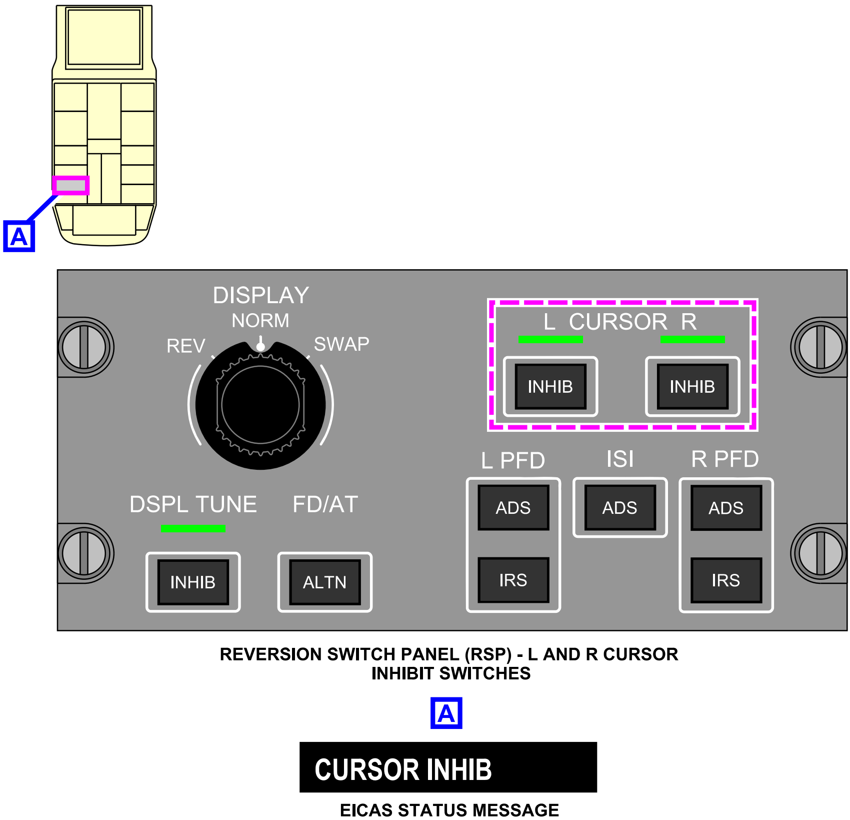


Single and multiple menu selection
Figure 08–02–37

F. Cursor inhibit

The associated cursor is inhibited when the L or R CURSOR INHIB switch on the Reversion Switch Panel (RSP) is pushed. When a cursor is inhibited, the associated green light is illuminated above the switch. When the L or R CURSOR INHIB switch is pushed again, the cursor is enabled (and the green light above it goes off).

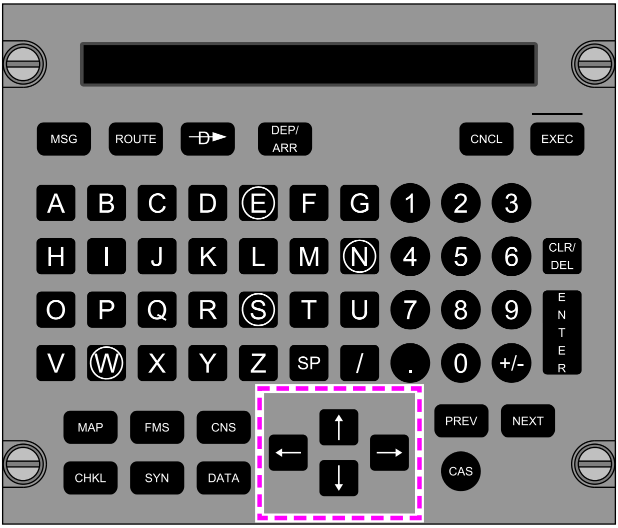
When a cursor is inhibited, the **CURSOR INHIB** status message is displayed on the EICAS page (refer to Figure 08–02–38).



Cursor inhibit
Figure 08–02–38

G. Alternate cursor control

The directional arrows on the MKP are an alternative way to control the cursor. The directional arrows have control priority if they are selected simultaneously with the trackball. On some MFW pages, directional arrows may be used to move one menu tab to another on the selected display (refer to Figure 08–02–39).

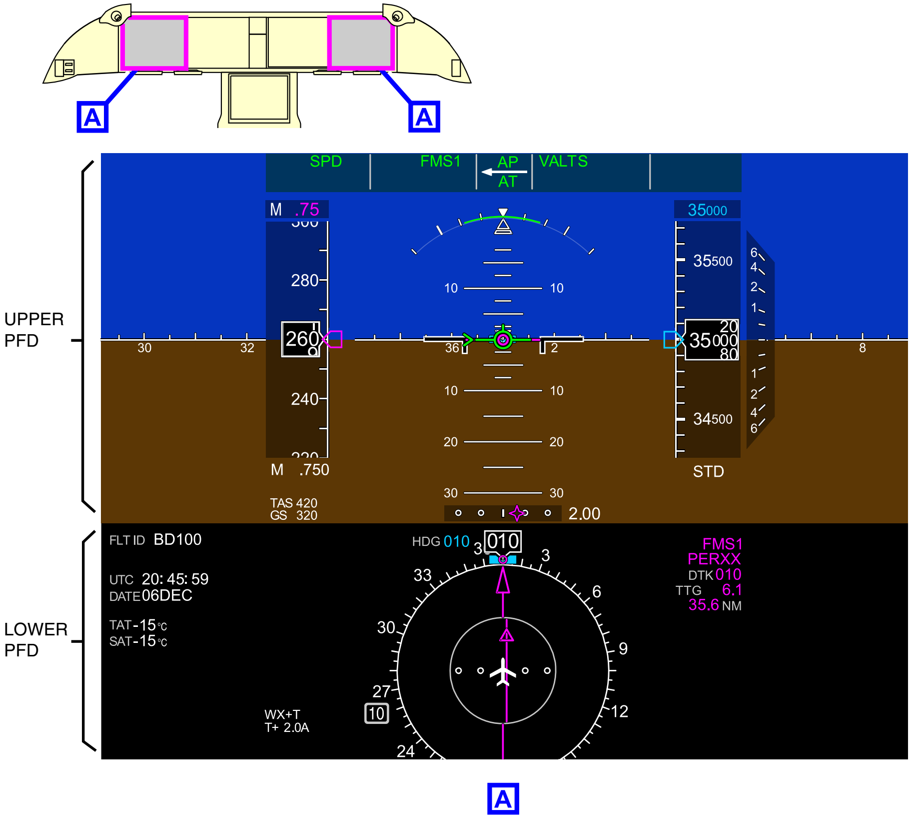


MULTIFUNCTION KEYBOARD PANEL

Alternate cursor control
Figure 08–02–39

PRIMARY FLIGHT DISPLAY – OVERVIEW

The Primary Flight Displays (PFDs) show flight and navigation data on DU 1 and DU 4 (refer to Figure 08–03–1). Each PFD includes the Flight Mode Annunciator (FMA), the Attitude Direction Indicator (ADI), and the Horizontal Situation Indicator (HSI).



Primary Flight Display (PFD)
Figure 08–03–1

The ADI supplies the information that follows:

- Attitude,

- Flight Path Vector (FPV),
- Airspeed,
- Altitude, and
- FMA.

The FMA is described in detail in the Automatic Flight chapter (refer to Chapter 03 – AUTOMATIC FLIGHT).

The HSI includes the information that follows:

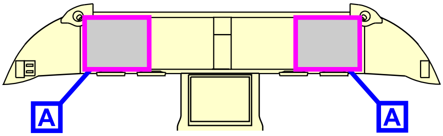
- Compass heading,
- Navigation data,
- Flight Management System (FMS) messages,
- Traffic Alert and Collision Avoidance System (TCAS),
- Weather radar, and
- Secondary flight data.

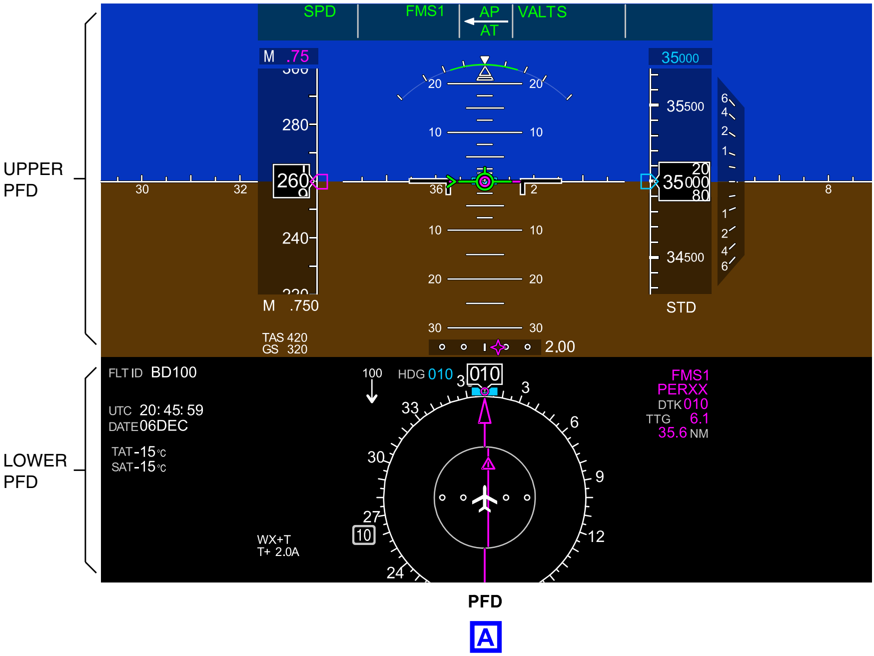
If there is a Display Unit (DU) failure, the PFD can be compressed (automatic or manual reversion). For detailed information about DU failure and reversion, refer to Chapter 08 – Electronic Display – Display System – Display Unit Reversion.

ATTITUDE DIRECTION INDICATOR (ADI) – ATTITUDE

A. ADI attitude – Overview

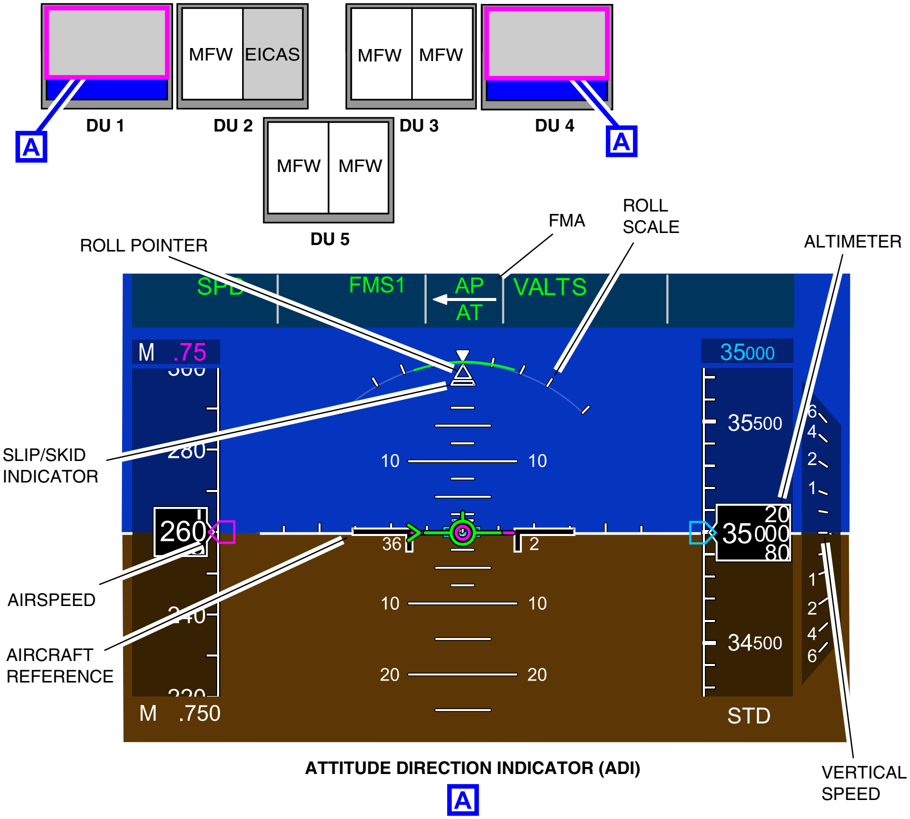
The Attitude Direction Indicator (ADI) is displayed on the top two-thirds of the DU (refer to Figure 08–03–2). The sky (blue) and the ground (brown) displays are separated by a horizon line (white). The FMA occupies the top portion of the ADI, the airspeed indication is on the left, and the altimeter and vertical speed indications are on the right. The attitude indications occupy the center portion.





PFD – ADI and HSI
Figure 08–03–2

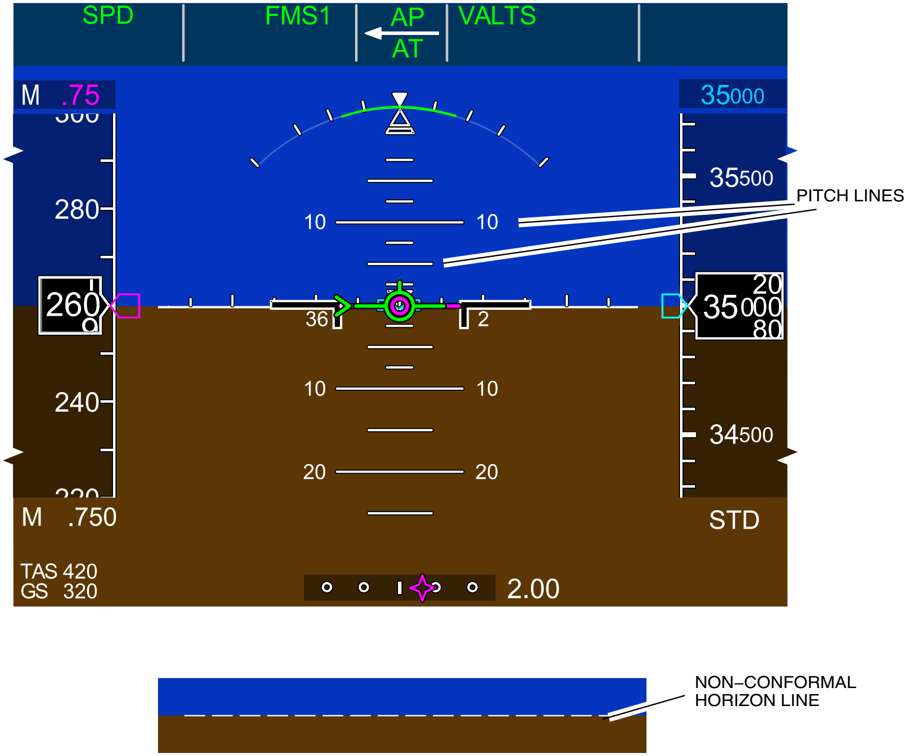
The aircraft is represented by two sideways L-shaped symbols. The pitch indications are located vertically, centered in the ADI. The roll scale and pointer are located at the top of the attitude display. The slip/skid indicator is below the white bank angle pointer (refer to Figure 08–03–3).



PFD – Attitude Direction Indicator (ADI)
Figure 08–03–3

B. Pitch indication

The pitch scale consists of horizontal white lines every 2.5 degrees above and below the horizon. The total pitch scale range is from 90 degrees below to 90 degrees above the horizon. When the aircraft pitch is 25 degrees above or 24 degrees below the horizon, the PFD horizon line has reached its travel limit and no longer conforms to the actual horizon. In this situation, the horizon line is displayed as a white dashed line (refer to Figure 08–03–4).



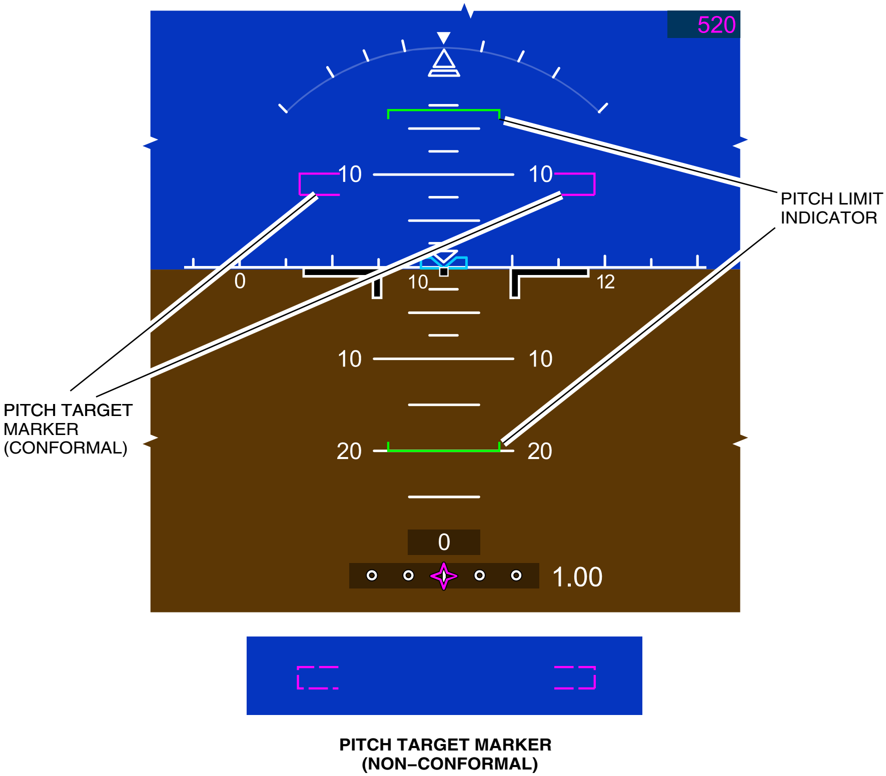
ADI – Pitch indication
Figure 08–03–4

(1) Pitch limit indicator

Pitch limits are calculated by the Fly-By-Wire (FBW) system. Pitch limits are indicated by a green indicator for nose up and nose down. The pitch limits correspond to the hard stops on the sidestick (refer to Figure 08–03–5).

(2) Pitch target marker

The magenta pitch target marker appears when the TOGA switch is pushed. It indicates the required pitch angle for takeoff and go-around (refer to Figure 08–03–5). For detailed information, refer to Automatic Flight, Chapter 03 – AUTOMATIC FLIGHT.

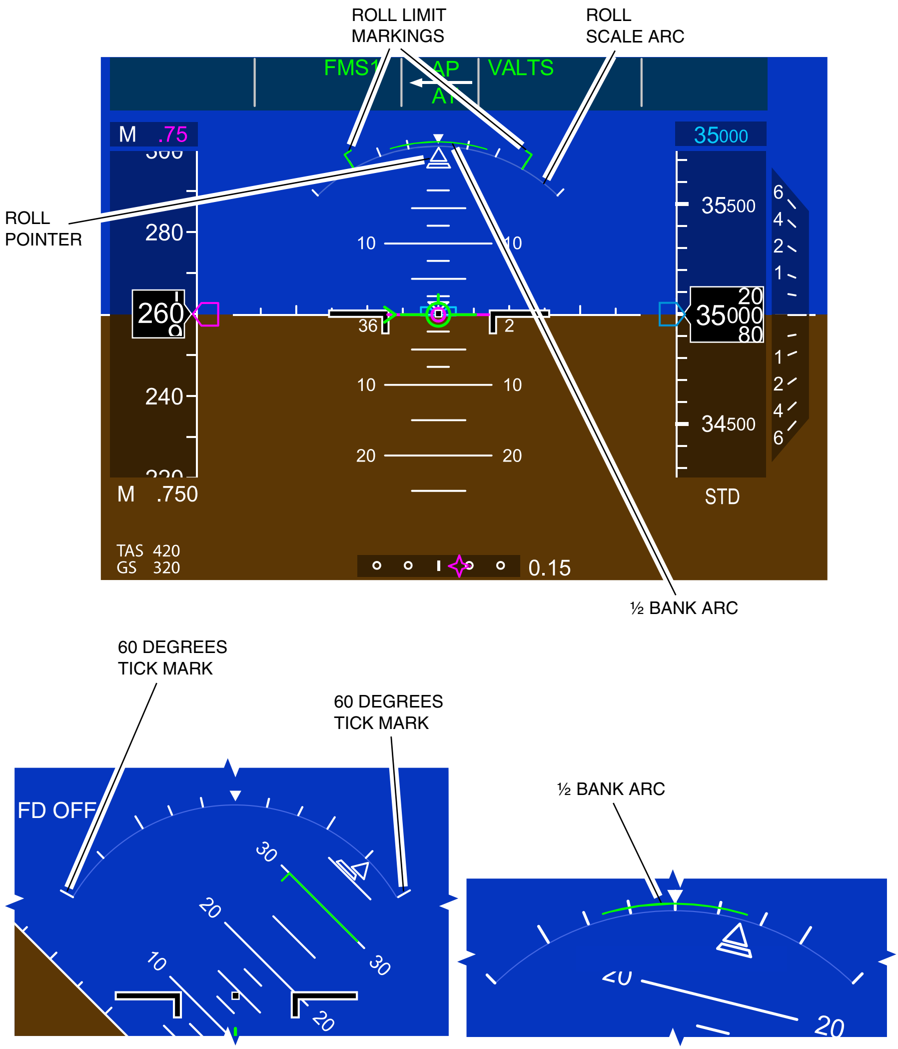


ADI – Pitch limit indicator and pitch target marker
Figure 08–03–5

C. Roll indication

The bank angle is displayed as a white triangle against a white roll scale arc. White marks on the roll scale correspond to the bank angles of 10, 20, 30 and 45 degrees on each side.

When the bank angle exceeds 40 degrees, the 60-degree bank angle marks (left and right) will be shown. The 60-degree marks are removed when the bank angle is less than 30 degrees (refer to Figure 08–03–6).

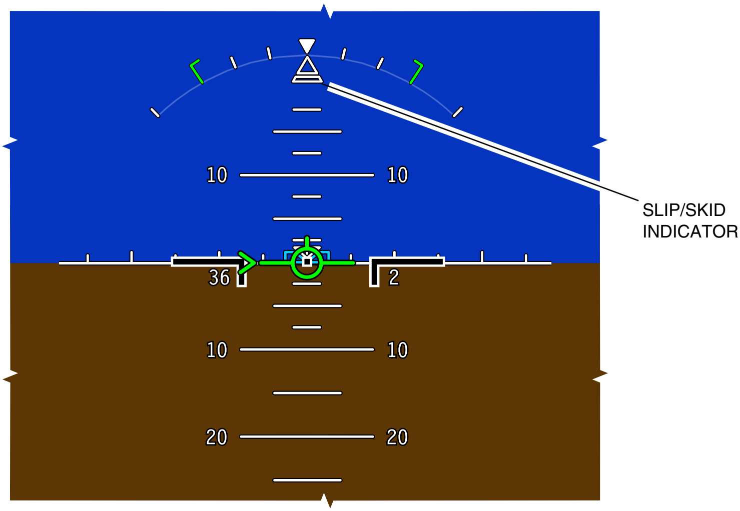


ADI – Roll indications
Figure 08–03–6

The Fly-By-Wire (FBW) roll limit markings are displayed as inverted green L-shaped marks on the roll scale. A green arc on the roll scale indicates the bank angle range when half bank mode is active.

(1) Slip/skid indicator

The slip/skid indicator is displayed as a white, unfilled trapezoidal shape below the roll indicator (white triangle) (refer to Figure 08–03–7). A displacement the width of the trapezoid is approximately equivalent to one ball displacement of a conventional turn coordinator.

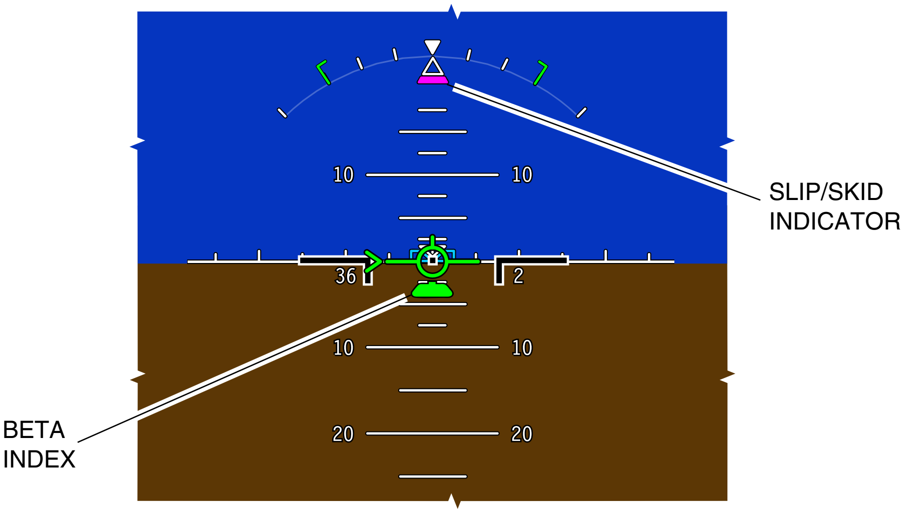


ADI – Slip/skid indicator in normal operation
Figure 08–03–7

The slip/skid indicator can also be displayed as a magenta-filled trapezoid during One Engine Inoperative (OEI) conditions with slats/flaps not retracted.

(2) Beta index

The beta index provides guidance for roll input and yaw compensation during single engine operation. The beta index is displayed under the Flight Path Vector (FPV) as a green trapezoid (refer to Figure 08–03–8).

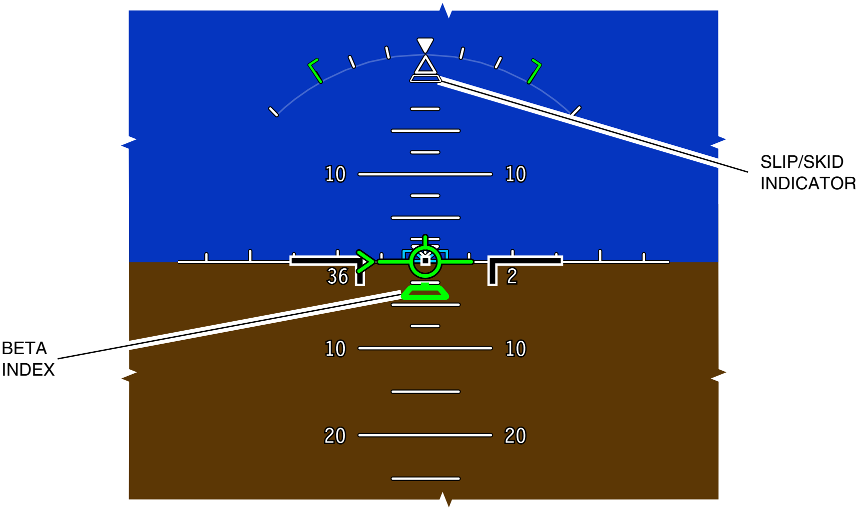


ADI – Slip/skid indicator and beta index (OEI at takeoff and weight–off–wheels)
Figure 08–03–8

The beta index computes roll offset based on aircraft configuration and environmental conditions.

When an engine failure event occurs at takeoff, the beta index is automatically displayed at weight-off-wheels as a green-filled trapezoid. In this condition, the slip/skid indicator becomes a magenta-filled trapezoid.

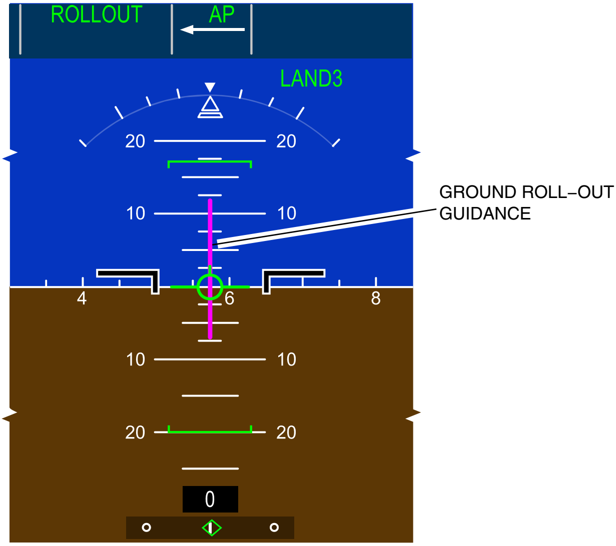
When the slats/flaps are retracted, the beta index remains in view as an unfilled green trapezoid and the slip/skid indicator returns to a white unfilled trapezoid (refer to Figure 08–03–9).



ADI – Slip/skid indicator and beta index (OEI with slats/flaps retracted)
Figure 08–03–9

(3) Ground roll-out guidance

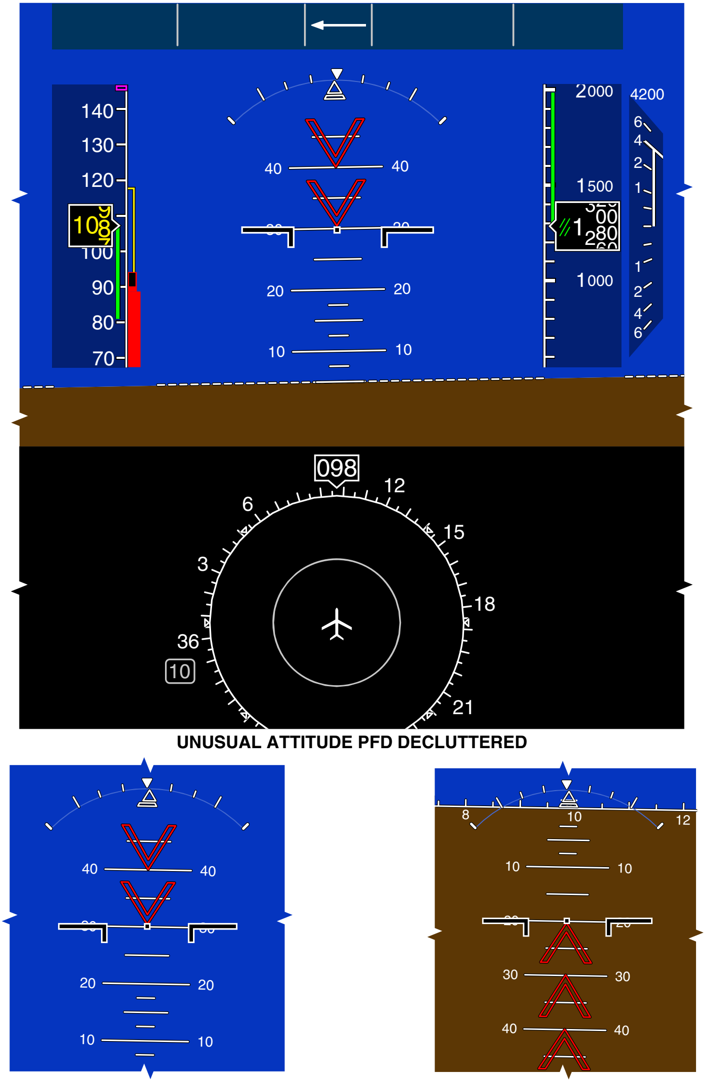
Ground roll-out guidance is displayed as a vertical magenta line used to maintain the aircraft on the center of the runway (refer to Figure 08–03–10). The ground roll-out guidance line is displayed when autoland roll-out mode is active (after landing). For detailed information about the roll-out mode, refer to Chapter 03 – AUTOMATIC FLIGHT.



ADI – Ground roll–out guidance
Figure 08–03–10

(4) Unusual attitude

Pitch chevrons indicate to the flight crew an exceedance in the pitch angle, and point towards the horizon line to assist attitude recovery (refer to Figure 08–03–11). They display starting on the 30 degree line when the pitch angle exceeds 25 degrees nose up. They will disappear when the pitch angle returns to less than 20 degree nose up.



UNUSUAL ATTITUDE PFD DECLUTTERED

PITCH CHEVRONS DOWNWARD

PITCH CHEVRONS UPWARD

ADI – Unusual attitude
Figure 08–03–11

The pitch chevrons are displayed, starting on the 20-degree line, when the pitch angle exceeds 25 degrees nose down. They will disappear when the pitch angle returns to less than 10 degrees nose down.

If the bank angle exceeds 60 degrees or the pitch angle exceeds 30 degrees nose up or 20 degrees nose down, the data shown on the PFD is reduced (decluttered) to increase unusual attitude awareness.

All PFD symbols are restored when the pitch attitude is between 25 degrees nose up and 15 degrees nose down, and the bank angle is less than 60 degrees.

D. ADI miscompare/fail flags

Miscompare fail flags will show on the PFDs when a difference of aircraft attitude is detected between the PFDs (refer to Figure 08–03–12).

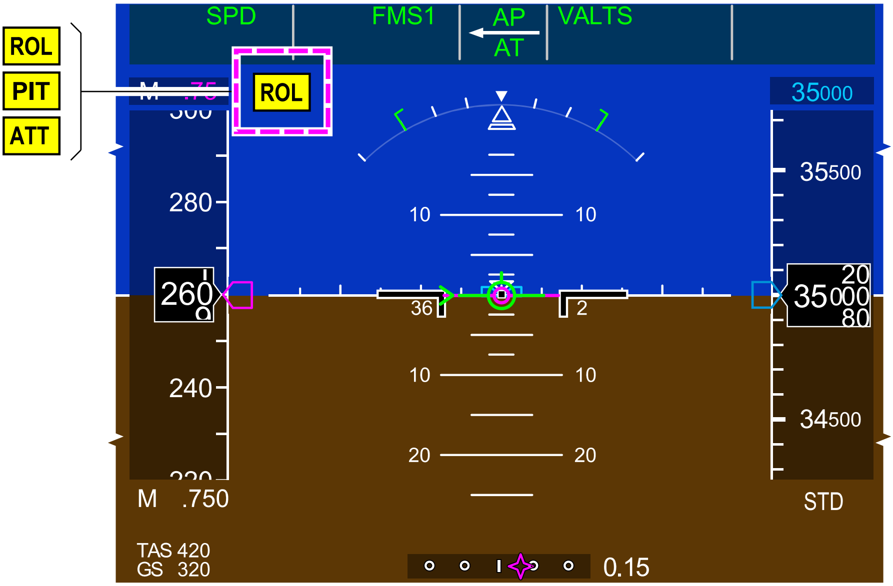
A PIT miscompare amber flag will show when a difference of more than 4 degrees (3 degrees when glideslope is captured) is detected between the pitch angle indicated on each PFD.

A ROL miscompare amber flag will show when a difference of more than 4 degrees is detected between the bank angle indicated on each PFD.

An ATT miscompare amber flag will show when a difference of more than 4 degrees is detected between both the pitch and the bank angle indicated on each PFD.

NOTE

PIT, ROL and ATT miscompares are displayed in the same position on the PFD.

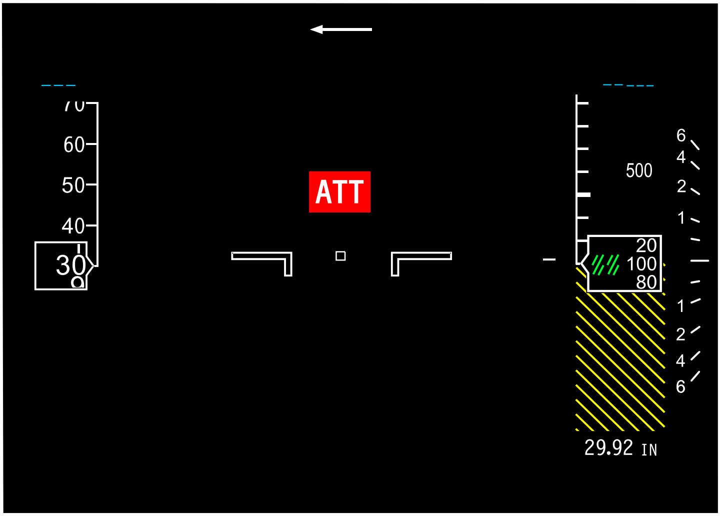


EFIS MISCOMPARE

EICAS CAUTION MESSAGE

ADI miscompare indications
Figure 08–03–12

If there is an invalid pitch and roll angle, the ATT red fail flag will show, and the attitude and the flight path indications are removed from the ADI (refer to Figure 08–03–13).



ADI failed indication
Figure 08–03–13

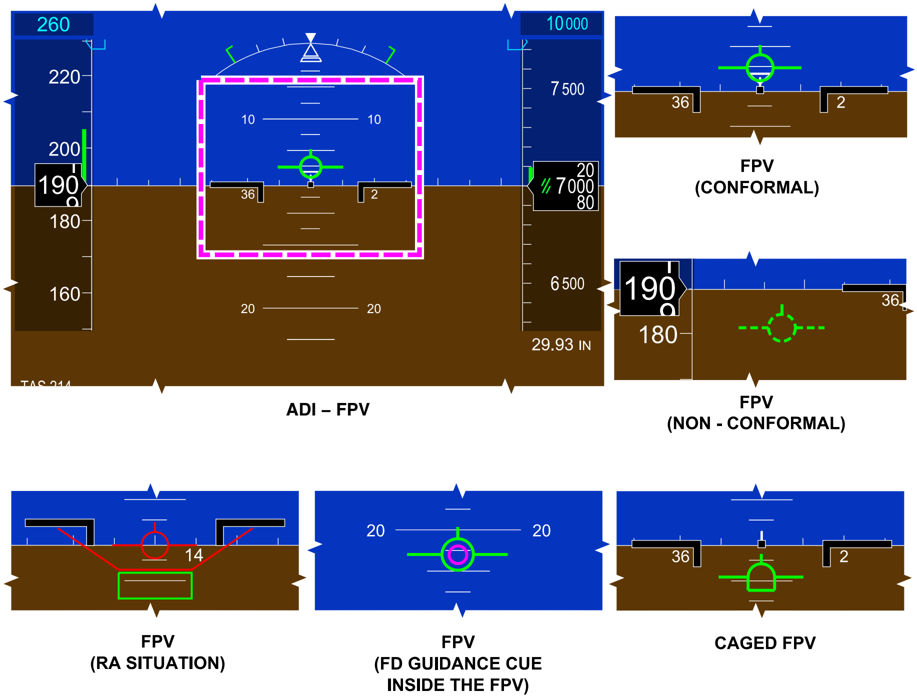
FLIGHT PATH VECTOR (FPV)

A. FPV symbol

The FPV is displayed as a green circle with marks that symbolize the aircraft fuselage, tail, and wings (refer to Figure 08–03–14). The FPV is laterally active at 80 knots and vertically active with the weight-off-wheels.

Unlike the aircraft symbol that shows the aircraft attitude, the FPV shows the projected path of the aircraft in two dimensions, within the attitude display on the PFD.

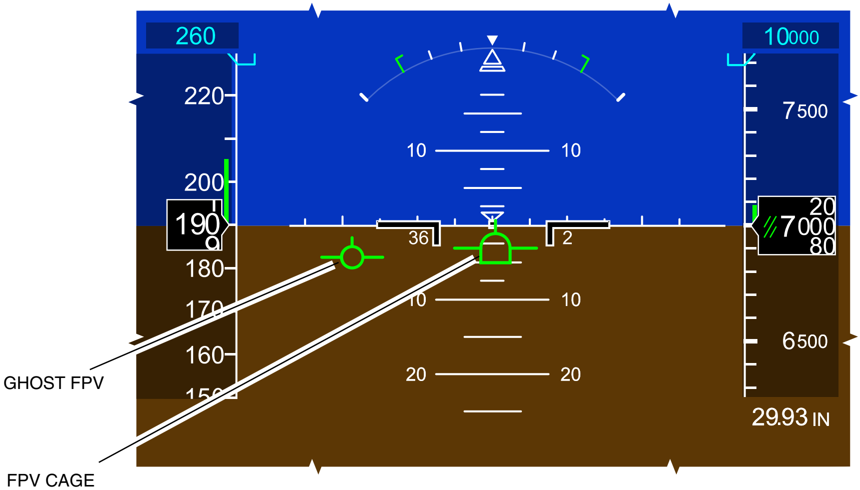
The flight director cue is displayed as a magenta circle, smaller in size than the green FPV symbol. It appears 3 seconds after the weight-off-wheels signal. The Flight Director (FD) provides pitch and roll commands on the ADI.



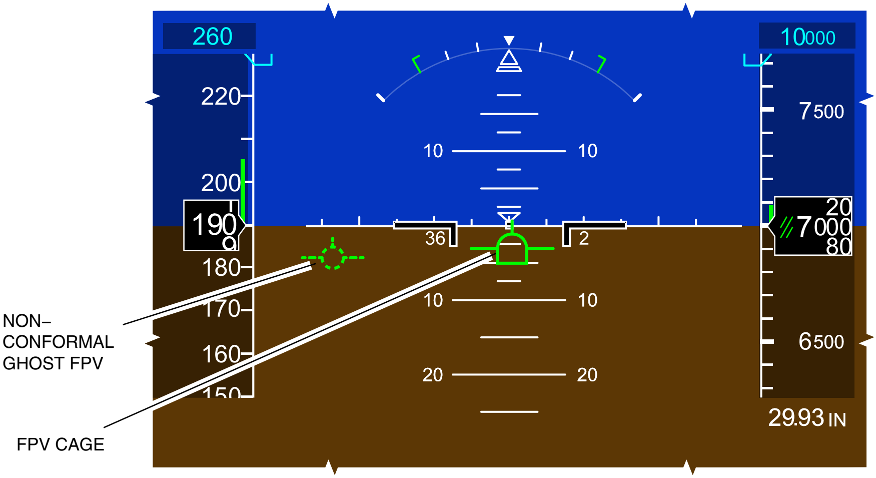
ADI – Flight Path Vector (FPV) legend
Figure 08–03–14

When autopilot is engaged, it maneuvers the aircraft so that the flight director cue stays in the center of the FPV. When flying manually, the flight crew uses the flight controls to accomplish the same task.

If the flight path (trajectory) of the aircraft is outside attitude display limits (for example, during high crosswind conditions), the FPV stays against the limit and no longer represent the exact flight path. In this case, the non-conformal ghost FPV is displayed as a dotted line (refer to Figure 08–03–15).



GHOST FPV INDICATES AIRCRAFT FLIGHT PATH
OUTSIDE THE CAGE FPV AREA



NON–CONFORMAL GHOST FPV INDICATES AIRCRAFT FLIGHT PATH
OUTSIDE OF THE CAGE FPV AREA LIMITS

ADI – Ghost FPV indications
Figure 08–03–15

When the flight path of the aircraft returns within the attitude display limits, the ghost FPV returns to the full line symbol (conformal state).

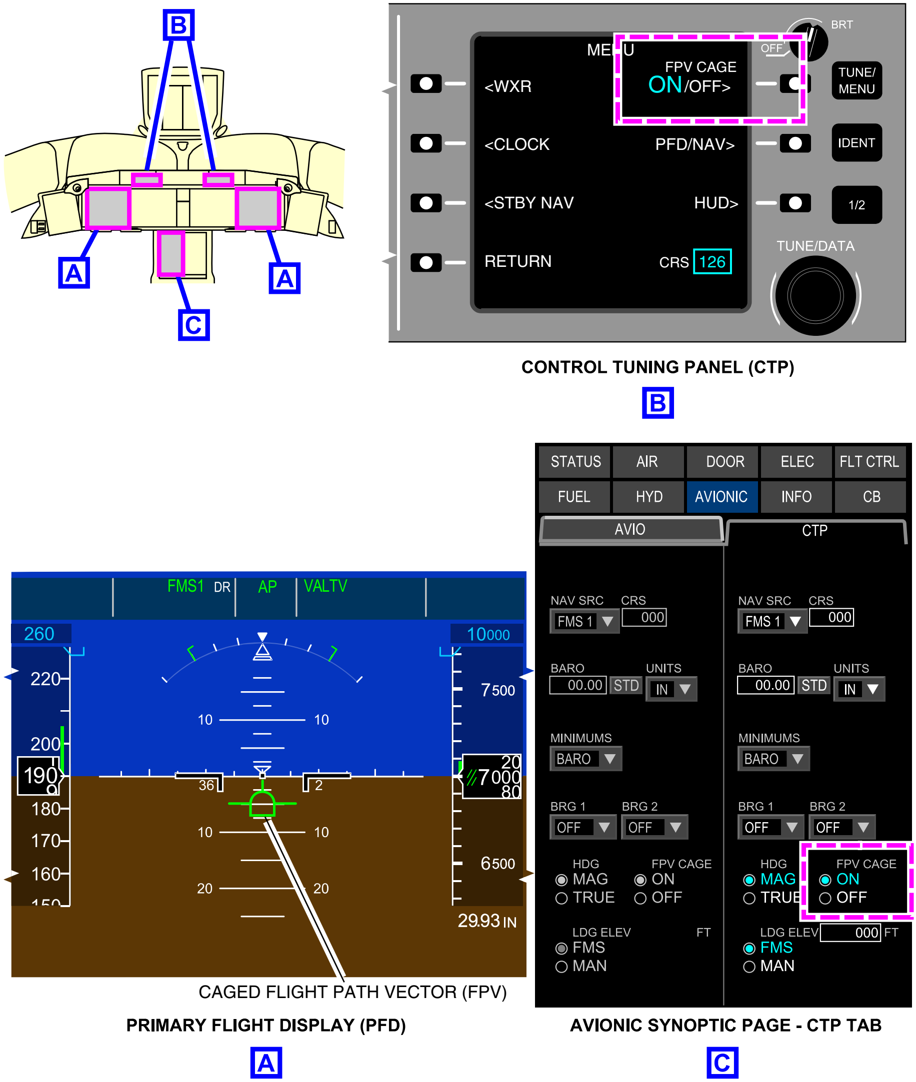
B. Cage mode

In cage mode, the FPV movement is restrained or caged, and only displays the vertical path of the aircraft (FPV can only move vertically).

This mode is accessed from:

- The Control Tuning Panel (CTP), by pushing the TUNE/MENU pushbutton and selecting FPV CAGE ON.
- The AVIONIC synoptic page, by selecting FPV CAGE ON from the CTP tab.

When cage mode is engaged, the bottom of the FPV symbol is flat (refer to Figure 08–03–16).



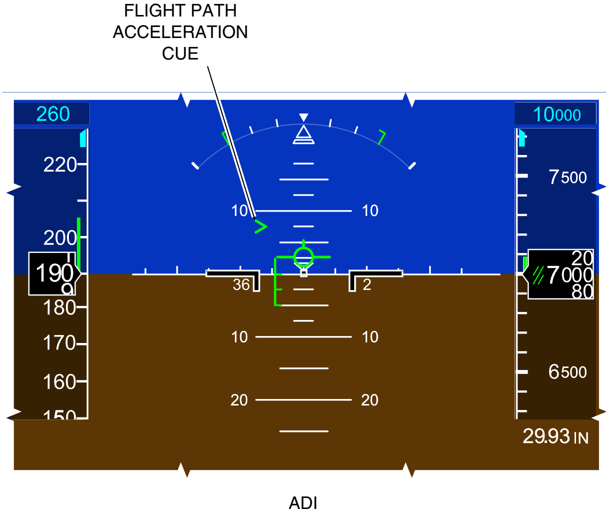
ADI – FPV cage mode control
Figure 08–03–16

In the caged mode, the FPV behaves more like traditional flight director command bars. The aircraft is maneuvered to bring the flight guidance cue inside the caged FPV. The FPV is fixed in the middle of the ADI, and no longer indicates the projected flight path of the aircraft. However, the flight director steering commands are still followed.

If the projected path of the aircraft moves outside of the attitude display limits while FPV is in caged mode, a smaller non-conformal symbol displays.

C. Acceleration cue

An acceleration cue is displayed as a green pointer moving vertically beside the left wing of the FPV (refer to Figure 08–03–17). The acceleration cue indicates the aircraft acceleration or deceleration along the flight path.

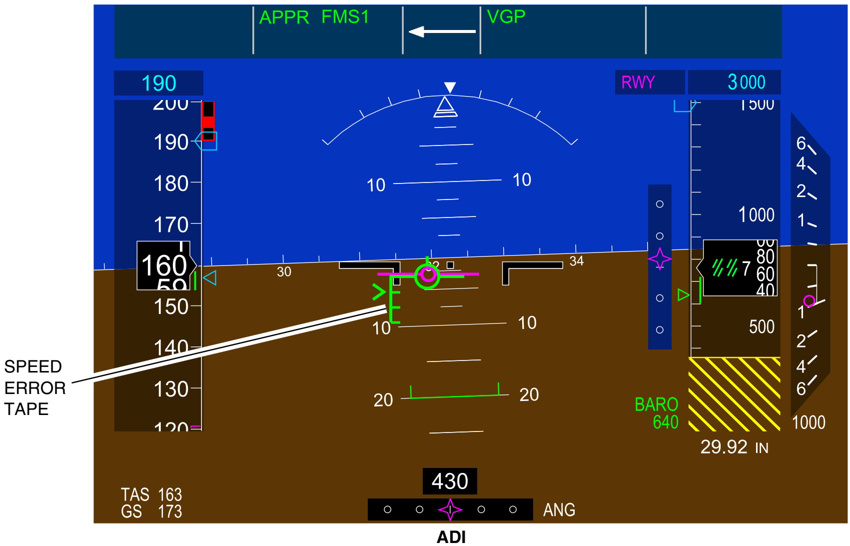


ADI – Acceleration cue
Figure 08–03–17

When the aircraft is accelerating, the acceleration cue is above the wing of the FPV. When the aircraft is decelerating, the acceleration cue is below the wing of the FPV. When the aircraft speed is constant, the acceleration cue points to the FPV wing. The distance between the acceleration cue and the FPV increase with an increase in acceleration or deceleration.

D. Speed error tape

The speed error tape is displayed as a green scale that extends above or below the left wing of the FPV. It shows the difference between the actual indicated airspeed and selected airspeed. Each tick mark represent a 5-knot difference, up to a maximum of 15 knots (three tick marks). When the actual airspeed is higher than the selected airspeed, the speed error goes up (above the FPV left wing) (refer to Figure 08–03–18).



ADI – Speed error tape
Figure 08–03–18

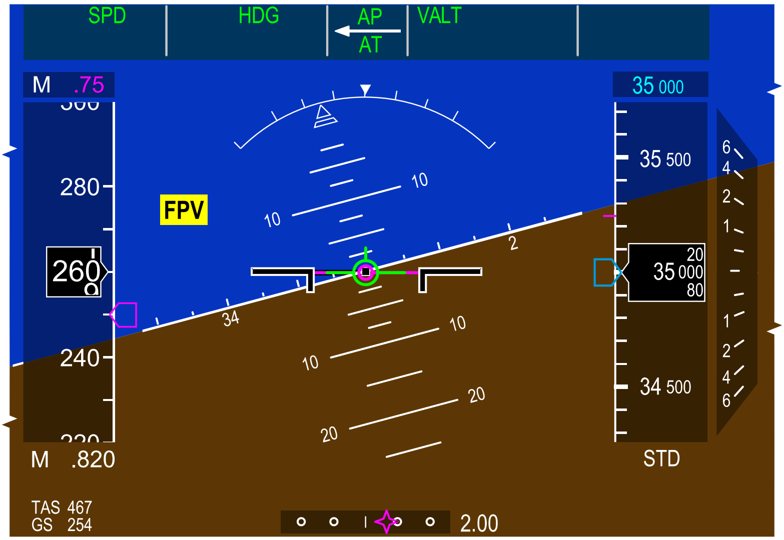
When the actual airspeed is less than the selected airspeed, the speed error goes down (below the FPV left wing).

NOTE

The speed error tape scale is not associated with the flight path acceleration symbol.

E. FPV miscompare

An FPV miscompare message (black text on amber background box) indicates a difference between the FPVs (refer to Figure 08–03–19).



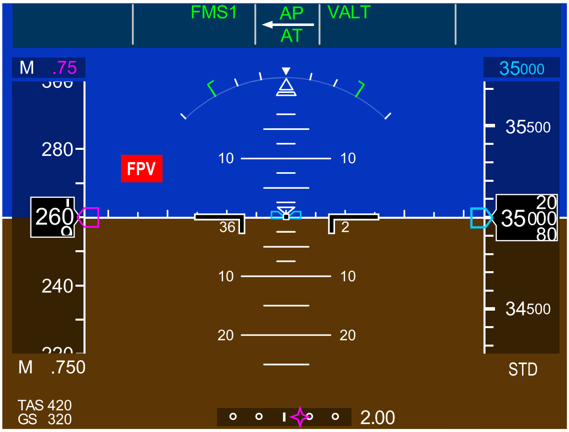
ADI

EICAS CAUTION MESSAGE

ADI – FPV miscompare indications
Figure 08–03–19

F. FPV fail indications

An FPV fail message (white text on red background box) on the PFD indicates failure of the FPV (refer to Figure 08–03–20).



ADI – FPV fail indications
Figure 08–03–20

ADI – AIRSPEED

A. Airspeed information

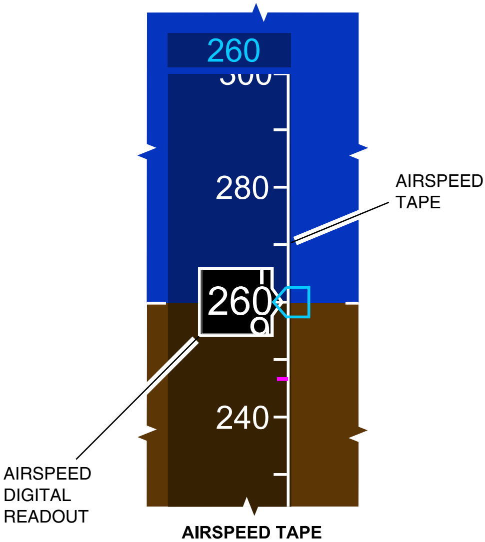
Airspeed information is displayed as a moving vertical tape located on the left side of each PFD. The airspeed information includes:

- Actual airspeed window (digital readout),
- Mach digital readout,
- Airspeed trend vector,
- Overspeed marker,
- Low speed marker,
- Selected airspeed,
- Takeoff or approach speeds,
- Flaps and gear limiting speed references,

- Best lift/drag airspeed bug, and
- Fly-by-wire trim speed.

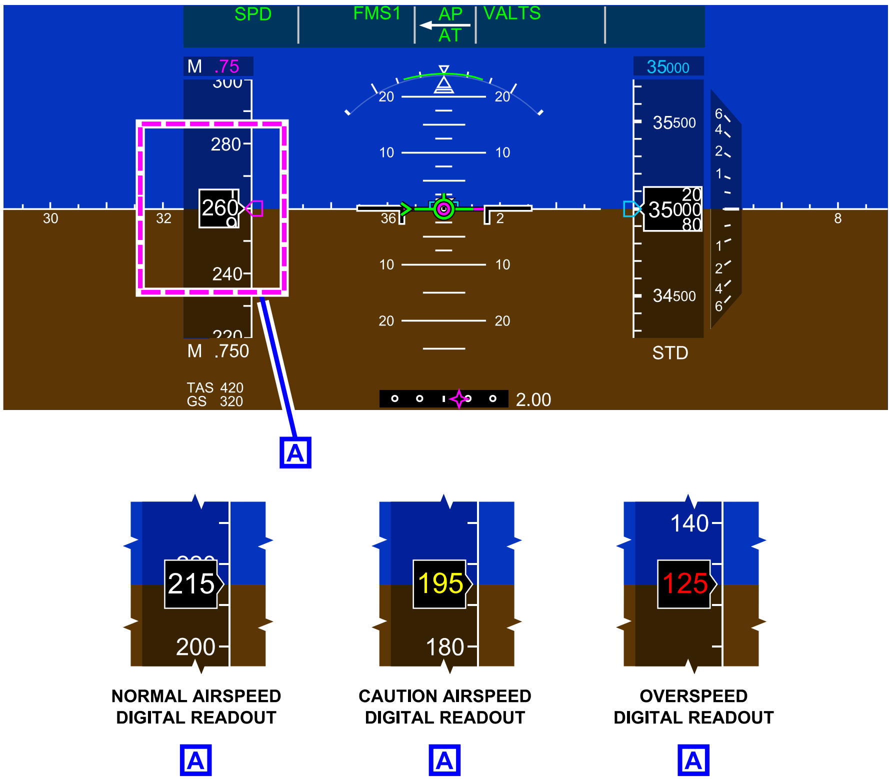
B. Airspeed tape

The airspeed tape is a vertical moving scale ranging from 30 to 400 knots with a visible range of ±40 knots of the Indicated Airspeed (IAS). The tape has a scale that is marked every 10 knots with a white tick mark, and numerically marked every 20 knots above 200 knots IAS. Below 200 knots IAS, the tape is numerically marked at every 10 knots. The current IAS displays in a digital readout window, at the center of the airspeed tape (refer to Figure 08–03–21).



ADI – Airspeed tape
Figure 08–03–21

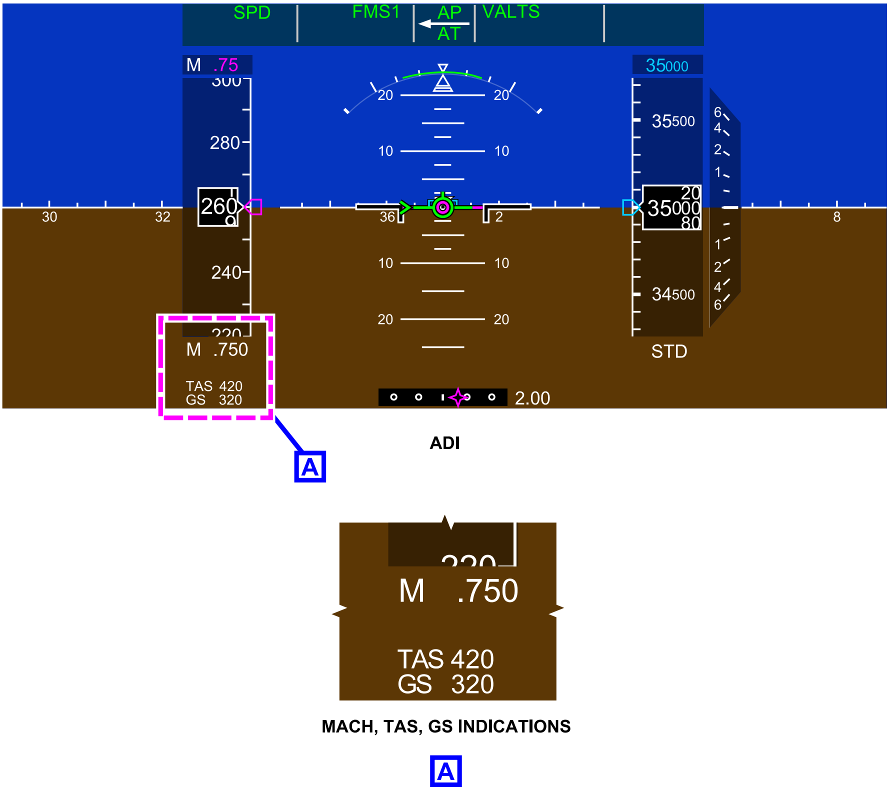
During the normal airspeed range, the digital readout is displayed in white. When the airspeed exceeds the normal range into the caution range, the digital readout changes to amber in the digital readout box only. If the airspeed continues into the overspeed range, the digital readout will change to red. In all airspeed ranges, the outline of the digital readout box remains white. Refer to Figure 08–03–22.



ADI – Airspeed tape – Airspeed digital readout
Figure 08–03–22

C. Mach speed, True Airspeed (TAS) and Ground Speed (GS) indication

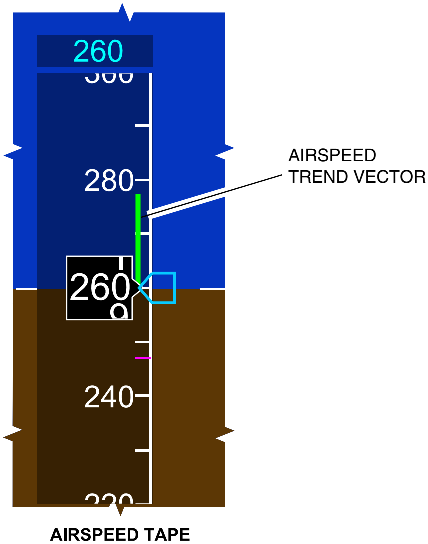
Mach speed (M) is displayed under the airspeed tape when the airspeed is more than 0.45 M and removed when Mach speed is less than 0.40 M. True Airspeed (TAS) and Ground Speed (GS) are displayed below Mach speed (refer to Figure 08–03–23).



ADI – Airspeed tape – Mach, TAS, GS indication
Figure 08–03–23

D. Airspeed trend vector

A green line, starting at the airspeed digital readout and extending upwards or downwards, represents the airspeed trend vector. Refer to Figure 08–03–24.



ADI – Airspeed tape – Airspeed trend indicator
Figure 08–03–24

The end of the line indicates the speed that the aircraft will achieve in 10 seconds if the current aircraft acceleration or deceleration is maintained. The trend vector extends upwards from the digital readout when accelerating, and downwards when decelerating. The length of the trend vector indicates the rate of acceleration or deceleration.

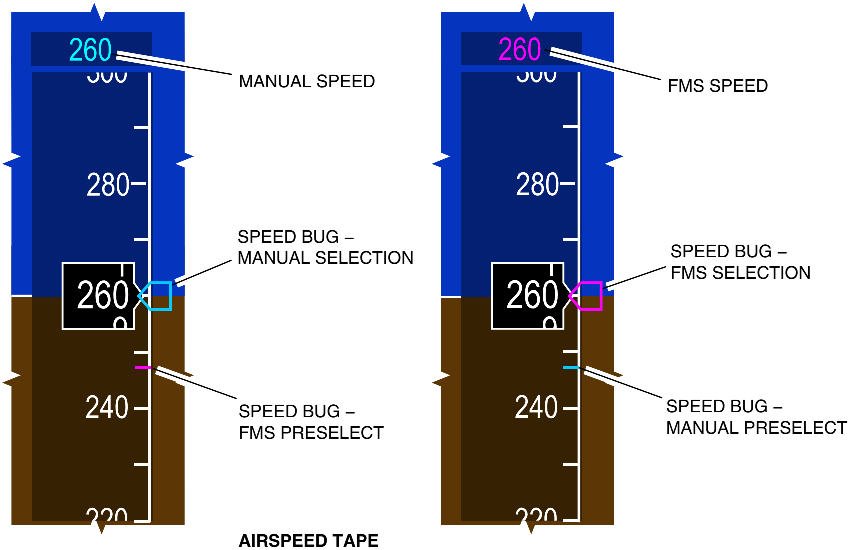
E. Displayed speed control

The selected speed is displayed as a pointer (speed bug) on the airspeed tape.

When airspeed is set manually (using the SPD switch on the FCP), the selected airspeed is displayed in cyan at the top of the airspeed scale and the speed bug is displayed in cyan. When the speed is managed by the FMS, the airspeed is displayed in magenta at the top of the airspeed tape and the speed bug is displayed in magenta (refer to Figure 08–03–25).

In FMS mode, the FMS speed is displayed as a magenta arrow. This is the FMS speed bug on the airspeed tape. The speed is displayed in magenta at the top of the airspeed tape. The manual speed is displayed as a cyan bar, or manual preselect speed bug, on the airspeed tape only.

In FMS mode, if the speed is manually selected, the manual preselect speed bug and the cyan speed value are displayed. After 5 seconds, the cyan speed value is replaced by the FMS speed but the manual preselect speed bug remains. The selected speed pointer display is limited between $V_{MINTRIM}$ and $V_{MO/}M_{MO.}$



ADI – Airspeed tape – Displayed speed bugs
Figure 08–03–25

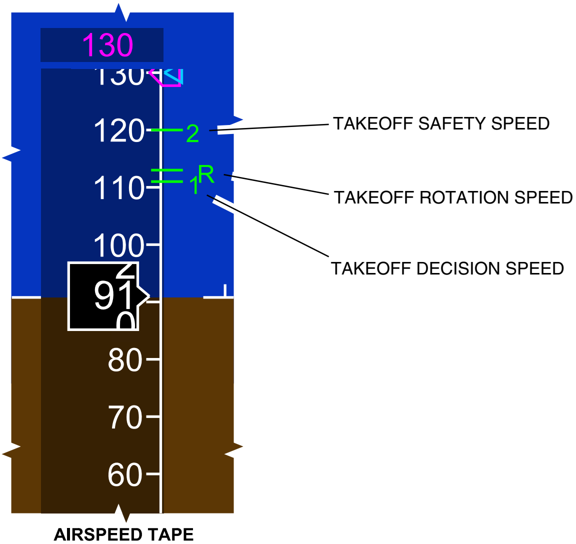
F. Takeoff speeds

The takeoff V speeds are manually entered from the FMS, on the PERF (performance) page DEP (departure) tab. When the SET VSPEEDS soft switch is selected, the digital V_1, V_R, and V_2 are automatically displayed in white at the bottom of the airspeed scale.

The takeoff reference speeds (V_1, V_R, V_2) are displayed during the takeoff roll when the speed settings are within the range of the airspeed scale, and are removed when airspeed is greater than V_2 + 20 knots. They are displayed in green, on the right side of the airspeed tape (refer to Figure 08–03–26). They are labelled as follows:

- 1: Takeoff decision speed V_1,
- R: Takeoff rotation speed V_R,
- 2: Takeoff safety speed V_2, and
- T: Final takeoff speed V_{FTO} (only displays with dual FMS failure).

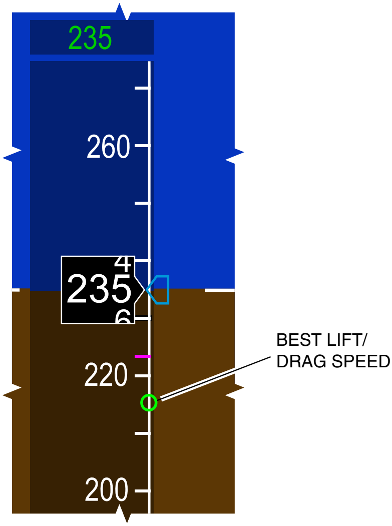
A "V1" aural message is generated when the aircraft reaches V_1.



ADI – Airspeed tape – Takeoff Speed Indications
Figure 08–03–26

G. Best lift/drag speed indications

The best lift/drag speed shows as a green dot on the airspeed tape and is displayed only during clean configuration (no slats/no flaps). Refer to Figure 08–03–27.



ADI – Airspeed tape – Best lift/drag speed
Figure 08–03–27

H. Approach speeds

The approach speed V_{REF}, also referred to as the landing reference speed, is calculated and provided by the FMS. It is displayed in green on the right side of the airspeed tape and labelled as REF (refer to Figure 08–03–28). It is displayed as follows:

- After FMS ARR tab SET VSPEEDS soft switch has been selected,
- Removed after GA mode activation, or
- Removed when on the ground and airspeed is less than 50 knots for more than 5 seconds.

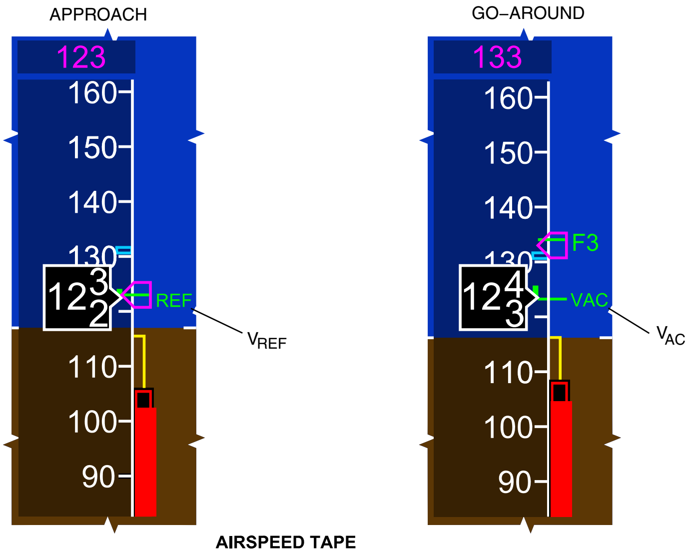
The vertical approach climb speed V_{AC} is calculated and supplied by the FMS. It is displayed in green on the right side of the airspeed tape and labelled as VAC (refer to Figure 08–03–28). It is displayed as follows:

- Displayed when GA mode is active, or

- Removed when another mode is activated.

NOTE

When not supplied by the FMS, the manually entered V_{REF} and V_{AC} speeds are displayed in cyan.



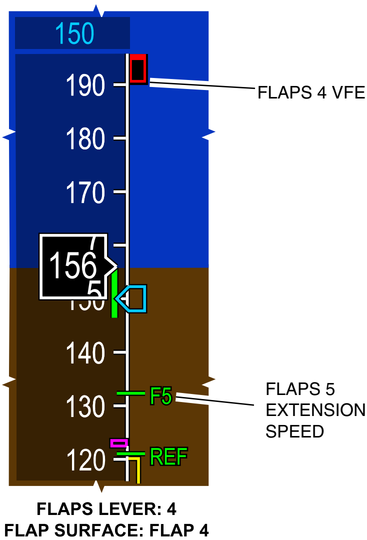
ADI – Airspeed tape – VREF and VAC indications
Figure 08–03–28

I. Flap speeds

The flap speeds are calculated by the FMS based on a 30-degree maneuver margin at the current flap setting. There is an additional speed allowance to permit aircraft deceleration during flap extension. The flap speeds are displayed as a green F with a number corresponding to the flap selection (F0 to F5). Flap speeds always indicate the recommended speed for flap retraction or flap extension. There is only one flap speed displayed at a time (refer to Figure 08–03–29).

The maximum speed of the current flap extension is shown as the lower limit of the overspeed marker. The minimum speed of the current flap extension is represented by an amber mark across the airspeed tape. Minimum and maximum flap speeds are changed at each flap retraction or extension, to reflect the actual flap setting.

During an approach with the flaps set at FLAP 1 (F1), the FMS speed is reduced to F2 on the airspeed tape. The F2 on the ADI represents the minimum speed for the FLAP 1 configuration.



ADI – Airspeed tape – Flap speeds
Figure 08–03–29

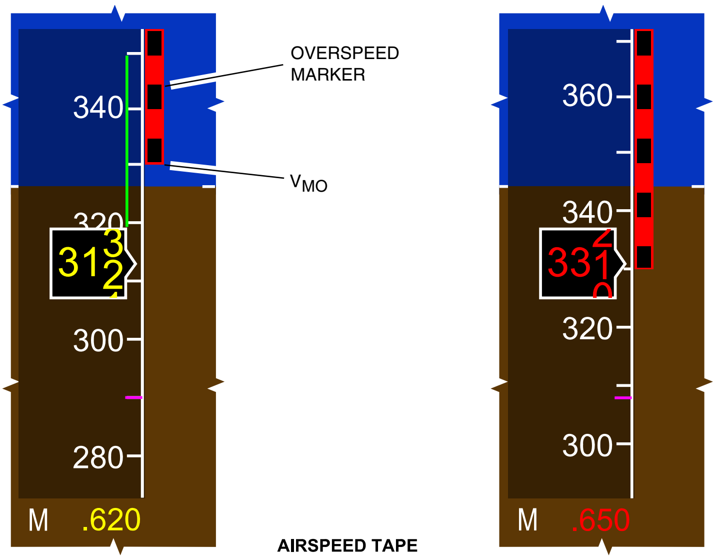
J. Overspeed indications

The overspeed area on the airspeed tape is displayed as a red and black marker. The lower limit of the overspeed marker is the maximum operation speed based on the aircraft configuration. In the clean configuration, the speed corresponds to V_{MO}/M_{MO} (Knots/Mach number) for maximum operating limits (refer to Figure 08–03–30).

When the flaps and/or the landing gear are extended, the lower limit of the bar is automatically adjusted to the maximum speed for the actual configuration, V_{FE} (maximum Flap Extended speed) or V_{LE} (maximum Landing gear Extended speed).

If the airspeed trend vector moves into the overspeed marker, the airspeed readout numbers become amber.

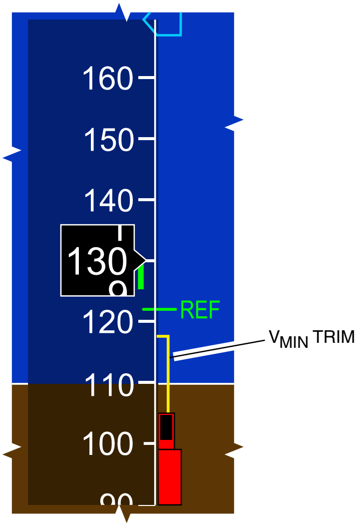
If the airspeed reaches the overspeed marker, the airspeed readout numbers become red and flash. When the airspeed exceeds the limits by 3 kt or more, the **"**OVERSPEED**"** aural alert sounds.



ADI – Airspeed tape – Overspeed indications
Figure 08–03–30

K. Minimum trim speed

Minimum trim speed is displayed as an amber inverted L above the red and black low-speed line of the airspeed tape. The minimum trim speed is the lowest trim speed or selectable speed from the FCP and provided by FBW (refer to Figure 08–03–31).



ADI – Airspeed tape – Minimum trim speed
Figure 08–03–31

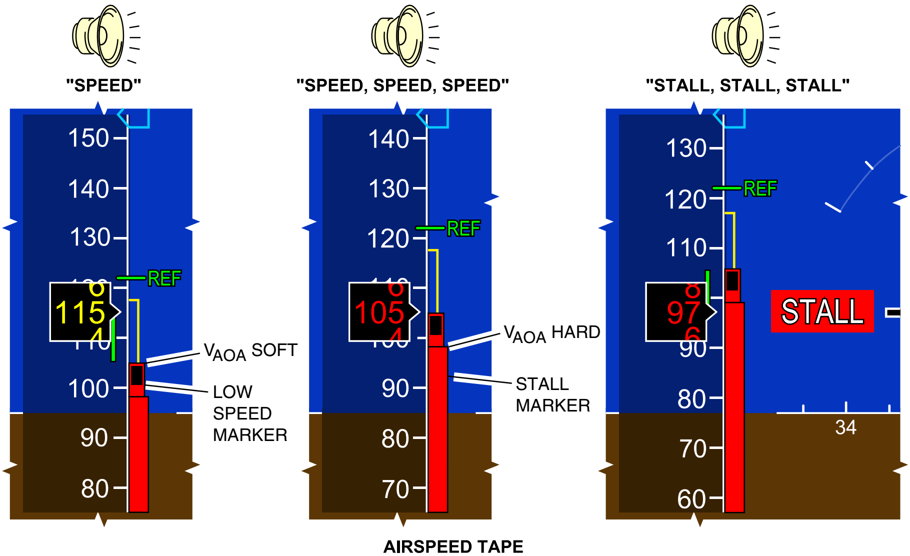
L. Low speed indications

The normal mode low speed indications are displayed as a red and black low speed marker and a red stall marker (refer to Figure 08–03–32 and Figure 08–03–33).

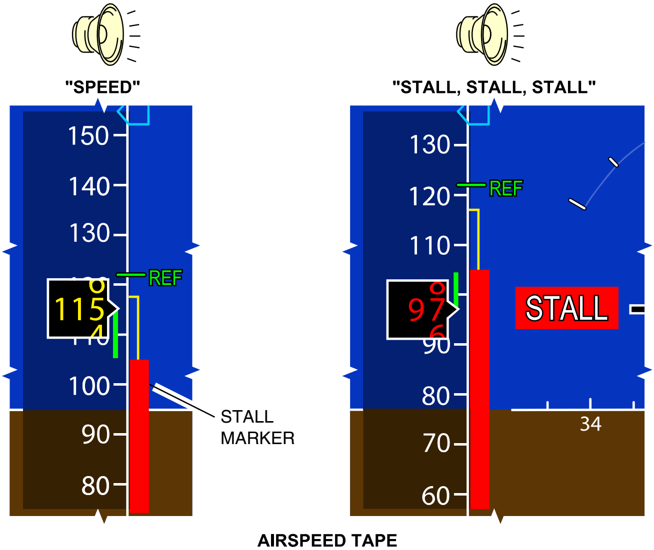
The top of the low speed marker (red and black line) is the minimum speed at the sidestick soft stop, or soft stop angle of attack (V_{AOA} soft). If the trend vector moves into the low speed marker, the airspeed digital readout numbers become amber and a **"**SPEED**"** aural message sounds. If the trend vector remains in the low speed marker for more than 1 second, the **"**SPEED**"** aural message is repeated.

The top of the stall marker (solid red line) is the minimum speed allowed by the FBW system when the sidestick is at the hard stop, or hard stop angle of attack (V_{AOA} hard).

If the airspeed moves into the low speed marker, the airspeed digital readout numbers become red, a repeating “STALL” aural message sounds, and a STALL message displays on the PFDs.



ADI – Airspeed tape – Low speed indications – Normal mode
Figure 08–03–32



ADI – Airspeed tape – Low speed indications – Direct mode
Figure 08–03–33

M. Airspeed miscompare/fail indications

An IAS miscompare flag (black text on amber background) indicates a difference of more than 10 knots between the airspeed indications on the PFDs (refer to Figure 08–03–34).

A caution message **EFIS MISCOMPARE** is displayed on the EICAS page.

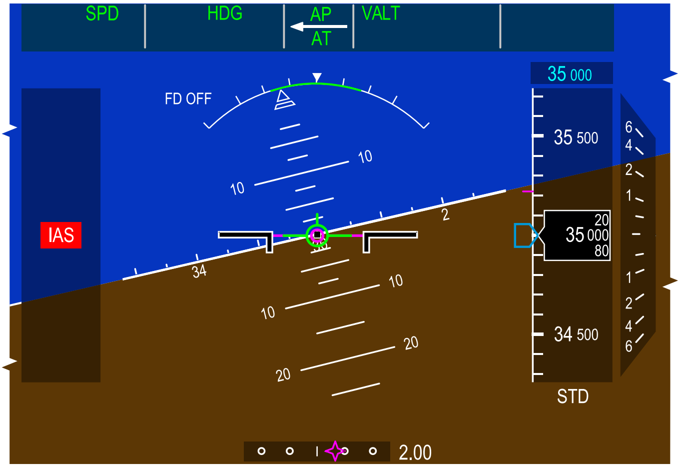
EFIS MISCOMPARE

EICAS CAUTION MESSAGE

ADI – IAS/Mach miscompare indications
Figure 08–03–34

An IAS failed flag (white text on red background) indicates failure of the airspeed indication. Refer to Figure 08–03–35.

If there is invalid airspeed or Mach data, an IAS or MACH fail flag is displayed. The numbers are removed from the airspeed tape and the airspeed digital readout.



ADI – IAS/Mach fail
Figure 08–03–35

ATTITUDE DIRECTION INDICATOR (ADI) – ALTITUDE

A. Altitude

Barometric and radar altitude information are shown on both PFDs.

B. Barometric Altitude

Barometric altitude shows as a vertical tape on the right side of the PFD (refer to Figure 08–03–36), and includes:

- Altitude tape,
- Digital altitude readout,
- Altitude trend vector,
- Preselect altitude,
- Low altitude awareness,
- Altimeter setting, and

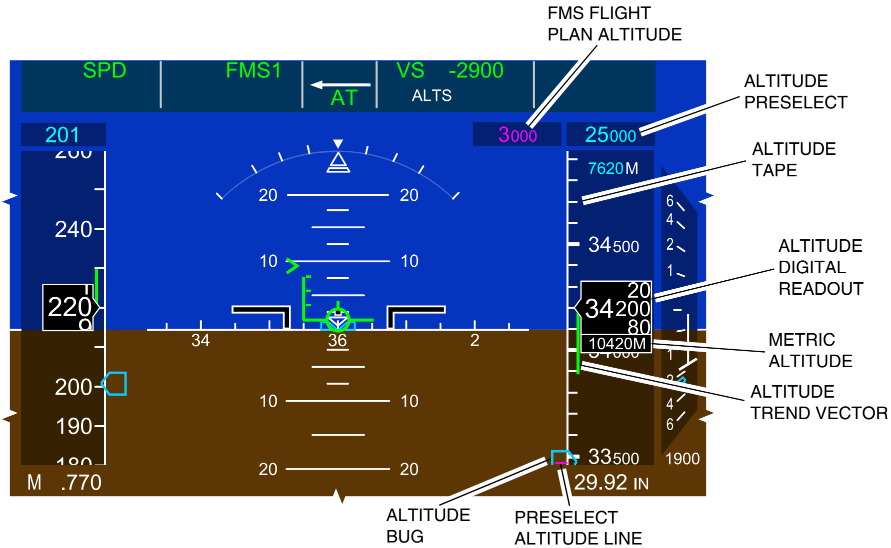
- Minimum Descent Altitude/Decision Height (MDA/DH) bug.

The moving vertical tape shows tick marks for every 100 feet, and larger marks for every 500 feet. Current altitude is displayed in a digital altitude readout window.

A green altitude trend vector, located to the right of the tape, gives a graphical representation of the projected altitude in 10 seconds if the current trend is maintained.

The selected altitude on the FCP is displayed on top of the altitude tape. It is also displayed as a cyan altitude bug on the altitude tape. The FMS planned altitude is displayed in magenta, to the left of the preselect altitude, and also as a magenta line on the altitude tape.

Metric altitude is displayed under the altitude as a white M if selected on the FCP.



ADI – Altitude indications
Figure 08–03–36

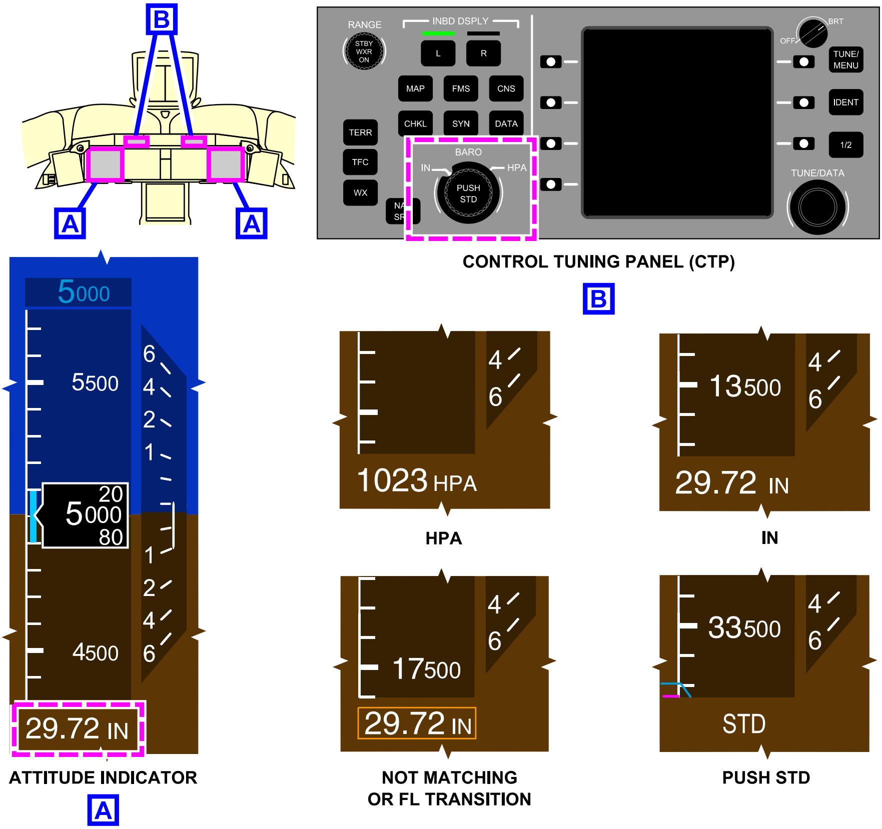
C. Altimeter setting

The altimeter setting (BARO) indication is displayed in white below the altitude scale tape, either in inches of mercury (IN) or hectopascal (HPA).

Each of the Control Tuning Panel (CTP) BARO switches or the CTP tab on the AVIONIC synoptic page can be used to set the altimeter setting on its respective PFD.

During climb, the center BARO switch is used at transition level to set the standard pressure (29.92 IN or 1013 HPA) when pressed, standard (STD) is displayed in white.

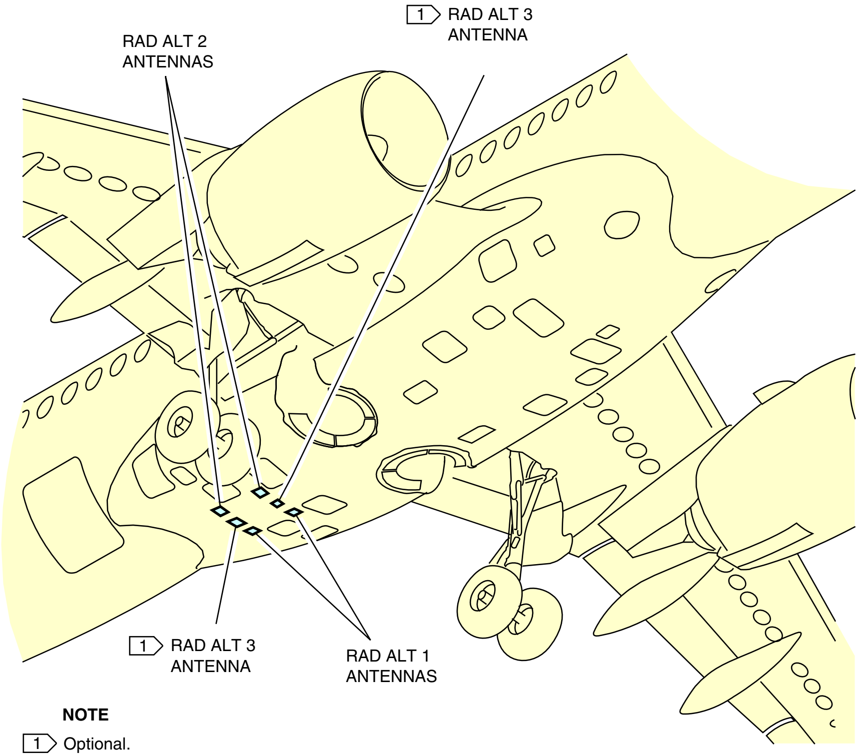
When the left and right BARO settings do not match or during transition level, the altimeter value becomes boxed in amber and remains amber until both values are identical. Refer to Figure 08–03–37.



ADI – Altimeter setting
Figure 08–03–37

D. Radio altitude (RAD ALT)

Two radio altimeters are installed to provide the aircraft height Above Ground Level (AGL). The readings of the left and the right radio altimeters are displayed on the left and right PFDs respectively. The radio altimeter antennas are located under the wing-to-body fairing, aft of the wheel well (refer to Figure 08–03–38).



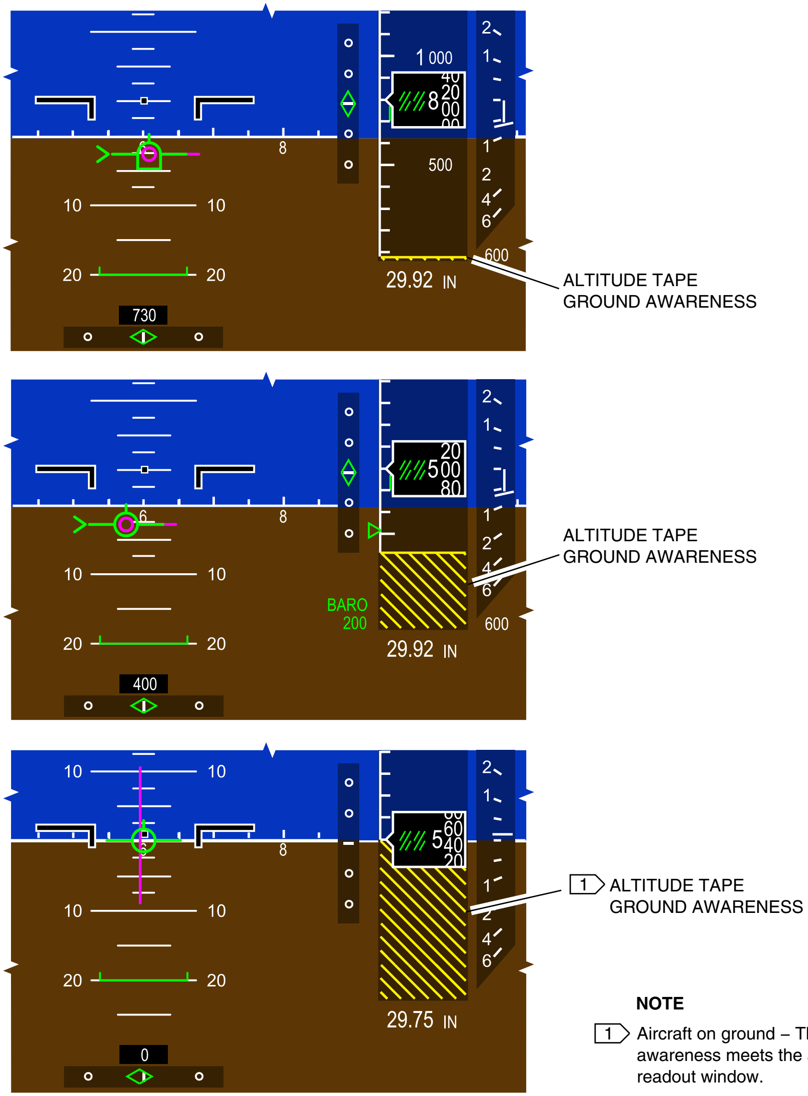
Radio altitude antennas
Figure 08–03–38

The Radio Altitude (RA) shows in the center of the PFD, below the ADI, as a digital readout from 0 to 2500 feet (refer to Figure 08–03–39). When in view, it is displayed in 50-foot increments between 1500 and 2500 feet, 10-foot increments between 200 and 1500 feet, and 5-foot increments between −20 and 200 feet. An optional “TWENTY FIVE HUNDRED” aural message sounds when 2500 is displayed.

ADI

ADI – Radio altitude display
Figure 08–03–39

A ground altitude awareness indication represents the ground on the altitude tape. It shows as an amber shaded area at the bottom of the altitude tape (refer to Figure 08–03–40). The ground altitude awareness starts to display when the RA is at 750 feet, and rises as the RA decreases. When the aircraft is on ground, the low altitude awareness meets the altitude window.



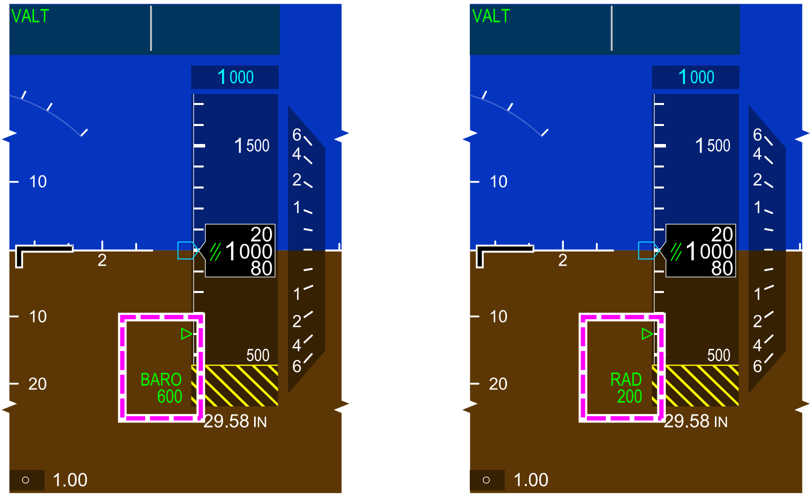
NOTE

1 Aircraft on ground – The ground awareness meets the altitude readout window.

ADI – Altitude indication – Ground awareness indications
Figure 08–03–40

E. Minimum setting

Barometric minimum altitude shows as a green BARO legend and digits beside the bottom left side of the altitude tape. Minimum height above ground (based on radar altitude) shows as a green RAD legend and digits at the same location. A green unfilled triangle displays on the altitude tape. Refer to Figure 08–03–41.



BAROMETRIC MINIMUM

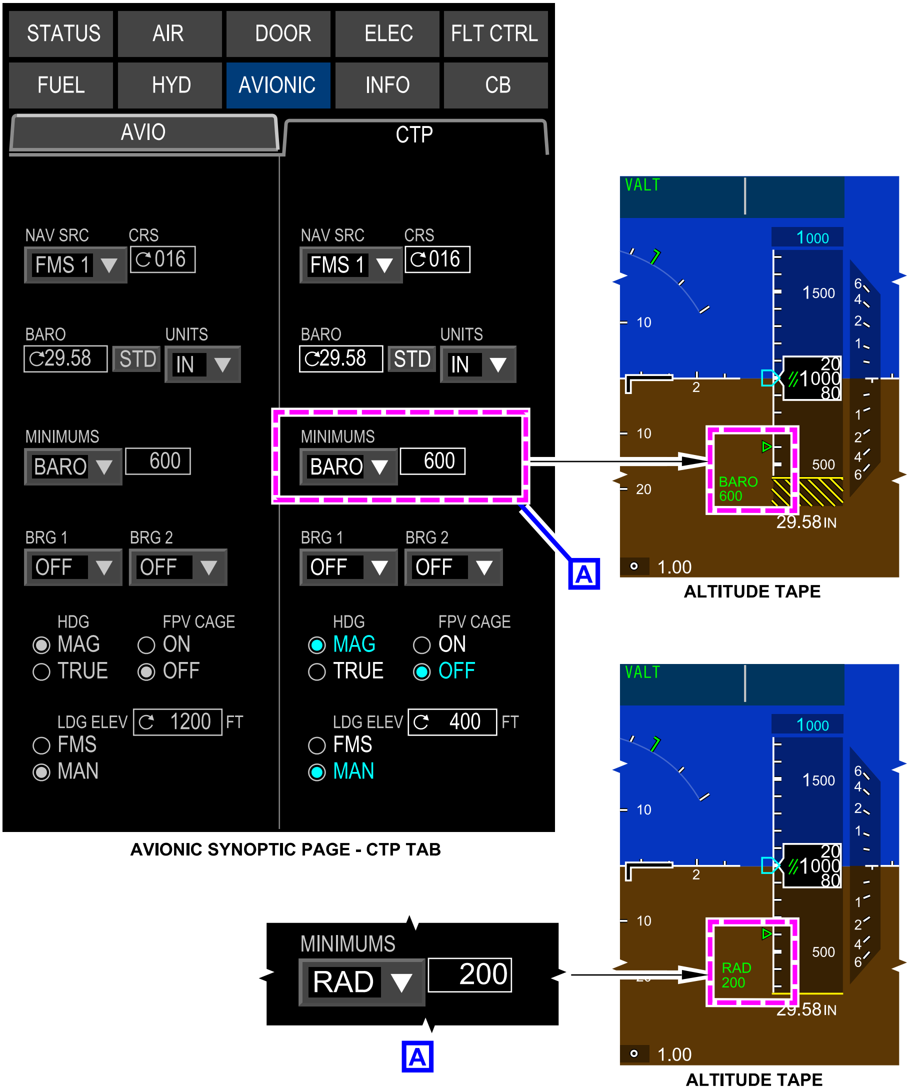
RADAR ALTIMETER MINIMUM

ALTITUDE TAPES

ADI – Altitude indications – BARO RAD minimums
Figure 08–03–41

The minimums are set using the CTP or the AVIONIC synoptic page.

On the CTP, when the PFD/NAV page is displayed, BARO, RAD or OFF is selected by pressing the associated LSK. The minimum value for BARO or RAD is set using the TUNE/DATA switch. When the AVIONIC synoptic page is displayed on a MFW, the BARO or RAD MINIMUM can also be selected and set using the cursor. Refer to Figure 08–03–42.



ADI – Altitude indications – Minimum setting MFW
Figure 08–03–42

When the aircraft reaches the minimum altitude, a large amber MIN is displayed below the BARO or RAD value, a "MINIMUM" aural message sounds, and the unfilled green triangle becomes amber. Both flash for 5 seconds and then become steady, and are removed from the PFD at touchdown.

F. Altitude miscompare/fail message

An ALT miscompare message (black text on amber background) is displayed when the current altitude difference between any PFD exceeds the altitude comparator limit. The altitude comparator limit decreases as a function of decreasing altitude when the current altitude is less than 29000 feet or more than 41000 feet.

The altitude comparator limit equals 200 feet when the current altitude is between 29000 feet and 41000 feet.

The altitude comparator limit is 75 feet when the Required Navigation Performance Authorization Required (RNP AR) approach mode is active.

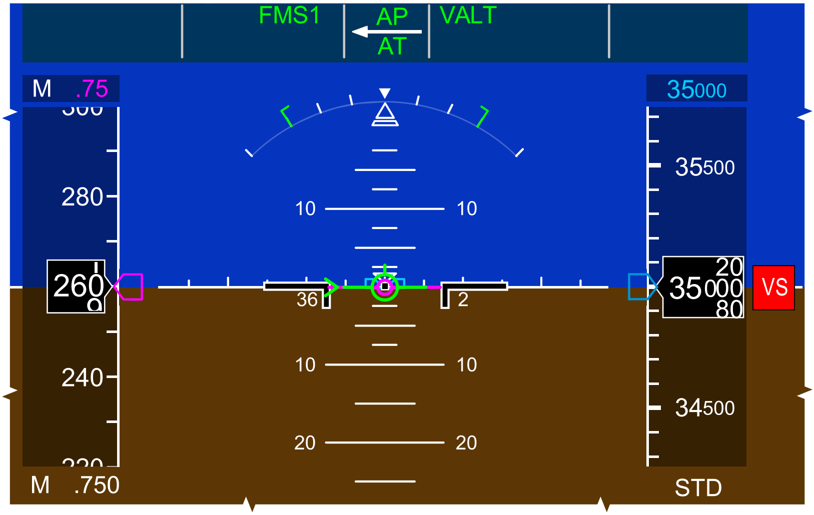
When ALT is displayed on the PFD, the caution message **EFIS MISCOMPARE** is displayed on the EICAS page. Refer to Figure 08–03–43.

ADI

EICAS CAUTION MESSAGE

ADI – Altitude miscompare indication
Figure 08–03–43

If Altitude or Vertical Speed data is invalid or failed, an ALT or VS fail message (white text on red background) is displayed (refer to Figure 08–03–44). The numbers are removed from the altitude and vertical speed tape.



ADI

ADI – Vertical speed fail indication
Figure 08–03–44

If the radio altitude indicated on each PFD is different (a miscompare), the readout is replaced by a RAD caution message (black text on amber background) (refer to Figure 08–03–45). When RAD is posted on the PFD, the caution message **EFIS MISCOMPARE** is displayed on the EICAS page.

ADI

EFIS MISCOMPARE

EICAS CAUTION MESSAGE

ADI – Radio altitude miscompare indications
Figure 08–03–45

If the radio altitude is not available, the readout is replaced by a RAD fail message (white text on red background), (refer to Figure 08–03–46).

NOTE

The allowable difference between PFDs increases with increasing altitude.

ADI

ADI – Radio altitude fail indication
Figure 08–03–46

G. Altitude aural alert

Aural alerts sound to increase crew awareness during aircraft altitude changes.

Refer to the table that follows for the altitude aural alerts:

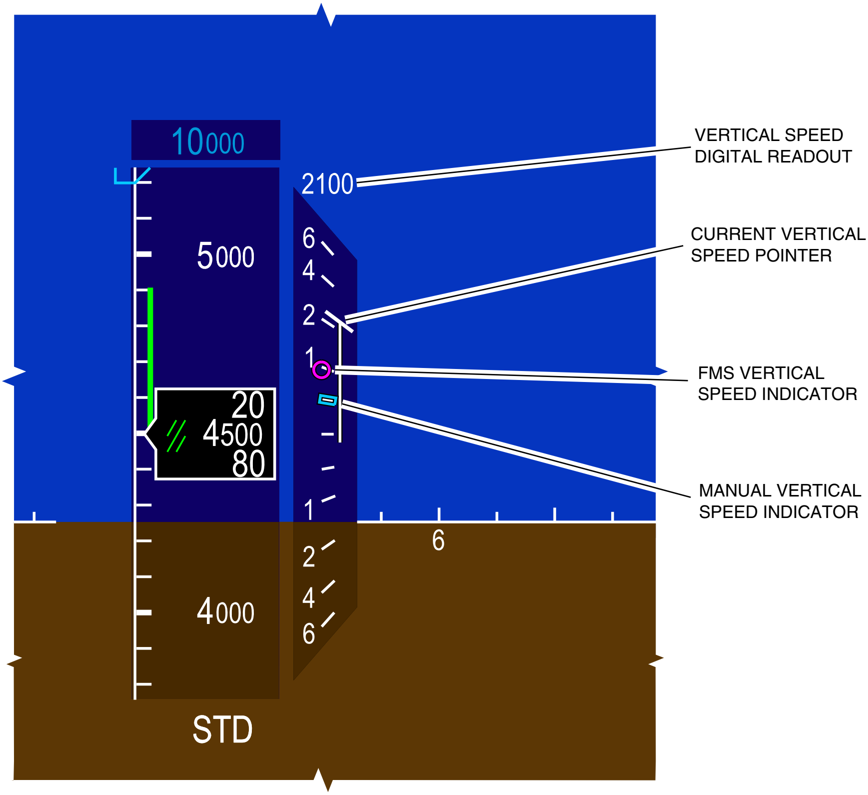
ALTITUDE AURAL ALERT	STANDARD	OPTIONAL
“RADIO ALTIMETER”		X

ALTITUDE AURAL ALERT	STANDARD	OPTIONAL
“DECISION HEIGHT”	X	
“DECIDE”		X
“MINIMUM”	X	
“MINIMUMS”		X
“MINIMUMS, MINIMUMS”		X
“2500”		X
“1000”	X	
“500”		X
“400”		X
“300”		X
“200”		X
“100”		X
“80”		X
“60”		X
“50”	X	
“40”		X
“35”		X
“30”		X
“20”		X
“10”	X	
“5”		X
“APPROACHING DECISION HEIGHT”		X
“APPROACHING MINIMUMS”		X
“PLUS HUNDRED”		X

ALTITUDE AURAL ALERT	STANDARD	OPTIONAL
"50 ABOVE"		X

H. Vertical speed indicator

A vertical speed indicator is located to the right of the altitude tape. A white pointer and a vertical line indicate the vertical speed scale (refer to Figure 08–03–47).



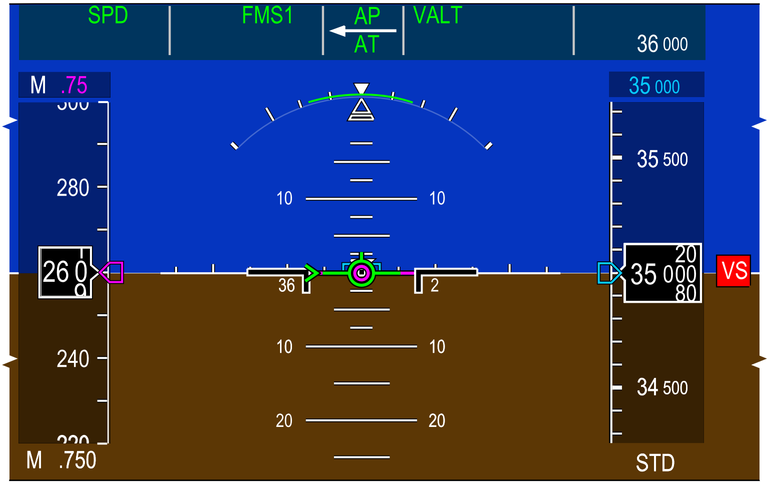
ADI – Altitude indications – Vertical speed indicator
Figure 08–03–47

A digital readout of the scale is displayed at the top (climb) or bottom (descent) of the vertical speed indicator when vertical speed is greater than 300 feet per minute. It stays in view until VS is less than 100 feet per minute.

A cyan unfilled box is displayed to indicate a manually-selected vertical speed. A magenta circle indicates the FMS selected vertical speed.

(1) Vertical speed fail

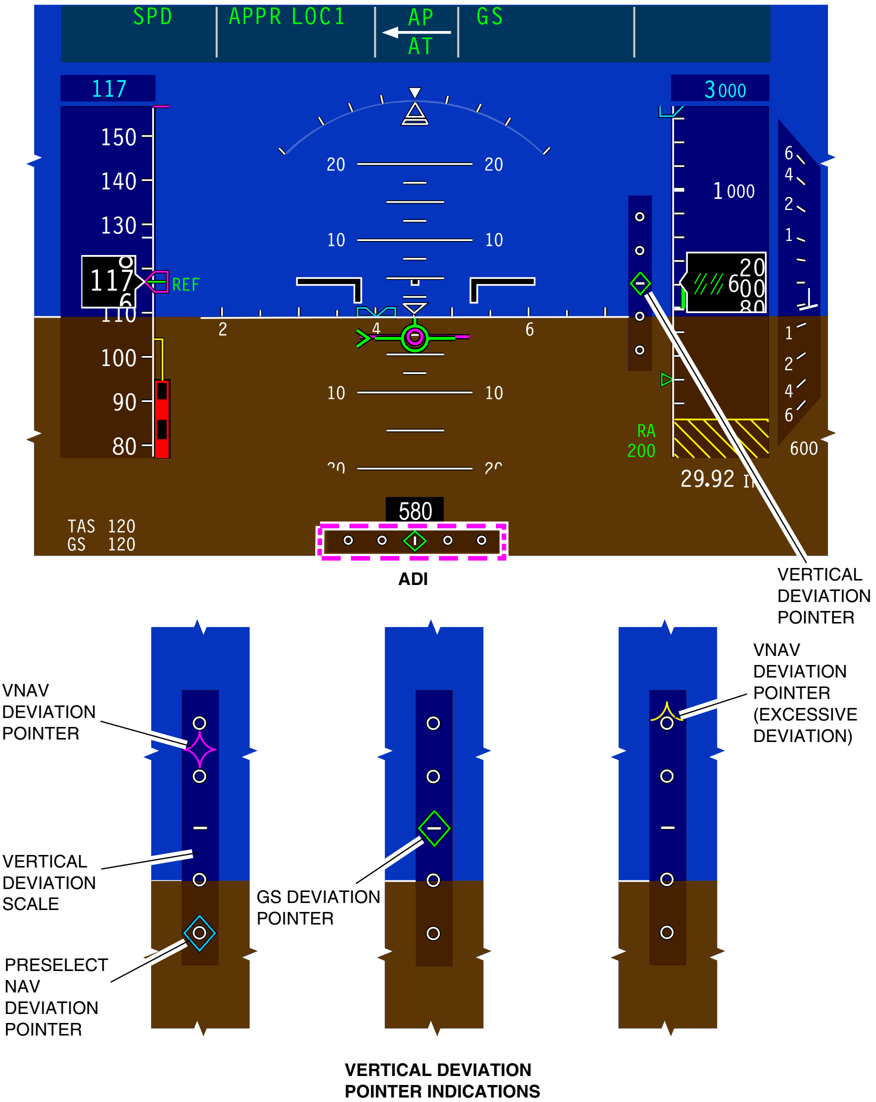
If the vertical speed data is invalid or failed, a red VS failed flag is displayed and the vertical speed tape is removed (refer to Figure 08–03–48).



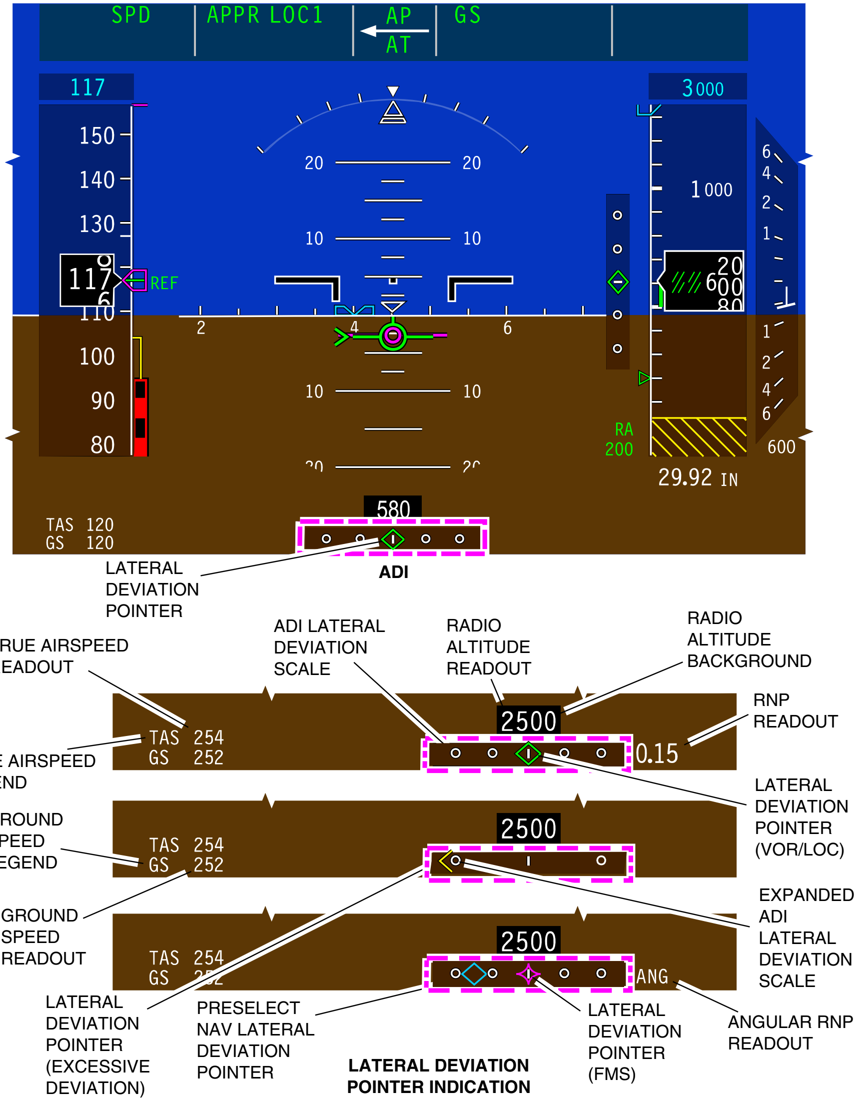
ADI – Vertical speed fail indication
Figure 08–03–48

VERTICAL AND LATERAL DEVIATION INDICATIONS

The vertical and horizontal path deviation scales are located on the ADI section of the PFD. The vertical deviation scale is located between the attitude section and the altitude tape (refer to Figure 08–03–49). The lateral deviation scale is centered below the attitude section (refer to Figure 08–03–50).



ADI – Vertical deviation indicator legend
Figure 08–03–49



ADI – Lateral deviation indicator legend
Figure 08–03–50

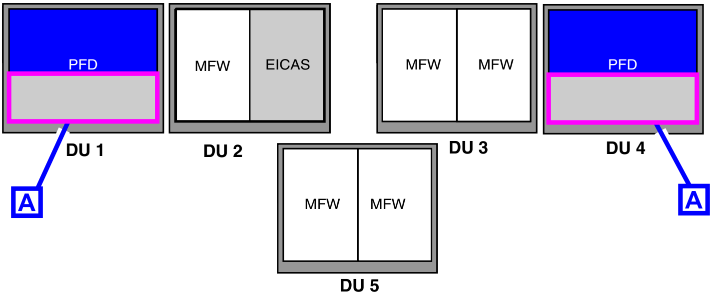
The deviation indicators are color coded:

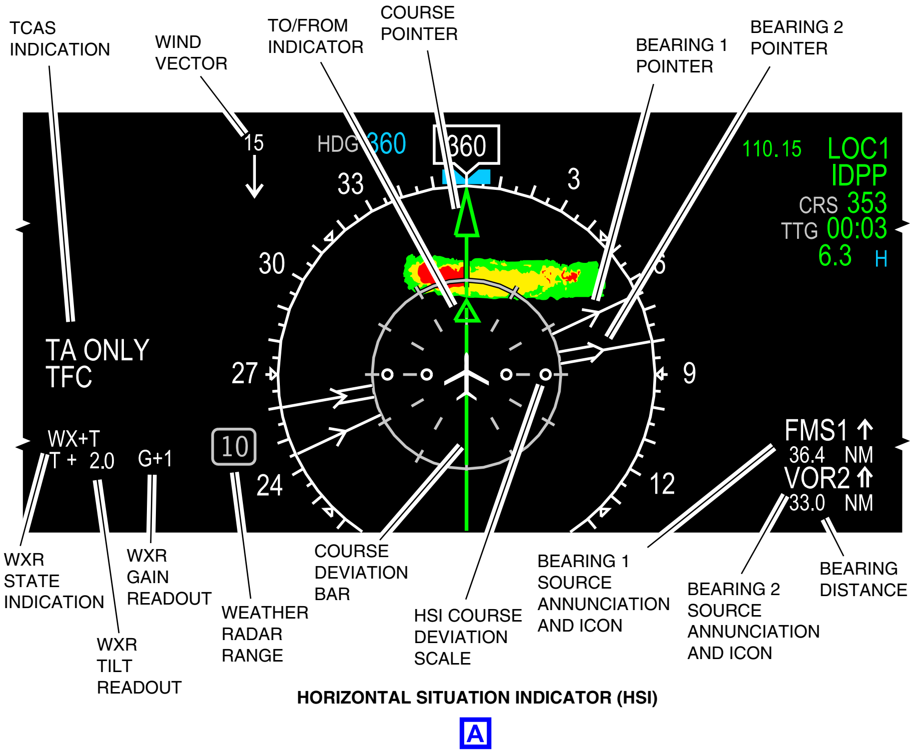
- Magenta for the FMS,
- Green for the ILS and VOR,
- Cyan for the preview mode, and
- Amber for excessive deviation.

HORIZONTAL SITUATION INDICATOR (HSI)

A. HSI information

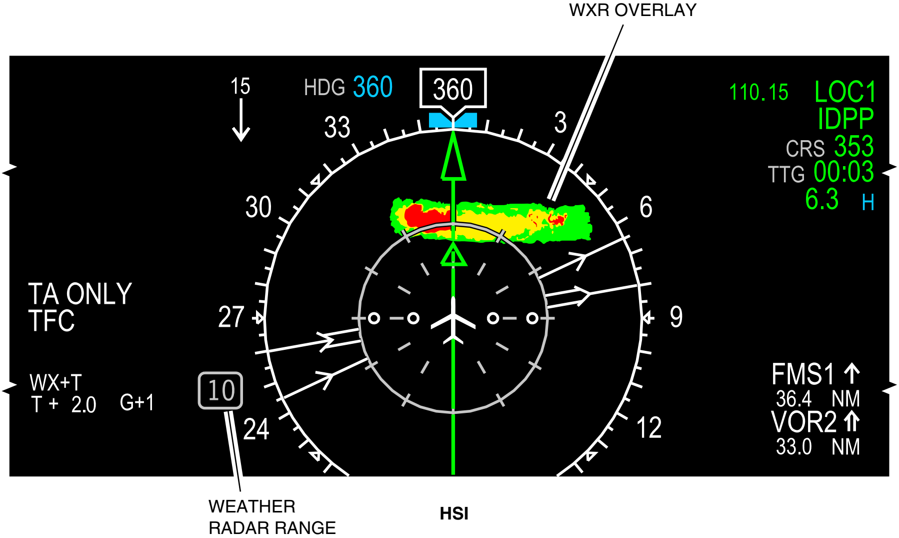
The lower section of the PFD (black background) shows a traditional Horizontal Situation Indicator (HSI) with compass, and bearing and course pointers. Weather map and traffic targets can be overlaid on the HSI. Traffic Alert and Collision Avoidance System (TCAS) and Weather Radar (WXR) settings are displayed on the left side of the HSI, and navigation data on the right side (refer to Figure 08–03–51).





PFD – Horizontal Situation Indicator (HSI)
Figure 08–03–51

TCAS alerts, weather radar, and terrain overlays are displayed only when conditions necessitate immediate attention (auto pop-up (refer to Figure 08–03–52).



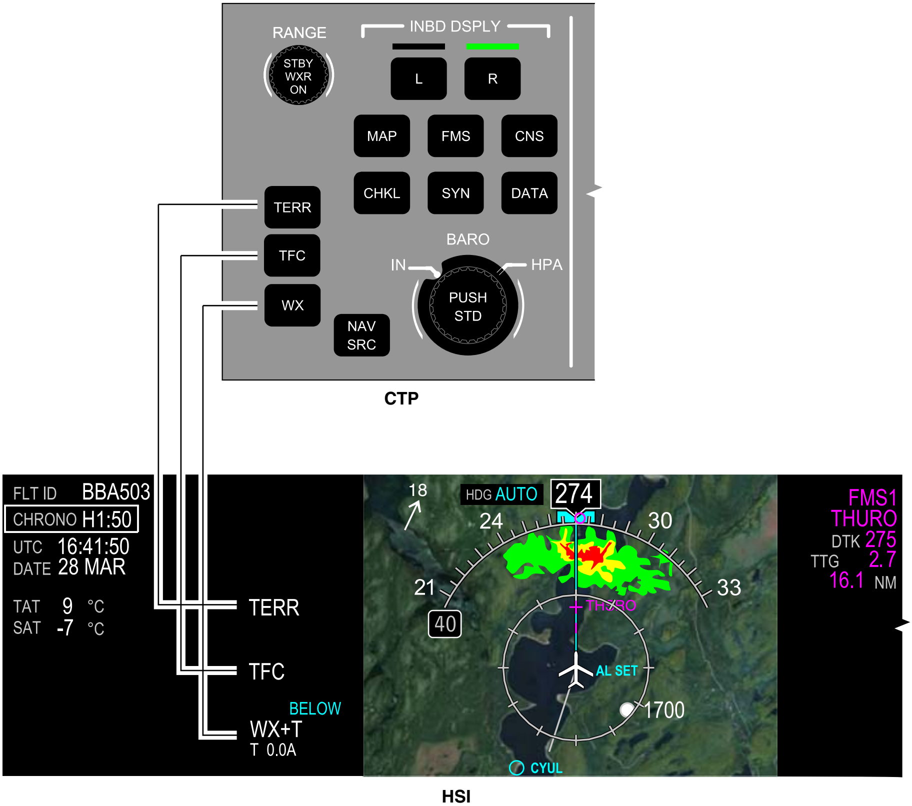
PFD – HSI overlay
Figure 08–03–52

If there is a DU failure where the map cannot be shown on the onside DU, the HSI can:

- Show FMS flight plan waypoints and route, and
- Show compass arc instead of compass rose (circle).

The necessary overlay can be selected with the CTP overlay switches (refer to Figure 08–03–53), or from the drop-down menus on the MFWs. The display options are:

- TERR to show terrain,
- TFC to show traffic targets (TCAS), and
- WX to show weather radar.

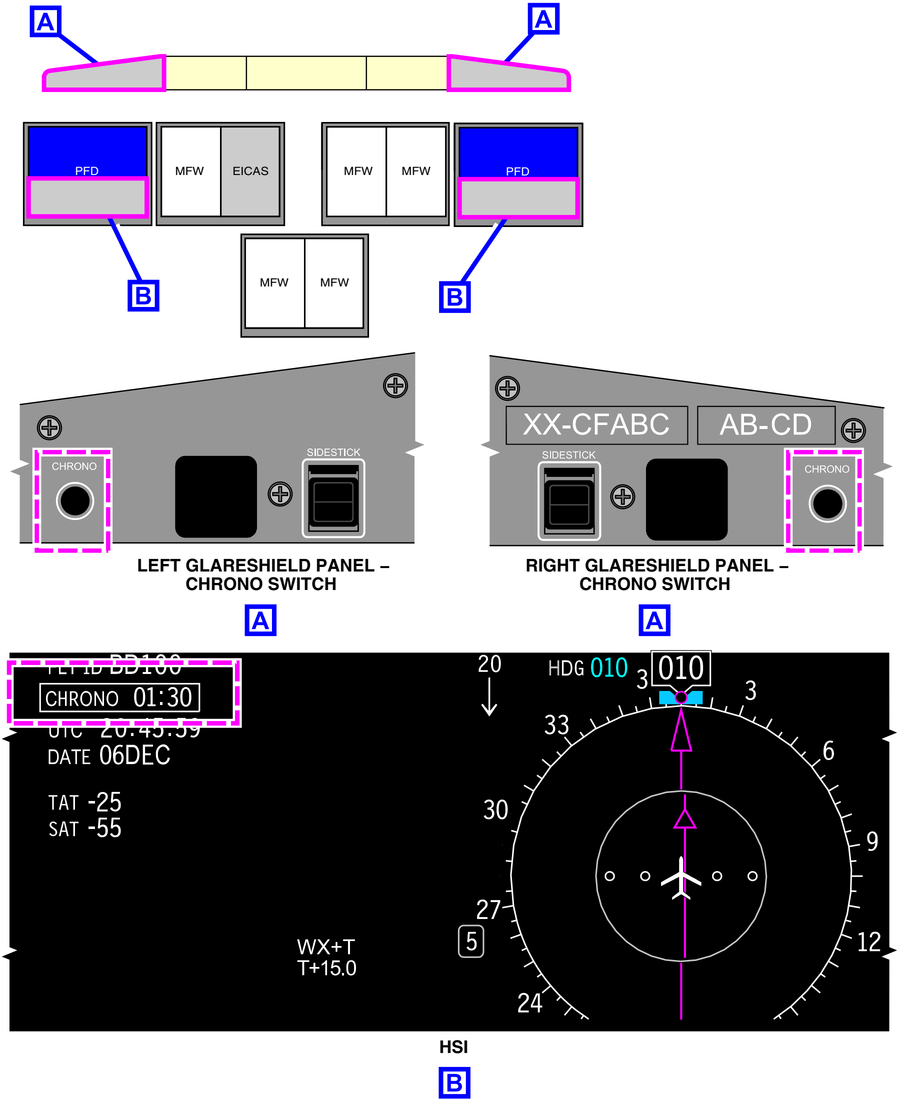


PFD – HSI mini map
Figure 08–03–53

The map range shows near the left end of the compass arc. The RANGE switch on the CTP is used to select the desired map range.

B. Chronometers

There is a chronometer available on each PFD. The chronometers are activated with the CHRONO switch on the glareshield panel. They are displayed in the secondary flight data section of the HSI (refer to Figure 08–03–54).



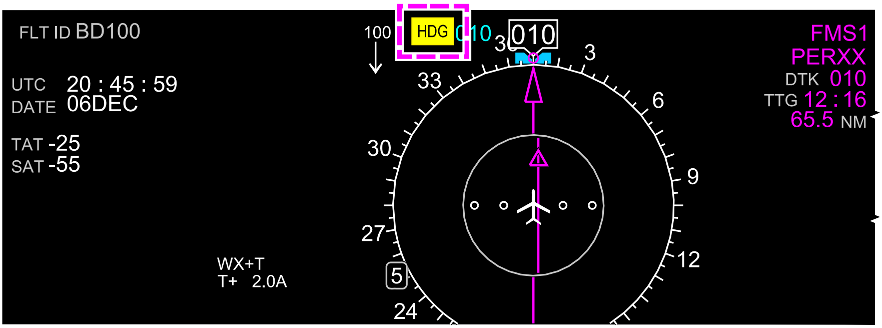
Chronometer controls
Figure 08–03–54

The CHRONO switch controls the chronometer as follows:

- First push displays and starts the chronometer,
- Second push stops the chronometer, and
- Third push resets and hides the chronometer.

C. HDG miscompare/fail indications

A HDG miscompare message (black text on amber background) is displayed when there is a difference of more than 6 degrees between the heading indicated on each PFD. Refer to Figure 08–03–55.

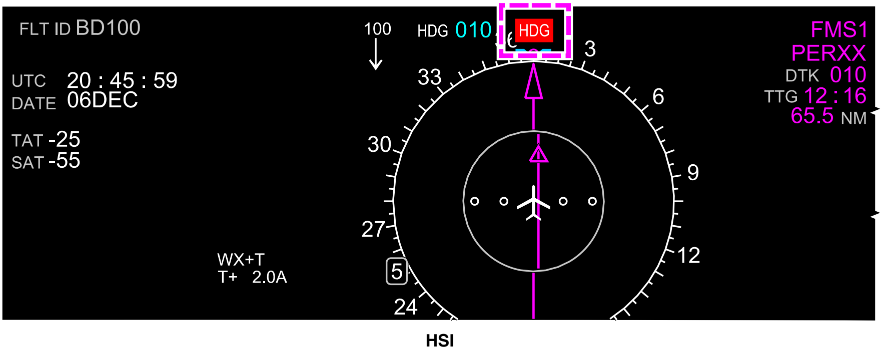


HSI

EICAS CAUTION MESSAGE

HSI – HDG miscompare indications
Figure 08–03–55

If there is invalid heading data, the HDG fail message (white text on red background) is displayed and the compass heading, numbers on the horizontal line, and digital readout are removed (refer to Figure 08–03–56).

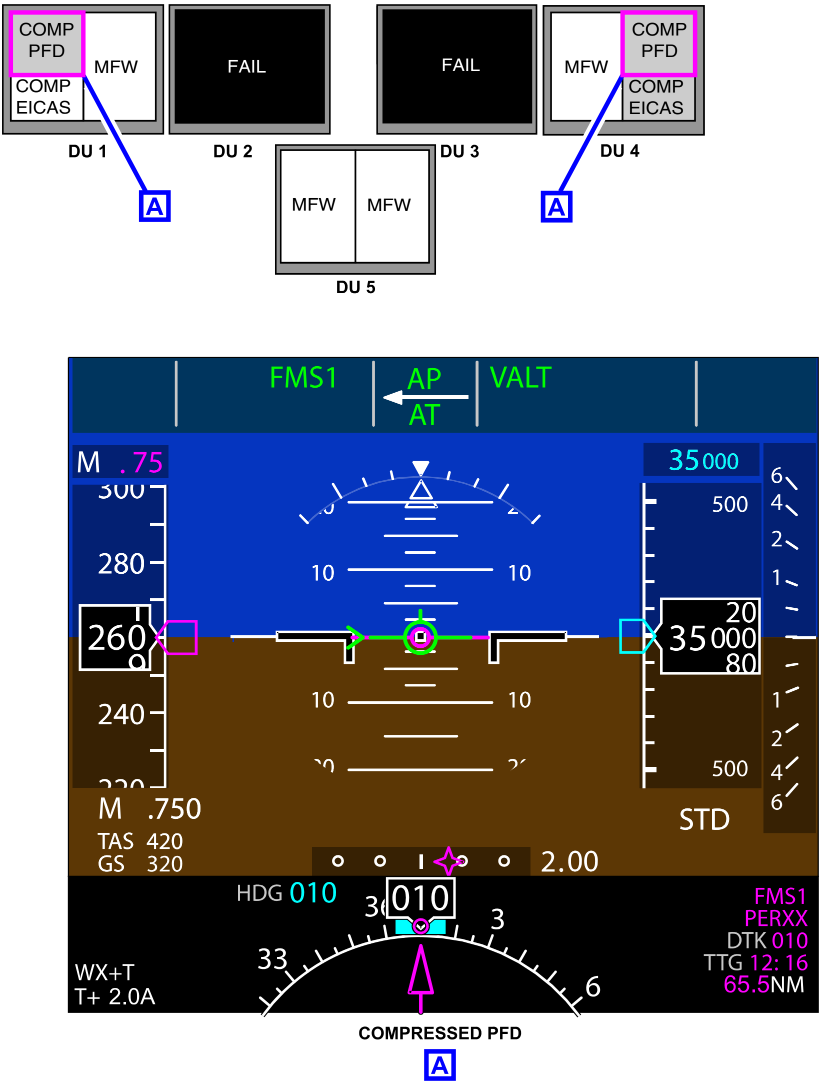


HSI – HDG fail indication
Figure 08–03–56

COMPRESSED PRIMARY FLIGHT DISPLAY (PFD)

The compressed PFD occupies a quarter of the total DU surface (refer to Figure 08–03–57). It is automatically displayed when two DUs on the same side or a total of three or more DUs have failed. When the automatic display reversion function has been triggered by opposite side DU failures, the compressed PFD can be manually displayed when the DISPLAY reversion switch is selected to REV. This will give access to additional MFWs.

The field of view and the lateral and vertical scaling of the ADI are the same, except that the elements are smaller to fit the size of the window. The HSI displays a compass arc with partial bearing needles.



Compressed PFD
Figure 08–03–57

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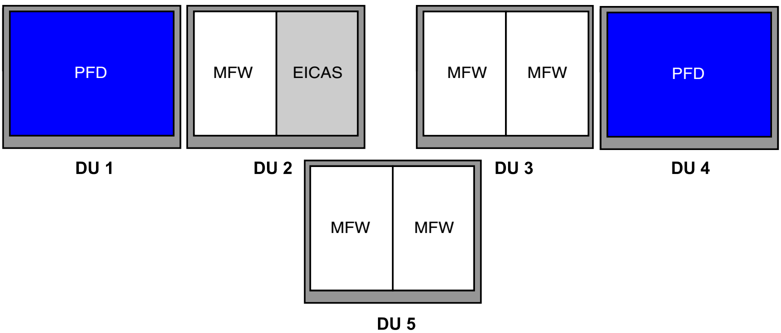
MULTIFUNCTION WINDOW (MFW) - OVERVIEW

Multifunction Windows (MFWs) show navigation, communication, flight planning, electronic checklist, and system data.

Each MFW is independent and can show any selected item from the MFW top menu, the Control Tuning Panel (CTP), or the Multifunction Keyboard Panel (MKP) menu switches.

The MFW occupies half of the Display Unit (DU) surface, so two MFWs can show on one DU. The MFW can occupy the full DU surface when it shows charts, maps or documents (refer to Figure 08–04–1).

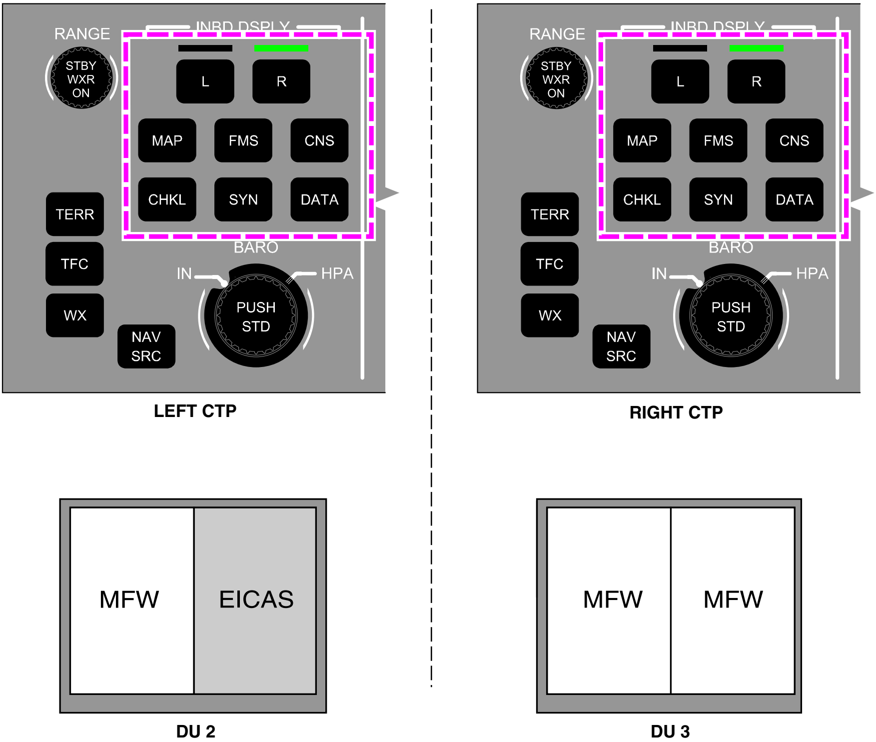


Multifunction Window (MFW) display
Figure 08–04–1

Depending on its location, the content of the MFW is controlled using the:

- Control Tuning Panel (CTP),
- Multifunction Keyboard Panel (MKP), and
- Cursor Control Panel (CCP).

The L and R switches on the left CTP select the left and right MFW on DU 2. The L and R switches on the right CTP select the left and right MFW on DU 3 (refer to Figure 08–04–2).



Control of MFWs from CTP
Figure 08–04–2

When an MFW is selected, a bar above the switch is illuminated green and the content of the MFW is selected when one of the Quick Access Keys (QAKs) is pushed:

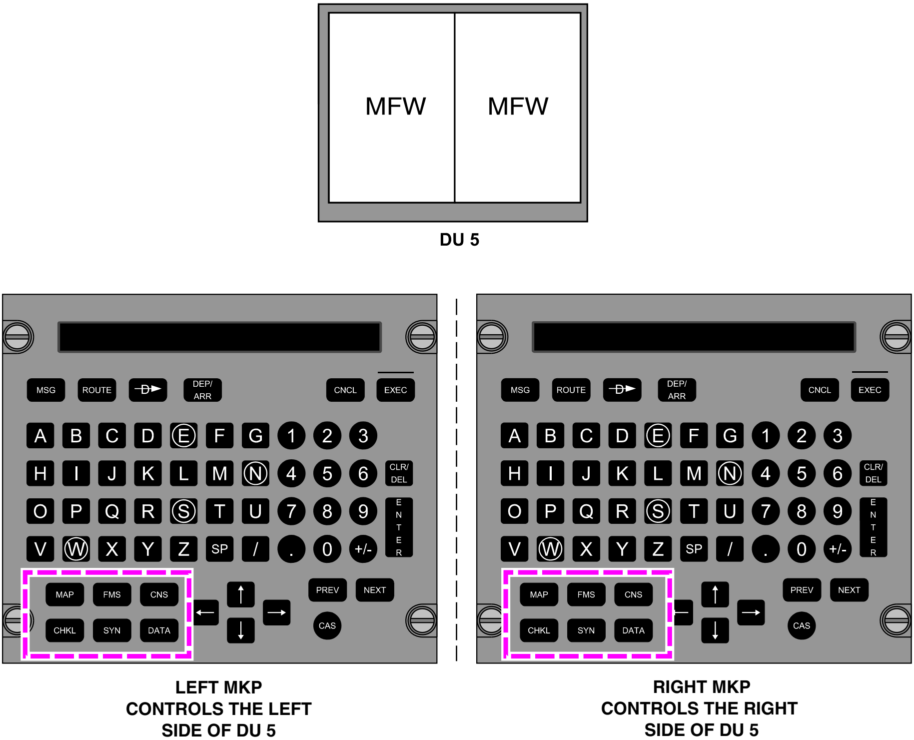
- MAP to show a map or a plan,
- FMS to show the FMS,

- CNS to show the communication/navigation page,
- CHKL to show the electronic checklist,
- SYN to show the synoptic pages, and
- DATA to show charts, video, documents, and database information.

NOTE

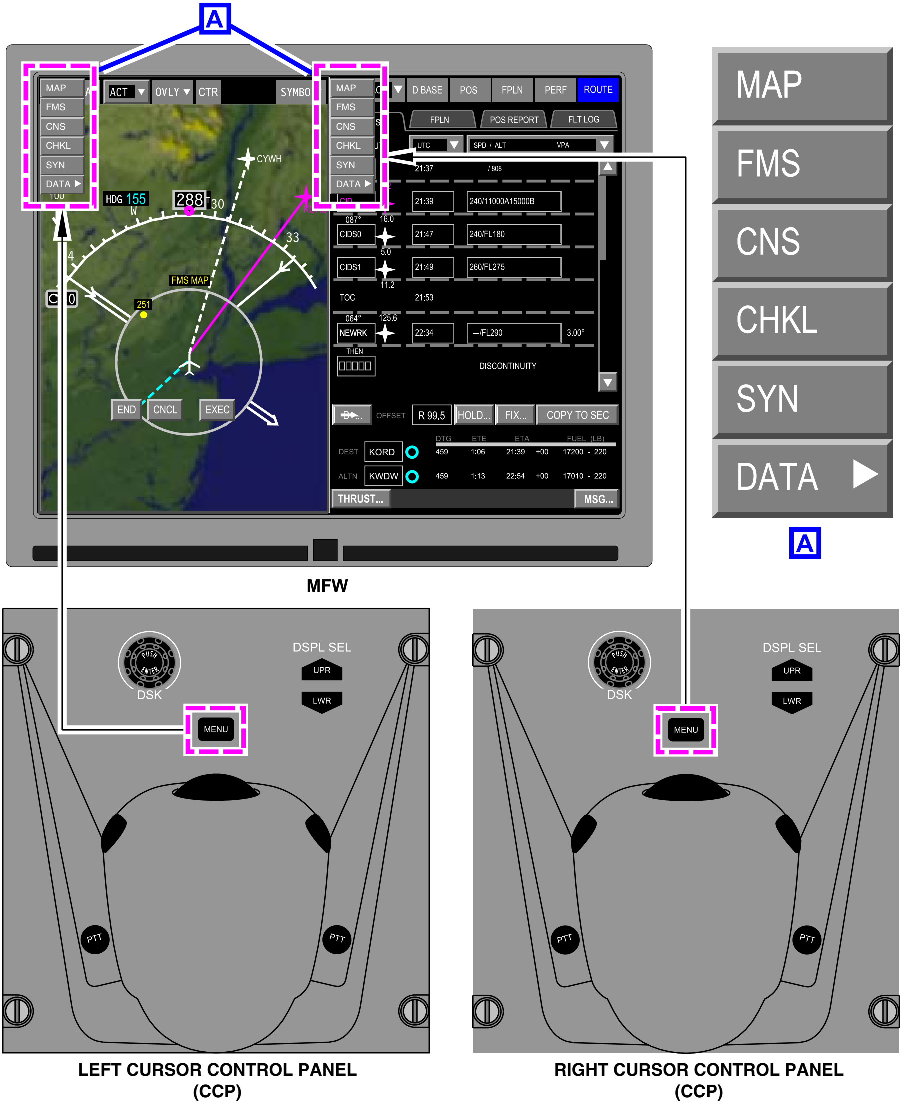
When the EICAS page shows on DU 2, the R switch on the left CTP is disabled. When the EICAS page shows on DU 3, the L switch on the right CTP is disabled.

The content of the MFW on DU 5 is controlled by the MKP. The left MKP controls the left MFW, and the right MKP controls the right MFW (refer to Figure 08–04–3). Each MKP has QAKs (same as the CTPs).



Control of MFWs from the MKP
Figure 08–04–3

The CCPs control the content of the MFW using the cursors. Pushing the MENU switch on the CCP shows a menu on the upper left corner of the MFW. The menu items are the same as the QAKs on the CTPs and the MKPs (refer to Figure 08–04–4).



Control of MFWs from the CCP
Figure 08–04–4

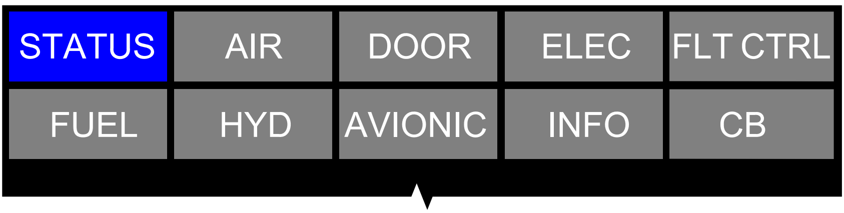
An arrow after a menu item indicates that there is a sub-menu when the item is selected.

MFW – SYNOPTIC PAGES

A. Synoptic pages – Overview

The synoptic pages include (refer to Figure 08–04–5):

- The STATUS page,
- The system synoptic pages:
  - AIR
  - DOOR
  - ELEC (Electrical)
  - FLT CTRL (Flight Control)
  - FUEL
  - HYD (Hydraulic)
  - AVIONIC
- The INFO page (Info Messages), and
- The CB page (Circuit Breakers).



Synoptic pages – Header
Figure 08–04–5

Synoptic pages are selectable on any MFW. The selected synoptic page will stay in view until another page or MFW window option is selected.

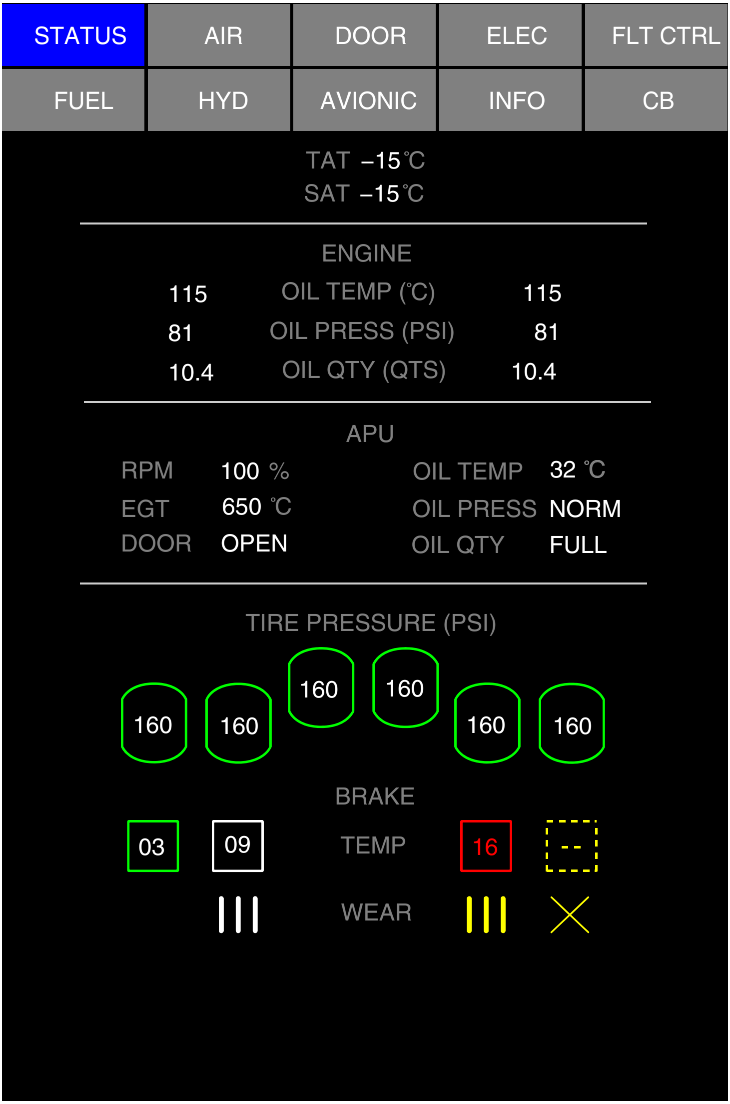
The synoptic pages include digital readouts, colored flow lines, component outlines, and system messages. Specific colors are used to depict normal, precautionary, and maximum or minimum system limits.

Color	Usage
Red	• Features/components exceeding limits to a warning level (overheat, overspeed, etc.). • Outlines, digital readouts, and analog pointers outside of the safe/normal range in a warning level or associated with a warning failure condition. • Icons related to an emergency system status, e.g. RUDDER FAIL.
Amber	• Flow lines where flow is not working properly at a caution level. • Features/components/surfaces (such as pump, valves etc.) failed, not operating, not generating normal flow when it should be, or exceeding limits to a caution level. • Outlines, digital readouts, and analog pointers outside of safe/normal range or associated with a caution failure condition. • Icons related to a caution system status (e.g. RUDDER DEGRADED).
Dashed amber	Status unknown or invalid for digital readouts or component outlines (valves, pumps, filters, etc.).
Amber X	Status unknown for system indications, scales, surfaces, etc.
Cyan	• Pilot-selected value only (e.g. Temperature). • Communication/Cabin flags that indicate a normal advisory request.

Color	Usage
White	• Features/components selected to OFF or closed. • Flow lines that have no flow. • Outlines and analog pointers not within normal range (but with no hazard/failures associated), non-operating state. • Digital readouts within safe/normal range. • Icons related to system status OFF. • Fixed features such as outlines, legends, and analog scales.
Green	• Flow lines that have normal flow (such as sufficient heat condition, etc.) If a component is failed ON, flow should stay depicted as normal. • Outlines and analog pointers within safe/normal range.
Gray	• Legend, units, static aircraft outlines, engine outlines and APU outlines. • Static data box outlines and text. • Gradient shading. • Engine/APU running.

B. STATUS page

The STATUS page (refer to Figure 08–04–6) can be selected with the STATUS tile on the synoptic page menu. When it is selected, it will be displayed on the selected MFW.



STATUS synoptic page
Figure 08–04–6

The STATUS page includes the indications and parameters that follow:

- Temperature (refer to Figure 08–04–7):
  - Static Air Temperature (SAT) , and
  - Total Air Temperature (TAT),
- Engine oil indications (refer to Figure 08–04–8):
  - Oil Temperature (OIL TEMP, in °C),
  - Oil Pressure (OIL PRESS, in PSI), and
  - Oil Quantity (OIL QTY, in QTS),
- APU indications (refer to Figure 08–04–9, and Figure 08–04–10):
  - APU speed (RPM, in %),
  - Exhaust Gas Temperature (EGT, in °C),
  - APU door position (DOOR), and
  - APU Oil Indications (OIL TEMP, OIL PRESS and OIL QTY),
- Tire Pressure indication (TIRE PRESSURE, in PSI),
- Brake Temperature (BRAKE – TEMP), and
- Brake Wear (BRAKE – WEAR).

Values for brake temperature are not the actual brake temperature. They are units converted into a specific scale value where 30 °C equals one unit. The units are indicated from 0 to 20, with the outline color changing from green, to white, to red, as shown in Figure 08–04–11.

STATIC AIR TEMPERATURE (SAT in grey)

Symbol	Color	Description
-15	WHITE	Normal condition
---	YELLOW	Temperature invalid

TOTAL AIR TEMPERATURE (TAT in grey)

Symbol	Color	Description
-15	WHITE	Normal condition
---	YELLOW	Temperature invalid

STATUS synoptic page – Temperature legend
Figure 08–04–7

OIL TEMPERATURE (OIL TEMP in grey)

Symbol	Color	Description
XX.X	WHITE	Oil temperature in normal range
XX.X	YELLOW	Oil temperature above high oil temperature yellow line threshold.
XX.X	RED	Oil temperature above high oil temperature red line threshold
XX.X	YELLOW	Oil temperature below oil temperature threshold
---	YELLOW DASHED	Invalid oil temperature

OIL PRESSURE (OIL PRESS in grey)

Symbol	Color	Description
XX.X	WHITE	Oil pressure in normal range
XX.X	YELLOW	Oil pressure above high threshold
XX.X	RED	Oil pressure below low threshold
---	YELLOW DASHED	Oil pressure invalid

OIL QUANTITY (OIL QTY in grey)

Symbol	Color	Description
XX.X	WHITE	Normal
XX.X	YELLOW	Below threshold
---	YELLOW DASHED	Invalid

EICAS page and STATUS synoptic page – Engine oil indication legend
Figure 08–04–8

APU RPM (RPM in grey)

Symbol	Color	Description
85	WHITE	APU operating at or below red line
107	RED	APU operating above red line (overspeed)
---	YELLOW	APU RPM value is invalid

APU EGT (EGT in grey)

Symbol	Color	Description
650	WHITE	APU operating at or below red line
820	RED	APU operating above red line (overtemperature)
---	YELLOW	APU EGT invalid

APU OIL TEMPERATURE (OIL TEMP in grey)

Symbol	Color	Description
32	WHITE	APU oil temperature in normal range
350	YELLOW	Oil temperature at or above high oil temperature yellow line threshold
---	YELLOW	Invalid oil temperature

STATUS synoptic page – APU indication legend (part 1)
Figure 08–04–9

APU OIL PRESSURE (OIL PRESS in grey)		
Symbol	**Color**	**Description**
NORM	WHITE	Oil pressure in normal range
LOW	YELLOW	Oil pressure below low oil pressure threshold
--	YELLOW	Oil pressure invalid

APU OIL QUANTITY (OIL QTY in grey)		
Symbol	**Color**	**Description**
FULL	WHITE	Oil quantity full
LOW	YELLOW	Oil quantity below low threshold
NORM	WHITE	Oil quantity in normal range
--	YELLOW	Oil quantity invalid

APU DOOR (DOOR in grey)		
Symbol	**Color**	**Description**
OPEN	WHITE	APU door open
CLOSED	WHITE	APU door closed
OPEN	YELLOW	APU door failed open
CLOSED	YELLOW	APU door failed closed
--	YELLOW	APU door position invalid

STATUS synoptic page – APU indication legend (part 2)
Figure 08–04–10

TIRE PRESSURE (TIRE PRESSURE in grey)

Symbol	Color	Condition on ground	Condition in flight
160	GREEN	Pressure ≥ Nominal	Pressure ≥ 90% nominal
150	WHITE	90% nominal ≤ Pressure < nominal	70% nominal ≤ Pressure < 90% nominal
110	YELLOW	Pressure < 90% nominal	Pressure < 70% nominal
- - -	YELLOW	No data	No data

BRAKE TEMPERATURE (TEMP in grey)

Symbol	Color	Condition
03	GREEN	Temperature in green range (00 ≤ TEMP ≤ 06)
09	WHITE	Temperature in white range (07 ≤ TEMP ≤ 14)
16	RED	Overheat - Temperature in red range (15 ≤ TEMP ≤ 20)
- -	YELLOW	Temperature invalid

BRAKE WEAR (WEAR in grey)

Symbol	Color	Condition
	BLACK	Brakes OK (no indication)
	WHITE	Brakes to be replaced in less than 100 flights
	YELLOW	Brakes to be replaced immediately
	YELLOW	Brake wear indication invalid

STATUS synoptic page – Landing gear legend
Figure 08–04–11

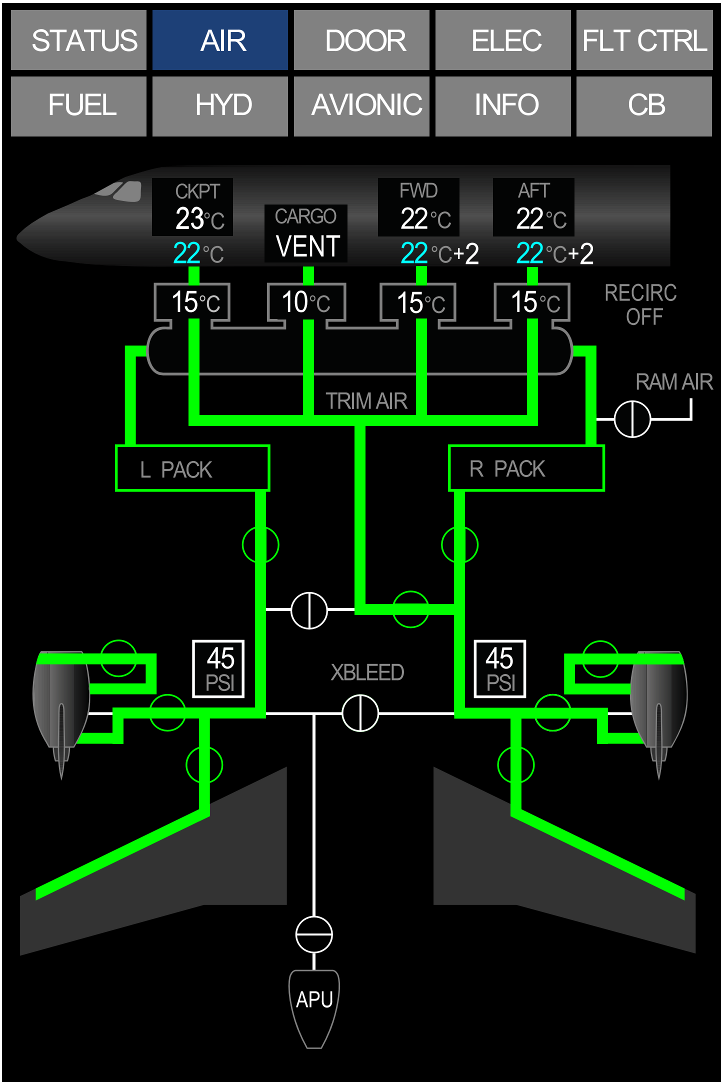
NOTE

In normal operation, BRAKE WEAR is not shown on the STATUS page (it appears only when brakes are degraded).

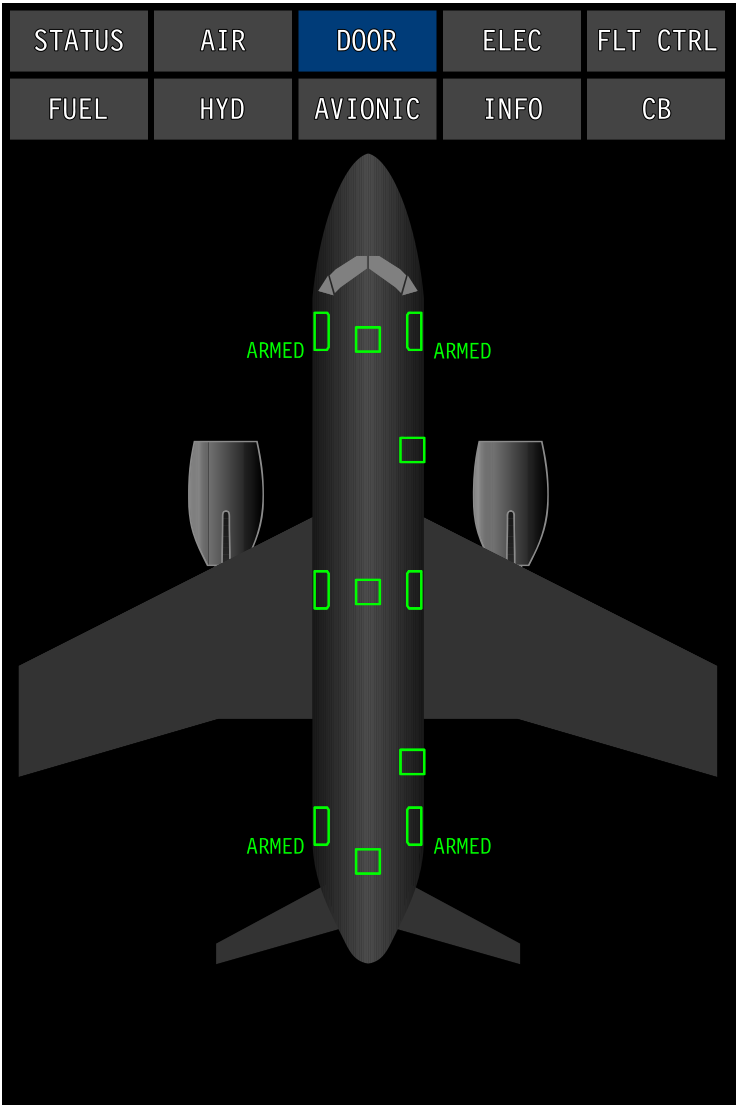
C. System synoptic pages

The synoptic pages that follow are linked to a system and detailed in their corresponding chapters:

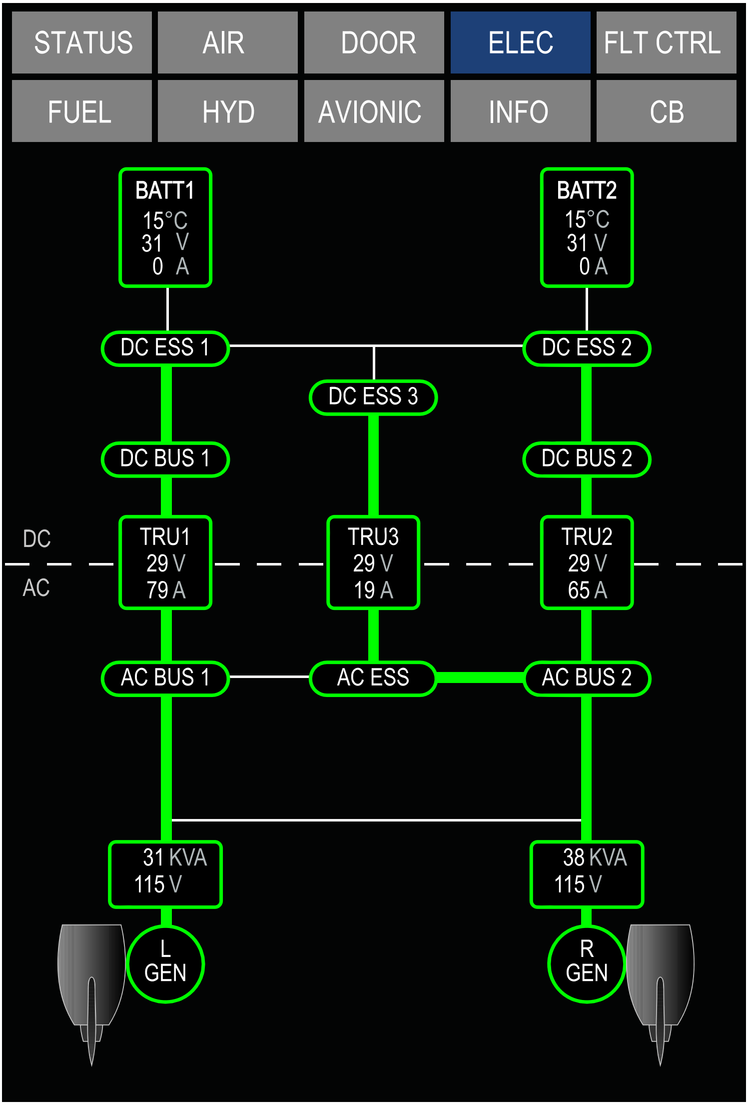
- AIR (refer to Figure 08–04–12). For detailed information, refer to Chapter 02 – Air-conditioning, bleed air and pressurization.
- DOOR (refer to Figure 08–04–13). For detailed information, refer to Chapter 06 – Doors.
- ELEC (refer to Figure 08–04–14). For detailed information, refer to Chapter 07 – Electrical.
- FLT CTL (refer to Figure 08–04–15). For detailed information, refer to Chapter 10 – Flight controls.
- FUEL (refer to Figure 08–04–16). For detailed information, refer to Chapter 11 – Fuel.
- HYD (refer to Figure 08–04–17). For detailed information, refer to Chapter 12 – Hydraulics.



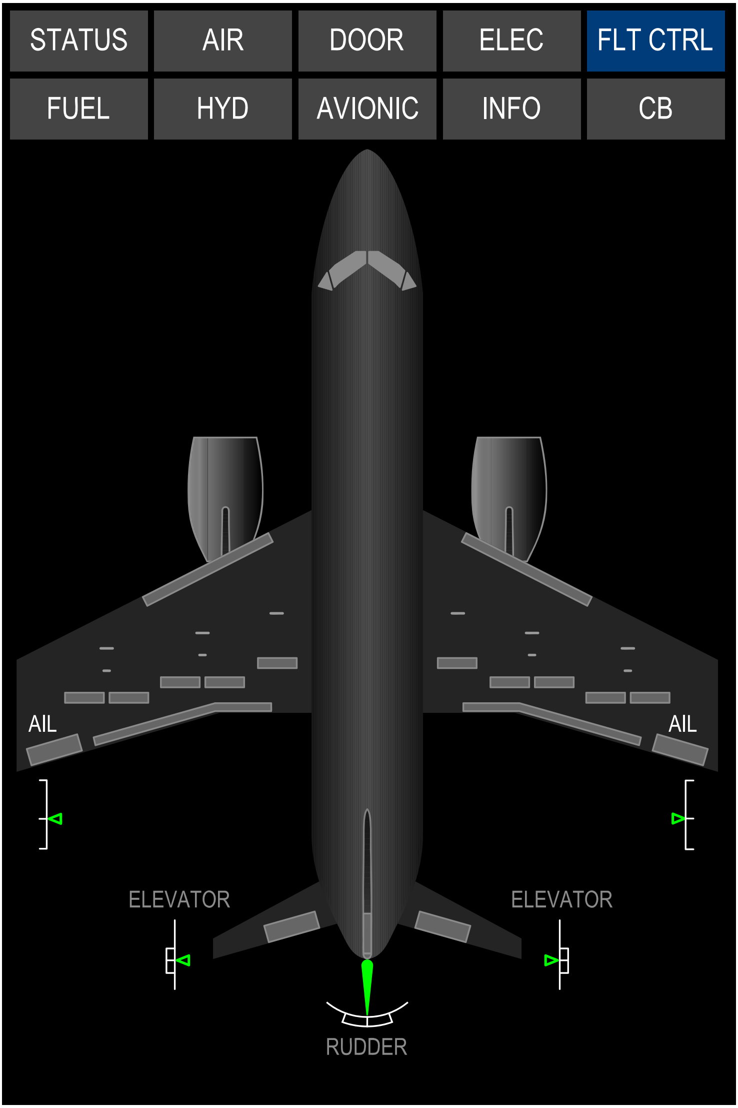
AIR synoptic page
Figure 08–04–12



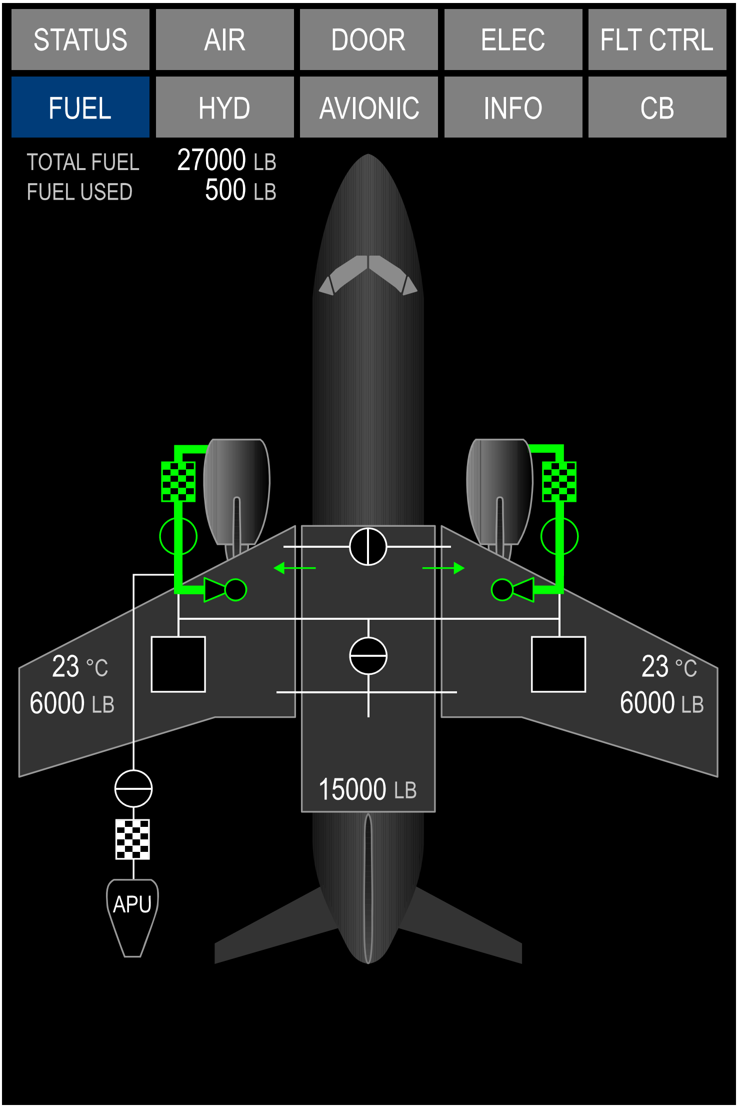
DOOR synoptic page
Figure 08–04–13



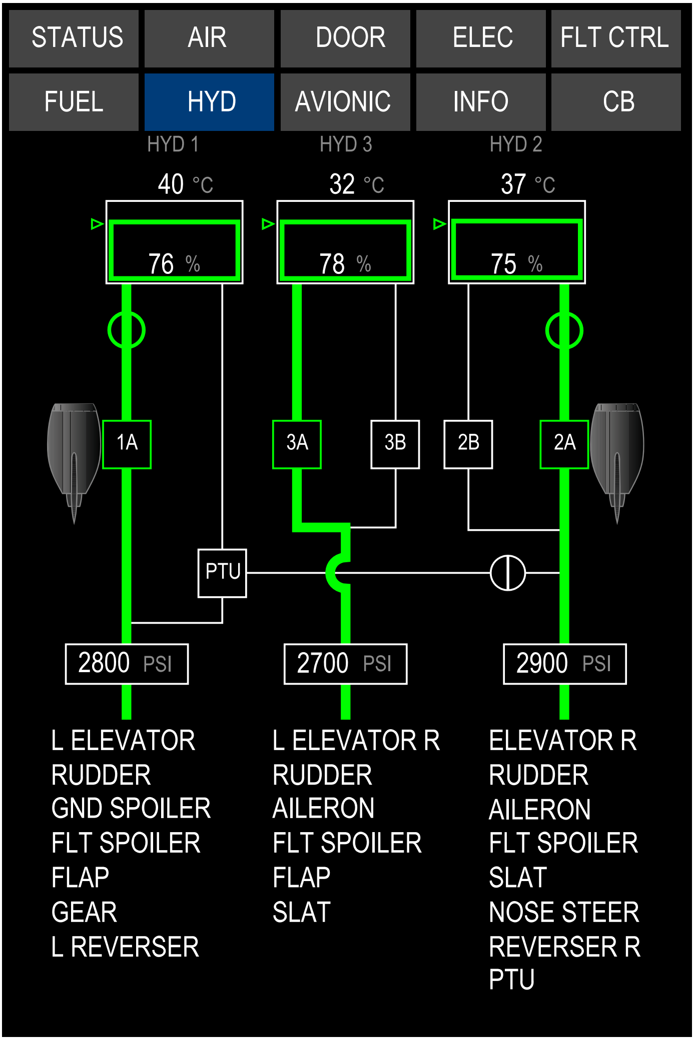
ELEC synoptic page
Figure 08–04–14



FLT CTRL synoptic page
Figure 08–04–15



FUEL synoptic page
Figure 08–04–16



HYD synoptic page
Figure 08–04–17

D. AVIONIC page

The AVIONIC page has two tabs: the avionic tab (AVIO) tab (refer to Figure 08–04–18) and the Control Tuning Panel (CTP) tab (refer to Figure 08–04–19).

(1) Avionic page (AVIO tab)

The AVIO tab has:

- Aural channel inhibit functions,
- VSPEEDS values, and
- Pilot initiated test commands.

The VSPEEDS symbology contains:

- V_1 – Takeoff decision speed,
- V_R – Rotation speed,
- V_2 – Takeoff safety speed,
- V_{FTO} – Final Takeoff speed,
- V_{REF} – Landing Reference speed, and
- V_{AC} – Approach Climb speed, also known as V_{2GA}.

The VSPEEDS appear only if both FMS are failed. In this particular failure case, speed values can be set manually.

The AVIO tab includes the test section with two categories of pilot-initiated tests:

- Self-running, and
- User-in-the-loop.

A test is considered to be self-running when, after the test is initiated, there are no more inputs required from the pilot and the test results are posted on the test page. If a self-running test requires more than 1 second to complete from test initiation to test result, a label IN PROG is displayed on the test page.

A test is considered to be user-in-the-loop when the test triggers events that require pilot monitoring.

Selection of the test switch with the CCP trackball initiates the test to verify the functionality of the system.

The status of the test is shown adjacent to corresponding test switch:

- PASS – Self-running test successfully completed,
- FAULT/FAIL – Self-running test failure (corresponding caution or advisory EICAS message appears on the EICAS page),
- DONE – Test sequence completed,
- PRESS TO STOP – Test has to be terminated by the user,
- IN PROG – Test in progress, and
- Amber dashes – Test is invalid (for self-running test).

The table that follows describes the test functions available from the AVIO tab.

Test	Category	Comments
AURAL	User-in-the-loop	The test will give the aural voice message “AURAL WARNING TEST 1” followed by the “AURAL WARNING TEST 2” voice message (for test of both channels).
LAMP	User-in-the-loop	This test will cause all the lamps in the flight compartments to come on, including the master WARNING/ CAUTION switch test. The duration of the test is approximately 20 seconds.
TAWS	Self-running	The duration of the test is approximately 2.5 minutes.
TCAS	Self-running	A successful test is indicated by a TCAS SYSTEM TEST OK aural alert.

Test	Category	Comments
WXR	Self-running	User has to terminate the test.
WING A/ICE	Self-running	Button grayed out after a test has been initiated and the result is valid.
ICE DETECT	Self-running	The duration of the test is approximately 10 seconds. **NOTE** The caution message **ICE** is displayed on the EICAS page during the test.
FIRE	User-in-the-loop	The test illuminates the FIREX lamps and lasts 4 seconds.
FLT CTRL	Self-running	The duration of the test is approximately 60 seconds.
SHAKER	User-in-the-loop	The duration of the test is approximately 6 seconds.

(2) AVIONIC synoptic page – CTP tab

The avionic CTP tab is a backup in case of CTP failure:

- Course (CRS),
- Navigation source (NAV SRC),
- Barometric value (BARO),
- Barometric units (UNITS),
- Heading selection (HDG),
- Magnetic HDG selection (MAG),
- True HDG selection (TRUE),
- Bearing pointers (BRG 1 and BRG 2),

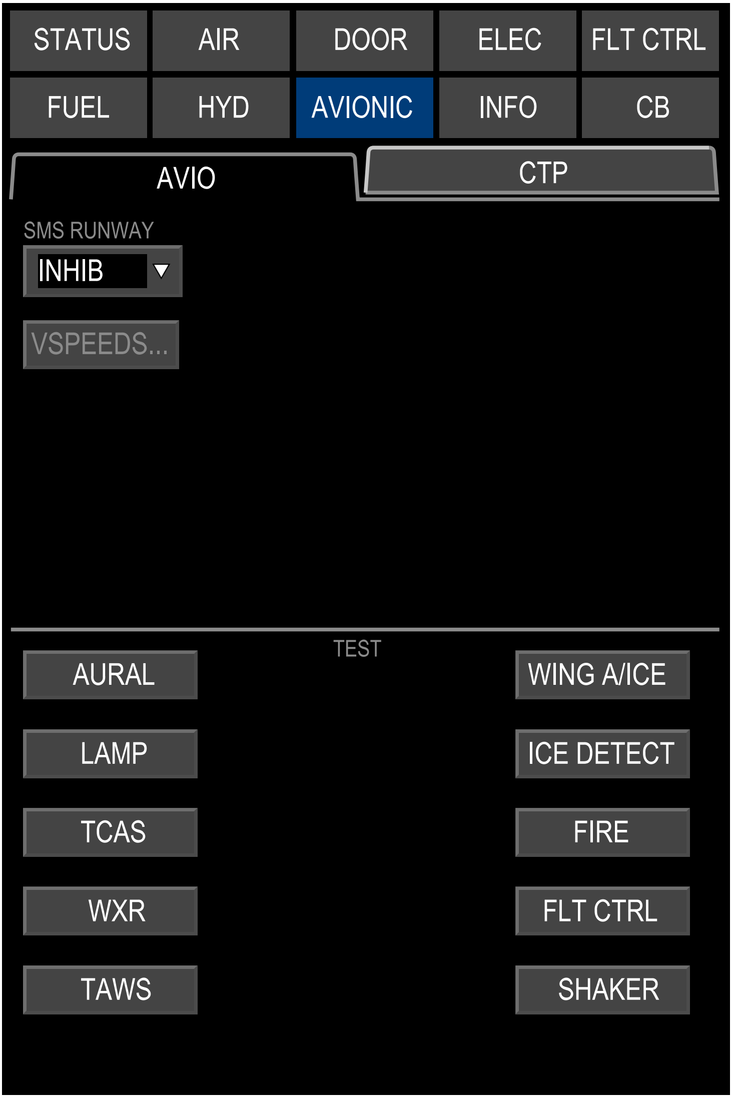
- Flight Path Vector selection (FPV CAGE ON or OFF),
- Landing elevation source selection (FMS or MAN), and
- Landing elevation entry when manual mode is selected.

When the L or R CTP OVRD (left or right CTP override command) control is selected, the CTP inputs are ignored, and a **CTP OVERRIDE** status message appears on the EICAS page.

NOTE

If both CTPs are inhibited, the radio frequency will automatically tune to 121.5 MHz.

For detailed information, refer to Chapter 16 – Navigation.



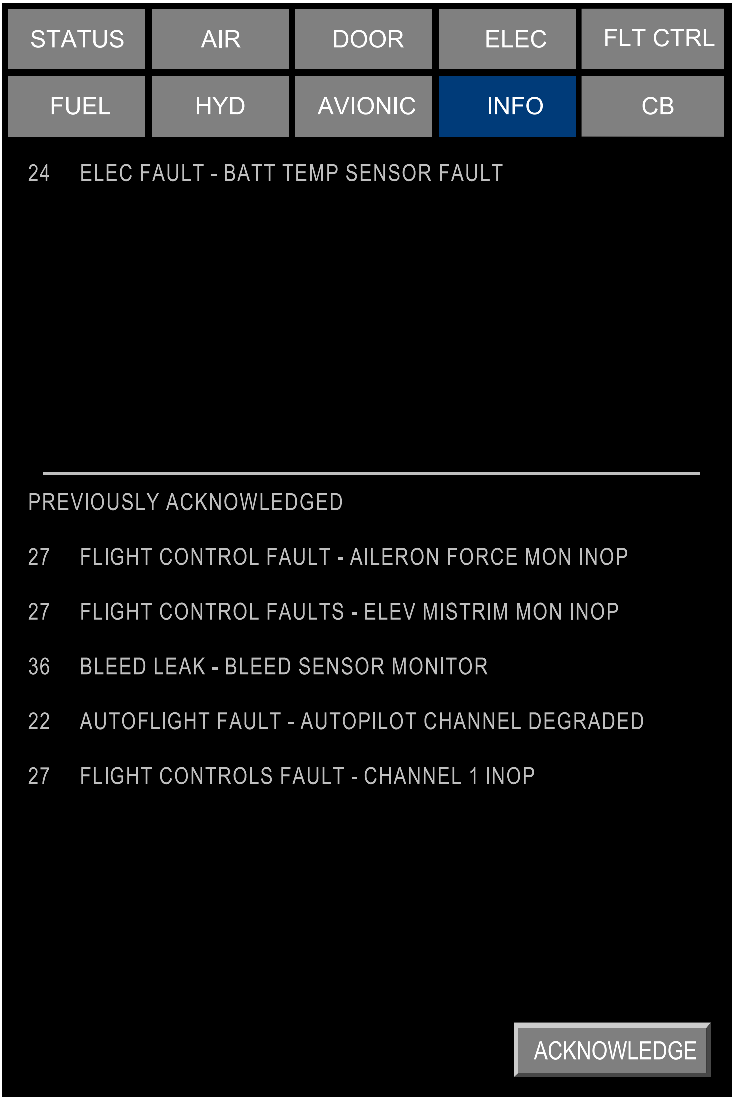
AVIONIC synoptic page – AVIO tab
Figure 08–04–18

AVIONIC synoptic page – CTP tab
Figure 08–04–19

E. INFO message page

The INFO messages are non-alerting-type messages with no in-flight associated procedures. The INFO messages are accessed on ground for troubleshooting.

The INFO page (refer to Figure 08–04–20) is divided into two sections. The upper section shows the non-acknowledged INFO messages and the lower section shows the acknowledged INFO messages. They are available in-flight for consultation.

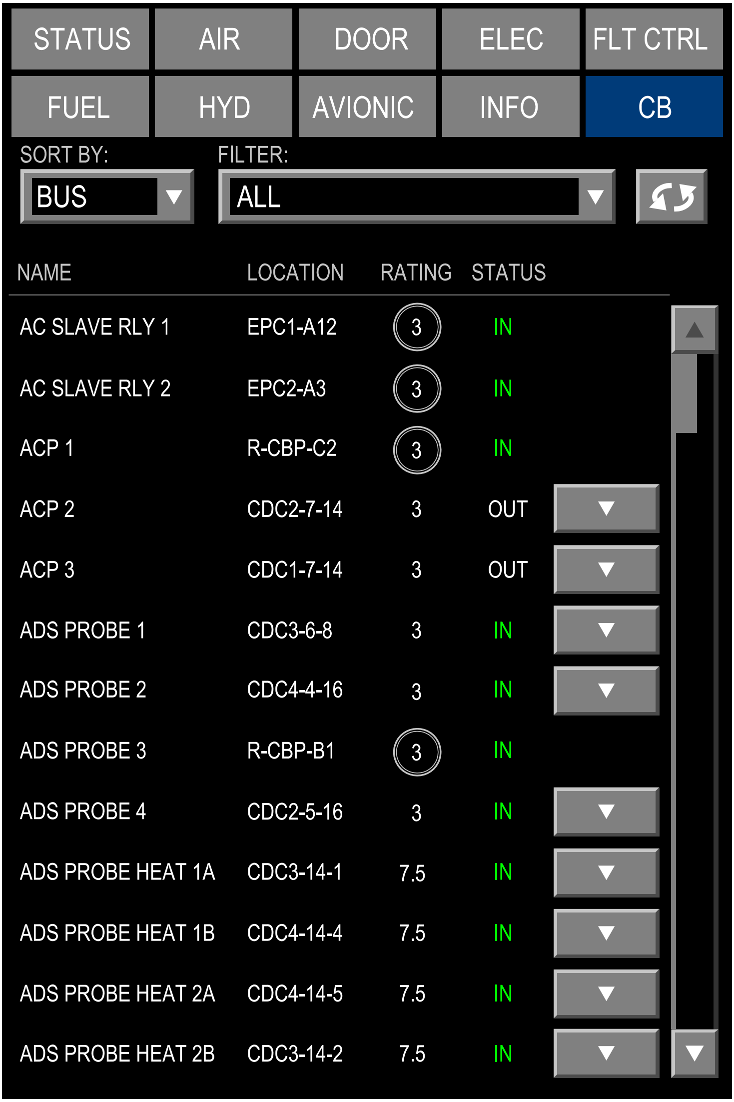


INFO synoptic page
Figure 08–04–20

F. Circuit Breaker (CB) synoptic page

The CB synoptic page allows the flight crew to monitor the status of all the CB including the Electronic Circuit Breaker (ECB) (refer to Figure 08–04–21). The interface is accessible through the synoptic page tile menu and gives control and status indication for the Solid State Power Controllers (SSPCs).

For detailed information, refer to Chapter 07 – Electrical.



CB synoptic page
Figure 08–04–21

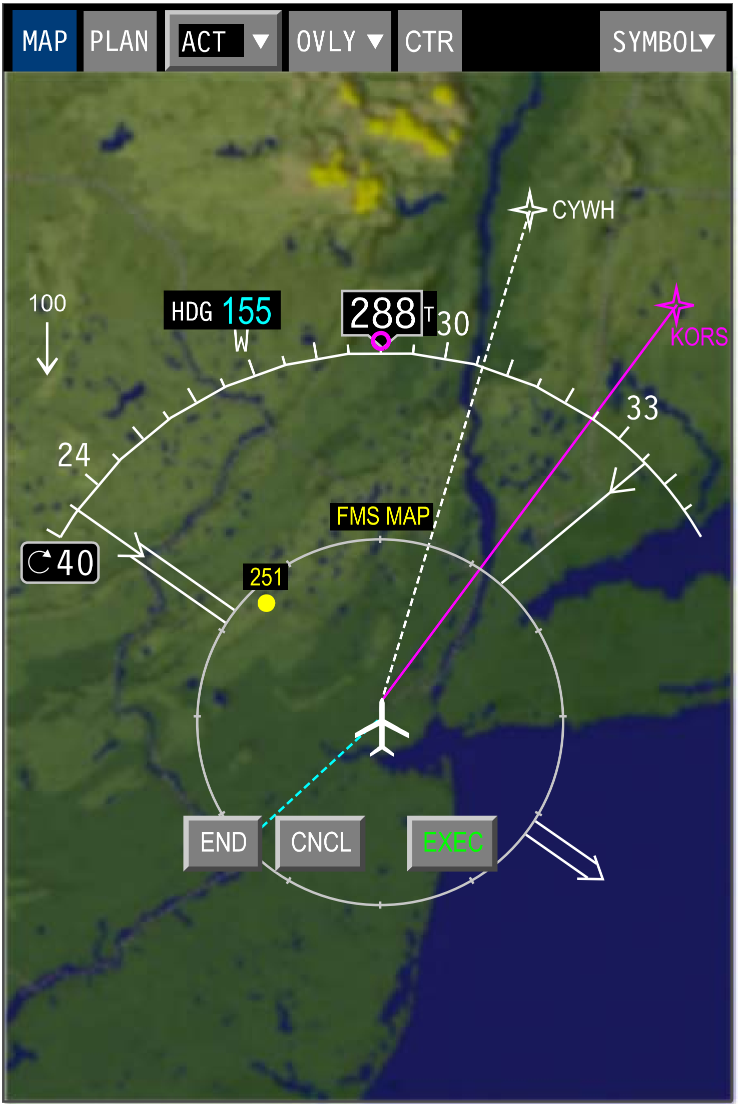
MFW – MAP

The MAP format can be displayed on one MFW (refer to Figure 08–04–22) or on both MFW at the same time.

The MAP format is accessed from:

- The MAP quick access key on the Control Tuning Panel (CTP),
- The MAP quick access key on the Multifunction Keyboard Panel (MKP), or
- The MENU switch on the Cursor Control Panel (CCP).

For detailed information, refer to Chapter 16 – Navigation.



MFW – MAP
Figure 08–04–22

MFW – FMS

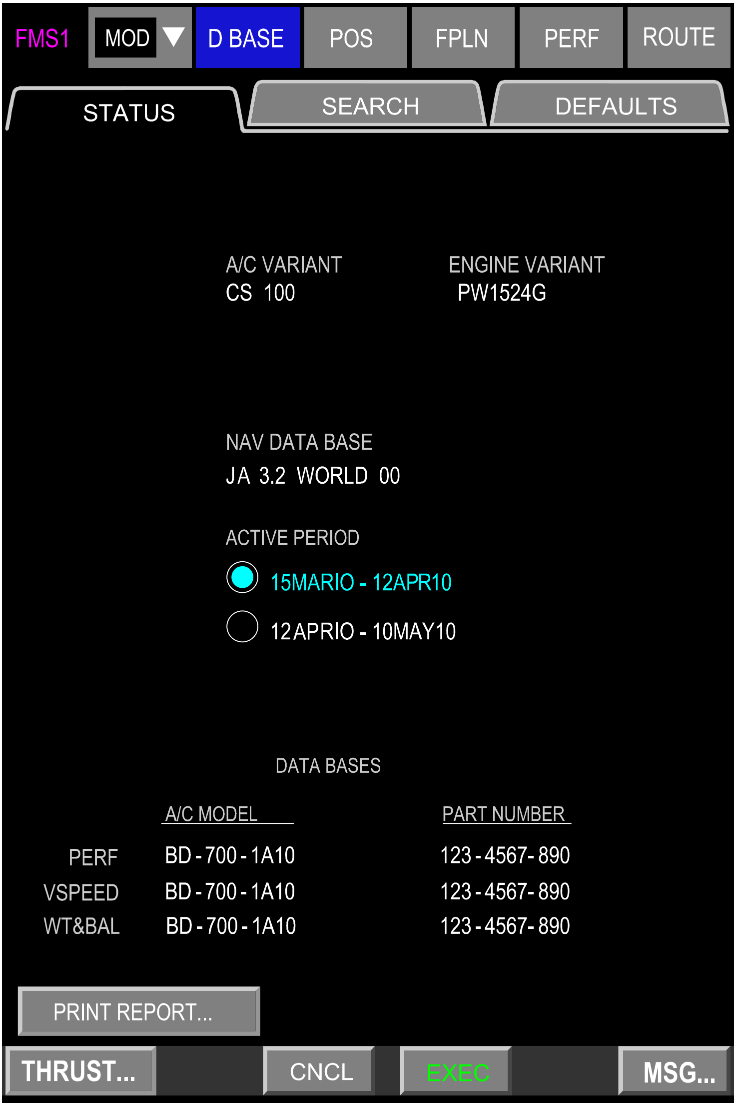
The main pages of the Flight Management System (FMS) can be selected from the header by selecting the respective soft switch. The main FMS pages are:

- DBASE (refer to Figure 08–04–23),
- POS (refer to Figure 08–04–24),
- FPLN (refer to Figure 08–04–25),
- PERF (refer to Figure 08–04–26), and
- ROUTE (refer to Figure 08–04–27).

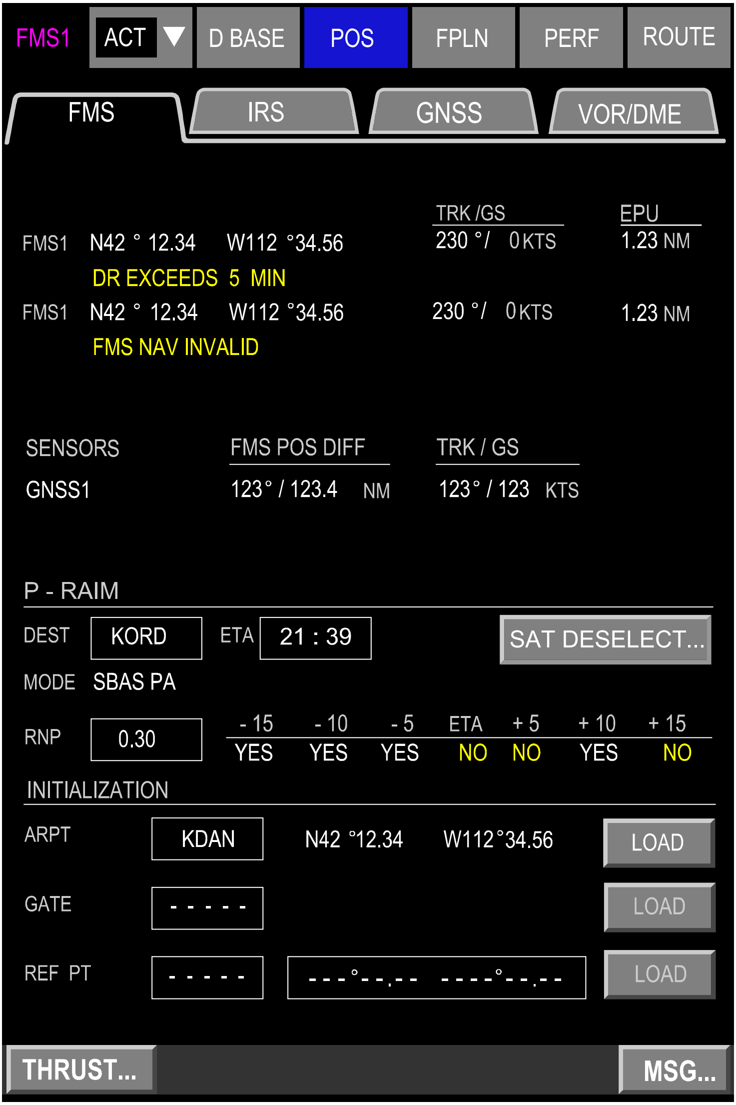
The FMS interface is accessed from:

- The FMS quick access key on the Control Tuning Panel (CTP),
- The FMS quick access key on the Multifunction Keyboard Panel (MKP), or
- The MENU switch on the Cursor Control Panel (CCP).

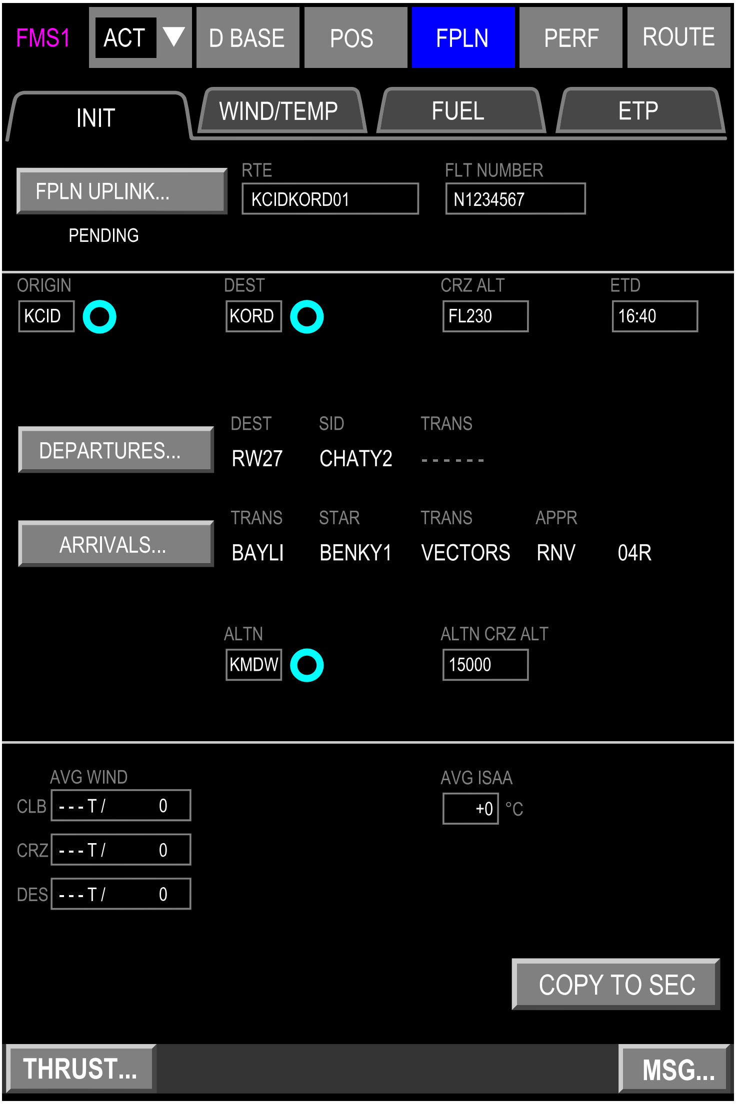
For detailed information, refer to Chapter 22 – Flight Management System.



FMS – DBASE page
Figure 08–04–23

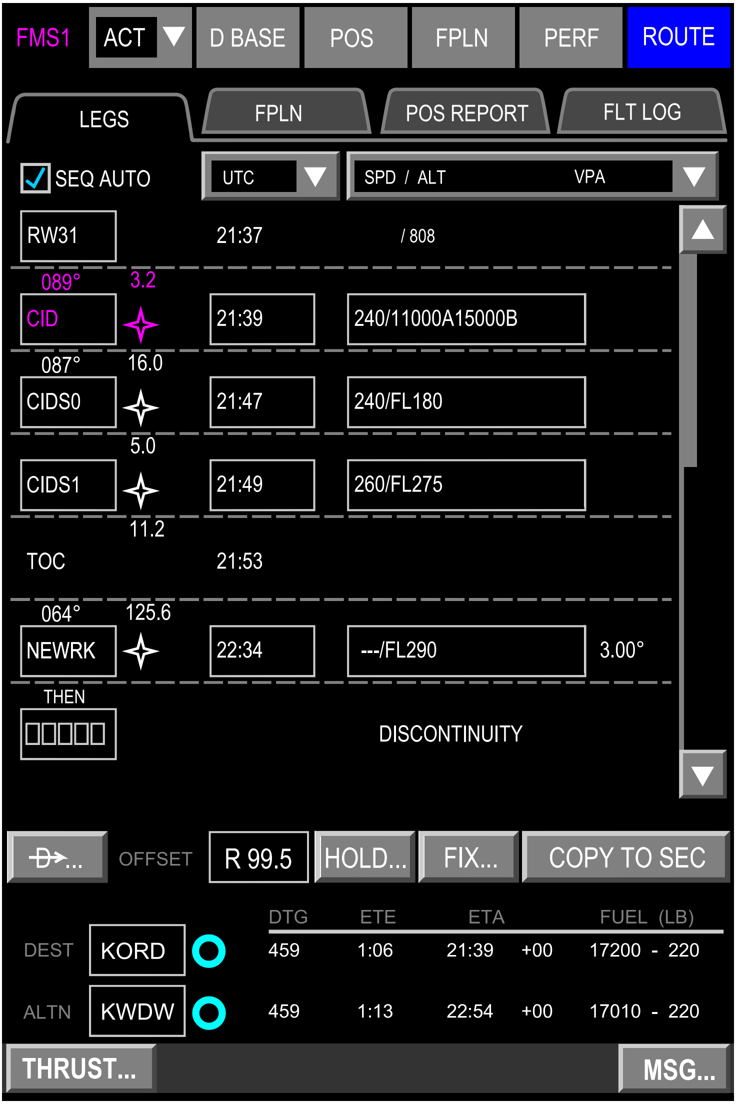


FMS – POS page
Figure 08–04–24



FMS – FPLN page
Figure 08–04–25

FMS – PERF page
Figure 08–04–26



FMS – ROUTE page
Figure 08–04–27

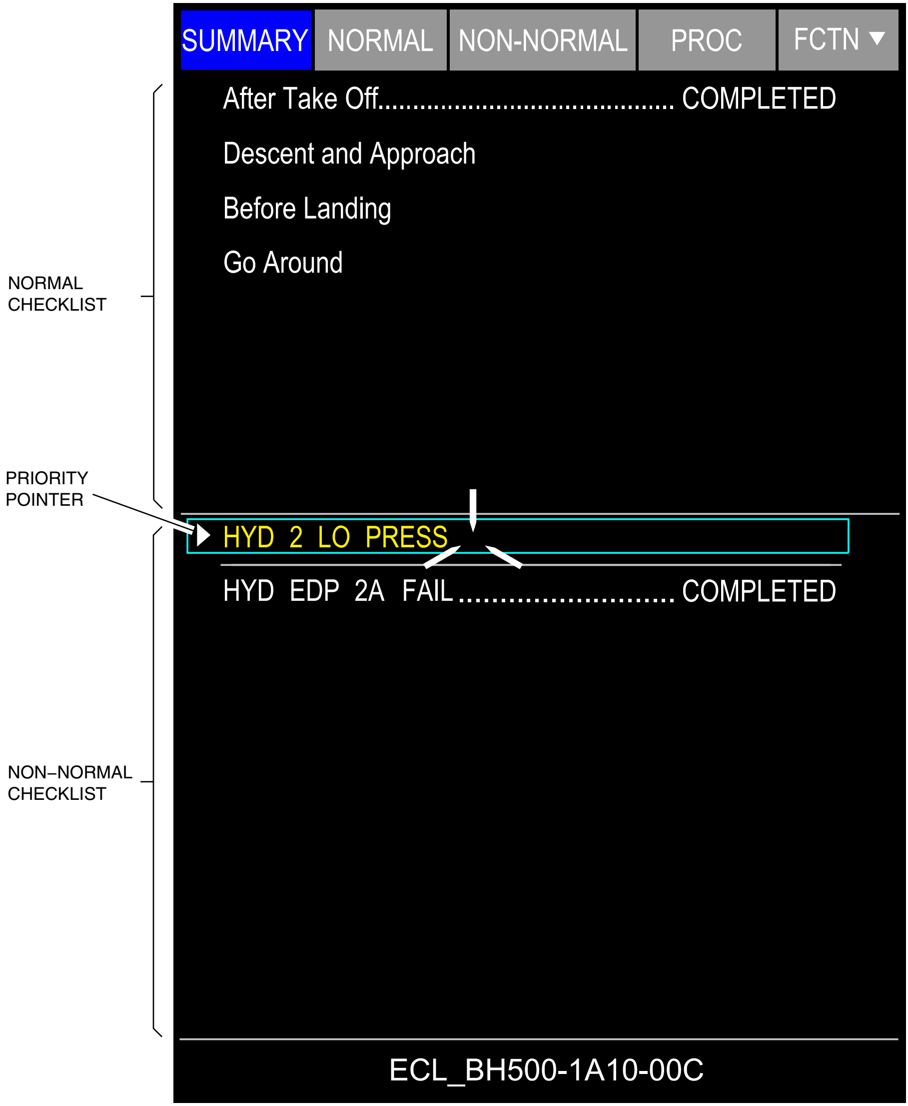
MFW – ECL

The Electronic Checklist (ECL) gives access to the normal and non-normal procedures and checklists (refer to Figure 08–04–28).

The ECL interface is accessed from:

- The CHKL quick access key on the Control Tuning Panel (CTP),
- The CHKL quick access key on the Multifunction Keyboard Panel (MKP), or
- The MENU switch on the Cursor Control Panel (CCP).

For detailed information, refer to Chapter 21 – Electronic Checklist.



ECL – SUMMARY page
Figure 08–04–28

MFW – CNS

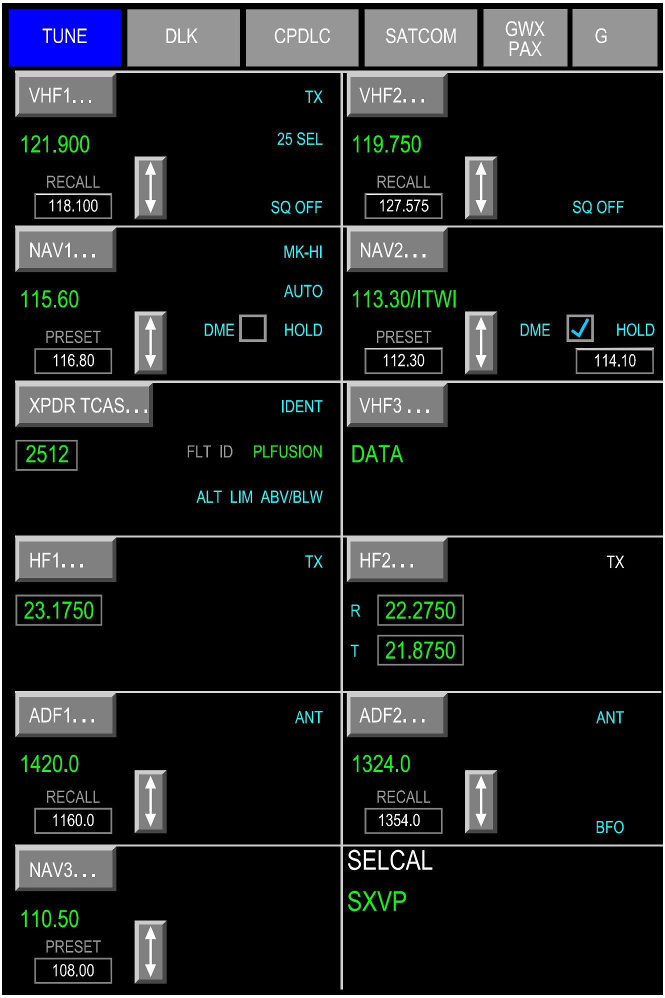
The Communication, Navigation and Surveillance (CNS) main pages can be selected from the header with the respective soft switch. The main CNS pages are:

- TUNE (refer to Figure 08–04–29)
- DLK (refer to Figure 08–04–30)
- CPDLC (refer to Figure 08–04–31) <23249001C>
- SATCOM (refer to Figure 08–04–32) <23150006C>

The CNS interface is accessed from:

- The CNS quick access key on the Control Tuning Panel (CTP),
- The CNS quick access key on the Multifunction Keyboard Panel (MKP), or
- The CNS switch on the Cursor Control Panel (CCP).

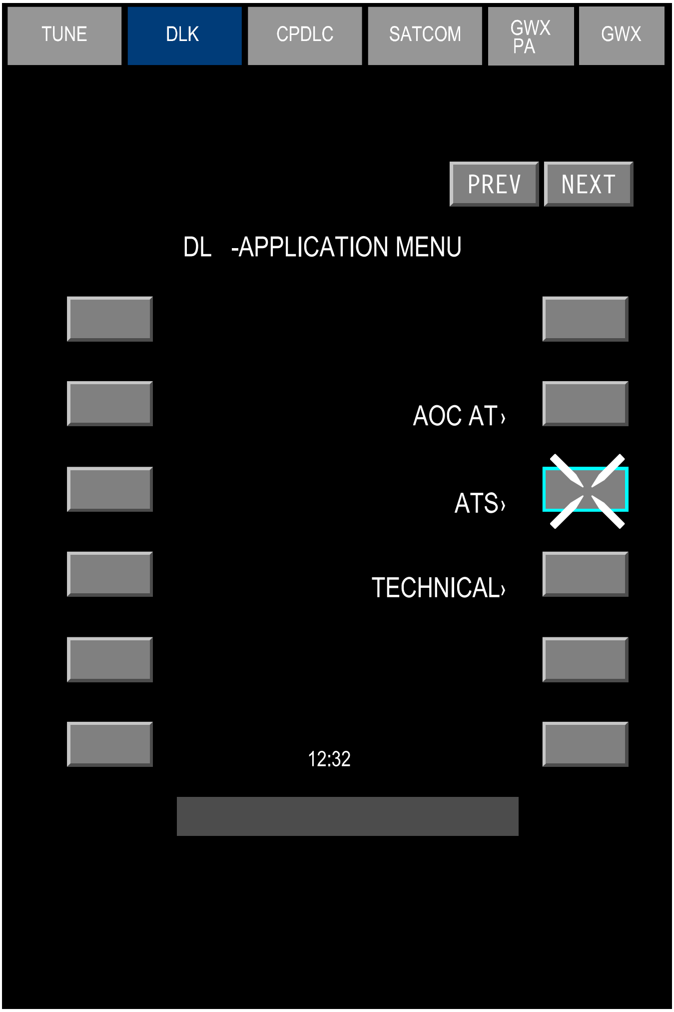
For detailed information, refer to Chapter 05 – Communication.



NOTE

This view shows options that may not be installed on your aircraft.

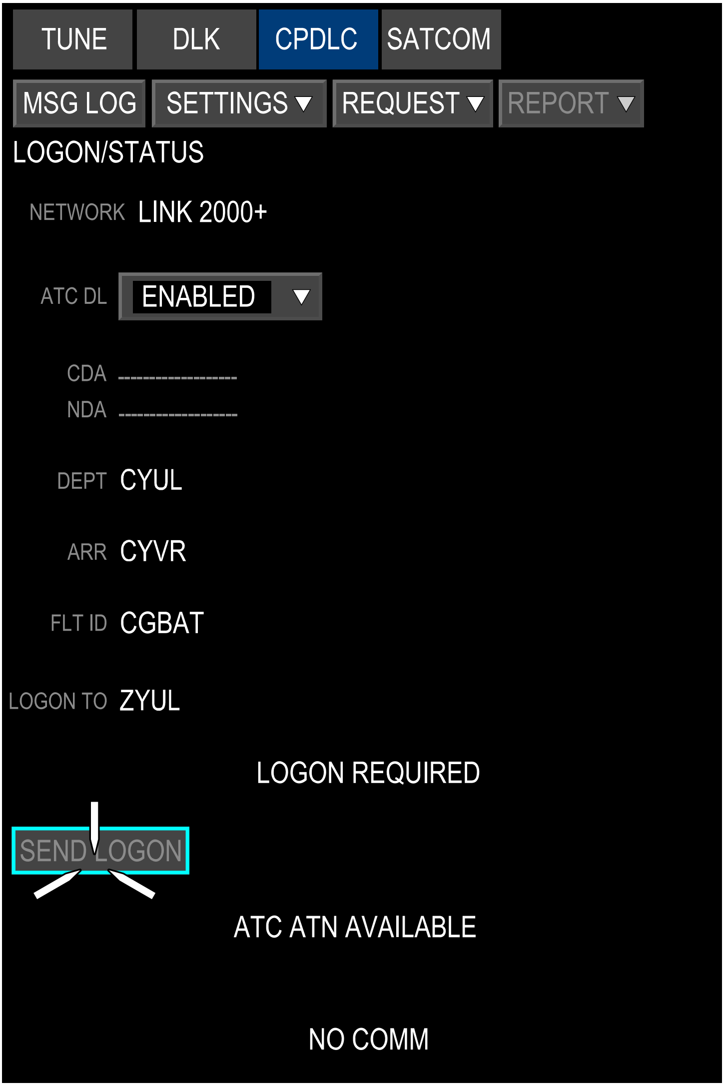
CNS – TUNE page
Figure 08–04–29



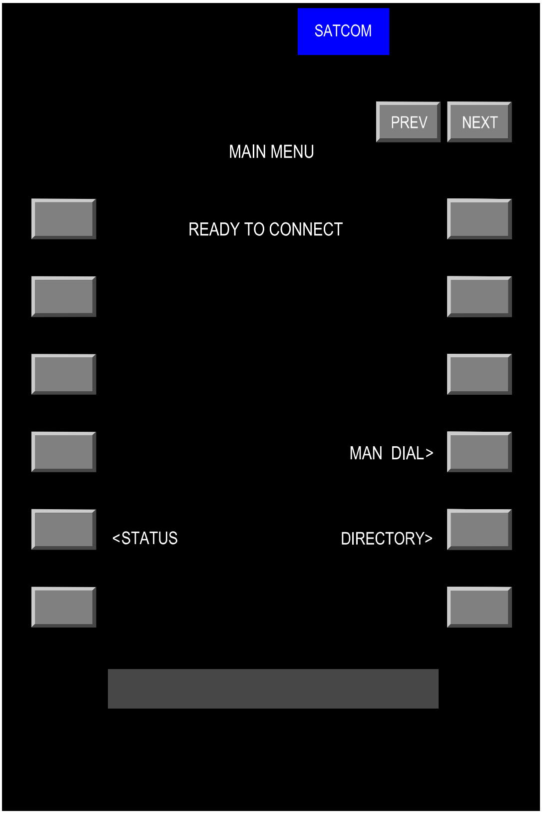
NOTE

This view shows options that may not be installed on your aircraft.

CNS – DLK page
Figure 08–04–30



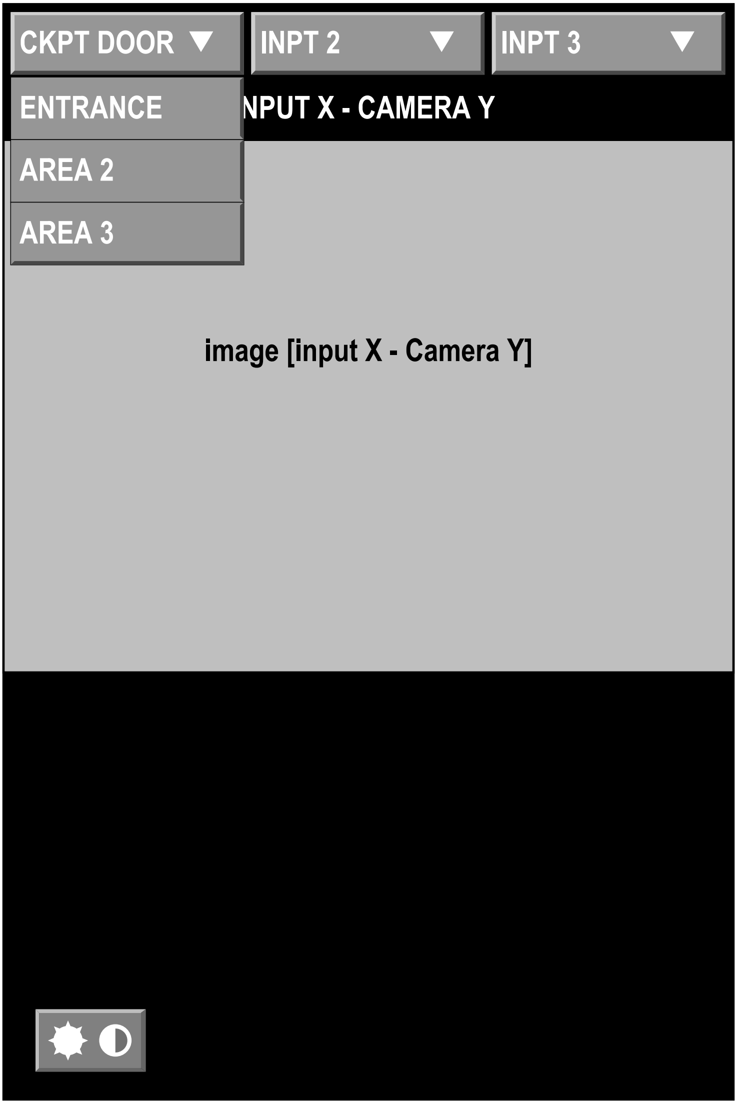
CNS – CPDLC page <23249001C>
Figure 08–04–31



CNS – SATCOM page <23150006C>
Figure 08–04–32

MFW – DATA

The VIDEO is displayed on DU 3 when the VIDEO DSPL L switch on the COCKPIT DOOR panel is selected (refer to Figure 08–04–33). Selection of the VIDEO DSPL R switch will display the video on DU 5. The VIDEO page can also be selected with the DATA Quick Access Key (QAK) on the MKP or the CTP, followed by the VIDEO soft switch on the drop-down menu on the MFW. A third way to display the VIDEO is to select the MENU switch on the CCP, then select the DATA QAK, followed by the VIDEO soft switch on the drop-down menu.



MFW – DATA – VIDEO
Figure 08–04–33

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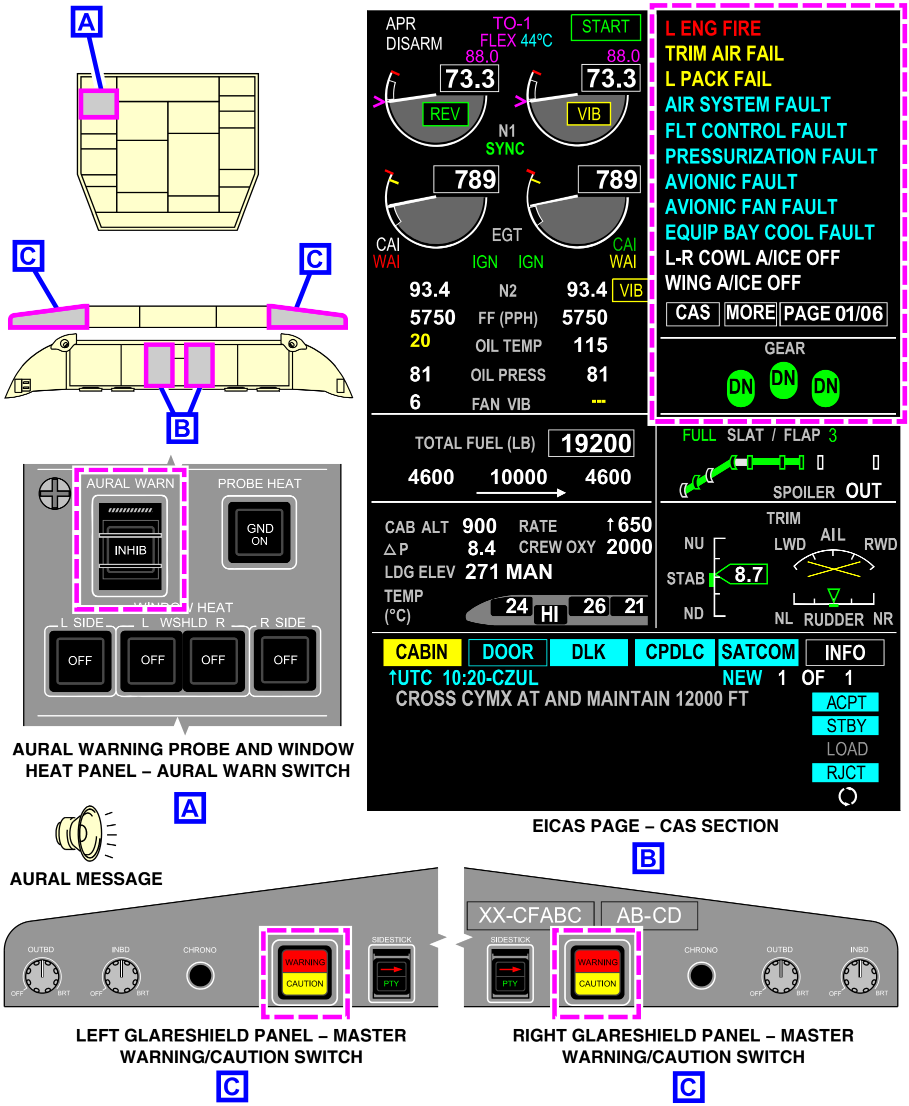
ENGINE INDICATION AND CREW ALERTING SYSTEM (EICAS) – OVERVIEW

The EICAS (refer to Figure 08–05–1) is part of the avionic system and is responsible for:

- Crew alerting,
- EICAS display page,
- Takeoff configuration warning, and
- Aural alerting.

The EICAS messages related to each system are described in specific EICAS tables at the end of each chapter.



Crew Alerting System (CAS)
Figure 08–05–1

EICAS

A. Description

The Crew Alerting System (CAS) reports system statuses, and malfunctions or hazardous conditions by messages displayed on the EICAS page, in the crew alerting section (refer to Figure 08–05–2).

EICAS page – Graphical layout
Figure 08–05–2

There are four types of messages, with specific colors for easy identification:

- Warning messages,
- Caution messages,
- Advisory messages, and
- Status messages.

The table that follows gives the definitions and related colors of the EICAS messages, depending on their level.

LEVEL	DEFINITION	COLOR
WARNING	Immediate awareness, immediate action or flight crew decision (immediate action required to do the checklist)	RED
CAUTION	Immediate awareness, subsequent action (crew action required before the end of the flight)	AMBER
ADVISORY	Crew awareness	CYAN
STATUS	Central indication of selected states	WHITE

Messages are displayed in groups according to their category and prioritized within their category by order of occurrence. The most recent message always appears on the top of the respective category list.

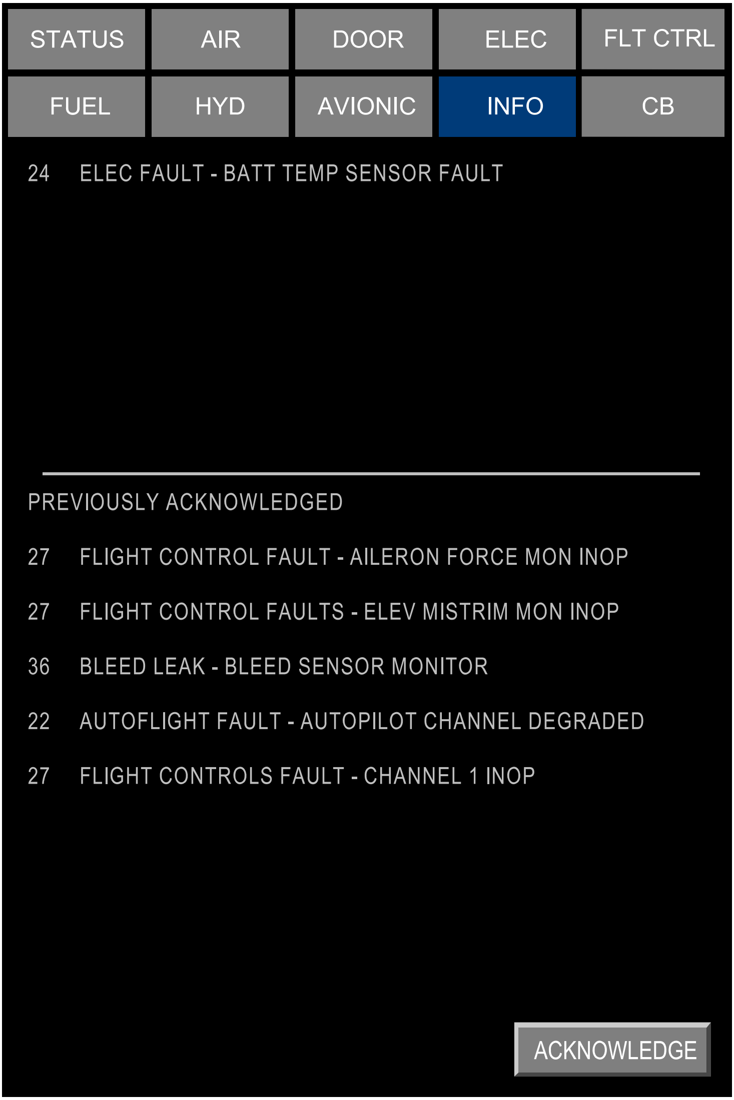
The maximum number of EICAS messages for the CAS stack is:

- Full usage – Cluttered: 12 total or 11 + 1 line for flags and paging,
- Full usage – Decluttered: 18 total or 17 + 1 line for flags and paging,
- Compressed – Cluttered: 7 total or 6 + 1 line for flags and paging, and
- Compressed – Decluttered: 11 total or 10 + 1 line for flags and paging.

Depending on the message category, aural and visual cues can be associated with EICAS messages:

- Master WARNING/CAUTION switch,
- Flags on PFD and EICAS page,
- Chimes,
- Bells,
- Tones, and
- Voice messages.

INFO messages are related to the EICAS messages. They are accessible from the INFO page (synoptic menu) (refer to Figure 08–05–3).

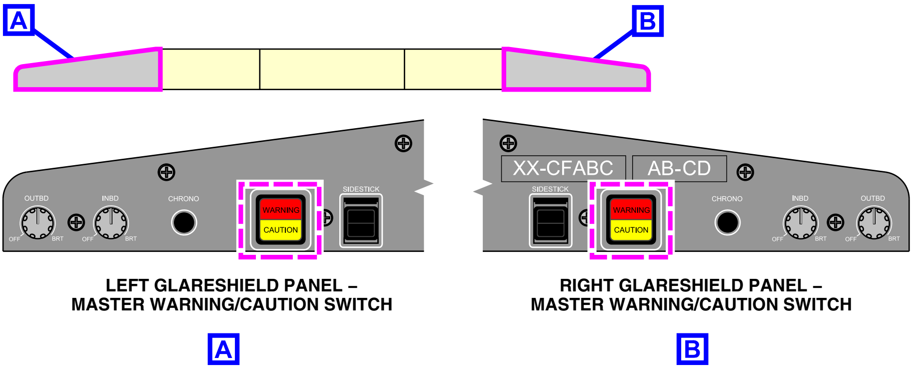


INFO synoptic page
Figure 08–05–3

B. Master WARNING/CAUTION switch

Two master WARNING/CAUTION switches, located on the glareshield (left and right side), flash when triggered by a warning or caution message (refer to Figure 08–05–4).

The master WARNING/CAUTION switch is divided into two parts. The upper part is labelled WARNING and flashes red when a warning message is triggered. The lower part is labelled CAUTION and flashes amber when a caution message is triggered.



Master WARNING/CAUTION switches
Figure 08–05–4

Acknowledgement of a warning or caution message is made when either the left or right master WARNING/CAUTION switch is pushed.

The master WARNING/CAUTION switch must be pushed to re-arm the alerting system. If a flashing WARNING/CAUTION switch is not pushed, the system will not be armed and ready to announce a new warning or caution message.

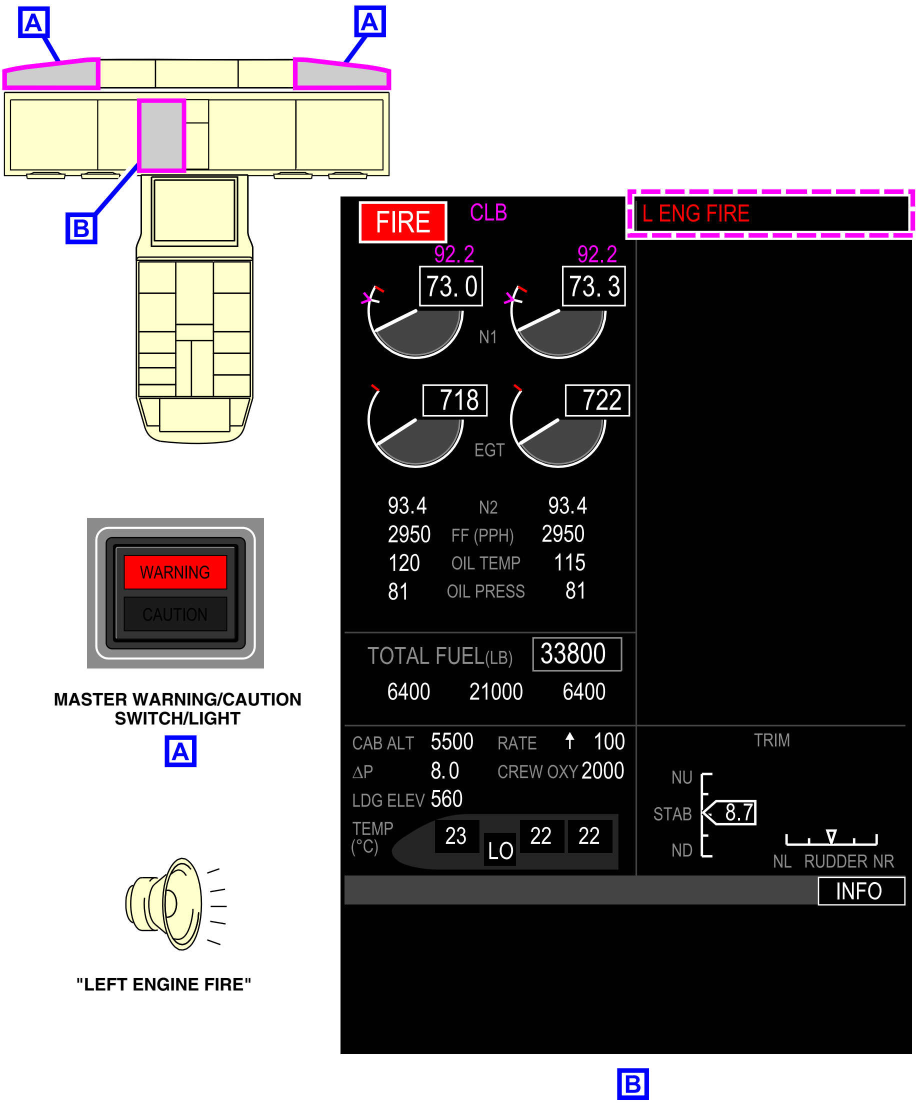
C. Definition of warning messages

Warning messages are the most urgent type of crew alerts and are generated when immediate flight crew attention and immediate action or decision are required. Warning messages appear in red at the top of the message area in order of occurrence. Warning messages cannot be removed from view unless the applicable failure has been rectified (refer to Figure 08–05–5).

When a warning message is triggered:

- The WARNING part of both WARNING/CAUTION switches will flash red,
- A triple chime will sound,
- An associated flashing warning message will be posted on the EICAS display, and
- An aural alert will sound (voice advisory).

There are specific aural alerts associated with some EICAS warning messages



WARNING message with related alert
Figure 08–05–5

When pushed, the master WARNING/CAUTION switch will cause the following:

- The WARNING legend will stop flashing and go off,
- Re-arms the master WARNING/CAUTION switch logic,
- Silences any associated aural alerts (voice message or triple chime (if alert can be cancelled)), and
- The EICAS warning message stops flashing.

The warning message is displayed for as long as the associated condition exists.

NOTE

Displayed warning messages stay in view. They cannot be inhibited, paged, or hidden.

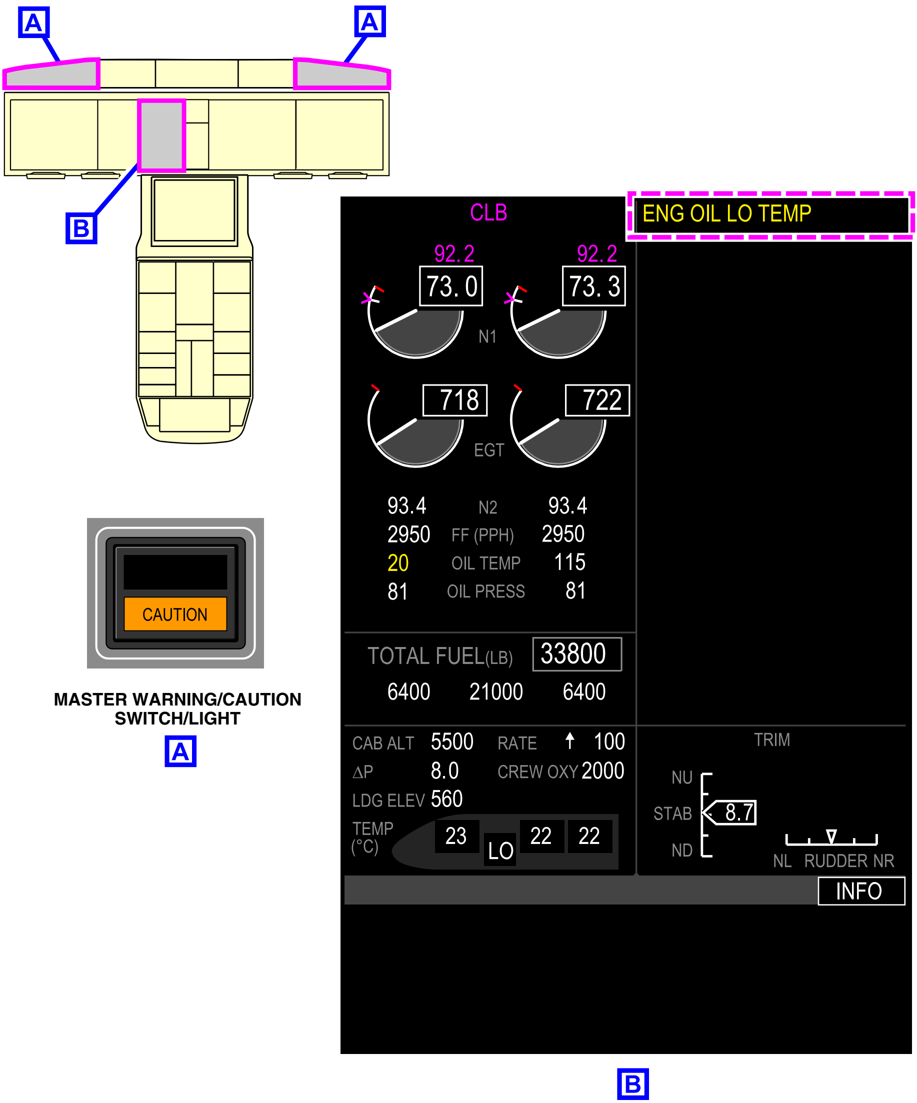
Each warning message has an associated procedure defined in the AFM (refer to AFM/FCOM2/QRH).

D. Definition of caution messages

Caution messages are generated when immediate crew awareness is required and subsequent crew actions are required (refer to Figure 08–05–6). Caution messages are amber, and are displayed below warnings (if any are present). They appear in order of occurrence.

When a caution message is triggered:

- The CAUTION part of both WARNING/CAUTION switches will flash amber,
- A single chime will sound,
- An aural alert (tone, bell and/or voice message) will sound, and
- An associated flashing caution message will be posted on the EICAS page.



Caution message with related alert
Figure 08–05–6

When pushed, the master WARNING/CAUTION switch does the following:

- The CAUTION legend will stop flashing and go off,
- Re-arms the Master WARNING/CAUTION switch logic,
- Silences the single chime,
- Silences any associated aural alerts (tone and voice message (if alert can be cancelled)), and
- The EICAS caution message stops flashing (caution message stays on steady).

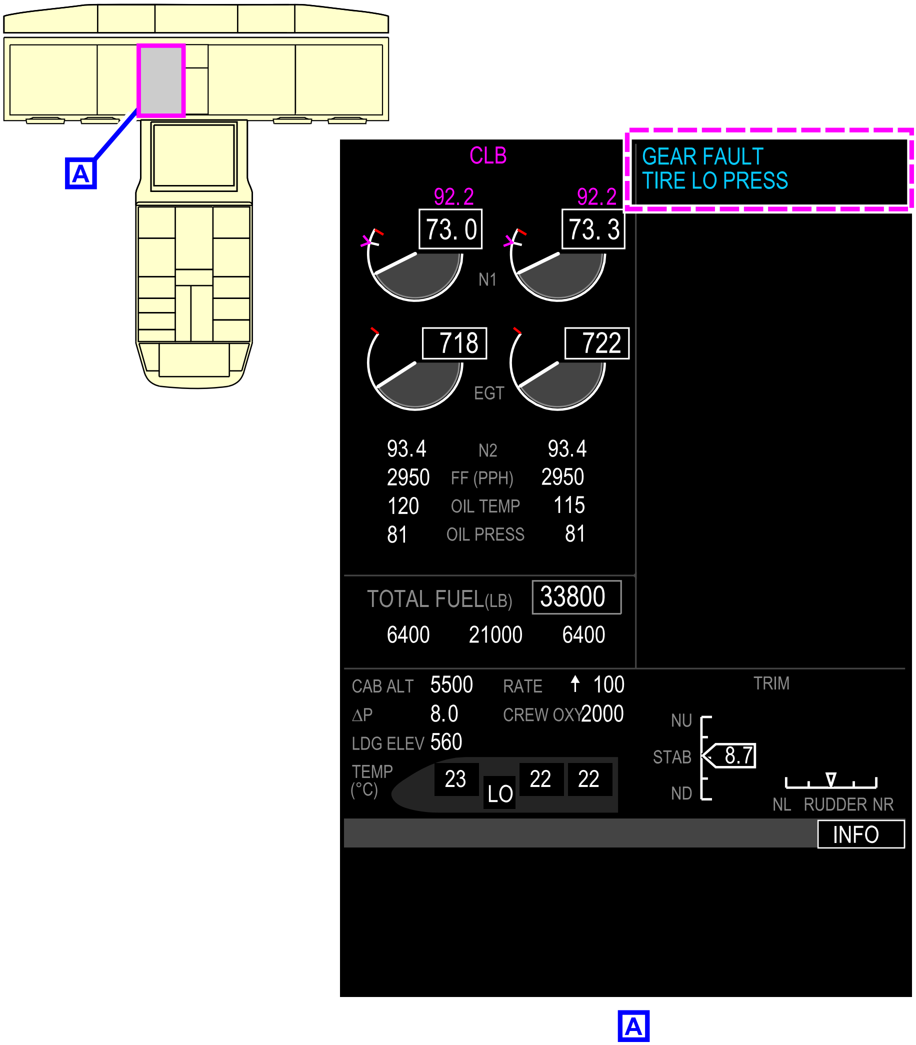
The caution message is displayed for as long as the associated condition exists.

Displayed caution messages can be inhibited, paged or hidden.

Each caution message has an associated procedure defined in the AFM (refer to AFM/FCOM2/QRH).

E. Definition of advisory messages

Advisory messages are generated when crew awareness is required and subsequent action may be required. Advisory messages are cyan and are displayed below warning and caution messages (if any are present) (refer to Figure 08–05–7). They appear in order of occurrence.



Advisory messages with related alert
Figure 08–05–7

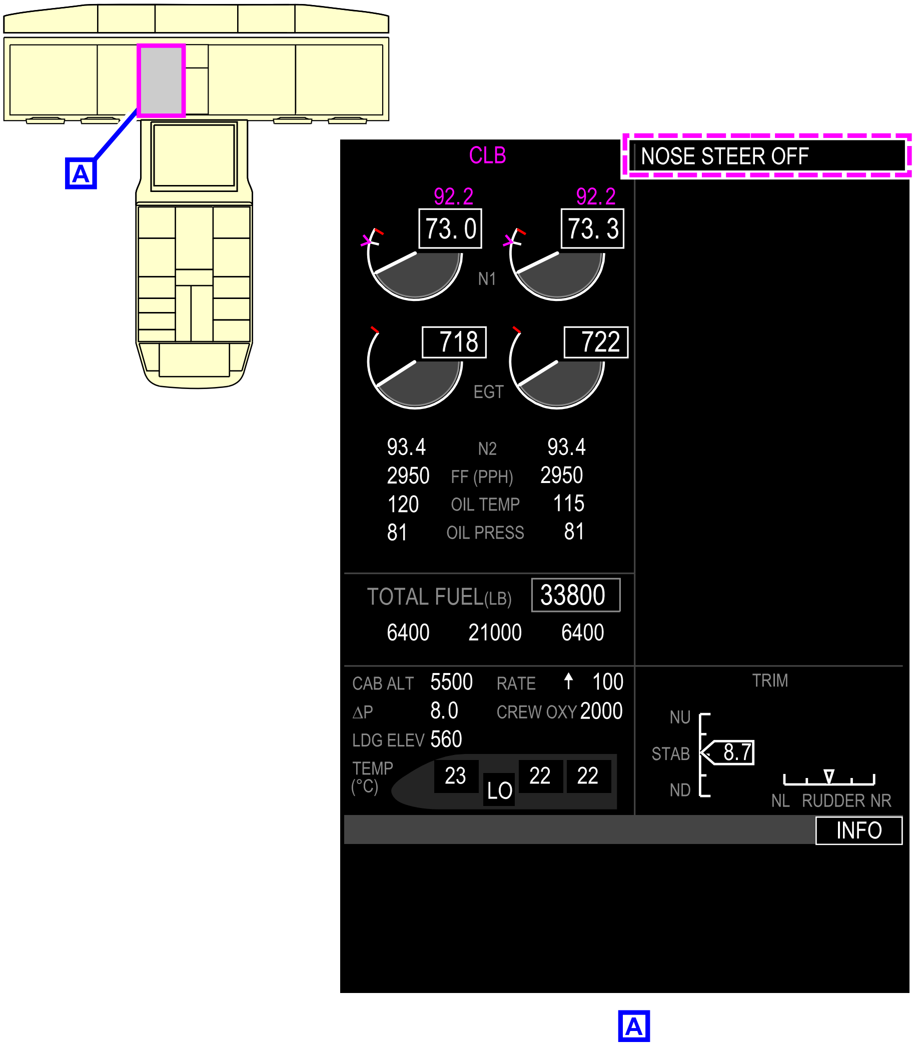
When triggered, an advisory message will flash for 5 seconds before it becomes steady. Advisory messages have no associated master WARNING/CAUTION lights or aural alerts.

An advisory messages does not have associated procedures or limitations, but certain messages can have associated information (refer to AFM/FCOM2/QRH).

F. Definition of status messages

Status messages are generated to indicate non-normal system selection and are reminders to the flight crew. Status messages are white and are displayed below warning, caution, and advisory messages (if any are present) (refer to Figure 08–05–8). They appear in order of occurrence. Status messages have no associated master WARNING/CAUTION lights or aural messages.

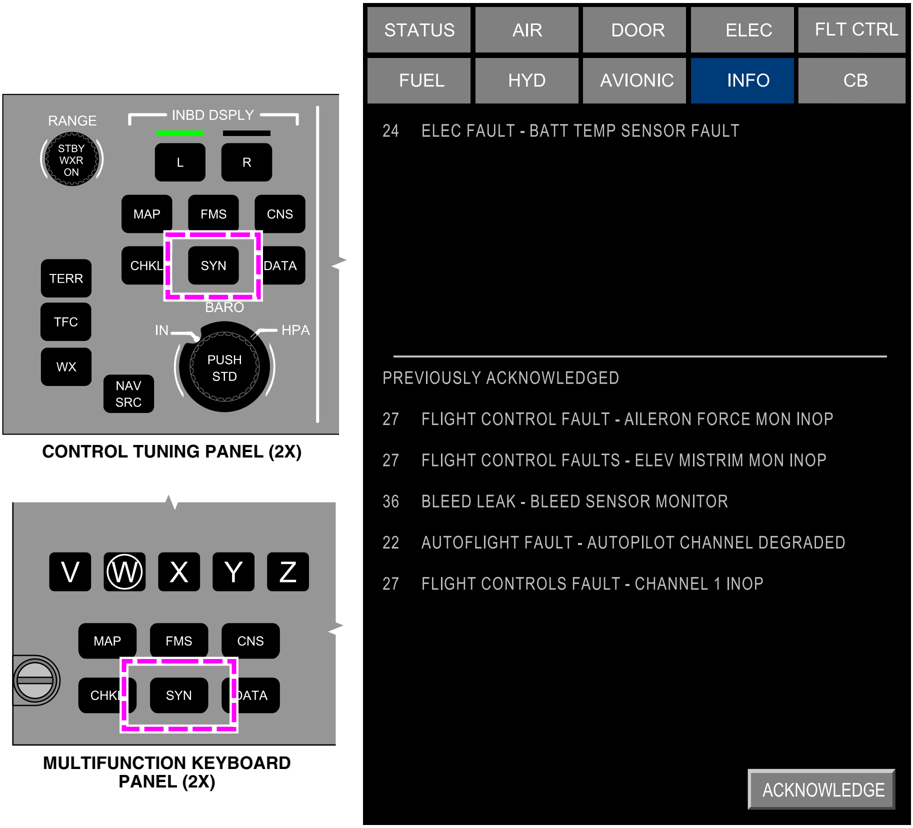
Status messages do not have associated procedures or limitations.



Status messages with related alert
Figure 08–05–8

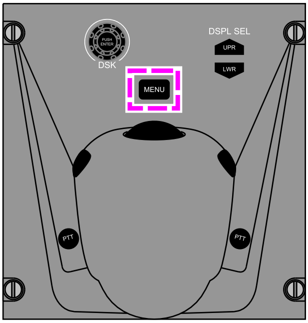
G. Definition of Information (INFO) messages

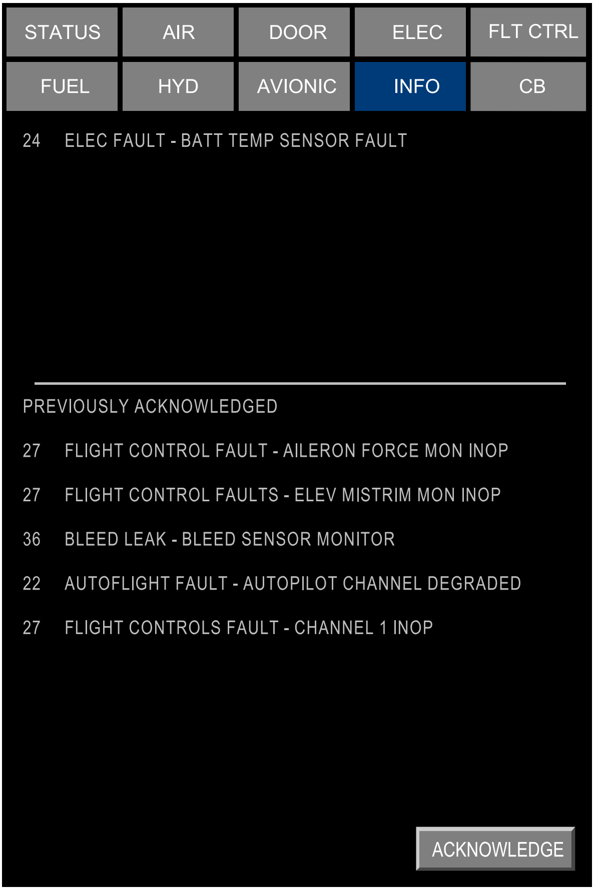
INFO messages give information about the status of aircraft systems. They are not associated with any flight procedures. They are displayed on the INFO synoptic page, which is accessed by pushing the SYN switch on the Control Tuning Panel (CTP) or the Multifunction Keyboard Panel (MKP), and selecting the INFO soft tile on the synoptic page (refer to Figure 08–05–9).



INFO synoptic page access via CTP or MKP
Figure 08–05–9

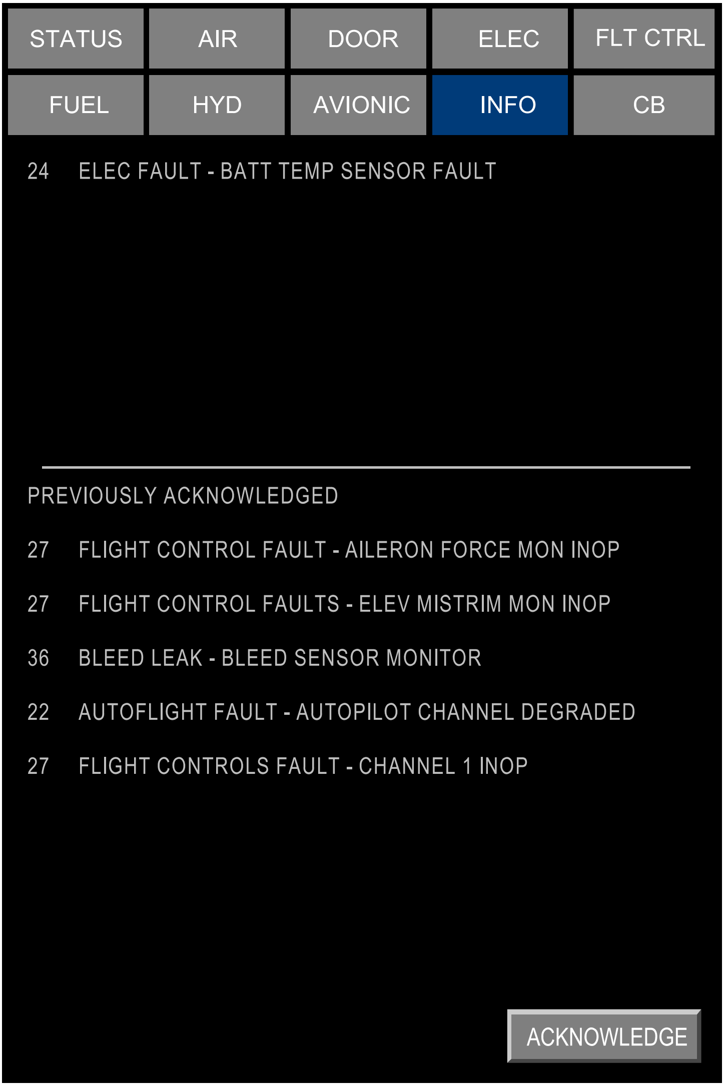
The INFO synoptic page can also be accessed by pushing the MENU switch on the Cursor Control Panel (CCP), selecting SYN on the drop-drown menu, and then the INFO soft tile (refer to Figure 08–05–10).





INFO synoptic page access via CCP
Figure 08–05–10

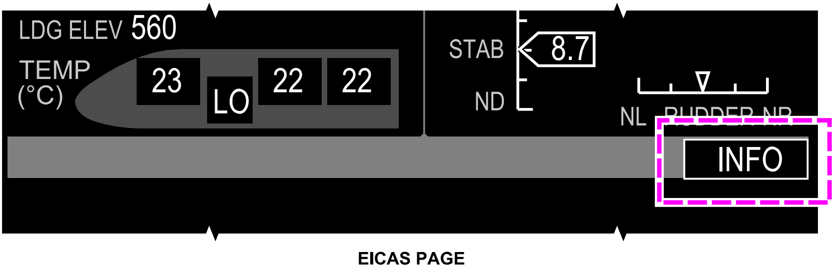
The upper section of the INFO synoptic page displays new INFO messages. The lower section displays acknowledged INFO messages. When the ACKNOWLEDGE soft switch located at the bottom of the INFO synoptic page is selected, all new INFO messages transfer from the upper section to the lower section (refer to Figure 08−05−11).



INFO synoptic page
Figure 08–05–11

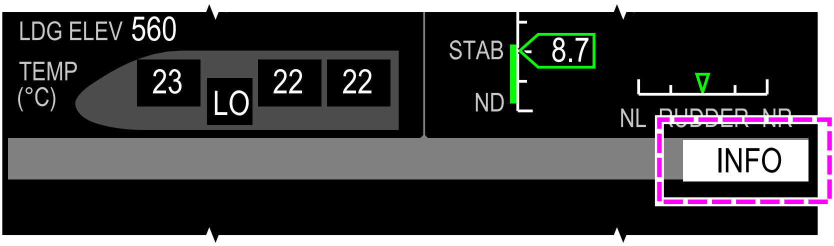
In compressed mode, the INFO tile will be removed and replaced by an EICAS message.

In flight, when a new INFO message is sent to the INFO synoptic page, an INFO flag is displayed in white with a black background. It is displayed on the right side of the EICAS communication flags section at the bottom of the EICAS page (refer to Figure 08–05–12). After the message has been acknowledged, the INFO flag is removed.



INFO – Communication flag – In flight
Figure 08–05–12

On the ground, when a new INFO message is sent to the INFO synoptic page, an INFO flag is displayed in black with a white background. It is displayed on the right side of the EICAS communication flags section at the bottom of the EICAS page (refer to Figure 08–05–13). After the message has been acknowledged, the INFO flag with the black background is displayed.



EICAS PAGE

INFO – Communication flag – On ground
Figure 08–05–13

NOTE

The INFO messages and INFO flag are inhibited during takeoff and landing.

H. EICAS message inhibit

To avoid unnecessary flight crew distraction during the takeoff and landing phases, most caution and advisory EICAS messages are inhibited if no immediate flight crew action is required.

Inhibited and non-inhibited messages are described in the EICAS tables at the end of each chapter.

The inhibition on takeoff and landing occurs under specific conditions:

- Takeoff phase EICAS inhibit – Starts when airspeed increases to 80 KIAS and all MLG (Main Landing Gear) have a Weight-On-Wheels (WOW) signal. It ends when the airplane altitude is 400 ft AGL.
- Landing phase EICAS inhibit – Starts when airplane is descending through 400 ft AGL and ends when the airplane speed is less than 50 Kt or during go around up to 400 ft AGL.

The table that follows lists the EICAS messages considered critical. These messages are available during takeoff and landing.

Message	Description	Aural
CONFIG AP	Autopilot engaged on takeoff	"CONFIG AUTOPILOT"
CONFIG BRAKE	Parking brake set	"CONFIG BRAKE"
CONFIG FLAP	Slat/Flap not configured for takeoff	"CONFIG FLAP"
CONFIG RUDDER TRIM	Rudder trim position not in T/O range (out of the green arc)	"CONFIG TRIM"
CONFIG SIDESTICK	One sidestick priority latched at takeoff	"CONFIG SIDESTICK"
CONFIG SPOILER	Spoiler not stowed	"CONFIG SPOILER"
CONFIG STAB TRIM	Stabilizer trim position not in T/O range (out of the green arc)	"CONFIG TRIM"

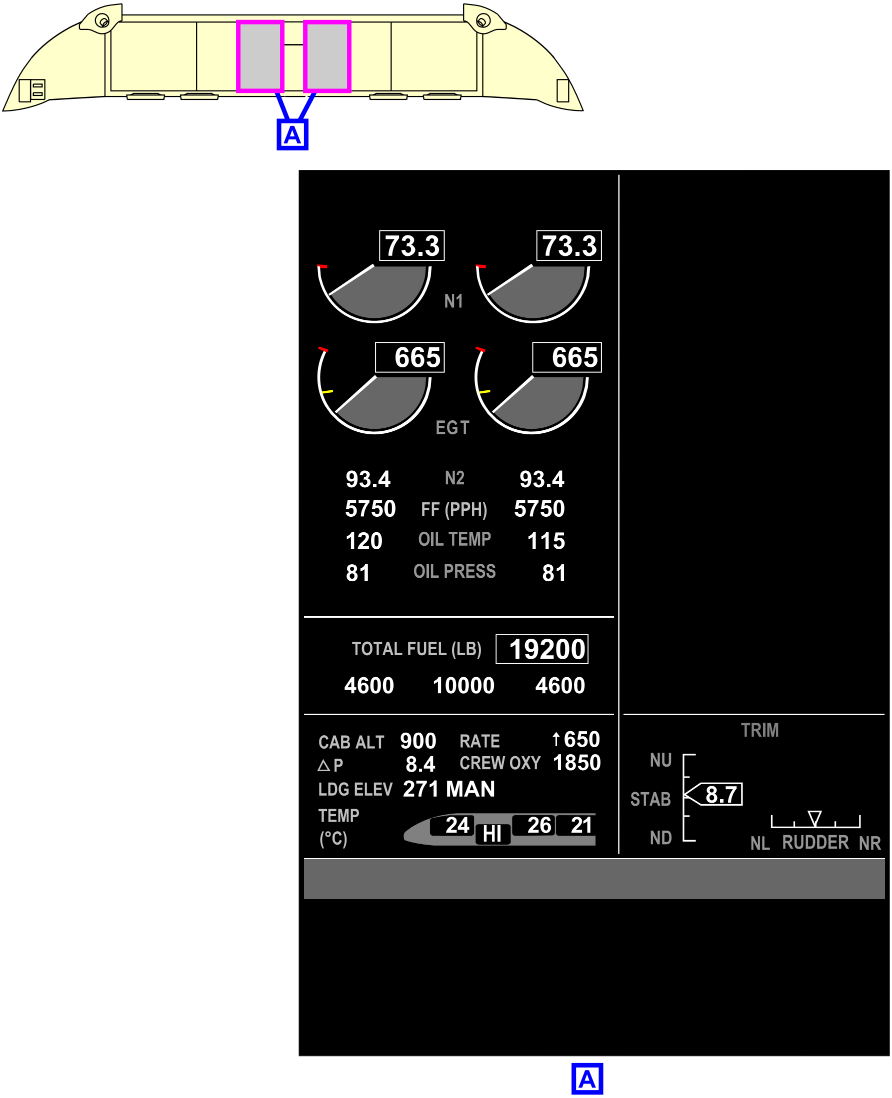
EICAS PAGE PRESENTATION

A. Overview

The EICAS primary page is normally shown on the right side of DU 2 (refer to Figure 08–05–14). The alternate location is the right side of DU 3 (if the copilot is the pilot flying).

The EICAS primary page includes the sections that follow:

- Engine and fuel indications,
- Crew alerting messages,
- Configuration and trim indications,
- Cabin air information, and
- Communications information.



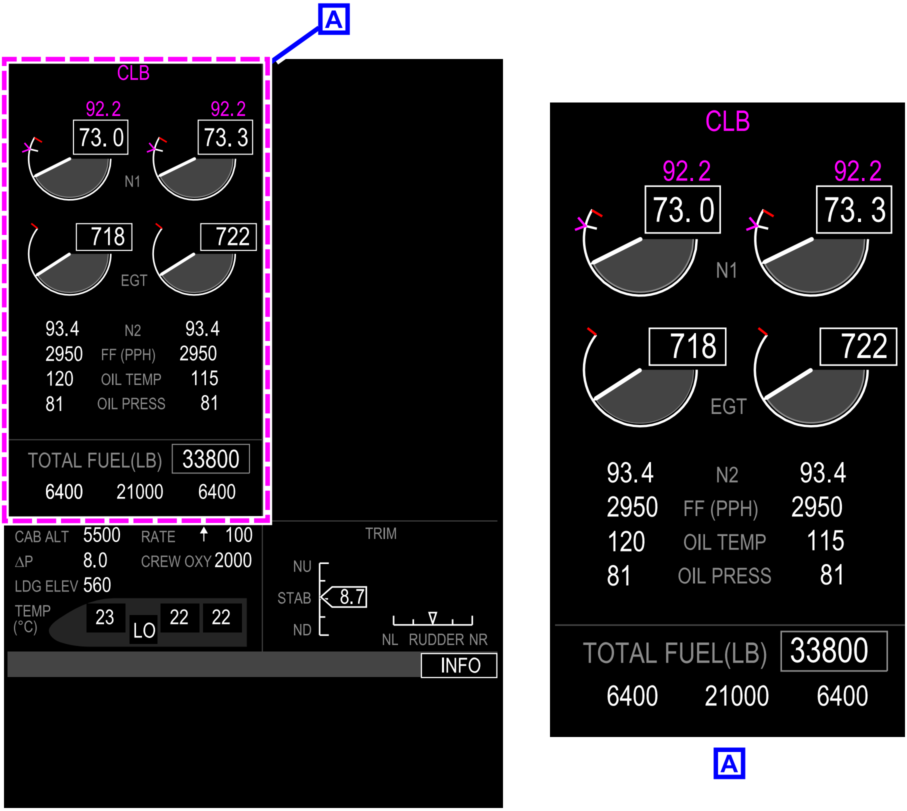
EICAS page – Decluttered
Figure 08–05–14

B. Engine and fuel indications section

Engine information for each engine is displayed on the top left of the EICAS page. The fuel information (quantity and transfer) is displayed below the engine information.

The ENGINE section of the EICAS page has two columns (refer to Figure 08–05–15). The left column displays left engine data and the right column displays the right engine data. The engine section displays the information that follows:

- N1 gauge and dedicated flags or status,
- Exhaust Gas Temperature (EGT) gauge and dedicated flags or status,
- N2,
- Fuel Flow (FF),
- Oil temperature (OIL TEMP),
- Oil pressure (OIL PRESS), and
- Fan vibration (FAN VIB), only if detected.



EICAS page – Engine indication section
Figure 08–05–15

The N1 data includes digital and analog value representation, thrust commands, and display of modes (selected by FMS or manual, FLEX values). The EGT gauge has digital and analog values and includes threshold representation.

The flags, symbols and status are important information displayed depending on engine conditions. They include:

- VIB symbol, shown only if vibrations are detected (FAN, N1 and N2),

- REV, IGN, WAI, CAI, APR flags, depending on engine configuration/mode, and
- FIRE, START, RELIGHT, ATS, WINDMILL status.

NOTE

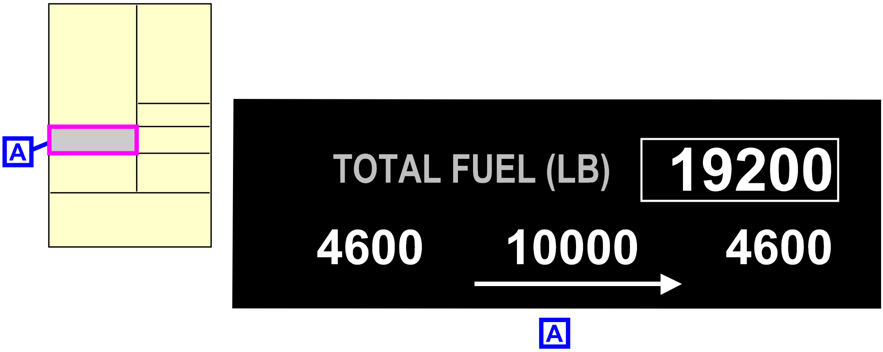
REV flag appears only on ground, and has priority over VIB symbol.

The ENGINE section also displays common indications and flags. Common indications appear between the left and the right engine indications, and include thrust modes and common engine-related flags (SYNC appears under N1 labels when engine synchronization is active). The thrust mode displays the selected mode (CLB, TO, MCT, GA, FLEX, derate) and assumed temperature for FLEX. Automatic modes (FMS selected) are displayed in magenta and manual modes in cyan.

For detailed information, refer to Chapter 18 – Power plant – Controls and indications.

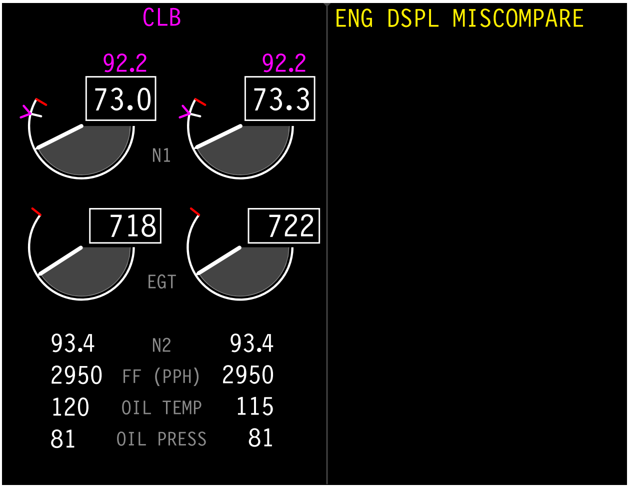
The fuel indications show the total fuel and the fuel quantities (in lbs) in each tank (left main tank, center tank, and right main tank). A crossfeed arrow is displayed when fuel transfer occurs automatically or is manually selected, and indicates the direction of the flow (refer to Figure 08–05–16).

For detailed information, refer to Chapter 11 – Fuel – Indications.

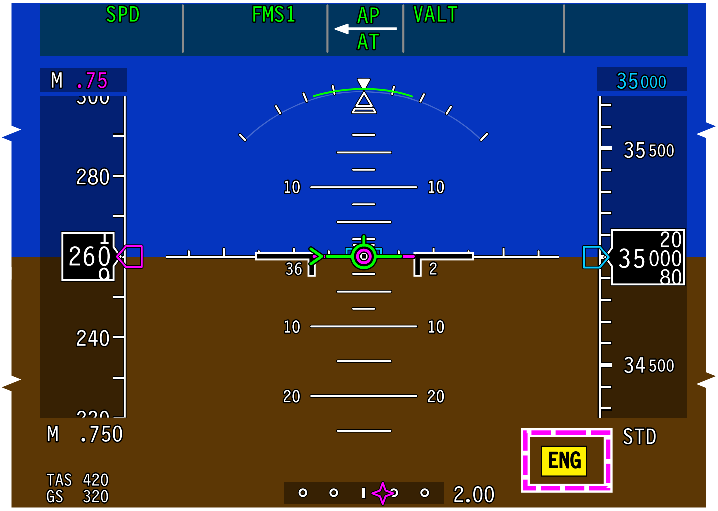


EICAS page – Fuel indication section
Figure 08–05–16

All DUs receive, process, and compare engine data, but only one DU displays the engine data. When engine data differs between the DUs, an ENG message is displayed on the PRDs, an ENG message is displayed on the PFDs, and the **ENG DSPL MISCOMPARE** EICAS caution message is displayed on the EICAS page (refer to Figure 08–05–17).



EICAS PAGE



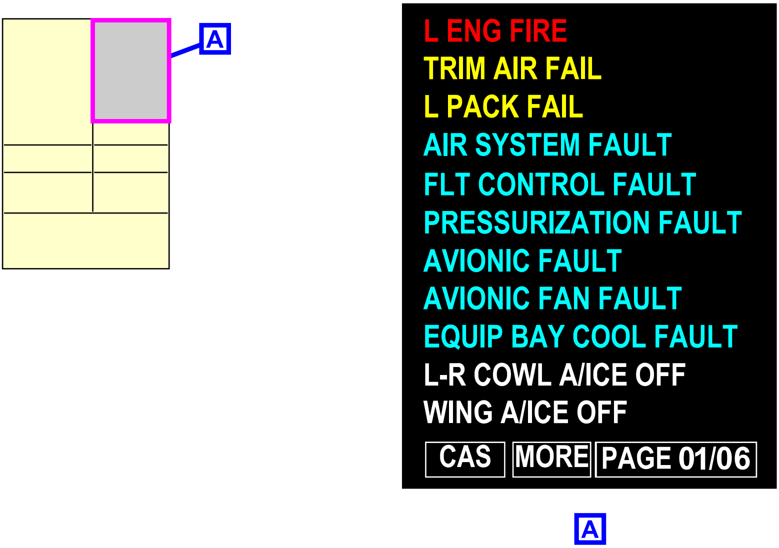
ADI

ENG miscompare indication
Figure 08–05–17

C. Crew alerting section

The crew alerting section displays up to 18 EICAS messages. When the landing gear, flap, and spoiler indications are shown, a maximum of 12 messages will be displayed.

If there are more than 18 messages (or more than 12 if trim section is shown), pages will be added to show the list of messages. When this occurs, there is a PAGE indication at the bottom of the crew alerting section to show that there are extra pages. The pages will be accessible with the CAS switch on the MKP (refer to Figure 08–05–18).



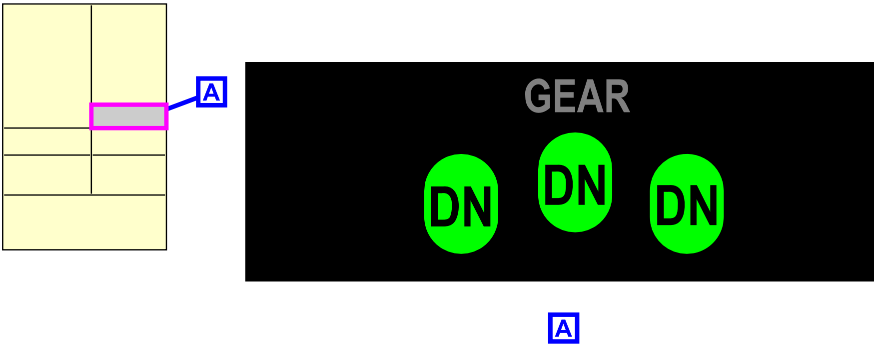
EICAS page – Crew alerting section
Figure 08–05–18

D. Configuration and trim indication section

The configuration and trim indication section shows:

- Landing gear position and status (refer to Figure 08–05–19),
- Slat and flap position and status, and
- Aileron, rudder, and horizontal stabilizer trim positions.

The GEAR indication gives the status and position of the landing gear. The indications for each of the three landing gear are independent. The gear indication will disappear when the landing gear is confirmed up and locked for 30 seconds. It will reappear when the landing gear is selected down or if there is a malfunction.



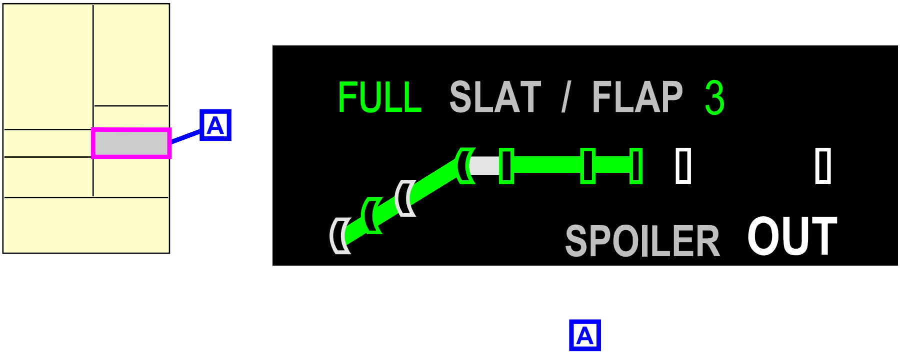
EICAS page – GEAR indication section
Figure 08–05–19

For detailed information, refer to Chapter 14 – Landing gear – Controls and indications.

The slat/flap indications disappear 30 seconds after the landing gear is up and locked and the slats are retracted.

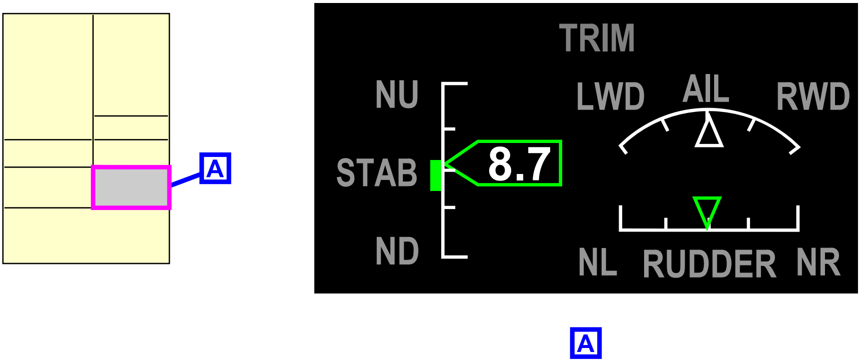
The EICAS SLAT/FLAP indication displays the selected position (lever), and the actual slat/flap position (refer to Figure 08–05–20).

During spoiler extension, the SLAT/FLAP indication will appear (if not already displayed) with the SPOILER OUT or SPOILER MAX indication.

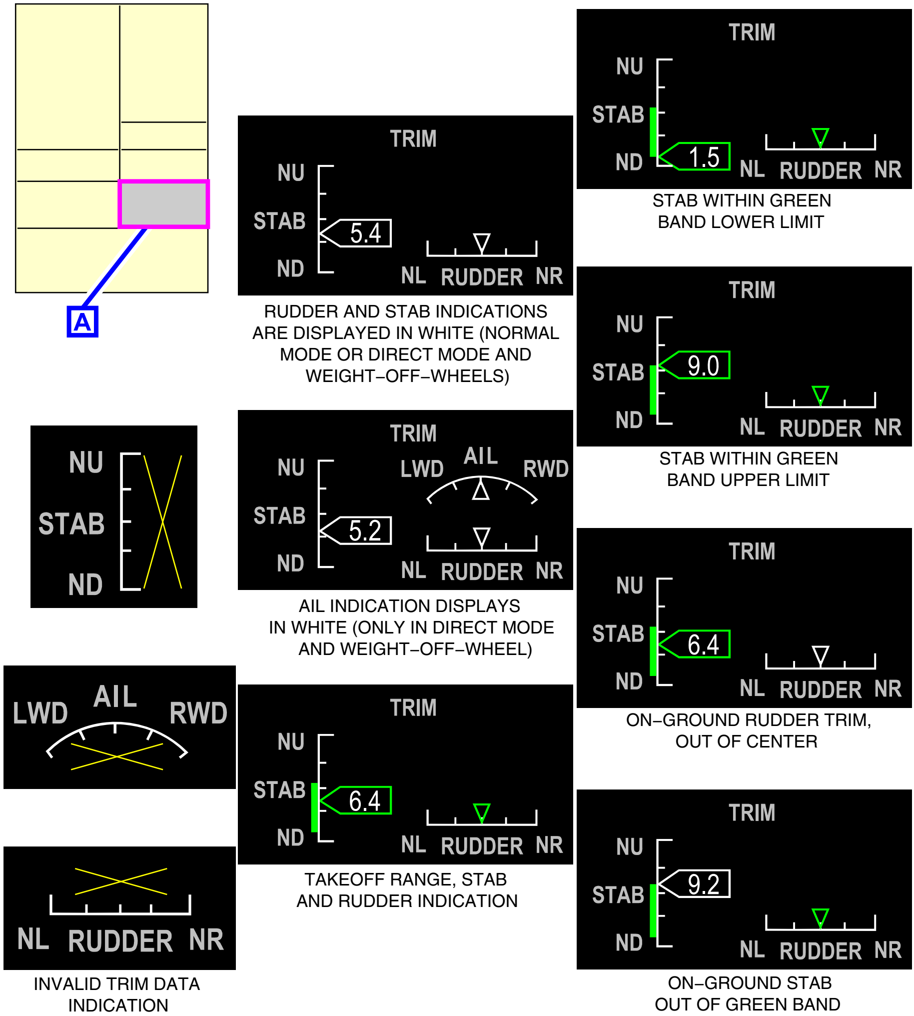


EICAS page – SLAT / FLAP indication section
Figure 08–05–20

The TRIM section includes stabilizer trim (STAB), aileron trim (AIL), and rudder trim (RUDDER) indications (refer to Figure 08–05–21 and Figure 08–05–22). Stabilizer trim (STAB) and rudder trim (RUDDER) indications are displayed only when valid data is available. Aileron trim (AIL) data is displayed only in direct mode.



EICAS page – TRIM indication section
Figure 08–05–21



DIFFERENT CONFIGURATION INDICATIONS
A

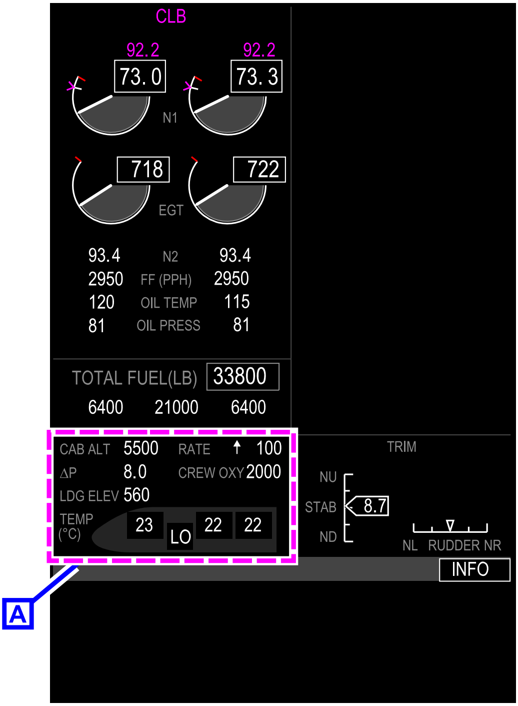
EICAS page – TRIM indication section legend
Figure 08–05–22

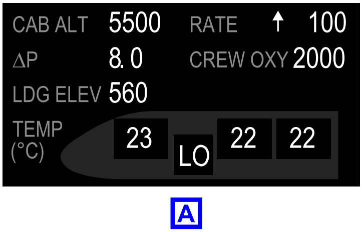
For detailed information, refer to Chapter 10 - Flight controls- Primary Flight Controls - Indications.

E. Cabin air section

The air section (refer to Figure 08–05–23) shows:

- Cabin altitude (CAB ALT), cabin climb rate (RATE), and differential pressure (∆P),
- Oxygen quantity,
- Landing elevation (LDG ELEV), and
- Flight compartment, cabin, and forward cargo compartment temperatures.





EICAS page – Cabin air indication section
Figure 08–05–23

For detailed information about cabin pressurization, refer to Chapter 02 – Air-conditioning, bleed air and pressurization – Pressurization system – Controls and indications.

For detailed information about the oxygen system, refer to Chapter 17 – Oxygen and emergency equipment – Controls and indications.

F. Communication section

The communication section (refer to Figure 08–05–24) has a dedicated zone for communication composed of flags and, if available, the Controller–Pilot Data Link Communications (CPDLC) zone.

The upper shaded area of the communication section displays the communication flags that follow:

- CABIN – Cyan or amber, or READY in green,
- DOOR – Cyan with black background,
- DLK – Cyan,
- CPDLC – Cyan, <23249001C>
- SATCOM – Cyan, and <23150006C>
- INFO – Boxed white with black background.

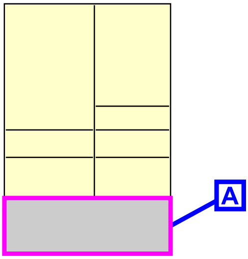
The lower area displays CPDLC messages. <23249001C>

All communication flags (except INFO) flash for 5 seconds when initially posted and then become steady.

NOTE

Communication flags are replaced by an EICAS message when the EICAS page is compressed, except for DOOR and INFO flags.

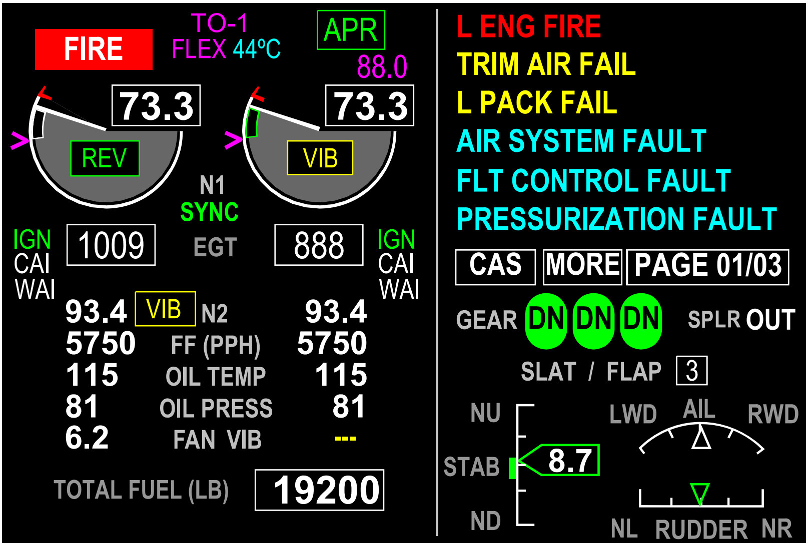
For detailed information, refer to Communication – Controls and indications – Indications.



Communication section
Figure 08–05–24

G. Compressed EICAS page

The compressed EICAS format displays EICAS information on a quarter of the DU screen if there are multiple DU failures (refer to Figure 08–05–25).

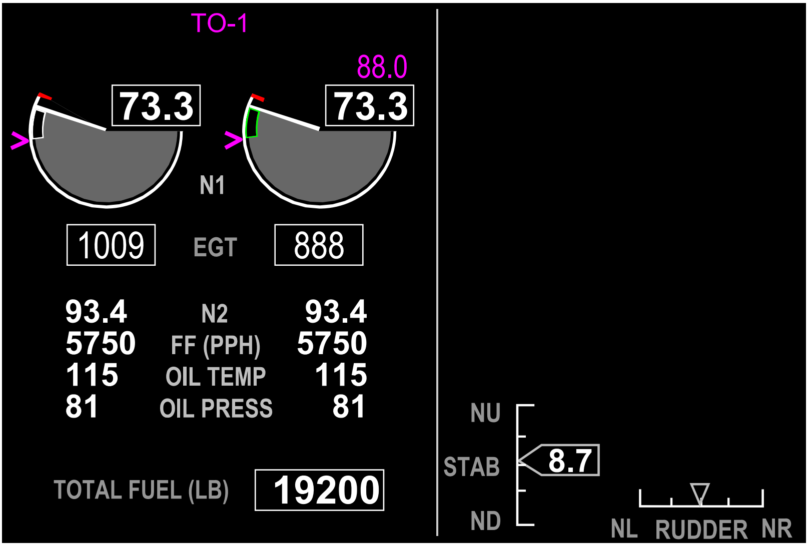


EICAS primary page (graphical layout) – Compressed (cluttered)
Figure 08–05–25

In the compressed EICAS page (refer to Figure 08–05–26), the information is modified as follows:

- EGT shows as digital readout,
- Relocation of engine flags,
- Total fuel only shows,
- Communication flags are replaced by EICAS messages, and
- Cabin air section does not show.

The compressed EICAS format can be manually selected by turning the DISPLAY switch to REV on the Reversion Switch Panel (RSP) (if two or more DUs are failed).



EICAS page – Compressed (cluttered)
Figure 08–05–26

TAKEOFF CONFIGURATION WARNING

The takeoff configuration warning system sends warning messages when takeoff is initiated while the aircraft is not properly configured.

The system monitors for:

- Horizontal stabilizer trim position,
- Rudder trim position,
- Sidestick priority,
- Flaps settings,
- Spoiler positions,
- Autopilot setting, and
- Parking brake setting.

The takeoff configuration warning is triggered when the Thrust Lever Angle (TLA) is above 23 degrees and indicated N_1 is above 55% on both engines. At sea level condition, a 23-degree TLA will occur with an N_1 of 68%. At that time, an aural message sounds, accompanied by an EICAS warning message. The warning message indicates that the item is not correctly set for takeoff.

ITEM	CONDITION	EICAS MESSAGE	AURAL MESSAGE
Rudder trim	Not in T/O range (out of the green arc).	CONFIG RUDDER TRIM	"CONFIG TRIM"
Elevator trim	Not in T/O range (out of the green arc).	CONFIG STAB TRIM	"CONFIG TRIM"
Sidestick	One sidestick priority latched at takeoff.	CONFIG SIDE-STICK	"CONFIG SIDE-STICK"
Flaps	Flaps not set for takeoff.	CONFIG FLAP	"CONFIG FLAP"
Spoilers	Spoilers not stowed.	CONFIG SPOIL-ER	"CONFIG SPOILER"
Autopilot	Autopilot engaged on takeoff.	CONFIG AP	"CONFIG AUTOPILOT"
Parking brake	Not in T/O range (out of the green arc).	CONFIG BRAKE	"CONFIG BRAKE"

AURAL ALERTS

Aural alerts include tones, chimes, and voice messages. Some aural tones can be manually cancelled.

TONE	DESCRIPTION
A-chord	Overspeed.
Double beep	Pitch trim reached running time limit (3 seconds).
Triple chime	Warning message.

TONE	DESCRIPTION
Single chime	Caution message.
Horn	Any gear not down.
Cavalry charge	Autopilot disconnect.
Single C-chord	Altitude alert.
Double C-chord	Vertical track alert.
Voice message	EICAS warning, TAWS, TCAS.

The order of priority for aural alerts is:

- “STALL” warning aural alert,
- “TAWS” aural alert,
- “TCAS” aural alert, and
- All other voice alerts.

A. Aural test

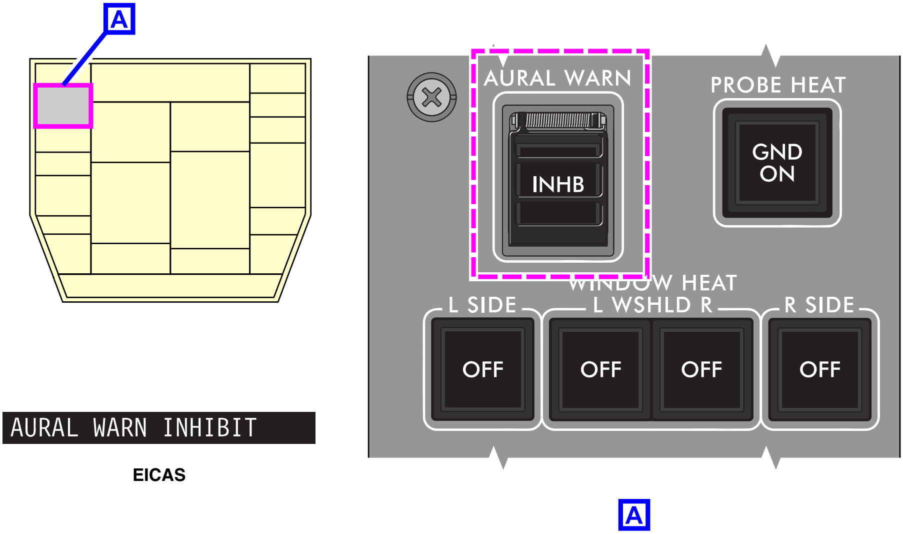
A test function is provided for aural alerts. The test is initiated by selecting the AURAL soft switch on the AVIO tab on the AVIONIC synoptic page. The test should sound the “AURAL WARNING TEST 1” and “AURAL WARNING TEST 2” aural messages. At the end of the test, DONE will be displayed next to the AURAL soft switch.

MESSAGE	DESCRIPTION
DONE	Test sequence completed.
PRESS TO STOP	Test has to be terminated.
IN PROG	Test in progress.
––––	Test invalid.

B. Aural Inhibit

The aural inhibit function allows all aural alerts to be silenced if there is a malfunction or failure of the aural system (EICAS, TAWS, Gear horn, etc.).

When the guarded AURAL WARN switch on the overhead panel is pushed (refer to Figure 08–05–27), all aural alerts are inhibited. A white INHB label is illuminated, and an AURAL WARNING INHIBIT status message is displayed on the EICAS page. Pushing the guarded AURAL WARN switch again cancels the aural inhibit.



Aural inhibit switch/light
Figure 08–05–27

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AIR DATA SYSTEM (ADS) – GENERAL

A. Overview

The Air Data System (ADS) supplies the flight parameters that follow to the aircraft systems:

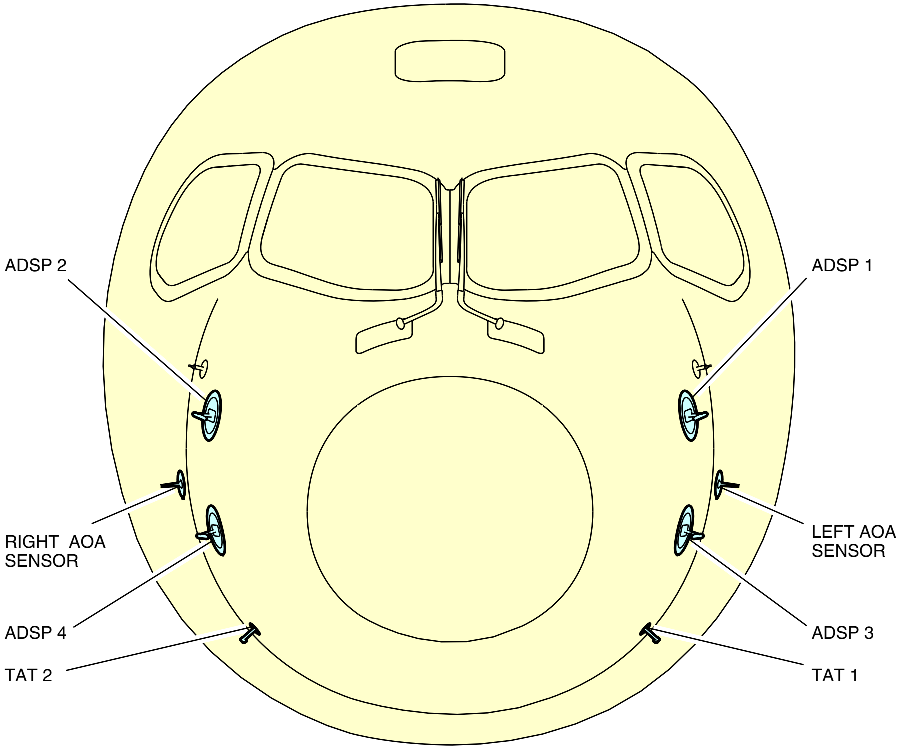
- Static pressure,
- Pitot pressure,
- Angle-Of-Attack (AOA), and
- Outside temperature.

The system uses:

- Four independent Air Data System Probes (ADSPs) to measure air pressure (dynamic and static) and angle of attack,
- Two Angle-Of-Attack (AOA) sensors, and
- Two Total Air Temperature (TAT) probes.

The ADSPs, AOA sensors, and the TAT probes are symmetrically installed on each side of the nose of the aircraft, below the flight deck windows (refer to Figure 08–07–1).

ADS malfunction messages are displayed on the EICAS page.



ADSP, AOA, TAT location
Figure 08–07–1

B. Air Data System Probes (ADSPs)

Each Air Data System Probe (ADSP) includes an air data computer that is fixed to the base of the probe mount (pitot tube). As a result, sensed air data is processed by each ASDP and routed to user systems as digital data.

The pitot port, located on the forward end of the ADSP, measures total air pressure for airspeed indications. Static air pressure is measured by two static ports on each side of the ADSPs are installed aft of the pitot port.

The static ports are also used to calculate Angle Of Attack (AOA). As the AOA changes, the pressure sensed at the different static ports also changes. The ADSP compares static port pressures and calculates the angle of attack.

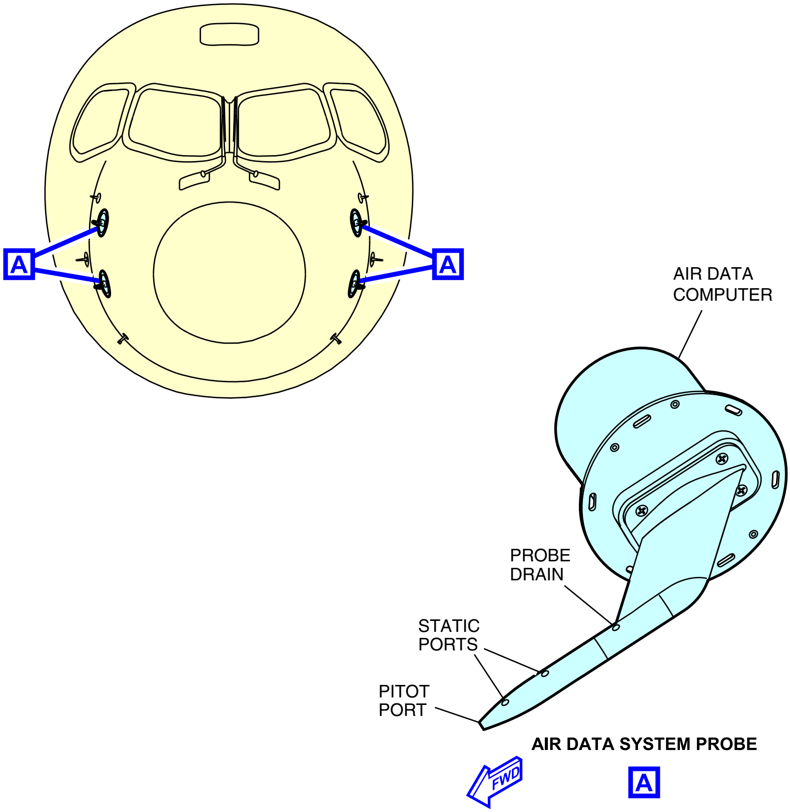
The rear pair of static ports provide static pressure for sideslip compensation and redundant sensing. Drain holes provide drainage for any trapped moisture.

A heater installed in each ADSP provides anti-ice protection.

Each ADSP is specific and supplies data to a specific location:

- ADSP 1 is on the top left side of the fuselage and provides data to the left PFD.
- ADSP 2 is on the top right side and provides data to the right PFD.
- ADSP 3 is on the lower left side and provides data to the Integrated Standby Instrument (ISI).
- ADSP 4 is on the lower right side and is used if there is an ADSP failure.

Figure 08–07–2 shows the air data system.



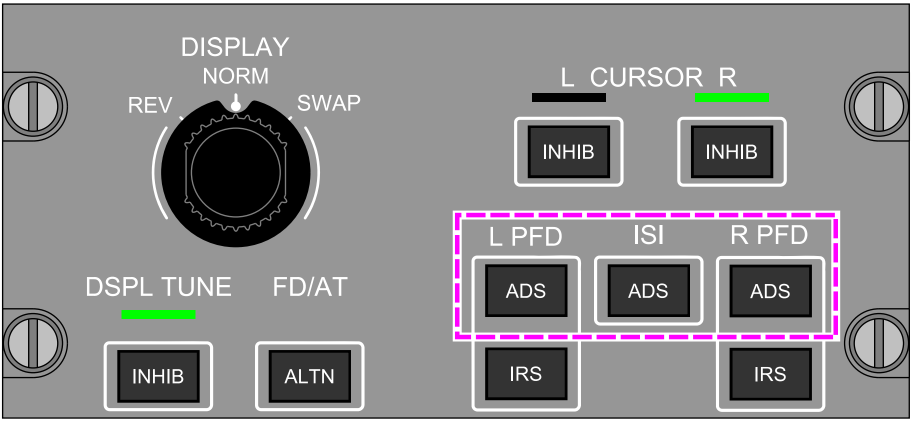
Air Data System Probes (ADSPs)
Figure 08–07–2

(1) Reversion

If an air data source fails, the affected display (left PFD, right PFD, or the ISI) switches to an alternate air data source.

The left PFD, right PFD, or ISI air data source can be changed by pushing the associated Air Data Source (ADS) switch on the Reversion Switch Panel (RSP) (refer to Figure 08–07–3). Pushing the selected ADS switch cycles through the air data sources for the affected display.

Affected display	Normal source	Alternate source 1	Alternate source 2	Alternate source 3
Left PFD	ADSP1	ADSP4	ADSP2	ADSP3
Right PFD	ADSP2	ADSP4	ADSP1	ADSP3
ISI	ADSP3	ADSP4	–	–



Reversion switch panel
Figure 08–07–3

(2) Indications

When the PFDs and the ISI use their normal air data source, no indication is displayed. When a PFD uses an alternate air data source, the source is displayed in white on the PFD (refer to Figure 08–07–4).

ADI

ADS 1 FAIL

EICAS ADVISORY MESSAGE

Air data source reversion indication
Figure 08–07–4

When both PFDs use the same air data source, the source is displayed amber on the PFD and the **ADS SAME SOURCE** caution message is displayed on the EICAS page (refer to Figure 08–07–5).

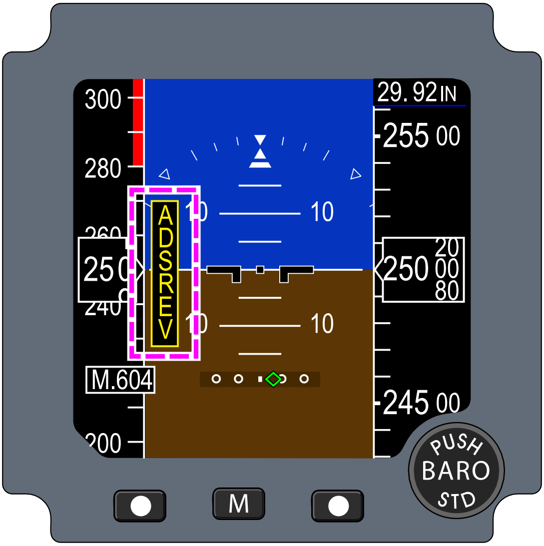
ADI

ADS SAME SOURCE

EICAS CAUTION MESSAGE

Reversion with same air data source
Figure 08–07–5

When the ISI uses an alternate air data source, an amber ADSREV is displayed on the ISI (refer to Figure 08–07–6).

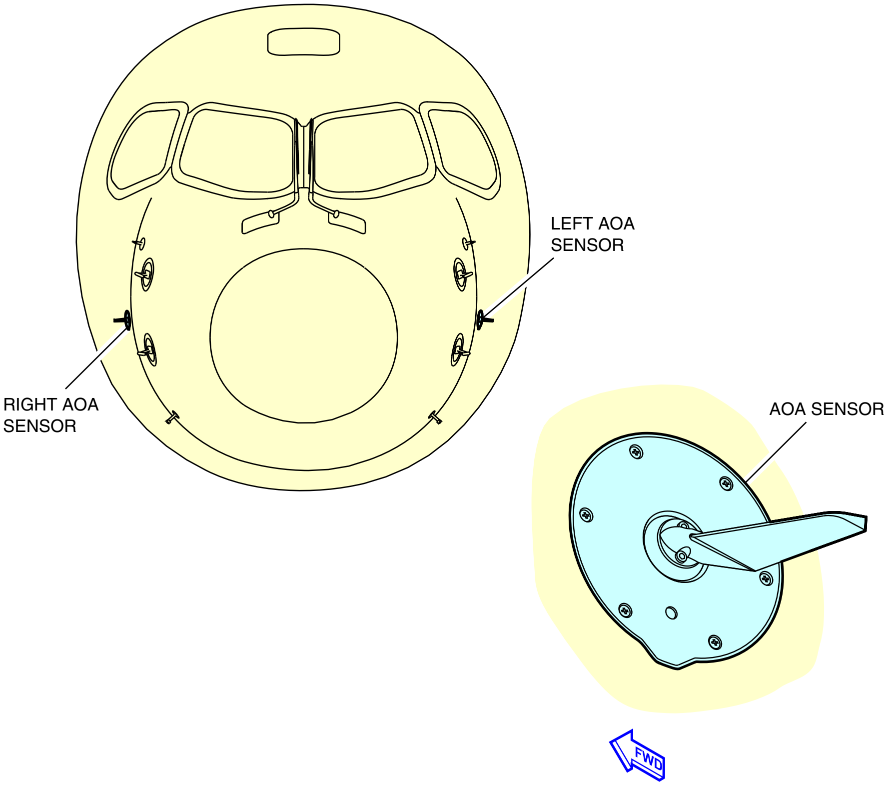


ISI air data source reversion
Figure 08–07–6

The indications are the same for automatic and manual reversion.

C. Angle Of Attack (AOA) vanes

There are two Angle Of Attack (AOA) vanes installed on the aircraft, one on each side of the nose fuselage, just behind the corresponding pair of ADSPs (refer to Figure 08–07–7). They supply angle-of-attack information and are a backup for the ADSPs.



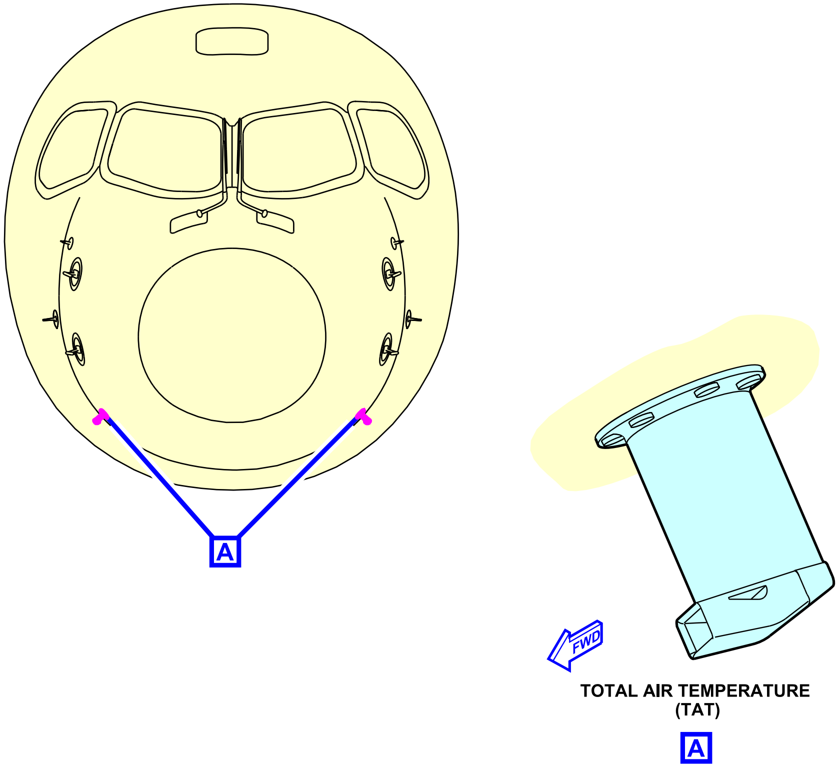
Angle–of–Attack (AOA) sensor
Figure 08–07–7

D. Total air temperature probe

There are two Total Air Temperature (TAT) probes (TAT 1 and TAT 2) installed on the aircraft, one on each side of the fuselage below the ADSPs (refer to Figure 08–07–8).

These probes supply TAT and Static Air Temperature (SAT) data, which is displayed on the PFDs and on the STATUS page.

If a single TAT probe fails, the ADS uses the same side engine TAT. If the engine TAT probe fails, the ADS uses the opposite side engine TAT. If both TATs fail, the ADS uses the opposite side fuselage TAT probe.



Total Air Temperature (TAT) probe
Figure 08–07–8

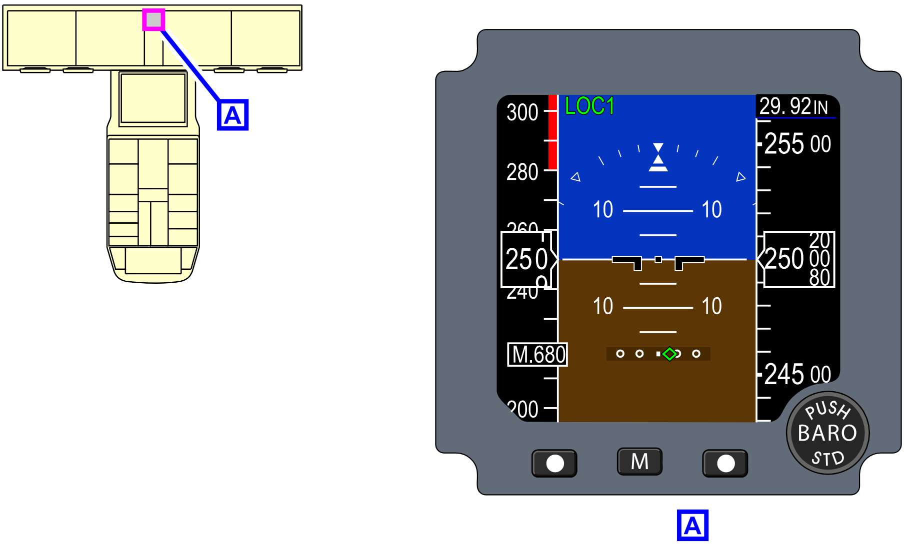
ISI – GENERAL

A. Overview

The Integrated Standby Instrument (ISI) supplies the information necessary to fly the aircraft when there is only emergency power (battery or RAT) available and no other display systems are available. The ISI is located on the main instrument panel (refer to Figure 08–08–1).

The ISI displays the flight parameters that follow:

- Aircraft attitude (pitch and roll),
- Slip/skid indication,
- Air data (airspeed (Mach), altitude), and
- Navigation display (localizer/glideslope).



Integrated Standby Instrument (ISI)
Figure 08–08–1

B. Attitude display

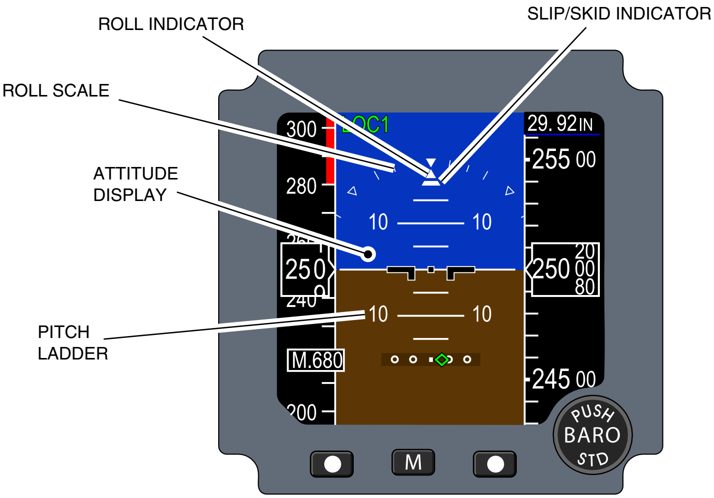
The ISI shows a sky/ground attitude display with the sky and earth separated by a white horizon line. An aircraft symbol is superimposed over the center of the attitude display.

Aircraft pitch is indicated by the pitch ladder (white pitch marks set above and below the horizon line).

Aircraft bank angle is displayed as a roll scale and a roll pointer.

The slip/skid indicator is located at the base of the roll pointer and moves laterally along the base of the triangular roll pointer. A displacement the width of the trapezoid is equivalent to approximately one ball displacement of a turn coordinator.

Figure 08–08–2 shows the attitude display.



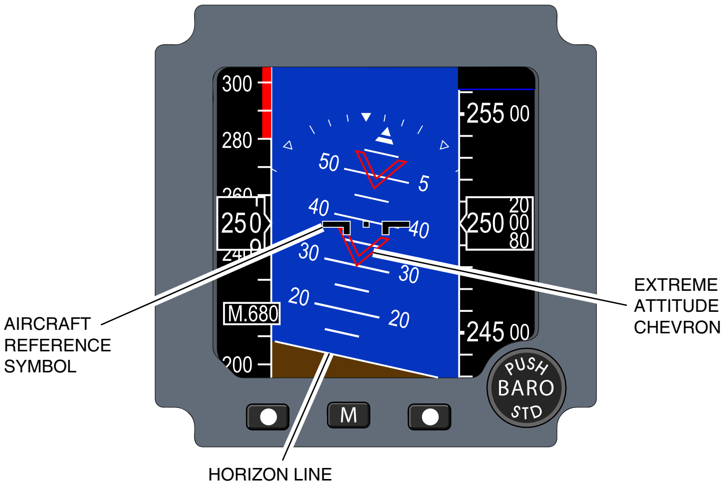
Attitude display
Figure 08–08–2

(1) Unusual attitude

When the roll angle exceeds 65 degrees or the pitch exceeds 30 degrees nose-up or 20 degrees nose-down, the ISI displays a red double-lined chevron on the pitch ladder. The pitch chevron is positioned at the +30 degrees pitch line or the –20 degrees pitch pointing upward or downward and towards the horizon line.

The display will be decluttered of all navigation data, air data source reversion indicator, and barometric adjustment readout. The barometric pressure adjustment is disabled.

Figure 08–08–3 shows the unusual attitude display.



Unusual attitude display
Figure 08–08–3

NOTE

The display is restored to normal condition when the aircraft pitch attitude is within +25 degrees pitch up or −15 degrees pitch down and/or the roll attitude is within 63 degrees to the left or to the right.

(2) Degraded attitude

An amber CROSS CHECK ATTITUDE message is displayed above the aircraft reference symbol when one of the conditions that follow occurs:

- Aircraft is operating without air data for more than 3 minutes, or
- Aircraft has exceeded 35 degrees of pitch or bank angle for more than 3 minutes.

The message flashes for 5 seconds and is then removed from the display.

Figure 08−08−4 shows the degraded attitude.

Degraded attitude
Figure 08–08–4

(3) Attitude fail

When the attitude indication fails or is missing, the changes that follow occur:

- All attitude data is removed from the display (pitch tape, roll scale, and slip/skid indicator).
- A white ATT message on a red background flashes for 5 seconds and then is steady.
- The background color changes to solid black.

Figure 08–08–5 shows the attitude display failed.

Attitude display failed
Figure 08–08–5

(4) SFIS reset

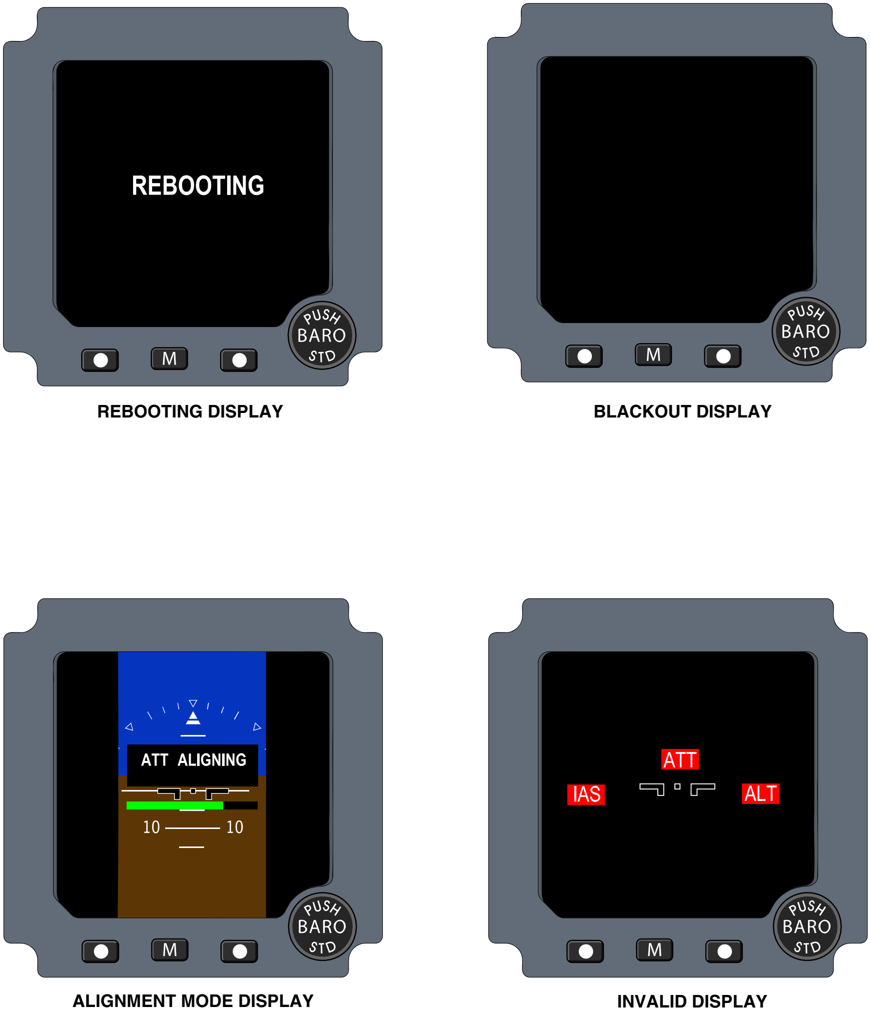
Some very unusual conditions can cause the ISI to reset (refer to Figure 08–08–6).

In flight, the displays will show as follows:

- REBOOTING (for few seconds),
- Blackout (reset/reboot and in-air BIT are executed (a few seconds)),
- Alignment mode (several minutes).

If the reset occurs on ground or the system cannot recover:

- The ALT, ATT, and IAS failed flags are displayed (ISI system invalid).



Abnormal behavior display
Figure 08–08–6

C. Air data

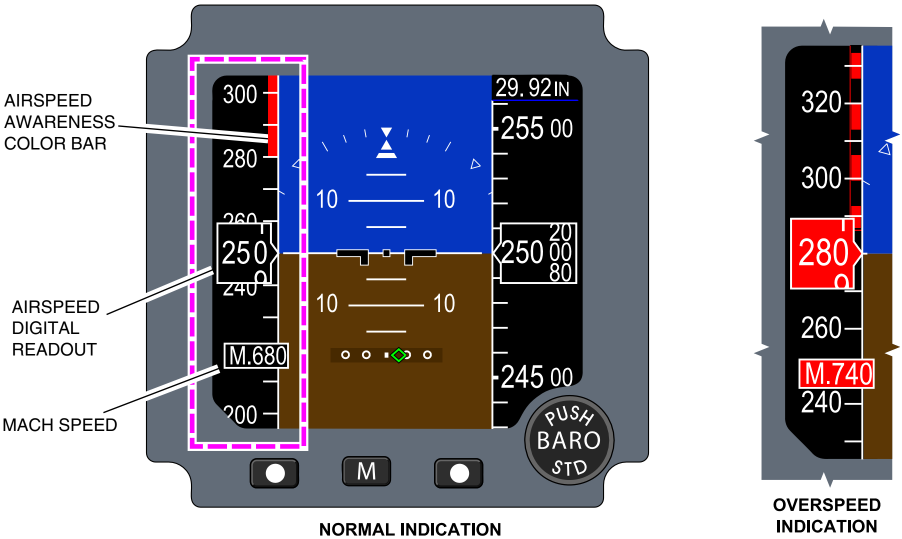
Air data includes vertical tapes for the altimeter and the airspeed indicator.

(1) Airspeed/Mach

Airspeed is indicated by an airspeed tape and an airspeed readout. When the Mach speed is greater than 0.40M, a Mach readout is displayed above the airspeed tape.

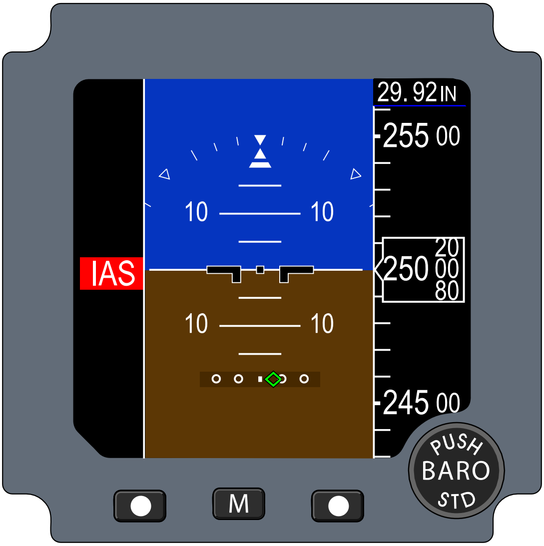
A red overspeed marker is displayed on the airspeed tape, from the appropriate limiting speed (either V_{FE}, V_{LE}, V_{MO} or M_{MO}) upward. When the airspeed exceeds the limit speed, the overspeed marker changes to a red and black checkerboard and the airspeed digital readout becomes red. If the Mach readout is displayed, the readout changes to red.

Figure 08–08–7 shows the airspeed indications.



Airspeed indications
Figure 08–08–7

If the airspeed indication fails, the airspeed tape is removed and an IAS white message on a red background is displayed. The message flashes for 5 seconds and then becomes steady (refer to Figure 08–08–8).

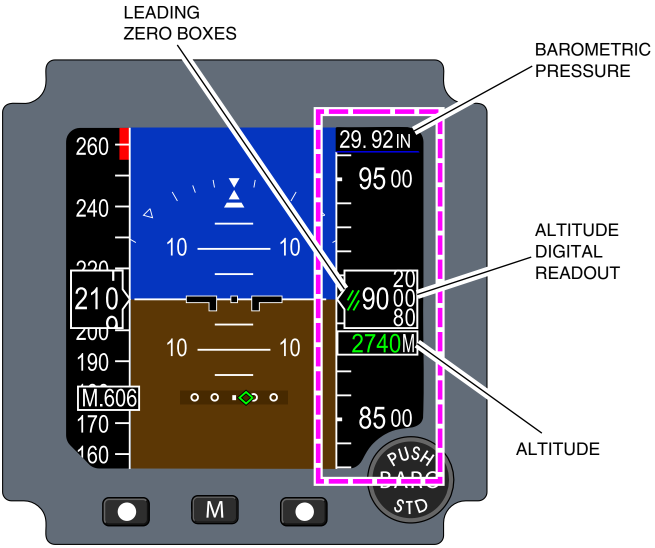


Airspeed failed
Figure 08–08–8

(2) Barometric altitude

Barometric altitude (refer to Figure 08–08–9) is displayed as a moving altitude tape on the right side of the display. A readout of the current altitude is displayed on the altitude tape. The altitude is displayed in feet or meters.

The altimeter setting is displayed above the altitude tape. It is referenced in either inches of mercury (IN) or hectopascal (HPA), as selected on the PFD altimeters. The value of the altimeter setting is adjusted by turning the BARO switch. When the BARO switch is pushed, the altimeter is set to standard barometric pressure (29.92 IN or 1013.2 HPA) and the legend STD is displayed instead of the numerical value. Subsequent use of the BARO switch will display the actual altimeter setting.



Altitude display
Figure 08–08–9

If the altitude indication fails, the altitude symbology (altitude tape, altitude readout) is removed and an ALT white message on a red background is displayed (refer to Figure 08–08–10). The message flashes for 5 seconds and then becomes steady.

Altitude fail indication
Figure 08–08–10

D. Navigation display

When the NAV mode is activated, the ISI displays course guidance for ILS/LOC approach. Based on the VHF NAV frequency selected (LOC), the ISI displays horizontal and vertical guidance scales.

The navigation information is displayed only if the NAV mode is selected ON.

Figure 08–08–11 shows the navigation display.

ILS/DME MODE

Navigation display
Figure 08–08–11

If the approach aid source is lost or invalid, the lateral and vertical (if applicable) deviation bars are removed and a LOC and/or GS white message on a red background displays.

Figure 08–08–12 shows the Nav/Approach fail indications.

ILS/DME FAIL

Nav/Approach fail indication
Figure 08–08–12

E. Controls and indications

The ISI includes the controls that follow:

- M (menu) switch,
- Left (UP) and right (DN (down)) switches on each side of the M switch, and
- BARO switch, which adjusts the parameters specific to the displayed mode.

(1) Menu functions

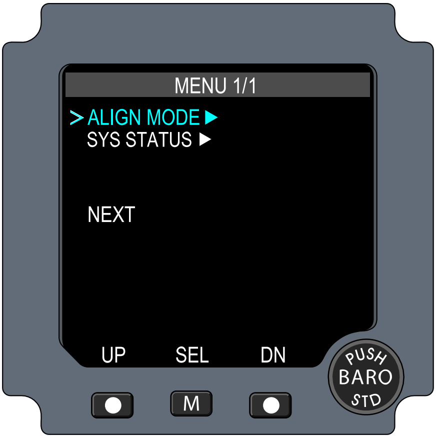
When the M (menu) switch is pushed, the ISI menu is displayed. On the ground, the menu occupies the total surface of the ISI. In the air, the menu occupies the bottom surface of the ISI and displays fewer items.

The left (UP) and right (DN) switches are used to select the desired menu items.

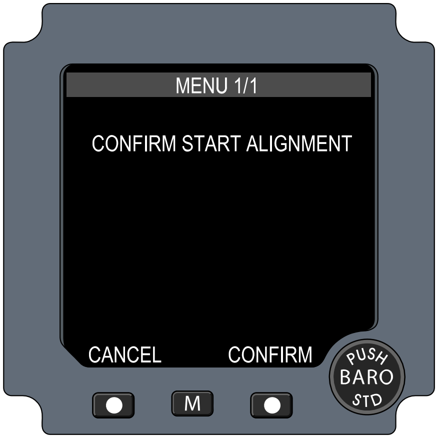
The main menu item is:

- ALIGN MODE – Starts manual alignment using the M switch.

Figure 08–08–13 shows the ISI menu.



ON-GROUND MENU



ON-GROUND MENU

IN-AIR MENU

IN-AIR MENU

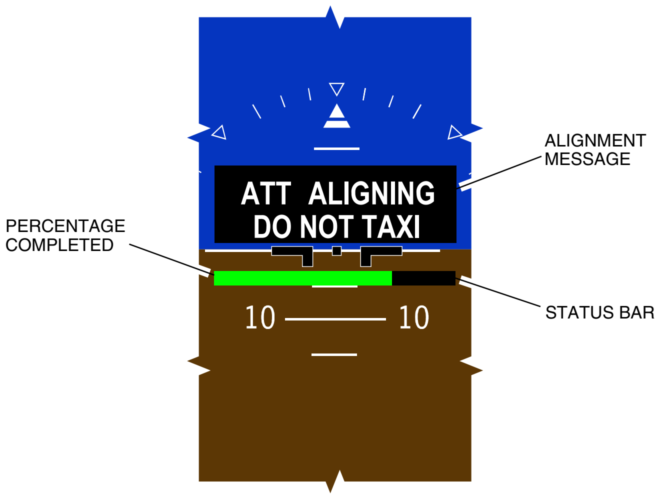
ISI menu
Figure 08–08–13

(2) Alignment

On the ground during ISI alignment (refer to Figure 08–08–14), an ATT ALIGNING DO NOT TAXI message is displayed above the aircraft reference symbol and a status bar tracks alignment progress. During alignment in flight, only the ATT ALIGNING message is displayed (refer to Figure 08–08–15).

During alignment, navigation data is not displayed. The menu can be accessed while the ISI aligns.

The ISI can be manually aligned by selecting ALIGN MODE on the menu.



Alignment on ground
Figure 08–08–14

ALIGNMENT

Alignment in–air
Figure 08–08–15

CAUTION

In-air alignment should only be done during straight and level flight without acceleration.

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EDS – EICAS MESSAGES

A. Warning messages

None

B. Caution messages

Message	Description	Inhibit
ADS 3 FAIL	Loss of data or internal failure of Air Data System No. 3.	TO, LDG
ADS 1 SLIPCOMP FAIL	Sideslip Compensation capability (cross and diagonal) is lost on ADSP 1. To avoid dual EICAS caution message, inhibited if reversion to Estimated Beta is due to cross–side PROBE HEAT FAIL.	TO, LDG
ADS 2 SLIPCOMP FAIL	Sideslip Compensation capability is lost on ADSP 2. To avoid dual EICAS caution message, inhibited if reversion to Estimated Beta is due to cross–side PROBE HEAT FAIL.	TO, LDG
ADS 3 SLIPCOMP FAIL	Sideslip Compensation capability is lost on ADSP 3. To avoid dual EICAS caution message, inhibited if reversion to Estimated Beta is due to cross–side PROBE HEAT FAIL.	TO, LDG
ADS 4 SLIPCOMP FAIL	Sideslip Compensation capability is lost on ADSP 4. To avoid dual EICAS caution message, inhibited if reversion to Estimated Beta is due to cross–side PROBE HEAT FAIL.	TO, LDG
ADS-B OUT FAIL	ADS-B function unavailable due to loss of GPS input at both transponder level.	TO, LDG

Message	Description	Inhibit
ADS-B 1 OUT FAIL	XPDR 1 is the selected XPDR and has declared an ADS-B out function failed (both GPS input invalid).	TO, LDG
ADS-B 2 OUT FAIL	XPDR 2 is the selected XPDR and has declared an ADS-B out function failed (both GPS input invalid).	TO, LDG
ADS ISI PROBE FAIL	ADSP 3 and ADSP 4 combined heater failure.	TO, LDG
ADS ISI SLIPCOMP FAIL	Sideslip Compensation capability is lost on ADSP 3 and ADSP 4.	TO, LDG
ADS SAME SOURCE	Two displays are using the same source of air data.	TO, LDG
AURAL WARN FAIL	Aural warning alerts failed.	TO
DMC 1 FAIL	Data Module Cabinet (DMC) channel 1A and 1B failed.	TO, LDG
DMC 2 FAIL	DMC channel 2A and 2B failed.	TO, LDG
DUAL ADS FAIL	Two ADS sources are failed.	TO, LDG
EFIS COMPARATOR FAIL	Electronic Flight Instrument System (EFIS) comparator has failed.	TO, LDG
EFIS MISCOMPARE	Data source parameters miscompare between the PFDs.	TO, LDG
ENG DSPL MISCOMPARE	Engine parameters do not agree between the Primary Flight Displays (PFDs).	TO, LDG
IPC 1 FAIL	Integrated Processing Cabinet (IPC) 1 has failed.	TO, LDG
IPC 2 FAIL	IPC 2 has failed.	TO, LDG
IPC 3 FAIL	IPC 3 has failed.	TO, LDG

Message	Description	Inhibit
IPC 4 FAIL	IPC 4 has failed.	TO, LDG
RAD ALT FAIL	Lost of radio altimeter function.	TO, LDG

C. Advisory messages

Message	Description	Inhibit
ADS FAULT	Lost of redundant or non-critical function for the Air Data System (ADS) system.	TO, LDG
ADS 1 DEGRADED	Static Source Error Connection (SSEC) correction lost and based on default input value(s) for ADS 1 – Includes loss of Angle Of Attack (AOA) offset.	TO, LDG
ADS 2 DEGRADED	SSEC correction lost and based on default input value(s) for ADS 2 – Includes loss of AOA offset.	TO, LDG
ADS 3 DEGRADED	SSEC correction lost and based on default input value(s) for ADS 3 – Includes loss of AOA offset.	TO, LDG
ADS 4 DEGRADED	SSEC correction lost and based on default input value(s) for ADS 4 – Includes loss of AOA offset.	TO, LDG
ADS 1 FAIL	Loss of ADS 1 channel.	TO, LDG
ADS 2 FAIL	Loss of ADS 2 channel.	TO, LDG
ADS 4 FAIL	Loss of ADS 4 channel.	TO, LDG
ADS MAINT MODE ACTIVE	Any of the ADS is in maintenance mode.	TO, LDG

Message	Description	Inhibit
CAS MISCOMPARE	EICAS processing logic for one particular message in disagreement between Data Module Cabinet (DMC) channels. (Miscompare is done for warning, caution, advisory, caution and aurals)	TO, LDG
DMC 1A FAIL	DMC channel 1A failure.	TO, LDG
DMC 1B FAIL	DMC channel 1B failure.	TO, LDG
DMC 2A FAIL	DMC channel 2A failure.	TO, LDG
DMC 2B FAIL	DMC channel 2B failure.	TO, LDG
RAD ALT 1 FAIL	Radio altimeter system 1 failure.	TO, LDG
RAD ALT 2 FAIL	Radio altimeter system 2 failure.	TO, LDG
RAD ALT 3 FAIL	Radio altimeter system 3 failure.	TO, LDG

D. Status messages

Message	Description	Inhibit
A/C MAINTENANCE SW	Maintenance switch in UPLOAD or MAINT position.	None
AURAL WARN INHIB	Aural system has been disabled manually.	None
CTP OVERRIDE	Left or right Control Tuning Panel (CTP) override through avionics EICAS page.	None
CURSOR INHIB	Left or right cursor is inhibited.	None

CHAPTER 9 – FIRE AND OVERHEAT PROTECTION

List of figures

APU FIRE PROTECTION

CARGO COMPARTMENT FIRE PROTECTION

EQUIPMENT BAY SMOKE DETECTION

MAIN LANDING GEAR OVERHEAT DETECTION

LAVATORY FIRE PROTECTION

CONTROLS AND INDICATIONS

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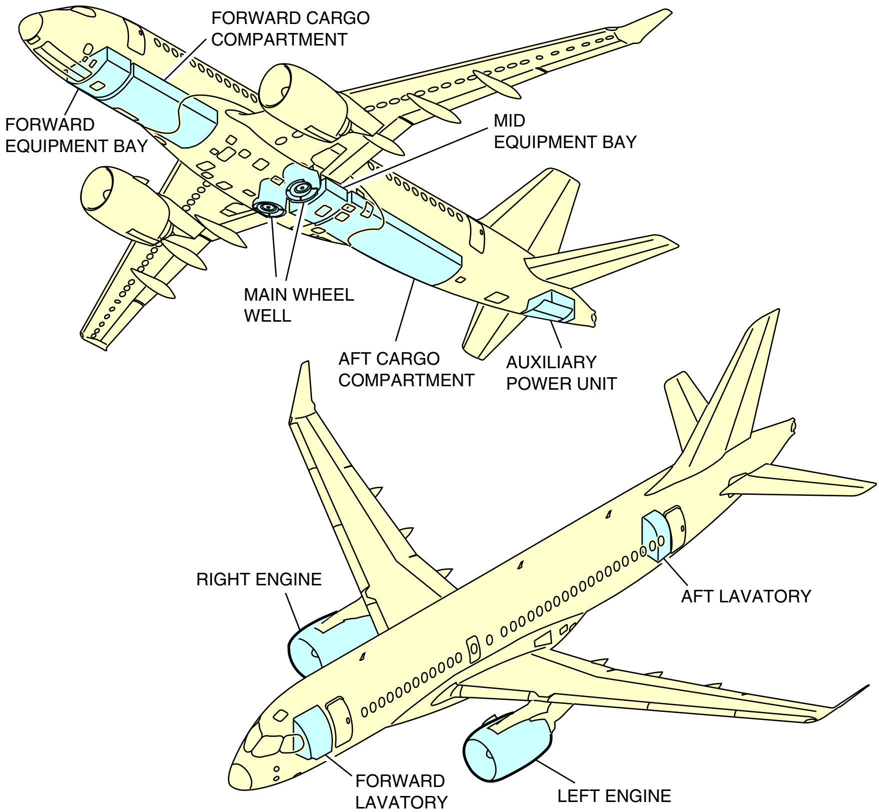
FIRE AND OVERHEAT PROTECTION SYSTEM – OVERVIEW

The Fire Detection and Extinguishing (FIDEX) system provides monitoring, warning and fire-extinguishing capabilities in specific areas (refer to Figure 09–01–1) of the aircraft.

The specific areas includes the following:

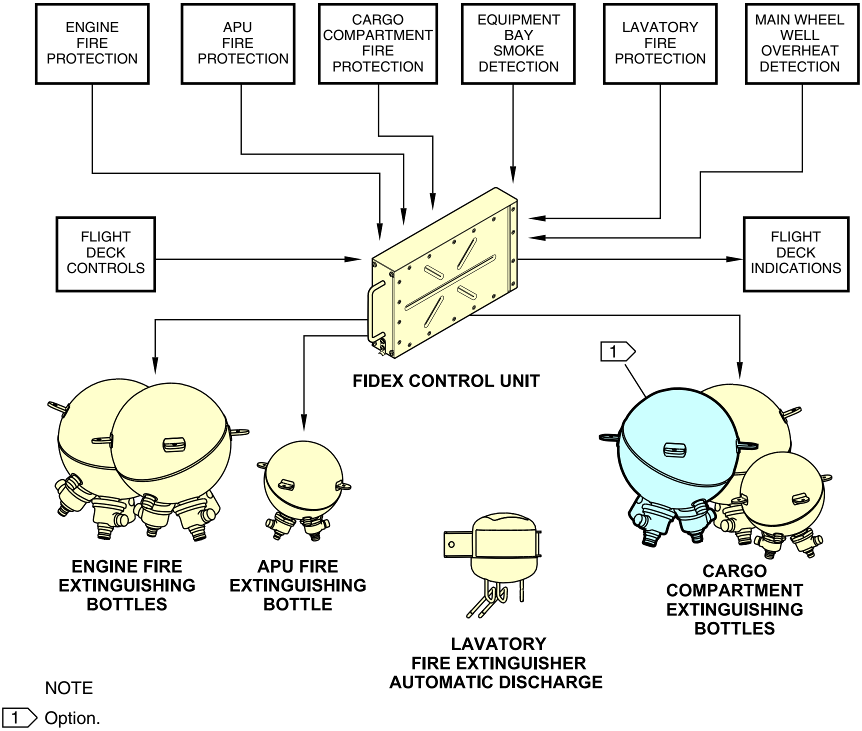
- Engine fire protection,
- Auxiliary Power Unit (APU) fire protection,
- Cargo compartment fire protection,
- Equipment bay smoke detection (no fire extinguishing available),
- Main landing gear overheat detection (no fire extinguishing available), and
- Lavatory fire protection.



Fire protection location
Figure 09–01–1

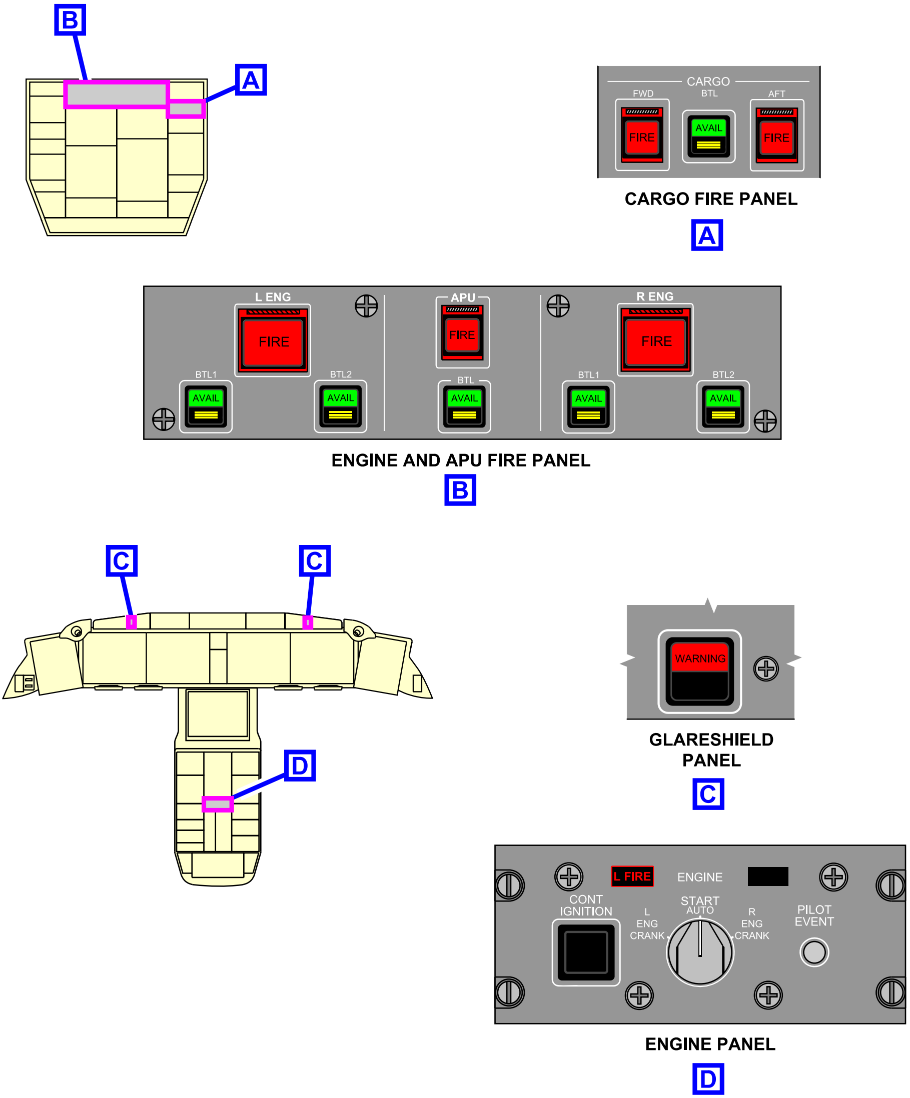
The central component of the FIDEX (refer to Figure 09–01–2) is a dual-channel control unit. Channel A is powered by DC ESS BUS 1 while channel B is powered by the DC ESS BUS 2. The fire extinguishers are powered by BATT DIR BUS 1 and 2.

The control unit monitors and controls all aspects of the FIDEX and uses the EICAS page to alert the flight crew of smoke, overheat and fire conditions, or system faults.



FIDEX control unit and associated sub–systems
Figure 09–01–2

FIDEX controls are located on the ENGINE and APU fire panel and on the CARGO fire panel (refer to Figure 09–01–3).



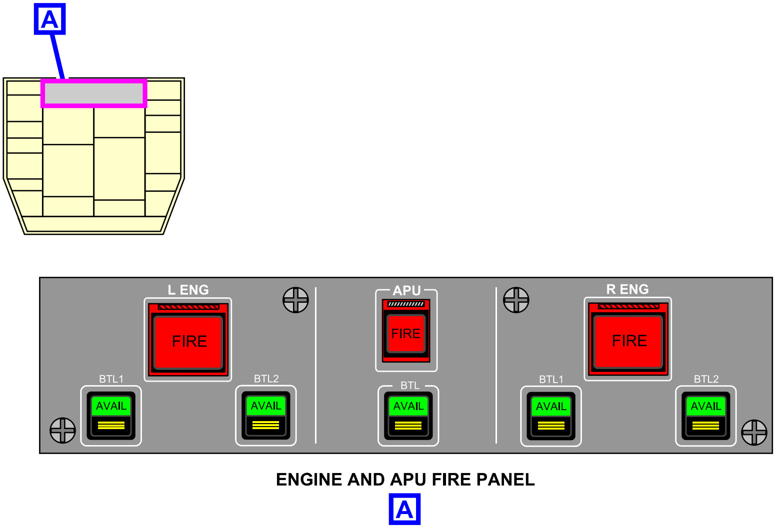
FIDEX control panels
Figure 09–01–3

ENGINE FIRE PROTECTION – OVERVIEW

The engine fire protection system consists of:

- Dual fire detection loops,
- EICAS and aural alerting, and
- Two fire-extinguishing bottles.

Fire extinguishing is accomplished through the engine and APU fire panel (refer to Figure 09–02–1).

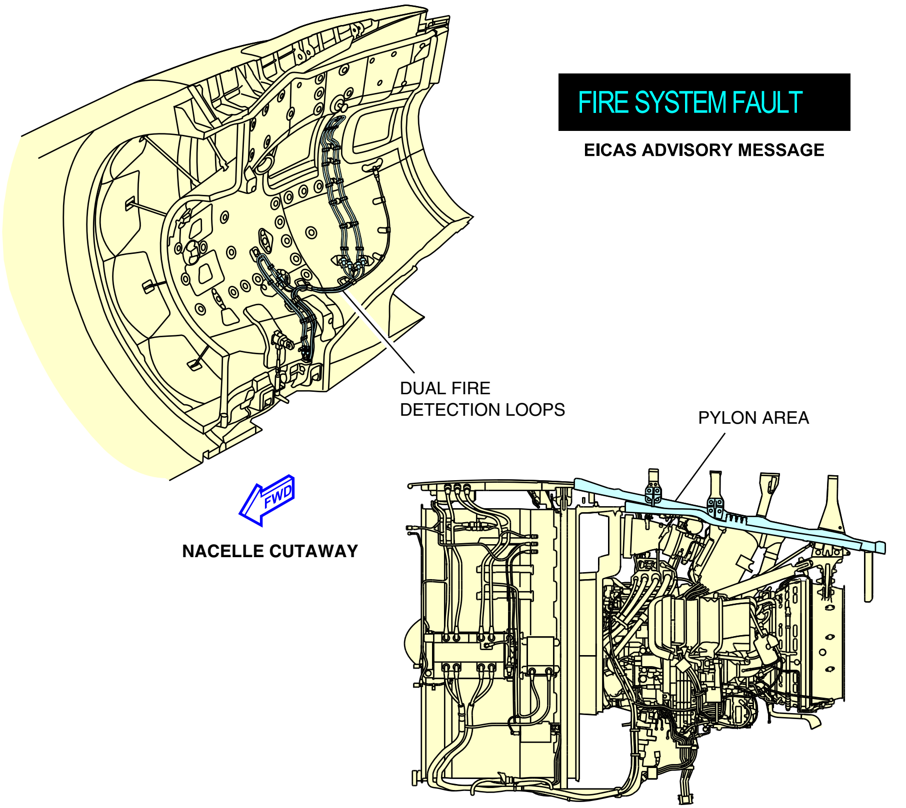


Engine and APU fire panel
Figure 09–02–1

ENGINE FIRE PROTECTION – DESCRIPTION AND OPERATION

A. Engine fire detectors

The engine fire detection system consists of dual fire detection loops, temperature-sensitive elements located in the engine nacelle and pylon. Each loop is continuously monitored by the FIDEX control unit for indications of both fire and loop faults. Normally, both loops must detect a fire for a warning to occur. If one of the engine fire detection loops fails, the FIDEX control unit automatically switches to single loop monitoring and displays a **FIRE SYSTEM FAULT** advisory message on the EICAS page (refer to Figure 09–02–2).



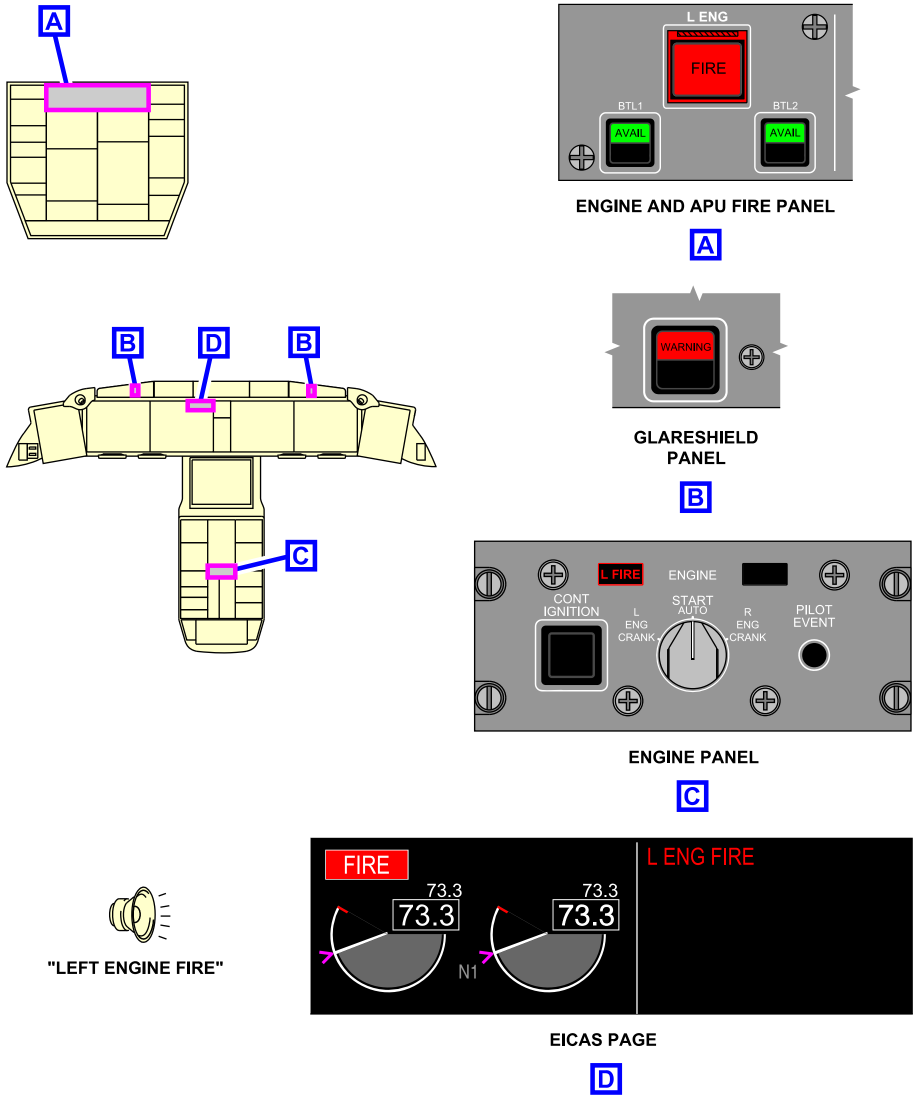
Engine fire loops
Figure 09–02–2

B. Engine fire indications

An engine fire is indicated when:

- The master WARNING lights illuminate on the glareshield,
- The "LEFT ENGINE FIRE" or "RIGHT ENGINE FIRE" aural warning sounds,
- A FIRE message displays above the N1 indication on the EICAS page,

- The L ENG FIRE or R ENG FIRE switch on the Engine and APU fire panel illuminates,
- A **L ENG FIRE** or **R ENG FIRE** warning message displays on the EICAS page, and
- A L FIRE or R FIRE indicator on the ENGINE panel illuminates (refer to Figure 09–02–3).



Left engine fire indications
Figure 09–02–3

C. Engine fire extinguishing

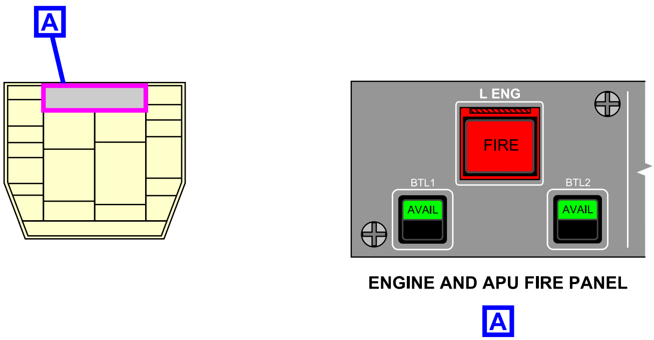
There are two engine fire-extinguishing bottles located in the wing-to-body fairing between the two wheel wells.

Both bottles can be used for either engine.

Two fire-extinguishing switches, BTL1 and BTL2, are located below each ENG FIRE switch. The BTL1 and BTL2 switches have a green AVAIL (available) light on the upper half and an amber light bar on the lower half.

The green AVAIL lights illuminate on the BTL1 and BTL2 switches when the associated ENG FIRE switch is pressed. The indicates that the fire-extinguishing bottles are armed. Refer to Figure 09–02–4.

Pressing the BTL switch when the AVAIL light is on discharges halon gas into the engine compartment. When the halon bottle discharges, the AVAIL light goes off and the amber light on the BTL switch illuminates. An **ENG BTL 1 LO** or **ENG BTL 2 LO** advisory message displays on the EICAS page.

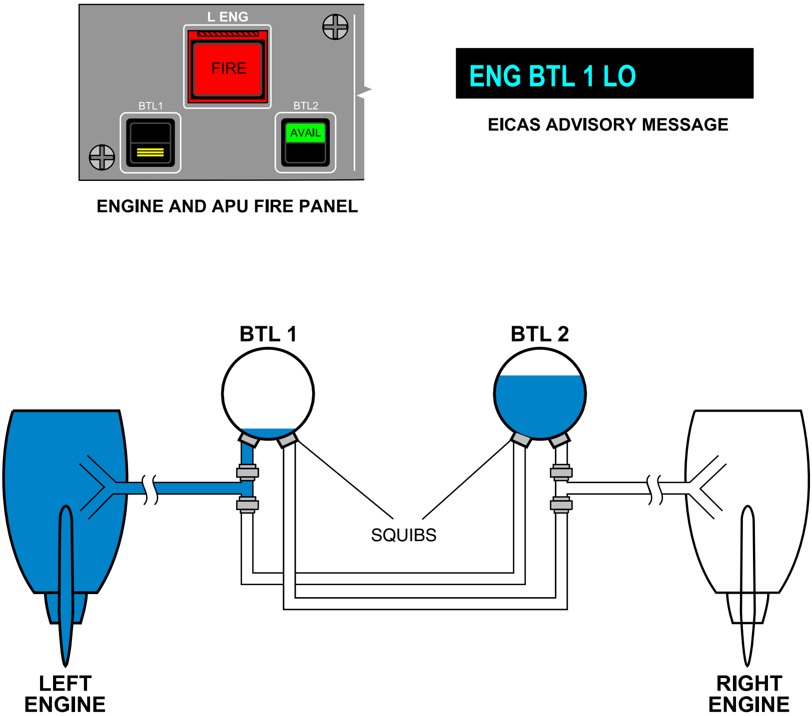


Left engine fire with fire–extinguishing bottles armed
Figure 09–02–4

NOTE

The amber bar also illuminates when bottle pressure is abnormally low, or a squib failure has been detected.

The L ENG FIRE or R ENG FIRE switch stays illuminated until fire is no longer detected. Refer to Figure 09–02–5.



Left engine fire with fire–extinguishing BTL1 discharged
Figure 09–02–5

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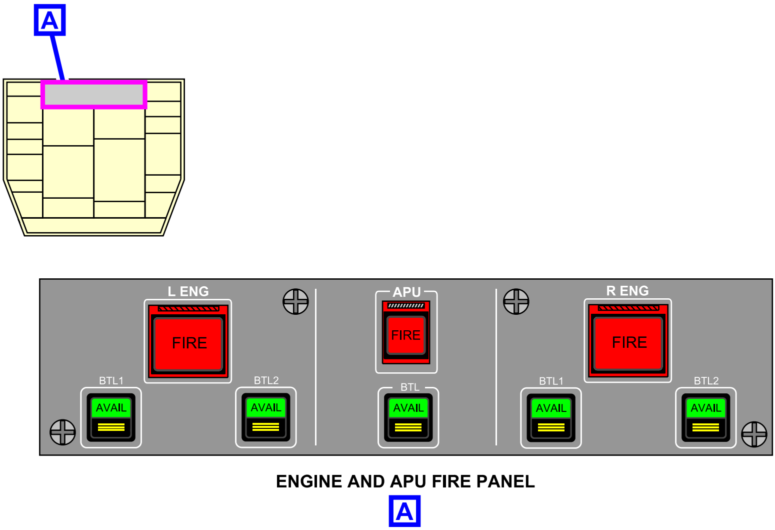
APU FIRE PROTECTION – OVERVIEW

The APU fire protection system consists of:

- Dual fire detection loops,
- EICAS and aural alerting, and
- APU fire-extinguishing bottle.

Emergency APU shutdown and fire extinguishing is accomplished through the engine and APU fire panel (refer to Figure 09–03–1).



Engine and APU fire panel
Figure 09–03–1

APU FIRE PROTECTION – DESCRIPTION AND OPERATION

A. APU fire detection

The APU fire detection system consists of dual fire detection loops, which are temperature-sensitive elements located in the APU compartment. Each loop is continuously monitored by the FIDEX control unit for overheat indications and faults.

Normally, both loops must detect a fire for a warning to occur. If one of the fire detection loops fails, the FIDEX control unit automatically switches to single loop monitoring and a **FIRE SYSTEM FAULT** advisory message displays on the EICAS page (refer to Figure 09–03–2).

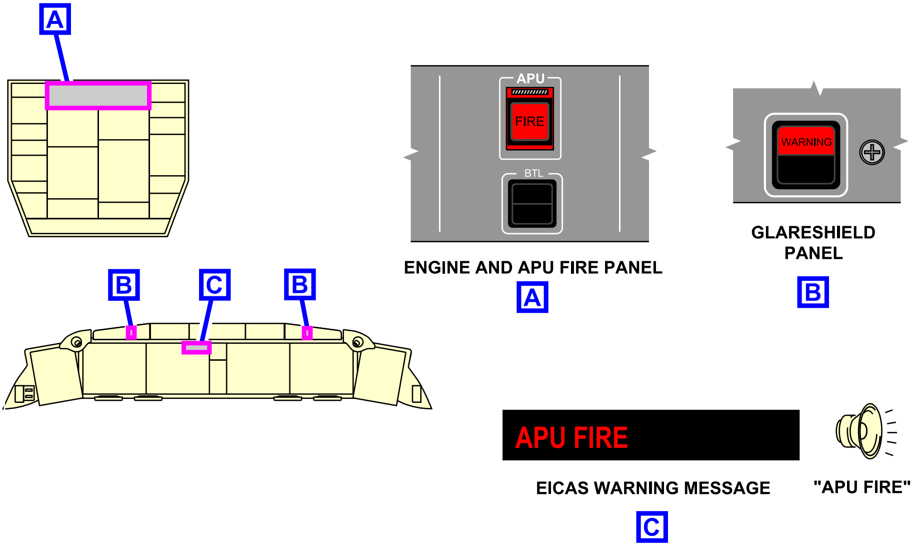
FIRE SYSTEM FAULT advisory message
Figure 09–03–2

B. APU fire indications

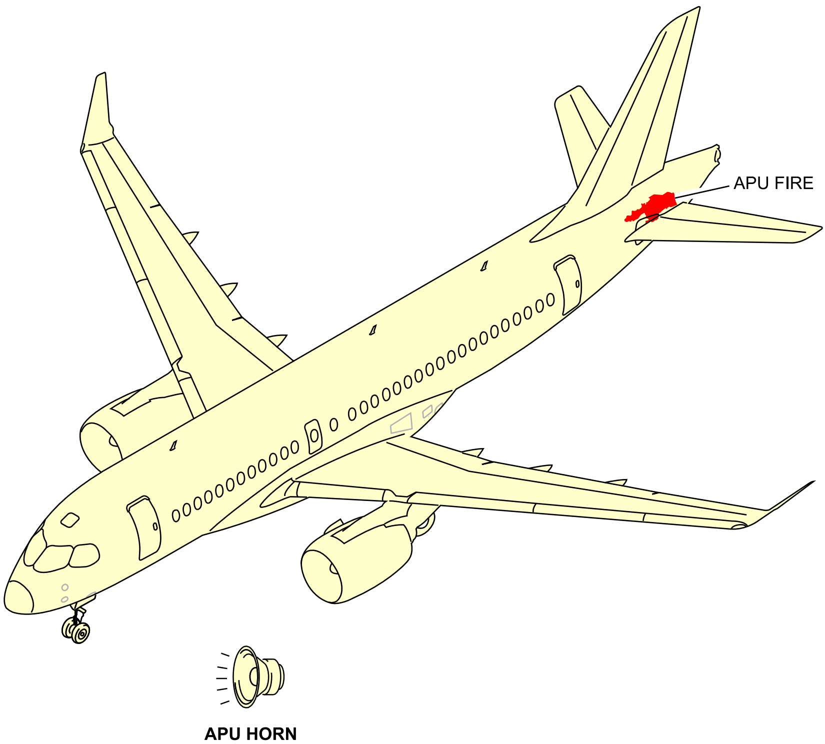
When an APU fire is detected the APU fire indications (refer to Figure 09–03–3) are:

- The master WARNING lights illuminate on the glareshield,
- The “APU FIRE” aural message sounds,
- The APU FIRE switch on the engine and APU fire panel illuminates,
- The warning message **APU FIRE** displays on the EICAS page, and

- The APU external warning horn sounds on the ground only (refer to Figure 09–03–4).



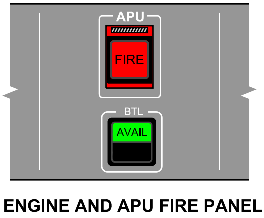
APU fire indications
Figure 09–03–3



On ground APU fire
Figure 09–03–4

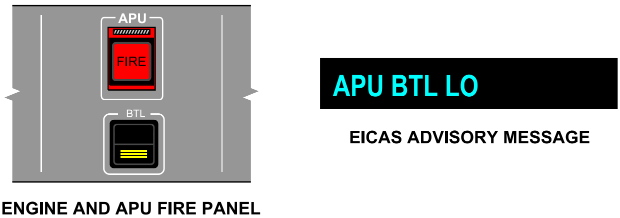
C. APU fire extinguishing

Pressing the APU BTL switch, when the AVAIL (available) light is on (refer to Figure 09–03–5), discharges the halon gas into the APU compartment.



APU fire switch with fire–extinguishing bottle armed
Figure 09–03–5

When the fire-extinguishing bottle discharges, the green AVAIL light goes off. When the bottle is empty, the amber light bar illuminates (refer to Figure 09–03–6). The advisory message **APU BTL LO** displays on the EICAS page.



APU fire with fire–extinguishing BTL discharged
Figure 09–03–6

NOTE

The amber bar also illuminates when bottle pressure is abnormally low, or squib failure has been detected.

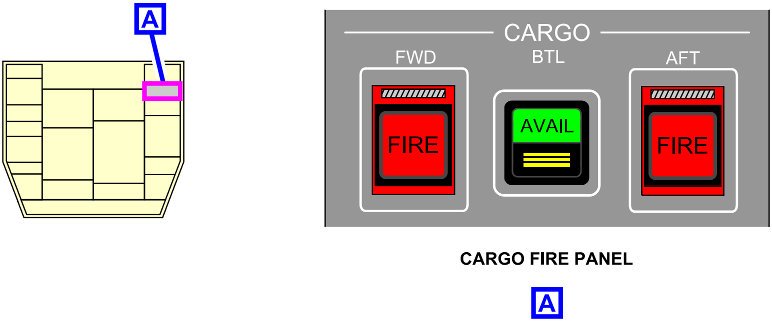
The APU FIRE guarded switch stays illuminated until fire is no longer detected.

CARGO COMPARTMENT FIRE PROTECTION – OVERVIEW

The cargo compartment fire protection system consists of:

- Smoke detectors,
- EICAS and aural alerting, and
- Three fire-extinguishing bottles. <26240002C> or <26240003C>

Cargo compartment fire extinguishing is accomplished through the CARGO fire panel (refer to Figure 09–04–1).



CARGO fire panel
Figure 09–04–1

CARGO COMPARTMENT FIRE PROTECTION – DESCRIPTION AND OPERATION

A. Cargo compartment smoke detection

Four Class C smoke detectors are located in the ceiling of both the forward and aft cargo compartments.

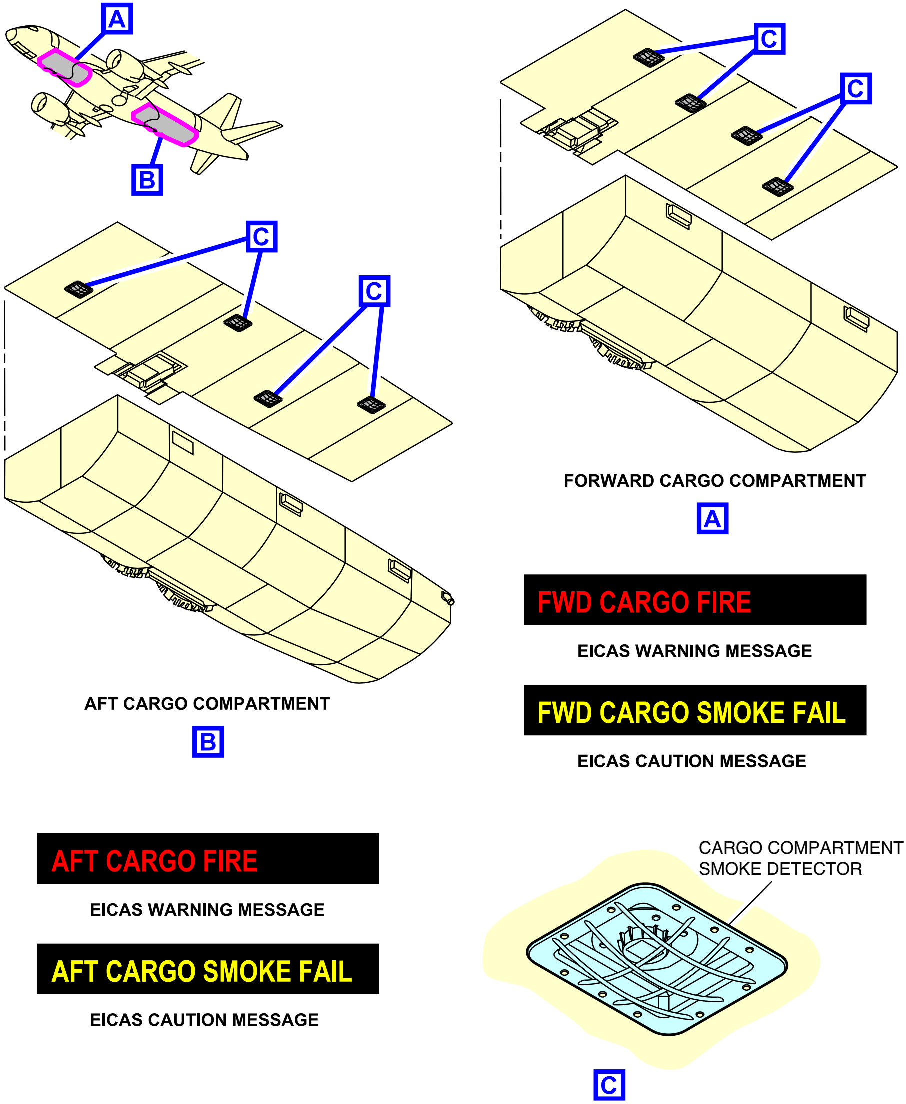
The detectors are monitored by the FIDEX control unit.

If one of the smoke detectors fails, a **FIRE SYSTEM FAULT** advisory message displays on the EICAS page (refer to Figure 09–04–2).

EICAS ADVISORY MESSAGE

FIRE SYSTEM FAULT advisory message
Figure 09–04–2

Before an alarm is given, a minimum of two cargo smoke detectors must indicate that smoke is present. Refer to Figure 09–04–3.

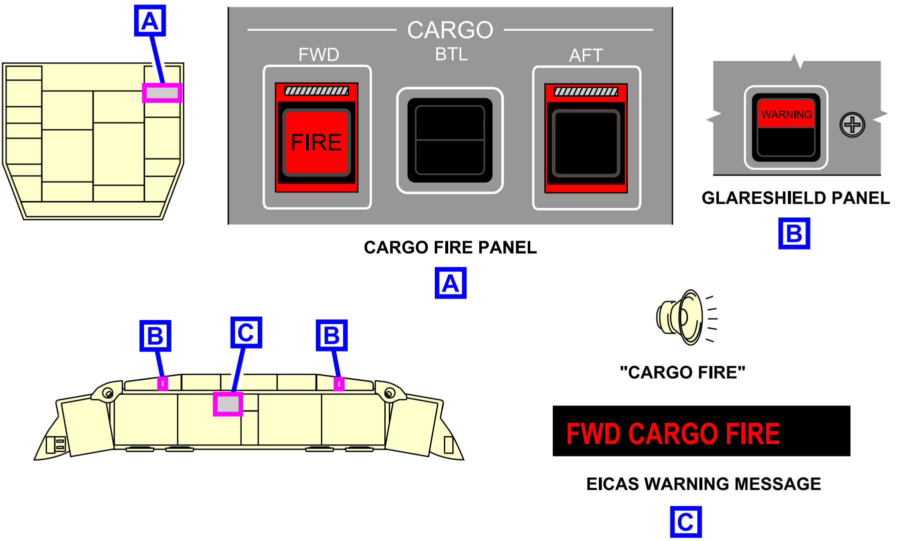


Cargo compartment smoke detectors
Figure 09–04–3

B. Cargo compartment fire indications

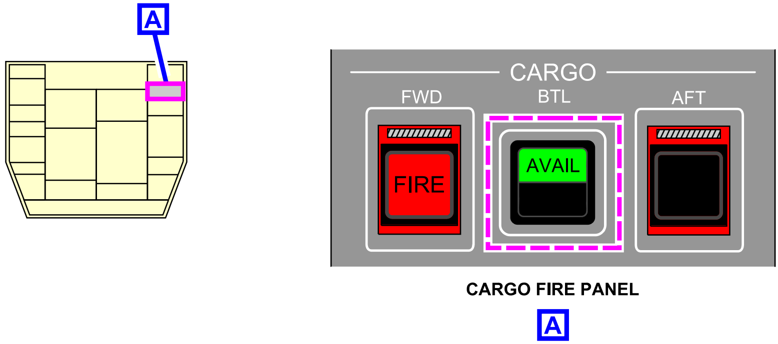
When smoke is detected in a cargo compartment:

- The Master WARNING / CAUTION lights illuminate on the glareshield
- The “CARGO FIRE” aural alert sounds,
- A **FWD CARGO FIRE** or **AFT CARGO FIRE** warning message appears on the EICAS page (refer to Figure 09–04–4), and
- The FWD FIRE CARGO switch or AFT FIRE CARGO switch illuminates.



FWD cargo compartment fire indications
Figure 09–04–4

When pressed, either guarded FIRE switch sends a signal to automatically shut off the associated cargo compartment ventilation shut-off valves and air conditioning RECIRC fans, and activates the appropriate squibs on the cargo compartment fire-extinguishing bottles. The green AVAIL (available) light illuminates, indicating that the bottles are armed and ready for discharge (refer to Figure 09–04–5).



FWD cargo compartment fire–extinguishing bottles armed
Figure 09–04–5

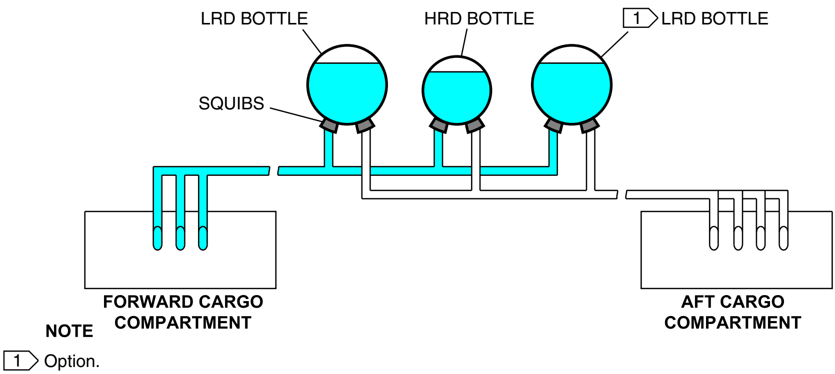
C. Cargo compartment fire extinguishing

Fire suppression in the cargo compartment is provided by a High Rate Discharge (HRD) and a Low Rate Discharge (LRD) fire-extinguishing bottles.

NOTE

An optional second LRD bottle can be installed for extended operations ETOPS configured aircraft to provide a longer period for fire suppression.

When the BTL switch (with the green AVAIL illuminated) is pressed, the bottle discharges halon gas into the corresponding cargo compartment (refer to Figure 09–04–6). The HRD bottle rapidly discharges, flooding the compartment with halon to extinguish the fire. The LRD bottle slowly discharges to suppress further fires for a minimum of 120 minutes + 15 minutes hold. <26240002C>

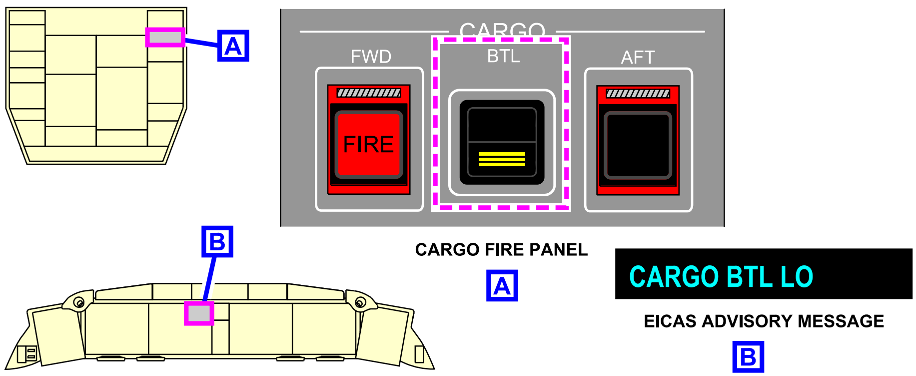


Cargo compartment fire–extinguishing bottles
Figure 09–04–6

After the HRD bottle discharges, the green AVAIL light on the CARGO BTL switch goes off and the amber light illuminates with the advisory message **CARGO BTL LO** displayed on the EICAS page (refer to Figure 09–04–7).

NOTE

The amber bar also illuminates when bottle pressure is abnormally low, or a squib failure has been detected.



FWD cargo compartment bottle discharged
Figure 09–04–7

EQUIPMENT BAY SMOKE DETECTION – OVERVIEW

There are two smoke detectors installed in the exhaust ducts of the forward and mid equipment bays. They detect smoke that could enter the cabin from the equipment bays. The FIDEX control unit continuously monitors the health and output of these detectors.

Under normal conditions, both detectors must detect smoke for a warning to occur. If one detector fails, the FIDEX control unit reverts to single detector operation and **FIRE SYSTEM FAULT** advisory message displays on the EICAS page (refer to Figure 09–05–1).

EICAS ADVISORY MESSAGE

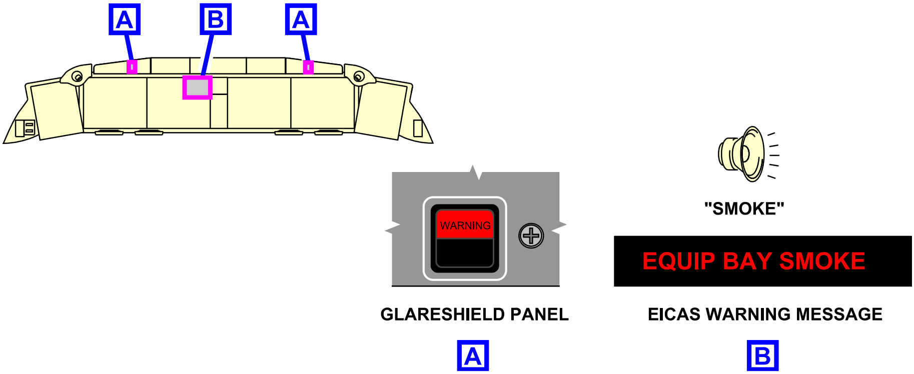
FIRE SYSTEM FAULT advisory message
Figure 09–05–1

EQUIPMENT BAY SMOKE DETECTION – DESCRIPTION AND OPERATION

When smoke is detected in either equipment bay, the equipment bay smoke detection indications (refer to Figure 09–05–2) are:

- The master WARNING lights illuminate on the glareshield,
- The "SMOKE" aural message sounds, and
- The warning message **EQUIP BAY SMOKE** displays on the EICAS page.

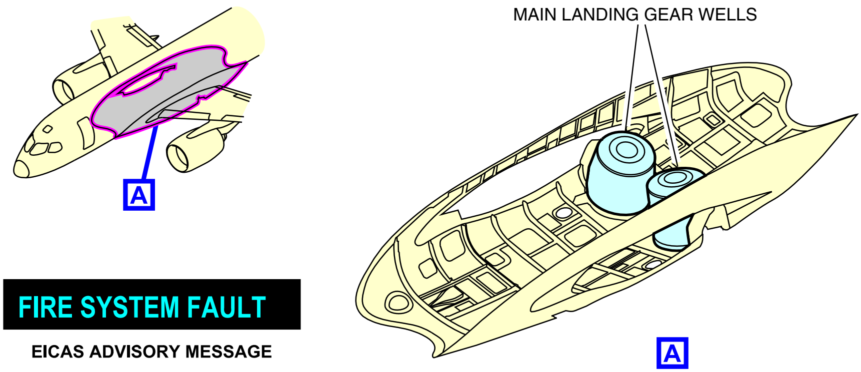
shows the equipment bay smoke detection indications.



Equipment bay smoke indications
Figure 09–05–2

MAIN LANDING GEAR OVERHEAT DETECTION – OVERVIEW

The main landing gear fire detection system consists of dual overheat detection loops mounted inside the top of each main landing gear wheel well (refer to Figure 09–06–1). The FIDEX control unit continuously monitors the status of the overheat detection loops. In normal operation, both loops must detect an overheat condition in order for a failure (warning) to occur. If one detector fails, the FIDEX control unit reverts to single detector operation, and a **FIRE SYSTEM FAULT** advisory message is displayed on the EICAS page.



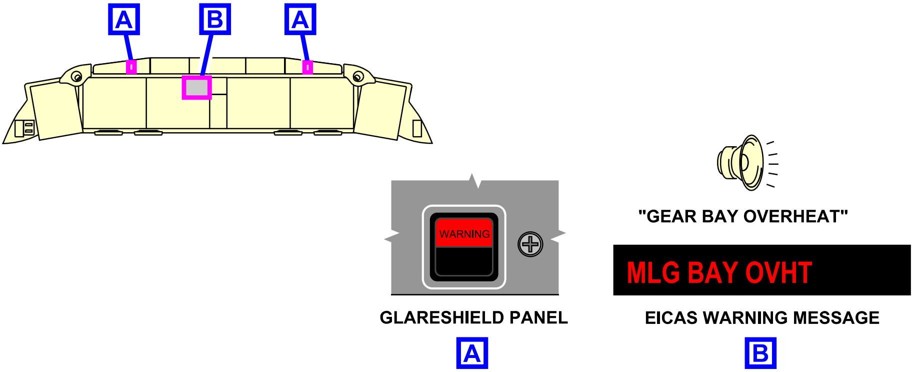
Main landing gear overheat detection loops
Figure 09–06–1

MAIN LANDING GEAR OVERHEAT DETECTION – DESCRIPTION AND OPERATION

When a main landing gear overheat is detected:

- The master WARNING lights illuminate on the glareshield,
- The “GEAR BAY OVERHEAT” aural message sounds, and
- The warning message **MLG BAY OVHT** displays on the EICAS page.

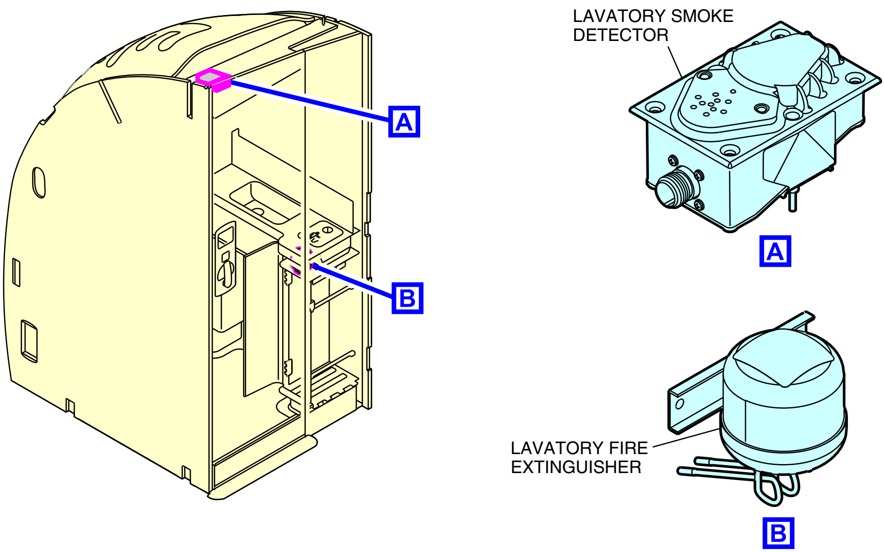
Figure 09–06–2 shows the main landing gear overheat detection indications.



Main landing gear overheat indications
Figure 09–06–2

LAVATORY FIRE PROTECTION – OVERVIEW

Each lavatory is equipped with a ceiling-mounted smoke detector monitored by the FIDEX control unit, and waste bin fire extinguishers (refer to Figure 09–07–1).



Lavatory smoke detector and fire extinguisher
Figure 09–07–1

A solid green Light-Emitting Diode (LED) on the detector indicates that it is functional. A red maintenance LED illuminates if a fault condition exists.

A fault in the detector generates the caution message **LAV SMOKE FAIL** on the EICAS page (refer to Figure 09–07–2).

LAV SMOKE FAIL caution message
Figure 09–07–2

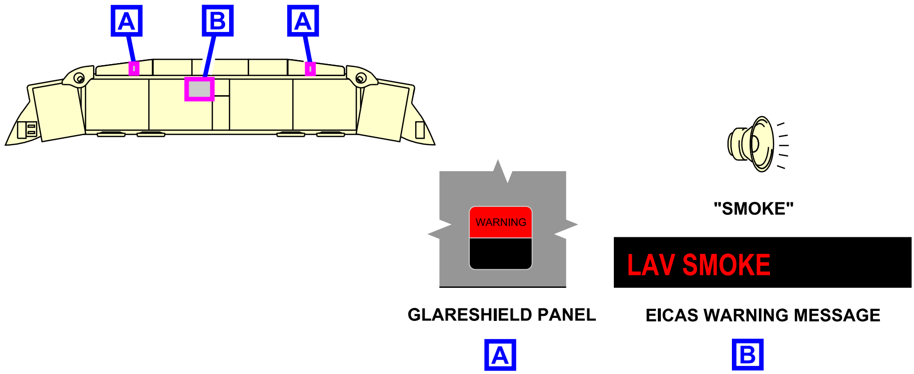
shows the lavatory smoke detector and fire extinguisher.

LAVATORY FIRE PROTECTION – DESCRIPTION AND OPERATION

A. Lavatory smoke indications

If smoke is detected in a lavatory, the lavatory smoke detection indications (refer to Figure 09–07–3) are:

- The master WARNING lights illuminate on the glareshield,
- The “SMOKE” aural message sounds,
- The warning message **LAV SMOKE** displays on the EICAS page, and
- Cabin Management System (CMS) indications.



Lavatory smoke indications
Figure 09–07–3

NOTE

The EICAS indication does not specify which lavatory has smoke. The specific FWD or AFT lavatory smoke status will be displayed on the Cabin Management System (CMS) panel at each of the flight attendant stations.

B. Lavatory fire extinguishing

The lavatory fire-extinguisher system is used to suppress a fire or source of heat in the lavatory waste bin. The bottle is installed under the sink area with the discharge tubes pointing into the waste bin.

The extinguisher discharges when the nozzles reach 76.5°C (170°F).

This fire extinguisher is not monitored by the FIDEX control unit and it does not send an EICAS message if it discharges.

NOTE

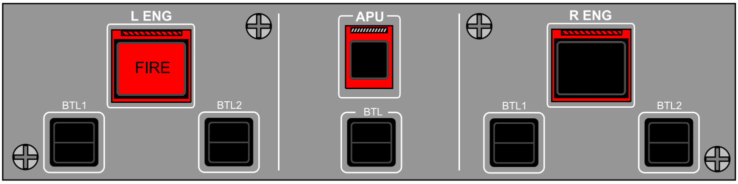
This fire extinguisher is not monitored by the FIDEX control unit, however a **LAV SMOKE FAIL** caution message will be displayed on the EICAS page if the smoke detector fails (refer to Figure 09–07–4).

LAV SMOKE FAIL caution message
Figure 09–07–4

FIRE AND OVERHEAD PROTECTION – CONTROLS

A. ENGINE AND APU FIRE panel – L ENG FIRE and R ENG FIRE guarded switches

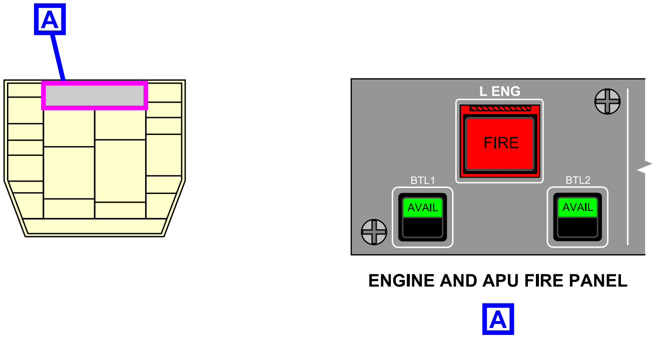
When a L or R ENG FIRE indicator illuminates on the ENGINE panel, the respective ENG FIRE guarded switch on the engine and APU fire panel illuminates and remains illuminated until the fire is extinguished (refer to Figure 09–08–1).



Left engine fire switch
Figure 09–08–1

Pressing the L ENG FIRE or R ENG FIRE guarded switch on the ENGINE AND APU FIRE panel initiates the sequence that follows for the respective engine:

- Both engine fire extinguishing bottles are armed for discharge (AVAIL green light illuminates on the BTL 1 and BTL 2 switches) (refer to Figure 09–08–2),
- Fuel shut-off valve closes,
- FADEC commands engine shut-down,
- Fan air valve closes,
- Pressure-Regulated Shut-off Valve (PRSOV) closes,
- Hydraulic shut-off valve closes, and
- Variable Frequency Generator (VFG) deactivates.



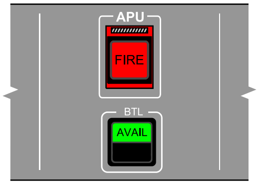
Left engine fire with fire–extinguishing bottles armed
Figure 09–08–2

When there is a fire, if the flight crew presses the L ENG or R ENG switch a second time there will be no change in the system states. However, the AVAIL green light on the BTL 1 and BTL 2 switches will go off.

B. ENGINE AND APU FIRE panel – APU FIRE guarded switch

When pressed, the guarded APU FIRE switch initiates the actions that follow:

- The APU fuel shut-off valve closes,
- APU bleed air valve closes,
- Variable Frequency Generator (VFG) deactivates,
- Electronic Control Unit (ECU) commands the APU shut down, and
- The fire-extinguishing bottle is armed (AVAIL green light illuminates on the BTL switch) (refer to Figure 09–08–3).



ENGINE AND APU FIRE PANEL

APU fire switch with fire–extinguishing bottle armed
Figure 09–08–3

If an APU fire is detected during ground operations, the FIDEX control unit immediately shuts down the APU, the external APU horn sounds and 10 seconds later the APU fire-extinguishing bottle discharges.

NOTE

In flight, detection of an APU fire will not cause an automatic shut-down.

The flight crew can override the automatic bottle discharge and silence the APU horn by pressing the APU FIRE guarded switch.

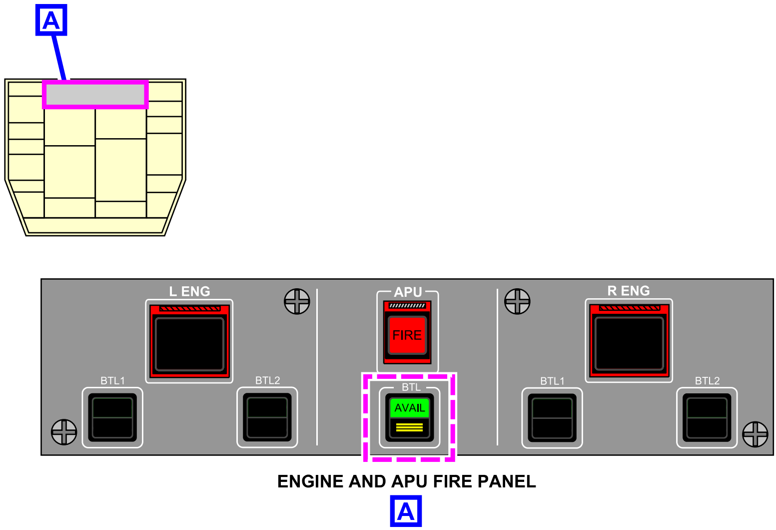
C. ENGINE AND APU FIRE panel – ENG FIRE and APU FIRE BTL switches

When a BTL switch is pressed, an electrical current fires the squib in the associated bottle and pressurized gas is directed into the corresponding engine or to the APU.

- AVAIL: When the associated L ENG, R ENG and APU FIRE guarded switch is pressed, the green AVAIL light illuminates on the top of the BTL switch to indicate that the fire-extinguishing bottle is armed and ready to be discharged.

- Amber light bar: When the bottle is discharged, the AVAIL green light goes off and the amber light bar illuminates on the bottom of the switch. An **ENG BTL 1 LO**, **ENG BTL 2 LO**, or **APU BTL LO** advisory message will also be displayed on the EICAS page.

The amber light bar also illuminates when a failure of the associated bottle is detected (abnormal gas pressure or squib failure). Refer to Figure 09–08–4.

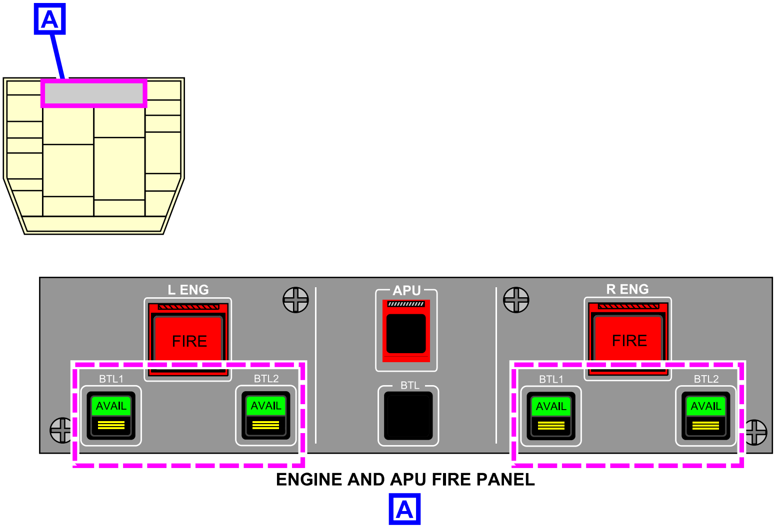


ENGINE AND APU FIRE panel – APU FIRE BTL switch
Figure 09–08–4

D. ENGINE and APU Fire panel – L FIRE and R FIRE indicators

- L FIRE: The indicator light illuminates when a fire is detected in the left engine. It goes off when fire is no longer detected.
- R FIRE: The indicator light illuminates when a fire is detected in the right engine. It goes off when fire is no longer detected.

Figure 09–08–5 shows the ENG FIRE BTL switches.

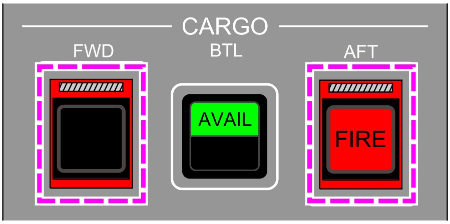


Engine and APU fire panel – ENG FIRE BTL switches
Figure 09–08–5

E. CARGO fire panel – FWD CARGO FIRE and AFT CARGO FIRE guarded switches

When smoke is detected in the FWD or AFT cargo compartment, the corresponding CARGO FIRE guarded switch on the CARGO fire panel illuminates (refer to Figure 09–08–6). When it is pressed:

- The cargo ventilation is automatically shut off, and
- The AVAIL light on the BTL switch illuminates to indicate that the fire-extinguishing bottles are armed and ready to be discharged.



CARGO fire panel – FWD and AFT CARGO FIRE guarded switches
Figure 09–08–6

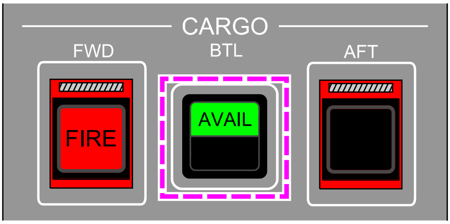
F. CARGO fire panel – BTL switch

When the BTL switch is pressed, an electrical current fires the squib in the fire-extinguishing bottles and pressurized gas is directed into the cargo fire zone.

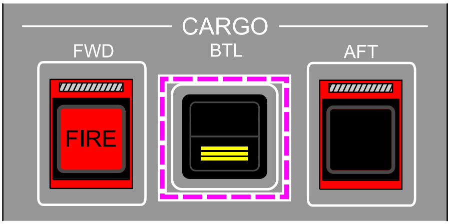
- AVAIL: When the associated CARGO FIRE switch is pressed, the AVAIL green light illuminates on the top of the BTL switch to indicate that the bottles are armed and ready to be discharged. When the BTL switch (with AVAIL illuminated) is pressed, the High Rate Discharge (HRD) bottle discharges first into in the cargo fire zone, followed by the discharge of the Low Rate Discharge (LRD) bottle (refer to Figure 09–08–7).
- Amber light bar: When the HRD bottle is discharged, the AVAIL green light goes off and the amber light bar illuminates (refer to Figure 09–08–8). The advisory message **CARGO BTL LO** displays on the EICAS page.

The amber light bar also illuminates when a failure is detected in the bottle (abnormal gas pressure or squib failure).

There is no flight deck indication when the Low Rate Discharge (LRD) bottle is discharged and when it is empty.



CARGO fire panel – BTL switch AVAIL
Figure 09–08–7



CARGO fire panel – BTL switch with amber light bar
Figure 09–08–8

G. AVIONIC synoptic page – FIRE test

The fire and overheat protection system can be tested at any time through the AVIONIC synoptic page by pressing the FIRE test soft switch. When the test is selected, the IN PROG message displays and the lights that follow illuminate:

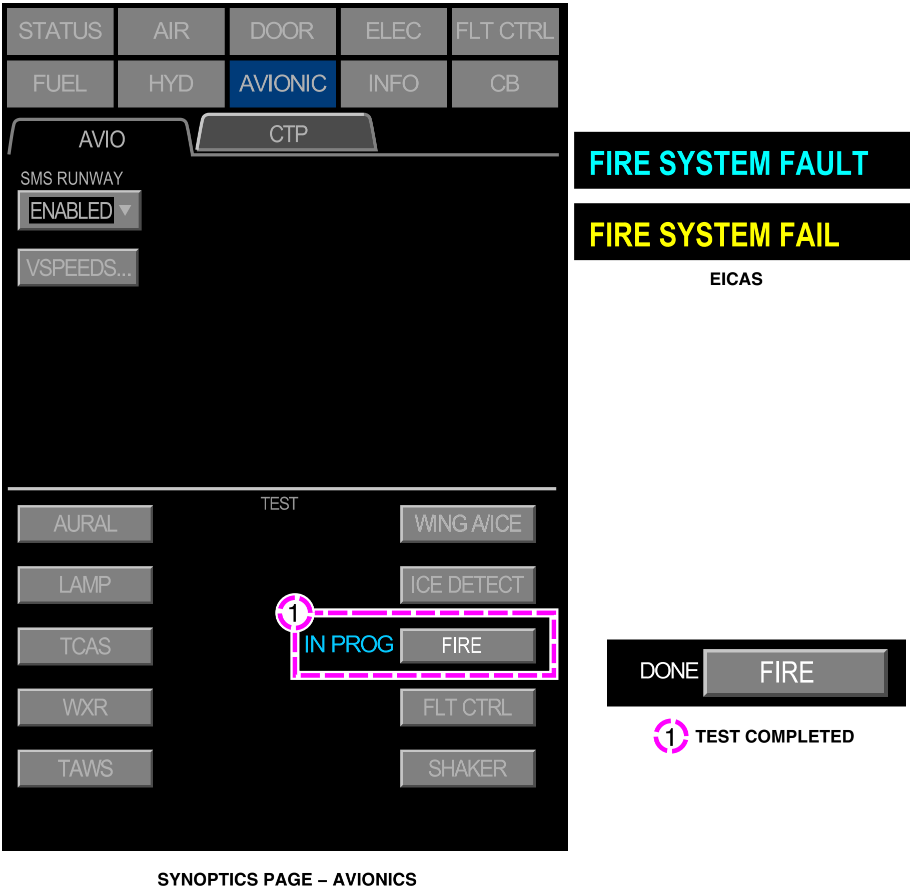
- L ENG, R ENG, APU, FWD CARGO and AFT CARGO FIRE guarded switches illuminate,

- L FIRE and R FIRE indicators on the ENGINE panel illuminate, and
- The AVAIL green and amber light bars illuminate on all the BTL switches.

The FIDEX control unit checks the fire loops and smoke detectors.

When the test is completed and no faults are detected, the message DONE is displayed beside the FIRE soft switch on the AVIO tab of the AVIONIC synoptic page. Figure 09–08–9 shows a successfully completed pilot–initiated test.

If a fault or failure is detected, the **FIRE SYSTEM FAULT** advisory message or the **FIRE SYSTEM FAIL** caution message is displayed on the EICAS page. The specific fault or failure is found on the INFO page.



AVIONIC synoptic page – FIRE test
Figure 09–08–9

FIRE AND OVERHEAT PROTECTION – EICAS MESSAGES

A. Warning messages

Message	Description	Aural	Inhibit
AFT CARGO FIRE	Aft cargo compartment smoke detected.	“CARGO FIRE”	None
APU FIRE	APU fire detected.	“APU FIRE”	None
EQUIP BAY SMOKE	Smoke is detected in either equipment bay.	“SMOKE”	None
FWD CARGO FIRE	Forward cargo compartment smoke detected.	“CARGO FIRE”	None
LAV SMOKE	Lavatory smoke detected.	“SMOKE”	None
L ENG FIRE	Left engine fire detected.	“LEFT ENGINE FIRE”	None
R ENG FIRE	Right engine fire detected.	“RIGHT ENGINE FIRE”	None
MLG BAY OVHT	Main landing gear bay overheat detected.	“GEAR BAY OVERHEAT”	None

B. Caution messages

Message	Description	Inhibit
AFT CARGO BTL FAIL	Failure (aft cargo squibs inoperative) of either of the cargo compartment fire-extinguishing bottles (HRD or LRD).	TO, LDG
AFT CARGO SMOKE FAIL	Failure of the aft cargo smoke detection system.	TO, LDG

Message	Description	Inhibit
APU BTL FAIL	Failure (low pressure or squib inoperative) of APU fire-extinguishing bottle.	TO, LDG
APU FIRE DET FAIL	Failure of the APU fire detection system.	TO, LDG
CARGO BTL FAIL	Failure (low pressure or both squibs inoperative) of either of the cargo compartment fire-extinguishing bottles (HRD or LRD).	TO, LDG
EQUIP BAY SMOKE FAIL	Failure of both smoke detectors in either equipment bay.	TO, LDG
FIRE SYSTEM FAIL	Total failure of FIDEX system, including loss of both channels of the controller unit.	TO, LDG
FWD CARGO BTL FAIL	Failure (forward cargo squibs inoperative) of either of the cargo compartment fire-extinguishing bottles (HRD or LRD).	TO, LDG
FWD CARGO SMOKE FAIL	Failure of the forward cargo smoke detection system.	TO, LDG
FWD CARGO HEAT FAIL	LO HEAT AND HI HEAT mode not available.	TO, LDG
FWD CARGO LO TEMP	Low temperature in FWD CARGO when FWD CARGO selected to LO/HI HEAT.	TO, LDG
LAV SMOKE FAIL	Failure of the lavatory smoke detection system.	TO, LDG
L–R ENG BTL FAIL	Failure (both bottles abnormal low pressure or all four squibs inoperative) of engine fire-extinguishing bottles.	TO, LDG

Message	Description	Inhibit
L ENG BTL FAIL	Failure (both squibs inoperative left engine – bottles 1 and 2) of fire-extinguishing bottles.	TO, LDG
R ENG BTL FAIL	Failure (both squibs inoperative right engine – bottles 1 and 2) of fire-extinguishing bottles.	TO, LDG
L ENG FIRE DET FAIL	Failure of the left engine fire detection system.	TO, LDG
R ENG FIRE DET FAIL	Failure of the right engine fire detection system.	TO, LDG
MLG BAY OVHT DET FAIL	Failure of the main landing gear bay overheat detection system.	TO, LDG

C. Advisory messages

Message	Description	Inhibit
APU BTL LO	Low pressure condition found on APU fire-extinguishing bottle (normal or abnormal).	TO, LDG
CARGO BTL LO	Low pressure condition found on either cargo compartment fire-extinguishing bottles – HRD or LRD (normal).	TO, LDG
ENG BTL 1 LO	Low pressure condition found on engine BTL 1 (normal or abnormal).	TO, LDG
ENG BTL 2 LO	Low pressure condition found on engine BTL 2 (normal or abnormal).	TO, LDG
FIRE SYSTEM FAULT	Loss of redundant or non-critical function for the FIDEX system.	TO, LDG
L ENG BTL FAULT	Loss of left squib on BTL 1 or BTL 2.	TO, LDG
R ENG BTL FAULT	Loss of right squib on BTL 1 or BTL 2.	TO, LDG

D. Status messages

None.

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CHAPTER 10 – FLIGHT CONTROLS

SECONDARY FLIGHT CONTROLS

List of figures

FLY–BY–WIRE (FBW) SYSTEM

PRIMARY FLIGHT CONTROLS

SECONDARY FLIGHT CONTROLS

HIGH LIFT SYSTEM

FLIGHT CONTROLS – OVERVIEW

The Primary Flight Control System (PFCS) consists of:

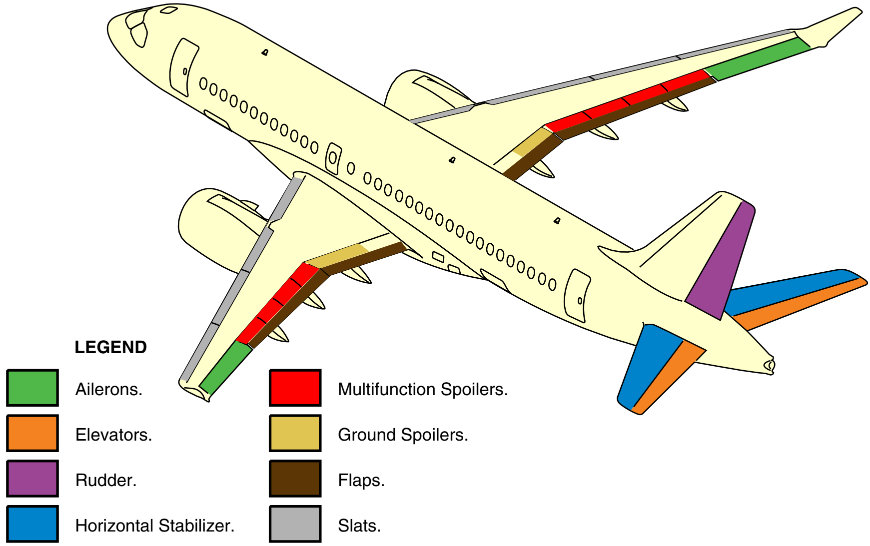
- Two ailerons,
- Two elevators, and
- A rudder.

The secondary flight controls include:

- Multifunction Spoilers (MFS) (four per wing),
- Ground Spoilers (GS) (one per wing), and
- Horizontal Stabilizer (HSTAB).

The high–lift flight system consists of leading edge slats and trailing edge flaps.

The primary and secondary control surfaces are hydraulically actuated. An electrically actuated horizontal stabilizer provides longitudinal (pitch) trim (refer to Figure 10–01–1).



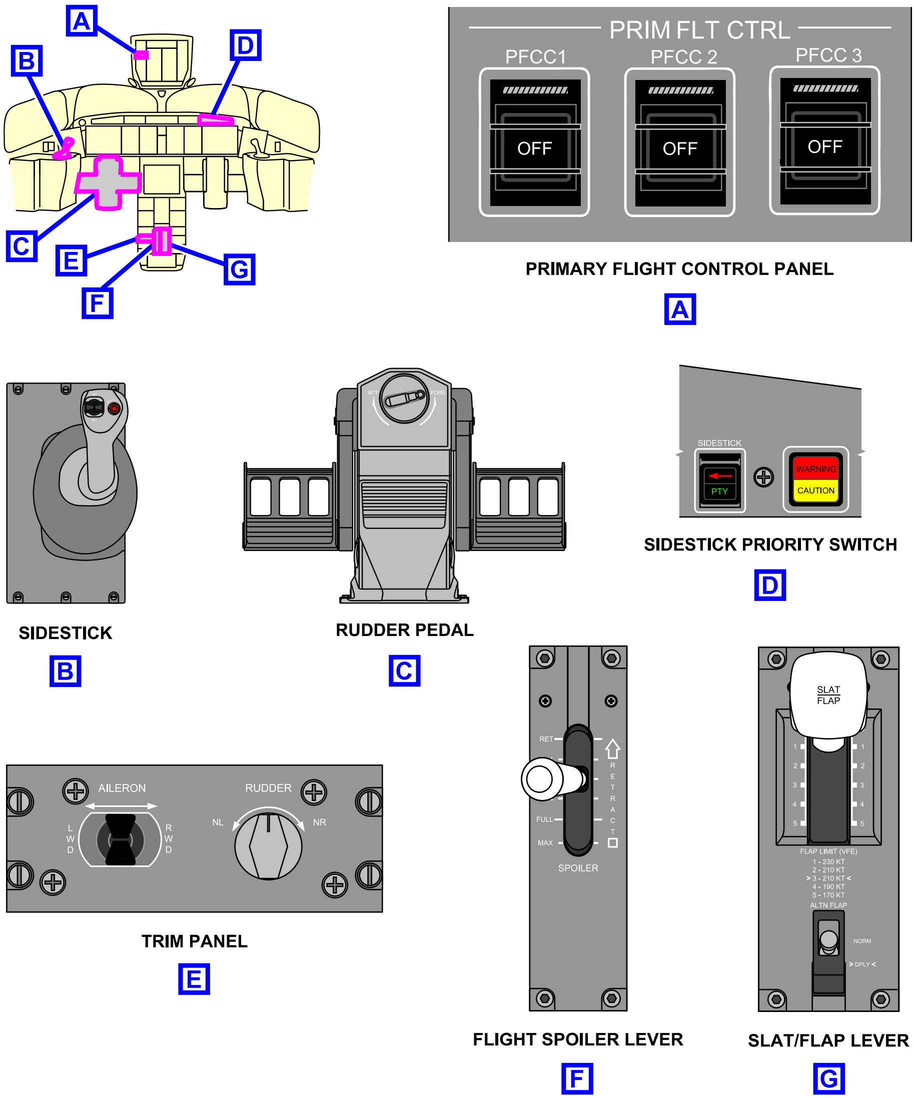
Flight control surfaces
Figure 10–01–1

An integrated Fly-By-Wire (FBW) system controls and monitors all primary and secondary flight controls, except high lift devices (leading edge slats and flaps).

The FBW system provides the following advantages:

- Improved control and envelope protection,
- Increased safety,
- Increased fuel economy, and
- Less weight, resulting in more efficient structural design.

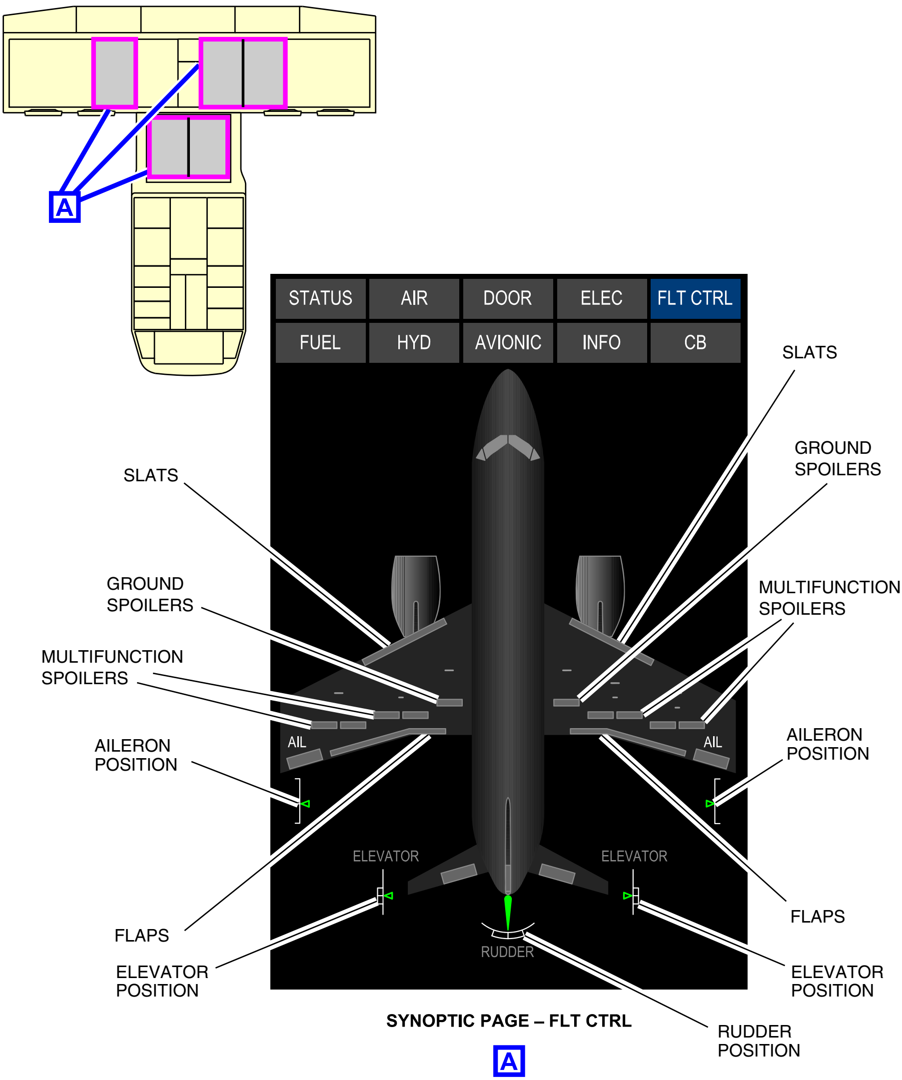
Two sidesticks located outboard of each pilot station are used to control pitch, roll, and horizontal stabilizer trim. Conventional rudder pedals, which use the FBW system, control yaw. A spoiler control lever and a slat/flap selection lever are located on the center pedestal. A pitch trim switch is installed on top of each sidestick. Aileron and rudder trim switches are located on the center pedestal. Refer to Figure 10–01–2.



Flight deck controls
Figure 10–01–2

The FLT CTRL synoptic page displays (refer to Figure 10–01–3) the layout and major elements of the primary and secondary flight control system that follow:

- Slats,
- Flaps,
- Aileron position (AIL),
- Elevator position (ELEVATOR),
- Rudder position (RUDDER),
- Ground spoilers, and
- Multifunction Spoilers (MFSs).

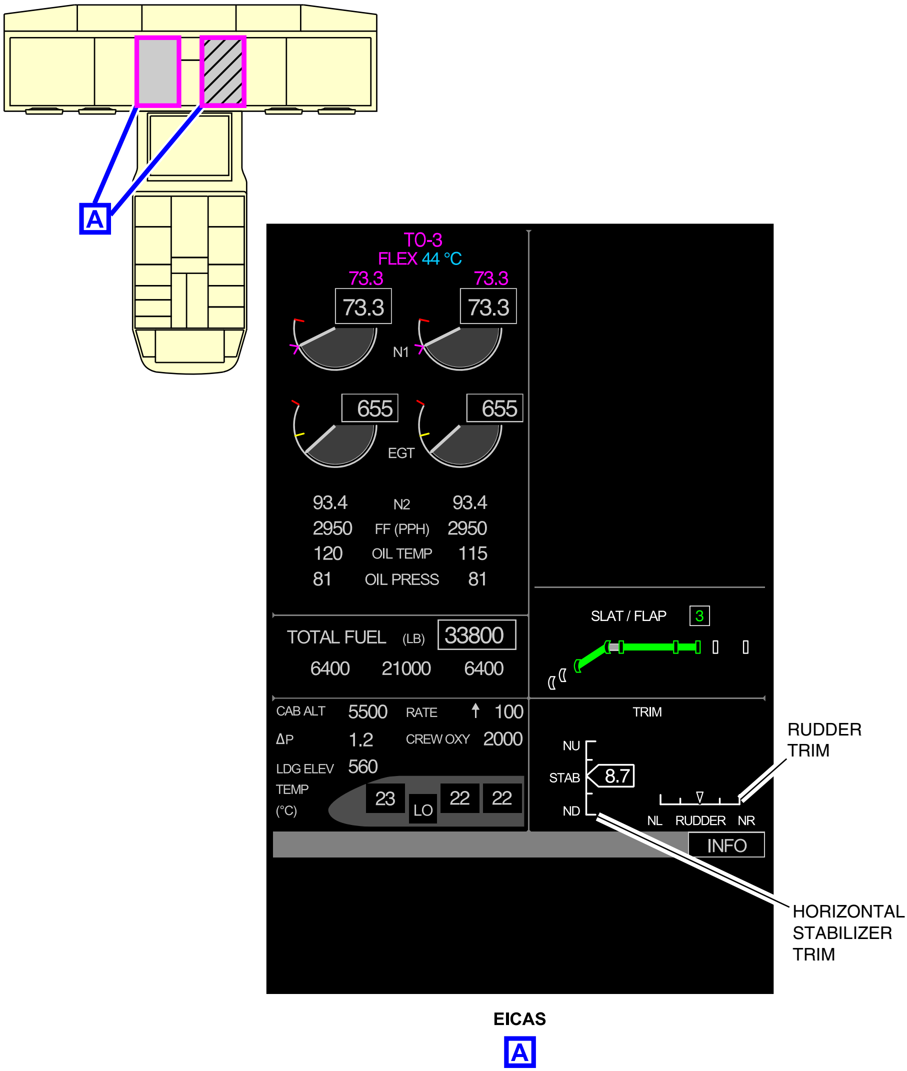


FLT CTRL synoptic page
Figure 10–01–3

The Engine Indication and Crew Alerting System (EICAS) page (refer to Figure 10–01–4) indicates the position of the following:

- Slats/flaps (SLAT/FLAP),
- Horizontal stabilizer trim (STAB), and
- Aileron (AIL) and rudder trim (RUDDER).

Aileron trim does not display under normal conditions, as it is automatically controlled by the FBW system. Failures that result in a degradation of the flight control modes allow pilot control of the aileron trim. In these cases, aileron trim position is displayed on the EICAS page.



EICAS page – Flight controls
Figure 10–01–4

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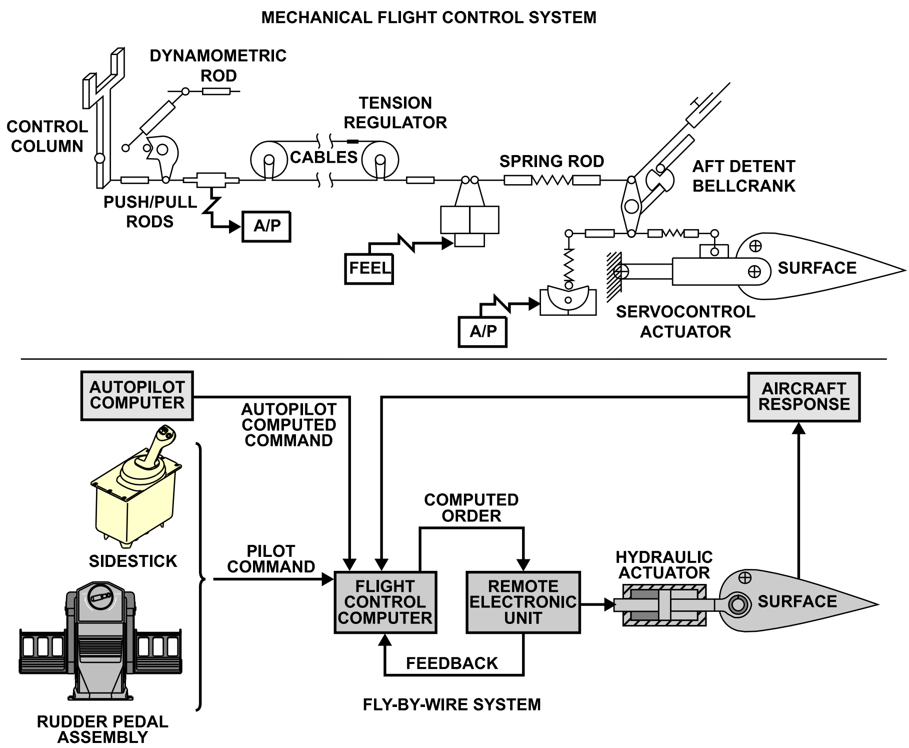
FBW SYSTEM – OVERVIEW

The Fly-By-Wire (FBW) system controls and monitors all primary and secondary flight controls (except the slats and flaps). The FBW system receives input commands electronically from the flight deck controls (initiated by the pilot) or directly from the autopilot. It converts them into output commands to move the aircraft control surfaces. Figure 10–02–1 shows a simplified schematic of FBW versus conventional flight controls.



Fly–By–Wire (FBW) versus conventional flight controls
Figure 10–02–1

There is no mechanical connection between the flight deck flight controls (sidestick controllers (SSC) and rudder pedals) and the aircraft control surfaces (ailerons, elevators and rudder). The FBW system transmits commands to the hydraulic actuators to move their associated flight control surfaces.

The FBW system operates in two distinct modes:

- Normal mode, and
- Direct mode.

In normal mode, the FBW provides full flight envelope protection for all phases of flight.

If the normal mode is not available, the FBW system switches to direct mode, to enable continued safe flight and landing only.

The three Fly–By–Wire (FBW) system control channels are powered by independent power sources.

FBW system control channels 1 and 2 receive DC power through two Fly–By–Wire Power Converters (FBWPCs). The primary source of power is from the DC busses. FBW channel 3 receives DC power from DC essential bus 3.

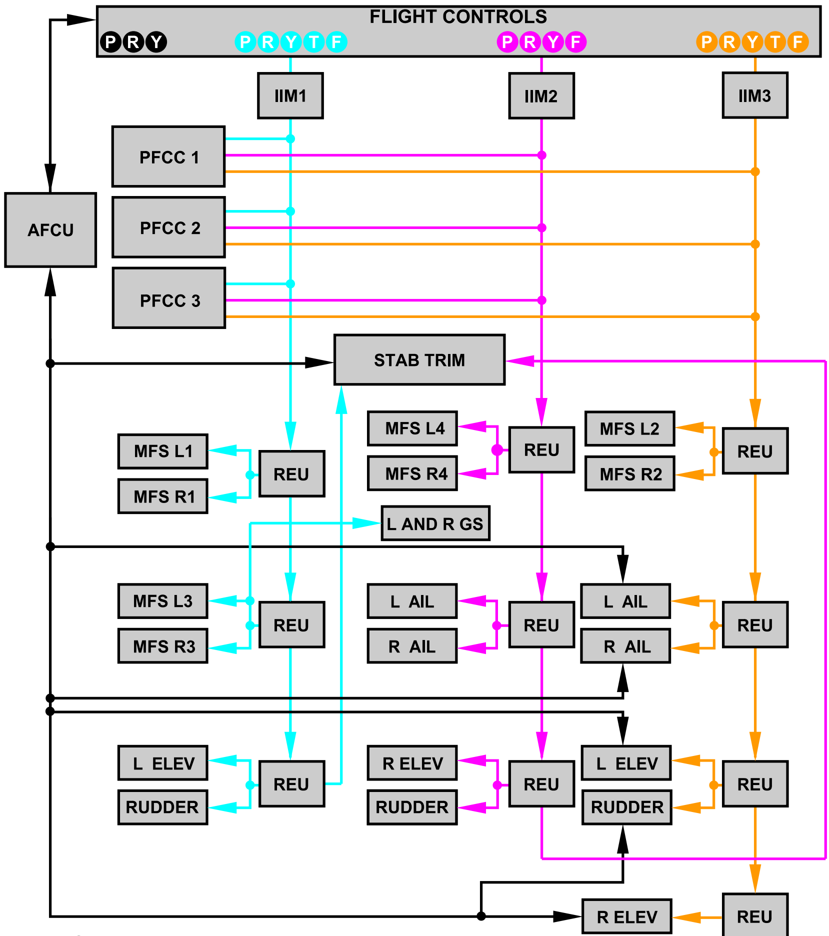
If there is a DC bus power loss, the secondary power sources are from the permanent magnet alternator/generator located on the N2 gearbox of each engine.

Any of the three FBW channels can allow safe flight and landing.

The FBW system includes:

- Flight deck controls,
- Inceptor Interface Modules (IIMs),
- Primary Flight Control Computers (PFCCs),
- Remote Electronic Units (REUs),
- Alternate Flight Control Unit (AFCU), and
- Horizontal stabilizer Motor Control Electronics (MCE) unit.

Figure 10–02–2 shows the simplified FBW system schematic.



LEGEND

- **P** Pitch.
- **R** Roll.
- **Y** Yaw.
- **T** Trim.
- **F** Flight spoiler lever.

AFCU Alternate Flight Control Unit
GS Ground Spoilers
IIM Inceptor Interface Module
MFS Multifunction Spoilers
PFCC Primary Flight Control Computer
REU Remote Electronic Unit

Fly–By–Wire (FBW) system schematic
Figure 10–02–2

FBW SYSTEM – DESCRIPTION AND OPERATION

A. Flight deck control inputs

The FBW system receives input signals from the flight deck controls. The control inputs include:

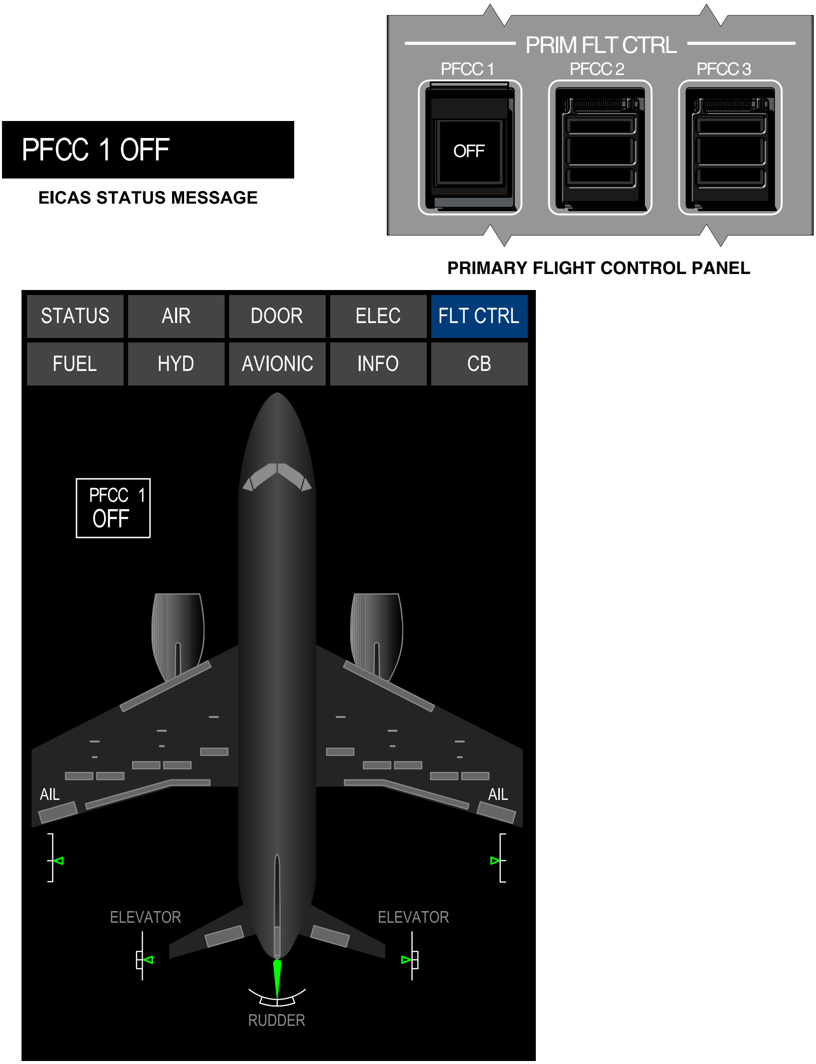
- Left and right sidestick,
- Left and right sidestick pitch trim switches,
- Sidestick priority switches,
- Aileron trim switch,
- Rudder trim switch,
- Left and right rudder pedal assemblies,
- Flight SPOILER lever, and
- TO/GA switches.

B. Inceptor Interface Modules (IIMs)

The FBW system includes three IIMs. The IIMs receive data from the flight deck controls and transmit it to the PFCCs. Each IIM is connected to the three PFCCs.

C. Primary Flight Control Computers (PFCCs)

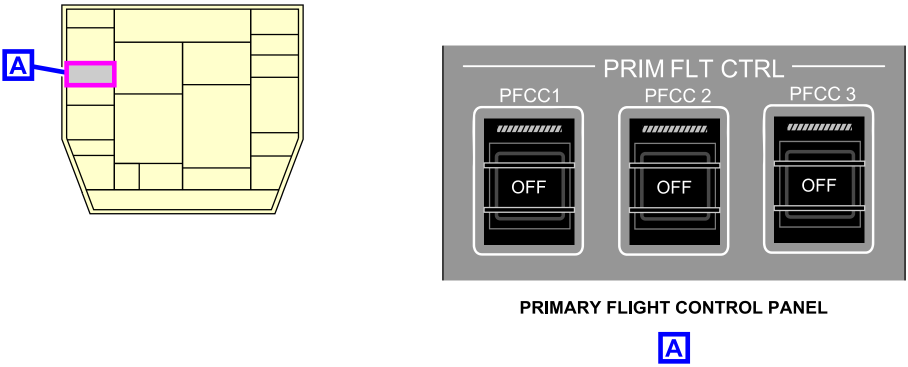
There are three identical Primary Flight Control Computers (PFCCs) in the aircraft. Two are located in the forward equipment bay and one in the mid equipment bay (refer to Figure 10–02–3). The PFCCs are responsible for the operation of the FBW system and its associated functions. The PFCCs receive commands from the flight deck controls through the IIMs, or from the autopilot/flight director systems. They issue appropriate commands to move the flight control surfaces and provide flight envelope and structural protection of the aircraft.



Primary Flight Control Computer (PFCC) switches
Figure 10–02–3

Each PFCC receives data from three Inertial Reference Units (IRUs) and four Air Data Smart Probes (ADSPs). Only one PFCC is in control of the FBW system at a time. The PFCC in control is automatically selected at power-up.

The PFCCs can be manually disabled by selecting the appropriate PFCC guarded switches, located on the overhead panel (refer to Figure 10–02–4). When a PFCC is selected to OFF, a white OFF light illuminates on the guarded switch, a **PFCC 1 OFF**, **PFCC 2 OFF**, or **PFCC 3 OFF** status message displays on the EICAS page and a message displays on the FLT CTRL synoptic page. When a PFCC has failed, a **PFCC 1 FAIL**, **PFCC 2 FAIL**, or **PFCC 3 FAIL** advisory message displays on the EICAS page.



Primary Flight Control Computer (PFCC) switches
Figure 10–02–4

D. Remote Electronic Units (REUs)

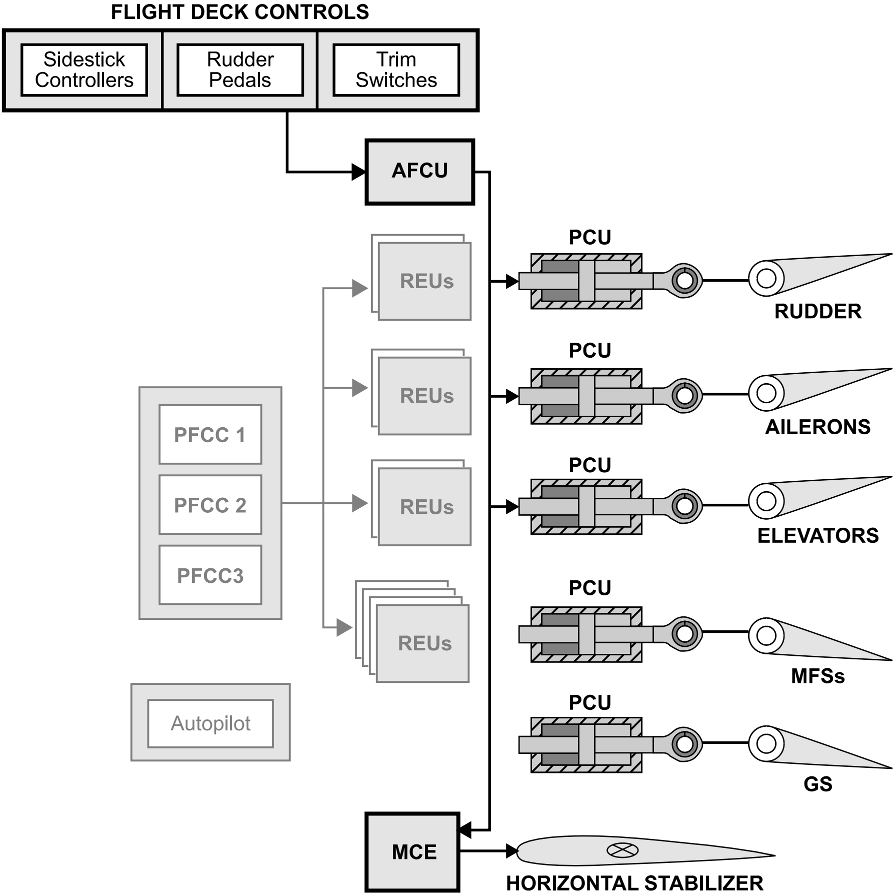
There are 10 Remote Electronic Units (REUs) in the aircraft. The REUs transmit commands from the PFCCs to the hydraulic Power Control Units (PCUs) of the control surfaces. Two REUs are also used to transmit commands to the electric trim motor of the horizontal stabilizer.

If all the PFCCs fail, the REUs would then receive their inputs directly from the cockpit controls through the IIMs. The REUs then command the hydraulic actuators and the electric trim motor. In this situation the FBW system operates in the REU direct mode (refer to FLY-BY-WIRE (FBW) SYSTEM OPERATION – DIRECT MODE, REU direct mode).

The REUs are monitored and self-tested but there is no direct indication or EICAS message on their condition.

E. Alternate Flight Control Unit (AFCU)

The Alternate Flight Control Unit (AFCU) bypasses the REUs in the event of a severe FBW system degradation (refer to Figure 10–02–5). It provides a direct interface between the flight deck controls, the HSTAB MCE, and a single PCU at each aileron, elevator, and rudder. In this situation, the FBW system operates in AFCU direct mode (refer to AFCU direct mode).

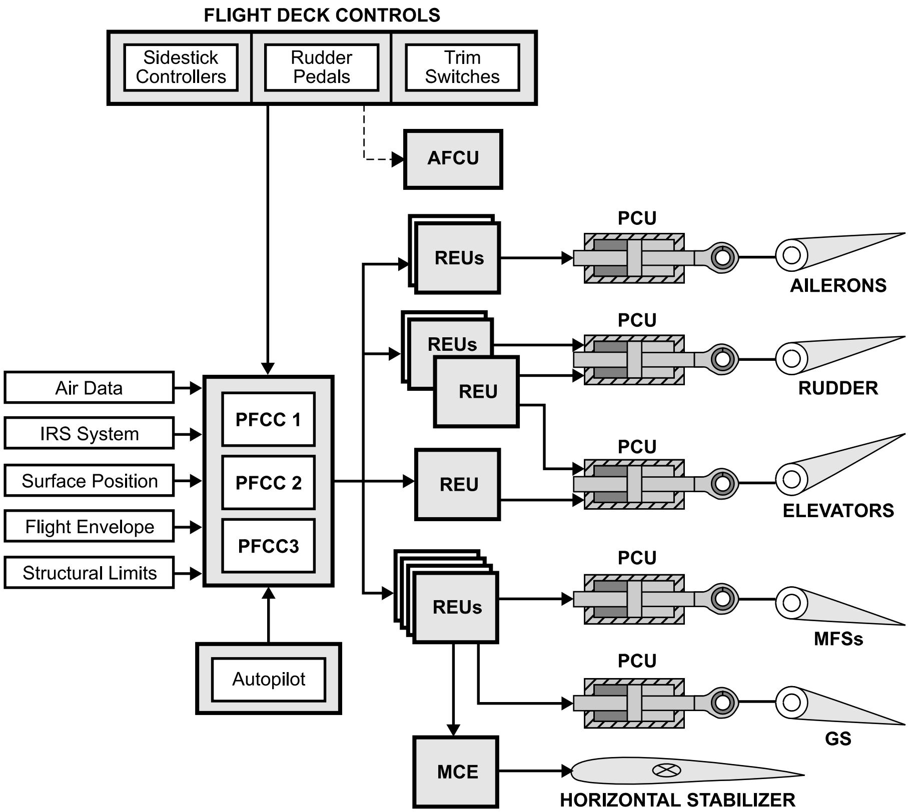


Alternate Flight Control Unit (AFCU) logic
Figure 10–02–5

FBW SYSTEM OPERATION – NORMAL MODE

A. Normal mode – Introduction

The FBW system normal mode is the operating mode used during all normal flight operations. It provides full authority and augmentation in all three axes with envelope protection functions, structural envelope protection and ground mode (refer to Figure 10–02–6).



Fly–By–Wire (FBW) normal mode
Figure 10–02–6

The following table shows the control functions and protections provided by the FBW system in the normal mode. The functions and protections are briefly described after the table.

	PITCH	ROLL	YAW	SPEED BRAKES/ LIFT DUMPING
Control functions	– Pitch command with speed stability – Manual speed trim – Auto stabilizer trim – Pitch compensation in turns – Nose landing gear loading	– Roll rate/attitude command – Neutral spiral stability, positive spiral stability beyond 30-degree bank – Conventional lateral/directional coupling	– Rudder command – Yaw damping – Turn coordination – Manual yaw trim – Backdriven rudder pedals with trim	– Proportional Lift Dump/speed brakes and Ground Lift Dump (PLD/GLD) (includes 10-degree aileron TEU)
Limiting/ Warning Functions	– Normal load factor – High angle of attack – High speed – Elevator command – Asymmetric (split) elevator – Tail strike reduction on takeoff – Tailplane angle-of-attack – Sidestick shaker	– Bank angle – Roll rate – Wing maneuver load alleviation	– Partial in-flight thrust asymmetry compensation – Rudder command	

B. Pitch control functions

The pitch control functions of the FBW system are:

- Pitch command with speed stability,
- Manual speed trim,
- Auto stabilizer trim,
- Pitch compensation in turns, and
- Nose landing gear loading.

(1) Pitch command with speed stability

In normal mode, the movement of the sidestick on the pitch axis commands a combination of pitch change rate and maneuver load factor. The neutral stick position corresponds to a demand of 1 g flight with zero pitch rate.

As the sidestick is moved forward or aft, the aircraft pitch is changed proportional to the sidestick position. When the sidestick is released, the pitch rate is zero and the pitch attitude is maintained.

The normal mode includes a speed stability function that uses pitch to automatically maintain a selected trim speed. If the aircraft speed moves away from the trim speed, the aircraft pitch changes to return to the trim speed.

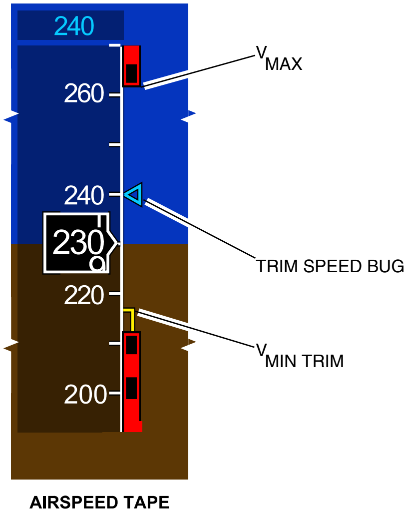
(2) Manual speed trim

When the autopilot is disengaged, the trim speed is set manually using the pitch trim switch on the sidestick. The trim speed displays as a bug on the Primary Flight Display (PFD) airspeed tape. Brief activation of the trim switch will enable fine-tuning of the trim speed.

Maximum trim speed V_{MAX}, is restricted to V_{MO}/ M_{MO}, V_{LE} or V_{FE}, depending on the aircraft configuration. It displays at the top of the speed tape as an alternating red and black tape.

The minimum trim speed is scheduled depending on the aircraft configuration and Mach speed. It is set to ensure that an appropriate margin related to the aircraft operational speed is respected. The minimum trim speed increases as load factor increases (during turns) and decreases when the load factors decrease (return to straight flight).

Figure 10–02–7 shows the speed trim indication.



Speed trim indication
Figure 10–02–7

(3) Auto stabilizer trim

The horizontal stabilizer is controlled by the FBW system normal laws and automatically moves to decrease the load on the elevators.

Under certain conditions, to ensure that adequate pitch authority is available for recovery, the FBW system inhibits stabilizer movement or allows trim in only one direction. For example, during a high angle-of-attack condition, the stabilizer is only allowed to trim nose-down. Also, during an overspeed condition, the stabilizer is only allowed to trim nose up. The nose-up autotrim is disabled below 50 feet AGL.

(4) Pitch compensation in turns

Automatic nose-up pitch compensation is provided in a turn for bank angles up to 33 degrees. Beyond this bank angle, aft sidestick must be applied to maintain flight path.

(5) Nose landing gear loading

On the ground, when both thrust levers are advanced to more than 24 degrees, a nose-down elevator is applied to increase the load on the nose gear. With sidestick at neutral position (no pilot input), the elevator is automatically set to 12 degrees nose down up to 80 kt and decreases to 0 degrees by 90 kt.

C. Pitch protection functions

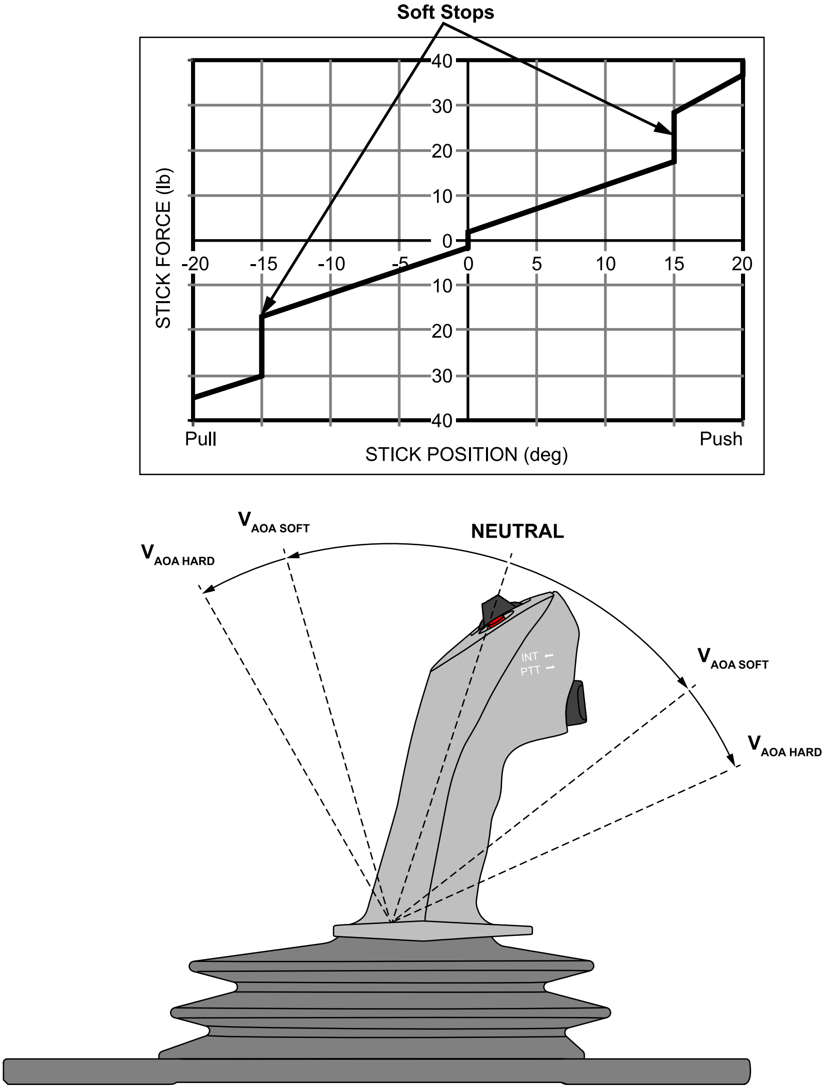
The normal mode provides flight envelope protection to help maintain the flight within the operational flight envelope. It also helps to recover the aircraft should there be excursions beyond the operational limits.

The soft limit (soft stop) is used to provide a tactile cue at the edge of the operational envelope. When a soft stop is exceeded, a tactile cue (and in most cases visual or aural cues) indicates that the aircraft is at or has exceeded the soft limit. The principal tactile cues are:

- Soft stop,
- Progressive increase in sidestick deflection force, and
- Sidestick shaker.

The hard limit (hard stop) allows limited safe excursion outside the operational envelope.

Figure 10–02–8 shows the pitch protection functions.



Pitch protection
Figure 10–02–8

(1) Normal load factor protection

The normal load factor protection limits the load factor, based on aircraft configuration and sidestick position (soft or hard stops).

The following table gives the maximum load factor at the soft stop and at full sidestick displacement (hard stop).

Description	SLATS/FLAPS retracted	SLATS/FLAPS deployed
Full aft sidestick hard stop	2.75 g	2.2 g
Aft sidestick soft stop	2.5 g	2.0 g
Forward sidestick soft stop	0.15 g	0.15 g
Full forward sidestick hard stop	–1 g	–0.25 g

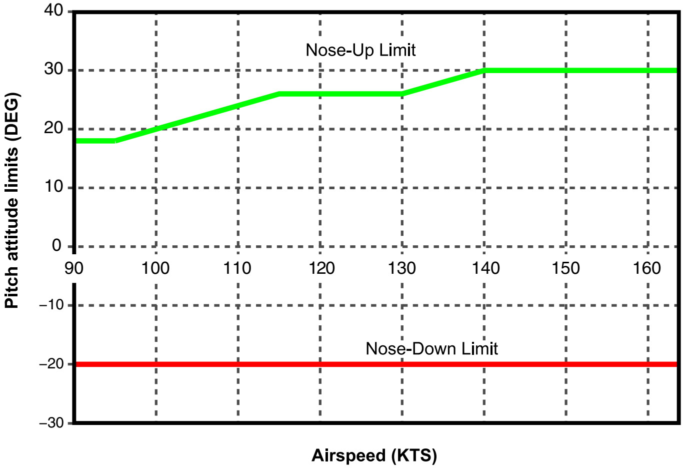
(2) Pitch attitude protection

The nose-up pitch attitude limit is set to 30 degrees and is sufficiently above the pitch attitudes required for normal operation. At less than 140 kt, the pitch attitude limit is reduced from 30 degrees to 26 degrees at 130 kt. The pitch attitude limit stays constant between 130 kt and 115 kt, and is then further reduced to 18 degrees at 95 kt. It stays constant below 95 kt.

The nose-down pitch attitude is limited to –20 degrees. This limit is sufficiently low so that it does not interfere with nose-down maneuvers such as emergency descent or low speed recovery.

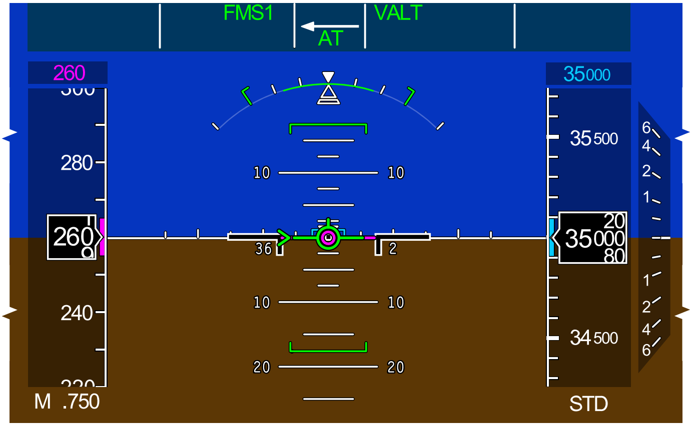
On the ground, the nose-up pitch attitude limit is set to 17 degrees. It is changed to the flight value after transition from ground to air.

Figure 10–02–9 summarizes the pitch attitude limits.



Pitch attitude limits
Figure 10–02–9

The pitch attitude limits are indicated by green bars with ends on the pitch ladder of the PFD, as shown in Figure 10–02–10.



Pitch limit indication
Figure 10–02–10

(3) High angle-of-attack protection

The High Angle-of-Attack Protection (HAP) ensures that the aircraft does not exceed the operational Angle-Of-Attack (AOA) envelope at the sidestick soft stop ($V_{AOA\ SOFT}$), and that it does not exceed its maximum AOA at full aft sidestick hard stop ($V_{AOA\ HARD}$).

Between $V_{MIN\ TRIM}$ and $V_{AOA\ SOFT}$:

- HSTAB noseup trim is disabled,
- Multifunction Spoilers (MFSs) automatically retract:
  - The spoiler lever must be reset to the RET position in order to redeploy the MFSs, and
  - Spoilers do not retract at speeds above Mach 0.65 to allow for emergency descent configuration.
- Maximum roll rate is reduced,
- The airspeed readout turns amber, and

- A single "SPEED" aural alert sounds.

Between $V_{AOA\ SOFT}$ and $V_{AOA\ HARD}$:

- The airspeed readout turns red,
- A repetitive "SPEED, SPEED, SPEED" aural alert sounds, and
- The stick shaker activates.

At $V_{AOA\ HARD}$:

- The red airspeed readout flashes,
- A red STALL warning flag is dispayed on the PFD, and
- A repetitive "STALL, STALL, STALL" aural alert sounds.

A system failure displays the **ALPHA LIMIT** EICAS caution message.

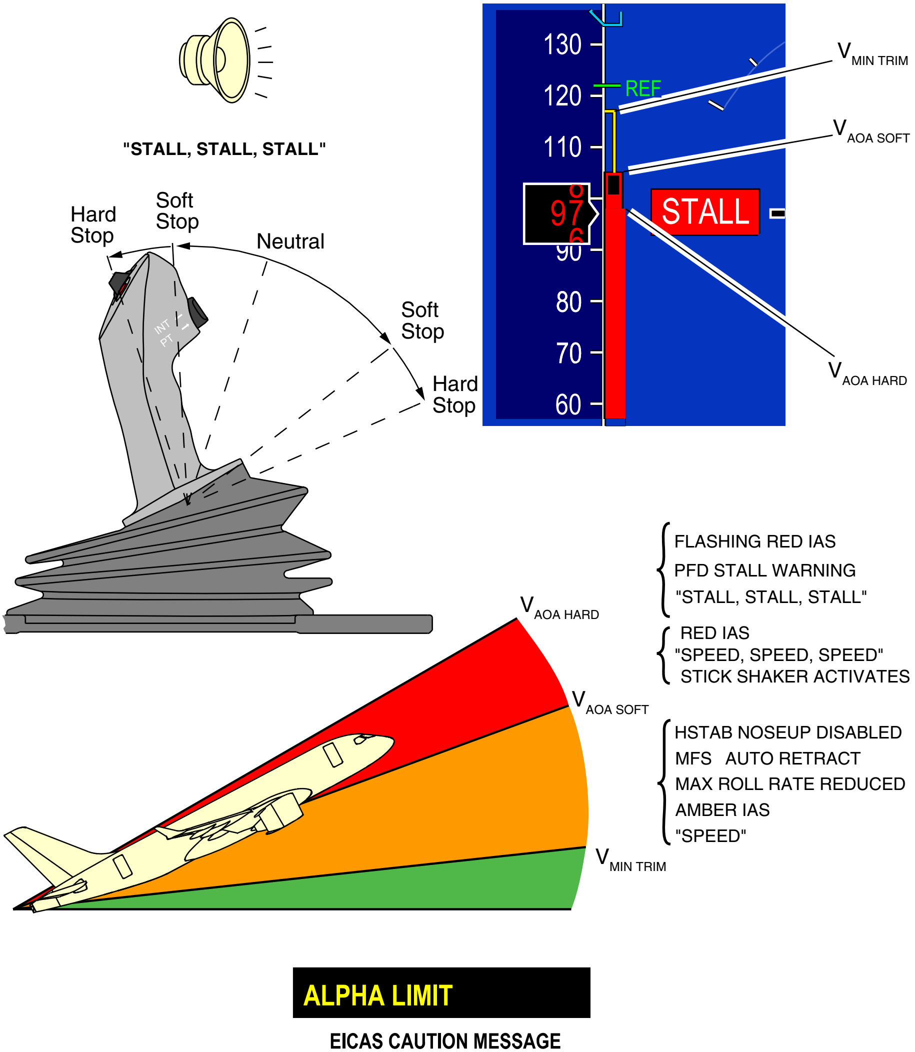
The HAP function adjusts the protection settings:

- When in icing conditions and the wing anti-ice system is not activated or has failed,
- During abnormal slat/flap configurations,
- When sideslip angles are greater than 5 degrees, and
- At high speed conditions (Mach > 0.65) to allow spoiler deployment during emergency without shaker activation.

NOTE

The sidestick shaker is inhibited below 60 kt.

Figure 10–02–11 illustrates the high angle-of-attack protection in normal mode.



High Angle–of–Attack protection normal mode
Figure 10–02–11

(4) High speed protection

The high speed protection limits the aircraft speed if it exceeds V_{MO}/M_{MO} due to pilot inputs or upsets, by applying an HSTAB nose–up bias and deploying the MFS under high g loads. It automatically recovers the aircraft to the trim speed if the sidestick is released to its neutral position during an overspeed condition.

The high speed protection is only active when the slats and flaps are retracted. When the landing gear is down, the maximum trim speed is reduced to maximum landing gear operating speed (V_{LO}), but other speed limits remain unchanged.

(5) Tail strike protection

To reduce the possibility of tail strike during takeoff, the FBW system reduces the aircraft pitch rate during aggressive rotations, and compensates for forward and aft Center of Gravity (CG) conditions. However, the combined effect of theses functions is insufficient to guarantee tail strike protection in all conditions.

(6) Tailplane angle-of-attack protection

The elevator command is limited as a function of airspeed to provide structural protection and to prevent a negative tailplane stall condition.

(7) Elevator command

The elevator command is limited as a function of airspeed, to provide structural protection.

(8) Elevator surface split limiting

The elevator split is limited as a function of airspeed and is disabled if reliable elevator position data is not available.

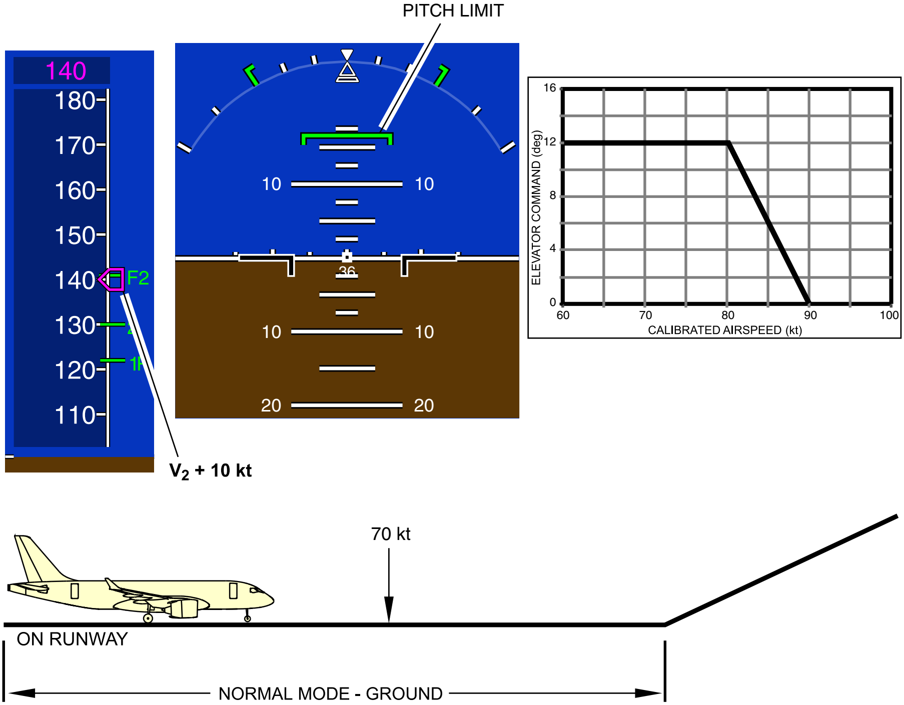
D. Ground/Air/Ground transition

(1) On ground (Normal mode – Ground)

On ground is defined as both main gear on the ground (typically indicated by a combination of radio altitude, wheel speed and weight on wheels). When the aircraft is on the ground, the normal mode provides:

- Direct, full travel authority of the elevator,
- Pitch rate damping,
- Direct control of the horizontal stabilizer trim,
- Automatic setting of the trim speed bug to V_2+ 10 kt (if an engine failure is detected, the trim speed bug is set automatically to V_2),
- Nose-up pitch attitude limit set to 17 degrees,
- Sidestick shaker function above 60 kt, and
- Yaw damper function enabled at 70 kt.

Figure 10–02–12 shows the normal ground mode.



Normal ground mode
Figure 10–02–12

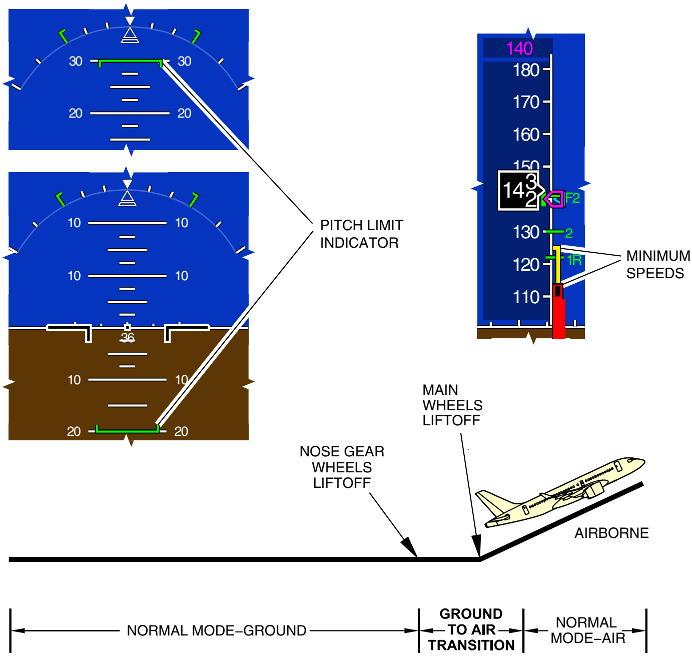
(2) Takeoff

The transition and envelope protection is designed to prevent exceedance of AOA limits during takeoff and to ensure a rapid and smooth transition from ground to air.

During the transition:

- Minimum speed markings on the PFD become active 1 second after liftoff.
- The transition is completed within 3 seconds after the aircraft leaves the ground.
- The nose-up pitch attitude limit is changed to the airborne setting after liftoff, as indicated by the limit marking on the PFD pitch ladder.
- Speed trimming and autotrim are enabled one second after ground-to-air transition. The nose-up autotrim is activated above 50 ft AGL.

Figure 10–02–13 shows the ground-to-air transition.



Ground–to–air transition
Figure 10–02–13

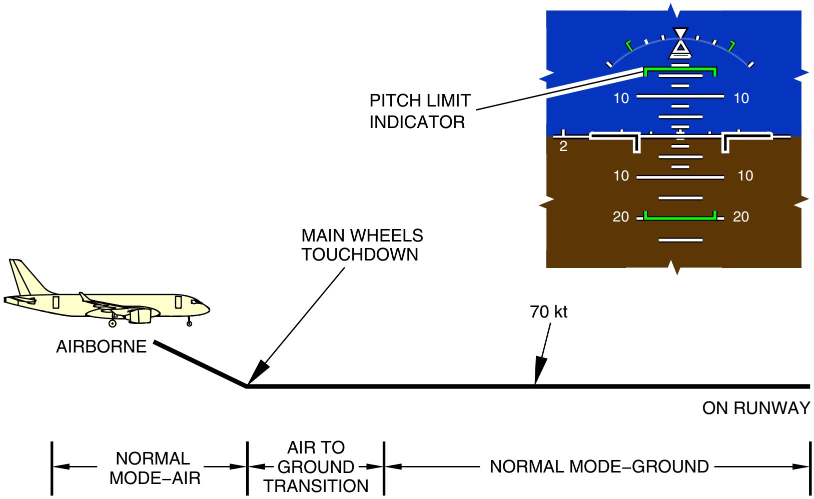
(3) Landing

The air-to-ground transition is designed to provide smooth, predictable handling during the transition.

- Speed trimming and the autotrim functions are disabled, and manual stab trim enabled. The nose-up autotrim is disabled below 50 ft AGL,
- Direct, full travel authority of the elevator following the weight-on-wheels signal.
- Nose-up pitch attitude limit is set to 17 degrees.
- The pitch nose-down command is set when the spoilers deploy after touchdown.

- Yaw damping is disabled at 70 kt.

Figure 10–02–14 shows the air-to-ground transition.



Air–to–ground transition
Figure 10–02–14

E. Roll/yaw control functions

(1) Roll control functions

When the sidestick is moved laterally, a roll rate is commanded and the aircraft banks. When the sidestick is released and the bank angle is less than 30 degrees, the roll stops and the aircraft maintains the bank angle.

When the sidestick is released and the bank angle is more than 30 degrees, the aircraft automatically rolls back to 30 degrees of bank. The sidestick must be held deflected in order to maintain a bank angle of more than 30 degrees.

The normal mode automatically provides turn coordination. Rudder pedal inputs are usually not required during normal coordinated turns.

(2) Aileron lift augmentation

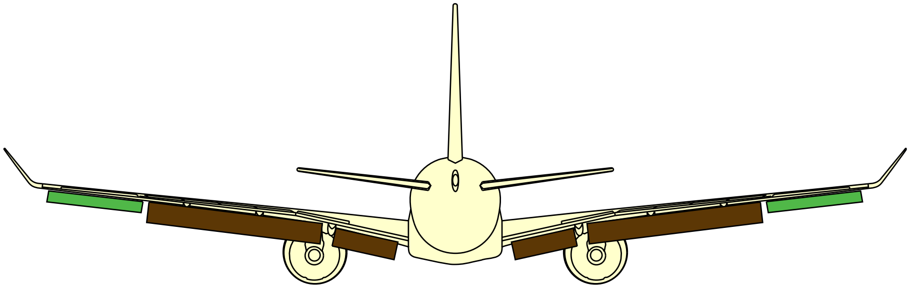
The ailerons deploy symmetrically (trailing edge down) for lift augmentation. The ailerons deploy from 0 degrees to 10 degrees as the flaps deploy, and retract on flap retraction.

Lever detent	**0**	**1**	**2**	**3**	**4**	**5**
Flap position (degrees)	0	0	10	15	25	37
Aileron droop (degrees)	0	0	10	10	10	5

NOTE

Roll assist has priority over the aileron lift augmentation function.

Figure 10–02–15 illustrates the aileron lift augmentation.

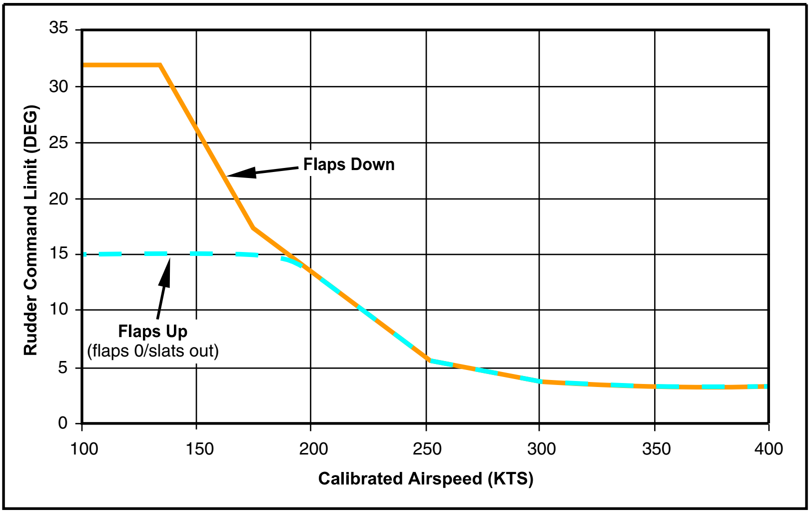


Aileron lift augmentation
Figure 10–02–15

(3) Yaw control functions

The rudder pedals control yaw. The FBW system sends calculated yaw commands to the rudder, based on air data and aircraft configuration.

The rudder travel is limited for structural loads and handling requirements. The rudder travel limits change with airspeed and flap position (refer to Figure 10–02–16).



Rudder command limits
Figure 10–02–16

Directional trim is available through a trim switch located on the center pedestal. It provides compensation for excessive rudder pedal sensor bias and system failures not fully compensated by the FBW system.

F. Roll/yaw protection function

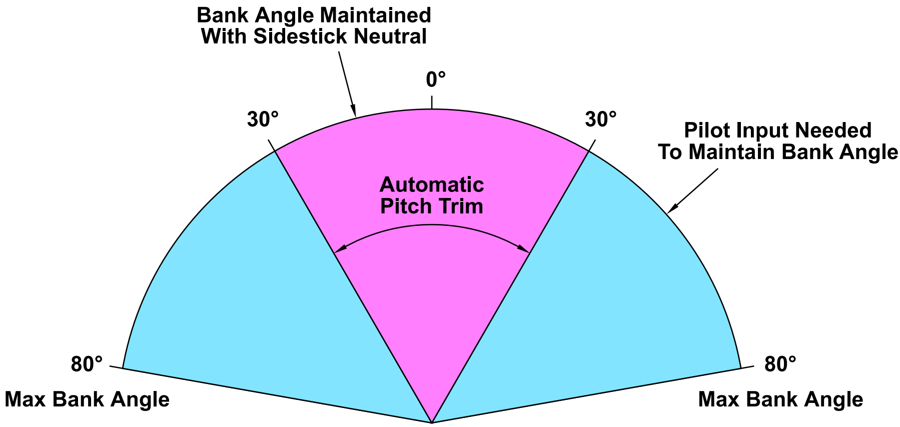
(1) Bank angle limiting

The bank angle is limited to 80 degrees on each side (refer to Figure 10–02–17).

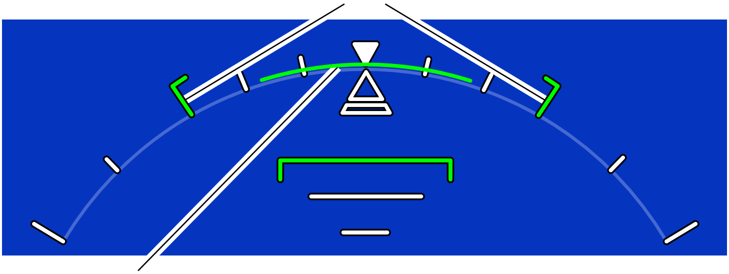
During overspeed, or when more than 10 degrees pitch nose down, the bank angle limits are reduced for high speed protection and/or pitch limiting.

Hard bank angle limits are indicated by green bars with ends on the roll attitude markings on the PFD (refer to Figure 10–02–18).

Above 31500 ft, the half bank angle limit (1/2 bank) is indicated by a green arc on the roll scale.



Bank angle/Roll rate
Figure 10–02–17



Bank angle limits
Figure 10–02–18

(2) Roll rate limiting

The maximum roll rate at full sidestick deflection is 20 degrees per second. At extreme pitch attitudes, maximum roll rate is reduced linearly to 10 degrees per second at the maximum angle of attack ($V_{AOA\ HARD}$).

(3) Wing maneuver load alleviation

To reduce wing root bending moment and for structural weight saving, the wing maneuver load alleviation function deflects the ailerons up (trailing edge up) during positive load factor maneuvers.

The function is activated at a load factor greater than 1.55 g. Between 1.55 g and 2.1 g, the ailerons are linearly commanded to 10 degrees trailing edge up (TEU). Above 2.1 g, the 10 degree TEU deflection is maintained.

When coupled with roll assist commands, the ailerons increase the up deflection, but not below the deflection required to provide wing maneuver load alleviation.

(4) In-flight engine out compensation

The engine out compensation provides partial automatic yaw compensation with an engine out condition (in the air). This compensation is equally applicable to most failures that cause significant yaw.

The aircraft typically rolls into the failed engine with a maximum bank angle of 20 degrees or less, and a sideslip angle of 5 degrees or less.

The intent of the engine out compensation is not to mask the engine failure, but to provide assistance in controlling the aircraft during and after the failure.

FBW SYSTEM OPERATION – DIRECT MODE

A. Direct mode – Introduction

The direct mode is automatically selected by the FBW system when the normal mode cannot be maintained. It is intended for continued safe flight and landing only.

The direct mode is a command-by-wire system. The positions of the flight control surfaces are calculated based on direct mode control laws, allowing sidestick surface control with limited augmentation. The direct mode provides limited pitch augmentation while the aileron and rudder surface deflections are proportional to the lateral sidestick and rudder pedal inputs.

DIRECT MODE displays in amber on the FLT CTRL synoptic page (refer to Figure 10–02–19).

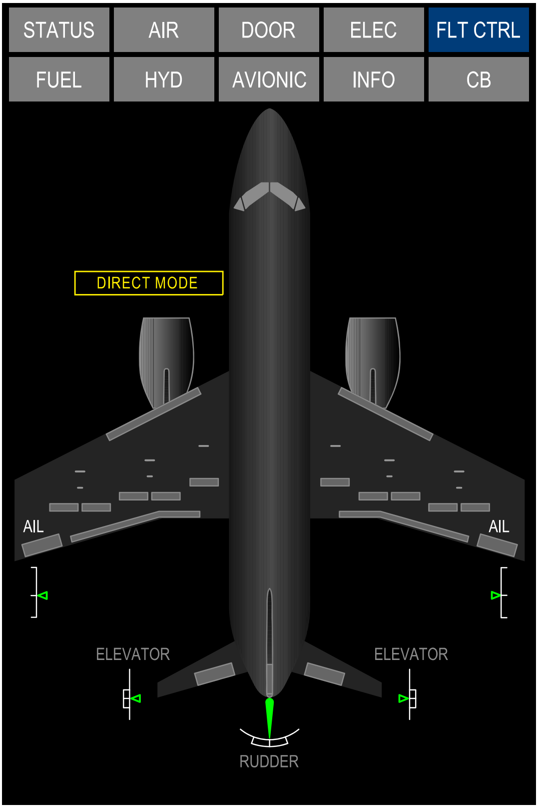
The following table shows the control functions and protections still provided by the FBW system in direct mode.

	PITCH	ROLL	YAW	SPEED BRAKES/ LIFT DUMPING
Control functions	– Surface command – Pitch rate damping – Manual stabilizer trim	– Surface command – Manual lateral trim	– Surface command – Yaw damping – Manual rudder trim – Back–driven rudder pedals with trim	– Proportional lift dump/speed brakes
Limiting/ Warning Functions	– Elevator command – High angle of attack – Sidestick shaker		– Rudder command	

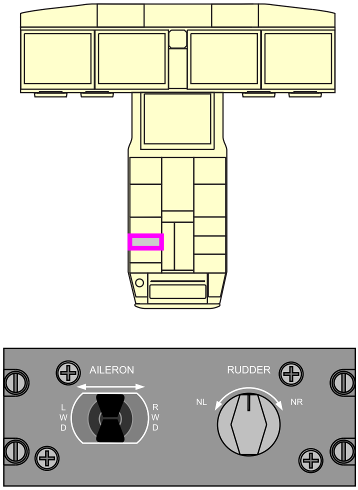
Depending on the type of failure, the system reverts to one of three types of direct mode:

- PFCC direct,
- REU direct, or
- AFCU direct.

Since direct mode is axis specific, it is possible to have different direct mode laws acting in unison.



SYNOPTIC PAGE – FLT CTRL



AILERON AND RUDDER TRIM SWITCHES

Direct mode
Figure 10–02–19

B. PFCC direct mode

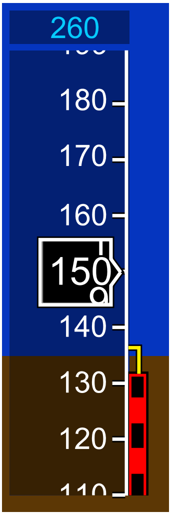
The PFCC direct mode is used when the information required for normal mode is degraded or not received by the PFCCs. In this mode, the Multifunction Spoilers (MFSs) and the ground spoilers are available. The sidestick pitch trim switches control the horizontal stabilizer position directly as a function of the slat/flap position.

When the PFCC direct mode is activated, an amber DIRECT message displays on the upper left corner of the Primary Flight Display (PFD) and the **FLT CTRL DIRECT** caution message displays on the EICAS page. The speed tape $V_{AOA\ HARD}$ indication is removed, and the low speed indication consists of a red and black tape below the $V_{MIN\ TRIM}$ amber marker.

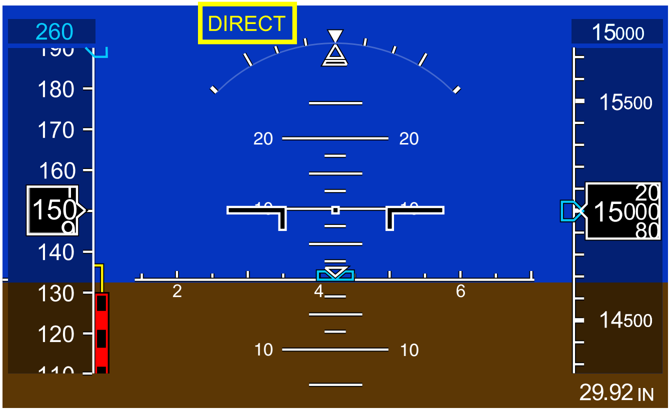
There are two PFCC direct sub-modes:

- PFCC direct mode due to all Air Data Smart Probes (ADSP) data input failure — the **FLT CTRL DIRECT ADS** caution message displays on the EICAS page.
- PFCC direct mode due to all inertial data input failure — the **FLT CTRL DIRECT IRS** caution message displays on the EICAS page.

Figure 10–02–20 shows the PFCC direct mode indications and the Figure 10–02–21 shows the PFCC direct mode logic diagram.

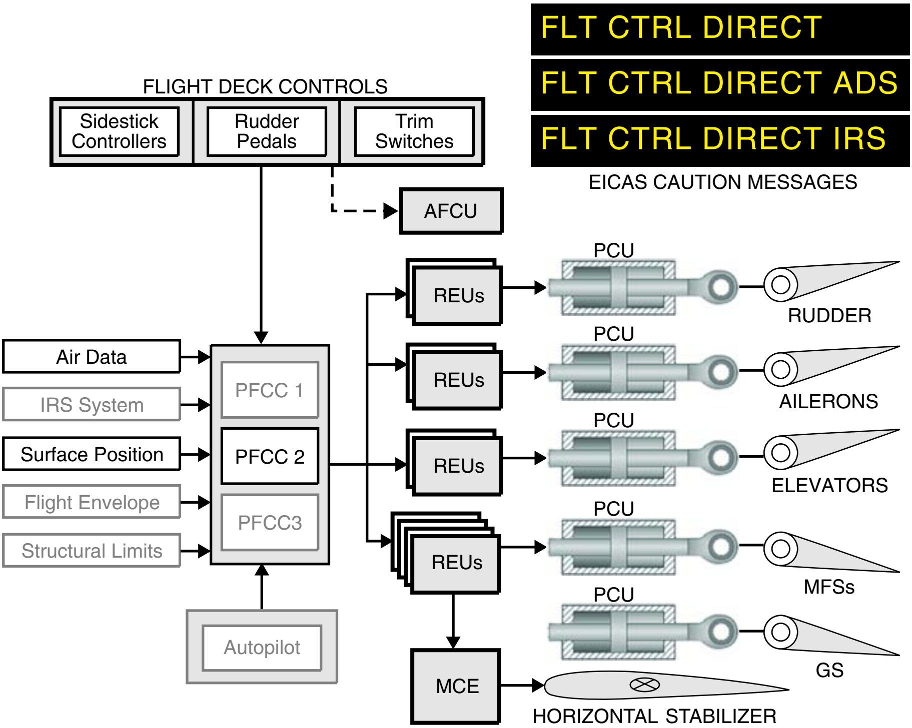


ASI



PFD

Low speed indication
Figure 10–02–20



PFCC direct mode
Figure 10–02–21

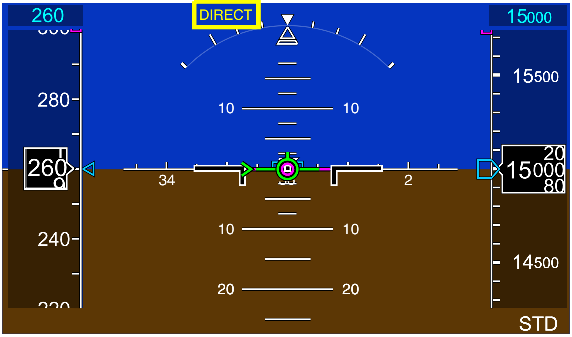
C. REU direct mode

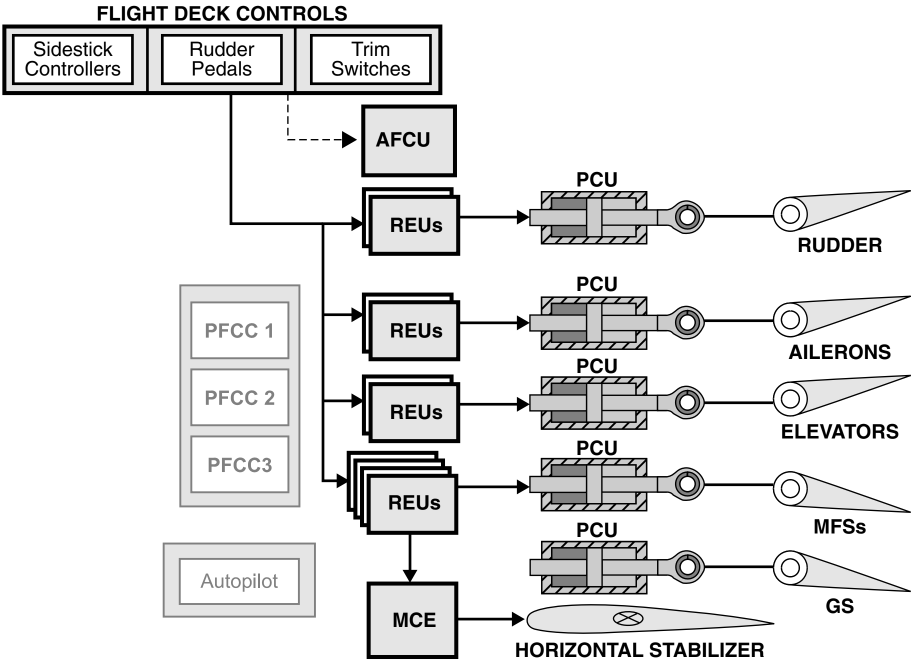
The REU direct mode is used when all the PFCCs have failed or all signals to the REUs are lost. This mode has the same functionality as PFCC direct mode, with the following exceptions:

- No selection of sidestick priority,
- Ground spoilers not available,
- No automatic ground lift dumping, the MFSs must be manually deployed, and
- The pitch trim rate is a function of the slat/flap position, but is slower than PFCC direct mode.

When the REU direct mode is activated, an amber DIRECT message is displayed in the upper left corner of the Primary Flight Display (PFD), and the **FLT CTRL DIRECT** caution message is shown on the EICAS page. Figure 10–02–22 shows the indications in REU direct mode. Additional advisory or status messages are also shown, depending on the cause of the reversion to the REU direct mode.

If a PFCC is recovered, the computer must be reset with its guarded switchlight on the overhead panel to revert to PFCC direct mode.





REU direct mode
Figure 10–02–22

D. AFCU direct mode

The AFCU direct mode is automatically selected when control requirement is lost due to failure of multiple REUs. In this mode, the AFCU interfaces directly with the flight deck controls and actuators, using dedicated sensors and channels with no reliance on the REUs. The AFCU direct mode provides an independent control path from the flight deck controls directly to all primary surfaces.

The AFCU direct mode has the same functionality as the REU direct mode, with the following exceptions:

- MFSs are not available,
- The rudder authority is set to single engine operation settings, and
- The pitch trim is like PFCC direct mode regardless of slat/flap configuration.

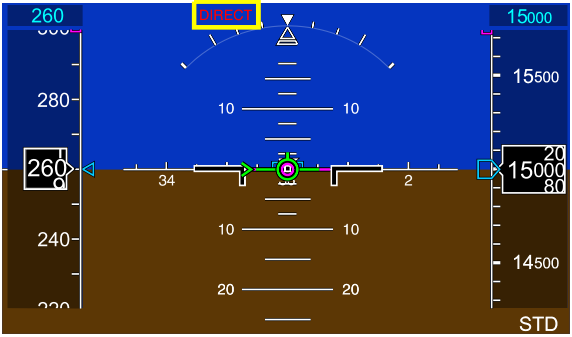
When the AFCU direct mode is activated, a red DIRECT message is displayed in the upper left corner of the PFD, and the **FLT CTRL DIRECT** warning message is shown on the EICAS page.

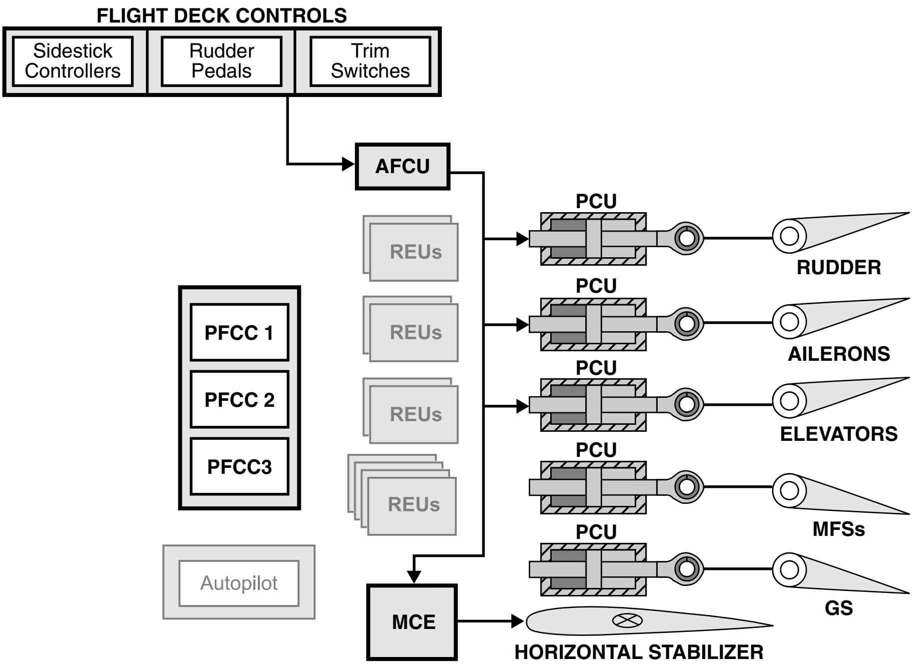
The FBW system automatically reverts back to REU direct mode on a given axis if any of the REUs are recovered.

Figure 10–02–23 shows the indications in AFCU direct mode.

FLT CTRL DIRECT

EICAS WARNING MESSAGE





AFCU direct mode
Figure 10–02–23

E. FBW control modes

FLY-BY-WIRE CONTROL MODES				
Functional Allocation	Normal	PFCC Direct	REU Direct	AFCU Direct
Autopilot	☑			
Envelope Protection	☑			
Spoiler Control	☑	☑	☑	
Roll Assist	☑	☑	☑	
Ground Spoilers (Auto Deploy)	☑	☑		
Manual HSTAB Trim		☑	☑	☑
Rudder Trim	☑		☑	☑
Manual Aileron Trim		☑	☑	☑
Sidestick Priority	☑	☑		

FBW control modes
Figure 10–02–24

F. High Angle-Of-Attack (AOA) protection direct mode

In direct mode, the FBW system does not provide low-speed information. Values for $V_{MIN\ TRIM}$ and the red stall marker tape are received from the air data system. As $V_{AOA\ SOFT}$ is calculated by the FBW system, it does not display.

When speed is between $V_{MIN\ TRIM}$ and the stall marker tape:

- The airspeed readout turns amber, and
- A single "SPEED" aural alert sounds.

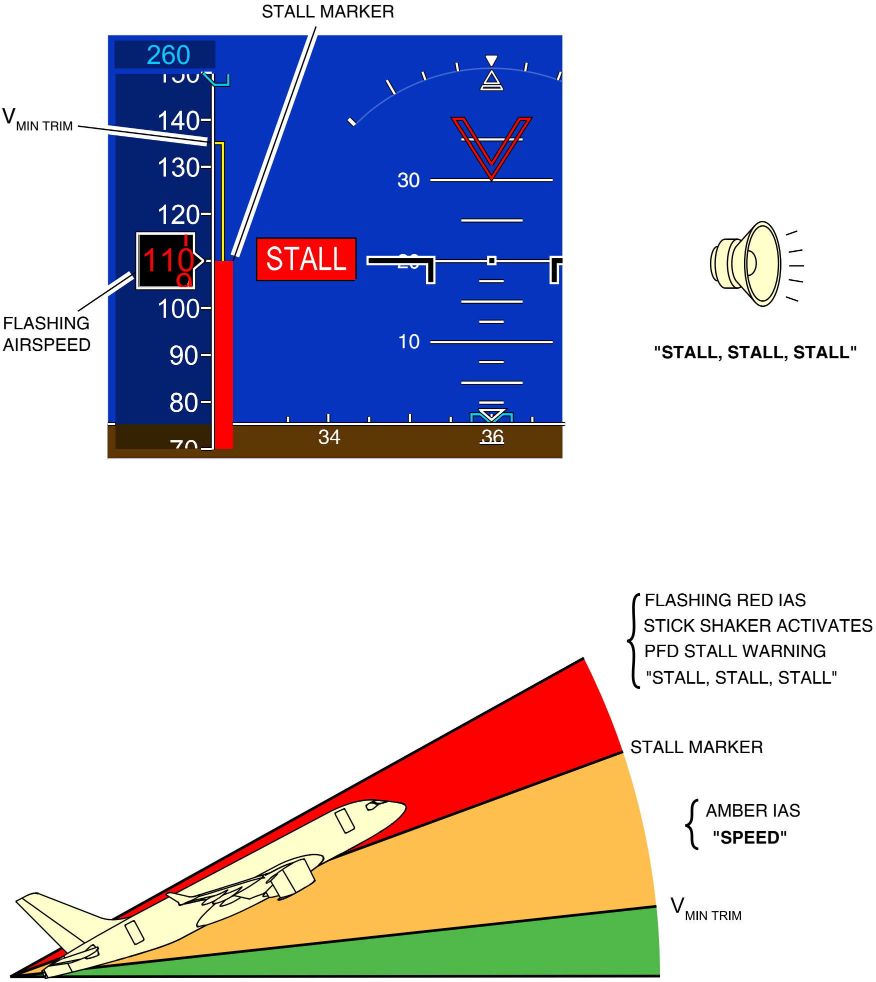
When speed is at or below the red stall marker tape:

- The airspeed readout turns red and flashes,
- The stick shaker activates,
- A red STALL warning flag displays on the PFD, and
- A repetitive "STALL, STALL, STALL" aural alert sounds.

NOTE

Multifunction spoilers, if extended, do not automatically retract in direct mode.

Figure 10–02–25 illustrates the high AOA protection in direct mode.



High Angle–of–Attack protection direct mode
Figure 10–02–25

SYSTEM TEST

The **FLT CTRL TEST REQ** EICAS advisory message indicates that a FLT CTRL test has not been recently performed.

The FBW system test and the sidestick shaker test are accomplished by selecting the FLT CTRL and SHAKER soft switches respectively on the AVIONIC synoptic page (AVIO tab). The test results are shown as messages on the side of each soft switch, as shown in Figure 10–02–26. IN PROG displays during either test.

During the SHAKER test, both sidesticks vibrate.

(1) FLT CTRL test

During this test, the EICAS displays the **FLT CTRL IN TEST** EICAS advisory message.

Possible test results are:

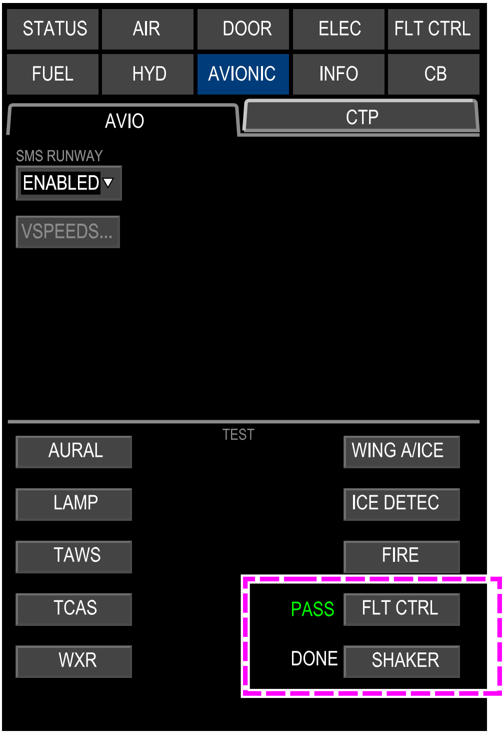
- FAULT - failure due to component fault,
- FAIL - test failure, and
- PASS - test successfully completed.

(2) SHAKER test

The test displays DONE when completed.

NOTE

Both FLT CTRL and SHAKER tests are inhibited when airborne.



AVIONIC SYNOPTIC PAGE - AVIO TAB

EICAS ADVISORY MESSAGES

MESSAGE	COLOR	TEST STATUS
IN PROG	Cyan	Test in progress.
–––––	Amber	Test invalid or aborted.
FAULT	Cyan	FLT CTRL test fault.
FAIL	Amber	FLT CTRL test failure.
PASS	Green	FLT CTRL test successfully completed.
DONE	White	SHAKER test completed.

AVIONIC synoptic page (AVIO tab)
Figure 10–02–26

The table that follows lists the test result messages.

TEST MESSAGE	DESCRIPTION
IN PROG (cyan)	Test in progress.
PASS (green)	Test successfully completed.
FAULT (cyan)	Test failure.
DONE (white)	Test sequence completed.
PRESS TO STOP (white)	Test has to be terminated manually.
FAIL (amber)	Test failed.
– – – – – – (amber)	Test invalid.

FLY–BY–WIRE SYSTEM – EICAS MESSAGES

A. Warning messages

MESSAGE	DESCRIPTION	AURAL	INHIBIT
FLT CTRL DIRECT	Aircraft in AFCU direct mode.	None	TO

B. Caution messages

MESSAGE	DESCRIPTION	INHIBIT
ADS DEGRADED	PFCC is reporting errors from the air data system that could impact the input to the CLAWS.	TO, LDG
ALPHA LIMIT	Reduction of upper aircraft pitch angle limit (stall protection limit) due to failures.	TO
FLT CTRL DIRECT	Aircraft in direct mode.	TO, LDG
FLT CTRL DIRECT ADS	Aircraft in direct mode due to air data input failure.	TO, LDG
FLT CTRL DIRECT IRS	Aircraft in direct mode due to inertial data input failure.	TO, LDG

C. Advisory messages

MESSAGE	DESCRIPTION	INHIBIT
FLT CTRL FAULT	Loss of redundant or non-critical function for the Primary Flight Control Systems (PFCCs).	TO, LDG
FLT CTRL IN TEST	Flight control FBW system in automated test.	TO, LDG
FLT CTRL TEST REQ	Power-up Built-In Test (PBIT) test interval exceeded.	TO, LDG
PFCC 1 FAIL	Loss of PFCC 1 (loss of redundancy).	TO, LDG
PFCC 2 FAIL	Loss of PFCC 2 (loss of redundancy).	TO, LDG
PFCC 3 FAIL	Loss of PFCC 3 (loss of redundancy).	TO, LDG

D. Status messages

MESSAGE	DESCRIPTION	INHIBIT
PFCC 1 OFF	PFCC 1 selected OFF.	None
PFCC 2 OFF	PFCC 2 selected OFF.	None
PFCC 3 OFF	PFCC 2 selected OFF.	None

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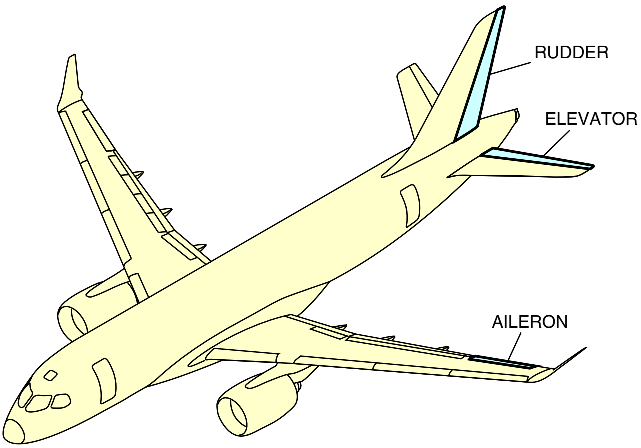
PRIMARY FLIGHT CONTROLS – OVERVIEW

The Primary Flight Control System (PFCS) consists of:

- Two ailerons,
- Two elevators, and
- A rudder.

All the primary flight controls are hydraulically powered and controlled by the FBW system.

Figure 10–03–1 shows the primary flight control surfaces.

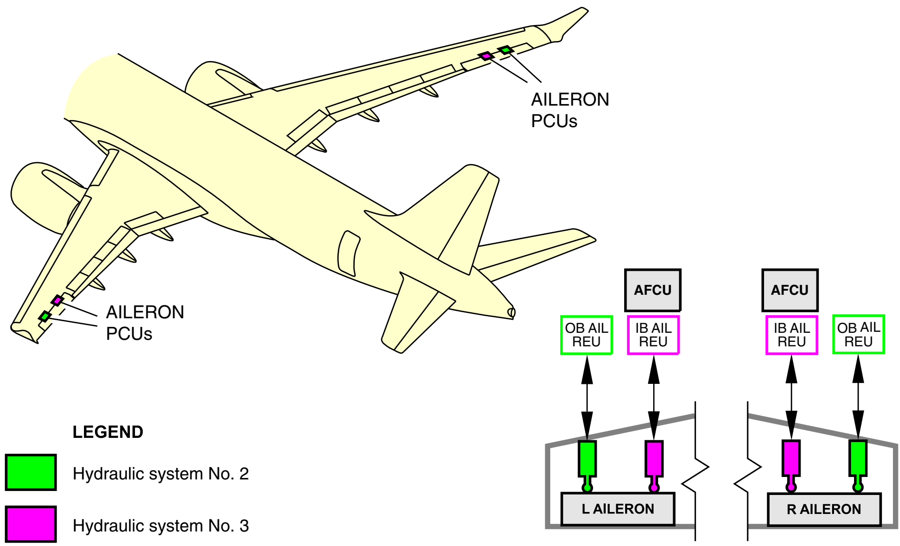


Primary flight control surfaces
Figure 10–03–1

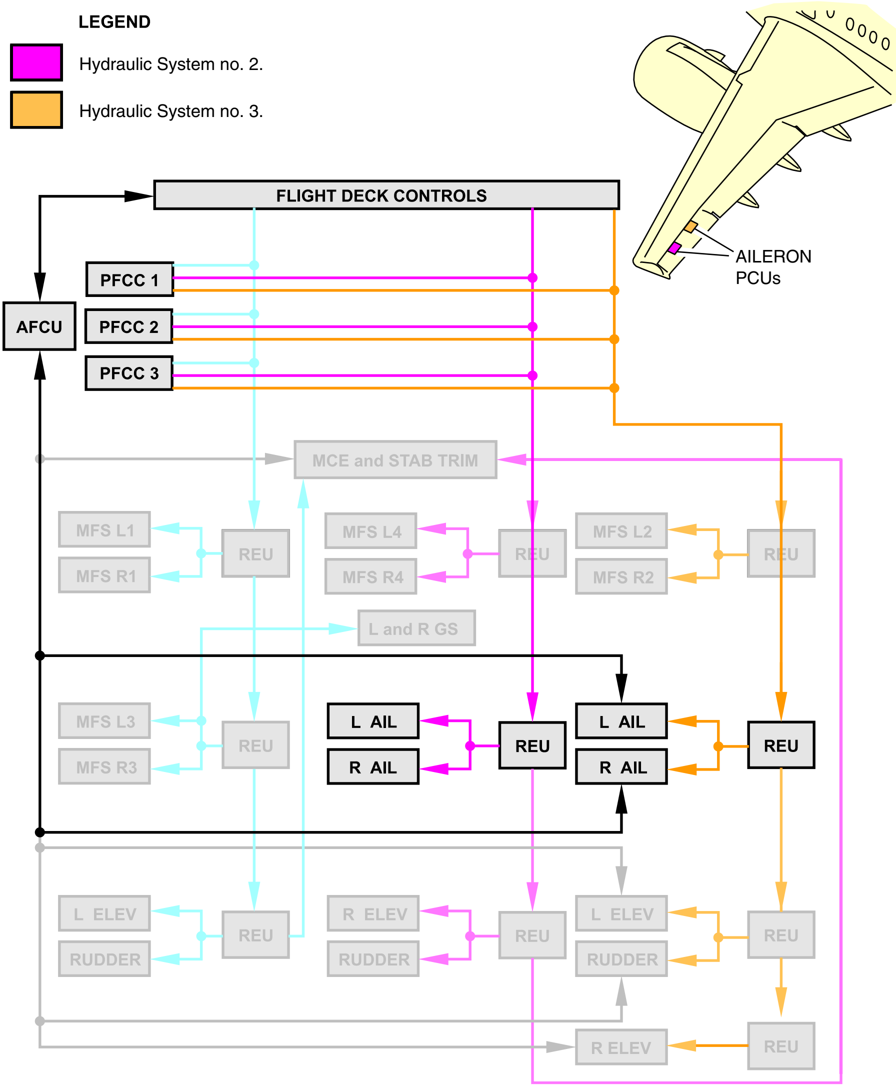
PRIMARY FLIGHT CONTROLS – DESCRIPTION AND OPERATION

A. Ailerons

There are two PCUs on each aileron. The inboard PCUs are powered by hydraulic system No. 3 and controlled by the inboard aileron Remote Electronic Unit (REU) (IB AIL REU). The outboard PCUs on each aileron are powered by hydraulic system No. 2 and controlled by the outboard aileron REU (OB AIL REU). The left and right ailerons are moved by Power Control Units (PCUs), which consist of electrically-controlled hydraulic actuators. Figure 10–03–2 shows the aileron architecture and Figure 10–03–3 the general schematic.



Aileron system
Figure 10–03–2



Aileron system schematic
Figure 10–03–3

In normal mode, the sidestick lateral movement, along with the Air Data System (ADS), Inertial Reference Units (IRUs), and configuration data are used to compute the aircraft roll commands. The commands are sent to the REUs to move the ailerons through the PCUs.

In REU direct mode, the sidestick lateral movement is sent directly to the REU for an aileron deflection.

In AFCU direct mode, the sidestick lateral movement is sent directly to the AFCU to move the ailerons, using hydraulic system No. 3 only.

B. Elevators

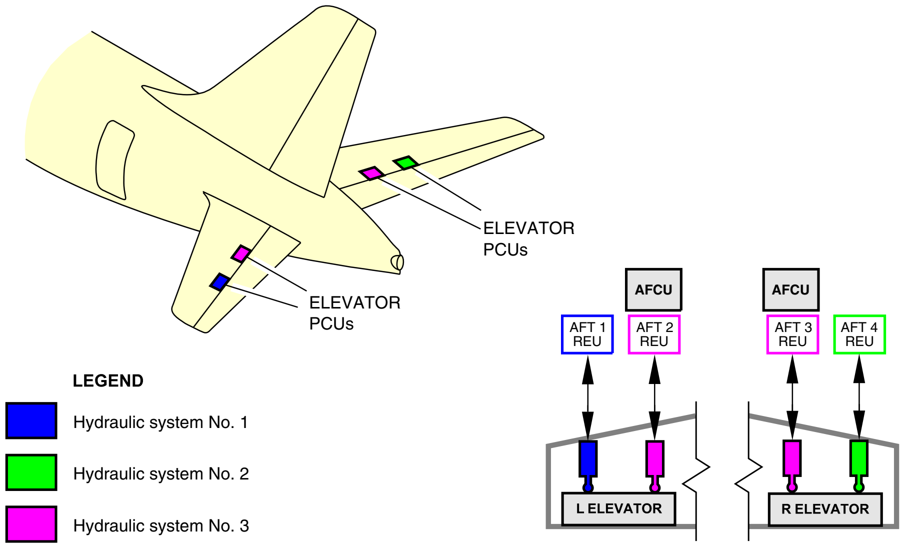
The left and right elevators are moved by Power Control Units (PCUs), which consist of electrically-controlled hydraulic actuators. There are two PCUs on each elevator.

The left elevator outboard PCU is powered by Hydraulic system No. 1, and the right outboard PCU is powered by the hydraulic system No. 2. Hydraulic system No. 3 powers the inboard elevator PCUs on both sides.

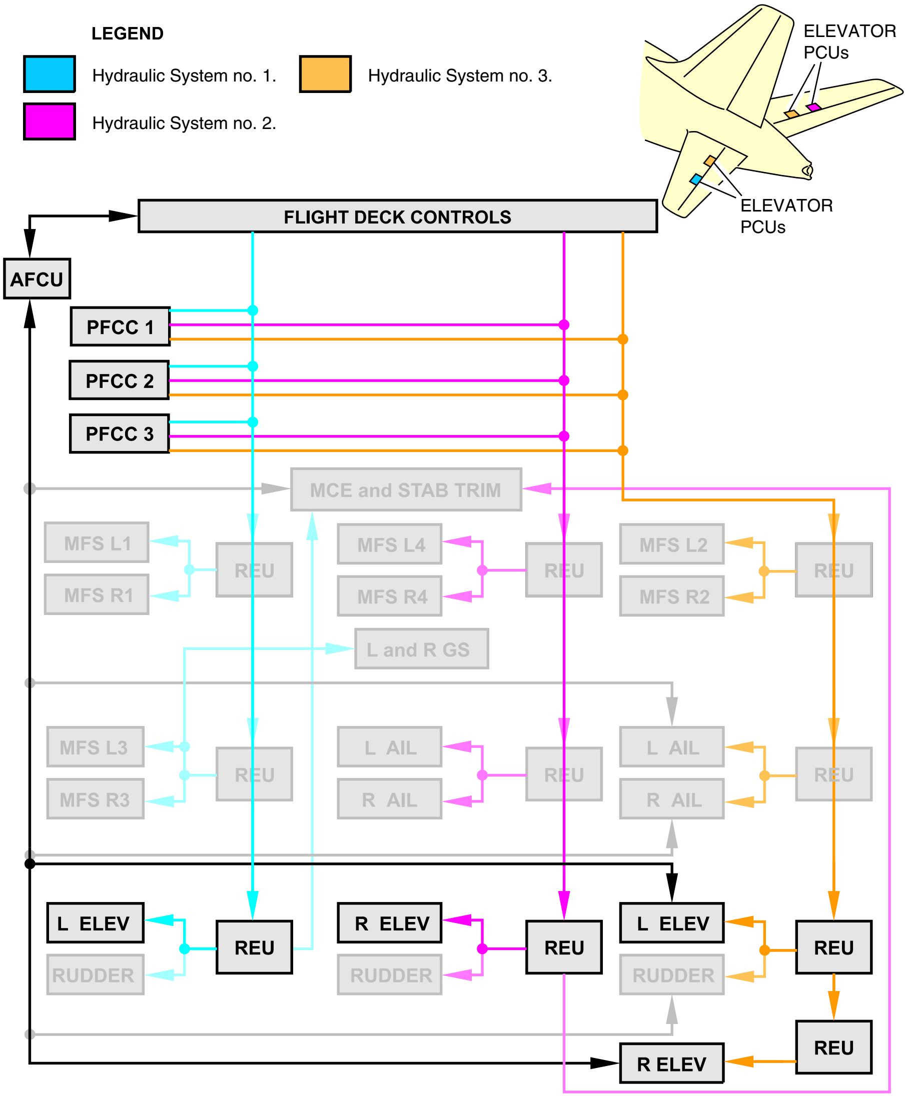
On the left elevator, the AFT 1 REU controls the outboard PCU, and the AFT 2 REU controls the inboard PCU. On the right elevator, the AFT 3 REU controls the inboard PCU, and the AFT 4 REU the outboard PCU.

Maximum elevator travel varies as a function of airspeed and configuration changes. Available deflection is indicated by a rectangle on the gray scale that varies in length. Lower airspeeds, and extension of flaps, increases the available elevator deflection. As airspeed increases, available deflection decreases.

Figure 10–03–4 shows the elevator architecture and Figure 10–03–5 the general schematic.



Elevator system
Figure 10–03–4



Elevator system schematic
Figure 10–03–5

The elevators operate symmetrically and are controlled by the sidestick pitch command.

In normal mode, the sidestick pitch movement, along with the Air Data System (ADS), Inertial Reference Units (IRUs), and configuration data, is used to compute the aircraft pitch commands and move the elevators.

In REU direct mode, the sidestick pitch information is provided directly to the REUs to move the elevators.

In AFCU direct mode, the sidestick pitch movement is sent directly to the AFCU to move the elevators, using hydraulic system No. 3 only.

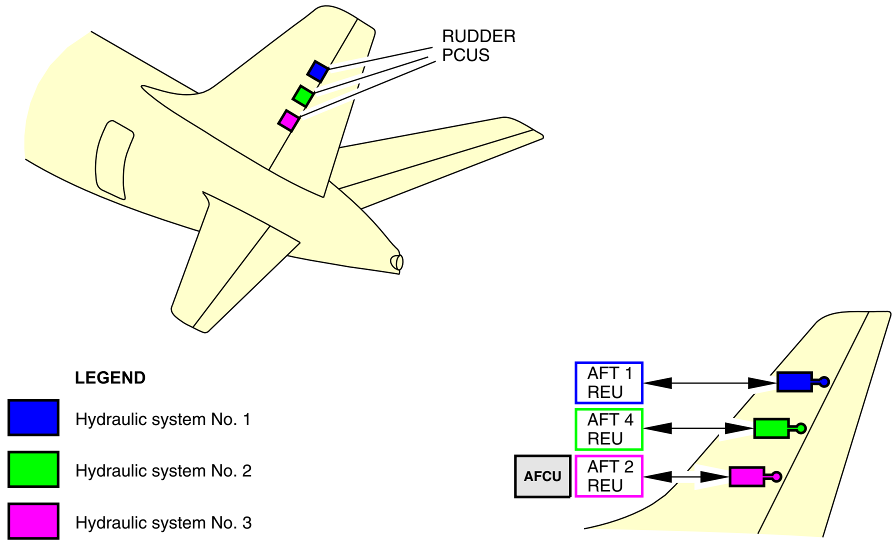
C. Rudder

The rudder is moved by Power Control Units (PCUs), which consist of electrically-controlled hydraulic actuators. There are three PCUs on the rudder.

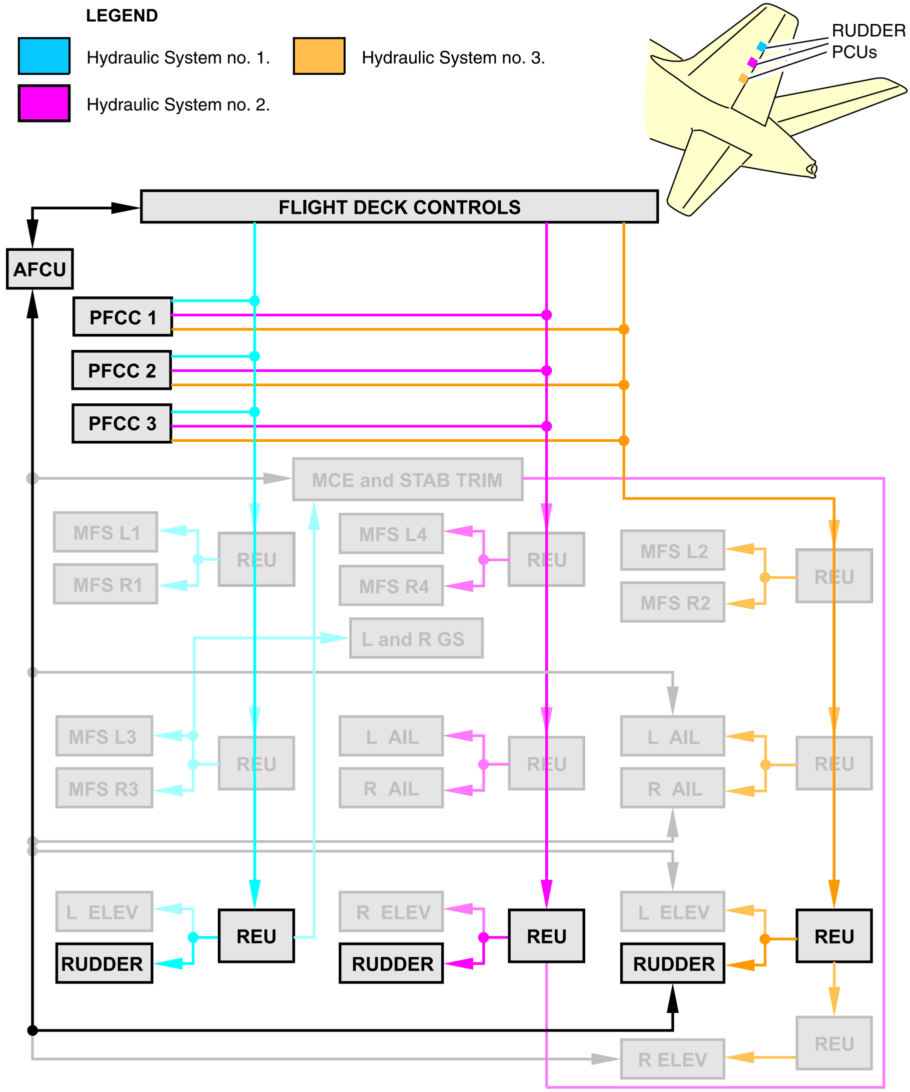
Hydraulic system No. 1 powers the upper PCU, which is by controlled by the AFT 1 REU. The middle PCU is powered by hydraulic system No. 2 and controlled by the AFT 4 REU. The lower PCU is powered by hydraulic system No. 3 and controlled by AFT 2 REU.

Maximum rudder travel varies as a function of airspeed and configuration changes. Available deflection is indicated by an arc on the gray scale that varies in length. Lower airspeeds, and extension of flaps, increases the available rudder deflection. As airspeed increases, available deflection decreases.

Figure 10–03–6 shows the rudder architecture and Figure 10–03–7 the general schematic



Rudder system
Figure 10–03–6



Rudder system schematic
Figure 10–03–7

In normal mode, the rudder pedal position, along with the Air Data System (ADS), Inertial Reference Units (IRUs), and configuration data, is used to compute the aircraft yaw commands. The commands are sent to the REUs to move the rudder through the PCUs.

In PFCC direct mode and REU direct mode, the rudder command is computed and modulated by the flap position.

In AFCU direct mode, the rudder pedal position is provided directly to the AFCU to move the rudder, using hydraulic system No. 3 only. The rudder has no travel restriction (full travel).

NOTE

The rudder trim pointer is referred to as a triangle in the aircraft Electronic checklist (ECL).

PRIMARY FLIGHT CONTROLS – CONTROLS

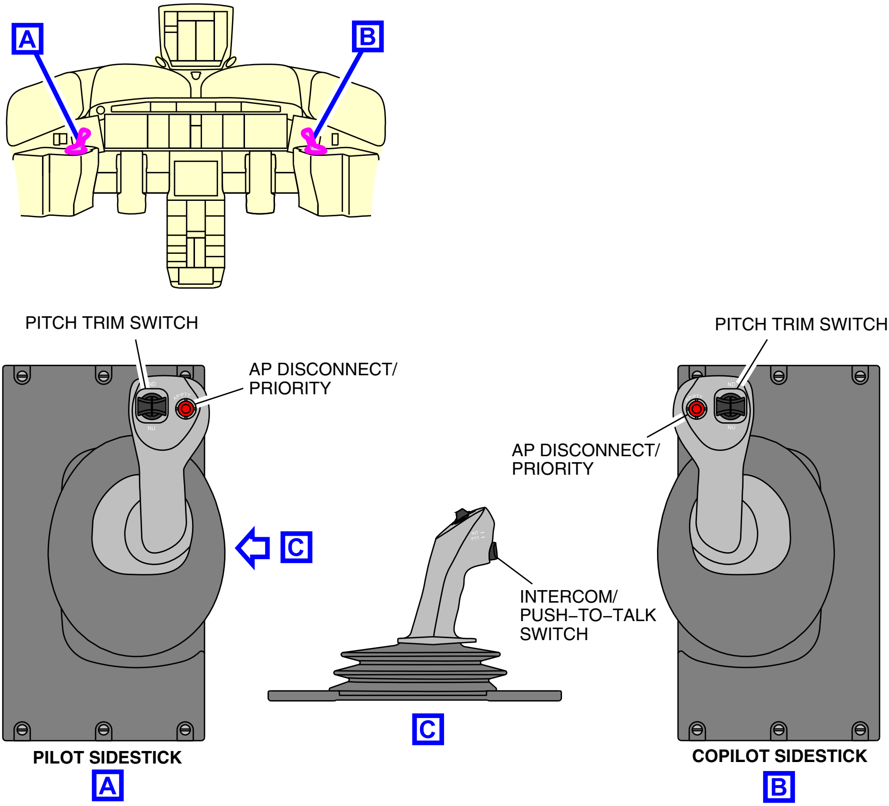
A. Sidestick Controllers (SSCs)

Two uncoupled sidesticks, one on each side console, are used for aircraft manual pitch and roll control (refer to Figure 10–03–8). The SSCs provide pitch and roll input proportional to sidestick positions in the pitch and roll axes. Each sidestick has:

- A dual pitch trim switch,
- An autopilot disconnect/priority switch (AP/PTY), and
- An intercom/Push-To-Talk (INT/PTT) switch.

Sidestick position is measured by four independent position sensors for pitch and roll axis. If there are fewer than two valid sensors per axis, the sidestick is declared faulty. In this case, the priority must be switched to the other sidestick (see sidestick priority). When all sensors are lost, the sidestick is failed. Failure of a sidestick displays the **L SIDESTICK** or the **R SIDESTICK** caution message on the EICAS.

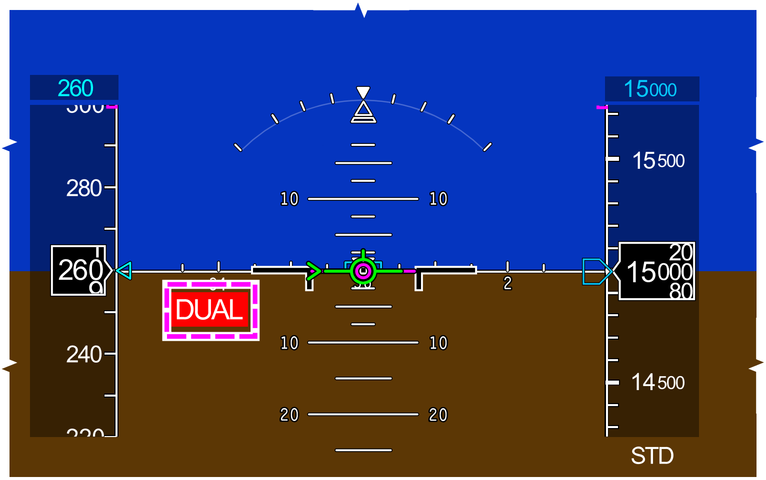
When the sidesticks are moved simultaneously in the same or opposite direction, the system adds the signals of both algebraically. A red DUAL message displays on both PFDs (refer to Figure 10–03–9) with a “DUAL INPUT” aural message.



Sidestick
Figure 10–03–8

NOTE

When both sidesticks are moved in the same direction, the total signal cannot exceed the signal from the maximum deflection of a single sidestick.



PFD

DUAL message
Figure 10–03–9

B. Sidestick priority

Normally, both sidesticks are active and can be used at any time. However, a priority can be assigned to either sidestick. The assigned priority can be a momentary priority (for a short time) or a latched priority (continuous).

(1) Momentary priority

The momentary priority is activated by pressing the AP/PTY switch on top of the sidestick.

When the switch is pressed and held:

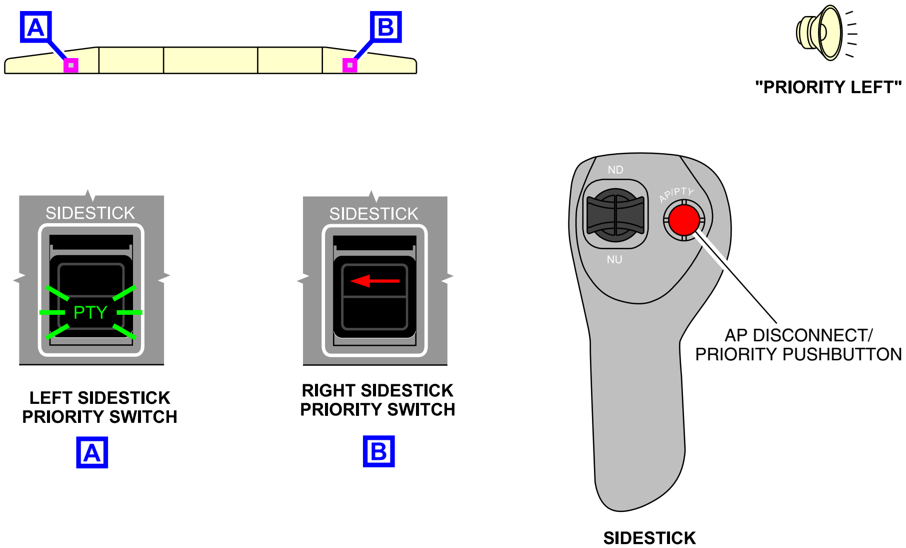
- The sidestick has full authority,
- The opposite sidestick is deactivated,
- The PTY green legend on the onside glareshield SIDESTICK switch flashes,

- A red arrow illuminates on the opposite SIDESTICK switch, and
- The autopilot disengages.

A “PRIORITY LEFT” or “PRIORITY RIGHT” aural message sounds once each time the corresponding priority is selected. If both AP/PTY switches are pressed, the last one pressed has priority.

Figure 10–03–10 shows indications for a momentary priority activated from the left sidestick AP/PTY switch.

The indications are reversed for momentary priority activated from the right sidestick.



Left sidestick momentary priority
Figure 10–03–10

(2) Latched priority

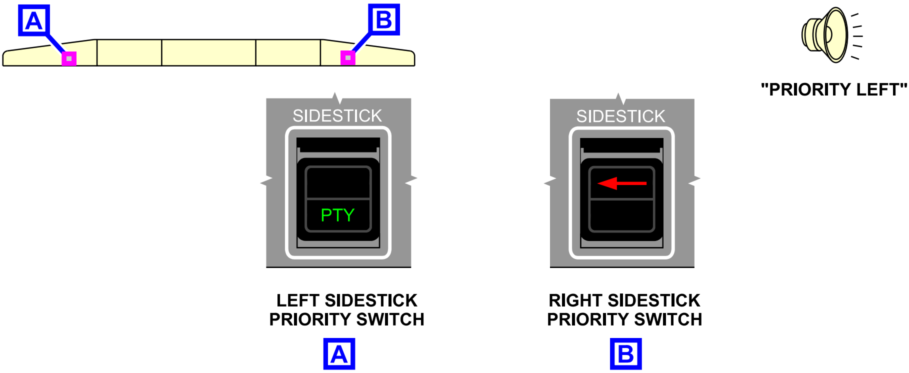
The latched priority is activated by lifting the guard and pressing the SIDESTICK switch on the glareshield corresponding to the side to be prioritized.

When the SIDESTICK switch is pressed:

- The sidestick has full authority,
- The opposite sidestick is deactivated,
- The PTY green legend on the onside glareshield SIDESTICK switch illuminates,
- A red arrow illuminates on the opposite SIDESTICK switch, and
- The autopilot disengages.

A “PRIORITY LEFT” or “PRIORITY RIGHT” aural message sounds once each time the corresponding priority is selected.

Figure 10–03–11 shows indications for a latched priority activated from the left SIDESTICK switch. The indications are reversed for latched priority activated from the right SIDESTICK switch.



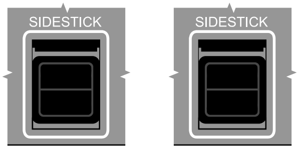
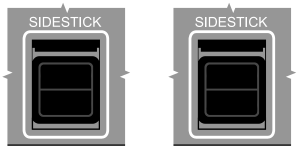
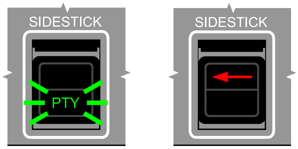
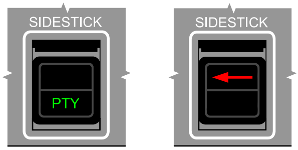
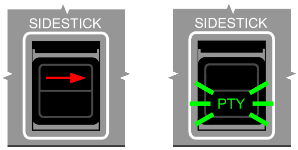
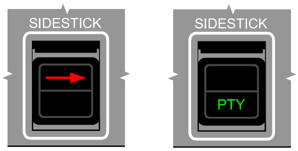
Left sidestick latched priority
Figure 10–03–11

If both SIDESTICK switches are pressed, the last one pressed has priority.

If the priority is latched, the disabled sidestick cannot obtain priority when the AP/PTY switch is pressed. The only way to disengage the latched priority is to press the SIDESTICK switch on the side of the selected priority.

If sidestick priority is latched on takeoff, the **CONFIG SIDESTICK** warning displays on the EICAS page, and the "CONFIG SIDESTICK" aural message sounds.

Figure 10–03–12 shows the priority switch indications associated with dual and priority conditions.

STATE	SIDESTICK SWITCH/LIGHT	VISUAL AND AURAL ANNUNCIATIONS
NORMAL		
DUAL INPUT		DUAL ON BOTH PFD "DUAL INPUT" AURAL MESSAGE
MOMENTARY PRIORITY LEFT		"PRIORITY LEFT" AURAL MESSAGE
LATCHED PRIORITY LEFT		"PRIORITY LEFT" AURAL MESSAGE
MOMENTARY PRIORITY RIGHT		"PRIORITY RIGHT" AURAL MESSAGE
LATCHED PRIORITY RIGHT		"PRIORITY RIGHT" AURAL MESSAGE

Priority switch
Figure 10–03–12

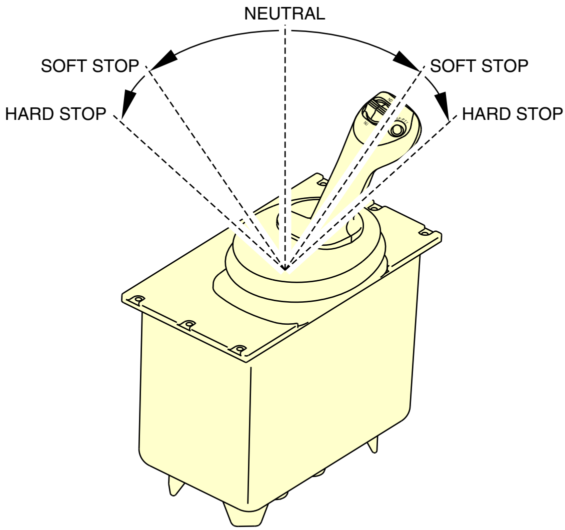
C. Sidestick feel force

As the sidestick is moved from neutral position, the sidestick controller provides feel forces (resistance to displacement). When the sidestick is released, the centering function brings it to the neutral position.

When the autopilot is engaged, the forces maintaining the sidesticks at their neutral positions are increased. If sufficient force is applied to either sidestick, the autopilot will disengage and the other sidestick will become free.

Soft stops and hard stops limit the travel of the sidestick on the pitch axis only. The soft stops correspond to the limits of the normal flight envelope. Increasing pressure at the soft stops moves the sidestick to the hard stop (mechanical stops), for temporary excursion outside of the normal flight envelope.

Figure 10–03–13 shows the sidestick envelope.



Sidestick feel force
Figure 10–03–13

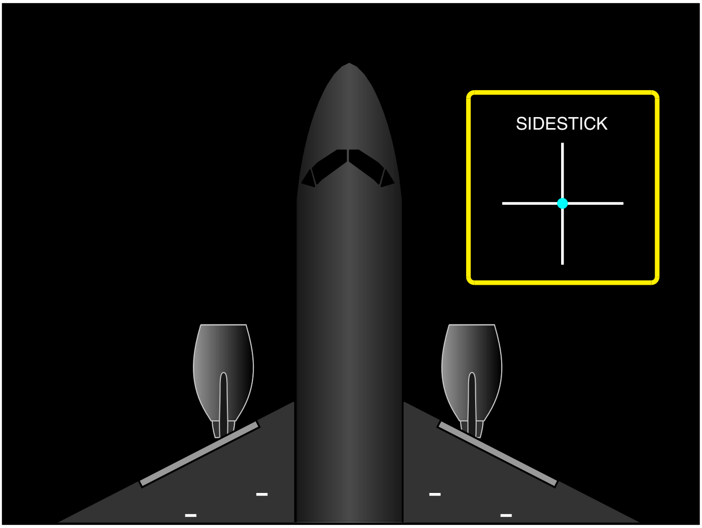
A sidestick shaker function provides a tactile cue for stall awareness.

D. Sidestick test

A sidestick cross test pattern is displayed on the FLT CTRL synoptic page when the aircraft is on ground, no engine running, and no hydraulic power is applied to the flight controls.

When the sidestick is moved, the blue dot should move in the same direction as the sidestick until the sidestick reaches the pitch (soft stops) and roll axis limits.

Figure 10–03–14 shows the sidestick test pattern.

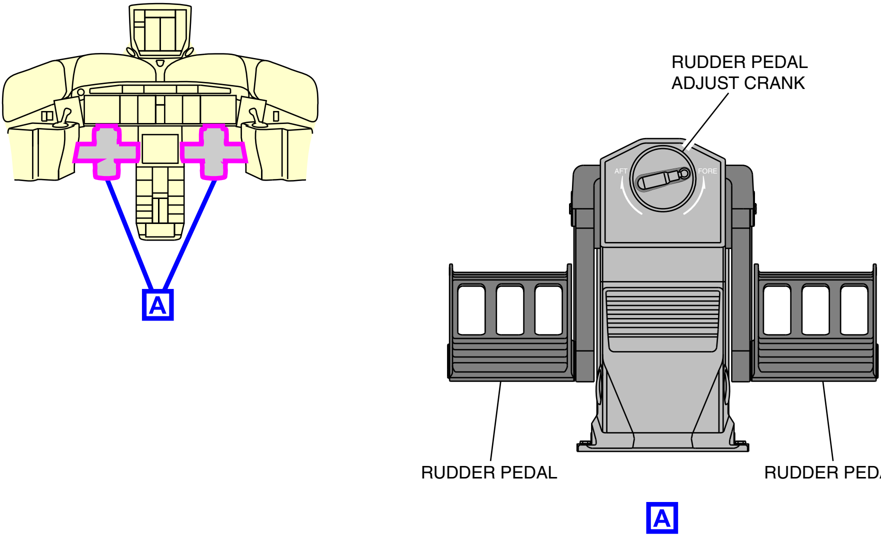


Sidestick test
Figure 10–03–14

E. Rudder pedals

A rudder pedal assembly is installed at each pilot station. Each assembly has 2 interconnected rudder pedals. The rudder pedal position is electrically transmitted to the FBW system for yaw control. The rudder pedals also include conventional wheel braking and limited nosewheel steering for ground operation. Feedback from the rudder trim is mechanically provided to the rudder pedals by a trim actuator.

Each rudder pedal assembly includes a rudder pedal adjust crank to adjust distance from the rudder pedals, as shown in Figure 10–03–15.

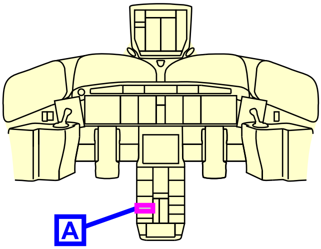


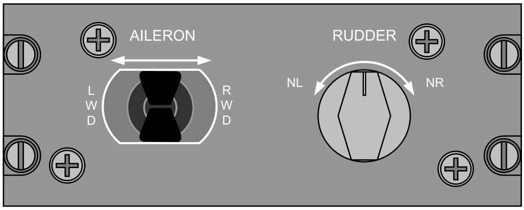
Rudder pedals
Figure 10–03–15

F. Trim panel

The trim panel, located on the center pedestal, includes the aileron trim switches (AILERON switch) and the rudder trim switch (RUDDER switch)

Figure 10–03–16 shows the trim panel.





TRIM PANEL

A

Trim panel
Figure 10–03–16

The AILERON trim switch is a split-switch design that is spring-loaded to the center position.

Aileron trim is achieved by moving both aileron trim switches. The aileron trim function is available on the ground, or during flight in direct mode only.

The aileron trim indication displays on the EICAS page as a white pointer against a graduated scale. The aileron trim only displays in direct mode.

The RUDDER trim switch is a rotary switch that is spring-loaded to the center position.

Rudder trim is achieved by moving the rudder trim switch.

As rudder trim is applied, the rudder pedals reposition from neutral in the direction of the trim.

The rudder trim indication displays on the EICAS page as a pointer against a graduated scale. The pointer is green when the aircraft is on the ground and the rudder centered. The pointer is white when the aircraft is in flight or not centered when on ground.

When the rudder pointer is not within the green band at takeoff, a **CONFIG RUDDER TRIM** warning message displays on the EICAS page with the associated “CONFIG TRIM” aural message.

PRIMARY FLIGHT CONTROLS – INDICATIONS

A. Synoptic page

The FLT CTRL synoptic page includes the primary flight controls indications for the:

- Ailerons (Refer to Figure 10–03–17),
- Elevators (Refer to Figure 10–03–18), and
- Rudder (Refer to Figure 10–03–19).

Aileron, elevator, and rudder status is indicated by the symbol color, and displays:

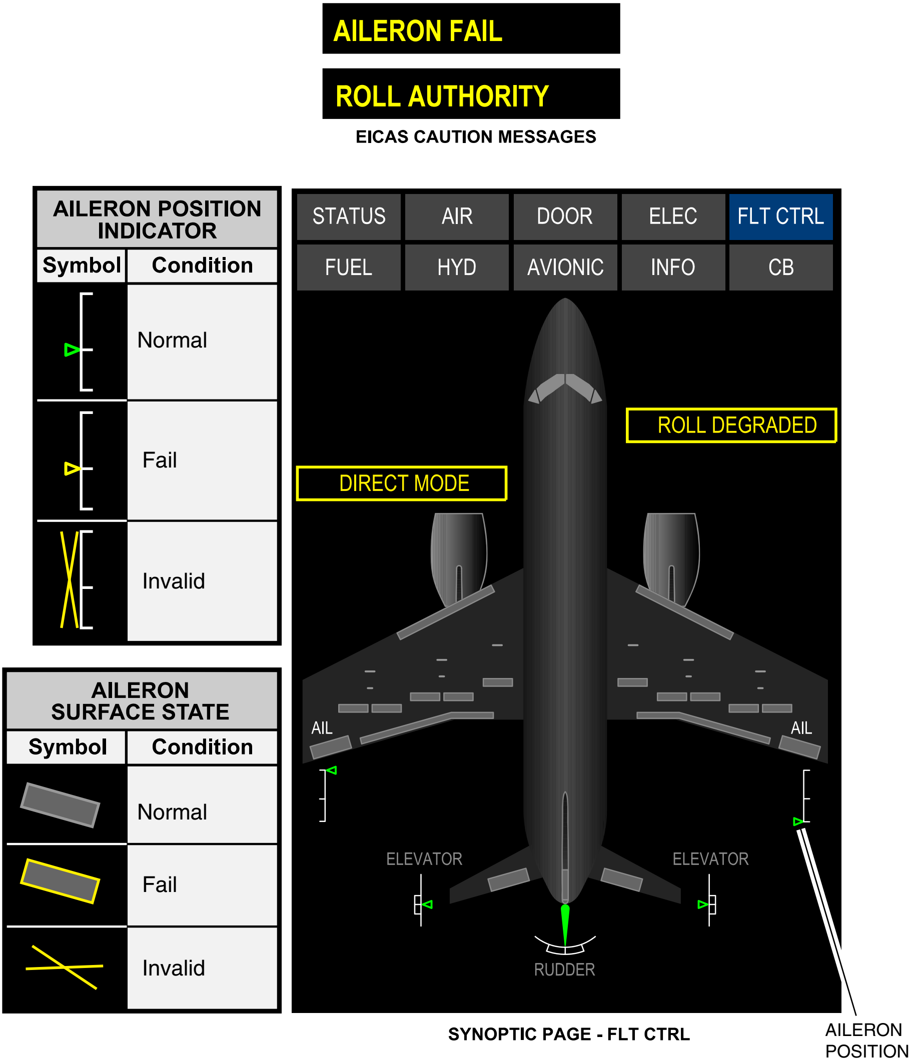
- Normal,
- Fail, and
- Invalid.

(1) Ailerons indications

A green triangle moving against a grey scale shows the deflection (up or down) of the aileron.

The **AILERON FAIL** EICAS caution message displays if both ailerons fail.

The **ROLL AUTHORITY** EICAS caution message displays if either aileron deflection command approaches its maximum operational authority.



Aileron indications
Figure 10–03–17

(2) Elevator indications

A green triangle moving against a grey scale shows the deflection (up or down) of the elevator.

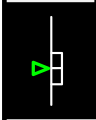
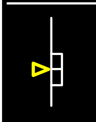
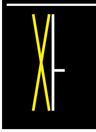
Maximum elevator travel varies as a function of airspeed and configuration changes. Available deflection is indicated by a rectangle on the gray scale that varies in length.

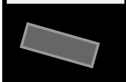
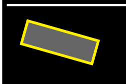
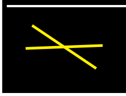
The **L ELEVATOR FAIL** or **R ELEVATOR FAIL** EICAS caution messages displays if either elevator fails.

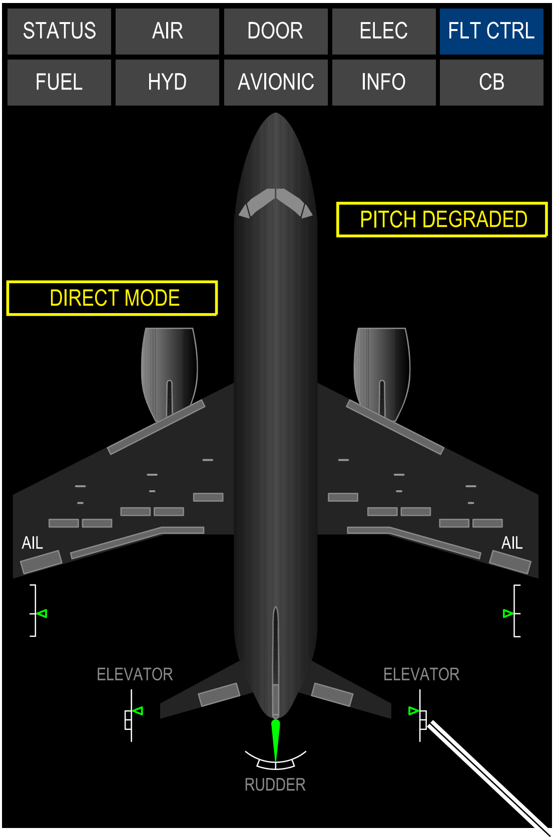
The message becomes a warning during the takeoff phase flight.

The **PITCH AUTHORITY** EICAS caution message displays if either elevator deflection command approaches its maximum operational authority.

EICAS CAUTION MESSAGES

ELEVATOR POSITION INDICATOR	
Symbol	**Condition**
	Normal
	Fail
	Invalid

ELEVATOR SURFACE STATE	
Symbol	**Condition**
	Normal
	Fail
	Invalid



SYNOPTIC PAGE - FLT CTRL

ELEVATOR POSITION

Elevator indications
Figure 10–03–18

(3) Rudder indications

The rudder symbol moving against a grey scale shows the deflection (left or right) of the rudder.

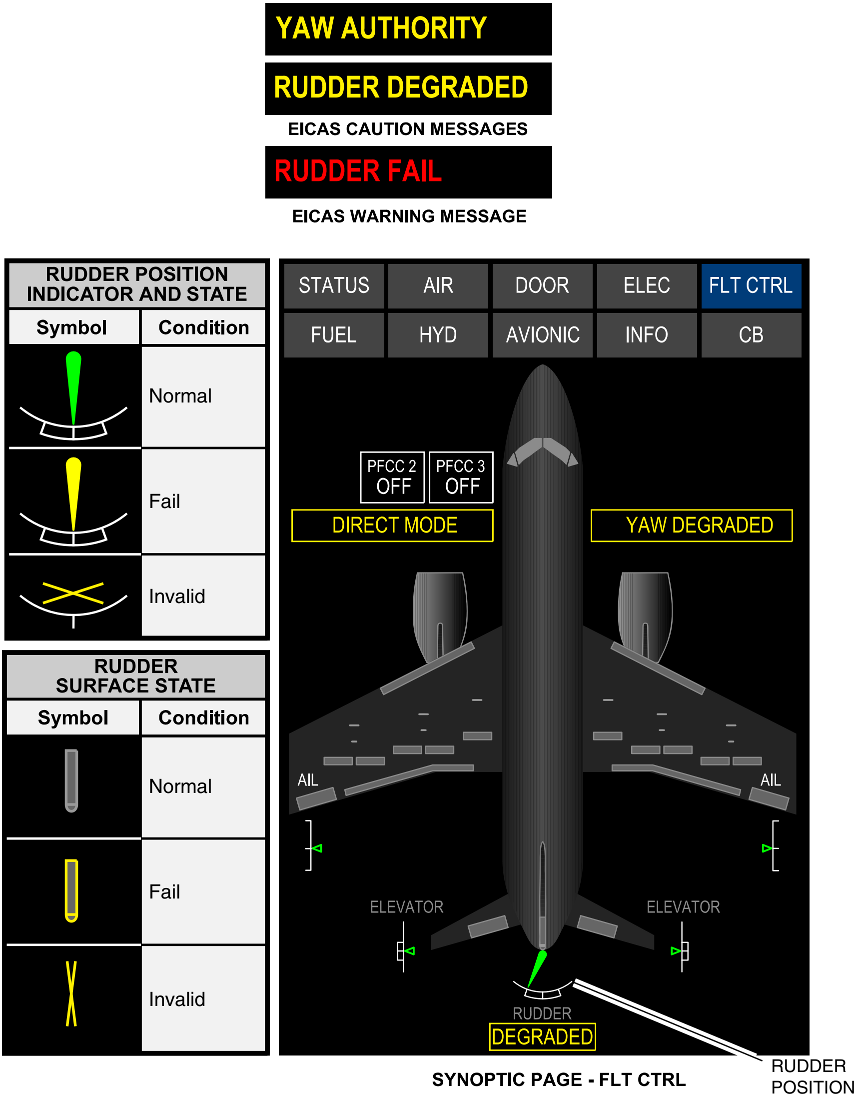
Maximum rudder travel varies as a function of airspeed and configuration changes. Available deflection is indicated by an arc on the gray scale that varies in length.

Failure of two PCUs displays the DEGRADED amber annunciation below the rudder symbol, and the **RUDDER DEGRADED** EICAS caution message.

AFCU direct mode engages in yaw axis or under dual hydraulic failure scenarios.

Failure of all three PCUs displays an amber rudder symbol, and the **RUDDER FAIL** EICAS warning message.

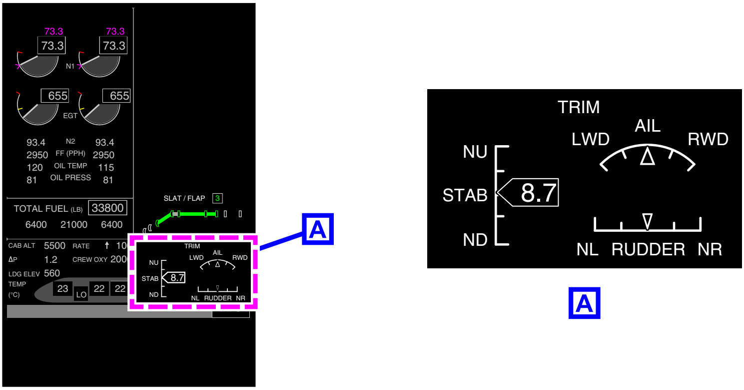
The **YAW AUTHORITY** EICAS caution message displays if the rudder deflection command approaches its maximum operational authority.



Rudder indications
Figure 10–03–19

B. EICAS page

Figure 10–03–20 shows the primary flight control EICAS indications.



Primary flight control EICAS indications
Figure 10–03–20

PRIMARY FLIGHT CONTROLS – EICAS MESSAGES

A. Warning messages

MESSAGE	DESCRIPTION	AURAL	INHIBIT
CONFIG RUDDER TRIM	Rudder trim position out of range for takeoff.	"CONFIG TRIM"	LDG
CONFIG SIDESTICK	Left or right sidestick priority latched at takeoff.	"CONFIG SIDE-STICK"	LDG
L ELEVATOR FAIL	Left elevator failed during takeoff phase.	None	None

MESSAGE	DESCRIPTION	AURAL	INHIBIT
R ELEVATOR FAIL	Right elevator failed during takeoff phase.	None	None
RUDDER FAIL	All three rudder PCUs failed.	None	None

B. Caution messages

MESSAGE	DESCRIPTION	INHIBIT
AILERON FAIL	Either left or right aileron failed.	TO, LDG
L ELEVATOR FAIL	Left elevator failed during non–takeoff phase.	TO
R ELEVATOR FAIL	Right elevator failed during non–takeoff phase.	TO,
L SIDESTICK	Left sidestick failed.	None
R SIDESTICK	Right sidestick failed.	None
RUDDER DEGRADED	Two of the three rudder PCUs failed.	TO, LDG
PITCH AUTHORITY	Left or right elevator command near maximum operational authority.	TO, LDG
ROLL AUTHORITY	Left or right aileron command near maximum operational authority.	TO, LDG
YAW AUTHORITY	Rudder command near maximum operational authority.	TO, LDG

C. Advisory messages

MESSAGE	DESCRIPTION	INHIBIT
L PITCH TRIM SW FAIL	Pilot pitch trim switch has failed.	TO, LDG

MESSAGE	DESCRIPTION	INHIBIT
R PITCH TRIM SW FAIL	Copilot pitch trim switch has failed.	TO, LDG

D. Status messages

None.

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SECONDARY FLIGHT CONTROLS – OVERVIEW

The secondary flight controls consist of:

- Multifunction Spoilers (MFSs),
- Ground Spoilers (GSs), and
- Horizontal Stabilizer (HSTAB).

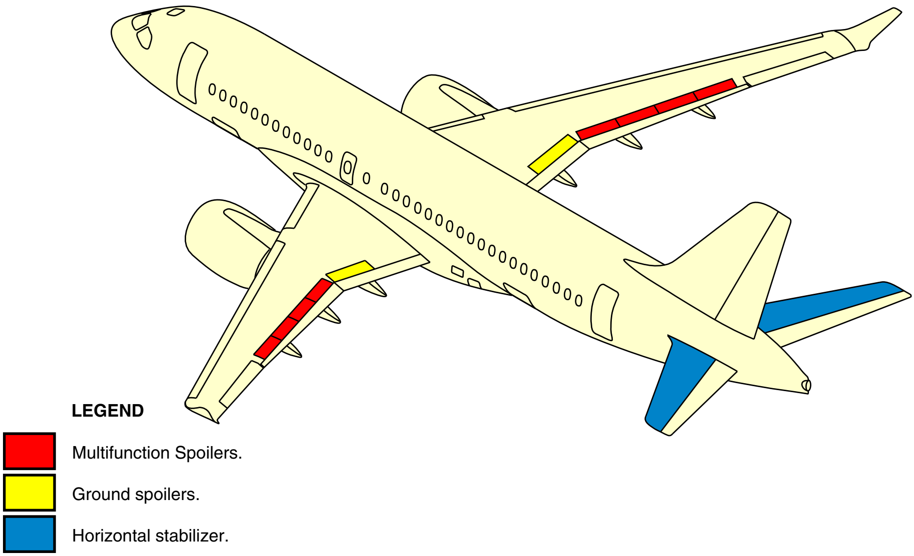
Spoilers (MFS and GS) are electrically controlled and hydraulically actuated.

The HSTAB is electrically controlled and actuated.

The FBW system controls the secondary flight controls, identified in Figure 10–04–1.

NOTE

ROLL assist is not provided in AFCU direct mode.



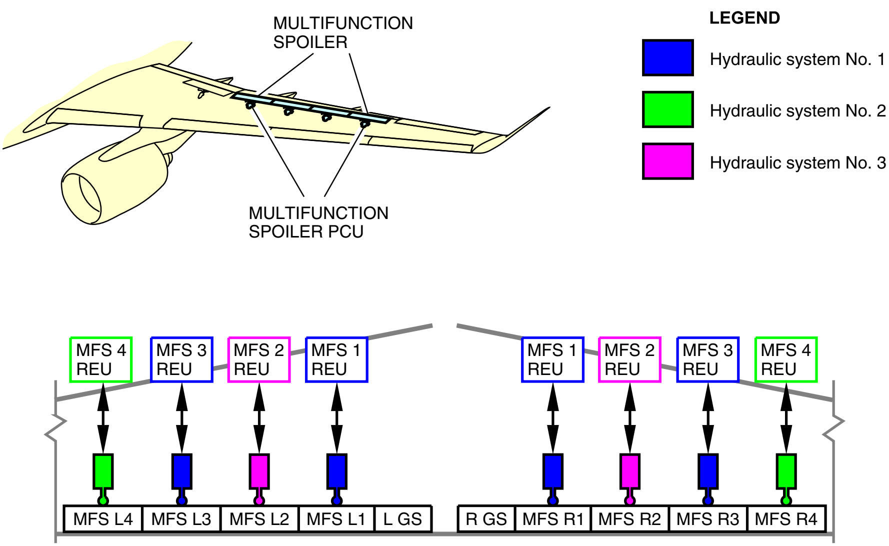
Secondary flight controls
Figure 10–04–1

SECONDARY FLIGHT CONTROLS – DESCRIPTION AND OPERATION

A. Multifunction Spoilers (MFS)

There are four multifunction spoilers on each wing. Each spoiler is operated by one hydraulic Power Control Unit (PCU), and is electrically controlled through a dedicated Remote Electronic Unit (REU). The MFSs are powered by hydraulic system No. 1, system No. 2, and system No. 3.

Figure 10–04–2 shows the MFSs.



Multifunction spoilers
Figure 10–04–2

The following table gives the interaction between the MFSs, REUs and the hydraulic systems.

MFS	Hydraulic system	REU
MFS L4	System No. 2	MFS 4 REU
MFS L3	System No. 1	MFS 3 REU
MFS L2	System No. 3	MFS 2 REU

MFS	Hydraulic system	REU
MFS L1	System No. 1	MFS 1 REU
MFS R1	System No. 1	MFS 1 REU
MFS R2	System No. 3	MFS 2 REU
MFS R3	System No. 1	MFS 3 REU
MFS R4	System No. 2	MFS 4 REU

The flight SPOILER lever, located on the center pedestal, controls the deployment of the MFS. The MFS status and position are shown on the FLT CTRL synoptic page and the EICAS page.

The MFS functions are:

- Roll assist,
- Speed braking (proportional lift dumping), and
- Ground lift dumping.

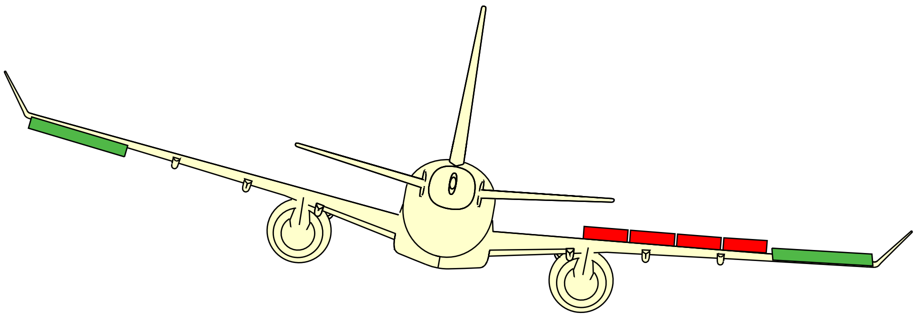
B. MFS – Roll assist

When necessary, the MFSs deploy automatically on one wing at a time to assist roll control. The MFSs also provide roll control in case of aileron failure. Roll assist function is available in normal and direct mode.

NOTE

Roll assist is not provided in AFCU direct mode.

Figure 10–04–3 illustrates the MFS roll assist.



Roll assist
Figure 10–04–3

C. MFS – Speed braking (proportional lift dumping)

The speed brakes/lift dump functions use the Multifunction Spoilers (MFSs) for speed braking in flight and MFS and Ground Spoilers (GS) for lift dumping on touchdown (refer to Figure 10–04–4).

When used as speed brakes, the MFSs are manually deployed (symmetrically on both wings) by moving the flight SPOILER lever. There are six lever positions, from RET (retracted) position, to FULL, and then to MAX position.

In the normal mode, depending on the aircraft configuration, the MFS can be deployed up to a maximum of 50 degrees, as shown in the following table.

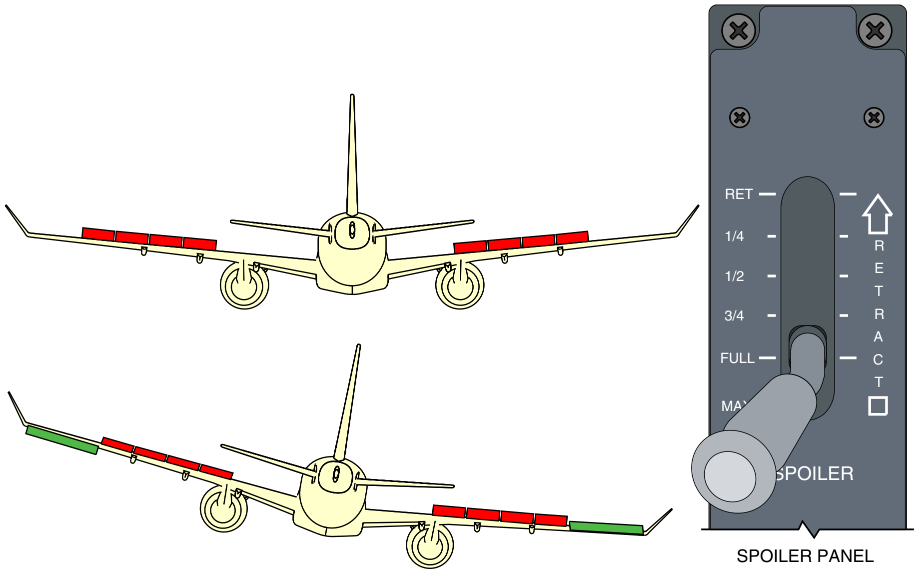
MODE	HIGH LIFT	SPOILER POSITION LEVER	MFS 1 (degrees)	MFS 2 (degrees)	MFS 3 (degrees)	MFS 4 (degrees)
Normal	Retracted	RET	0	0	0	0
		FULL	15	15	15	15
		MAX	30	30	30	30
	Extended	RET	0	0	0	0
		FULL	0	30	30	0
		MAX	0	50	50	0
Steep approach	Extended	RET	0	18	18	0
		FULL	0	34	34	0
		MAX	0	34	34	0

In the direct mode, depending on the aircraft configuration, the MFS can be deployed up to a maximum of 30 degrees, as shown in the following table:

Mode	HIGH LIFT	SPOILER POSITION LEVER	MFS 1 (degrees)	MFS 2 (degrees)	MFS 3 (degrees)	MFS 4 (degrees)
Direct	Retracted	RET	0	0	0	0
		FULL	8	8	8	8
		MAX	8	8	8	8
	Extended	RET	0	0	0	0
		FULL	15	15	15	15
		MAX	30	30	30	30

In normal mode only, when the left or right thrust lever is set at a lever angle greater than 24 degrees or during high angle-of-attack conditions, the MFSs retract automatically to the stowed position and the **SPOILER MISMATCH** advisory message displays on the EICAS page. The **SPOILER DPLY** advisory message displays in flight, at FLAP 4 or 5, when gear is down.

To redeploy the MFS, the SPOILER lever must be placed to the RET position, then back to the desired setting.



Proportional lift dumping
Figure 10–04–4

D. MFS – Ground lift dumping

In the normal mode, when the aircraft lands, all the MFSs are automatically extended to full deflection to provide ground lift dumping. This function is automatic and requires no pilot input.

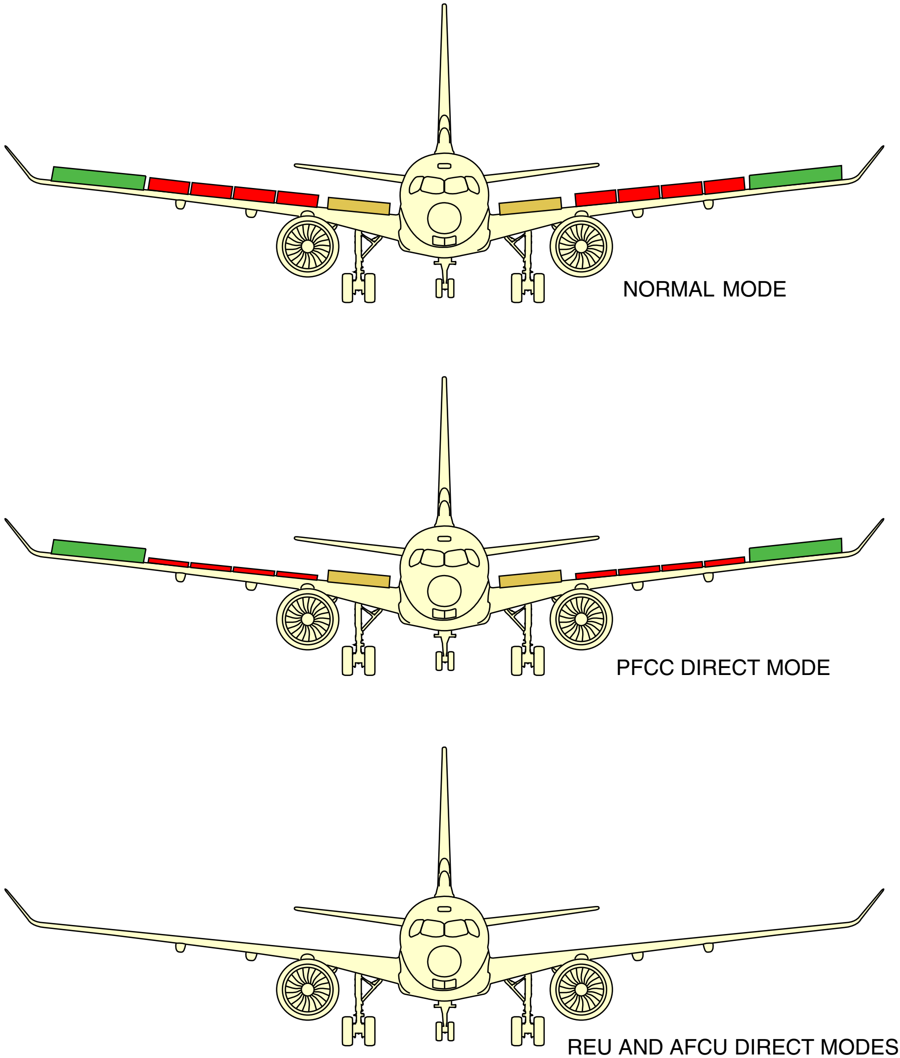
In the PFCC direct mode, the ground lift dumping function deploys the MFSs to 5 degrees to prevent excessive nose pitch up after landing. The flight SPOILER lever must be manually moved to the FULL or MAX position for additional MFS deployment.

In REU direct mode, there is no automatic ground lift dumping function. The flight SPOILER lever must be manually moved to the FULL or MAX position for MFS deployment.

MFSs will not automatically retract in direct mode.

In AFCU direct mode, MFSs are not available.

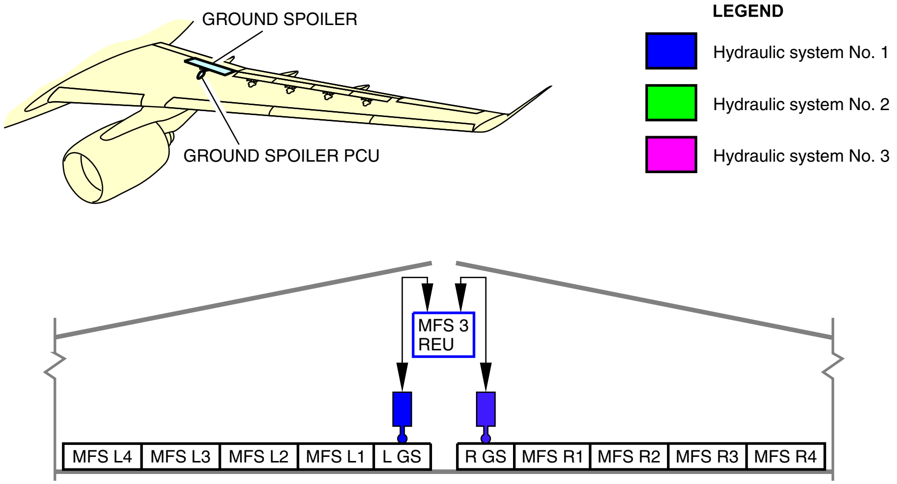
Figure 10–04–5 illustrates the MFS ground lift dumping.



Ground lift dumping
Figure 10–04–5

E. Ground Spoilers (GS)

There is one ground spoiler on each wing (refer to Figure 10–04–6). Each spoiler is operated by one hydraulic Power Control Unit (PCU) and is electrically controlled through the MFS 3 Remote Electronic Unit (REU). The ground spoilers are powered by hydraulic system No. 1.



Ground spoilers
Figure 10–04–6

The ground spoilers operate symmetrically to provide lift dumping at touchdown. Automatic deployment of the ground spoilers is computed through the PFCCs. Deployment logic is based on air data, IRS, weight-on-wheels, wheel speed, and radio altitude data. The lift dump function is automatic and does not need to be armed.

Ground spoilers operate automatically in normal and PFCC direct modes only.

The position and status of the ground spoilers is shown on the FLT CTRL synoptic page.

F. Spoiler operation on landing

The ground spoilers only deploy on touchdown. Each ground spoiler surface extends to 50 degrees for lift dumping during the landing rollout. Activation is automatic in normal and Primary Flight Control Computer (PFCC) direct modes. Deployment of the ground spoilers is not available in Remote Electronic Unit (REU) direct or Alternate Flight Control Unit (AFCU) modes.

The Multifunction Spoilers (MFSs) automatically extend to 50 degrees for lift dumping during the landing rollout in normal mode, and to 5 degrees in PFCC direct mode. In PFCC direct mode, the MFS can be extended more with the Flight Spoiler Control Lever (FSCL).

The inputs that follow are necessary for the PFCC to deploy the ground spoilers:

- Both Main Landing Gear (MLG) are WOW,
- Radio altimeter,
- Thrust lever position,
- Engine running signal,
- Wheel speed,
- Pitch attitude (GS only), and
- Airspeed.

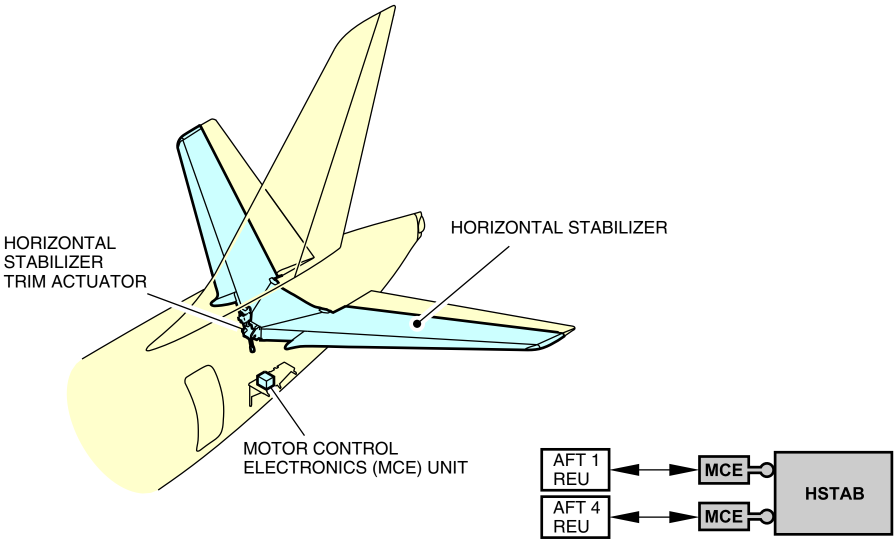
The spoilers are armed for deployment on the ground when wheel speed is greater than 60 kt.

Deployment occurs when the WOW condition is sensed, radio altitude is less than 7 feet, and the wheel speed is greater than 16 kt. The GSs also require the pitch attitude to be less than 2.5 degrees.

The spoilers stow automatically if the thrust levers are advanced to more than forward idle thrust, or when any of the arming conditions are no longer valid.

G. Horizontal stabilizer

The horizontal stabilizer achieves the pitch trim function by varying its angle of incidence. A dual-channel Horizontal Stabilizer Trim Actuator (HSTA) moves the horizontal stabilizer. The HSTA includes two electrical motors, each controlled by a Motor Control Electronics (MCE) unit. The MCE receives commands from two REUs (AFT 1 REU and AFT 4 REU). Refer to Figure 10–04–7.



Horizontal stabilizer
Figure 10–04–7

The pitch trim is controlled by two pitch trim switches, one on each sidestick.

The pitch trim indication displays on the EICAS page as a graduated scale from 0 to 17. The pitch trim takeoff range is indicated by a green rectangle. The trim pointer becomes green when within this range.

When thrust is set for takeoff with the horizontal stabilizer outside of the takeoff range, the **CONFIG STAB TRIM** EICAS warning message is displayed, and the “CONFIG TRIM” aural alert sounds repeatedly (refer to Figure 10–04–8).

CONFIG STAB TRIM EICAS warning and aural messages
Figure 10–04–8

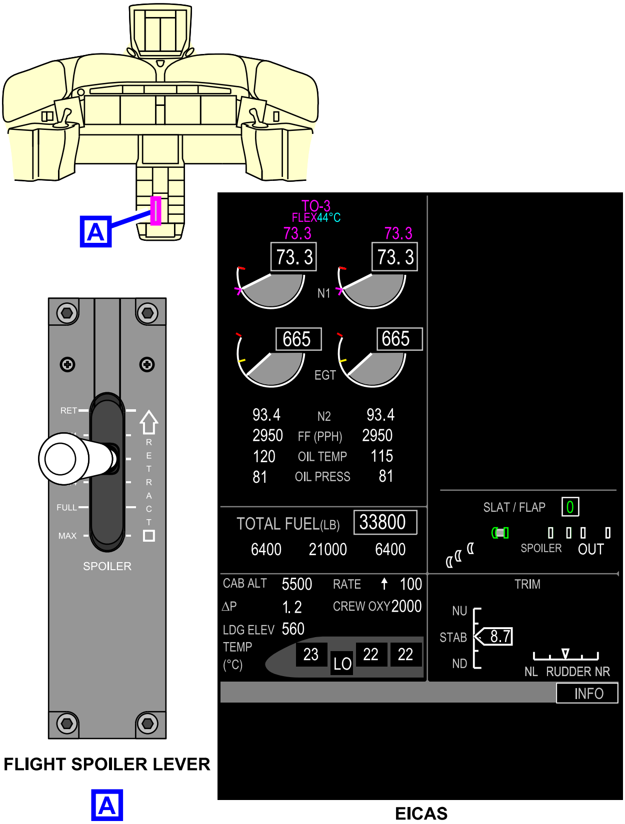
In normal mode, the stabilizer position is determined by the FBW Control Laws (CLAWS). The autotrim function automatically off-loads the stabilizer, independent of the sidestick trim switches. During manual flight, the trim speed is set by the pitch trim switches.

In direct mode, the pitch trim switches move the horizontal stabilizer directly. Refer to FBW system operation – Direct mode for more information.

SECONDARY FLIGHT CONTROLS – CONTROLS

A. SPOILER lever

The SPOILER lever is located on the center pedestal (refer to Figure 10–04–9). The MFSs are manually deployed by moving this lever to the required setting. There are six lever positions, from RET (retracted) position, to FULL and then to MAX position.



EICAS

EICAS

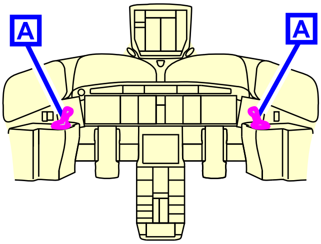
EICAS

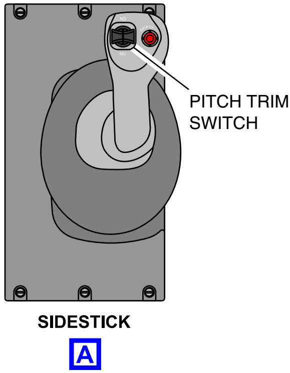
SPOILER LEVER	
Lever Position	**Label**
0	RET
1 (gated)	1/4
2	1/2
3	3/4
4	FULL
5 (gated)	MAX

Flight SPOILER lever
Figure 10–04–9

B. Sidestick pitch trim switch

The pitch trim is controlled by two pitch trim switches, one located on each sidestick (refer to Figure 10–04–10).





Sidestick pitch trim switch
Figure 10–04–10

In normal mode, the horizontal stabilizer position is determined by the FBW Control Laws (CLAWS). The autotrim function automatically off-loads the stabilizer, independent of the sidestick trim switches.

In direct mode, the pitch trim switches move the horizontal stabilizer directly. Refer to FBW system operation – Normal mode for more information.

The PFCC will disable trimming in the air if a trim switch is actuated continuously for more than 3 seconds. Pilots are alerted with a double beep sound. Releasing the trim switch resets the trim function.

Trim system failures generate related EICAS caution or advisory messages:

- **STAB TRIM FAIL**,
- **STAB DEGRADED**,
- **L PITCH TRIM SW FAIL**, and
- **R PITCH TRIM SW FAIL**.

SECONDARY FLIGHT CONTROLS – INDICATIONS

A. Synoptic page – Spoiler indications

The FLT CTRL synoptic page (refer to Figure 10–04–11) includes the spoiler indications that follow:

- MFS indications, and
- GS indications.

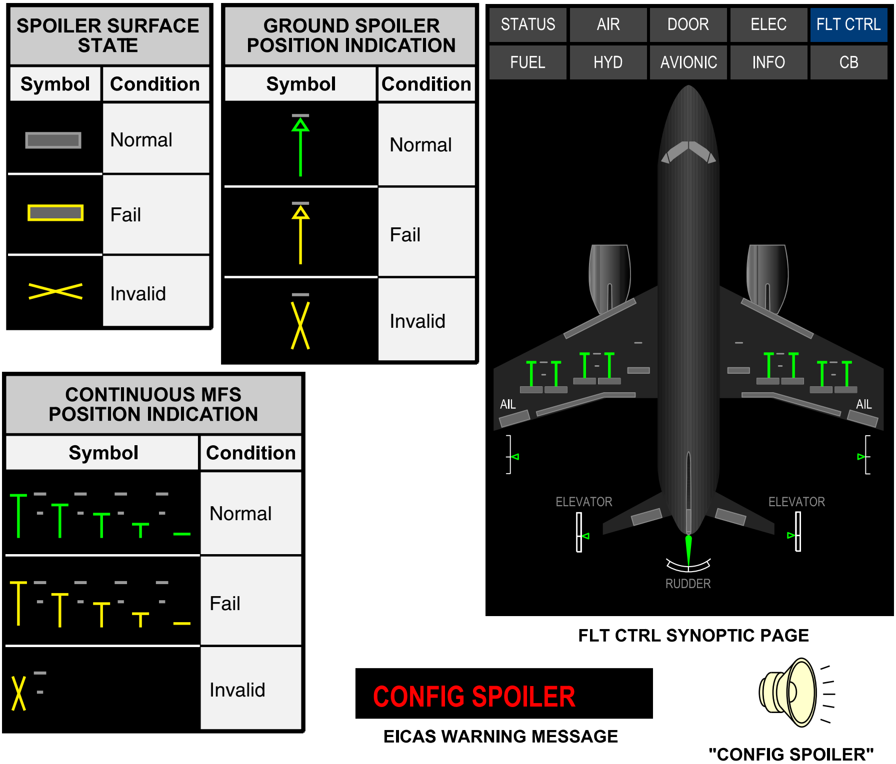
The MFS deployment indication and status is a T–symbol moving against two grey indicators, which shows the deployment (up or down) of the MFS.

The GS deployment indication and status is a green arrow moving against a single grey indicator, which shows the deployment (up or down) of the GS.

For both MFS and GS deployments:

- The spoiler status is indicated by the color: green for normal, and amber for failure.
- An invalid signal displays an amber **X** in place of the surface. If an invalid signal occurs after spoiler extention, the symbol is replaced with an amber **X**.

When thrust is set for takeoff with any spoiler not stowed, the **CONFIG SPOILER** EICAS warning message displays and the "CONFIG SPOILER" aural alert sounds repeatedly.



Spoiler (MFS and GS) indications on synoptic page
Figure 10–04–11

B. EICAS page

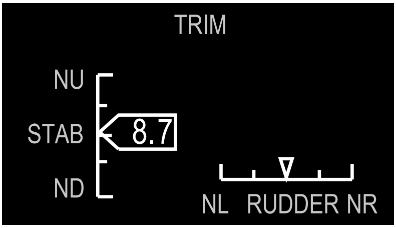
The EICAS page includes the secondary flight control indications that follow:

- Stab trim indications,
- Spoiler indications, and
- Slat and flap indications.

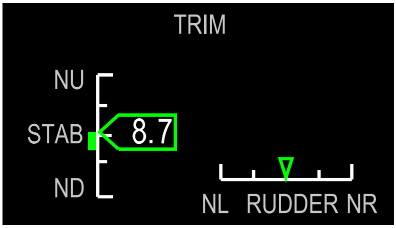
The stab trim displays on the EICAS page as a white pointer, containing the trim value from 0 to 17 against a graduated scale. On the ground, a green rectangle on the scale indicates the takeoff trim range. The trim pointer also becomes green when within this range.

The EICAS page displays SPOILER OUT for selections up to FULL. SPOILER MAX is displayed when the flight SPOILER lever is in the MAX detent position.

Refer to Figure 10–04–12 for secondary flight control EICAS indications.



EICAS - IN FLIGHT



EICAS - ON GROUND

Secondary flight control EICAS indications
Figure 10–04–12

SECONDARY FLIGHT CONTROLS – EICAS MESSAGES

A. Warning messages

MESSAGE	DESCRIPTION	AURAL	INHIBIT
CONFIG SPOILER	Spoiler (MFS or GS) out at takeoff.	“CONFIG SPOIL-ER”	LDG
CONFIG STAB TRIM	Stab trim position out of range for takeoff.	“CONFIG TRIM”	LDG

B. Caution messages

MESSAGE	DESCRIPTION	INHIBIT
GND LIFT DUMP FAIL	Automatic ground lift dump function failed.	TO
GND SPOILER FAIL	Ground spoilers failed retracted (Panel).	TO
SPOILER DEGRADED	2 pairs of MFS failed.	TO
SPOILER DPLY	Flight spoiler deployed below 300ft.	TO
SPOILER FAIL	Three or more MFS failed.	TO
SPOILER LEVER FAIL	Spoiler lever manual control failed.	TO, LDG
STAB DEGRADED	Selected stab position is invalid.	TO, LDG
STAB TRIM FAIL	Stab trim function failed.	TO, LDG

C. Advisory messages

MESSAGE	DESCRIPTION	INHIBIT
SPOILER MISMATCH	Spoiler autoretract function engaged.	TO

MESSAGE	DESCRIPTION	INHIBIT
SPOILER DPLY	Flight spoiler deployed with either gear deployed or flaps.	Power-up, TO

D. Status messages

None.

HIGH LIFT SYSTEM – OVERVIEW

The high lift system consists of leading edge slats and trailing edge flaps.

The slats and flaps are commanded by the Slat/Flap Electronic Control Units (SFECUs).

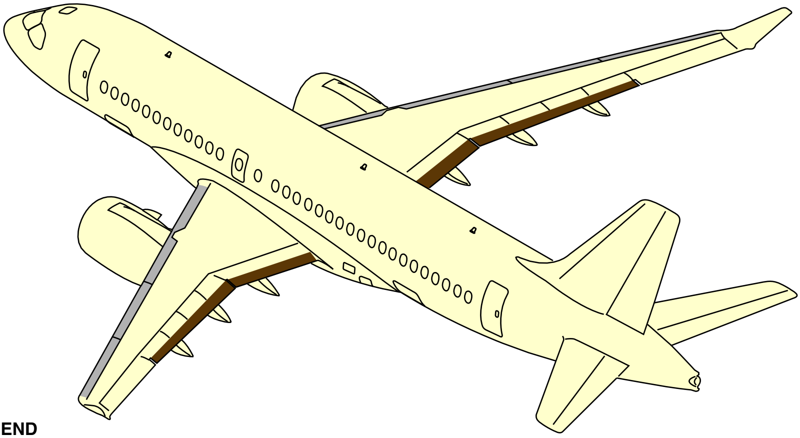
HIGH LIFT SYSTEM – DESCRIPTION AND OPERATION

A. High lift system (slats/flaps)

The high lift system includes:

- Four leading edge slat panels on each wing, and
- Two Fowler-type flaps on each wing.

The slats and flaps are hydraulically actuated and electrically controlled. The slat/flaps are controlled by two Slat/Flap Electronic Control Units (SFECUs) located in the mid equipment bay. Refer to Figure 10–05–1.



LEGEND

Slats.

Flaps.

Slats and flaps
Figure 10–05–1

A single SLAT/FLAP lever controls both systems. An ALTN FLAP guarded switch enables the pilots to deploy the slats and flaps to position 3, if required.

NOTE

The high lift system is not part of the FBW system, but provides input to it.

B. Slat system

There are four slat panels on each wing. Slat panel 1 is located between the fuselage and the engine. Slat panels 2, 3, and 4 are located from outboard of the engine to the wing tip.

The slats are driven by two hydraulic motors in the Power Drive Units (PDUs) through a system of rigid torque tubes and rotary geared actuators. The system uses pressure from hydraulic system No. 2 and system No. 3.

The slat system can be operated with one motor and/or one hydraulic system inoperative. In this case, the slats will reach the full deployment position, but at half the speed.

One outboard hydraulic brake at each wing tip holds the slats in position between selections. It can also stop the motion of the slats if an abnormal condition is detected. The position sensing and skew detection systems provide slat position and monitor the condition of the slat system.

C. Flap system

There are two Fowler-type flaps on each wing. The flaps are driven by two hydraulic motors in the Power Drive Units (PDUs) through a system of rigid torque tubes and rotary geared actuators. The system uses pressure from hydraulic system No. 1 and system No. 3.

The flap system can be operated with one motor and/or one hydraulic system inoperative. In this case, the slats will reach the full deployment position, but at half the speed.

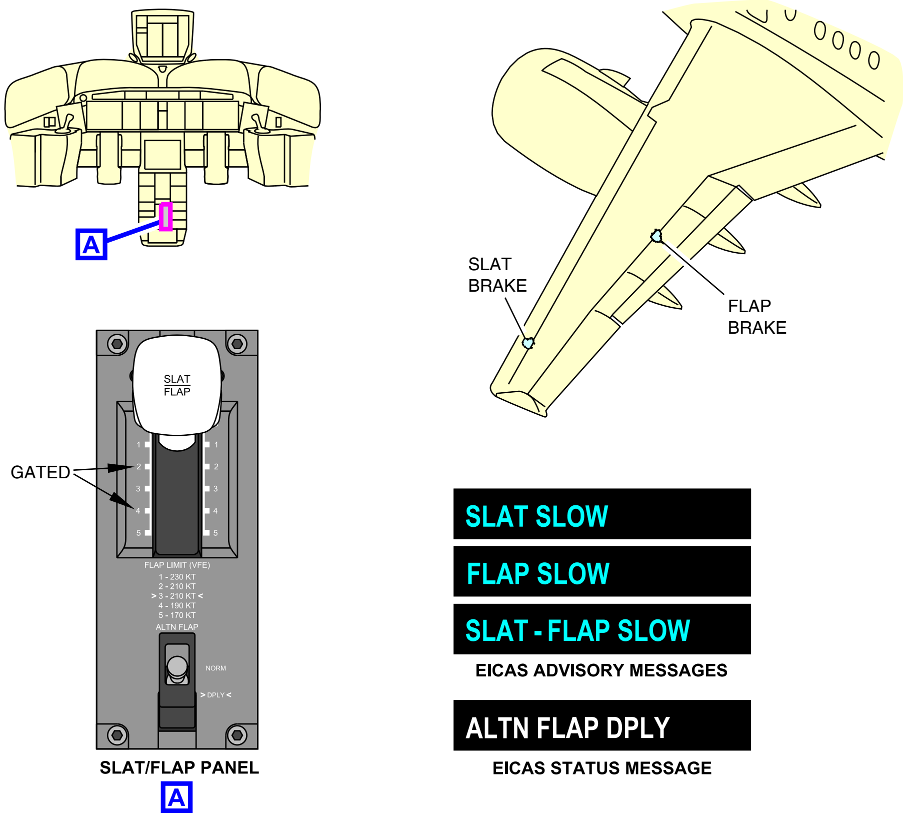
Like the slat system, the flap system includes:

- Outboard hydraulic brakes, and
- Position sensing and skew detection system.

HIGH LIFT SYSTEM – CONTROLS

A. Slat/flap panel

The slat/flap panel is located on the center pedestal. It includes the SLAT/FLAP lever and the ALTN FLAP switch. Refer to Figure 10–05–2.



SLAT/FLAP panel
Figure 10–05–2

The SLAT/FLAP lever allows the deployment and retraction of the slats and flaps. It has six positions, numbered from 0 to 5. Position 2 and position 4 are gated, and the SLAT/FLAP lever release handle must be used to go through these positions.

Each lever position represents a specific setting of the slats and flaps according to the operational mode of the aircraft (takeoff, approach, steep approach, etc.). The following table shows the settings of the slats and flaps for each lever position.

LEVER POSITION	FLIGHT PHASE	SLAT ANGLE (degree)	FLAP POSITION (degree)
0	Cruise	0	0
1	Slats only	21	0
2 (gated)	Takeoff (best climb)	21	10
3	Takeoff	21	15
4 (gated)	Takeoff (short field)	24	25
	Landing		
5	Landing	27	37

When the guarded ALTN FLAP switch is at NORM, the slats and flaps are controlled by the SLAT/FLAP lever. When the switch is set to DPLY (deploy), the SLAT/FLAP lever is overridden and the slats and flaps are deployed to position 3. The **ALTN FLAP DPLY** status message is displayed on the EICAS page.

HIGH LIFT SYSTEM – INDICATIONS

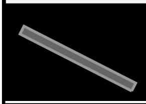
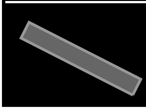
A. Synoptic page – High lift normal indications

The FLT CTRL synoptic page includes the slats and flaps indications (refer to Figure 10–05–3). The indications are displayed when either:

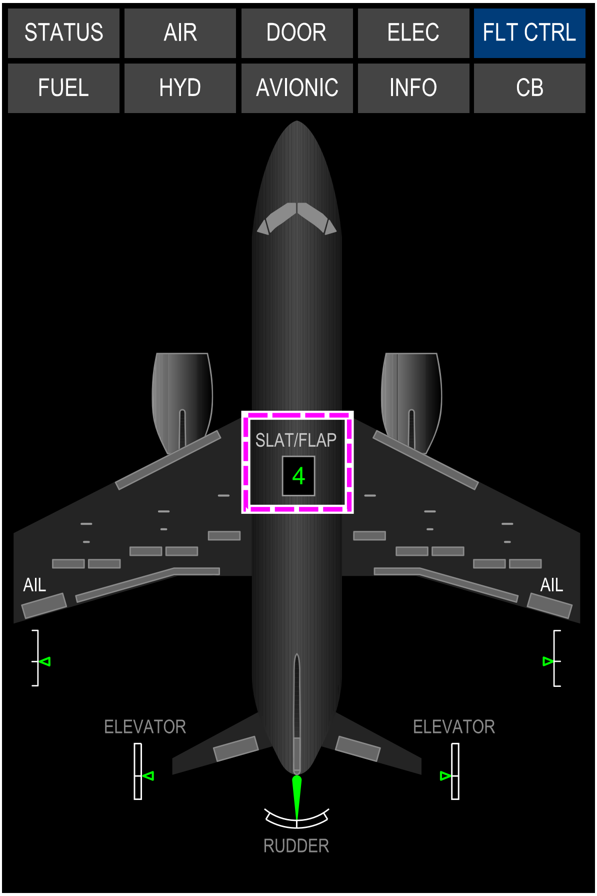
- The slat/flap selection is made, or
- The landing gear is extended.

A combined SLAT/FLAP position indicator displays the actual position of the slats and flaps with a green number in a square. The number corresponds to the SLAT/FLAP lever position. When the surfaces are in transit, the number will be white showing the positions achieved as the slats/flaps extend/retract, then green when the selected setting is reached.

The slat and flap symbols increase in size when the slats or flaps are extended (OUT).

FLAP AND SLAT SURFACE STATE	
Symbol	Condition
	Normal – In
	Normal – Out

SLAT/FLAP INDICATION	
Symbol	Condition
SLAT/FLAP 0 1 2 3 4 5	In commanded position
0 1 2 3 4 5	In transit



FLT CTRL SYNOPTIC PAGE

Slat and flap normal indications on synoptic page
Figure 10–05–3

B. Synoptic page – High lift non-normal indications

If a malfunction occurs, the combined SLAT/FLAP indicator is replaced by separate SLAT and FLAP indicators on the EICAS page and on the FLT CTRL synoptic page. Refer to Figure 10–05–4.

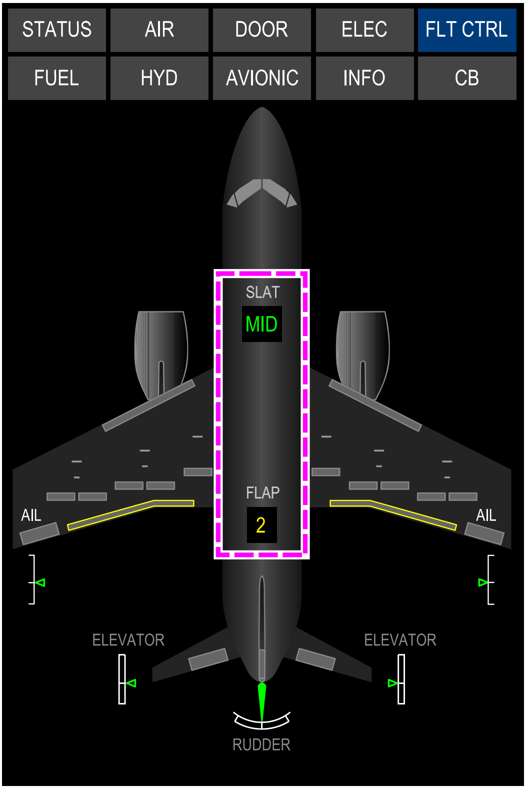
The malfunctioning system(s) display the indication in amber.

The slat position indicator displays the slat positions with the words IN, OUT, MID and FULL. If the slats are failed or malfunctioning, the word displays in amber and corresponds to the last achieved position.

The flap position indicator displays the flap position with a number from 0 to 5. If the flaps are failed or malfunctioning, the number is amber and corresponds to the last achieved position.

FLAP AND SLAT SURFACE STATE		
Symbol	Symbol	Condition
		Failed – In
		Invalid – In
		Failed – Out
		Invalid – Out

SINGLE FLAP AND SLAT INDICATION		
Symbol	Symbol	Condition
FLAP 0 1 2 3 4 5 0	SLAT IN OUT MID FULL	In commanded position
1 2 3 4 5	IN OUT MID	In transit
0 1 2 3 4 5	IN OUT MID FULL	Failed
-	---	Invalid



FLT CTRL SYNOPTIC PAGE

Slat and flap non–normal indications on synoptic page
Figure 10–05–4

C. EICAS page - Slat/Flap indications

The slats and flaps position displays on the EICAS whenever it is displayed on the FLT CTRL synoptic page (refer to Figure 10–05–5).

The right horizontal portion of the position indicator displays flaps position, and has five marks representing flaps up to fully extended.

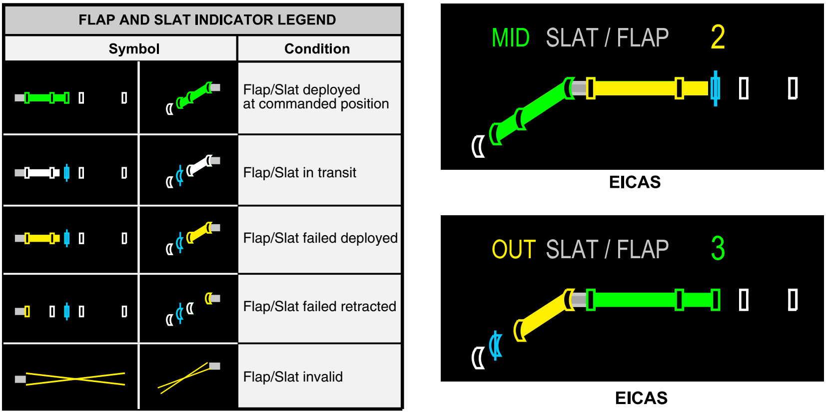
The left downward pointing portion of the position indicator displays slats position. The four marks represent slats retracted to fully extended.

When a selection is made with the SLAT/FLAP lever:

- Cyan markers identifying the selected surface positions display on the EICAS indicator,
- Surfaces in transit display an animated white line moving along the indicator to the cyan markers, and
- A white number in a box above the position indicator displays the last achieved extension during surface movement.

When the slats and flaps reach their selected positions:

- The cyan markers are removed from the indicator,
- The white lines on the indicator turn green, and
- The white boxed number turns green.



Abnormal indication on EICAS
Figure 10–05–5

When thrust is set for takeoff with the slats and flaps outside of the takeoff range, the **CONFIG FLAP** EICAS warning message displays and the "CONFIG FLAPS" aural alert sounds repeatedly (refer to Figure 10–05–6).

CONFIG FLAP EICAS warning and aural messages
Figure 10–05–6

HIGH LIFT SYSTEM – EICAS MESSAGES

A. Warning messages

MESSAGE	DESCRIPTION	AURAL	INHIBIT
CONFIG FLAP	Slat/Flap not configured for takeoff.	“CONFIG FLAP”	None

B. Caution messages

MESSAGE	DESCRIPTION	INHIBIT
FLAP FAIL	Any failure that results in the flap system being inoperable. Both flap channels unavailable due to monitor failure.	TO, LDG
FLAP SLOW	Flap speed less than 30% of dual channel nominal speed.	TO, LDG
SLAT FAIL	Any failure that results in the slat system being inoperable. Both slat channels unavailable due to monitor failure.	TO, LDG

MESSAGE	DESCRIPTION	INHIBIT
SLAT SLOW	Slat speed less than 30% of dual channel nominal speed.	TO, LDG
SLAT SKEW	Slat skew condition detected or slat asymmetry.	TO, LDG
SLAT-FLAP FAIL	Any failure that results in the slat and flap systems being inoperable. All channels unavailable due to monitor failure.	TO, LDG
SLAT-FLAP LEVER FAIL	Failure to command flaps through the flap lever.	TO, LDG

C. Advisory messages

MESSAGE	DESCRIPTION	INHIBIT
FLAP FAULT	Loss of redundancy or loss of non-critical functions within the flap system.	TO, LDG
FLAP SLOW	Only one flap channel available to drive system at approximately half speed (30% – 60%).	TO, LDG
SLAT FAULT	Loss of redundancy or loss of non-critical functions within the slat system.	TO, LDG
SLAT SLOW	Only one slat channel available to drive system at approximately half speed (30% – 60%).	TO, LDG
SLAT-FLAP SLOW	One flap and one slat channel available to drive system at slow speed (RAT deployment) (30% – 60%).	TO, LDG

D. Status messages

MESSAGE	DESCRIPTION	INHIBIT
ALTN FLAP DPLY	Alternate flap setting deployed selected (setting 3).	None

CHAPTER 11 – FUEL

FUEL QUANTITY AND TEMPERATURE SYSTEM

REFUELING/DEFUELING SYSTEM

FUEL INERTING SYSTEM

FUEL – CONTROLS AND INDICATIONS

List of figures

FUEL MANAGEMENT SYSTEM

FUEL QUANTITY AND TEMPERATURE SYSTEM

REFUELING/DEFUELING SYSTEM

FUEL INERTING SYSTEM

FUEL – CONTROLS AND INDICATIONS

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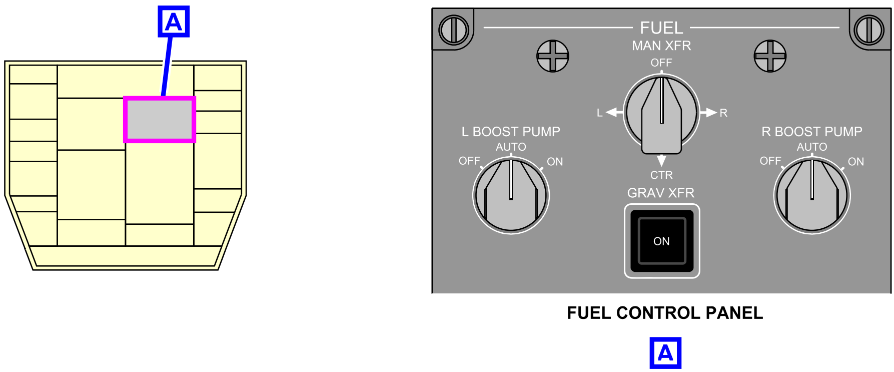
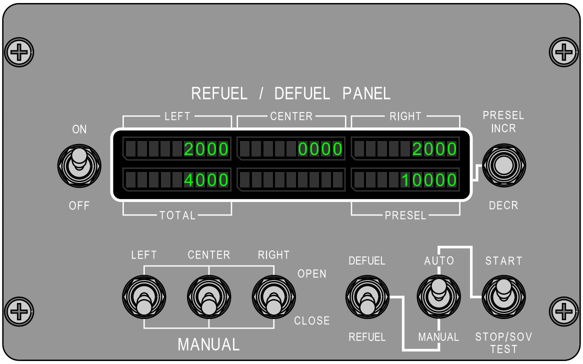
FUEL SYSTEM – OVERVIEW

The fuel system consists of three fuel tanks (left and right main tanks, and center tank) and a distribution system to feed the engines and the Auxiliary Power Unit (APU). The fuel distribution system is capable of powered (automatic or manual) and gravity fuel transfers, as well as cross-feed operations. A fuel inerting system uses Nitrogen-Enriched Air (NEA) to reduce the risk of fuel fumes igniting in the fuel tanks. The pressurized refuel/defuel system operates in automatic or manual mode. A dual–channel Fuel Quantity Computer (FQC) monitors fuel quantity and temperature, and controls refuel/defuel operations.

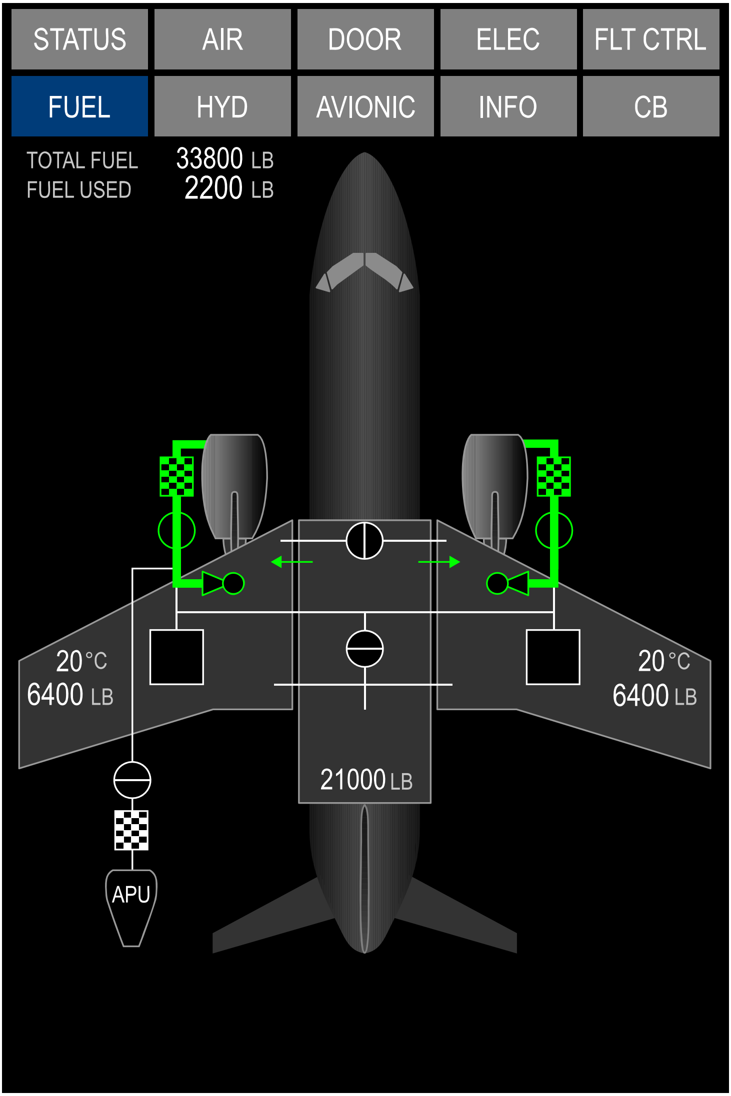
System controls are located on the FUEL panel (refer to Figure 11–01–1) and on the REFUEL / DEFUEL panel (refer to Figure 11–01–2). System indications are provided by the FUEL synoptic page (refer to Figure 11–01–3) and the fuel section of the EICAS synoptic page (refer to Figure 11–01–4). Status and fault messages are reported on the EICAS synoptic page.



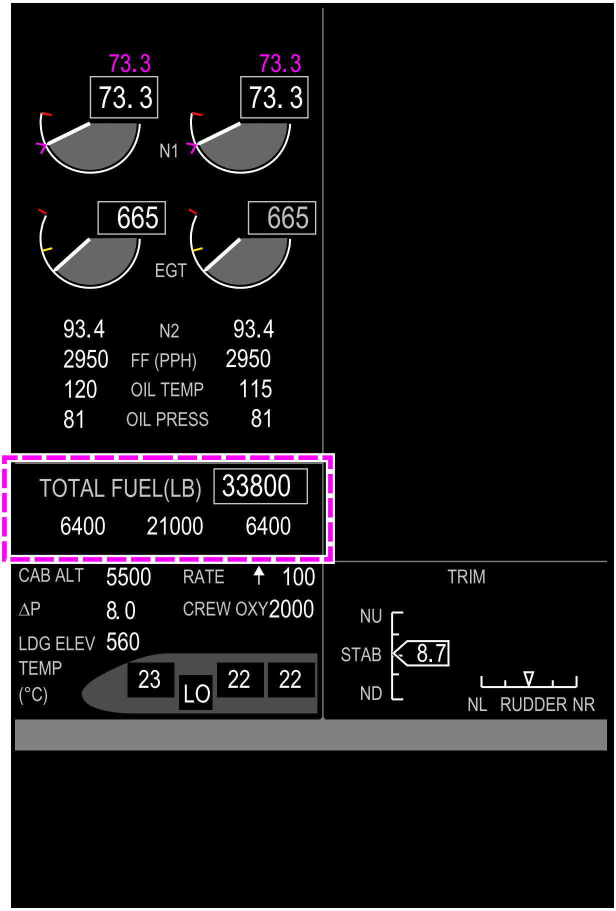
Fuel panel
Figure 11–01–1



REFUEL / DEFUEL panel
Figure 11–01–2



Fuel synoptic page
Figure 11–01–3



EICAS page – Fuel indications
Figure 11–01–4

FUEL STORAGE SYSTEM – OVERVIEW

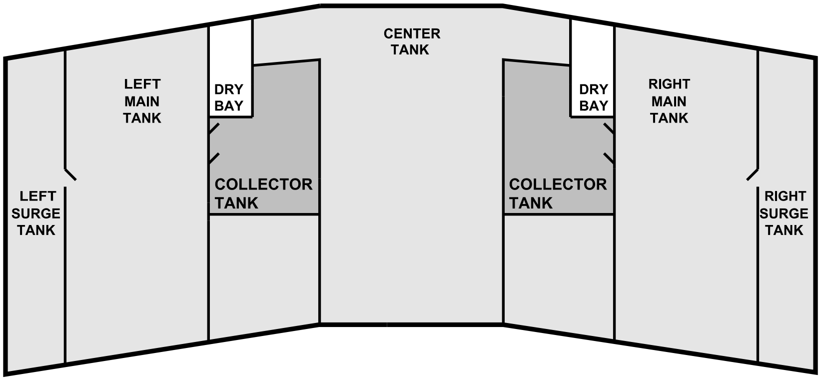
A. Fuel tanks

Fuel is stored in the left main, right main, and center fuel tanks (refer to Figure 11–02–1). These tanks are integral with the wing structure and separated by structural ribs. A collector tank in each main tank ensures a positive supply of fuel to each engine and APU in all aircraft attitudes. Fuel is fed from the collector tanks to the engines. Flapper check valves installed in the ribs of the main tanks allow fuel to flow inboard to the collector tanks, but prevent outboard flow. The left and right surge tanks serve as ventilation space, they do not store fuel but they collect excess fuel from the vent system and return it to the respective main tank through a flapper check valve.

The table that follows shows the maximum usable fuel load distribution in each tank.

Maximum usable fuel load				
Tank	Tank volume		Fuel mass [1]	
	L	US gal	kg	lb
Left main tank	3770	996	3050	6725
Right main tank	3770	996	3050	6725
Center tank	13968	3689	11300	24900
Total	21508	5681	17400	38350

[1] Based on a fuel density of 0.809 kg/L (6.75 lb/US gal), rounded to the nearest 10 kg or 25 lb. Fuel mass is provided for reference only and should not be considered limiting.



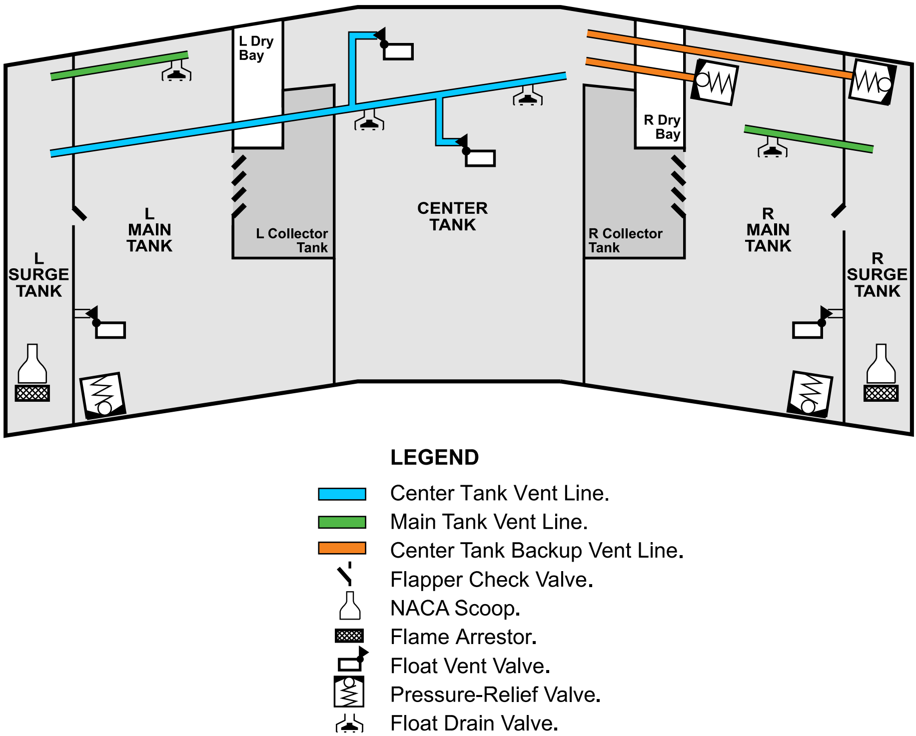
Fuel storage system
Figure 11–02–1

B. Fuel tank ventilation

The fuel vent system (refer to Figure 11–02–2) maintains the air pressure inside the fuel tanks within the structural design requirements by providing an airflow path between the fuel tanks and the atmosphere in all operating conditions. Each fuel tank is vented to a wing surge tank through a dedicated tank vent system.

The center tank and left main tank are vented into the left surge tank. The right main tank is vented into the right surge tank. The float vent valves close the vent lines when the tanks are near full or when the aircraft is in an attitude that would cause fuel to enter the vent tank lines. Each main tank has a pressure relief valve. The center tank has two alternate vent tank lines, both with a pressure relief valve attached.

In flight, NACA scoops located in each surge tank provide ram air pressure to maintain a positive pressure on the fuel in the tanks. During ground operations, NACA scoops provide static ventilation of the tanks and relieve the buildup of air pressure during refueling or thermal expansion of the fuel.



Fuel tank venting system
Figure 11–02–2

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FUEL DISTRIBUTION SYSTEM – DESCRIPTION AND OPERATION

The fuel distribution system controls the movement of fuel as follows:

- Supply of fuel to the engines,
- Supply of fuel to the APU,
- Automatic center tank to main tank transfer,
- Manual fuel transfer, which can move fuel from:
  - The main tanks to the center tank,
  - One main tank to the opposite main tank,
- Automatic fuel balancing, and
- Gravity crossflow.

The major components of the fuel distribution system are:

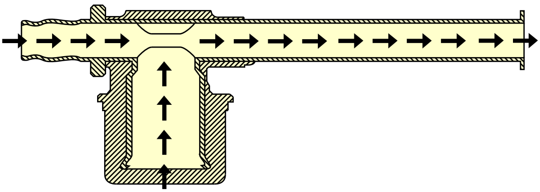
- Two AC boost pumps,
- Two AC boost pump pressure switches,
- Two engine main fuel ejector pumps,
- Two scavenge ejectors pumps,
- Two transfer ejectors pumps,
- Two transfer float valves,
- One gravity crossflow shutoff valve,
- Two engine fuel shutoff valves,
- Two engine feed pressure switches, and
- One APU fuel shutoff valve.

A. Motive flow

Motive flow is the primary means to move fuel throughout the fuel distribution system. When the high pressure fuel from the Engine Driven Pump (EDP) passes through a venturi-shaped fuel ejector, a low pressure is created (refer to Figure 11–03–1). The suction caused by the low pressure moves the fuel out of the tank.

The fuel distribution system uses motive flow to:

- Transfer fuel from the center tank into the main tanks,
- Transfer fuel from the main tanks to the collector tanks, and
- Supply fuel to the engines and APU.



Motive flow ejector pump
Figure 11–03–1

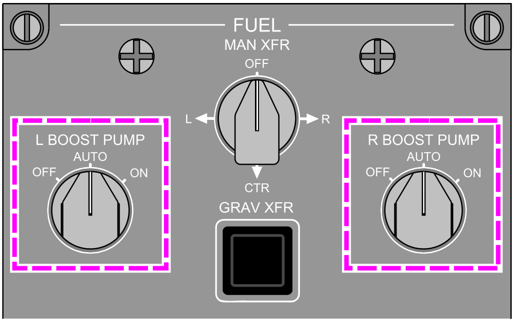
B. AC boost pumps

An AC boost pump in each collector tank is the backup for the main fuel ejector pump. The AC boost pumps are AC electrical pumps that provide the functions that follow:

- Engine fuel feed backup,
- APU fuel feed backup,
- Fuel crossfeed,
- Fuel transfer, and

- Support engine start in flight.

The AC boost pumps are controlled by the L BOOST PUMP switch and R BOOST PUMP switch on the FUEL panel (refer to Figure 11–03–2). They are normally selected to AUTO but can be manually selected to ON or OFF.

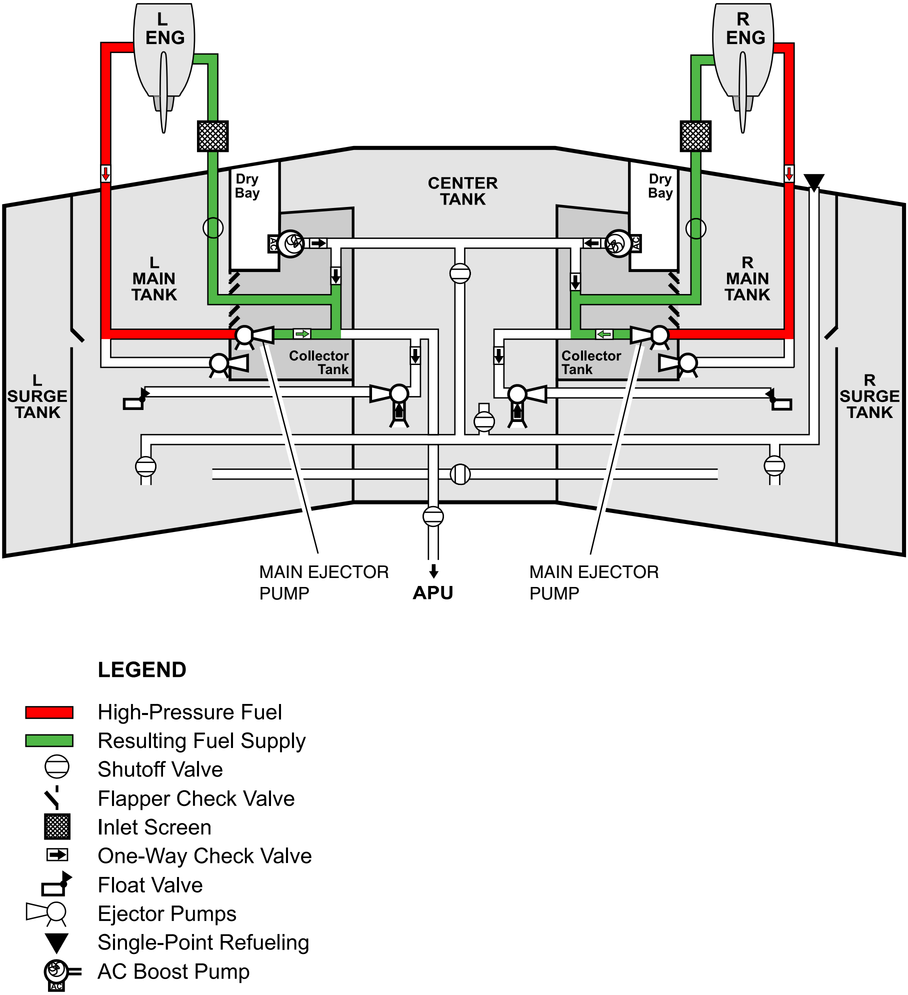


L BOOST PUMP and R BOOST PUMP switches
Figure 11–03–2

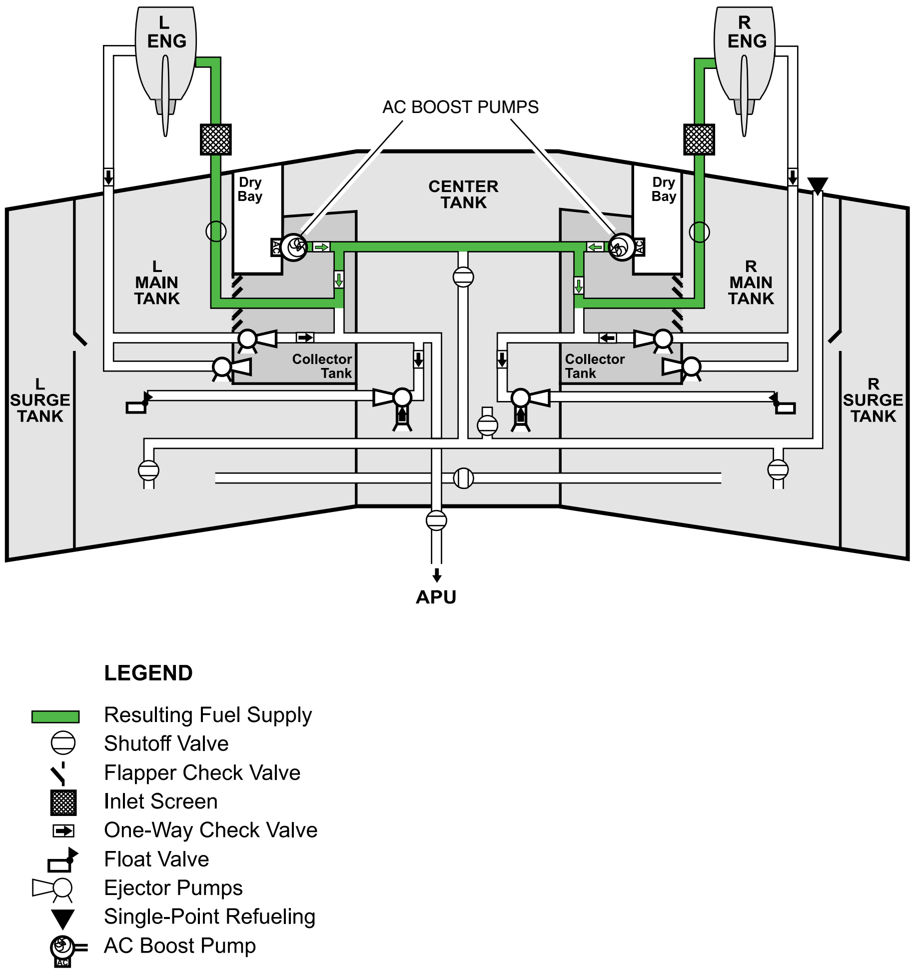
C. Engine fuel feed

The engine fuel feed system uses the main fuel ejector pumps as the primary means to pump fuel from the collector tanks to the engines (refer to Figure 11–03–3). One-way check valves prevent the ejector pumps from cross feeding. The ejector pumps require high pressure motive fuel flow from the EDP to operate.

If one or both main ejector pumps fail, both AC boost pumps will automatically come on (if set to AUTO) and supply fuel to the engines (refer to Figure 11–03–4).



Normal engine fuel feed
Figure 11–03–3

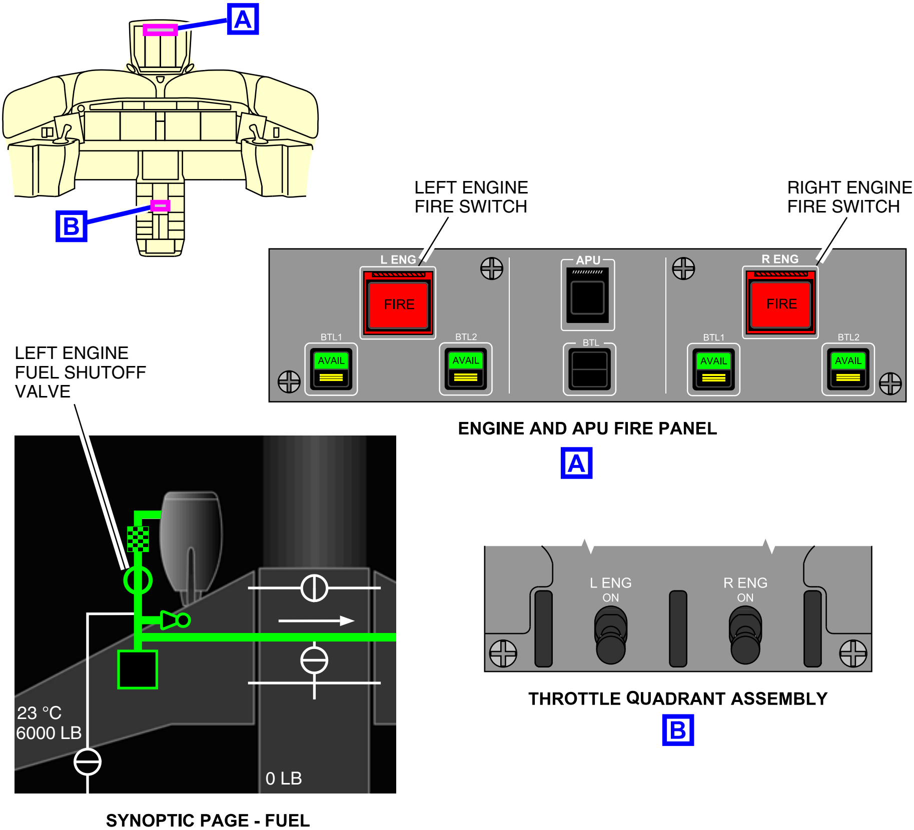


Engine fuel feed by the AC boost pumps
Figure 11–03–4

D. Engine fuel shutoff valves

A motor-operated shutoff valve is installed in each of the engine feed lines to isolate the fuel flow. The valves are controlled by the L ENG and R ENG run switches on the Throttle Quadrant Assembly (TQA) (refer to Figure 11–03–5).

The L ENG FIRE and R ENG FIRE switches close the fuel shutoff valve when pressed.



Engine fuel shutoff valve controls
Figure 11–03–5

E. APU fuel feed

The APU receives fuel through the left engine feed line from either:

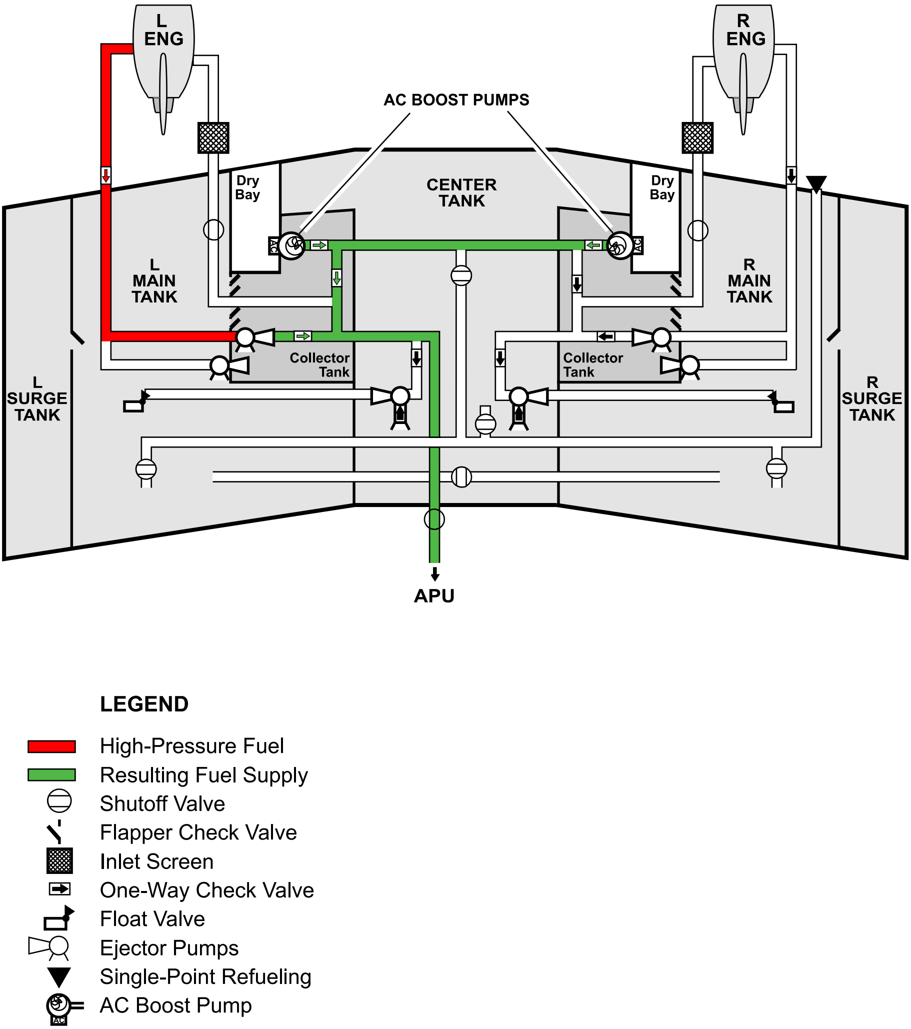
- The left engine main fuel ejector pump, or
- The left or right AC boost pump, or
- Suction-feed if AC power is not available and the left engine is not in operation.

When the left engine is in operation, the left main ejector pump supplies fuel directly to the APU.

When the left engine is not in operation, both AC boost pump switches are at AUTO and the external AC is available, the APU Electronic Control Unit (ECU) activates the left AC boost pump. If the left AC boost pump is not available, the ECU will activate the right AC boost pump. The respective BOOST PUMP switch must be set to AUTO.

If the AUTO logic is not available, the flight crew can manually activate either AC boost pump to supply fuel to the APU.

Figure 11–03–6 shows the APU fuel feed operation.



APU fuel feed
Figure 11–03–6

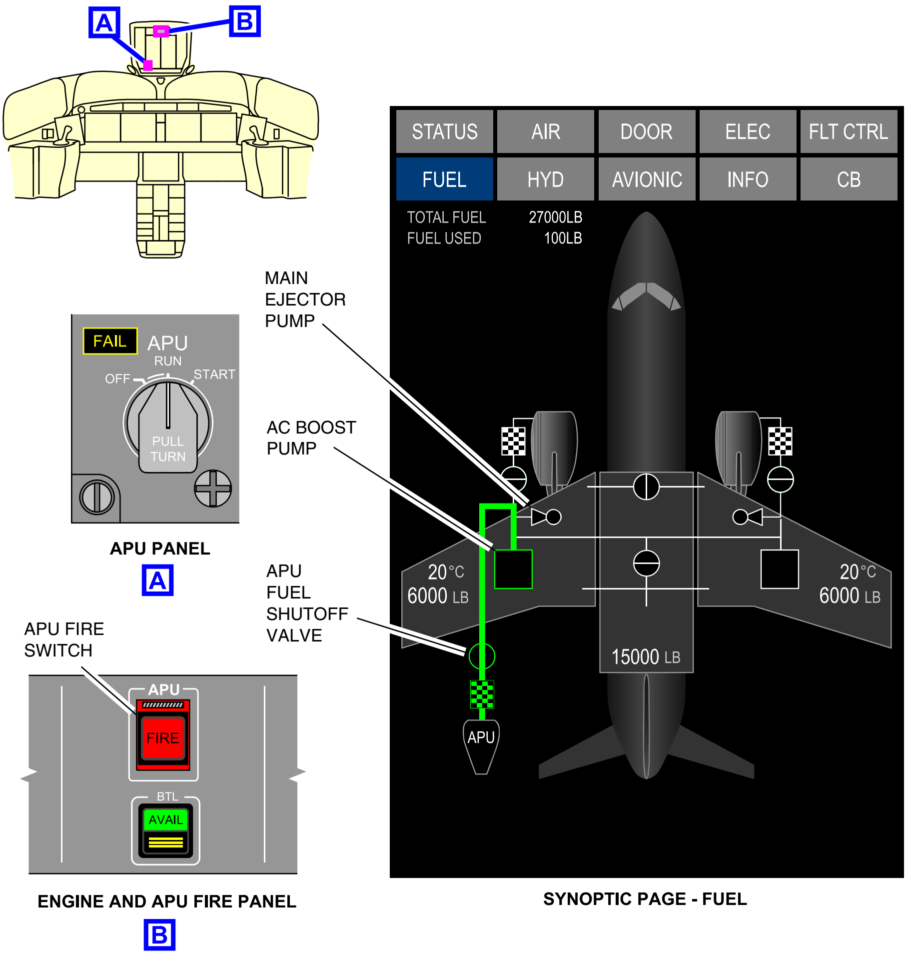
F. APU fuel shutoff valve

Fuel for the APU goes through the APU fuel shutoff valve. The APU Electronic Control Unit (ECU) opens the valve during the APU start sequence.

The APU fuel shutoff valve can be closed by:

- Turning off the APU switch (refer to Figure 11–03–7),
- Pressing the guarded APU FIRE switch (refer to Figure 11–03–7), or
- Automatically by the ECU, when serious faults occur on the ground or in flight.

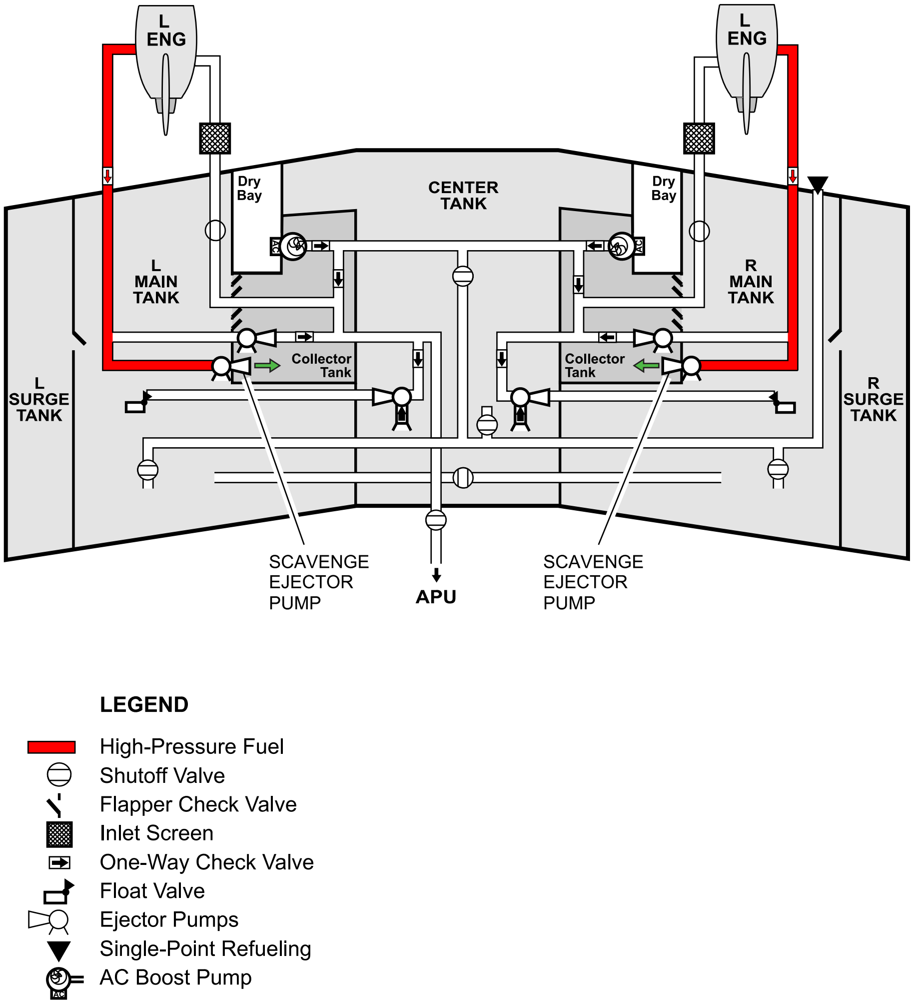
For additional information refer to Chapter 04 – Auxiliary Power Unit



APU fuel feed shutoff valve controls
Figure 11–03–7

G. Scavenge System

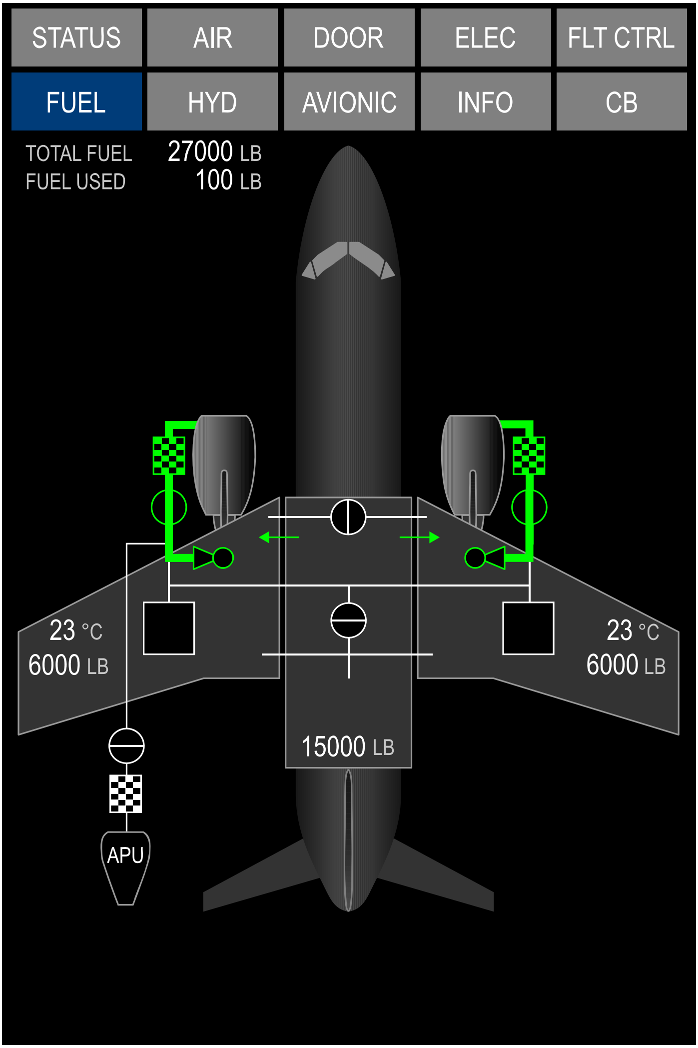
A scavenge ejector pump, located in each main tank, continuously moves fuel from the main tank to the collector tank. The scavenge ejector pumps require motive flow from the engine EDP to function (refer to Figure 11–03–8).



Scavenge System
Figure 11–03–8

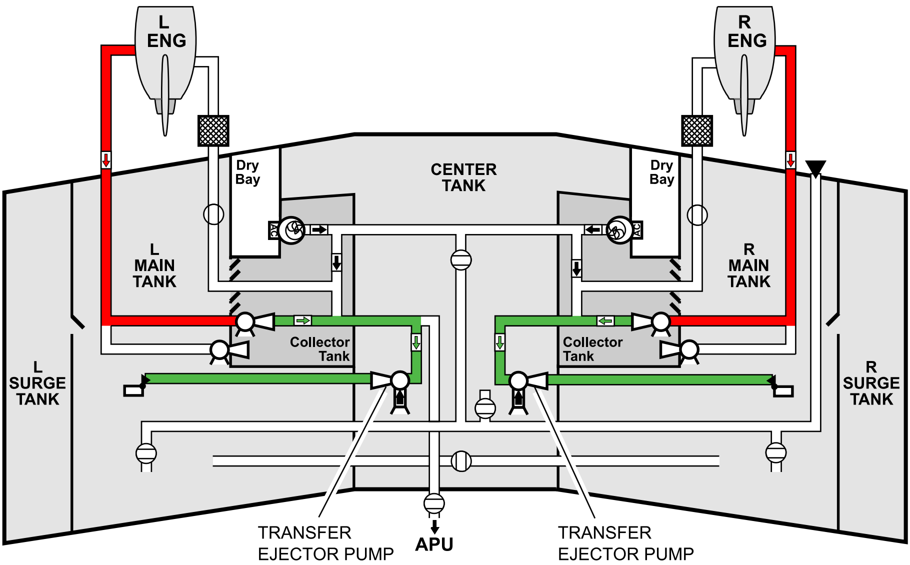
H. Center tank to main tank transfer

Fuel from the center tank is automatically transferred to the main tanks by transfer ejector pumps. When the fuel quantity of a main tank drops to 85.6% of its maximum usable fuel volume, a float valve opens to allow the center tank transfer ejector to move fuel from the center tank into the main tanks. Fuel pressure from the main fuel ejector pumps allows the transfer ejector pump to function. The AC boost pumps can also provide motive fuel flow to the transfer ejector pumps. The flight crew has no control over this transfer process. The FUEL synoptic page shows the center tank transfer by displaying two green arrows pointing outward from the center tank (refer to Figure 11–03–9).

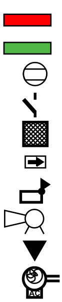


Fuel synoptic page – Normal fuel feed
Figure 11–03–9

Figure 11–03–10 shows the center tank to main tank automatic fuel transfer operation.



LEGEND



High-Pressure Fuel
Resulting Fuel Supply
Shutoff Valve
Flapper Check Valve
Inlet Screen
One-Way Check Valve
Float Valve
Ejector Pumps
Single-Point Refueling
AC Boost Pump

Center to main tank auto fuel transfer
Figure 11–03–10

FUEL MANAGEMENT SYSTEM – OVERVIEW

The fuel management system consists of:

- Manual (powered) fuel transfer,
- Gravity transfer, and
- Automatic fuel imbalance correction (auto-crossfeed).

Manual fuel transfer is done with the MAN XFR (manual transfer) switch on the FUEL panel.

FUEL MANAGEMENT SYSTEM – DESCRIPTION AND OPERATION

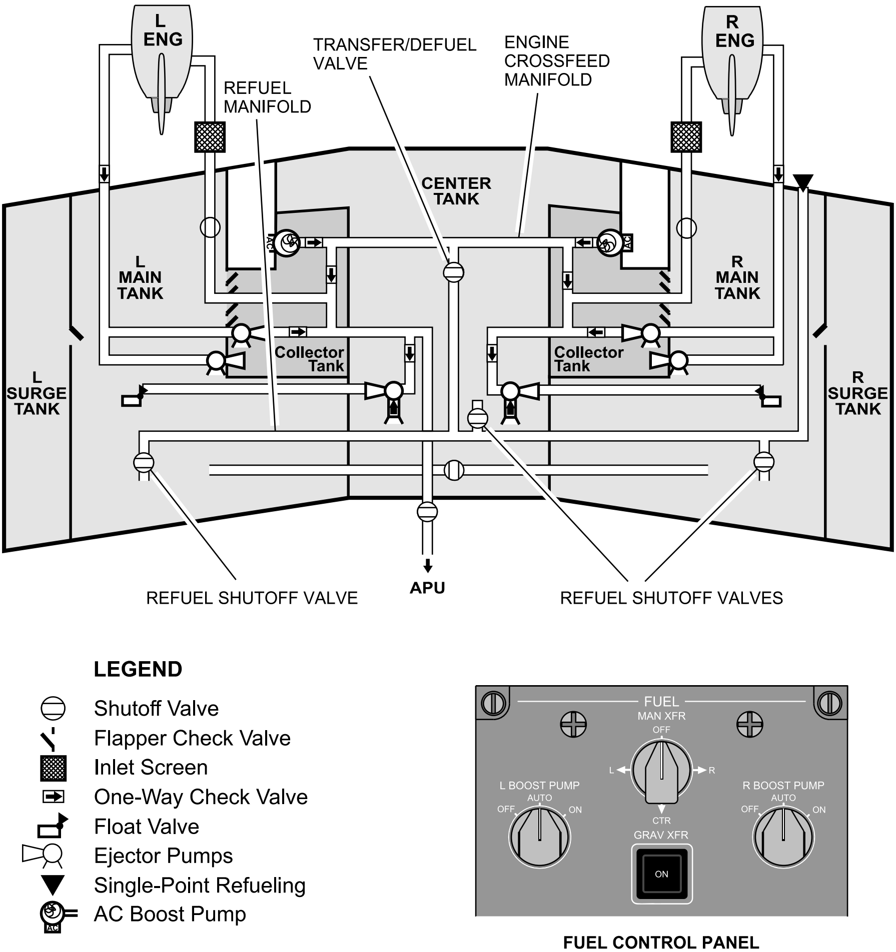
A. Manual transfer system

Fuel can be manually transferred between main tanks or from a main tank to the center tank. The Fuel Quantity Computer (FQC) allows only 180 kg (400 lb) of fuel to be transferred from main tank to main tank, or 360 kg (800 lb) from a main tank to the center tank at any time.

Manual fuel transfer is done with the L BOOST PUMP switch or R BOOST PUMP switch, and the MAN XFR (manual transfer) switch on the FUEL panel. The MAN XFR switch opens the transfer/defuel valve and the destination tank refuel valve. This connects the engine fuel feed manifold and the refuel manifold, making it possible to transfer fuel by turning on the appropriate AC boost pump.

NOTE

With both boost pumps operating, fuel transfer still occurs but performance of the manual transfer is significantly decreased.

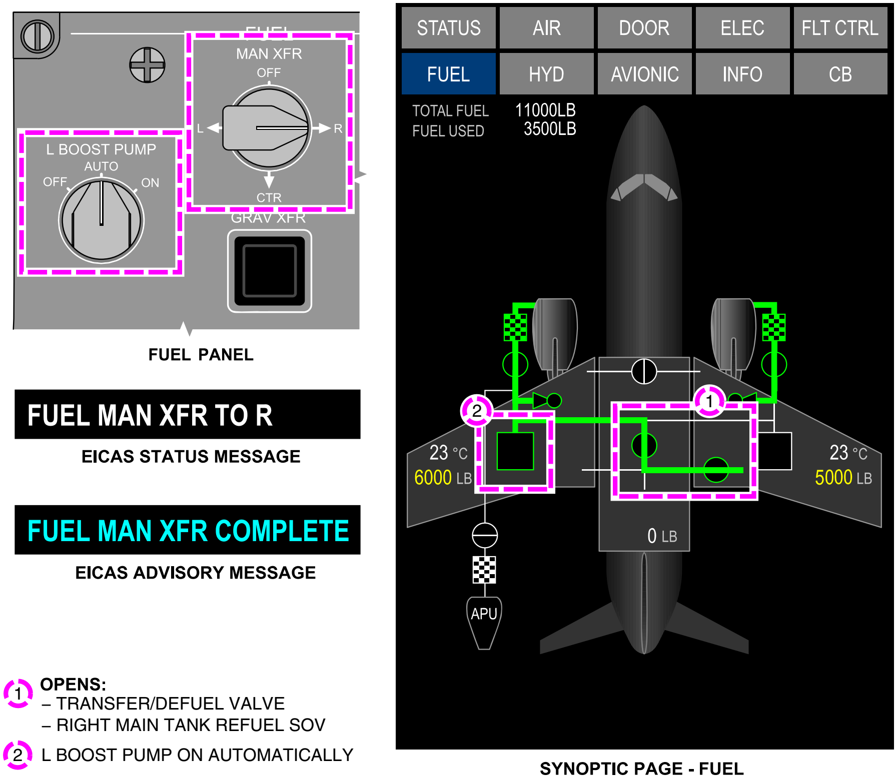


Manual (powered) fuel transfer
Figure 11–04–1

B. Main tank to main tank manual transfer

When the L or R position is selected on the MAN XFR switch, the FQC opens the transfer/defuel valve and the refuel shutoff valve of the selected tank. With the L BOOST PUMP or R BOOST PUMP switch selected to AUTO or ON, 180 kg (400 lb) of fuel will transfer to the selected main tank. When the transfer operation is completed, the FQC closes the transfer/defuel valve and the refuel shutoff valve and turns off the AC boost pump (left or right if in AUTO). The advisory message, **FUEL MAN XFR COMPLETE** appears on the EICAS page. The transfer operation is shown on the FUEL synoptic page and on the fuel section of the EICAS page.

Figure 11–04–2 shows a manual transfer from the left main tank to the right main tank.



Main tank to main tank manual fuel transfer
Figure 11–04–2

C. Main tank to center tank manual transfer

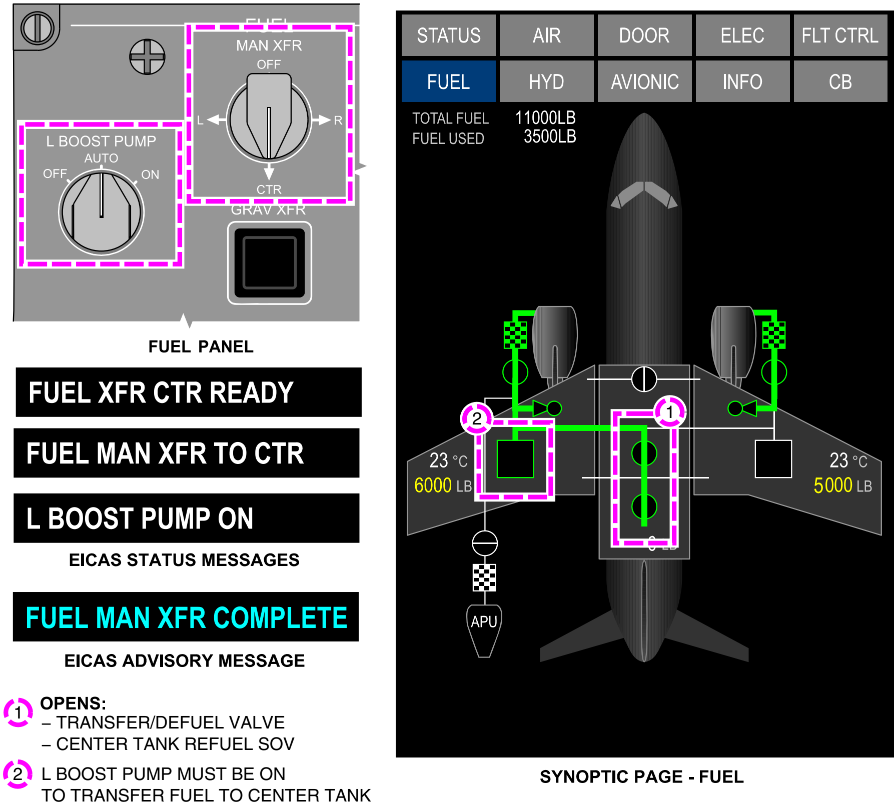
In flight, when a manual fuel transfer is required from wing tank to center tank, the MAN XFR switch is set to CTR. Both the fuel transfer shutoff valve and the center tank refuel valve open.

The left or right AC boost pump must be selected to ON and the status messages **L BOOST PUMP ON** or **R BOOST PUMP ON** and **FUEL MAN XFR TO CTR** show on the EICAS synoptic page. A maximum of 360 kg (800 lb) of fuel can be transferred to the center tank before the valves will close. The AC boost pump will continue to operate and must be selected back to AUTO manually.

The status message **FUEL XFR CTR READY** only shows on the EICAS synoptic page if the boost pumps are not turned on.

During ground operation, when a manual fuel transfer is required from a wing tank to center tank, both AC boost pumps are selected to AUTO. The selection of the MAN XFR switch to CTR will automatically activate both AC boost pumps to transfer fuel to the center tank. When the system has transferred a maximum of 360 kg (800 lb) of fuel, the fuel transfer shutoff valves will close and the fuel transfer ends.

The advisory message **FUEL MAN XFR COMPLETE** shows on the EICAS synoptic page (refer to Figure 11–04–3) when the manual fuel transfer is completed.



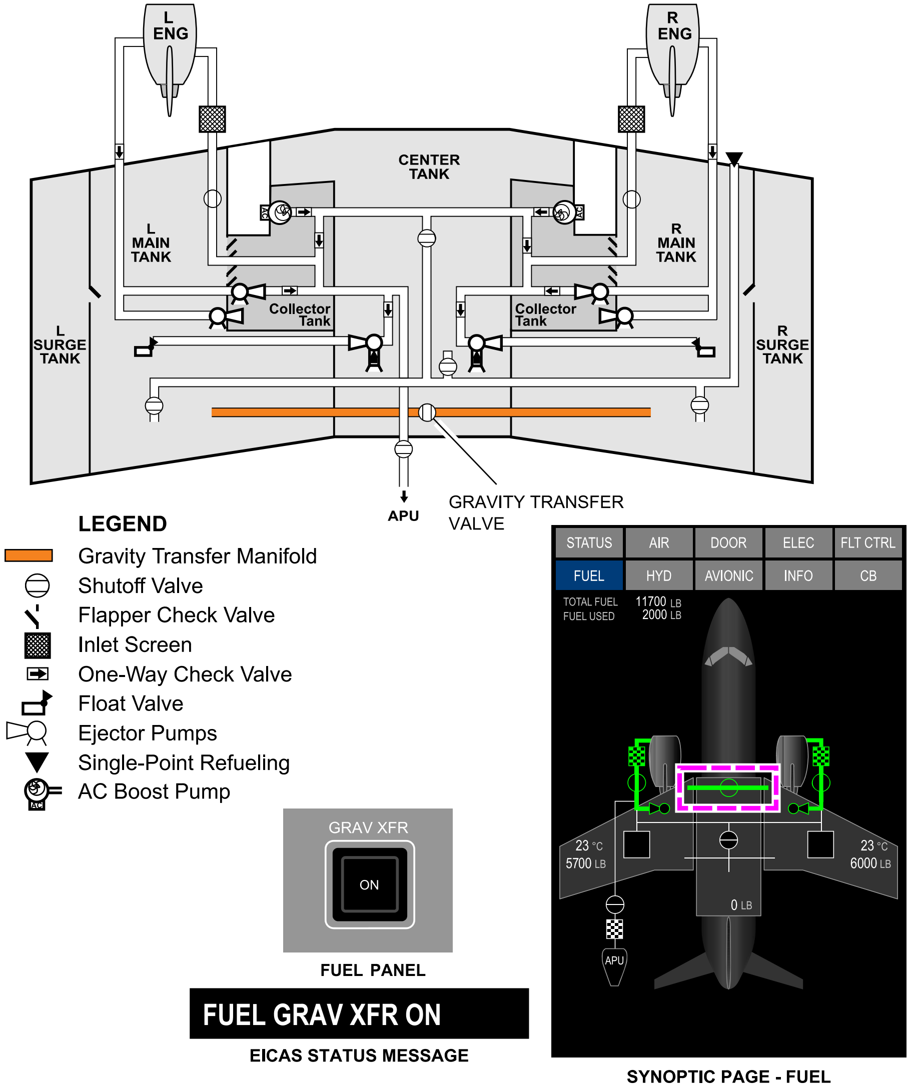
Main tank to center manual fuel transfer
Figure 11–04–3

D. Gravity transfer system

A gravity transfer manifold connects the left and right main tanks. The manifold is separated by the gravity crossflow valve, which is normally closed. The GRAV XFR switch on the FUEL panel opens the gravity transfer valve and allows the main tanks to equalize. If the gravity crossflow switch is inoperative, the gravity crossflow valve can be manually overridden on the ground only.

The indications that follow confirm that the GRAV XFR switch is in operation:

- The label ON illuminates in the GRAV XFR switch,
- The status message **FUEL GRAV XFR ON** displays on the EICAS synoptic page, and
- The gravity transfer flow bar illuminates green on the FUEL synoptic page (refer to Figure 11–04–4).

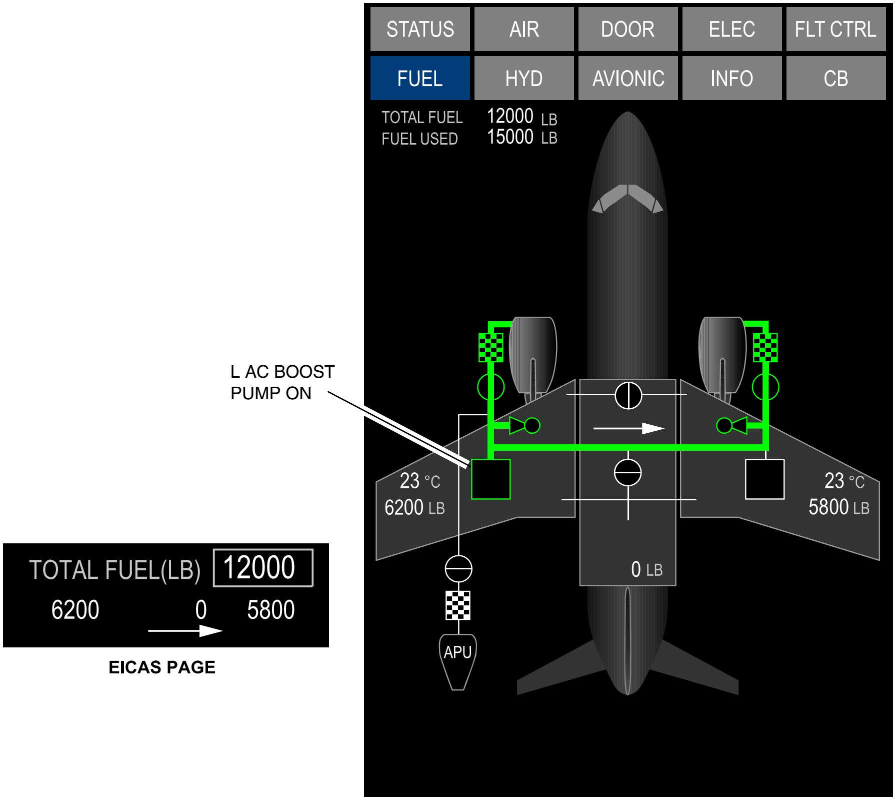


Gravity fuel transfer
Figure 11–04–4

E. Automatic fuel balancing (automatic crossfeed)

With AC boost pumps set to AUTO on the FUEL panel, if the FQC senses an imbalance of more than 180 kg (400 lb) between the main tanks, the AC boost pump of the heavier tank turns on automatically. Both engines are fed directly from the heavier tank until the tanks are within 45 kg (100 lb) of each other. The FUEL synoptic page displays the operating AC boost pump in green and a white arrow shows the direction of crossfeed (refer to Figure 11–04–5).

Automatic correction of fuel imbalance is only activated when the center tank is empty. Additionally, if the fuel pressure drops in the engine fuel feed line, both AC boost pumps will be automatically activated to supply engine feed fuel. With both boost pumps operating, automatic fuel balancing is no longer available.



Auto fuel imbalance correction (auto crossfeed)
Figure 11–04–5

When the left or right AC boost pump is manually selected ON, fuel is transferred to the opposite engine. The related **L BOOST PUMP ON** or **R BOOST PUMP ON** status message is displayed on the EICAS page, and a white arrow, pointing to the direction of flow, is displayed on the FUEL synoptic page and EICAS page.

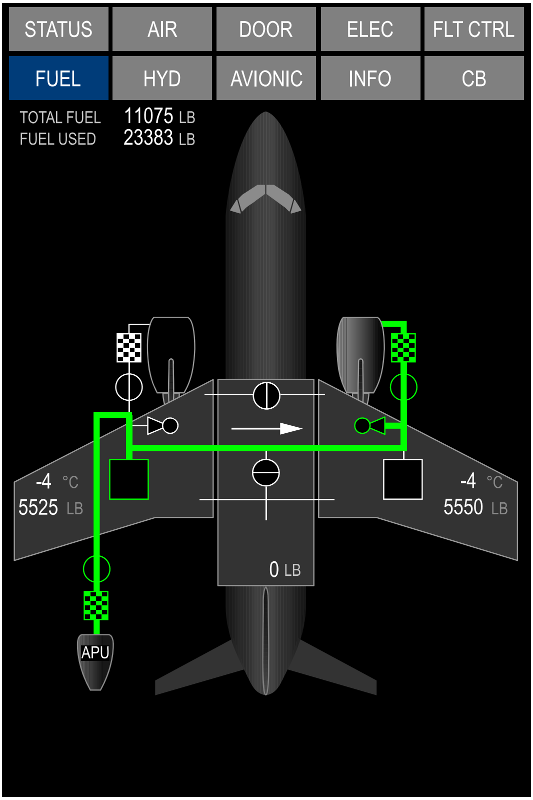
F. Automatic fuel balancing with one engine inoperative

The automatic fuel balancing function (automatic crossfeed) stays active during an engine inoperative scenario when both AC boost pumps are in AUTO. The crossfeed function display logic (white arrow) is based on the condition of the AC boost pumps (on or off).

(1) Left engine inoperative – APU ON – Both AC boost pumps set to AUTO

With the left engine inoperative and the APU ON, the L BOOST PUMP operates automatically for APU fuel feed (switch is set to AUTO). As a result, fuel from the left wing tank is fed to the right engine while the R BOOST PUMP stays off (switch is set to AUTO) (refer to Figure 11–04–6).

EICAS PAGE

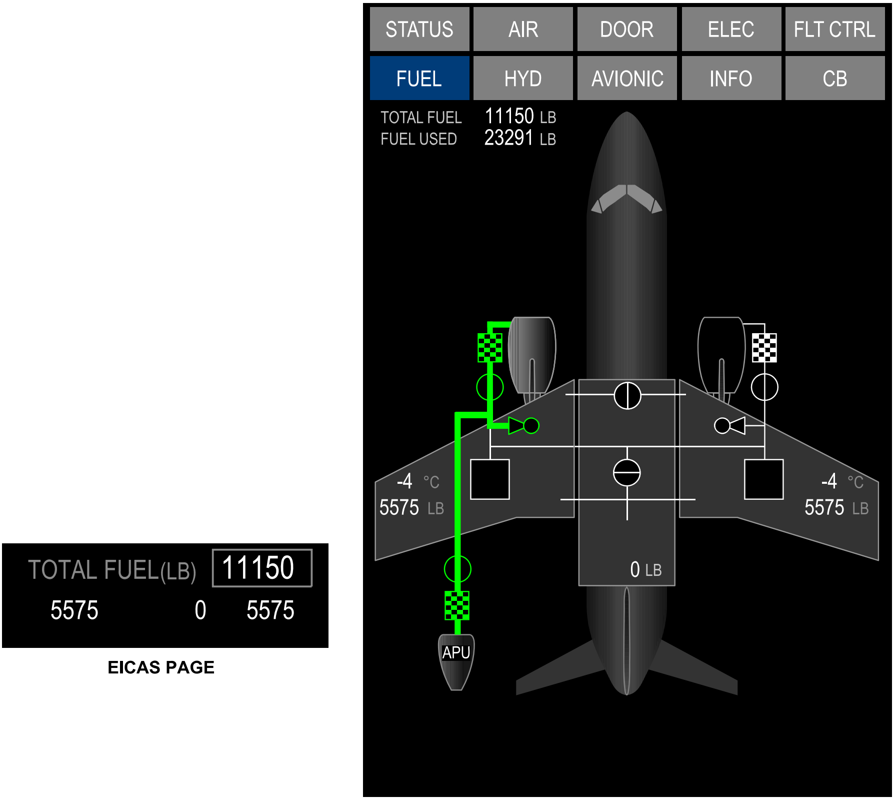


Automatic fuel balancing – Left engine INOP
Figure 11–04–6

When the center tank is empty, and as the crossfeed from the left wing tank to the right engine continues, a fuel imbalance between the left and right tanks will occur. At the imbalance threshold, 180 kg (400 lb), the Fuel Quantity Computer (FQC) turns on the right boost pump (for automatic fuel imbalance correction). As a result, the right wing tank sends fuel to the right engine until the imbalance is corrected. During this automatic imbalance correction, the white arrow is not displayed because both AC boost pumps are on. This process will be repeated periodically to correct the imbalance.

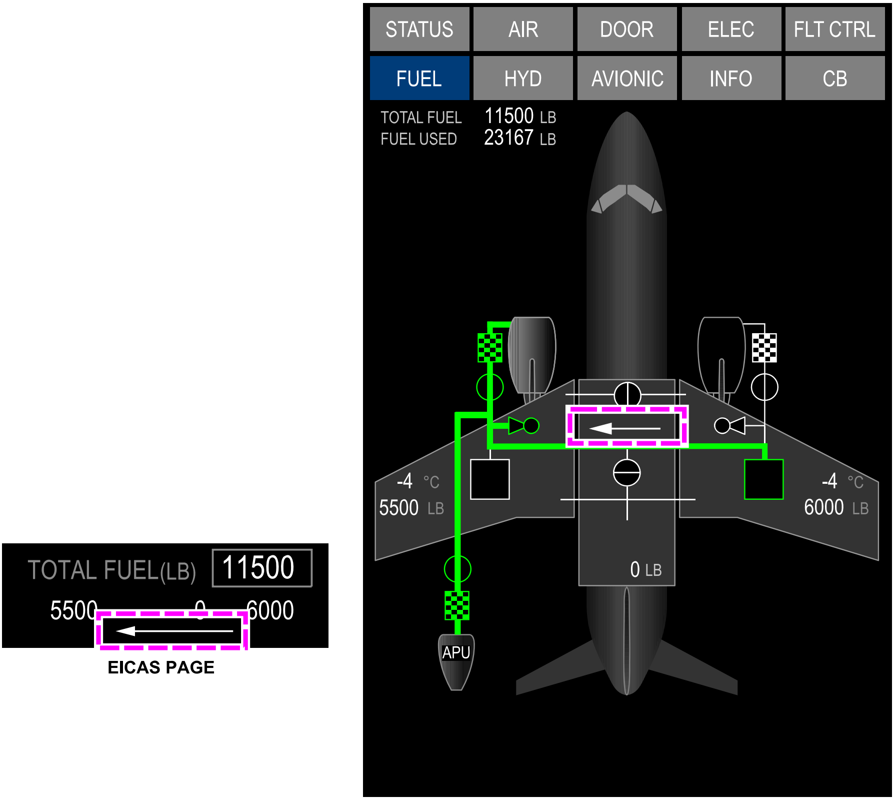
(2) Right engine inoperative – APU ON – Both AC boost pumps set to AUTO

With the right engine inoperative and the APU ON, fuel from the left wing tank is used to feed both the APU and the left engine (refer to Figure 11–04–7).



Automatic fuel balancing – Right engine INOP
Figure 11–04–7

When the center tank is empty, an imbalance between the left and right wing tanks will occur. At the imbalance threshold, 180 kg (400 lb), the FQC turns on the right boost pump (for automatic fuel imbalance correction). The left AC boost pump will be in AUTO (pump is off) and the white arrow on the fuel synoptic page may incorrectly show fuel transferring to the left engine. The synoptic page inconsistency is due to the fact that the right AC pump is powered by the APU generator and cannot supply sufficient pressure to overcome the pressure of the left main fuel ejector pump when the left engine is above 85% N2. Even though the white arrow indicates that fuel from the right tank is being fed to the left engine, while the left engine is above 85% N2 the only fuel source to the left engine is the left wing tank (refer to Figure 11–04–8).



Automatic fuel balancing – Right engine INOP
Figure 11–04–8

The fuel imbalance will continue to occur and the **FUEL IMBALANCE** caution message will be displayed on the EICAS page. After the FUEL IMBALANCE non-normal procedure is done and the imbalance is corrected, and depending on the left engine N2, the fuel imbalance condition may occur again approximately every 15 minutes.

When the right engine is inoperative and the center tank is empty, the flight crew can make pre-emptive manual transfers (or make two manual transfers) (refer to AFM, Chapter 4 – Non-normal procedures, Fuel, FUEL IMBALANCE (Caution).

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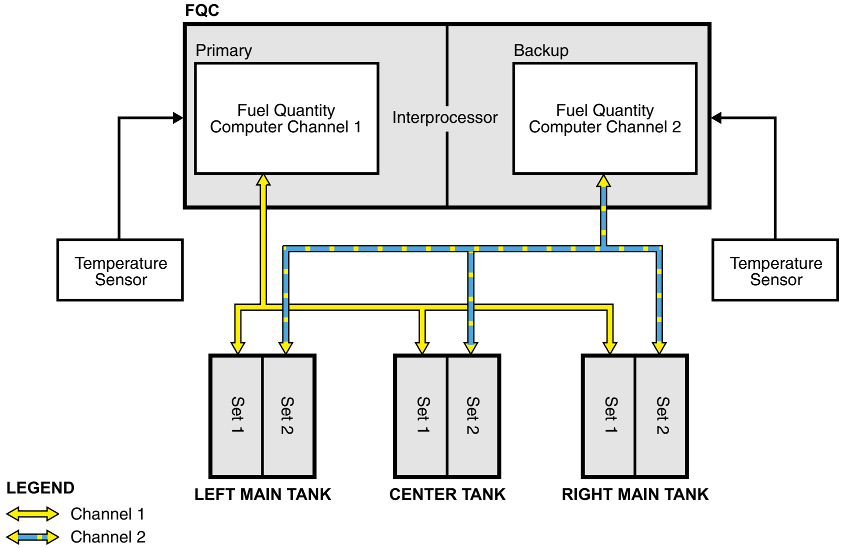
FUEL QUANTITY AND TEMPERATURE SYSTEM – OVERVIEW

Each fuel tank contains two separate and independent sets of capacitance-type fuel quantity probes. Each set includes high and low level sensors. Data from the sensors are sent to the Fuel Quantity Computer (FQC).

The FQC has two channels. Channel 1 is the primary and Channel 2 serves as a backup. Each channel receives independent data from all three tanks. Refer to Figure 11–05–1.



Fuel Quantity and Temperature
Figure 11–05–1

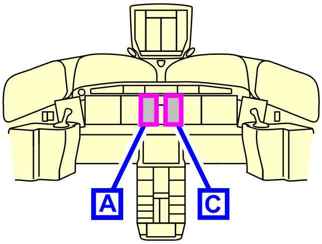
If an individual fuel quantity probe failure occurs, the FQC will calculate the quantity based on the inputs of the functional probes.

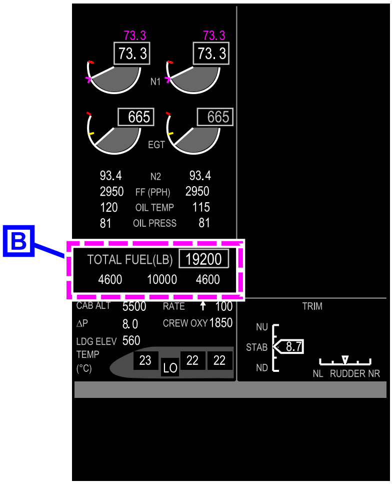
The flight management system (FMS) monitors calculated fuel quantity and the FQC monitors measured fuel quantity. A **L FUEL LO QTY** or **R FUEL LO QTY** caution message is displayed on the EICAS page when the fuel quantity is less than 442.2 kg (975 lb). A **FUEL LEAK SUSPECT** caution message is displayed on the EICAS page if the FQC detects a mismatch between the measured fuel quantity and the calculated fuel quantity.

Each channel receives fuel temperature from a temperature probe installed in each main tank.

The TOTAL FUEL quantity and the quantity in each tank are displayed on the FUEL synoptic page and on the EICAS page. Only the FUEL USED quantity is displayed on the FUEL synoptic page. All fuel quantity indications are displayed in pounds (LB) or kilograms (KG) (refer to Figure 11–05–2).

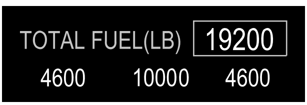
Fuel used quantity indicates the amount of fuel used since the last flight. Fuel used quantity is reset to zero when either engine is started or when AC and DC power are removed from the aircraft.





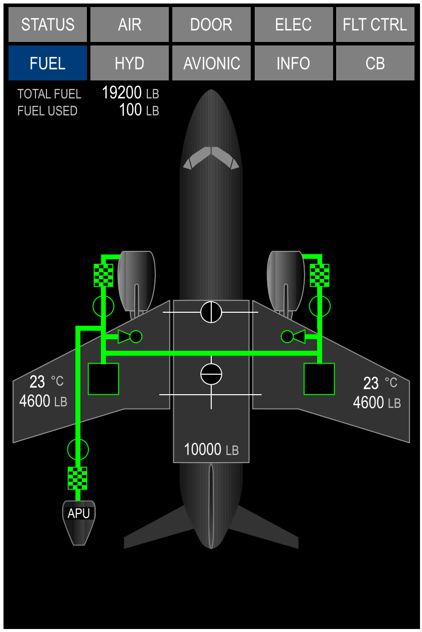
EICAS PAGE

A



FUEL QUANTITY

B



FUEL SYNOPTIC PAGE

C

EICAS page and FUEL synoptic page
Figure 11–05–2

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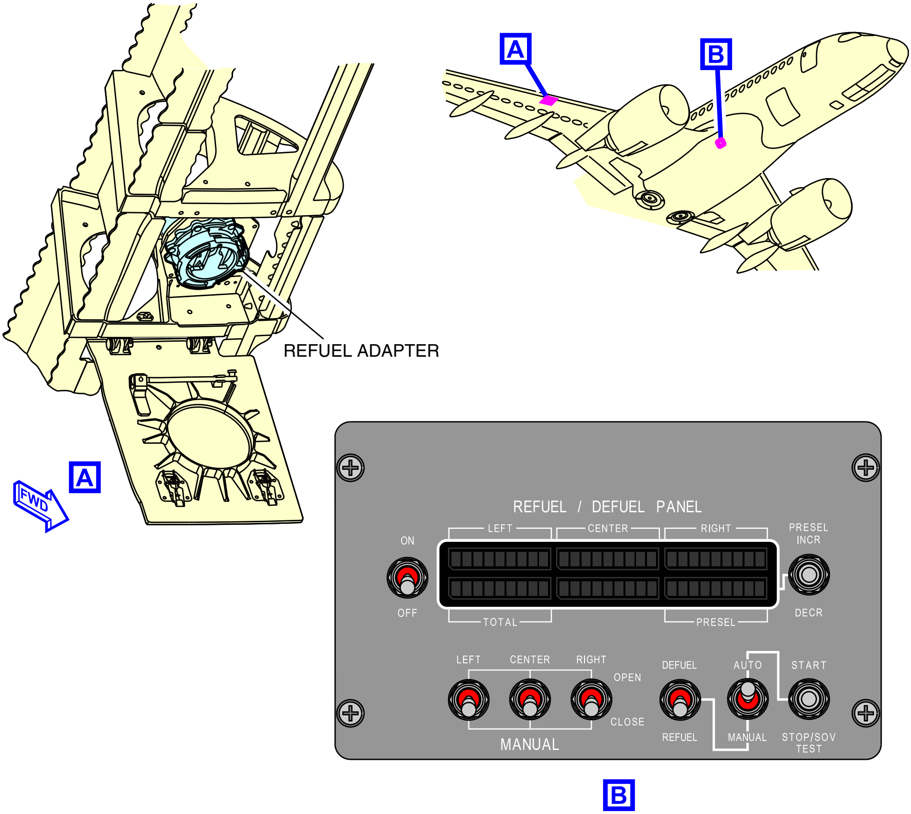
REFUELING/DEFUELING SYSTEM – DESCRIPTION AND OPERATION

To refuel or defuel the aircraft, a standard adapter is connected to the refuel/defuel point. It is located at the right wing leading edge. The appropriate switch selections are made on the REFUEL/DEFUEL panel (refer to Figure 11–06–1).

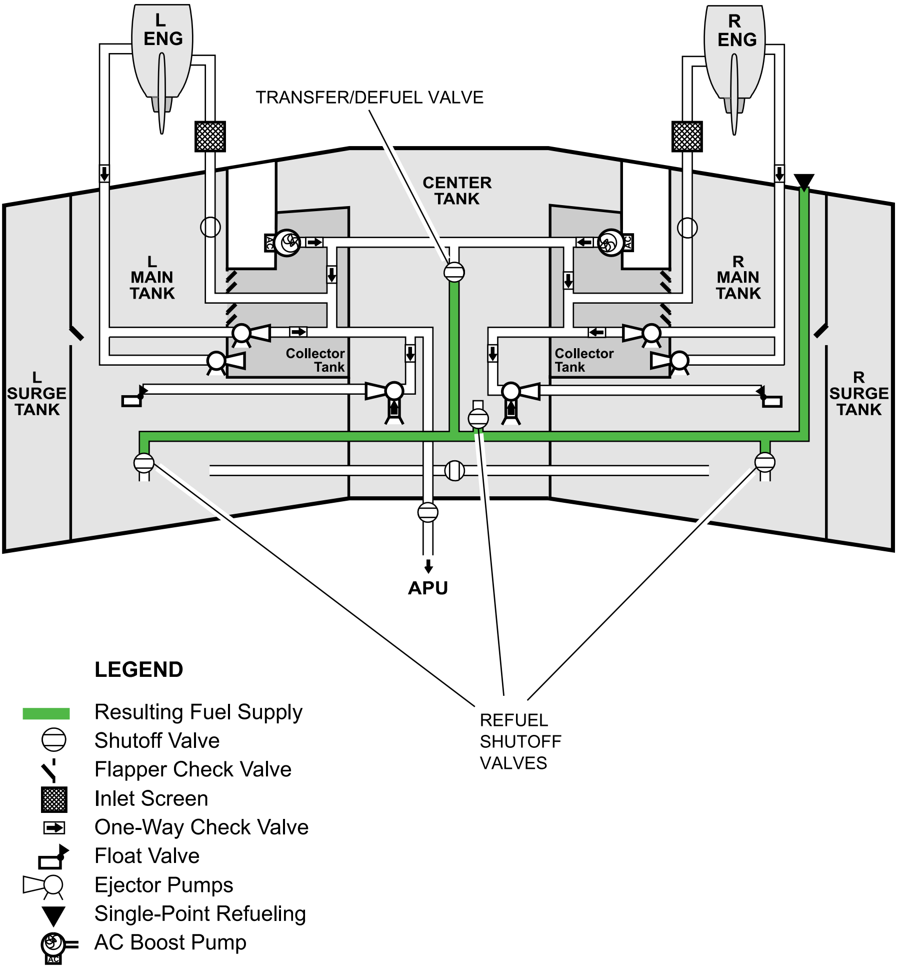


REFUEL / DEFUEL panel location
Figure 11–06–1

Refueling can be done in AUTO mode or MANUAL mode. Defueling can only be carried out in the MANUAL setting on the REFUEL / DEFUEL panel.

Refueling can be accomplished with battery power only, however, for defueling, AC power is required.

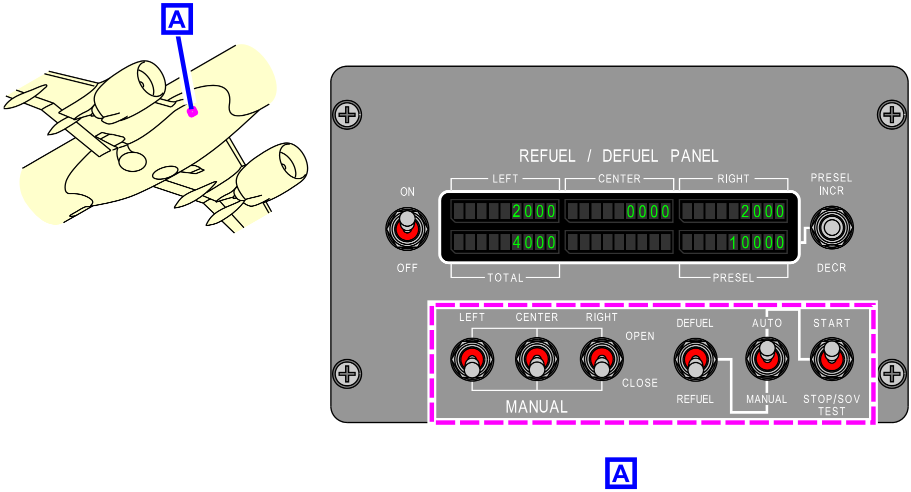
For refueling, the refuel shutoff valves open to allow fuel to be supplied to each tank. For defueling, the transfer/defuel valve connects the engine crossfeed manifold to the refuel manifold, allowing fuel to be pumped out of the collector tanks. Refer to Figure 11–06–2.

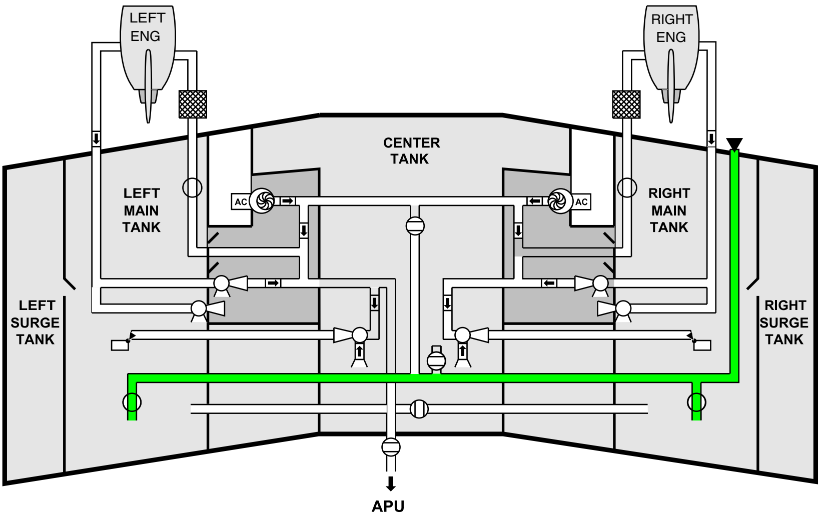


Refuel/defuel system schematic
Figure 11–06–2

A. Auto Refueling

In the AUTO setting, the Fuel Quantity Computer (FQC) controls the refuel shutoff valve in each tank. The total quantity of fuel required onboard is entered using the PRESEL switch on the REFUEL / DEFUEL panel (refer to Figure 11–06–3). The FQC controls the refueling of each tank so that the fuel is appropriately loaded and distributed.



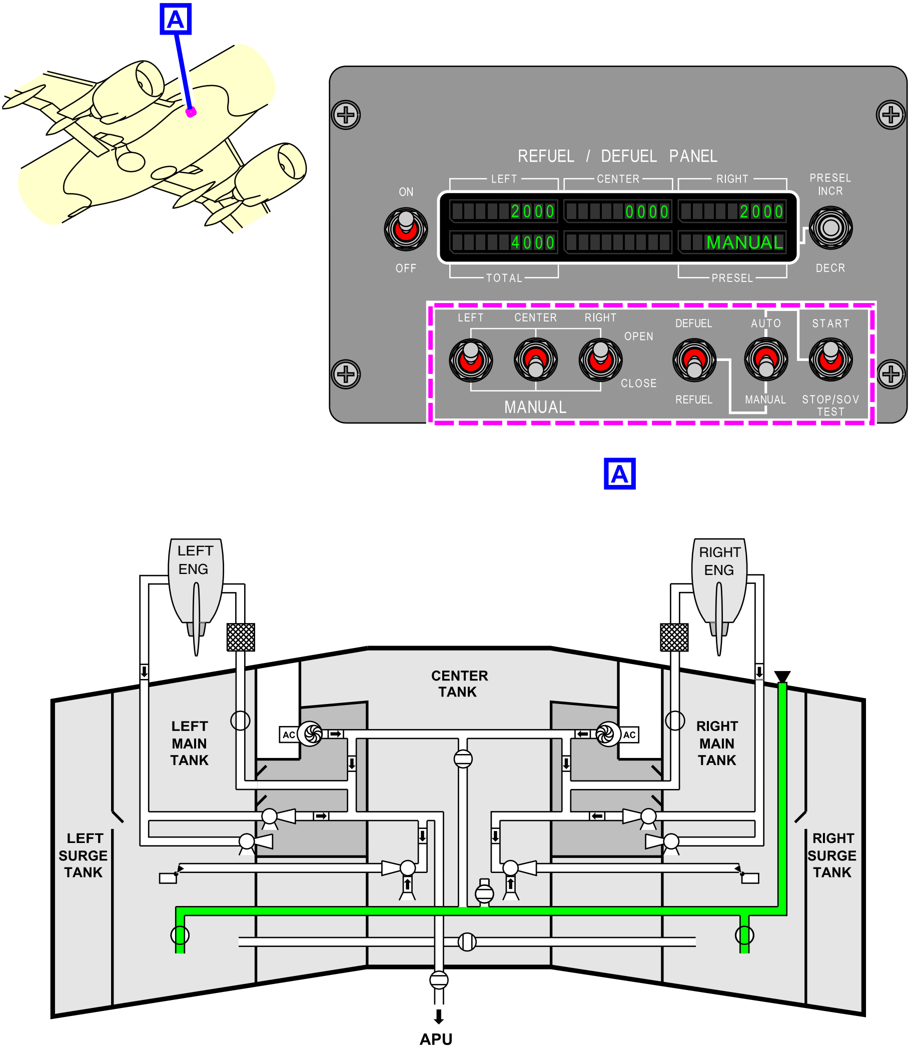


Auto refueling controls
Figure 11–06–3

B. Manual refueling

In manual refueling mode, the refuel shutoff valves for each tank must be operated and closed individually at the REFUEL / DEFUEL panel (refer to Figure 11–06–4).

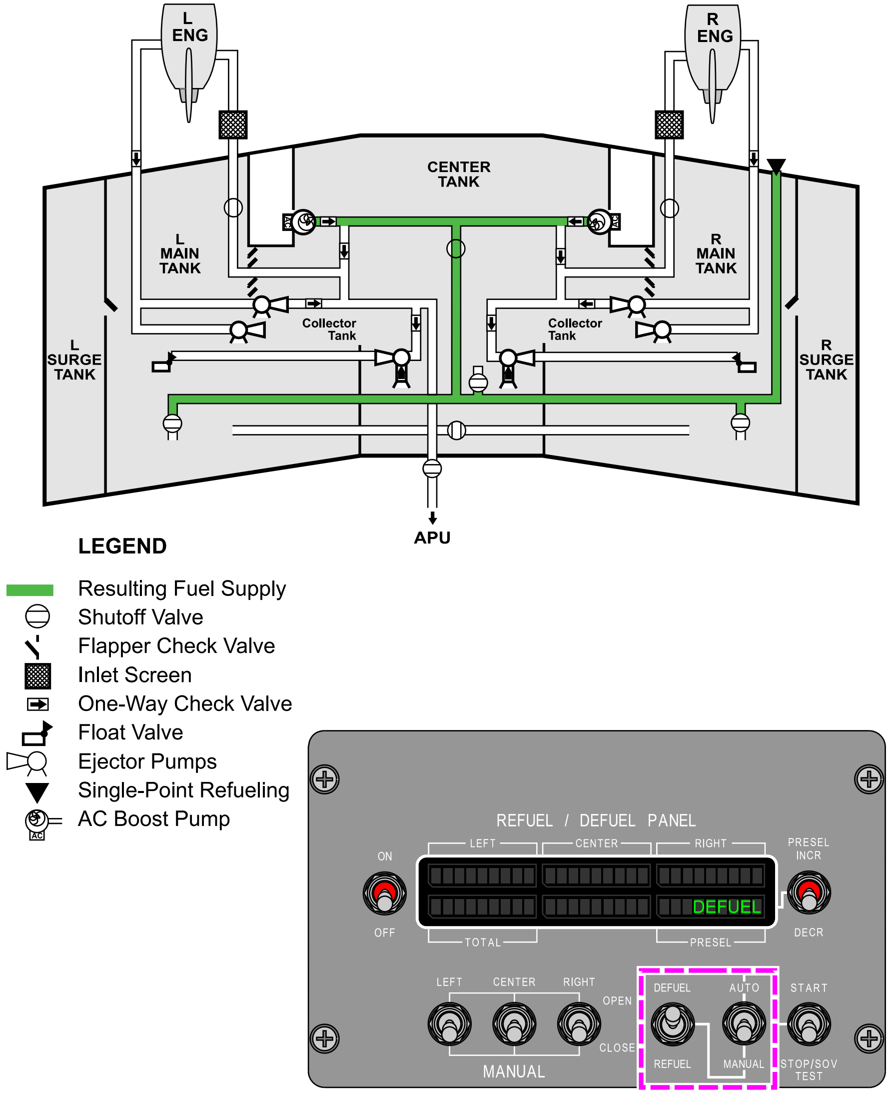
In MANUAL mode or AUTO, the refuel shutoff valves close when the fuel tanks are full.



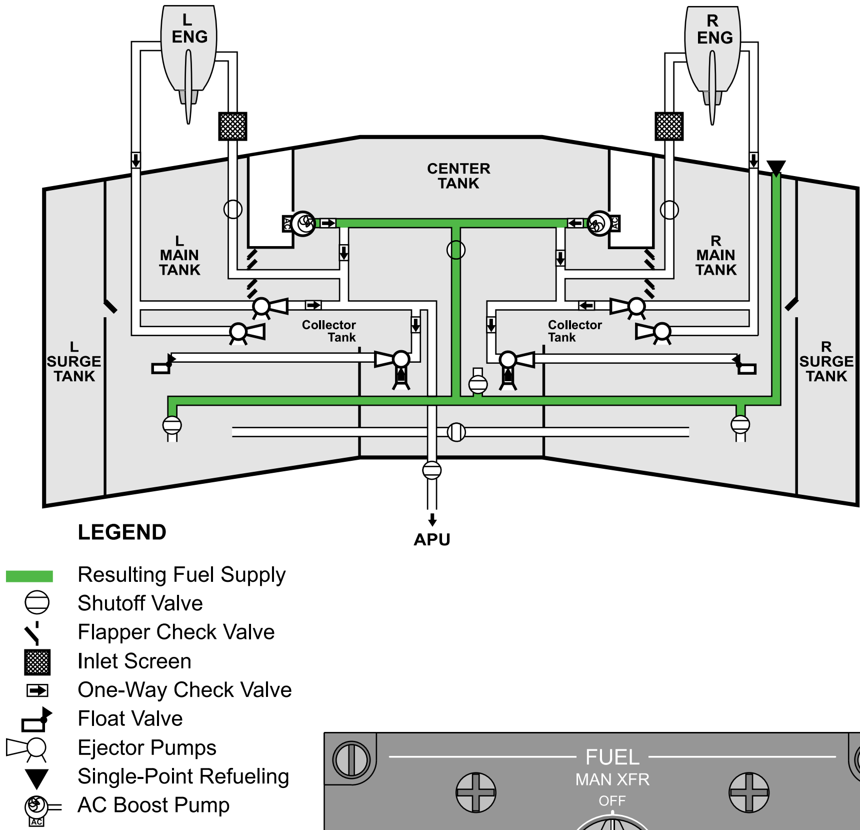
Manual refueling controls
Figure 11–06–4

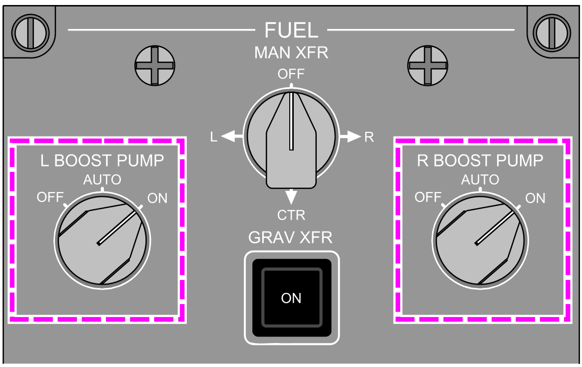
C. Manual Defueling

To defuel, MANUAL and DEFUEL must be selected on the REFUEL / DEFUEL panel. A green DEFUEL label will be displayed on the PRESEL screen of the REFUEL / DEFUEL panel when the DEFUEL switch is selected (refer to Figure 11–06–5). The FQC opens the transfer/defuel shutoff valve that connects the engine crossfeed manifold to the refuel manifold. When the manifolds are connected, the AC boost pumps are energized to pump the fuel out of the collector tank (refer to Figure 11–06–6). To defuel the center tank, the fuel must be transferred to the main tanks first.



Defueling controls – External
Figure 11–06–5





Defueling controls – Internal
Figure 11–06–6

FUEL TANK INERTING SYSTEM (FTIS) – OVERVIEW

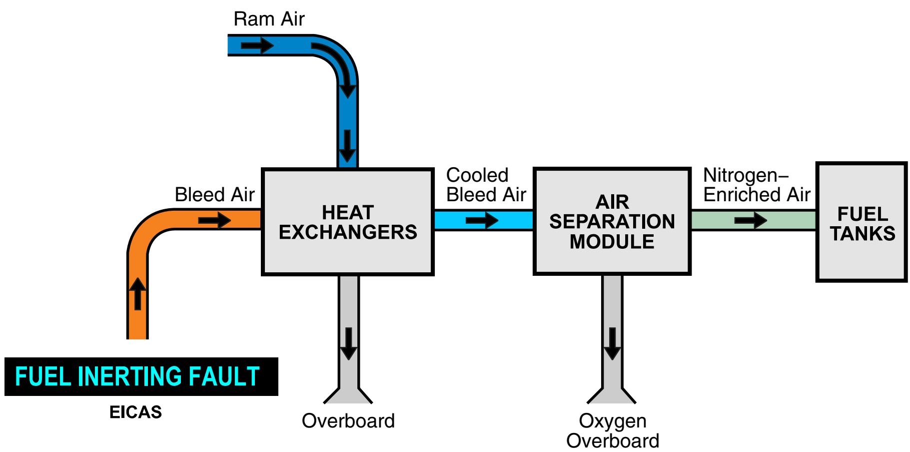
The Fuel Tank Inerting System (FTIS) generates nitrogen-enriched air and distributes it into the air space in the fuel tanks to provide non-flammable air in the tanks.

The bleed air, cooled by a ram air heat exchanger, passes through an air separation module that removes oxygen to create the nitrogen-enriched air. The oxygen is expelled overboard and the nitrogen-enriched air is directed into the fuel tanks.

An inerting control unit varies the flow of Nitrogen-Enriched Air (NEA) entering the fuel tanks, based on the aircraft flight of phase. In climb and cruise, the flow is low. During descent and approach, the flow is medium or high depending on the aircraft vertical speed.

The flight crew has no control or indications of the system except the advisory message **FUEL INERTING FAULT** if the system fails.

Figure 11–07–1 shows an overview of the fuel inerting system.



Fuel inerting system schematic
Figure 11–07–1

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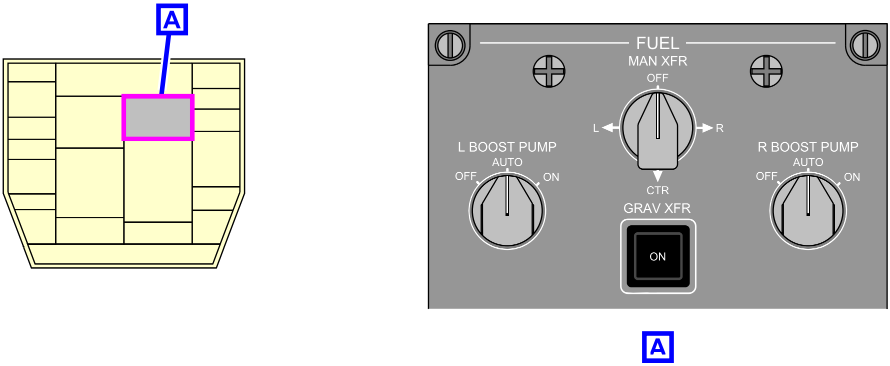
FUEL – CONTROLS

A. FUEL panel

The fuel system controls are located on the FUEL panel (refer to Figure 11–08–1) and consist of the switches that follow:

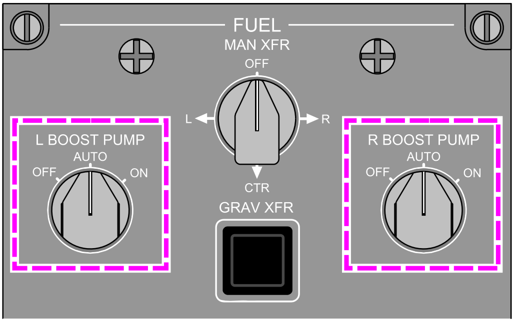
- L BOOST PUMP switch and R BOOST PUMP switch,
- MAN XFR (manual transfer) switch, and
- GRAVITY XFR (gravity transfer) switch.



FUEL panel
Figure 11–08–1

B. FUEL PANEL – L BOOST PUMP switch and R BOOST PUMP switch

The AC boost pumps are controlled by the L BOOST PUMP switch and R BOOST PUMP switch (refer to Figure 11–08–2).



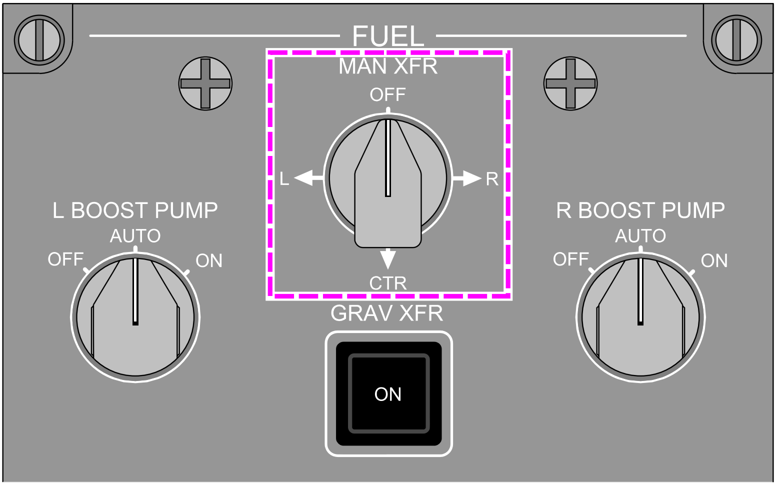
L BOOST PUMP and R BOOST PUMP switches
Figure 11–08–2

The switches have three positions:

- AUTO: AC boost pumps start automatically when either:
  - Low fuel pressure is sensed
  - Fuel imbalance is sensed
  - APU is configured for start
- ON: The respective boost pump is turned on.
- OFF: The respective boost pump is turned off.

C. FUEL PANEL – MAN XFR (manual transfer) switch

Automatic and manual (powered) fuel transfer is controlled by the MAN XFR (manual transfer) switch (refer to Figure 11–08–3).



MAN XFR switch
Figure 11–08–3

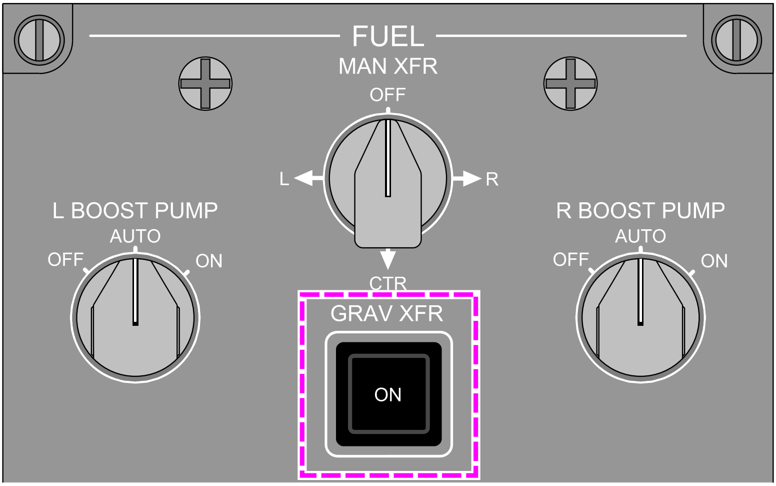
The switch has four positions:

- OFF: The fuel imbalance correction is in automatic mode.
- R: The fuel flow is initiated from the left wing to the right wing:
  - Right main tank refuel valve opens,
  - Transfer/defuel valve opens,
  - Left AC boost pump comes on, if set to AUTO
  - 180 kg (400 lb) of fuel transfers from left main to right main tank, then the valves close and the left boost pump turns off.
- L: The fuel flow is initiated from the right wing to the left wing:
  - Left main tank refuel valve opens
  - Transfer/defuel valve opens
  - Right AC boost pump comes on, if set to AUTO

  - 180 kg (400 lb) of fuel transfers from right main to left main tank, then the valves close and the right AC boost pump turns off
- CTR: The fuel flow is initiated from the left or the right wing to the center tank:
  - Centre tank refuel valve opens
  - Transfer/defuel valve opens
  - Left or right AC boost pump must be set to ON to transfer fuel to centre tank. A maximum of 360 kg (800 lb) of fuel will transfer before the valves close. The respective AC boost pump will not turn off automatically, the respective AC boost pump switch must be set to AUTO or OFF.
- OFF:
  - Refuel valves close
  - Transfer/defuel valve closes
  - Left and/or right AC boost pumps turn off (if selected to AUTO)

D. FUEL PANEL – GRAV XFR switch

The GRAV XFR switch controls the gravity transfer operation (refer to Figure 11–08–4).



GRAV XFR switch
Figure 11–08–4

When the switch is pressed, the ON label illuminates white, the gravity transfer valve opens, and the status message **FUEL GRAV XFR ON** displays on the EICAS synoptic page.

When the switch is pressed again, the ON label goes out and the transfer valve closes.

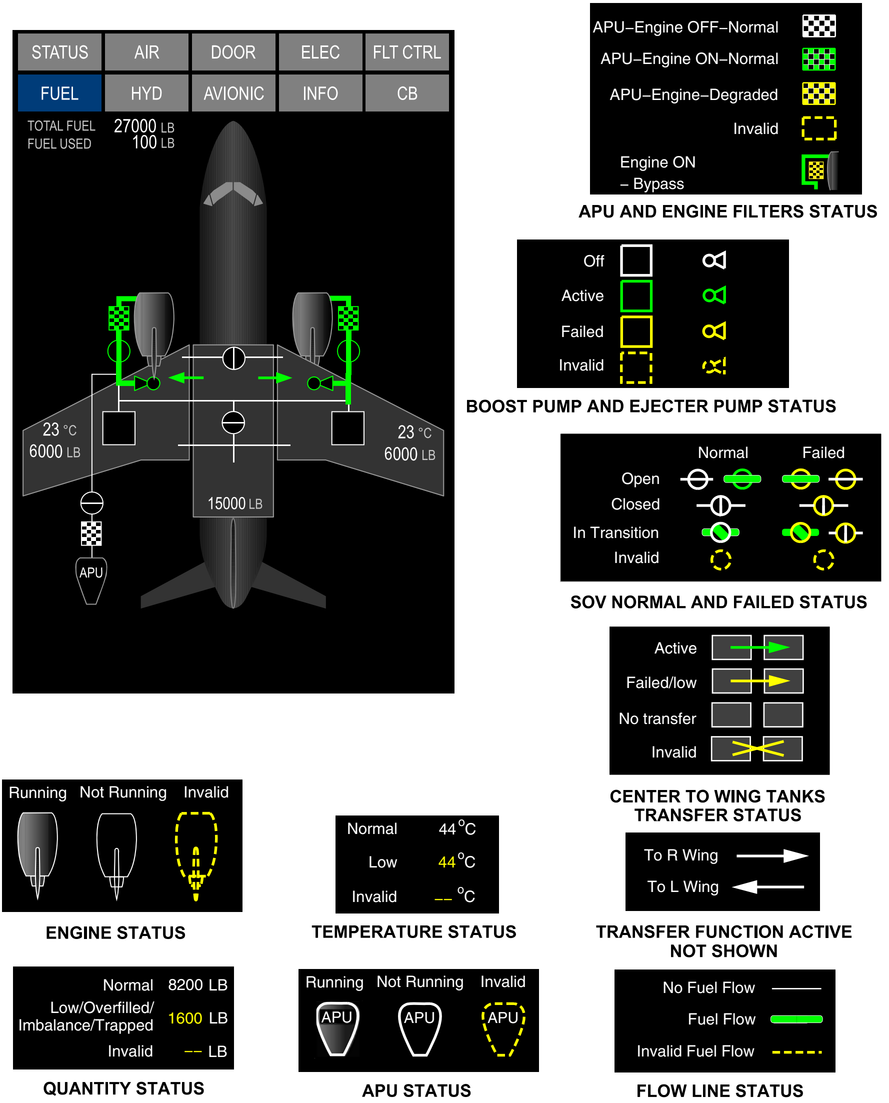
FUEL – INDICATIONS

A. FUEL synoptic page

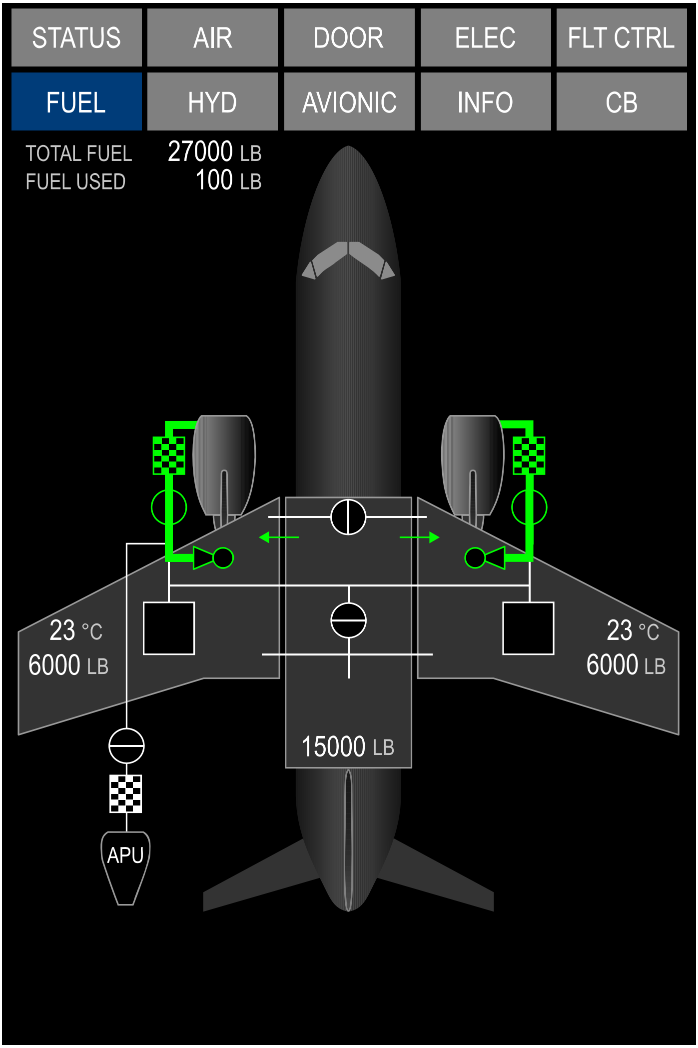
The FUEL synoptic page shows the current status of the fuel system components, fuel quantity and temperature, as well as fuel transfer (refer to Figure 11–08–5).

Figure 11–08–6 shows the FUEL synoptic page display when engines are fed by the engine main fuel ejector pumps and fuel is being transferred from the center tank to the main tanks.

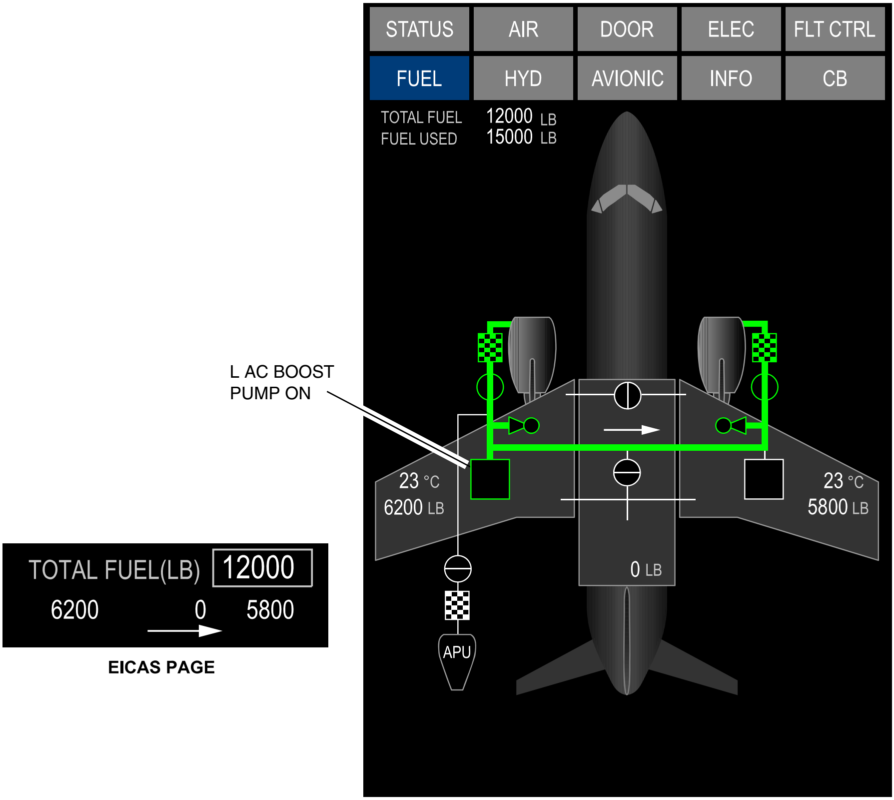
Figure 11–08–7 shows the FUEL synoptic page display during a crossfeed operation from the left main tank to the right main tank.



Fuel synoptic page description
Figure 11–08–5



Fuel synoptic page – Normal fuel feed
Figure 11–08–6



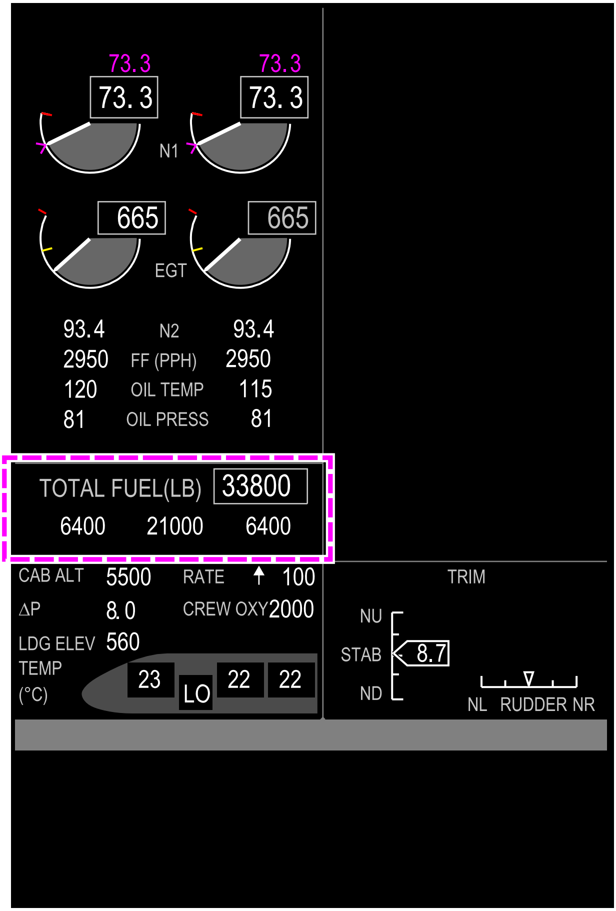
Fuel synoptic page – Left main tank to right main tank crossfeed
Figure 11–08–7

B. EICAS synoptic page – Fuel indications

The fuel indication section on the EICAS page (refer to Figure 11–08–8) shows the information that follows:

- Total fuel quantity,
- Left wing tank fuel quantity,
- Center tank fuel quantity,

- Right wing tank fuel quantity, and
- Crossfeed flow direction arrow.



EICAS page – Fuel indications
Figure 11–08–8

FUEL – EICAS MESSAGES

A. Warning messages

None

B. Caution messages

Message	Description	Inhibit
APU FUEL SOV FAIL	APU fuel SOV failed to close/open properly.	TO, LDG
FUEL COLLECTOR LO LVL	Fuel in the collector is low. The respective transfer ejector pump may be inoperative for the left tank or right wing tank.	None
FUEL CTR XFR FAIL	Fuel transfer out of center tank has failed, center tank fuel may become unusable.	TO, LDG
FUEL IMBALANCE	Fuel imbalance between left and right wing tank is greater than 360 kg (800 lb).	TO, LDG
FUEL LEAK SUSPECT	Potential fuel leak suspected.	None
FUEL MAN XFR FAIL	Manual transfer failed to perform the commanded operation or to stop the transfer.	TO, LDG
FUEL TANK HI TEMP	Fuel temperature above the operating limit.	TO, LDG
FUEL TANK LO TEMP	Fuel temperature is near Jet A fuel freezing point of –37 °C (–35 °F).	TO, LDG
L ENG FUEL LO PRESS	Left engine fuel feed pressure is low.	TO, LDG
R ENG FUEL LO PRESS	Right engine fuel feed pressure is low.	TO, LDG

Message	Description	Inhibit
L ENG FUEL SOV FAIL	Left fuel Shutoff Valve (SOV) failed to close/open properly.	TO, LDG
R ENG FUEL SOV FAIL	Right fuel SOV failed to close/open properly.	TO, LDG
L FUEL LO QTY	Low fuel level detected in left wing tank.	TO, LDG
R FUEL LO QTY	Low fuel level detected in right wing tank.	TO, LDG

C. Advisory messages

Message	Description	Inhibit
APU FUEL SOV CLSD	APU fuel SOV is closed after the APU FIRE switch is pressed.	TO, LDG
FUEL COMPUTER FAIL	Fuel Quantity Computer (FQC) has failed or loss of both ARINC 429 channels from FQC to DMC.	TO, LDG
FUEL CTR XFR FAULT	Fuel transfer from center tank to the left or right wing tank has failed.	TO, LDG
FUEL FAULT	Loss of redundant or non-critical function of the fuel system.	TO, LDG
FUEL GRAV XFR FAIL	Fuel gravity SOV failed to open or close.	TO, LDG
FUEL INERTING FAULT	Fault detected in the Fuel Tank Inerting System (FTIS).	TO, LDG
FUEL MAN XFR COMPLETE	Wing tank to wing tank target fuel transfer of 180 kg (400 lb) or wing tank to center tank target fuel transfer of 360 kg (800 lb) has been completed.	TO, LDG
L BOOST PUMP FAIL	Left AC boost pump has failed to indicate pressure when it is turned on manually or automatically.	TO, LDG

Message	Description	Inhibit
R BOOST PUMP FAIL	Right AC boost pump has failed to indicate pressure when it is turned on manually or automatically.	TO, LDG
L ENG FUEL SOV CLSD	Left fuel SOV is closed after the L ENG FIRE switch is pressed.	TO, LDG
R ENG FUEL SOV CLSD	Right fuel SOV is closed after R ENG FIRE switch is pressed.	TO, LDG
L FUEL EJECTOR FAIL	Left engine motive flow is faulty.	TO, LDG
R FUEL EJECTOR FAIL	Right engine motive flow is faulty.	TO, LDG

D. Status messages

Message	Description	Inhibit
FUEL GRAV XFR ON	Gravity SOV has been commanded open on the FUEL panel.	None
FUEL MAN XFR TO CTR	MAN XFR switch selected to CTR (center tank) and either L or R BOOST PUMP switch has been selected ON.	None
FUEL MAN XFR TO L	MAN XFR switch selected to L (left wing tank) on the FUEL panel.	None
FUEL MAN XFR TO R	MAN XFR switch selected to R (right wing tank) on the FUEL panel.	None
FUEL XFR CTR READY	MAN XFR switch selected to CTR (center tank) but no AC boost pump has been selected ON on the FUEL panel.	None
L BOOST PUMP OFF	Left AC boost pump is turned off through the FUEL panel.	None

Message	Description	Inhibit
R BOOST PUMP OFF	Right AC boost pump is turned off through the FUEL panel.	None
L BOOST PUMP ON	Left AC boost pump is turned on through the FUEL panel.	None
R BOOST PUMP ON	Right AC boost pump is turned on through the FUEL panel.	None

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CHAPTER 12 – HYDRAULICS

GENERAL

HYDRAULIC SYSTEM NO. 1 AND NO. 2

HYDRAULIC SYSTEM NO. 3

List of figures

HYDRAULIC SYSTEM NO. 1 AND NO. 2

HYDRAULIC SYSTEM NO. 3

HYDRAULICS – CONTROLS AND INDICATIONS

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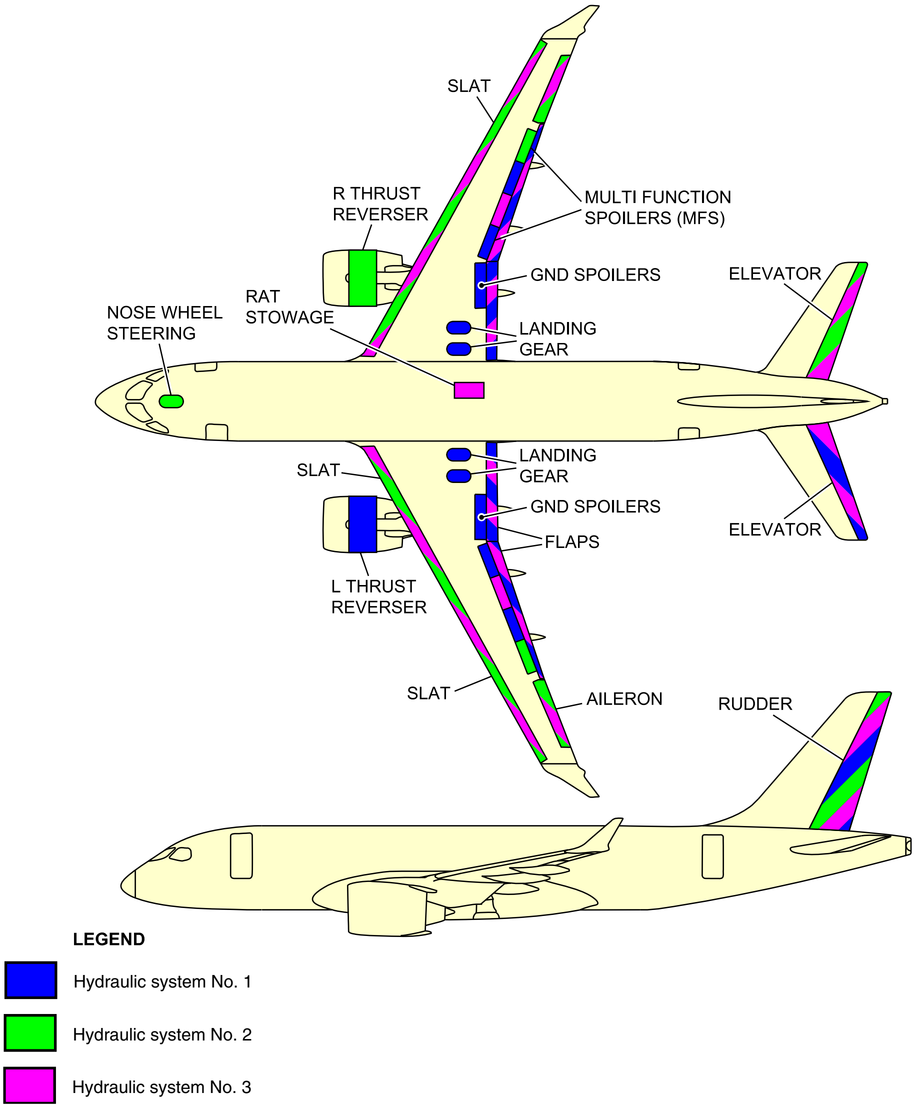
HYDRAULIC SYSTEM – OVERVIEW

The hydraulic power is provided by three independent systems: System No. 1, No. 2, and No. 3. Each system delivers a nominal pressure of 3000 psi to the components that follow (refer to Figure 12–01–1):

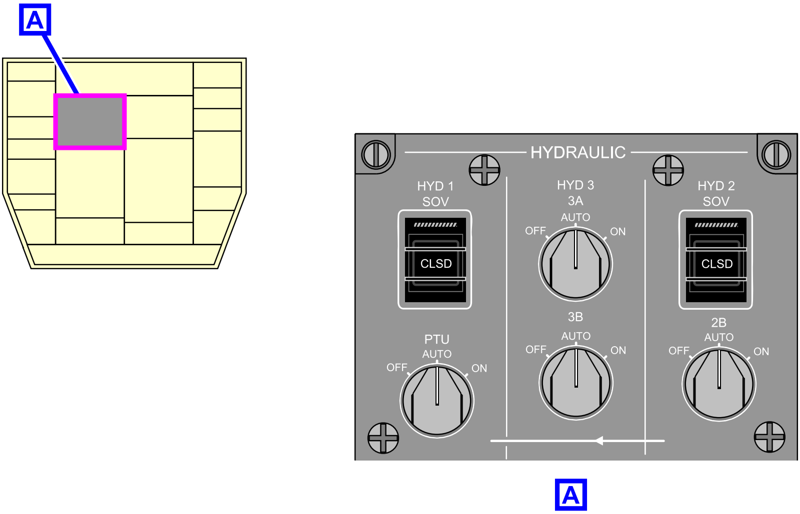
- Primary flight controls:
  - Ailerons,
  - Elevators, and
  - Rudder.
- Secondary flight controls:
  - Flaps/slats,
  - Multifunction Spoilers (MFSs), and
  - Ground spoilers.
- Thrust reversers,
- Landing gear (extension and retraction),
- Nosewheel Steering (NWS), and
- Ram Air Turbine (RAT) stow actuator.

Each hydraulic system uses a reservoir to store hydraulic fluid and to supply it to the components. The systems are equipped with a main pump and a backup pump to supply pressure. There is no fluid exchange between hydraulic systems. Each system is protected to ensure a safe operation of the aircraft.



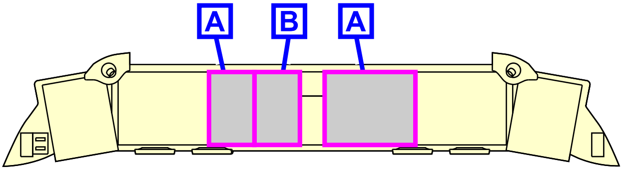
Hydraulic system distribution
Figure 12–01–1

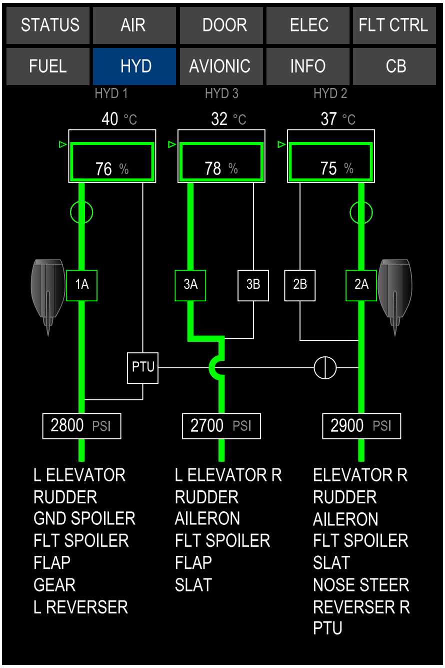
The system controls are located on the HYDRAULIC panel (refer to Figure 12–01–2).



HYDRAULIC panel
Figure 12–01–2

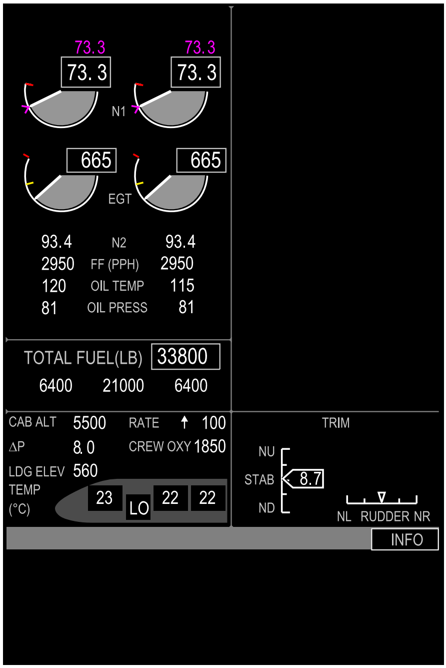
The indications are provided by the HYD synoptic page. System status and faults messages are reported on the EICAS page. Refer to Figure 12–01–3.





HYD SYNOPTIC PAGE

A

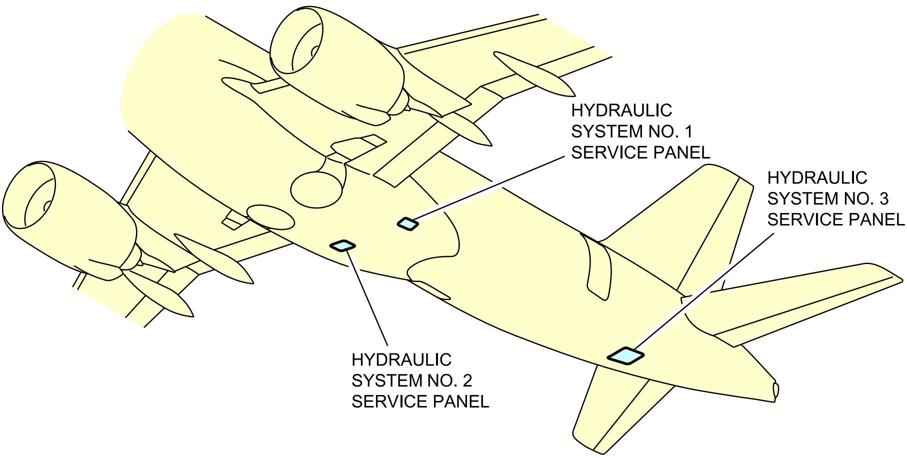


EICAS PAGE

B

Hydraulic system indications
Figure 12–01–3

Each hydraulic system is serviced by an external hydraulic service panel, located under the aircraft fuselage. Refer to Figure 12–01–4.



Hydraulic service panels
Figure 12–01–4

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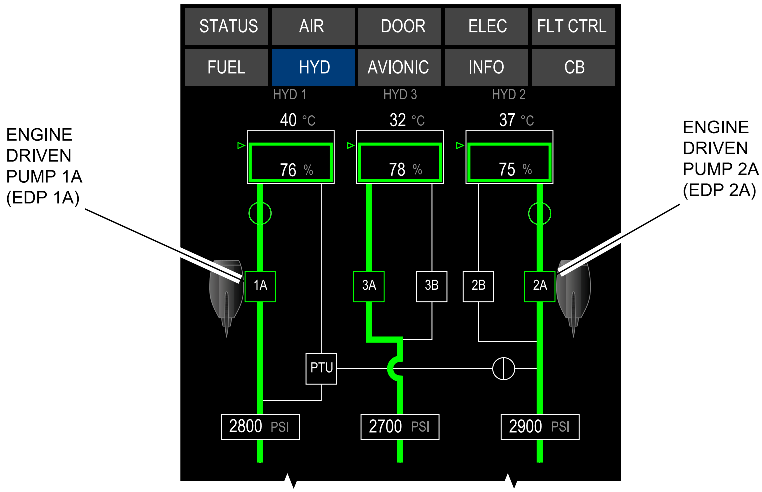
HYDRAULIC SYSTEM NO. 1 AND NO. 2 – OVERVIEW

Hydraulic system No. 1 and No. 2 have a similar operation. The differences between hydraulic system No. 1 and No. 2 are the reservoir capacity and the type of backup pumps. The main components (refer to Figure 12–02–1) of these systems are:

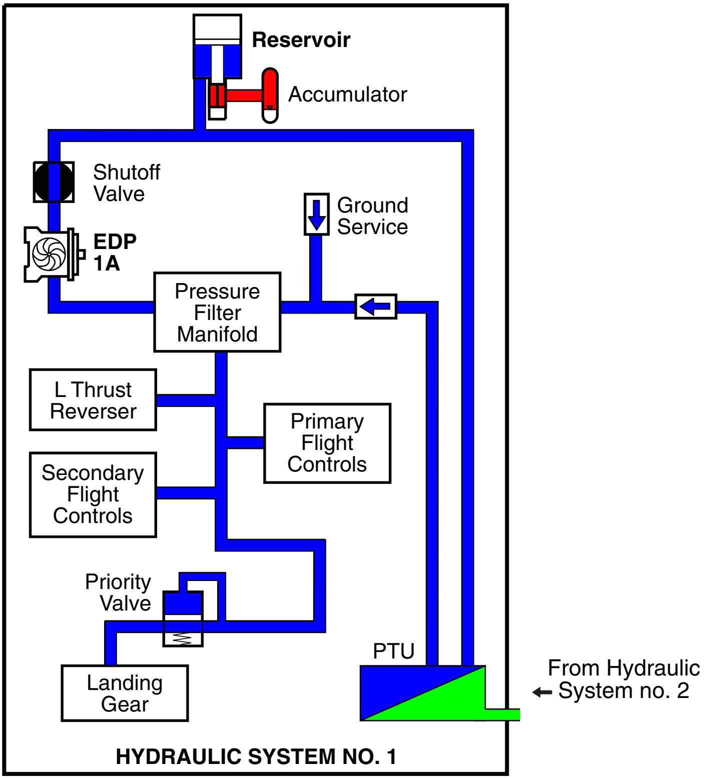


Hydraulic system No. 1 and No. 2 – Engine Driven Pump (EDP)
Figure 12–02–1

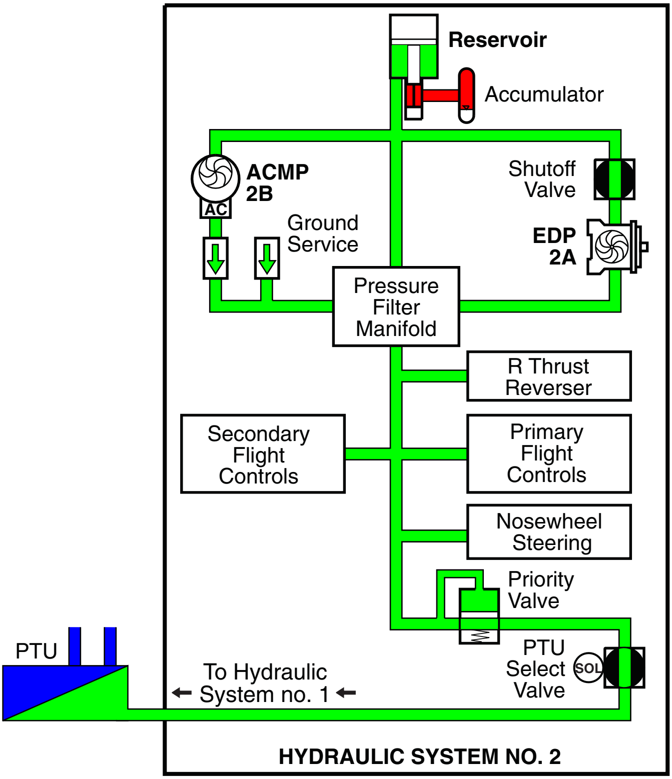
- Reservoirs that are connected to an accumulator,
- Engine Driven Pumps (EDP 1A and EDP 2A),
- Power Transfer Unit (PTU)(backup of system No. 1),
- AC Motor Pump (ACMP 2B)(backup of system No. 2),
- Heat exchangers,
- Shutoff Valves (SOVs), and
- Priority Valves (PVs).

Figure 12–02–2 shows the distribution of the hydraulic system No. 1.

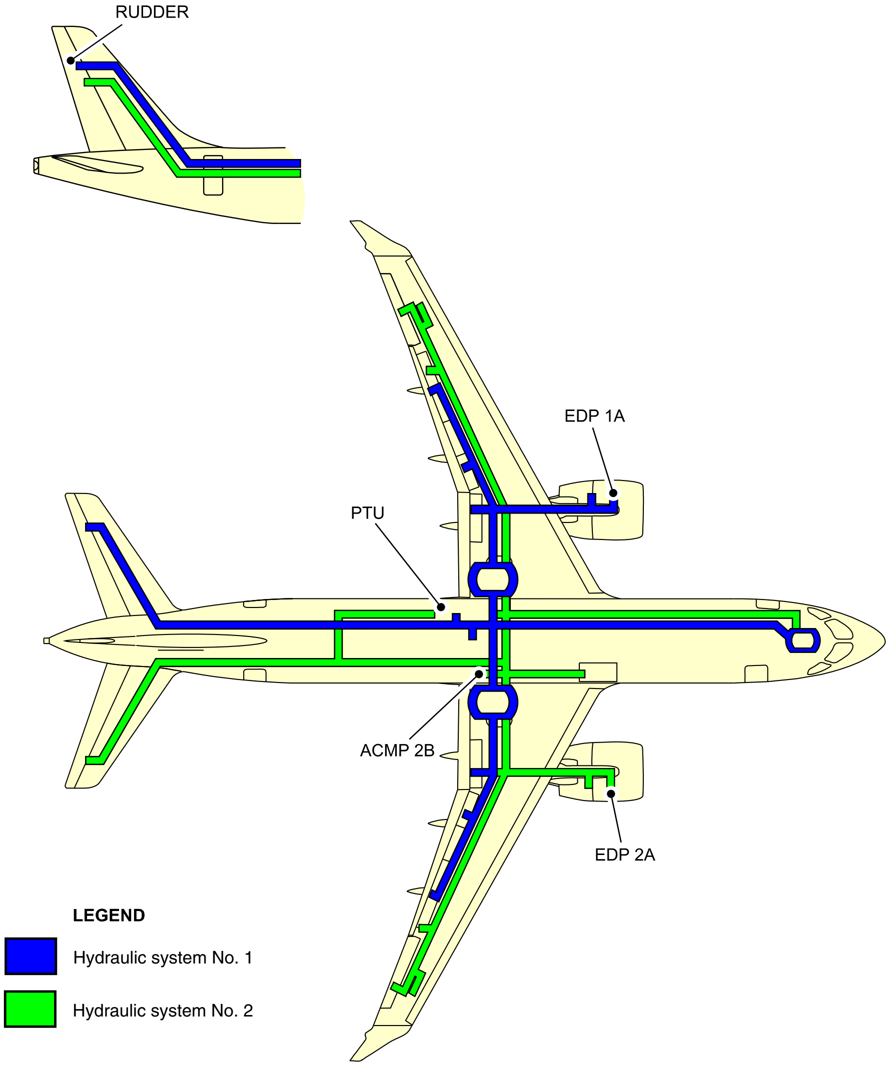
Figure 12–02–3 shows the distribution of the hydraulic system No. 2.



System No. 1 distribution – schematic
Figure 12–02–2



System No. 2 distribution – schematic
Figure 12–02–3



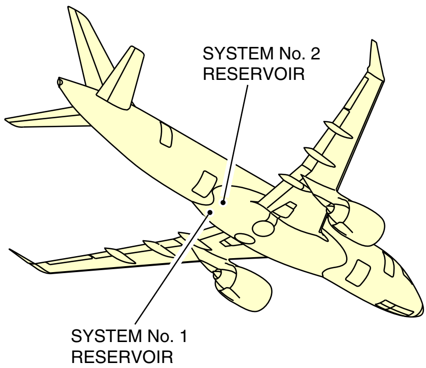
Hydraulic system No. 1 and No. 2 – Main components
Figure 12–02–4

HYDRAULIC SYSTEM NO. 1 AND NO. 2 – DESCRIPTION AND OPERATION

A. Hydraulic system No. 1 and No. 2 reservoirs

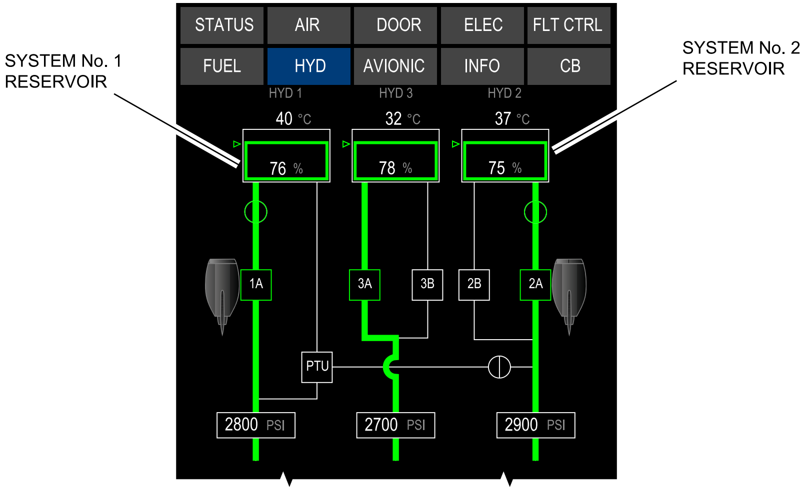
The system No. 1 reservoir has a slightly bigger capacity than the system No. 2 reservoir. The reservoir assemblies do not need to be pressurized by the engine bleed air. The high-pressure fluid return acts on a piston to create a positive pressure in the low-pressure section of the reservoir. This positive pressure pushes the hydraulic fluid to the Engine Driven Pumps (EDPs) through the Shutoff Valve (SOV) to prevent pumps from cavitation and to ensure supply during negative g situations. The system No. 1 and No. 2 reservoirs are equipped with temperature and quantity transducers that transmit data to the HYD synoptic page. Both reservoirs are equipped with a thermal fuse to drain fluid overboard in case of an uncontrolled overheat (overtemperature and a SOV failure situation). An accumulator pressurized with nitrogen is connected to each reservoir. The accumulator helps to supply pressure to the reservoir after the pump stops.

Each system reservoir is located inside the wing-to-body fairing, behind the left and the right wheel wells (refer to Figure 12–02–5).



System No. 1 and No. 2 reservoir locations
Figure 12–02–5

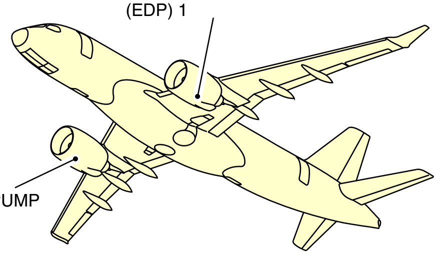
Figure 12–02–6 shows the system No. 1 and No. 2 reservoir representations on the synoptic page.



Hydraulic system No. 1 and No. 2 – Reservoirs
Figure 12–02–6

B. Hydraulic system No. 1 and No. 2 main pumps

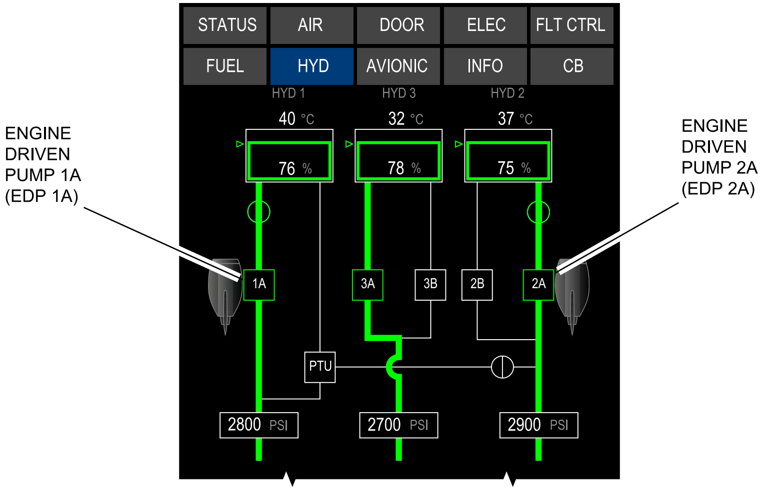
During normal conditions, the pressure in system No. 1 and No. 2 is generated by the Engine Driven Pumps (EDPs). The pumps are labelled as 1A for system No. 1 and 2A for system No. 2 (refer to Figure 12–02–7). The speed of the EDPs is driven by the related engine gearboxe of each EDP.



Hydraulic EDP 1 and EDP 2
Figure 12–02–7

The EDP draws the hydraulic fluid from the system reservoir through the SOV (refer to Figure 12–02–8). The hydraulic fluid is then pumped, filtered, and distributed to the hydraulic components. The EDP 1A and EDP 2A produce hydraulic pressure when:

- The corresponding engine N2 is above a few percent,
- The corresponding SOV is open, and
- The EDP is not depressurized.

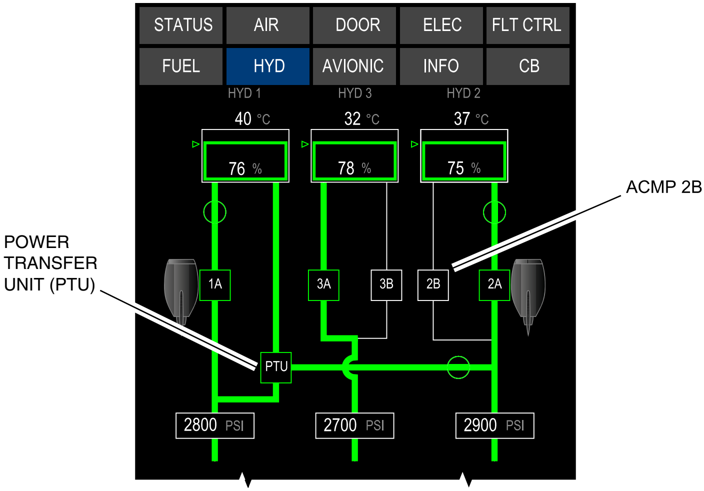


Hydraulic system No. 1 and No. 2 – Engine Driven Pump (EDP)
Figure 12–02–8

C. Hydraulic system No. 1 and No. 2 backup pumps

(1) Power Transfer Unit (PTU)

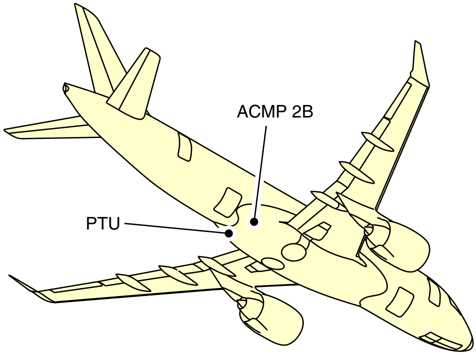
The PTU is the backup unit for system No. 1 if there is an EDP 1A failure or when high flow is required. The system No. 2 fluid pressure drives the PTU pump to deliver pressure to system No. 1 without fluid exchange. The backup unit is located in the left aft section of the wing-to-body fairing, and it is attached to the fuselage. Refer to Figure 12–02–9.



Hydraulic system No. 1 and No. 2 – Backup pumps
Figure 12–02–9

(1) AC Motor Pump (ACMP 2B)

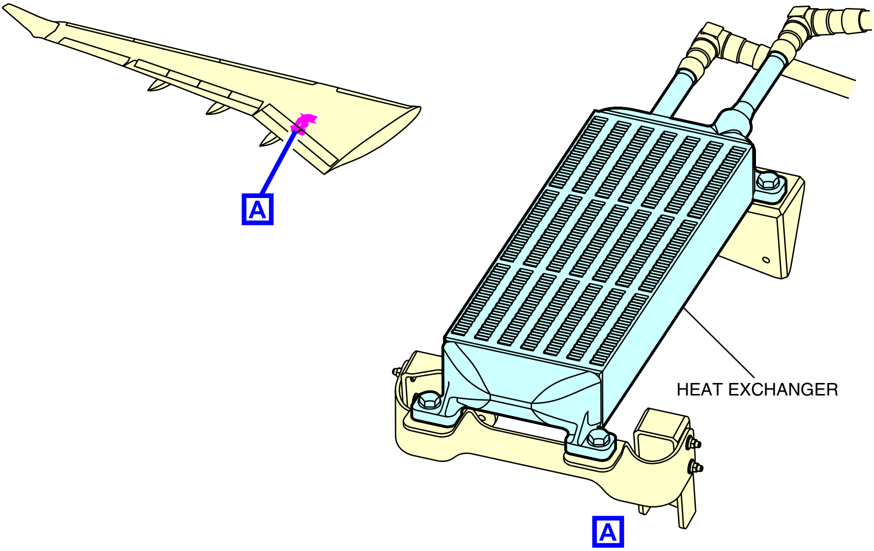
The ACMP 2B is the backup unit for system No. 2 if there is an EDP 2A failure or when high flow is required. The electrical pump uses a 115 VAC motor, powered by AC BUS 1, to deliver hydraulic pressure to system No. 2. The ACMP 2B is located in the right aft section of the wing-to-body fairing, and it is attached to the fuselage. Refer to Figure 12–02–10.



System No. 2 ACMP 2B location
Figure 12–02–10

D. Hydraulic system No. 1 and No. 2 heat exchangers

Both system No. 1 and No. 2 have a fuel/hydraulic heat exchanger that uses fuel to cool the hydraulic fluid. The heat exchangers are located in the right and left main fuel tanks. Refer to Figure 12–02–11.



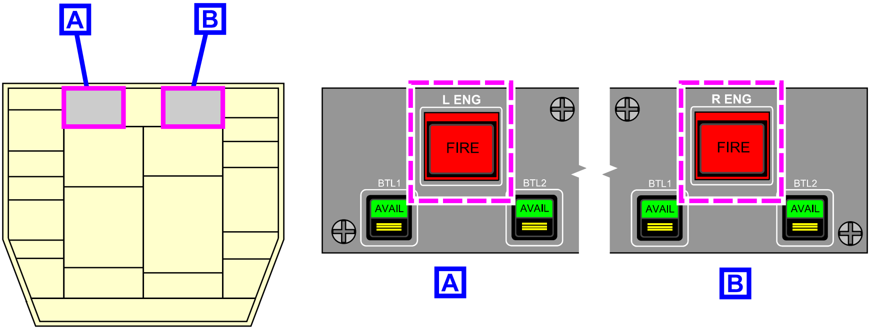
Hydraulic Systems no. 1 and no. 2 – Heat Exchangers
Figure 12–02–11

E. Hydraulic system No. 1 and No. 2 Shutoff Valves (SOVs)

Both system No. 1 and No. 2 have a SOV located in the engine pylons. The SOVs are powered by DC EMER BUS (28 VDC). The SOVs are normally in open position and let the hydraulic fluid goes to their related EDP. The SOVs stop to supply the hydraulic fluid to their EDP during the situations that follow:

1. Engine fire:

   The SOV closes when the fire extinguishing system is armed. Refer to Figure 12–02–12.



Left and right engine fire switch/light
Figure 12–02–12

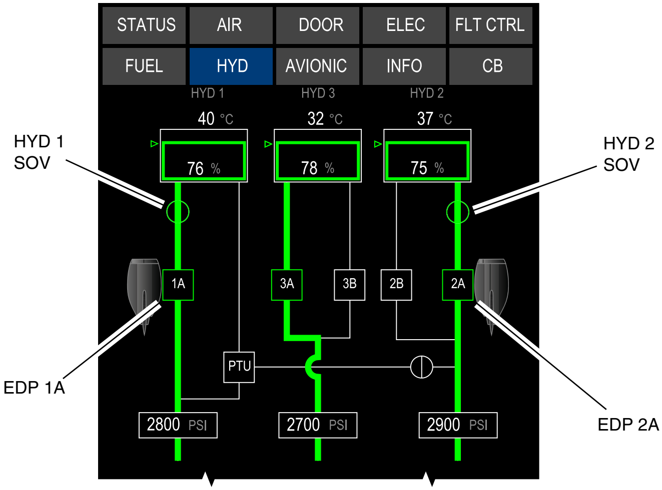
2. Hydraulic fluid overtemperature:

   The SOV closes automatically when the hydraulic fluid temperature exceeds 125 °C (257 °F).

3. Manual selection by the flight crew:

   The SOV closes manually when the flight crew presses the HYD 1 SOV and/or the HYD 2 SOV guarded switches on the HYDRAULIC panel.

Figure 12–02–13 shows the graphic representation of the SOVs on the HYD synoptic page.

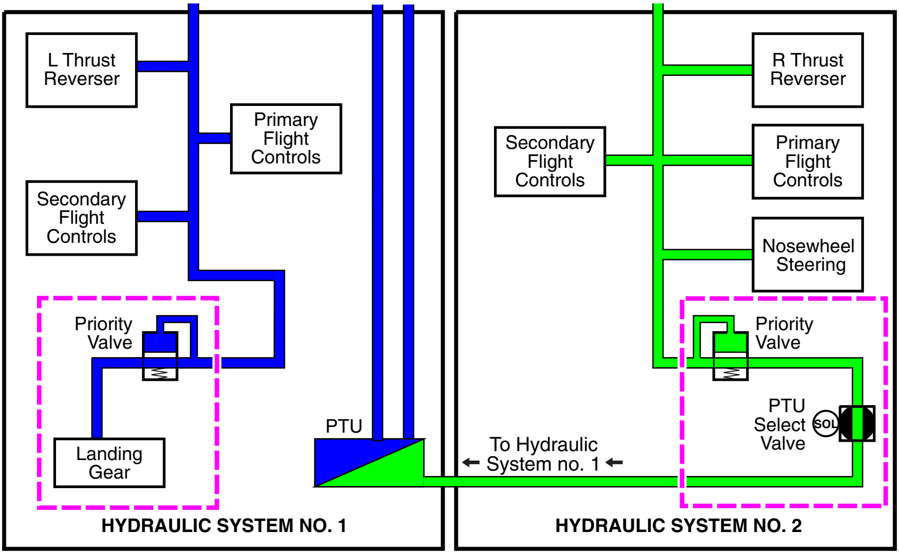


Hydraulic system No. 1 and No. 2 – Shutoff Valves (SOV)
Figure 12–02–13

F. Hydraulic system No. 1 and No. 2 Priority Valves (PVs)

Both system No. 1 and No. 2 have a PV to preserve system pressure and flow capability for higher priority users if there is a pressure drop to 1700 psi or less.

In system No. 1, the PV isolates the landing gear control valve to maintain the pressure for the flight controls and the left thrust reverser (refer to Figure 12–02–14). In this case, the landing gear can still be deployed with the ALTN GEAR switch on the landing gear panel for alternate extension.



Hydraulic Systems no. 1 and no. 2 – Priority Valves
Figure 12–02–14

In system No. 2, the PV isolates the PTU to maintain the pressure for the flight controls and the right thrust reverser.

HYDRAULIC SYSTEM NO. 3 – OVERVIEW

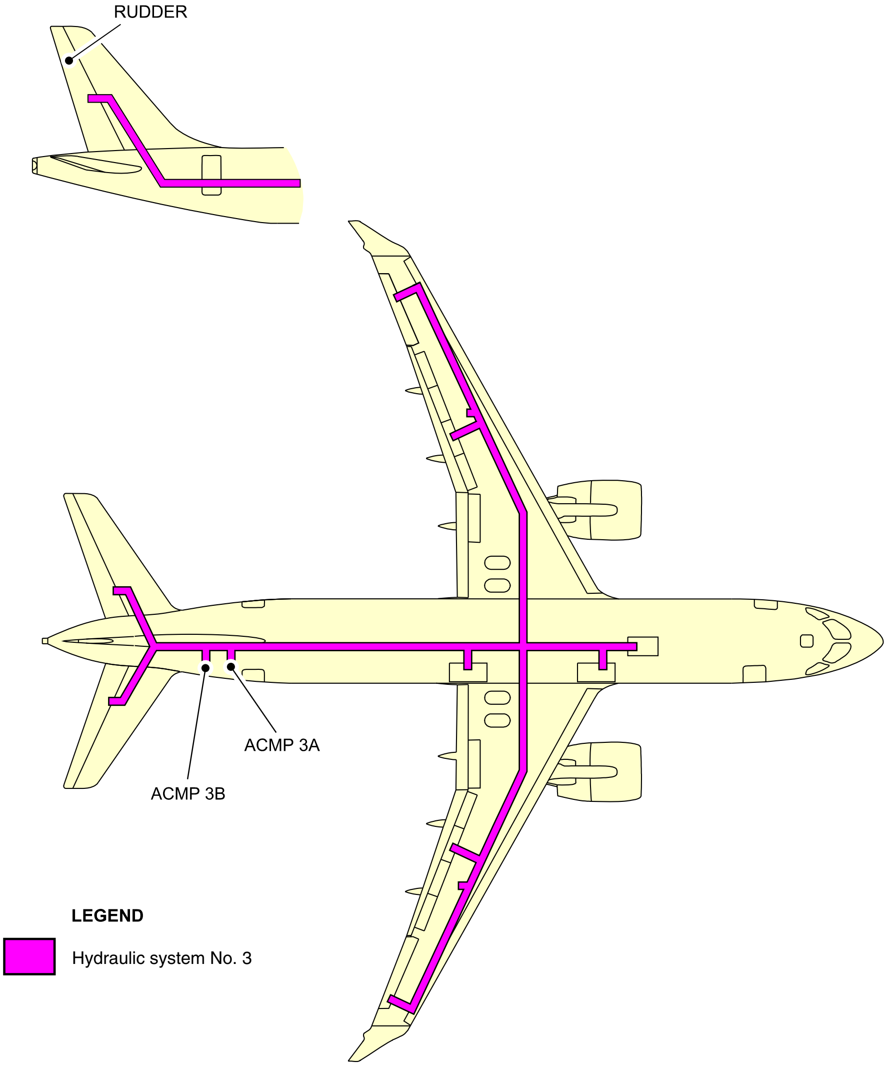
The main components of hydraulic system No. 3 are:

- The Reservoir connected with two accumulators,
- The AC Motor Pumps (ACMP 3A and ACMP 3B),
- The RAT hydraulic pump,
- The accumulators, and
- The Priority Valve (PV).

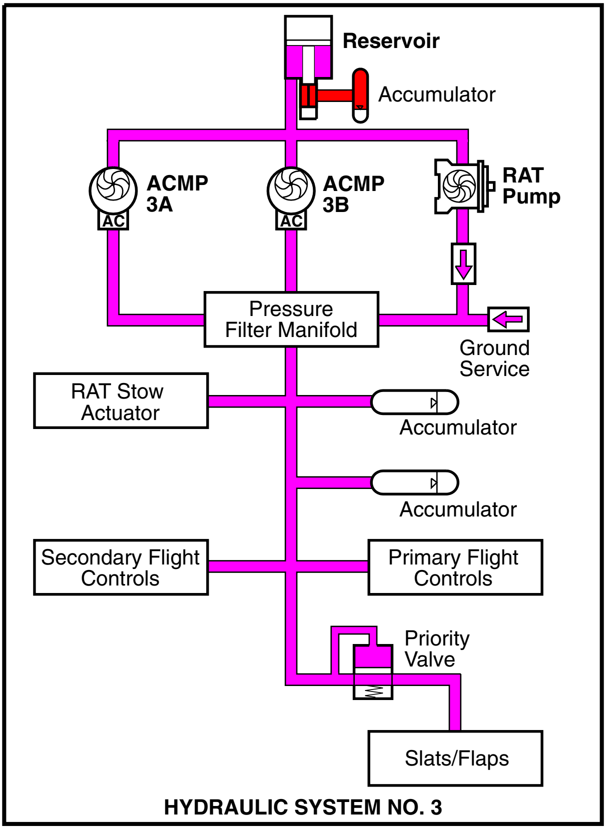
The system No. 3 hydraulic fluid is cooled by ventilation in the aft equipment bay.

Figure 12–03–1 shows the hydraulic system No. 3 main components.

Figure 12–03–2 shows the distribution schematic of system No. 3.



Hydraulic system No. 3 – Main components
Figure 12–03–1

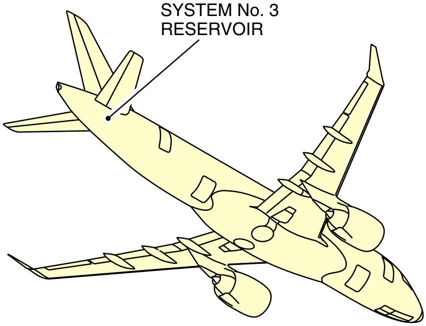


System No. 3 distribution – schematic
Figure 12–03–2

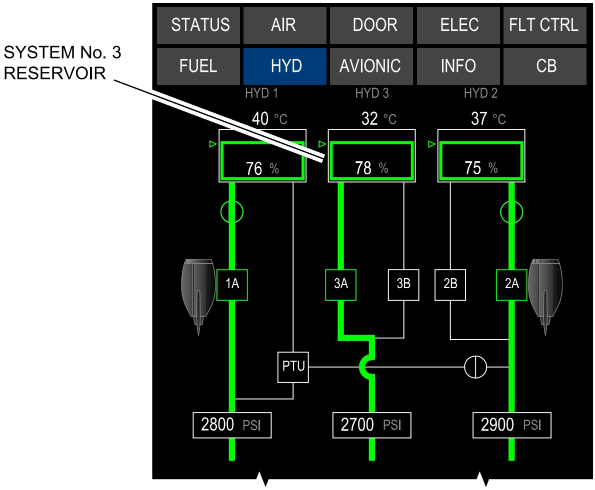
HYDRAULIC SYSTEM NO. 3 – DESCRIPTION AND OPERATION

A. Hydraulic system No. 3 reservoir

The hydraulic system No. 3 reservoir (refer to Figure 12–03–3) has the same design as the reservoirs of system No. 1 and system No. 2 but it has the smallest capacity. Accumulators pressurized with nitrogen are connected to the reservoir. The accumulator helps to supply pressure to the reservoir after the pump stops. The unit is equipped with a temperature and a quantity transducer that transmit data to the HYD synoptic page (refer to Figure 12–03–4).



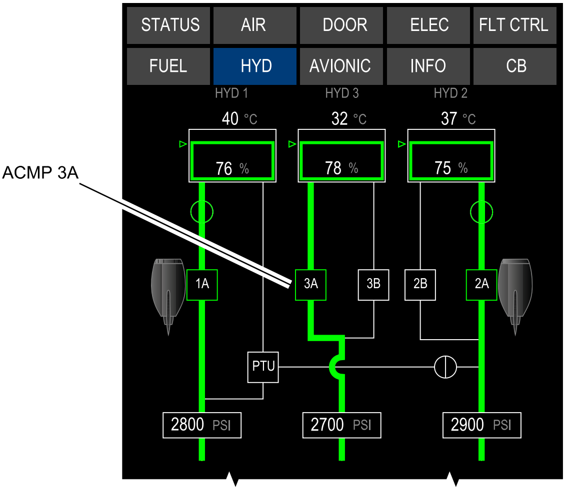
System No. 3 reservoir location
Figure 12–03–3



Hydraulic system No. 3 – Reservoir
Figure 12–03–4

B. Hydraulic system No. 3 main pump

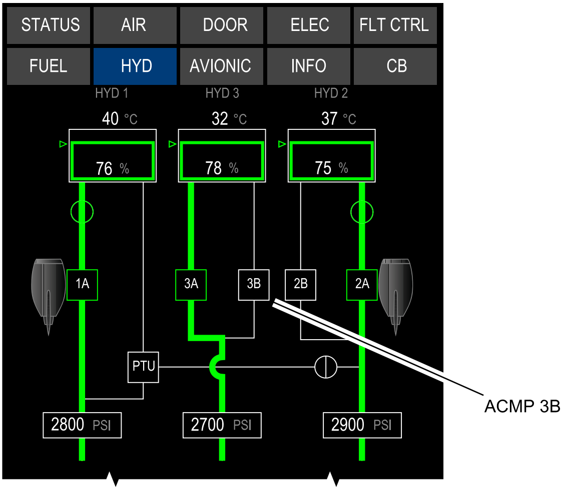
ACMP 3A is the main pump for hydraulic system No. 3 (refer to Figure 12–03–5). This electrical pump is driven by a 115 VAC motor powered by the AC BUS 2. It has the same design as ACMP 2B and ACMP 3B and are located in the aft equipment bay under the system No. 3 reservoir.



Hydraulic system No. 3 – Main pump
Figure 12–03–5

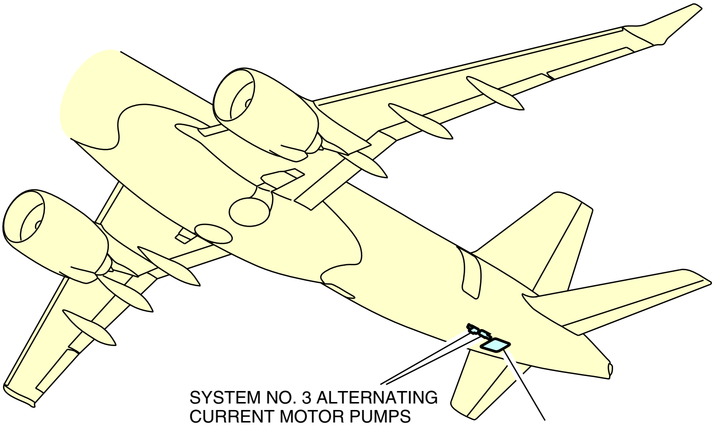
C. Hydraulic system No. 3 backup pump

ACMP 3B is used as a backup pump for system No. 3 if there is an ACMP 3A failure or when high flow is required (refer to Figure 12–03–6). The electrical pump is driven by a 115 VAC motor and powered by AC BUS 2. ACMP 3B has the same design as ACMP 2B and ACMP 3A.



Hydraulic system No. 3 – Backup pump
Figure 12–03–6

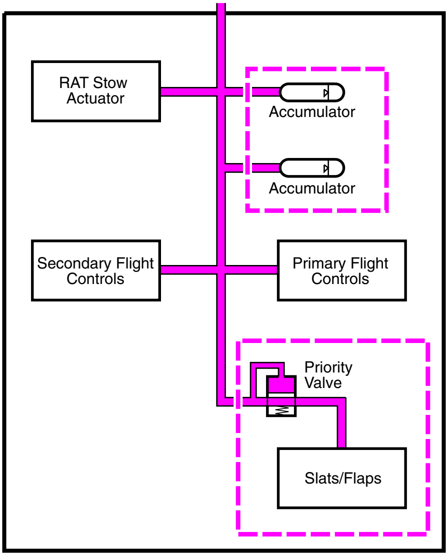
ACMP 3B is located in the aft equipment bay under the system No. 3 reservoir, next to ACMP 3A (refer to Figure 12–03–7).



System No. 3 Alternating Current Motor Pumps (ACMPs)
Figure 12–03–7

D. Hydraulic system No. 3 Priority Valve (PV)

System No. 3 includes a PV to preserve system pressure and flow capability for higher priority users if there is a pressure drop in the system. In system No. 3, the PV isolates the flap and slat Power Drive Units (PDUs) to maintain the pressure for the flight controls. Refer to Figure 12–03–8.



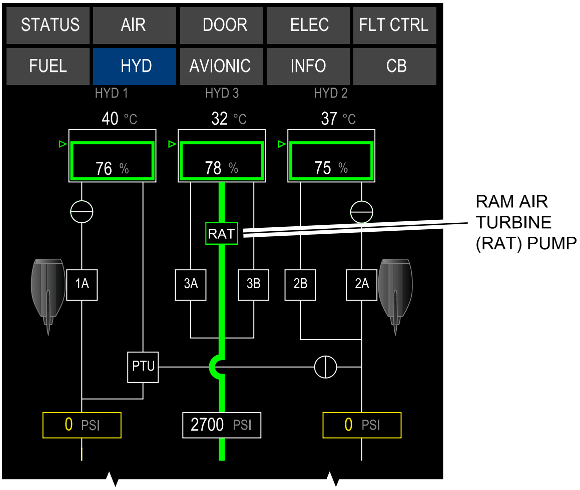
Hydraulic System no. 3 – Accumulators and Priority Valve
Figure 12–03–8

E. Hydraulic system No. 3 accumulators

System No. 3 is equipped with two accumulators. Their function is to maintain the pressure for system No. 3 during RAT deployment and to dampen pressure transience during rapid movement of the hydraulic components.

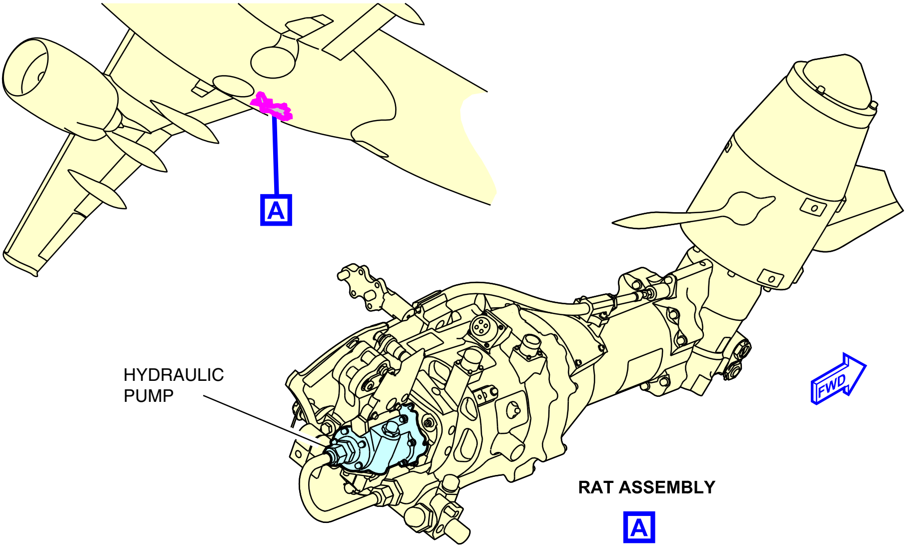
F. Hydraulic system No. 3 Ram Air Turbine (RAT) pump

The RAT will deploy and provide backup hydraulic pressure to system No. 3 automatically if there is a total loss of AC power in flight. It can also be manually deployed when the flight crew presses the RAT GEN guarded switch on the ELECTRICAL panel. A status representation of the RAT is displayed on the HYD synoptic page (refer to Figure 12–03–9).



Hydraulic system No. 3 – Ram Air Turbine (RAT) pump
Figure 12–03–9

The RAT pump is operational when the RAT is fully extended (automatically or manually). During the deployment period, system No. 3 accumulators deliver the hydraulic pressure. When the RAT is deployed, the hydraulic pump operates at a nominal hydraulic pressure of 2850 psi and supplies hydraulic pressure to the primary flight controls for all phases of flight. The RAT pump is stowed in the RAT compartment between the main landing gear (as shown in Figure 12–03–10).



RAT hydraulic pump location
Figure 12–03–10

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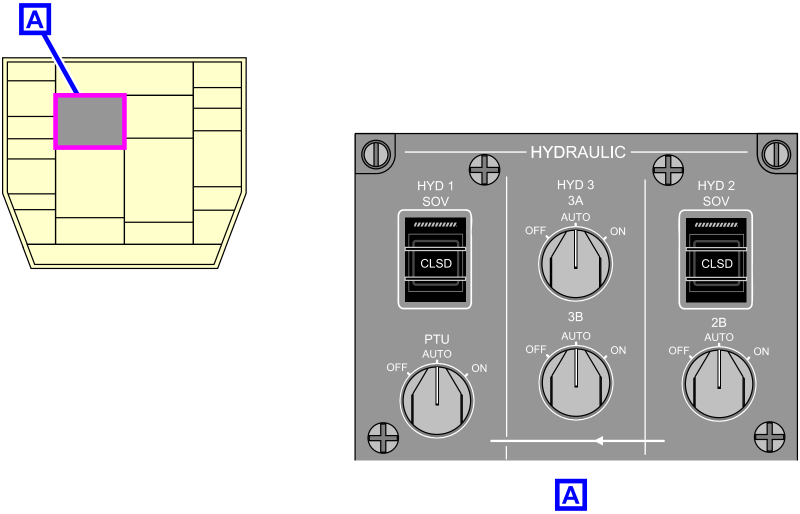
HYDRAULIC – CONTROLS

A. HYDRAULIC panel and ELECTRICAL panel

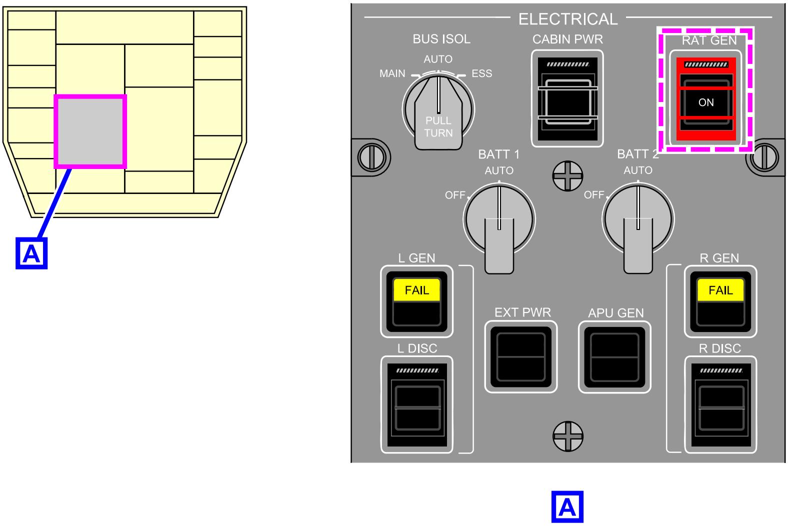
The HYDRAULIC panel (refer to Figure 12–04–1) is located on the overhead panel, and contains the switches that follow:

- PTU (Power Transfer Unit) switch,
- ACMP 2B switch,
- ACMP 3A switch,
- ACMP 3B switch, and
- HYD 1 SOV and HYD 2 SOV guarded switches.

The ELECTRICAL panel (refer to Figure 12–04–2) is located on the overhead panel, and contains the RAT GEN switch.



HYDRAULIC panel
Figure 12–04–1



ELECTRICAL panel – RAT GEN guarded switch
Figure 12–04–2

B. HYDRAULIC panel – PTU (Power Transfer Unit) switch

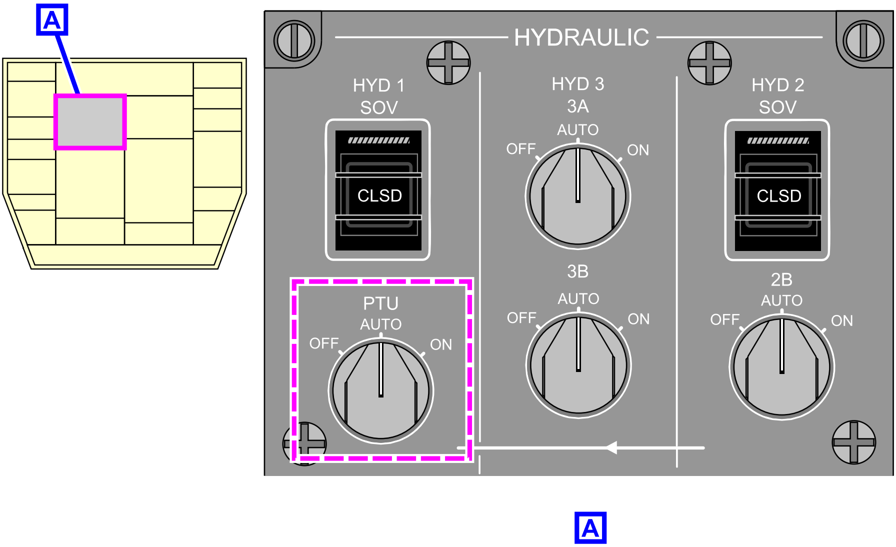
The PTU switch (refer to Figure 12–04–3) has three positions:

- OFF: The PTU does not operate and does not produce pressure.
- ON: The PTU operates and produces pressure to system No. 1 if:
  - System No. 2 is pressurized, and
  - System No. 1 has enough fluid quantity (more than 5%).
- AUTO: When there is no overtemperature condition (less than 107 °C), system No. 2 is pressurized, and system No. 1 has enough fluid quantity (more than 5%), the PTU will operate automatically when one of the conditions that follow occurs:
  - Takeoff thrust is applied,
  - The aircraft is in flight, and slats/flaps are deployed (F4 (landing) or F5 selected) or the ALT/FLAP switch is selected,

- Engine Driven Pump 1A (EDP 1A) has failed,
- Left engine has failed when the aircraft is in flight, or
- Single engine taxi (right engine only), when park brake is set to OFF.

NOTE

When the parking cycles OFF – ON – OFF, with the PTU and ACPM 2B rotary switch in AUTO position, the PTU and the ACMP 2B will run for 6 minutes.



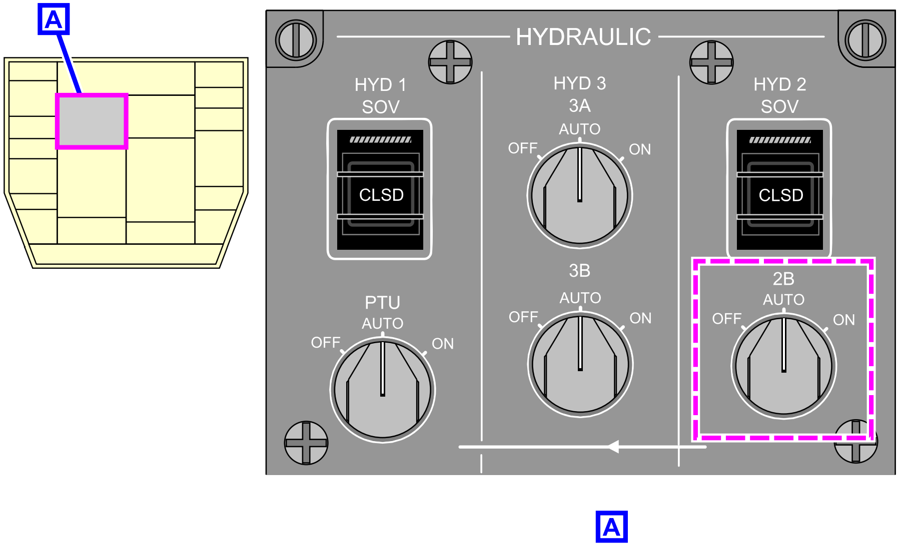
HYDRAULIC panel – PTU switch
Figure 12–04–3

C. HYDRAULIC panel – ACMP 2B switch

The ACMP 2B switch (refer to Figure 12–04–4) has three positions:

- OFF: The electrical pump does not operate and does not produce pressure.

- ON: The electrical pump operates and produces pressure if AC power is available, and fluid quantity is greater than 5%.
- AUTO: When there is no overtemperature condition, AC power is available, and system No. 2 has enough fluid quantity (more than 5%), the ACMP 2B will operate automatically if one of the following conditions occurs:
  - Takeoff thrust is applied,
  - The aircraft is in flight and flaps/slats are deployed (F4 (landing) or F5 selected) or ALT FLAP switch is selected,
  - EDP 2A has failed,
  - Right engine has failed when aircraft is in flight,
  - The PTU switch has been selected ON,
  - The parking brake is set to OFF during the single (left) engine taxiing, or
  - EDP 1A fail or left engine fail.

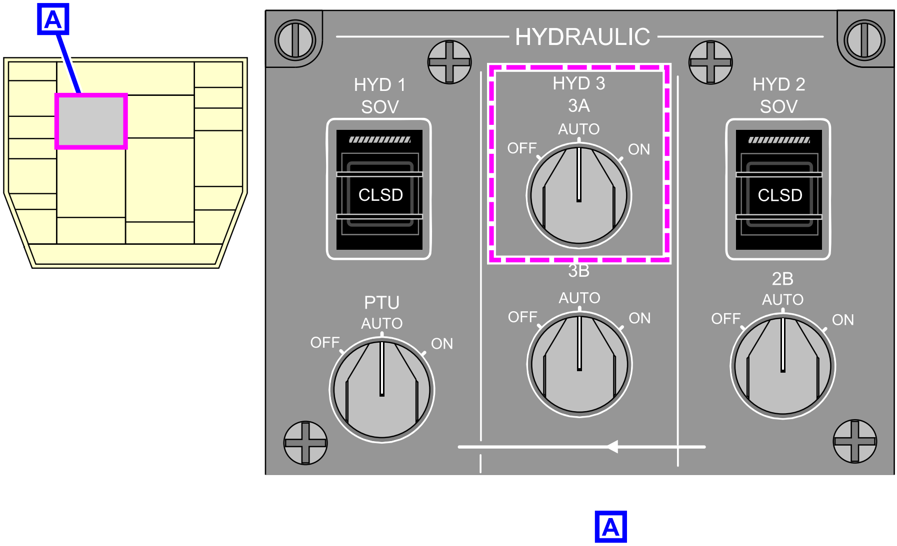


HYDRAULIC panel – ACMP 2B switch
Figure 12–04–4

D. HYDRAULIC panel – ACMP 3A switch

The ACMP 3A switch (refer to Figure 12–04–5) has three positions:

- OFF: The electrical pump will not operate and will not produce pressure.
- ON: The electrical pump operates and produces pressure to system No. 3 if AC power is available.
- AUTO: With no overtemperature condition, AC power available, enough fluid quantity (more than 5%), and less pressure than 3350 psi in system No. 3, the ACMP 3A will operate automatically when either the left or right engine has started or when the aircraft is airborne.



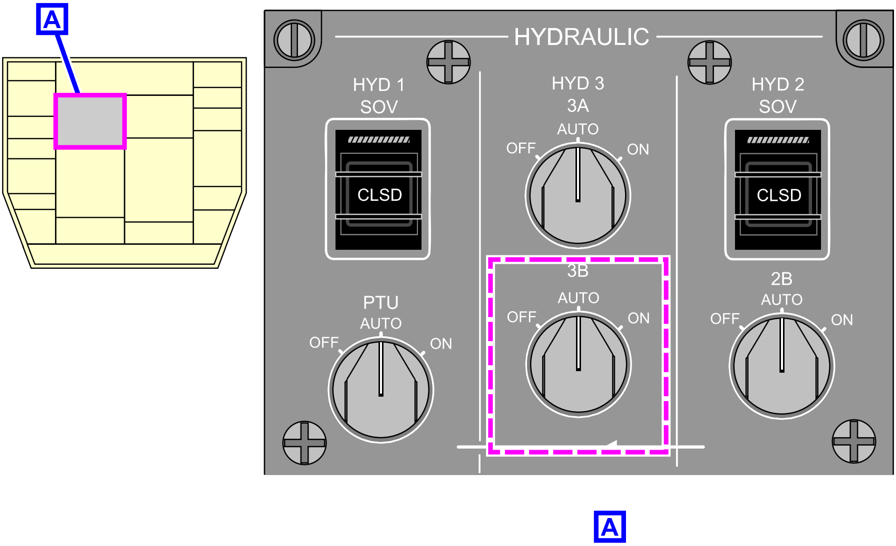
HYDRAULIC panel – ACMP 3A switch
Figure 12–04–5

E. HYDRAULIC panel – ACMP 3B switch

The ACMP 3B switch (refer to Figure 12–04–6) has three positions:

- OFF: The electrical pump does not operate and does not produce pressure.
- ON: The electrical pump operates and produces pressure to system No. 3 if AC power is available.
- AUTO: With no overtemperature condition, AC power available, enough fluid quantity (more than 5%) in system No. 3, the ACMP 3B will operate automatically if one of the conditions that follow occurs:
  - Takeoff thrust is applied,
  - The flaps/slats are deployed (on ground), or
  - The flaps/slats handle is out of zero (in flight), or

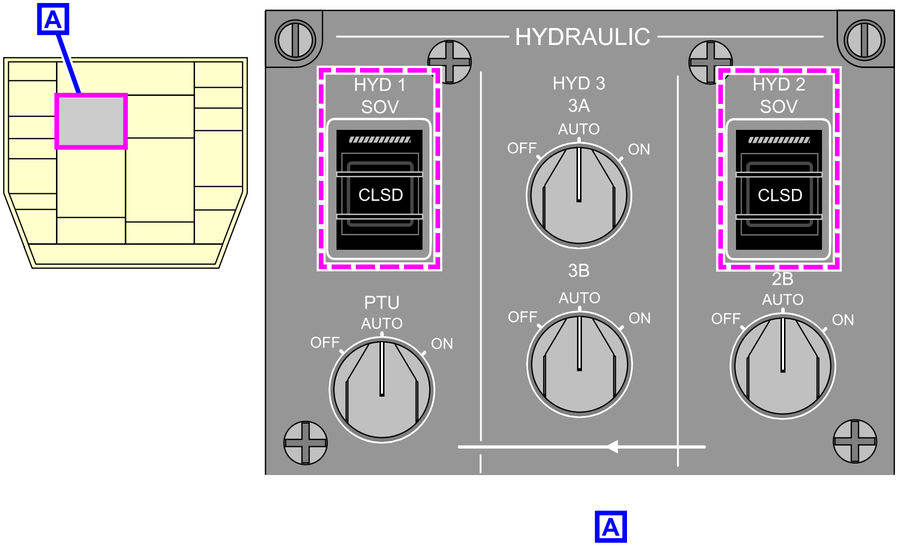
- ACMP 3A has failed.



HYDRAULIC panel – ACMP 3B switch
Figure 12–04–6

F. HYDRAULIC panel – HYD 1 SOV and HYD 2 SOV guarded switches

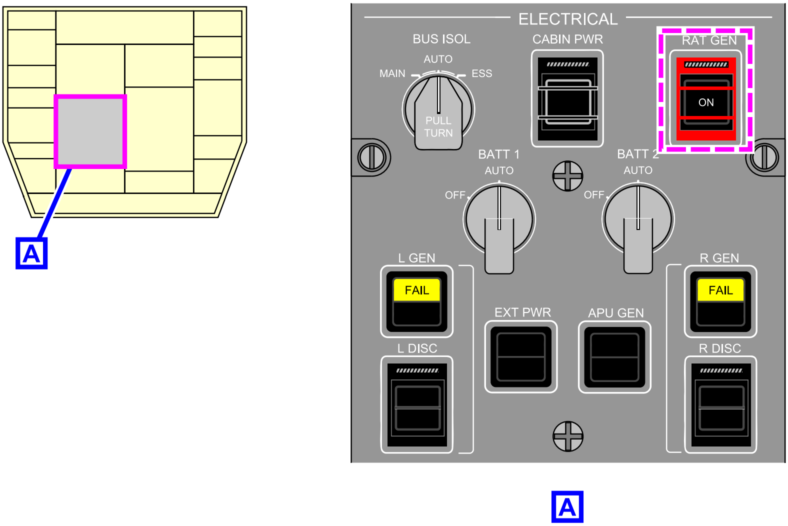
There are two guarded Shutoff Valve (SOV) switches: HYD 1 SOV guarded switch for system No. 1 and HYD 2 SOV guarded switch for system No. 2 (refer to Figure 12–04–7). When either switch is pressed, the hydraulic fluid supply to the respective EDP is shut off.



SOV switches
Figure 12–04–7

G. ELECTRICAL panel – RAT GEN guarded switch

The RAT hydraulic pump operates and produces hydraulic pressure whenever the RAT is deployed in flight. The RAT deploys automatically when all the AC busses lose power in flight. The RAT can be deployed manually when the RAT GEN guarded switch, located on the ELECTRICAL panel, is pressed (refer to Figure 12–04–8).



ELECTRICAL panel – RAT GEN guarded switch
Figure 12–04–8

HYD (HYDRAULIC) SYNOPTIC PAGE

The HYD (Hydraulic) synoptic page shows the system operations and status (Figure 12–04–9). It displays the data that follows:

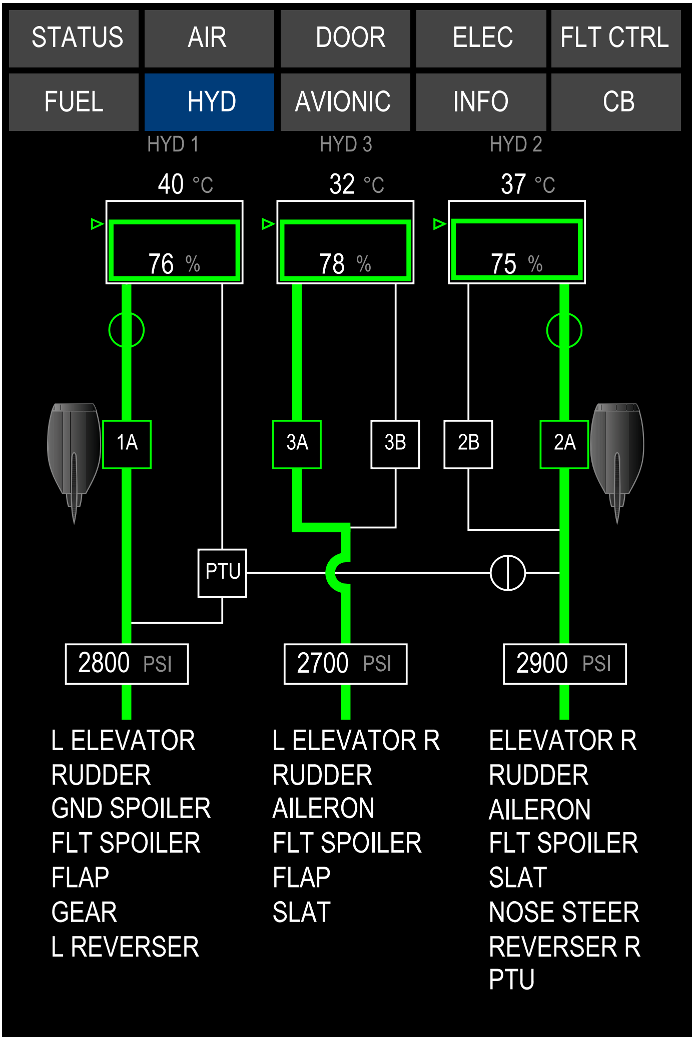
- Reservoir quantities,
- Hydraulic fluid temperature,
- SOV positions,
- EDP status,
- ACMP status,
- Systems pressure, and
- Hydraulic components status.

Figure 12–04–10 shows the HYD synoptic page when the RAT is deployed.

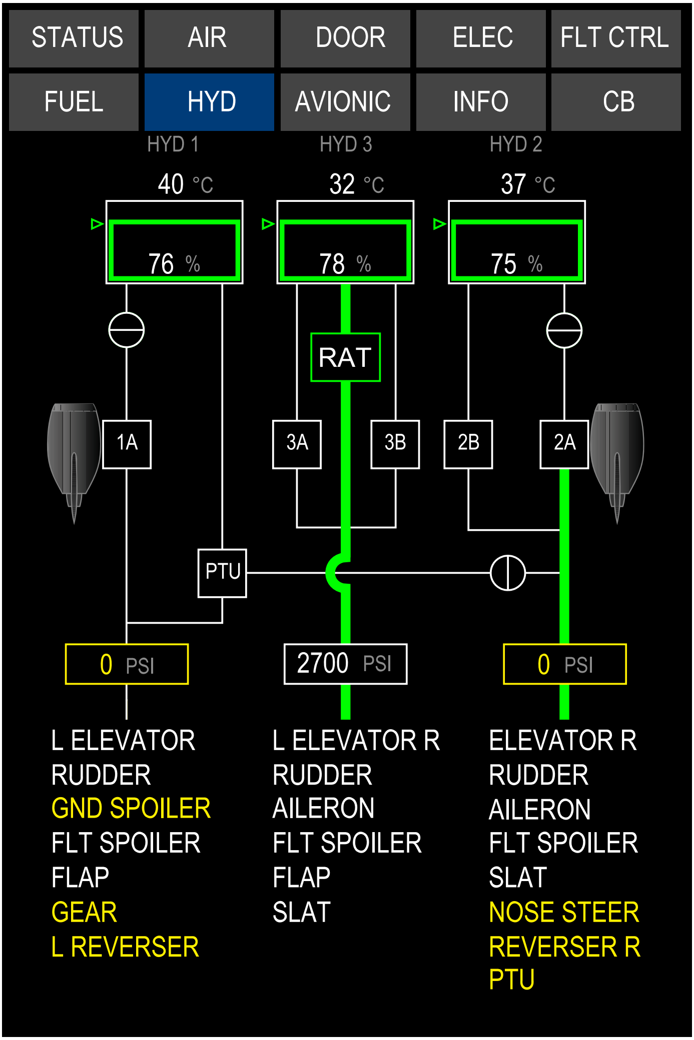
Figure 12–04–11 shows the HYD synoptic page when the PTU is operational.

Figure 12–04–12 shows the description of each item in the HYD synoptic page.

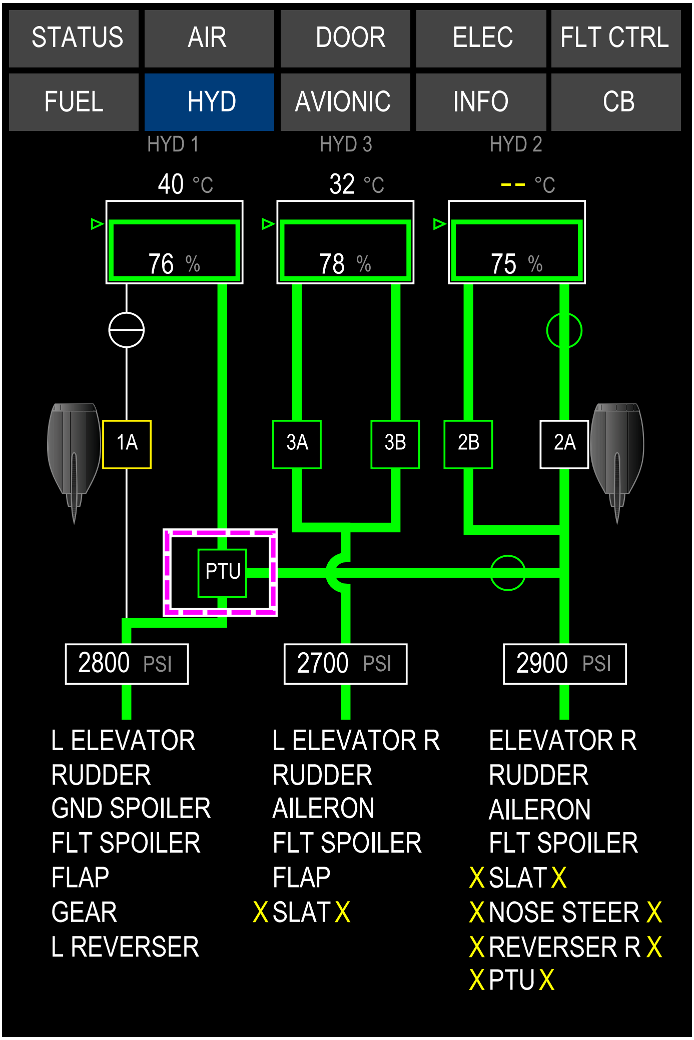
Figure 12–04–13 shows the legend of the HYD synoptic page.



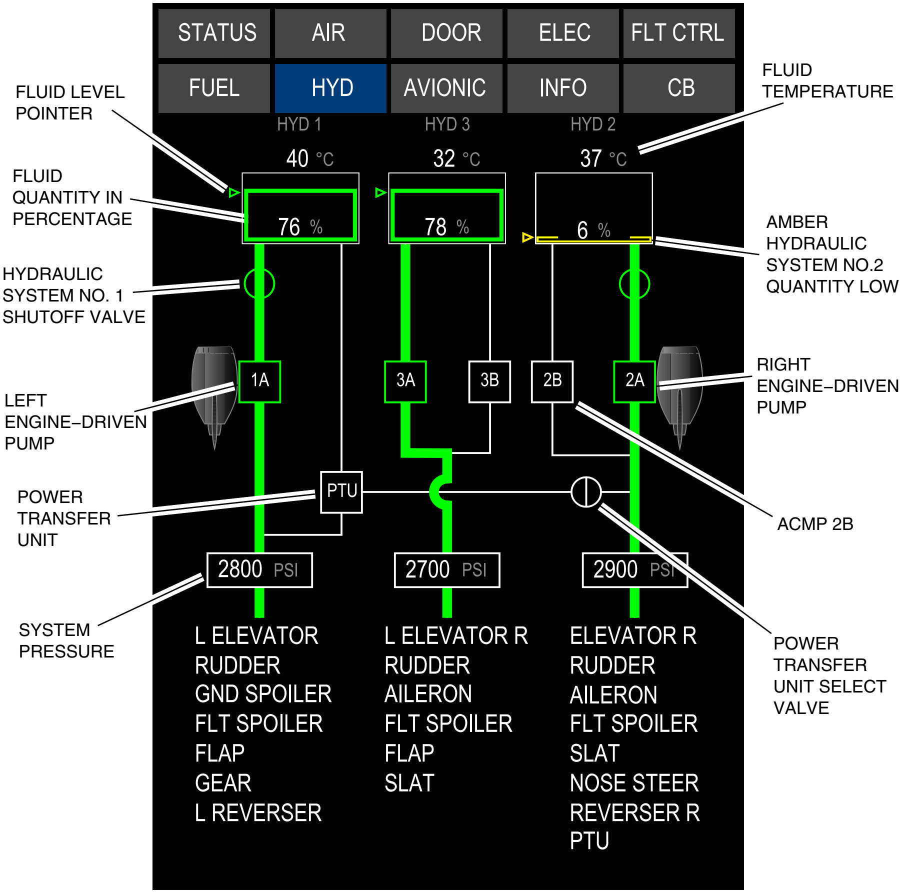
HYD synoptic page – Normal operation
Figure 12–04–9



HYD synoptic page – RAT deployed
Figure 12–04–10



HYD synoptic page – PTU operational
Figure 12–04–11



Hydraulic synoptic page
Figure 12–04–12

VALVE POSITION NORMAL OPERATION	
Symbol	**Condition**
	Close
	Open
	In Transition
	Invalid

VALVE POSITION FAIL OPERATION	
Symbol	**Condition**
	Close
	Open
	In Transition

FLOW LINES	
Symbol	**Condition**
	Normal Flow
	Low or No flow
----	Invalid

QUANTITY	
Symbol	**Condition**
76 %	Normal
6 %	Low
--- %	Invalid

PUMPS	
Symbol	**Condition**
1A	Fail
3B	On
3A	Off
2B	Invalid

USERS	
Symbol	**Condition**
ELEVATOR	Pressure
GND SPOILER	No Pressure
X R REVERSER X	Invalid

TEMPERATURE	
Symbol	**Condition**
107 °C	Hi Temp
40 °C	Normal
-- °C	Invalid

PRESSURE	
Symbol	**Condition**
0 PSI	CAS LO PRESS
2100 PSI	Normal
---- PSI	Invalid

HYD synoptic page legend
Figure 12–04–13

HYDRAULIC – EICAS MESSAGES

A. Warning messages

None

B. Caution messages

Message	Description	Inhibit
HYD 1 HI TEMP	The system No. 1 reservoir temperature is greater than 107 °C (225 °F) or 30 seconds after temperature switch indicates high temperature.	TO, LDG.
HYD 2 HI TEMP	The system No. 2 reservoir temperature is greater than 107 °C (225 °F) or 30 seconds after the reservoir temperature switch indicates high temperature.	TO, LDG
HYD 3 HI TEMP	The system No. 3 reservoir temperature is greater than 107 °C (225 °F) or 30 seconds after the reservoir temperature switch indicates high temperature.	TO, LDG
HYD 1 LO PRESS	Low pressure is detected in system No. 1 by: • Engine Driven Pump (EDP 1A) pressure switch, • Power Transfer Unit (PTU) pressure switch, or • System No. 1 pressure transducer.	TO, LDG
HYD 2 LO PRESS	Low pressure is detected in system No. 2 by: • EDP 2A pressure switch, • ACMP 2B pressure switch, or • System No. 2 pressure transducer.	TO, LDG
HYD 3 LO PRESS	Low pressure is detected in system No. 3 by either ACMP 3A and/or ACMP 3B pressure switches or by system No. 3 pressure transducer.	TO, LDG

Message	Description	Inhibit
HYD 1-2 LO PRESS	Low pressure detected in system No. 1 and system No. 2.	TO, LDG
HYD 1-3 LO PRESS	Low pressure detected in system No. 1 and system No. 3.	TO, LDG
HYD 2-3 LO PRESS	Low pressure detected in system No. 2 and No. 3.	TO, LDG
HYD 1 SOV FAIL	System No. 1 Shutoff Valve (SOV) failed to close when commanded or open when supposed to be closed automatically.	TO, LDG
HYD 2 SOV FAIL	System No. 2 SOV failed to close when commanded or open when supposed to be closed automatically	TO, LDG
HYD EDP 1A FAIL	Low pressure in system No. 1 when system No. 1 SOV is open.	TO, LDG
HYD EDP 2A FAIL	Low pressure in system No. 2 when system No. 2 SOV is open.	TO, LDG
HYD PTU FAIL	PTU low pressure detected when PTU commanded to be online.	TO, LDG
HYD PUMP 2B FAIL	ACMP 2B low pressure detected when commanded to be online.	TO, LDG
HYD PUMP 3A FAIL	ACMP 3A low pressure detected when commanded to be online.	TO, LDG
HYD PUMP 3B FAIL	ACMP 3B low pressure detected when commanded to be online.	TO, LDG
HYD RAT PUMP FAIL	Ram Air Turbine (RAT) is deployed and system No. 3 pressure is less than 1800 psi.	TO, LDG

C. Advisory messages

Message	Description	Inhibit
HYD 1 LO QTY	Aircraft on ground: Reservoir quantity less than 18%. Aircraft in flight: Reservoir quantity less than 13%.	TO, LDG
HYD 2 LO QTY	Aircraft on ground: Reservoir quantity less than 16%. Aircraft in flight: Reservoir quantity less than 13%.	TO, LDG
HYD 3 LO QTY	Aircraft on ground: Reservoir quantity less than 14%. Aircraft in flight: Reservoir quantity less than 11%.	TO, LDG
HYD 1 SOV CLSD	System No. 1 SOV is automatically closed by the L ENG switch on the firex panel or by the overheat relay.	TO, LDG
HYD 2 SOV CLSD	System No. 2 SOV is automatically closed by the R ENG switch on the firex panel or by the overheat relay.	TO, LDG
HYDRAULIC FAULT	Loss of non-critical functions or loss of redundancy in the hydraulic systems.	TO, LDG

D. Status messages

Message	Description	Inhibit
HYD 1 SOV CLSD	System No. 1 SOV manually closed by the HYD 1 SOV guarded switch on the HYDRAULIC panel.	None
HYD 2 SOV CLSD	System No. 2 SOV manually closed by the HYD 2 SOV guarded switch on the HYDRAULIC panel.	None

Message	Description	Inhibit
HYD PTU OFF	PTU manually selected OFF.	None
HYD PTU ON	PTU manually selected ON.	None
HYD PUMP 2B OFF	ACMP 2B manually selected OFF.	None
HYD PUMP 2B ON	ACMP 2B manually selected ON.	None
HYD PUMP 3A OFF	ACMP 3A selected OFF.	None
HYD PUMP 3A ON	ACMP 3A selected ON.	None
HYD PUMP 3B OFF	ACMP 3B selected OFF.	None
HYD PUMP 3B ON	ACMP 3B selected ON.	None

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CHAPTER 13 – ICE AND RAIN PROTECTION

List of figures

GENERAL

ICE DETECTION SYSTEM

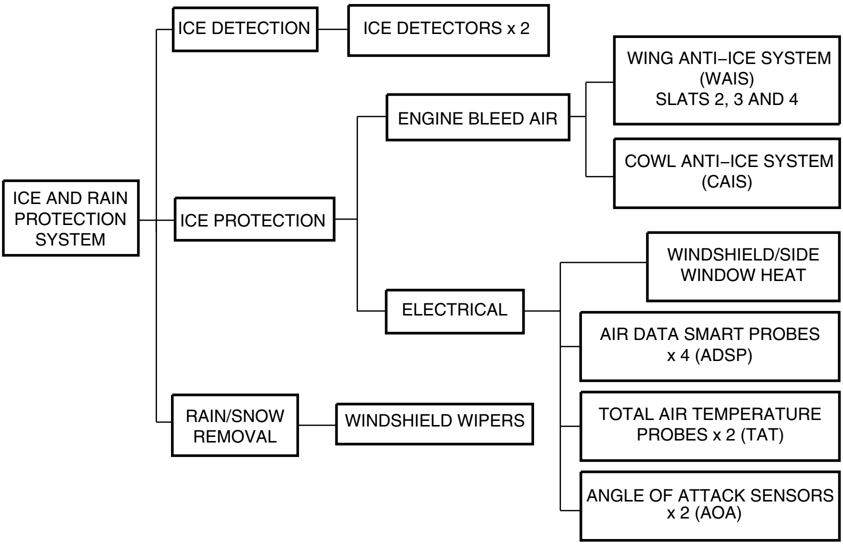
WING ANTI–ICE SYSTEM (WAIS)

COWL ANTI–ICE SYSTEM (CAIS)

ICE AND RAIN PROTECTION SYSTEM – OVERVIEW

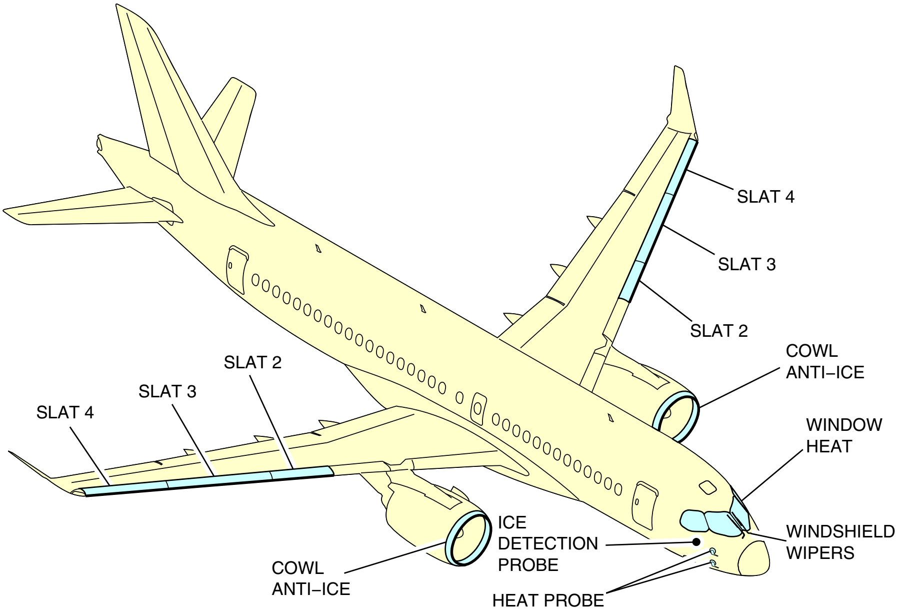
Ice and rain protection (refer to Figure 13–01–1) is provided for the:

- Wing leading edges (slats 2, 3, and 4),
- Engine cowls,
- Flight deck windshields/side windows, and
- Air Data System (ADS) probes and sensors.



Ice and rain protection system (schematic)
Figure 13–01–1

Bleed air from the 4th and 6th stage compressor provides anti-icing for the wing leading edges and engine cowls. Electrical power is used for anti-icing of the flight deck windshield and side windows, and ADS probes and sensors. The flight deck windshields are equipped with wipers for rain or snow removal (refer to Figure 13–01–2)



Ice and rain protection
Figure 13–01–2

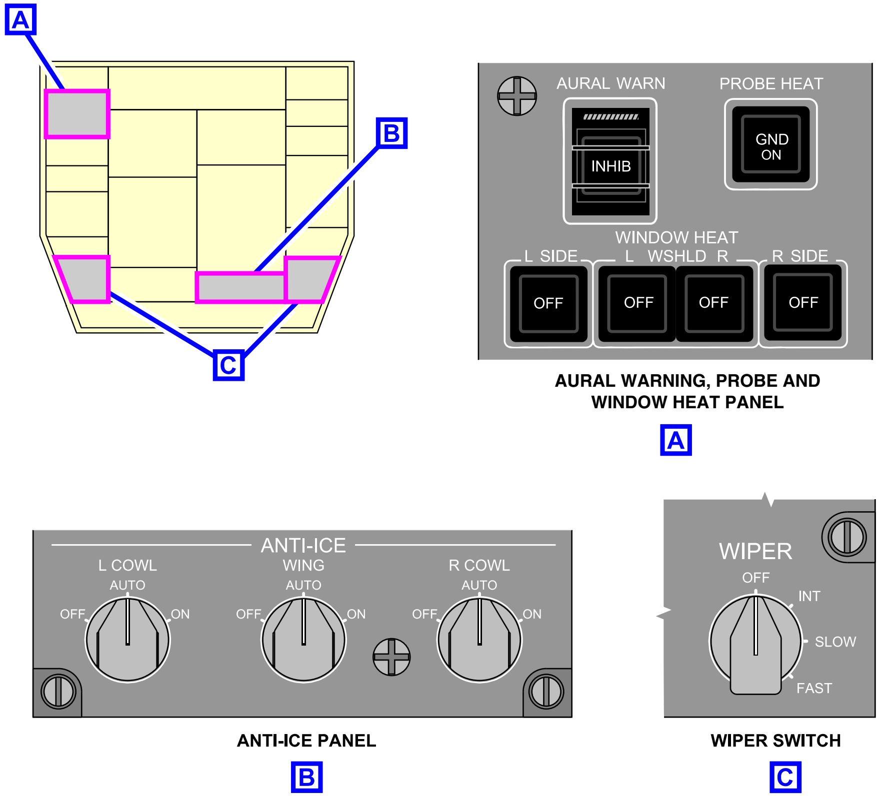
An automatic ice detection system provides icing condition status to the Integrated Air System Controllers (IASCs), and the Full Authority Digital Engine Control (FADEC).

NOTE

The leading edge, inboard, and outboard slats of the engine do not require anti-ice. Ice accumulation is not considered significant in these areas, even in adverse icing conditions. For the same reason, there is no anti-icing on the vertical and horizontal stabilizers.

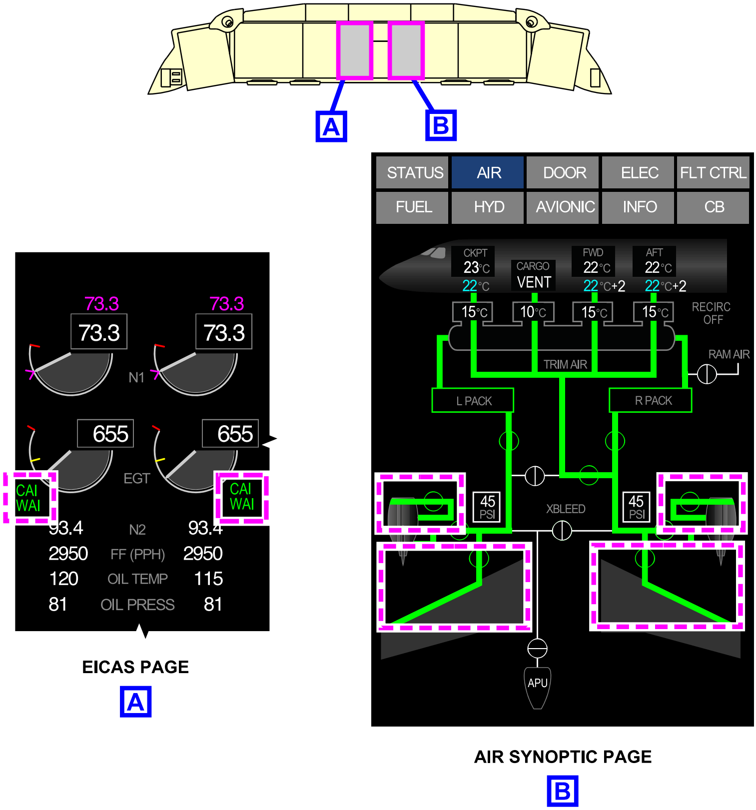
System controls are located on the panels (refer to Figure 13–01–3) that follow:

- ANTI-ICE panel,
- Aural Warning, Probe and Window Heat panel, and
- WIPER switches.



Ice and rain protection system controls
Figure 13–01–3

System status and fault messages are reported on the EICAS page. The Wing Anti-Ice System (WAIS) and Cowl Anti-Ice System (CAIS) operation is reported on the AIR synoptic page.



Ice and rain protection system indications
Figure 13–01–4

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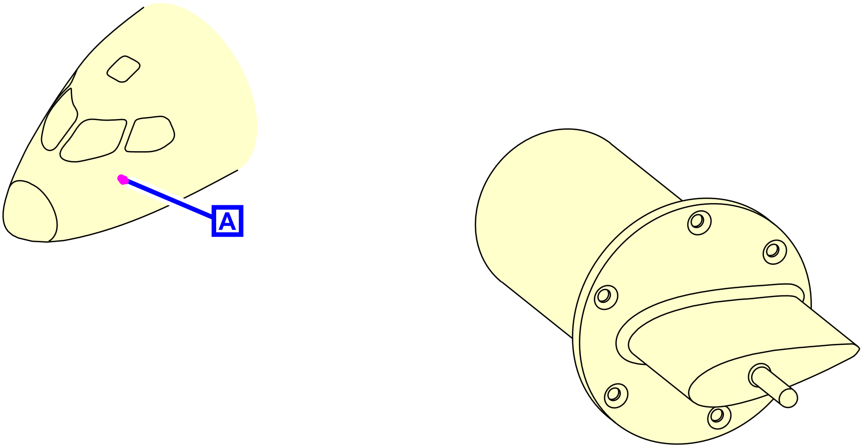
ICE DETECTION SYSTEM – OVERVIEW

The ice detection system alerts the flight crew when in icing conditions. Two ice detectors, one mounted on each side of the forward fuselage, provide independent detection of icing conditions. When anti-ice is selected to ON or AUTO, if either ice detector senses ice accumulation, a signal is sent to the Integrated Air System Controller (IASC) to open the wing anti-ice valves and to the Electronic Engine Control (EEC) to open the cowl anti-ice valves. A signal is also sent to the Fly-By-Wire (FBW) system to adjust the stall warning parameters. Ice detection system status and fault messages are reported on the EICAS page. Refer to Figure 13–02–1.



NOTE

Left ice detector shown. Right ice detector similar.

ICE DETECTOR
A

Ice detection system
Figure 13–02–1

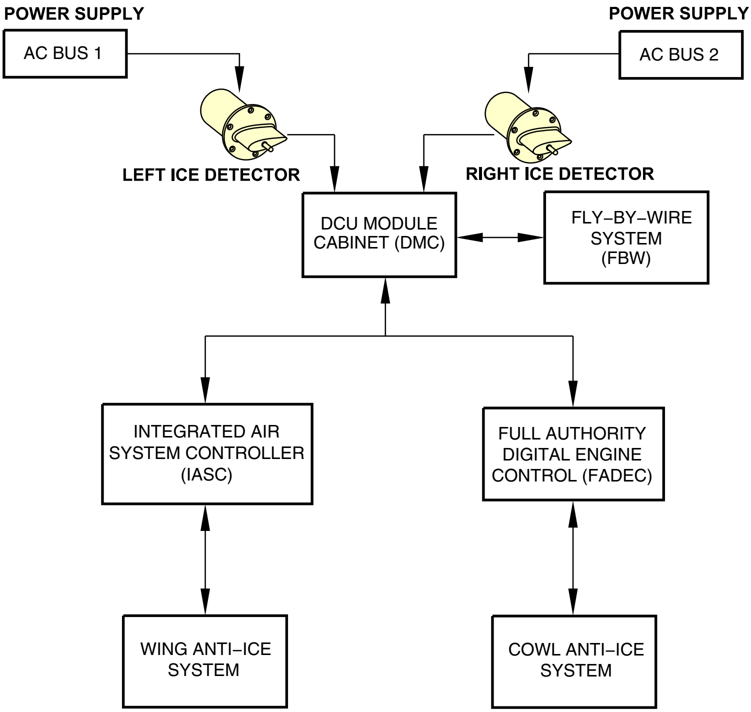
ICE DETECTION SYSTEM – OPERATION

A. Operation

The sensing element in the ice detector probe is an electrical oscillator that vibrates at a specific frequency. The presence of ice on the sensing element is detected by a change in the vibration frequency of the oscillator. When ice is detected, the sensing element momentarily heats up to de-ice.

The ice detector will continue to indicate icing conditions for one minute after they are detected. The anti-ice system will then remain on for an additional two minutes, to limit the system from cycling on and off in intermittent icing conditions.

Figure 13–02–2 shows an overview of the ice detection system operation.



Ice detection operation
Figure 13–02–2

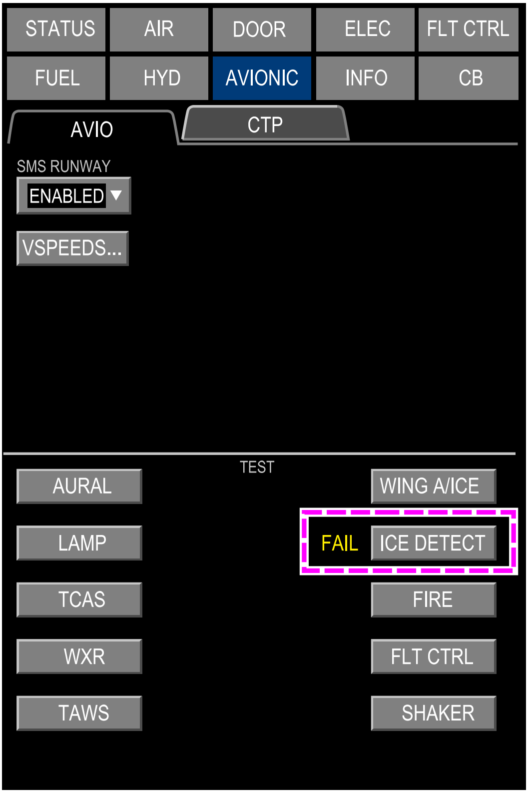
B. Ice detection system test

The flight crew can test the ice detection system through the ICE DETECT soft switch on the AVIONIC synoptic page using the Cursor Control Panel (CCP). When ICE DETECT soft switch is selected, during all the test, an IN PROG message displays on the AVIONIC synoptic page and the caution message **ICE** is displayed on the EICAS page at the same time.

Upon completion of the test, if no fault is detected, a white DONE message displays.

If a fault is detected, an amber FAIL message displays on the AVIONIC synoptic page, and a **L ICE DET FAIL** and/or **R ICE DET FAIL** caution messages displays on the EICAS page.

Figure 13–02–3 shows the ice detection system test function.



AVIONIC SYNOPTIC PAGE

EICAS CAUTION MESSAGES

Ice detector test
Figure 13–02–3

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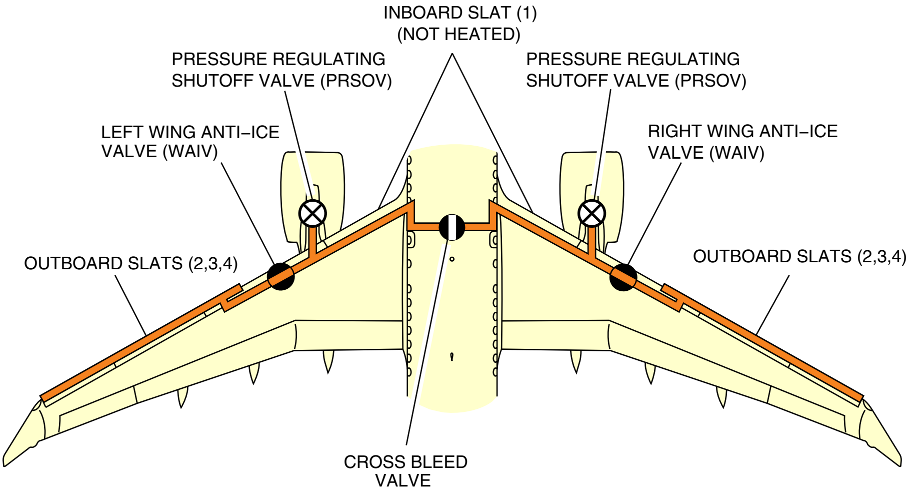
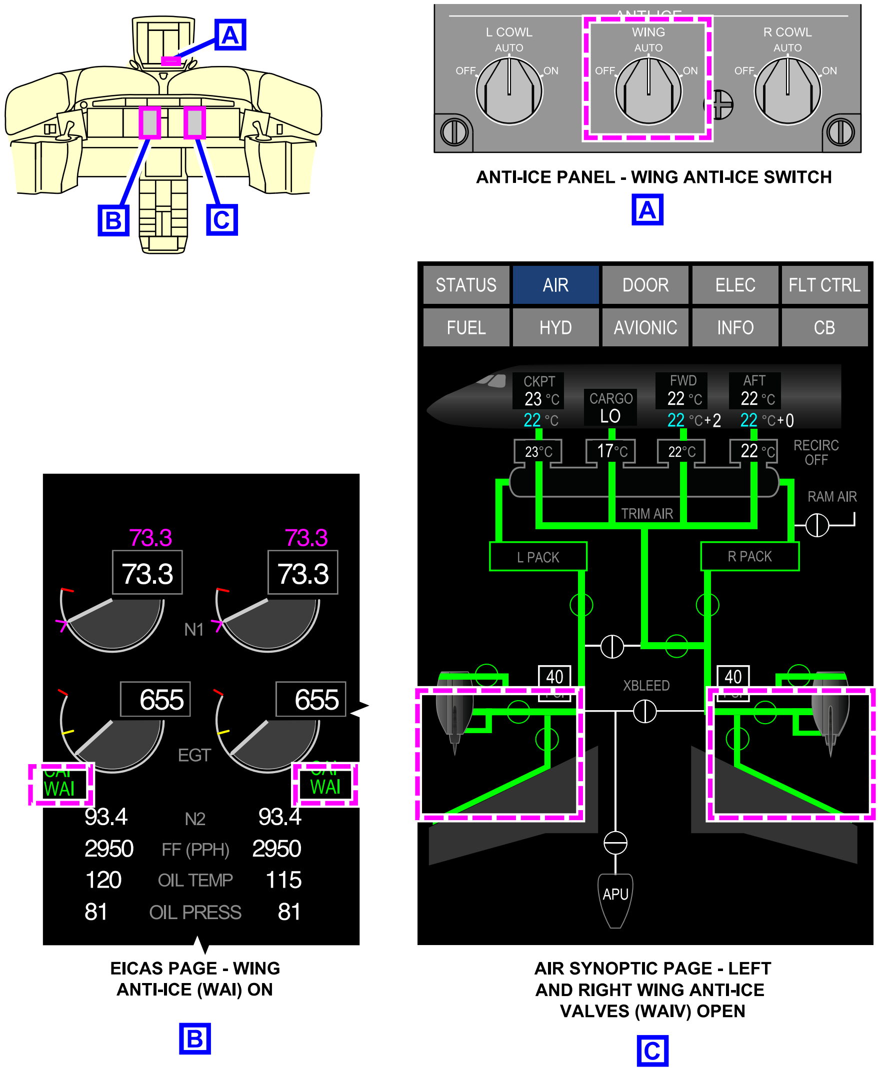
WING ANTI-ICE SYSTEM (WAIS) – OVERVIEW

The WAIS distributes the engine bleed air coming out of the Pressure Regulating Shutoff Valve (PRSOV) to the wing leading edge (slats 2, 3, and 4) on each wing (refer to Figure 13–03–1).

The WING ANTI-ICE switch located on the ANTI-ICE panel controls the WAIS (refer to Figure 13–03–2). Status and fault messages are reported on the EICAS page and system status is shown on the AIR synoptic page.



Wing anti–ice system
Figure 13–03–1



Wing anti–ice system controls and indications
Figure 13–03–2

WING ANTI-ICE SYSTEM (WAIS) – DESCRIPTION AND OPERATION

A. Components description

The main components of the Wing Anti-Ice System (WAIS) are:

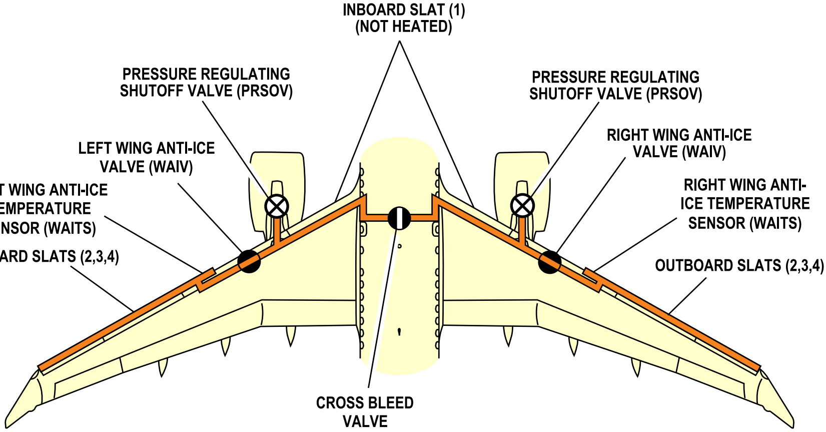
- Wing Anti-Ice Valves (WAIVs),
- Wing Anti-Ice Temperature Sensor (WAITS), and
- Wing piccolo tubes,

(1) Wing Anti-Ice Valves (WAIVs)

The WAIVs are located outboard of the engine nacelles, and are electrically controlled and pneumatically operated. In normal operations, the onside engine supplies bleed air for anti-icing. In the event of an engine failure or a single bleed source, the cross bleed valve connects both wings to the single bleed source.

(2) Wing Anti-Ice Temperature Sensors (WAITS)

The WAITS, installed downstream of the left and right WAIVs, monitor the temperature of hot bleed air supplied to the piccolo tubes.

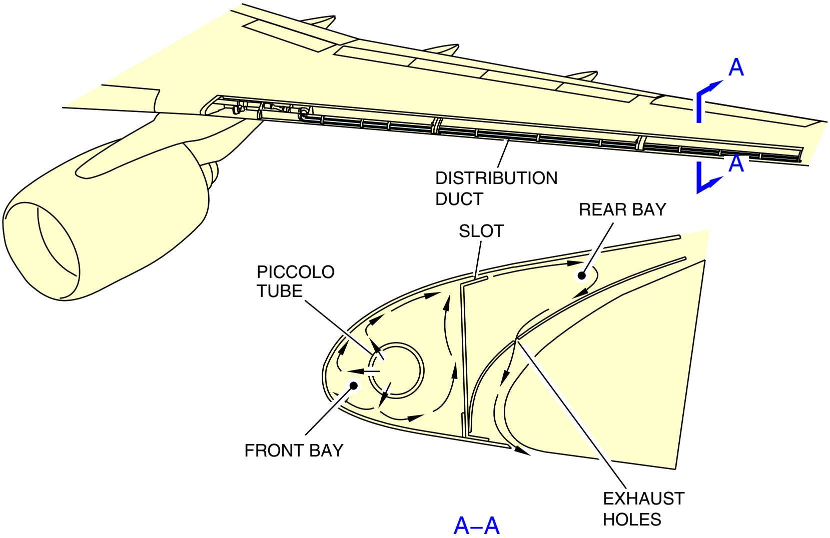


Wing Anti–Ice System (WAIS) components
Figure 13–03–3

(3) Piccolo tubes

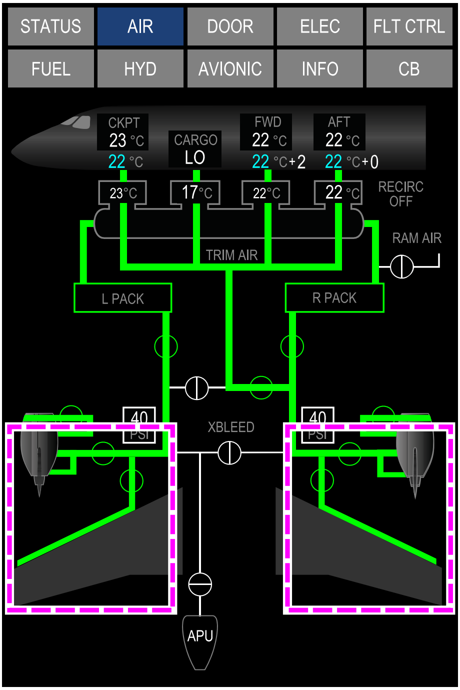
A telescopic duct, capable of extending with the leading edge slats, allows the hot bleed air to be routed to piccolo tubes that run along the wing leading edge. The piccolo tubes are perforated to allow bleed air to heat the wing leading edge. The air is then vented through exhaust holes underneath the leading edge.

Figure 13–03–4 shows the WAIS distribution duct and the piccolo tube.



Wing anti–ice system (WAIS) – Distribution duct
Figure 13–03–4

Figure 13–03–5 shows the Pressure Regulating Shut Off Valves (PRSOVs) and the WAIVs status indication on the AIR synoptic page.



AIR SYNOPTIC PAGE – PRESSURE REGULATING SHUTOFF VALVES (PRSOV) AND WING ANTI–ICE VALVES (WAIV) OPEN

Wing anti–ice valves
Figure 13–03–5

B. Wing Anti-Ice System (WAIS) operation

(1) Automatic mode

When the WING ANTI-ICE switch is selected to AUTO, wing heat is controlled automatically by the ice detection system and the IASCs. Upon ice detection, the Integrated Air System Controllers (IASCs) command both WAIVs to the open position and an **ICE** advisory message displays on the EICAS page.

NOTE

In icing conditions, the system activates when the altitude reaches 1500 feet or 2 minutes after takeoff, whichever occurs first (AUTO switch position).

(2) Manual mode

When the WING ANTI-ICE switch is selected OFF, the WAIVs are closed.

NOTE

When the WING ANTI-ICE switch is selected OFF and ice is detected, an **ICE** caution message and a **WING A/ICE OFF** status message display on the EICAS page to indicate a misconfiguration.

When the WING ANTI-ICE switch is selected to ON, the IASCs command the WAIVs to open when in flight. An **WING A/ICE ON** status message displays on the EICAS page.

If ice conditions are anticipated, the WING ANTI-ICE switch is set to ON. The WAIS is inhibited on the ground prior to 60 KIAS (except for testing).

NOTE

If the APU is the source of bleed air when wing anti-icing is required, the IASC will change the bleed air source to the engines, prior to opening the WAIVs.

NOTE

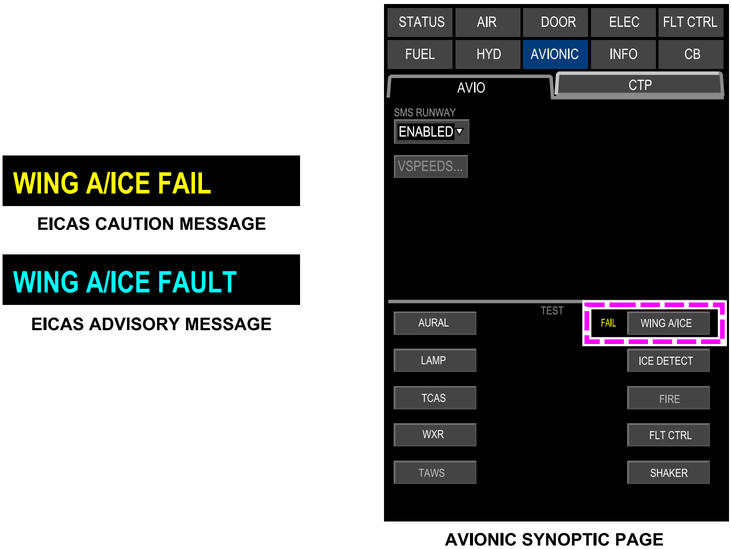
Please refer to the AFM, Chapter 2 - Limitations, operation in icing conditions, for the use of WAI.

C. Wing Anti-Ice System (WAIS) test

The WAIS test is available on ground by pressing the WING A/ICE soft switch on the AVIONIC synoptic page using the Cursor Control Panel (CCP). With WAI selected ON, the test opens one of the Pressure Regulating Shutoff Valves (PRSOVs) (bleed valves), turns on the WAIVs, monitors the pressure, and tests for approximately 30 seconds. During the test, a cyan IN PROG message displays.

If there is no fault detected, a green PASS message displays. If a fault is detected, an amber FAIL or a FAULT message displays on the AVIONIC synoptic page and the **WING A/ICE FAIL** caution message or **WING A/ICE FAULT** advisory message displays on the EICAS page.

Figure 13–03–6 shows the wing anti-ice test function.

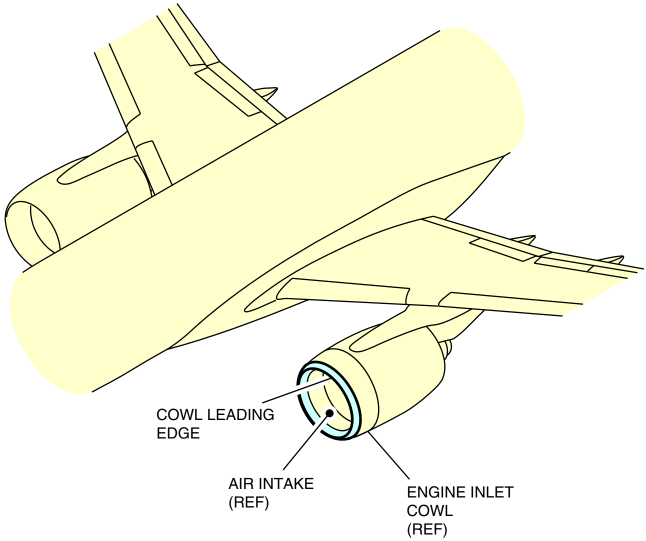


Wing Anti–Ice System (WAIS) – Test
Figure 13–03–6

COWL ANTI-ICE SYSTEM (CAIS) – OVERVIEW

The Cowl Anti-Ice System (CAIS) uses 6th stage engine bleed air to heat the engine cowl leading edge and prevent ice accumulation. The system is controlled by the L (R) COWL switches located on the ANTI-ICE panel. When set to AUTO, the Electronic Engine Control (EEC) controls the Cowl Anti-Ice Valves (CAIVs) according to ice detector signals.

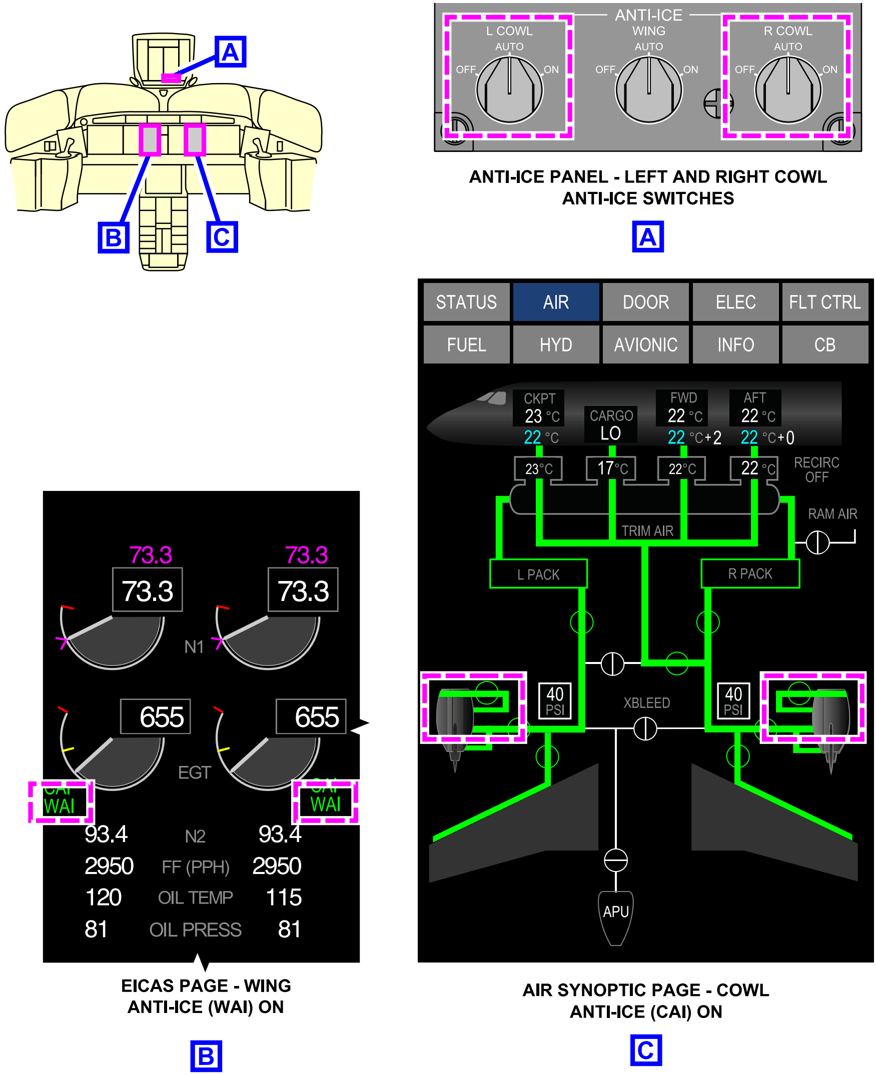
Figure 13–04–1



Cowl anti–ice system
Figure 13–04–1

System status and fault messages are reported on the EICAS page. The CAIVs status is reported on the AIR synoptic page.

Figure 13–04–2 shows the CAIS controls and indications.



Cowl Anti–Ice System (CAIS) – Controls and indications
Figure 13–04–2

COWL ANTI-ICE SYSTEM (CAIS) – DESCRIPTION AND OPERATION

A. Components description

The main components of the CAIS are:

- Cowl Anti-Ice Valves (CAIVs), and
- Cowl Anti-Ice Temperature Sensors (CAITS).

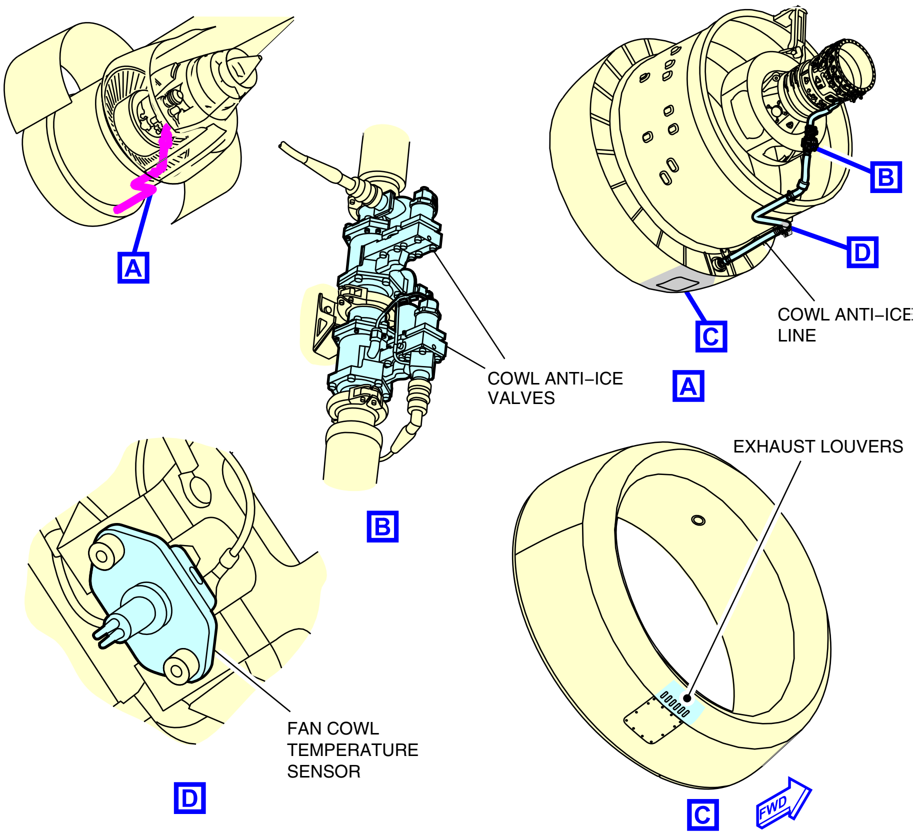
(1) Cowl Anti-Ice Valves (CAIVs)

Two pressure-regulated CAIVs, mounted in series (refer to Figure 13–04–3), provide each engine cowl with anti-ice protection. They are electrically controlled by the EEC, pneumatically operated and are fail-safe to the open position.

The valves regulate 6th stage compressor bleed air inside the nose cowl. The bleed air is then discharged overboard through exhaust louvers. When either ice detector senses ice, the CAIVs open to supply engine bleed air to the engine cowl when in AUTO position.

(2) Cowl Anti-Ice Temperature Sensors (CAITS)

Two temperature sensors located in each cowl area sense and monitor engine case temperatures. In the event of a cowl anti-ice duct leak, the EEC closes the CAIV.



Cowl anti–ice valves
Figure 13–04–3

B. Operation

(1) Automatic mode

When the L/R COWL ANTI-ICE switch is selected to AUTO, cowl heat is controlled automatically by the ice detection system and EECs. Upon ice detection, the EEC opens both CAIVs and an **ICE** advisory message displays on the EICAS page.

NOTE

The CAIS is inhibited until 1500 feet or 2 minutes after takeoff, whichever occurs first.

(2) Manual mode

When the L/R COWL ANTI-ICE switch is selected OFF, the CAIVs close and a **L/R COWL ANTI-ICE OFF** or **L - R COWL A/ICE OFF** status message displays on the EICAS page.

NOTE

When the L/R COWL ANTI-ICE switch is selected OFF and ice is detected, an **ICE** caution message displays on the EICAS to indicate a misconfiguration.

When an engine is running and the associated side CAI switch is selected ON, the CAIV on that side is commanded open without delay. A **L/R COWL ANTI-ICE ON** or **L - R COWL A/ICE ON** status message displays on the EICAS page.

NOTE

The CAIS is inhibited on the ground if the corresponding engine is not running, or if the outside temperature is greater than 15°C (59°F).

NOTE

Please refer to the AFM, Chapter 2 - Limitations, operation in icing conditions, for the use of CAI.

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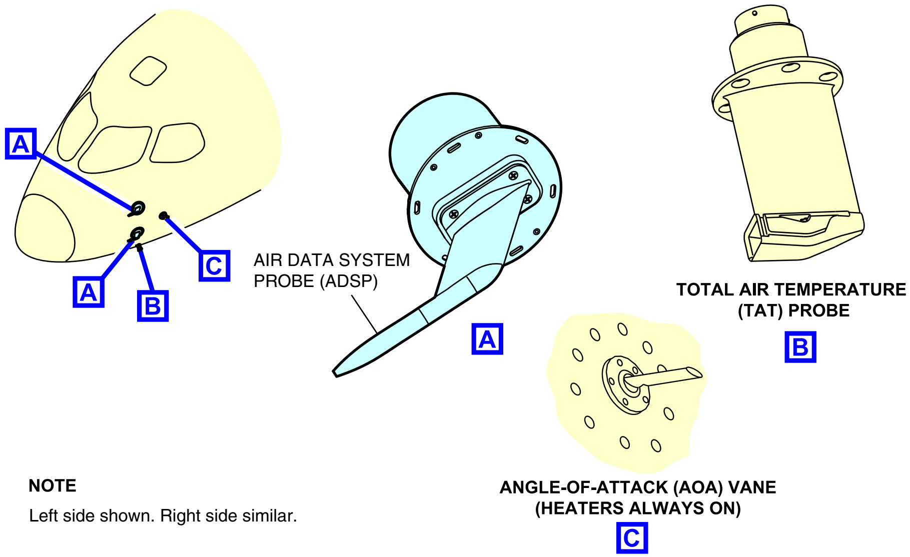
ADS PROBE AND SENSOR ICE PROTECTION – DESCRIPTION AND OPERATION

The Air Data System (ADS) probes and sensors (refer to Figure 13–05–1) consist of:

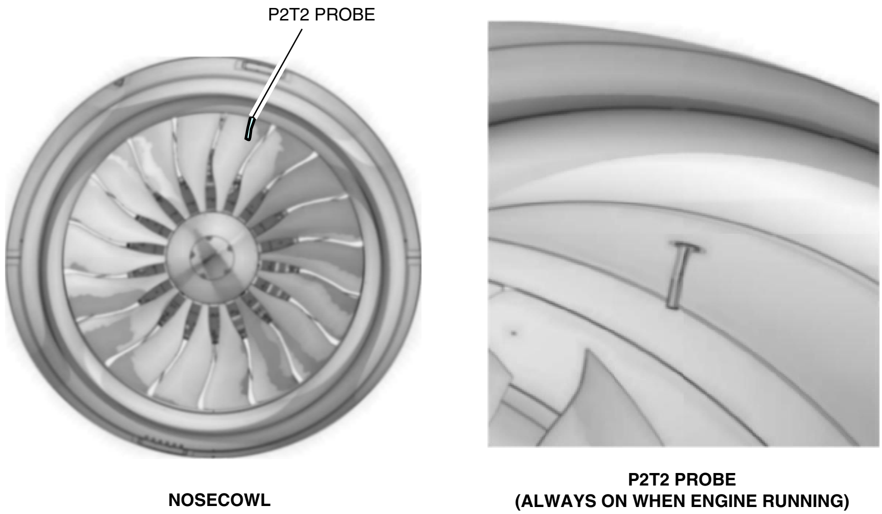
- Four cross-coupled Air Data System Probes (ADSPs),
- Two Total Air Temperature (TAT) probes,
- Two Angle Of Attack (AOA) vanes, and
- Two P2T2 probes.



Air data system (ADS) – Probes location
Figure 13–05–1

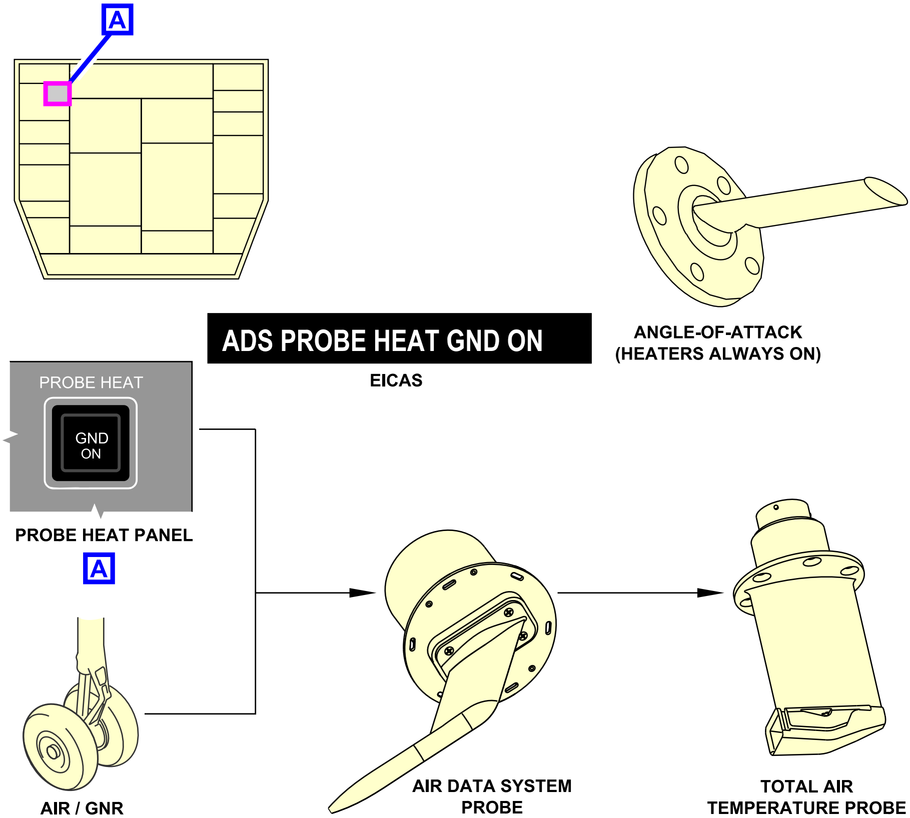
The ADSPs, TATs probes, AOA vanes, and P2T2 probes are electrically heated. Each ADSP consists of a pitot port, static port, and AOA detector combined with an Air Data Computer (ADC). The AOA vanes located behind the ADSPs are used as a backup. The TAT, AOA vanes, and ADSPs probe heaters are automatically selected on when weight-off-wheels or if any engines are running.

The P2T2 probes (refer to Figure 13–05–2) on each engine cowl are electrically heated when the engine is operating. The Electronic Engine Control (EEC) controls the operation of the P2T2 probes.



P2T2 probes
Figure 13–05–2

When the aircraft is on the ground, and powered by the Auxiliary Power Unit (APU) or a Ground Power Unit (GPU), the PROBE HEAT switch on the overhead panel can be used to turn on the TAT and ADSP probe heaters. The probe heaters are on a 2 minutes timer. When the switch is pressed, the system activates, the GND ON legend illuminates and a ADS PROBE HEAT GND ON status message displays on the EICAS page.



Probes heating
Figure 13–05–3

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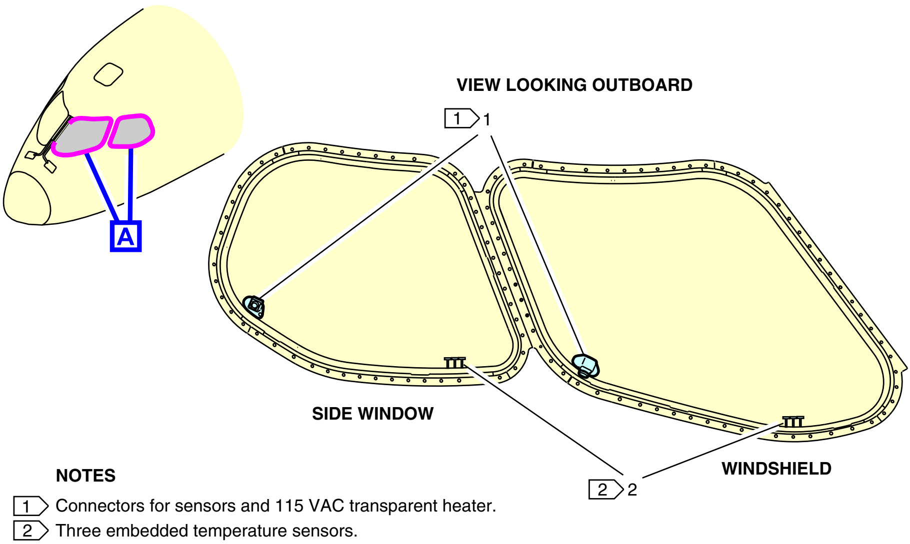
WINDSHIELD AND SIDE WINDOW ANTI-ICE SYSTEM – DESCRIPTION AND OPERATION

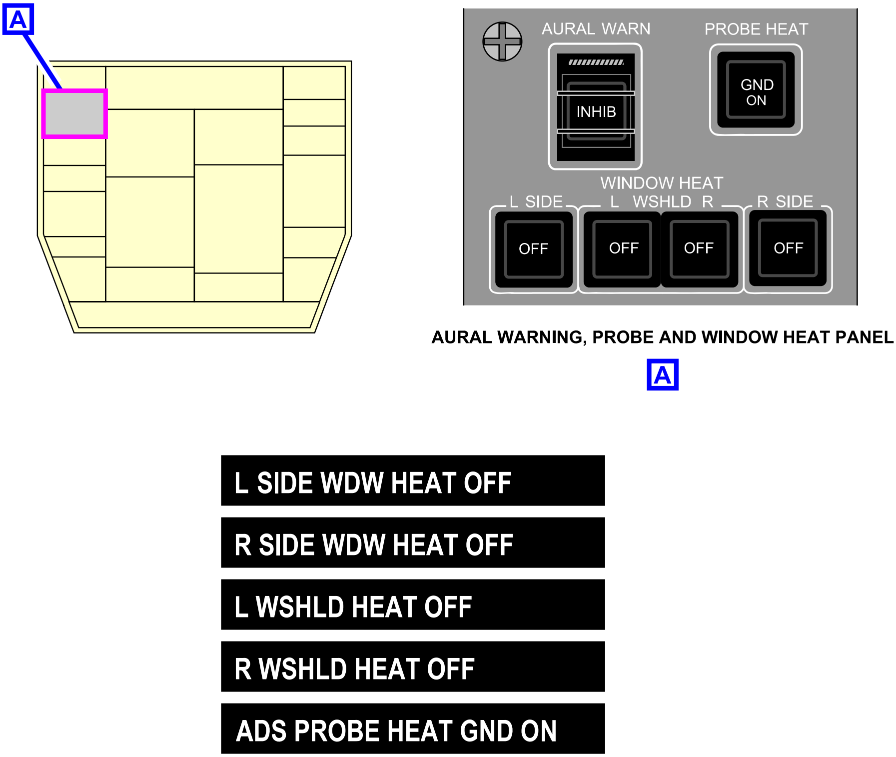
The windshields and side windows are electrically heated by a 115 VAC transparent heater elements powered by AC BUS 1, AC BUS 2, and AC ESS (refer to Figure 13–06–1). Each windshield and side window contains three sets of transparent heater elements, and three sets of temperature sensors. The windshield and side window anti-ice system is turned on automatically when AC electrical power is available, and the flight crew has the ability to select each windshield/side window heat off, as necessary. Each heating element is monitored by its own Windshield Ice Protection Controller (WIPC), which is located in the forward avionics bay.



Windshields/side windows anti–ice system
Figure 13–06–1

The controller maintains the windshield and window temperature by varying the AC power applied to the heating element. A built-in-test is periodically performed to detect and annunciate faults within the WIPC.

Controls are located in the Aural Warning, Probe and Window Heat panel (refer to Figure 13–06–2). System status and fault messages are reported on the EICAS page.



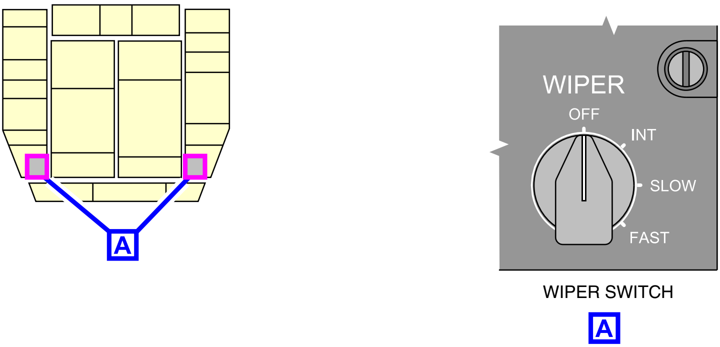
AURAL WARNING, PROBE AND WINDOW HEAT PANEL

EICAS STATUS MESSAGES

Windshields/side windows anti–ice system – Controls and indications
Figure 13–06–2

WINDSHIELD WIPER SYSTEM – DESCRIPTION AND OPERATION

Rain, snow and moisture are removed from the windshields by two electrically operated wipers. Each wiper system consists of one electronic controller, one electric motor, and one mechanical converter. The left and right wipers are synchronized if both switches are selected to the same operational mode (INT, SLOW or FAST) (refer to Figure 13–07–1). If they are not selected to the same operational mode, the wipers function independently. The maximum operating speed for the windshield wipers is 250 KIAS.



Windshields wiper control
Figure 13–07–1

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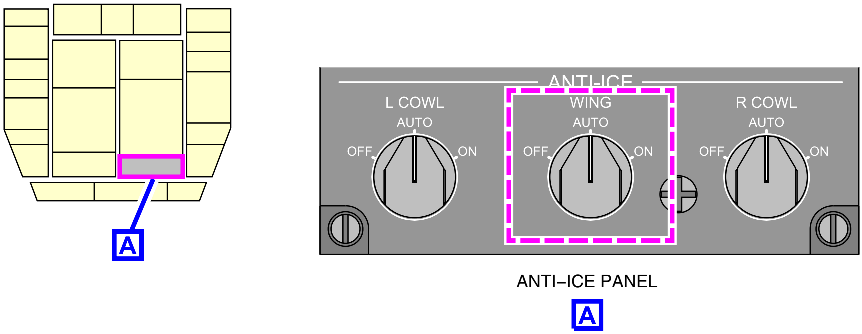
ICE AND RAIN PROTECTION – CONTROLS

A. Wing Anti-Ice System (WAIS) controls

The WAIS is controlled by the WING ANTI-ICE switch located on the overhead panel (refer to Figure 13–08–1).



Anti–ice panel – Wing anti–ice switch
Figure 13–08–1

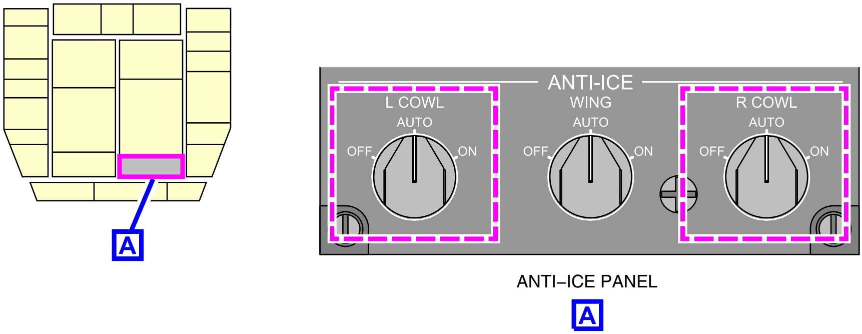
- OFF: When the WING ANTI-ICE switch is selected OFF, the Wing Anti-Ice Valves (WAIVs) are closed.
- AUTO: When the WING ANTI-ICE switch is selected to AUTO, wing heat is controlled automatically by the ice detection system and the IASCs.
- ON: When the WING ANTI-ICE switch is selected to ON, the IASCs command the WAIVs to open any time in flight.

NOTE

Please refer to the AFM, Chapter 2 - Limitations, operation icing conditions, for the use of WAI.

B. Cowl Anti-Ice System (CAIS) controls

The CAIS is controlled by the L/R COWL ANTI-ICE switches on the overhead panel (refer to Figure 13–08–2).



Anti–ice panel – Cowl anti–ice switches
Figure 13–08–2

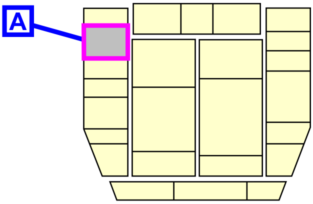
- OFF: When the L/R COWL ANTI-ICE switch is selected OFF, the CAIVs close.
- AUTO: When the L/R COWL ANTI-ICE switch is selected to AUTO, cowl heat is controlled automatically by the ice detection system and EECs.
- ON: When the L/R COWL ANTI-ICE switch is selected to ON, the valves are manually commanded open.

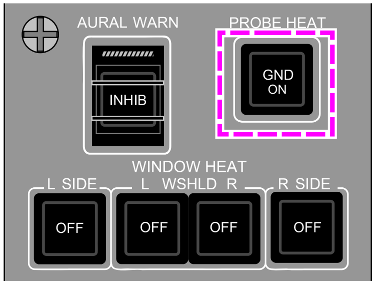
NOTE

Please refer to the AFM, Chapter 2 – Limitations, operation in icing conditions, for the use of the CAI.

C. Aural warning, probe and window heat panel

The heating controls for the ADS probes/sensors and side window/windshield are located on the aural warning, probe and window heat panel.Refer to Figure 13–08–3.





AURAL WARNING, PROBE AND WINDOW HEAT PANEL

A

Probe heat switch
Figure 13–08–3

(1) PROBE HEAT switch

- Automatic mode (not selected): ADSP and TAT probe heaters are controlled automatically. Depending on the condition, they will:
  - Modulate (on and off, depending on probe temperature) on ground, when at least one engine running and speed is less than 55 kt.
  - ON (full heat) when speed is greater than 55 kt or weight off wheels.
- GND ON: When pressed in, the GND ON label on the switch illuminates white and the ADSP and TAT probe heater activates for 2 minutes and then automatically turns off. The GND ON label on the switch turns off after the 2 minutes delay.

(2) L/R WINDOW and L/R WINDSHIELD switches

- Automatic mode (not selected): Modulates automatically on and off, depending on window temperature.
- OFF: When pressed in, the OFF label illuminates white and the left and right side window/windshield heating is turned off.

D. Windshield wiper controls

There are two wiper switches, one on each side of the overhead panel. Refer to Figure 13–08–4.

Wiper switch
Figure 13–08–4

- OFF: The onside wiper is turned off (vertical position),
- INT: One wiping cycle every 5 seconds,
- SLOW: 80 cycles per minute, and
- FAST: 120 cycles per minute.

NOTE

When both LH and RH switches are in the same position, the wipers are synchronized.

ICE AND RAIN PROTECTION – INDICATIONS

The tables that follow describe the Wing Anti-Ice System (WAIS) and Cowl Anti-Ice System (CAIS) indications on the AIR synoptic page.

WING ANTI-ICE SYSTEM	
EICAS Flag	**Condition**
WAI	Wing anti-ice active
WAI	Wing anti-ice armed, but inactive
WAI	Wing anti-ice failure reported
WAI	WAI failed in warning condition
Symbol	**Condition**
	Off
	Normal
	Non-normal

VALVE POSITION NORMAL OPERATION	
Symbol	**Condition**
	Closed
	Open with flow
	Open with no flow

COWL ANTI-ICE SYSTEM	
EICAS Flag	**Condition**
CAI	Cowl anti-ice active
CAI	Cowl anti-ice armed, but inactive
CAI	Cowl anti-ice failure reported
Symbol	**Condition**
	Off
	Normal
	Non-normal

VALVE POSITION FAIL OPERATION	
Symbol	**Condition**
	Closed
	Open with flow
	Open with no flow
	Invalid

Ice and rain protection synoptic page symbology
Figure 13–08–5

ICE AND RAIN PROTECTION – EICAS MESSAGES

A. Warning messages

Message	Description	Aural	Inhibit
L WING A/ICE FAIL	Left Wing Anti-Ice Valve (WAIV) not closed in any condition on ground, out of test sequence, overpressure, or low pressure when WAI is not inhibited for at least 15 seconds.	None	None
R WING A/ICE FAIL	Right Wing Anti-Ice Valve (WAIV) not closed in any condition on ground, out of test sequence, overpressure, or low pressure when WAI is not inhibited for at least 15 seconds.	None	None

B. Caution messages

Message	Description	Inhibit
ADS ISI PROBE HEAT	ADS 3 – 4 combined heaters failed.	TO, LDG
ADS 1 PROBE HEAT FAIL	ADS 1 probe not heated per expectations.	TO, LDG
ADS 2 PROBE HEAT FAIL	ADS 2 probe not heated per expectations.	TO, LDG
ADS 3 PROBE HEAT FAIL	ADS 3 probe not heated per expectations.	TO, LDG
ADS 4 PROBE HEAT FAIL	ADS 4 probe not heated per expectations.	TO, LDG

Message	Description	Inhibit
COWL A/ICE ON	Left or right Cowl Anti-Ice System (CAIS) manually selected ON while the Outside Air Temperature (OAT) is more than approximately 15 °C (59 °F).	TO, LDG
ICE	Ice detected and Wing Anti-Ice System (WAIS) or Cowl Anti-Ice System (CAIS) are failed or off. During the ice detection test (approximately 10 seconds) it is displayed on the EICAS page.	TO
L COWL A/ICE FAIL	Left cowl anti–ice system failed (valves closed). This message is inhibited when ENG OPER DEGRADED EICAS is set.	TO, LDG
L COWL A/ICE FAIL ON	Left cowl anti–ice system failed (valves open). This message is inhibited when ENG NACELLE OVHT EICAS is set.	TO, LDG
L ICE DET FAIL	Left ice detector has failed.	TO, LDG
L SIDE WDW HEAT FAIL	Heater for left side window failed.	TO, LDG
L WING A/ICE LO HEAT	Combination of low pressure and temperature for left Wing Anti-Ice System (WAIS) (also function of altitude) when properly configured.	TO, LDG
L WING A/ICE OVHT	Left wing bleed overtemperature detected.	TO, LDG
L WSHLD HEAT FAIL	Heater for left windshield failed.	TO, LDG
R COWL A/ICE FAIL	Right cowl anti–ice system failed (valves closed). This message is inhibited when ENG OPER DEGRADED EICAS is set.	TO, LDG

Message	Description	Inhibit
R COWL A/ICE FAIL ON	Right cowl anti–ice system failed (valves open). This message is inhibited when ENG NACELLE OVHT EICAS is set.	TO, LDG
R ICE DET FAIL	Right ice detector has failed.	TO, LDG
R SIDE WDW HEAT FAIL	Heater for right side window failed.	TO, LDG
R WING A/ICE LO HEAT	Combination of low pressure and temperature for right Wing Anti-Ice System (WAIS) (also function of altitude) when properly configured.	TO, LDG
R WING A/ICE OVHT	Right wing bleed overtemperature detected.	TO, LDG
R WSHLD HEAT FAIL	Heater for right windshield failed.	TO, LDG
WING A/ICE FAIL	Left or right Wing Ant-Ice System (WAIS) failed.	TO, LDG.
WING A/ICE LEAK	Left or right wing anti-ice leak detected.	TO, LDG
WING A/ICE MISCONFIG	Wing Anti-Ice System (WAIS) selected to ON or Wing Anti-Ice System (WAIS) selected to AUTO and ice detected with the engine bleed OFF for both engines or WAIS inhibited in high altitude due to single bleed operation.	TO, LDG
WING A/ICE ON	Wing Anti-Ice System (WAIS) selected to ON and Total Air Temperature (TAT) above 15 °C (59 °F).	TO, LDG

C. Advisory messages

Message	Description	Inhibit
ICE	Ice detected, Wing Anti-Ice System (WAIS), and Cowl Anti-Ice System (CAIS) are working properly.	TO, LDG
L SIDE WDW HT FAIL ON	Heater of the left side window failed operative.	TO, LDG
R SIDE WDW HT FAIL ON	Heater of the right side window failed operative.	TO, LDG
L WSHLD HEAT FAIL ON	Heater of the left windshield failed operative.	TO, LDG
R WSHLD HEAT FAIL ON	Heater of the right windshield failed operative.	TO, LDG
WING A/ICE FAULT	Loss of redundant or non–critical function for the WAIS, or WAIV high leakage.	TO, LDG

D. Status messages

Message	Description	Inhibit
ADS PROBE HEAT GND ON	Probe heaters manually commanded ON and the Air Data Smart Probes (ADSP) is heating the Multifunction Probes (MFPs).	None
L COWL A/ICE OFF	Left cowl anti-ice manually selected off.	None
R COWL A/ICE OFF	Right cowl anti-ice manually selected off.	None
L-R COWL A/ICE OFF	Left and right cowl anti-ice manually selected off.	None
L COWL A/ICE ON	Left cowl anti-ice manually selected on.	None
R COWL A/ICE ON	Right cowl anti-ice manually selected on.	None

Message	Description	Inhibit
L-R COWL A/ICE ON	Left and right cowl anti-ice manually selected on.	None
L SIDE WDW HEAT OFF	Heater for left side window selected to OFF.	None
R SIDE WDW HEAT OFF	Heater for right side window selected to OFF.	None
L WSHLD HEAT OFF	Heater for left windshield selected to OFF.	None
R WSHLD HEAT OFF	Heater for right windshield selected to OFF.	None
WING A/ICE OFF	Wing Anti-Ice System (WAIS) selected to OFF.	None
WING A/ICE ON	Wing Anti-Ice System (WAIS) selected to ON.	None

CHAPTER 14 – LANDING GEAR

List of figures

GENERAL

LANDING GEAR SYSTEM

NOSEWHEEL STEERING SYSTEM

WHEELS, TIRES, AND BRAKE SYSTEM

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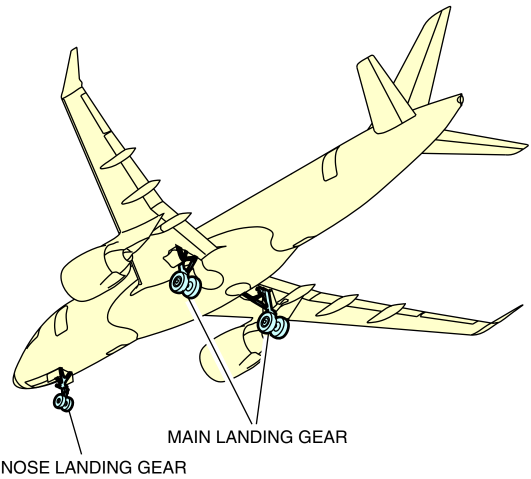
SYSTEM OVERVIEW

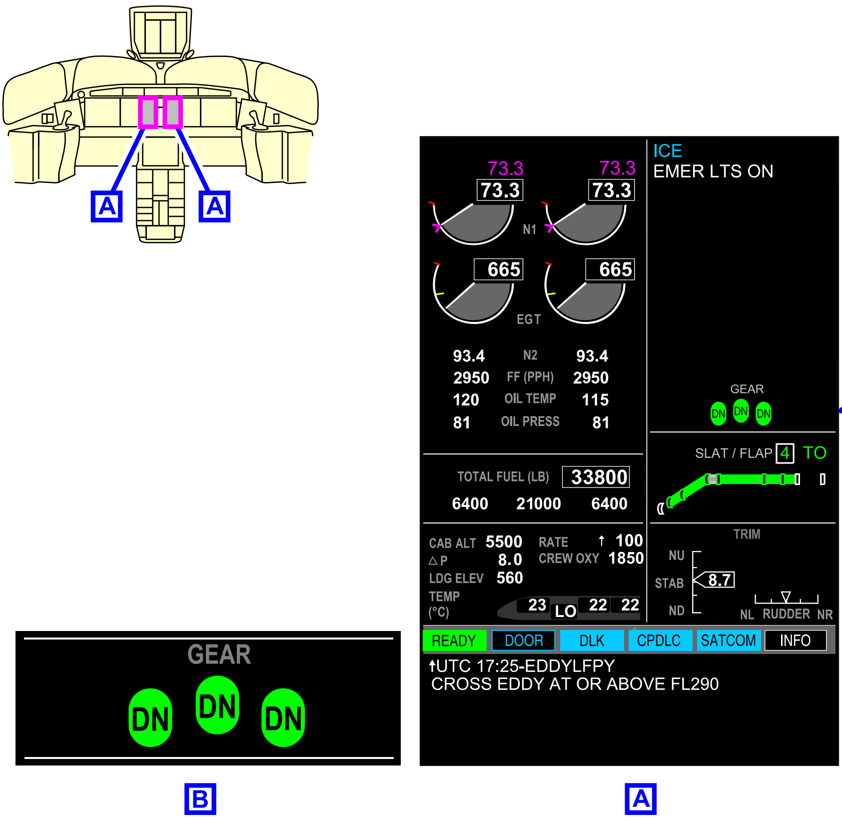
The landing gear system is installed in a tricycle configuration (refer to Figure 14–01–1). It has two main landing gear (MLG) assemblies, mounted on the wing roots, and one nose landing gear (NLG) assembly mounted on the forward fuselage.



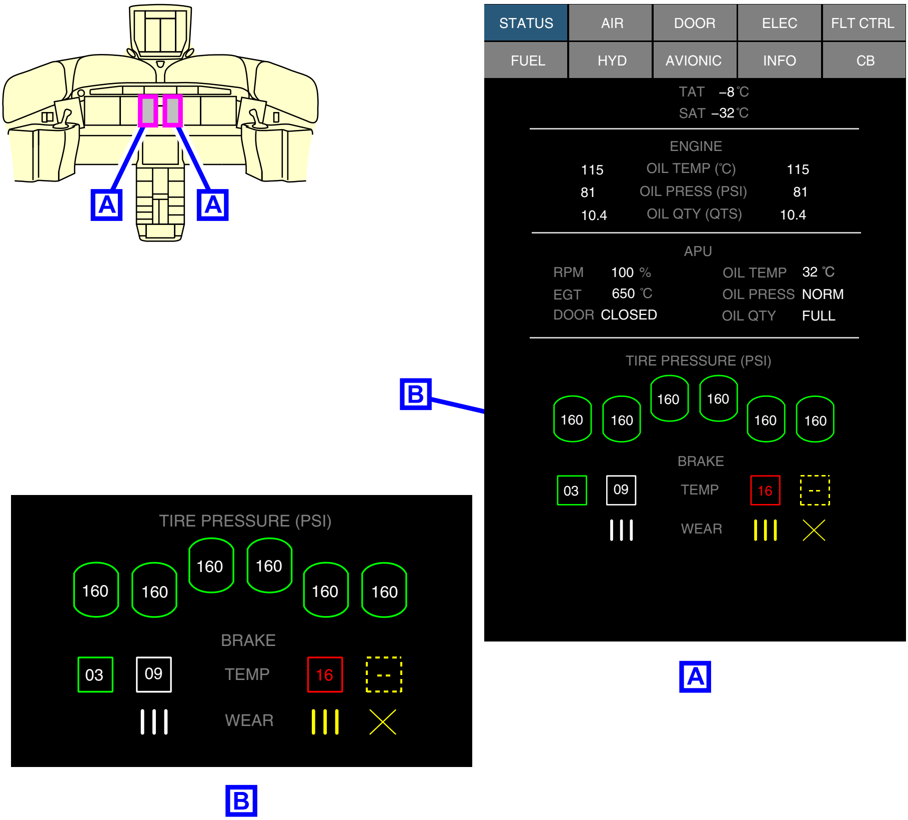
Landing gear system
Figure 14–01–1

Each assembly is a hydraulically–actuated, dual–wheel, telescopic type. The assembly is also equipped with an alternate extension system. Associated subsystems include electrically–controlled, hydromechanical nosewheel steering, electric brakes, and proximity sensors.

Two Landing Gear and Steering Control Units (LGSCUs) control the gear extension/retraction system and nosewheel steering. Two Brake Data Concentrator Units (BDCUs) control the brakes. The LGSCUs and the BDCUs provide operational monitoring, protection, and control functions. They send the related respective information to the EICAS synoptic page (refer to Figure 14–01–2) and STATUS synoptic page (refer to Figure 14–01–3). System controls are provided by the landing gear panel, rudder pedals, and tiller.



EICAS page – Landing gear position indications
Figure 14–01–2



STATUS synoptic page – Indications
Figure 14–01–3

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LANDING GEAR SYSTEM – OVERVIEW

The landing gear system consists of two main landing gear assemblies and one nose landing gear assembly. Each assembly is equipped with two tires. The landing gear is extended and retracted by hydraulic actuators and pressure from hydraulic system No. 1.

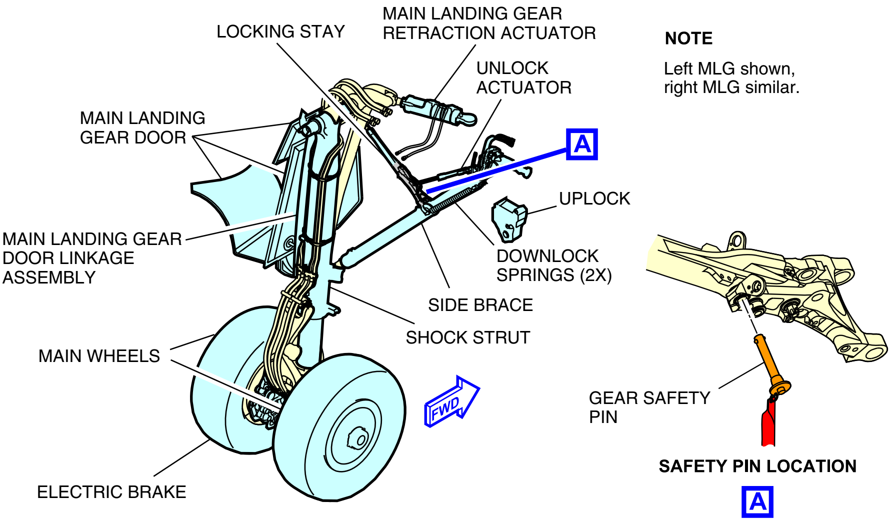
The normal extension and retraction of the landing gear is controlled by the Landing Gear Steering and Control Units (LGSCUs). The alternate extension allows free-fall extension of the landing gear if normal extension fails.

LANDING GEAR SYSTEM – DESCRIPTION AND OPERATION

A. Main Landing Gear (MLG)

Each main landing gear assembly (refer to Figure 14–02–1) has the components that follow:

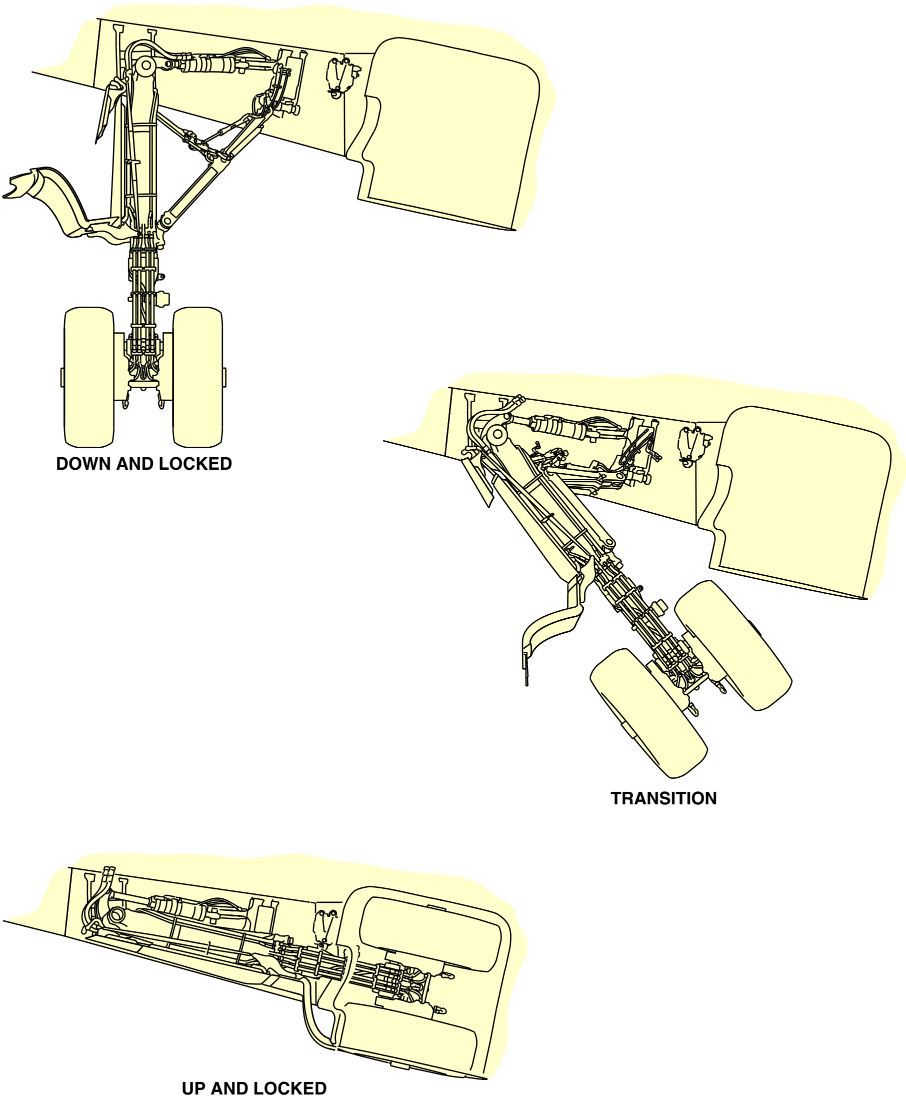
- Twin wheel assembly,
- Single-stage shock strut,
- Main landing gear retraction actuator,
- Foldable side brace,
- Over-center locking mechanism,
- Unlock actuator,
- Uplock,
- Door mechanism, and
- Brake system.



Main landing gear
Figure 14–02–1

The shock strut is filled with a conventional single–stage mixed nitrogen/oil oleo pneumatic shock absorber damped by an internal metering pin. The normal extension and retraction of the main landing gear is done by a retraction actuator. Hydraulic system No. 1 (HYD 1) supplies the hydraulic pressure required to extend and retract the landing gear. In the extended position, the retraction actuator stays pressurized. In the retracted position, the retraction actuator is not pressurized.

The foldable side brace holds the strut in the extended position and folds for retraction (refer to Figure 14–02–2). The over-center locking mechanism keeps the side brace in the extended position. The unlock actuator overpowers the over-center locking mechanism and allows the side brace to fold so that the gear can retract. The uplock holds the strut in the retracted position.



Main Landing Gear − Retraction/Extension
Figure 14−02−2

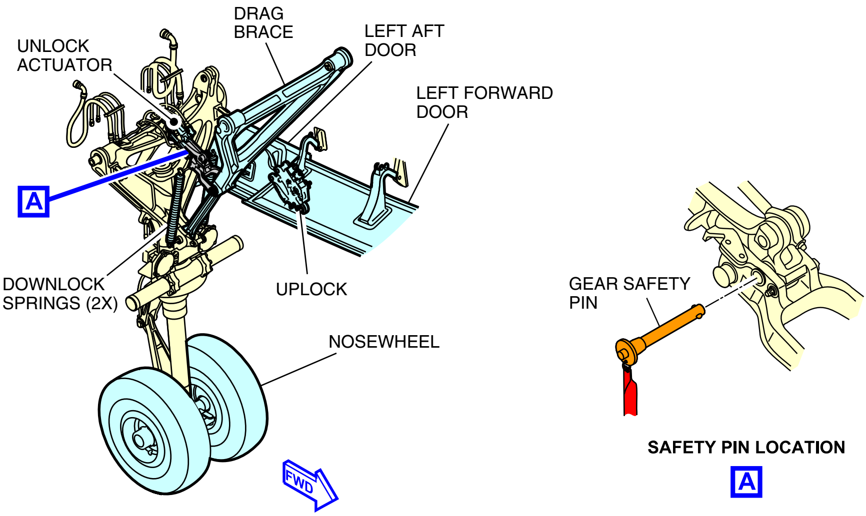
The door mechanism is hinged to the aircraft structure and attached to the main landing gear. The wheels are not covered when retracted.

On the ground, a safety pin is inserted into each MLG locking stay to mechanically lock the MLGs to prevent accidental retraction.

B. Nose Landing Gear (NLG)

The nose landing gear assembly (refer to Figure 14–02–3) has the components that follow:

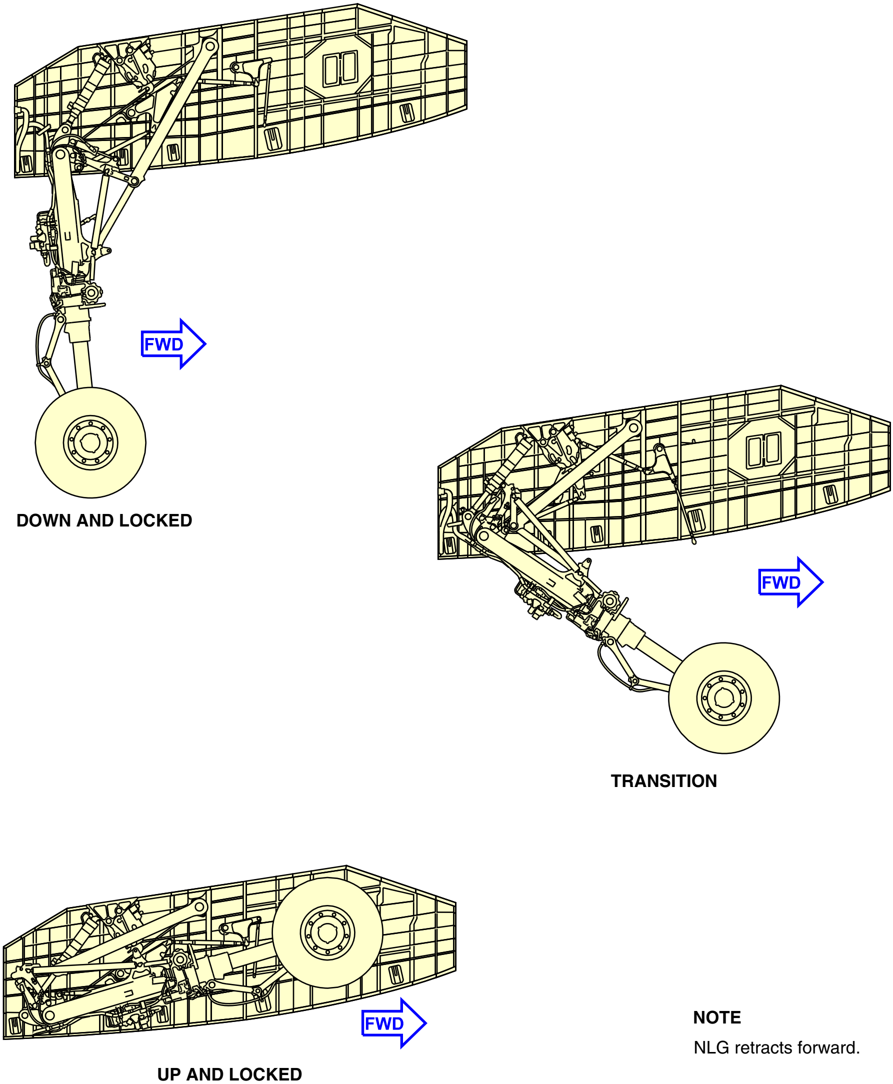
- Twin wheel assembly,
- Single-stage shock strut,
- Landing gear retraction actuator,
- Foldable drag brace,
- Over-center locking mechanism,
- Unlock actuator,
- Uplock,
- Downlock spring,
- Door mechanism, and
- Steering system.



Nose landing gear
Figure 14–02–3

The shock strut is filled with a conventional single-stage mixed nitrogen/oil oleo pneumatic shock absorber damped by an internal metering pin. The normal extension and retraction of the nose landing gear is done by a retraction actuator. Hydraulic system No. 1 (HYD 1) supplies the hydraulic pressure required extend and retract the landing gear. In the extended position, the actuator remains pressurized. When retracted, the actuator is not pressurized.

The foldable drag brace holds the strut in the extended position and folds for retraction (refer to Figure 14–02–4). The over-center locking mechanism keeps the drag brace in the extended position. The unlock actuator overpowers the over-center locking mechanism and allows the drag brace to fold so that the gear can retract.



Nose Landing Gear – Retraction/Extension
Figure 14–02–4

The nose landing gear door is hinged to the aircraft structure and linked to the nose landing gear. When retracted, the nose landing gear is entirely covered by the nose landing gear doors.

On the ground, a safety pin is inserted into the NLG locking stay to mechanically lock the NLG to prevent accidental retraction.

C. Landing Gear and Steering Control Unit (LGSCU)

Extension/retraction is controlled by two redundant Landing Gear and Steering Control Units (LGSCUs). The two LGSCUs operate in an active/active configuration so that both controllers operate at the same time for the landing gear control function (extension/retraction).

The two LGSCUs operate in an active/stand–by configuration so that only the active steering controller operates the steering system based on the commanded cockpit control. The two LGSCUs change active/stand–by roles at each flight. If there is a detected failure, the stand–by LGSCU will become active.

Four proximity sensors (two for up detection and two for down detection) are installed on each landing gear (Main Landing Gear (MLG) and Nose Landing Gear (NLG)) to provide landing gear position information to the LGSCU and for display on the EICAS page.

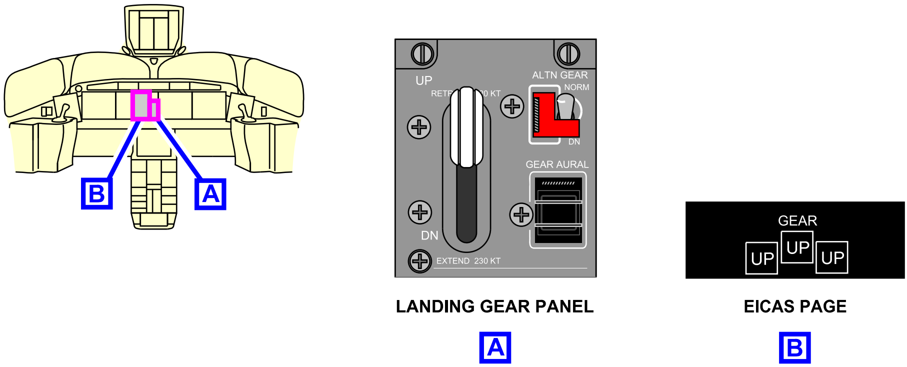
D. Landing gear retraction

When the landing gear lever on the landing gear panel is selected to UP, the LGSCU is activated. Hydraulic system No. 1 (HYD 1) pressurizes the unlock actuators and retract actuators. At the beginning of the retraction cycle, the unlock actuators lift the locking stay out of the over-center locking mechanism, overpowering the downlock spring mechanism. Then the landing gear retraction actuator retracts the landing gear. Once retracted, cams and locks of the uplock actuator hold the landing gear in the up position and the retraction actuators are de-pressurized.

The main landing gear retracts inboard. In the fully retracted position, the main wheel tires remain partially exposed at the tire circumference.

The Nose Landing Gear (NLG) retracts forward. It is connected to the door linkage assembly that drives the four NLG doors to close when the NLG is fully retracted. The nosewheel tires are completely protected by four NLG doors.

When the landing gear is fully retracted, three black boxes labeled UP will display on the EICAS page (refer to Figure 14–02–5). Thirty seconds after the LGSCU has confirmed that the landing gear is up and locked, the landing gear indications on the EICAS page will be removed (de-cluttered). The indications will reappear when the landing gear lever is selected or if there is a landing gear malfunction.

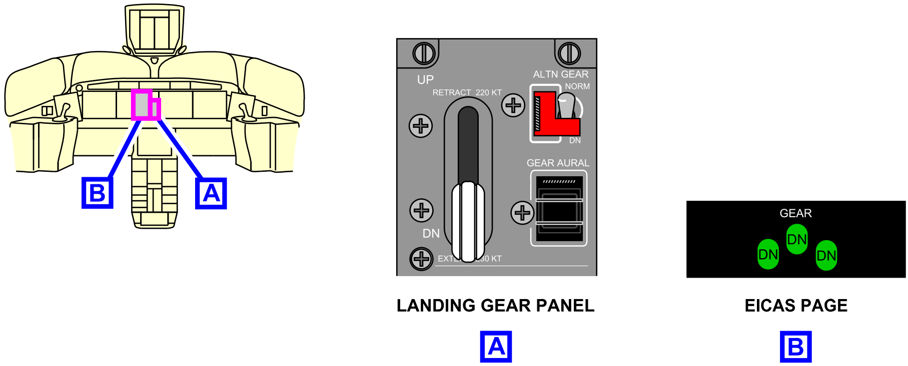


Retraction operation
Figure 14–02–5

E. Landing gear extension

When the landing gear lever on the landing gear panel is selected to DN (down), the LGSCU is activated. Hydraulic System No. 1 (HYD 1) pressurizes the UP lines of the landing gear to lift them from their resting position. This is done to unload the uplock mechanisms during gear release. Once the LGSCU senses the uplock is unloaded, the landing gear actuator is pressurized to extend the gear. The over-center locking mechanisms lock the landing gear in the extended position with the aid of the downlock spring. When the nose landing gear is fully extended, the forward doors are closed while the aft doors remain open.

When the landing gear is fully extended, three green tire symbols, labeled DN, display on the EICAS page (refer to Figure 14–02–6).

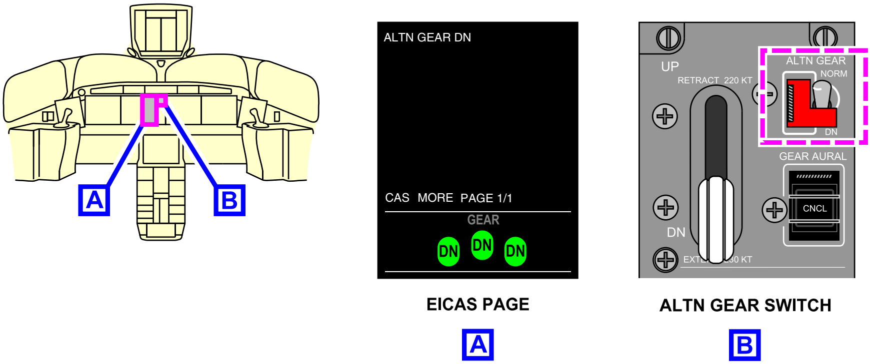


Extension operation
Figure 14–02–6

F. Alternate extension

The alternate extension is a backup for normal extension. When the ALTN GEAR guarded switch on the landing gear panel is selected to DN, DC essential bus 3 (DC ESS 3) powers the Electro-Mechanical Actuators (EMAs) to release the uplock hooks and to allow free-fall landing gear extension.

When selected to DN, the status message **ALTN GEAR DN** displays on the EICAS page (refer to Figure 14–02–7).



Alternate extension operation
Figure 14–02–7

G. Alternate extension dormancy check

At the next extension after each 550 flight hours, the LGSCU performs an alternate extension instead of a normal extension. This is to test the alternate extension circuitry to detect abnormal conditions. While the test is in progress, an **ALTN GEAR DN** advisory message displays on the EICAS synoptic page. When the landing gear is down and locked, the LGSCU reverts to normal operation by pressurizing the landing gear extension actuators, and the advisory message is removed.

LANDING GEAR – CONTROLS AND INDICATIONS

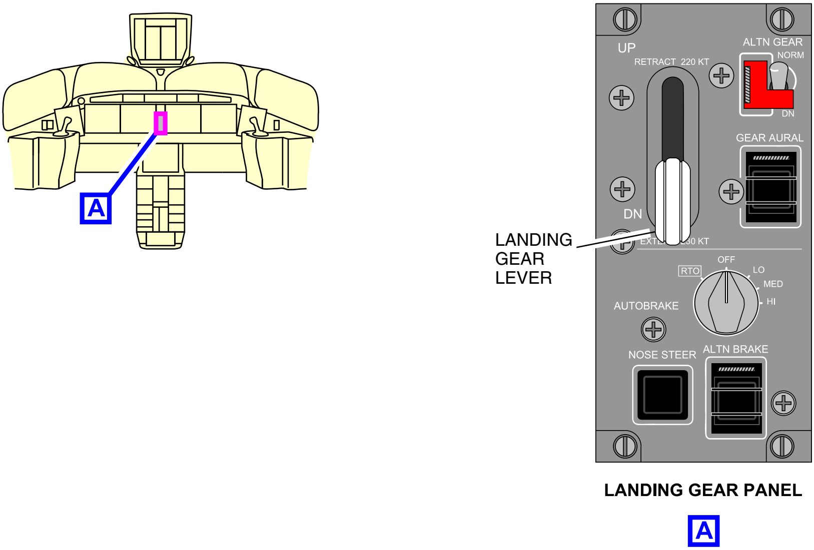
A. Landing gear lever

The landing gear lever, located on the landing gear panel, is used to extend and retract the landing gear (refer to Figure 14–02–8). The lever has an up (UP) and a down (DN) position. This lever must be pulled out before it can be moved up or down.

- UP: The landing gear retract.
- DN: The landing gear extend.

NOTE

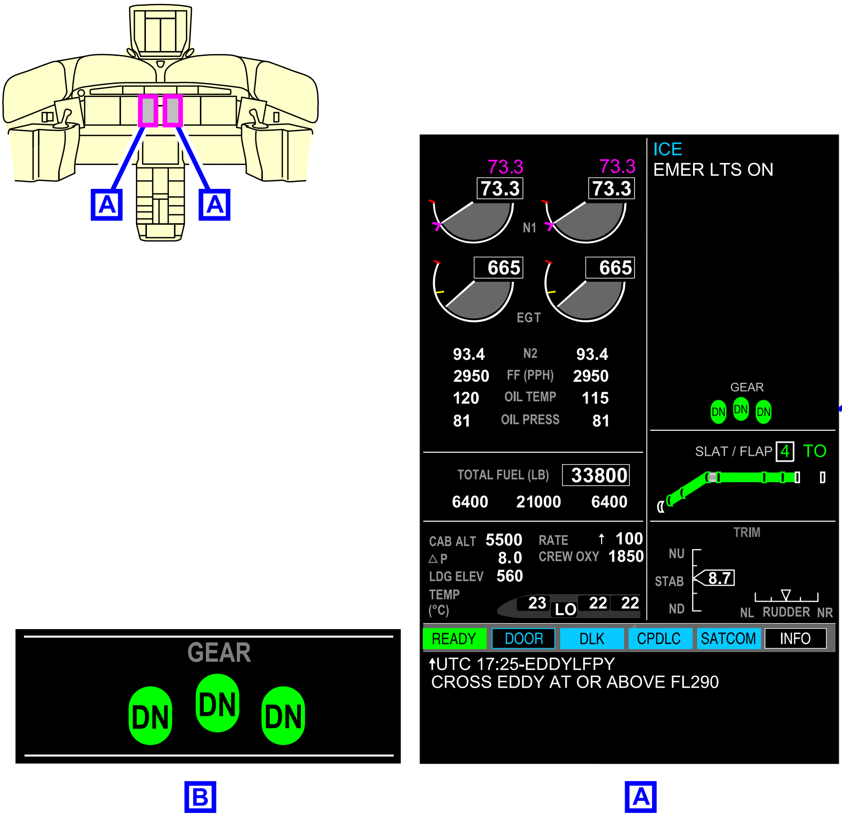
When the aircraft is on the ground the LGSCU inhibits gear retraction.



Landing gear lever
Figure 14–02–8

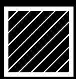
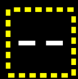
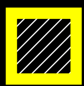
B. EICAS page

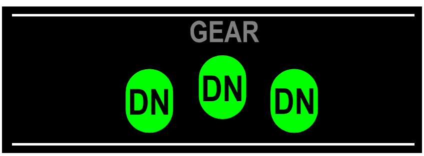
The landing gear position indication is displayed on the GEAR section of the EICAS page (refer to Figure 14–02–9).



EICAS page – Landing gear position indications
Figure 14–02–9

Figure 14–02–10 describes the landing gear position indications on the EICAS page.

Symbol	Color	Description
DN	Green	Landing gear down and locked.
UP	White	Landing gear up and locked.
	White	Landing gear in transit.
	Amber Dashed	Data not available or invalid.
UP	Amber	GEAR DISAGREE caution message on the EICAS. After a confirmation delay, gear position (up and locked) not consistent with commanded position (extended) on the lever.
	Amber	GEAR DISAGREE caution message on the EICAS. After a confirmation delay, gear position (in transit) not consistent with commanded position (extended or retracted) on the lever.
UP	Red	GEAR warning message on the EICAS. During approach or landing, 30 seconds after command, gear position (up and locked) not consistent with commanded position (extended) on the lever.
	Red	GEAR warning message on the EICAS. During approach or landing, 30 seconds after command, gear position (in transit) not consistent with commanded position (extended) on the lever.



EICAS PAGE

EICAS WARNING MESSAGE

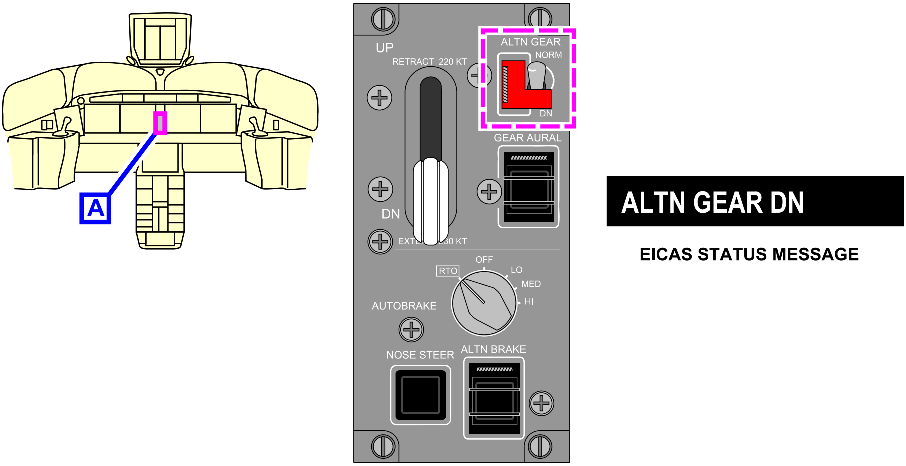
EICAS CAUTION MESSAGE

EICAS page – Landing gear position legend
Figure 14–02–10

C. ALTN GEAR switch

The ALTN GEAR (alternate gear) switch, located on the landing gear panel (refer to Figure 14–02–11), is used to electrically release the landing gear uplocks which allow the gear to free-fall.

- NORM: The alternate extension is off.
- DN: The landing gear free-falls to the down and locked position and the status message **ALTN GEAR DN** displays on the EICAS page.



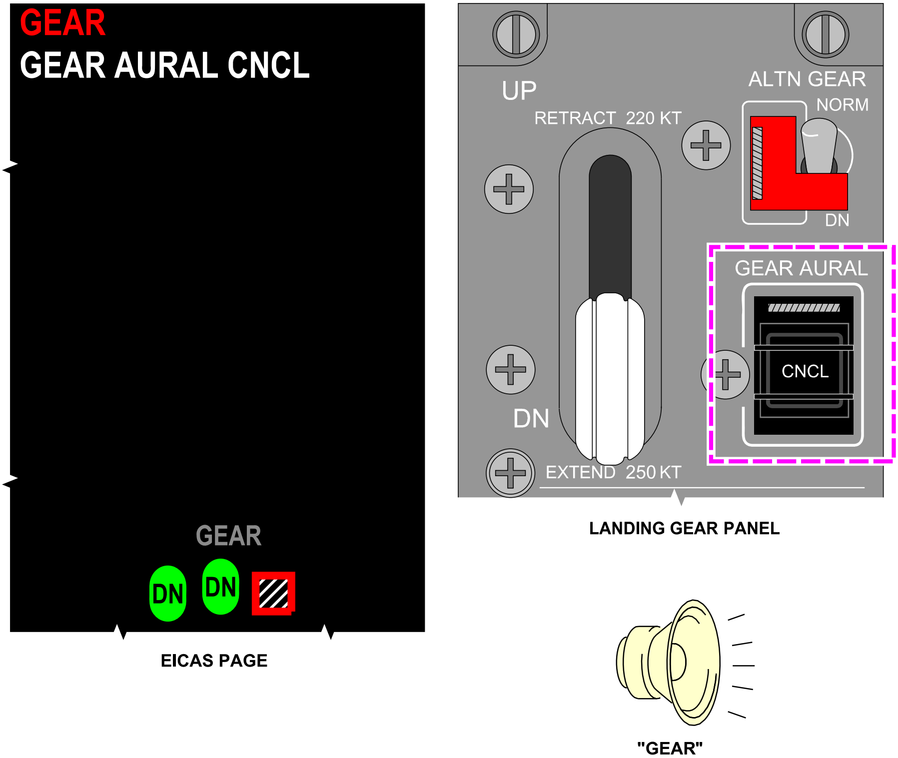
LANDING GEAR PANEL

A

ALTN GEAR Switch
Figure 14–02–11

D. GEAR AURAL switch

The guarded GEAR AURAL switch (refer to Figure 14–02–12) allows the crew to mute the "GEAR" aural warning. When selected, the white CNCL legend is illuminated and the **GEAR AURAL CNCL** status message is displayed on the EICAS page.



GEAR AURAL switch
Figure 14–02–12

If the landing gear is not down and locked during approach, the “GEAR” aural warning sounds continuously.

The “GEAR” aural warning cannot be muted if:

- The landing gear is not down and locked, and,
- RAD ALT is less than 1000 ft AGL, with both thrust levers set to approach idle, or

- The SLAT/FLAP lever is set to a landing position and the aircraft is in a descent.

The “GEAR” aural warning can be muted if all the conditions that follow are met:

- The landing gear is not down and locked,
- All radio-altimeters have failed and pressure altitude is below 15000 ft,
- Both thrust levers are at idle, and
- The SLAT/FLAP lever is in the landing position.

LANDING GEAR – EICAS MESSAGES

A. Warning messages

Message	Description	Aural	Inhibit
GEAR	Attempt to land is detected and one (or more) of the landing gear is not down and locked.	GEAR	TO

B. Caution messages

Message	Description	Inhibit
GEAR DISAGREE	Discrepancy in landing gear position and commanded position of the landing gear lever after time delay.	None
GEAR FAIL	Landing gear normal extension/retraction system failed or no communication is available.	TO
WOW FAIL	Weight-On-Wheels (WOW) functionality system failed or no communication is available.	TO, LDG

C. Advisory messages

Message	Description	Inhibit
ALTN GEAR DN	Alternate extension dormancy check is performed on the uplocks.	TO, LDG
GEAR FAULT	Landing gear extension/retraction system redundancy is lost or dormancy test has detected a failure of the alternate extension.	TO, LDG
WOW FAULT	Weight-On-Wheels (WOW) functionality system redundancy is lost.	TO, LDG

D. Status messages

Message	Description	Inhibit
ALTN GEAR DN	Alternate extension switch is detected in down position.	None
GEAR AURAL CNCL	Gear aural warning inhibited.	None
PEDAL STEER DISC	Pedal steering has been disconnected.	None

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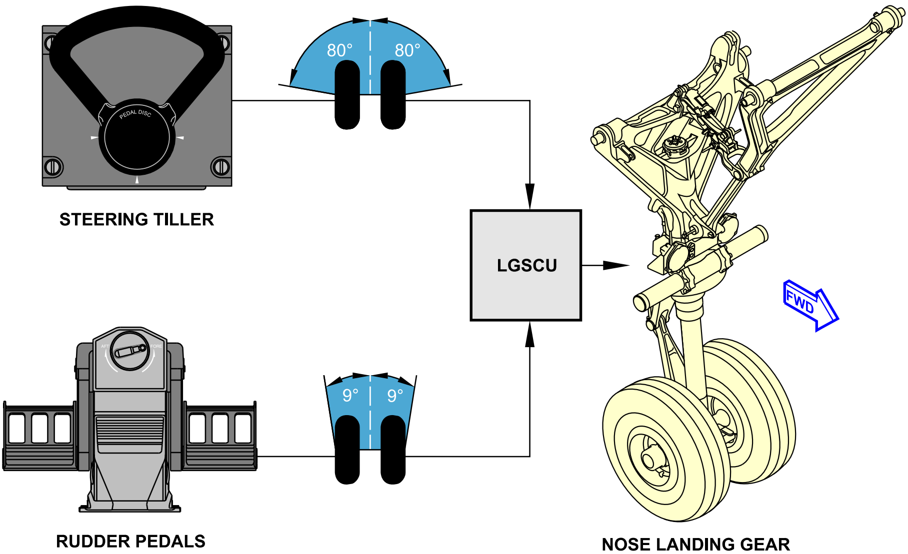
NOSEWHEEL STEERING SYSTEM – OVERVIEW

The Landing Gear and Steering Control Unit (LGSCU) commands and monitors the steer-by-wire steering system (refer to Figure 14–03–1). It receives the input from the rudder pedals or tiller to command the steering control valve. The steering control valve supplies hydraulic pressure from hydraulic system No. 2 to the steering motor, which drives a rack and pinion gear to turn the nose landing gear.

Position sensors, installed on the nose landing gear main fitting, supply steering angle feedback to the LGSCUs.



Nosewheel steering system
Figure 14–03–1

NOSEWHEEL STEERING SYSTEM – DESCRIPTION AND OPERATION

A. Operation

The Landing Gear and Steering Control Unit (LGSCU) controls the nosewheel position based on the inputs from the steering tiller on the pilot side console, or the rudder pedals. <32510001D>

The steering tiller turns the nosewheel up to 80 degrees either side of center, and is intended for low speed taxi and maneuvering in the ramp area. The steering tiller is automatically centered by a spring and it's movement is damped to avoid overtravel and to be more representative of nose wheel motion.

The steering angle limitations are automatically a function of the aircraft speeds that follow:

(1) Turning with one steering tiller only

Ground speed below 30 kt: There is no reduction. The steering tiller controls the nosewheel up to 80 degrees either side of center, and is intended for low speed taxi.

Ground speed between 30 kt and 100 kt: There is a proportional reduction. As the ground speed increases, steering tiller control of the nosewheel decreases automatically from 80 to 9 degrees either side of center.

Ground speed above 100 kt: There is maximum reduction. The steering tiller control of the nosewheel is limited to 9 degrees either side of center.

The rudder pedals turn the nosewheel to 9 degrees either side of the center and are intended for high speed taxi, take-off, and landing rollouts.

When a turn is executed with the steering tiller and rudder pedals at the same time in the same direction, the LGSCU algebraically adds the two commands. This results in an increased angle for the turn up to the maximum of 80 degrees.

When a turn is executed with the steering tiller and rudder pedals in the opposite directions and at the same time, the LGSCU algebraically adds the two commands. This results in a decreased angle for the turn.

NOTE

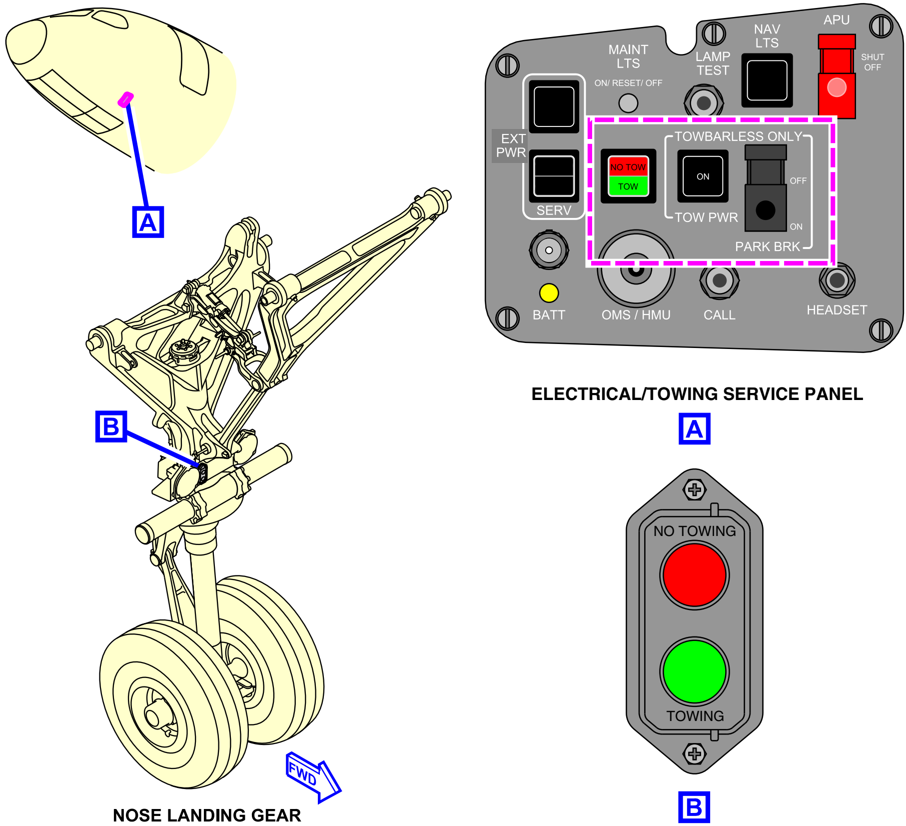
In the event of a nosewheel steering system failure, the nosewheel is capable of castering.

B. Towbarless towing

Towbarless towing permits ground crew to configure and tow the aircraft without having to access the flight compartment. When the TOW PWR switch (refer to Figure 14–03–2 <23410001D> or <23411001C>), located on the electrical/towing service panel, is selected ON, electrical power from the DC EMER BUS is used to apply or release the parking brake by selecting the PARK BRK switch to the required position.

The TOW/NO TOW lights (refer to Figure 14–03–2 <23410001D> or <23411001C>), also powered by the TOW PWR switch, indicate to the ground crew if the aircraft can be safely towed. The red NO TOW light illuminates if the nosewheel steering system is active and/or if any braking force is applied to the brakes. The green TOW light illuminates to indicate that the aircraft can be safely towed when both the nosewheel steering system and the brake system are disengaged.

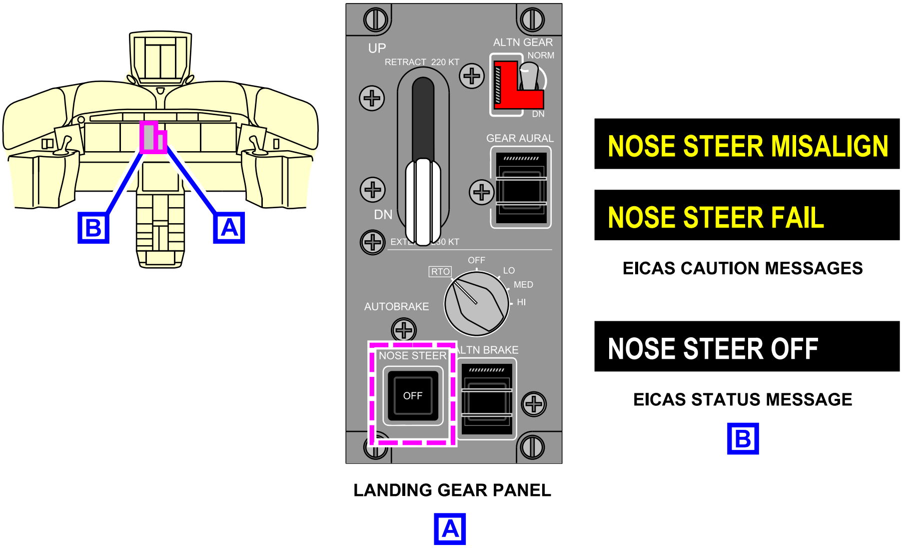
TOWING/NO TOWING indicator lights (refer to Figure 14–03–2 <23410001D> or <23411001C>) are installed on the nose landing gear, between the taxi light and landing light, to provide the same indications as described above.



Towbarless towing indications <23410001D> or <23411001C>
Figure 14–03–2

C. Nosewheel steering system disconnect

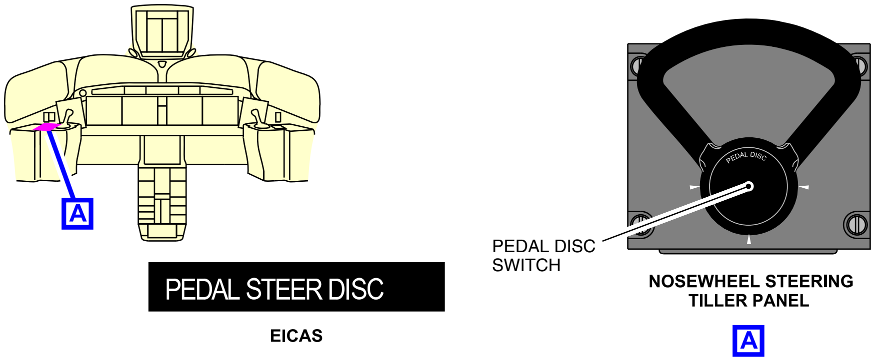
The NOSE STEER switch on the landing gear panel disengages the nosewheel steering system for towing and ground safety. This allows a larger towing turn radius of up to 130 degrees either side of center, without disconnecting the torque links. When selected, the OFF label illuminates white and the status message **NOSE STEER OFF** displays on the EICAS synoptic page (refer to Figure 14–03–3).



NOSE STEER switch
Figure 14–03–3

D. Rudder pedal disconnect

The PEDAL DISC (Disconnect) switch (refer to Figure 14–03–4), located on the steering tiller, disconnects the rudder pedals from the steering system to allow for ground rudder checks without steering the nosewheel. A PEDAL STEER DISC status message is displayed on the EICAS page.

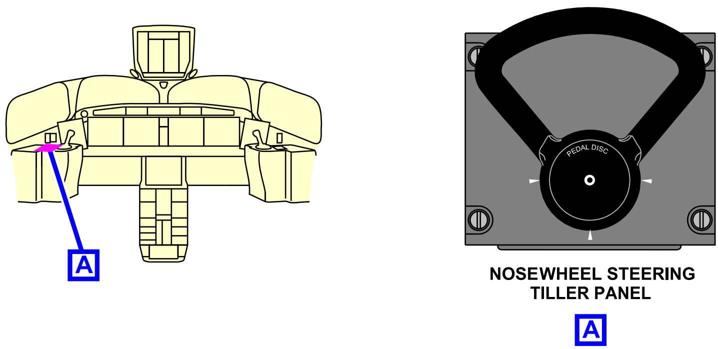


Rudder pedal disconnect
Figure 14–03–4

NOSEWHEEL STEERING SYSTEM – CONTROLS AND INDICATIONS

A. Steering tiller

The steering tiller commands up to ±80 degrees of the nosewheel steering deflection. The PEDAL DISC (Pedal disconnect) switch (refer to Figure 14–03–5), is integrated in the center of the tiller. When pushed, it disconnects the rudder pedals from the steering system to facilitate rudder control checks.

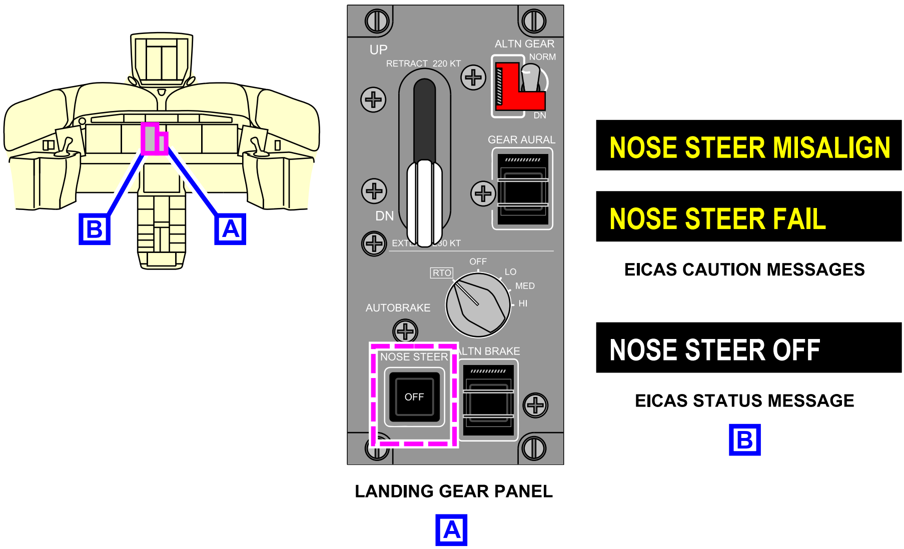


Steering tiller
Figure 14–03–5

B. NOSE STEER switch

The NOSE STEER switch on the landing gear panel is used to turn the nosewheel steering system on and off.

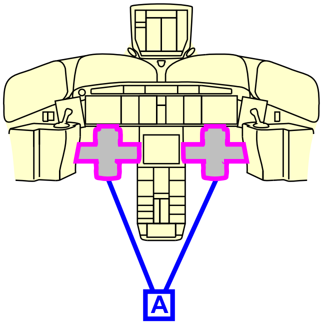
- OFF: When the NOSE STEER switch (refer to Figure 14–03–6) is pushed, it disables the nosewheel steering system. The OFF label illuminates white on the switch and the **NOSE STEER OFF** status message displays on the EICAS page.

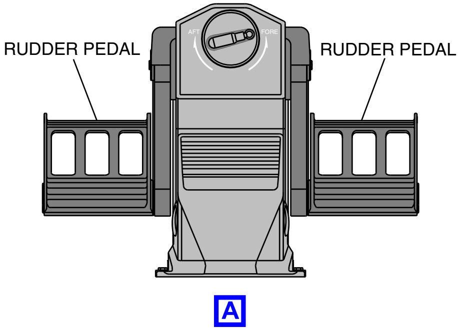


NOSE STEER switch
Figure 14–03–6

C. Rudder pedals

The rudder pedals (refer to Figure 14–03–7) provide fine-angle inputs for the nosewheel steering control system. The rudder pedals command a deflection up to 9 degrees either side of the center of the nosewheel steering.





Rudder pedals
Figure 14–03–7

NOSEWHEEL STEERING – EICAS MESSAGES

A. Warning messages

None

B. Caution messages

Message	Description	Inhibit
NOSE STEER FAIL	Nosewheel steering system failed OR no communication is available from both LGSCUs.	TO
NOSE STEER MISALIGN	Nosewheel angle is beyond active steering range.	TO, LDG

C. Advisory messages

Message	Description	Inhibit
NOSE STEER FAULT	Loss of redundancy of nosewheel steering system, or reduced functionality.	TO, LDG

D. Status messages

Message	Description	Inhibit
NOSE STEER OFF	Steering disabled (castor mode) through the NOSE STEER switch.	None
PEDAL STEER DISC	Rudder pedal steering off is evaluated, and reported by one of the Landing Gear Steering Control Units (LGSCUs).	None

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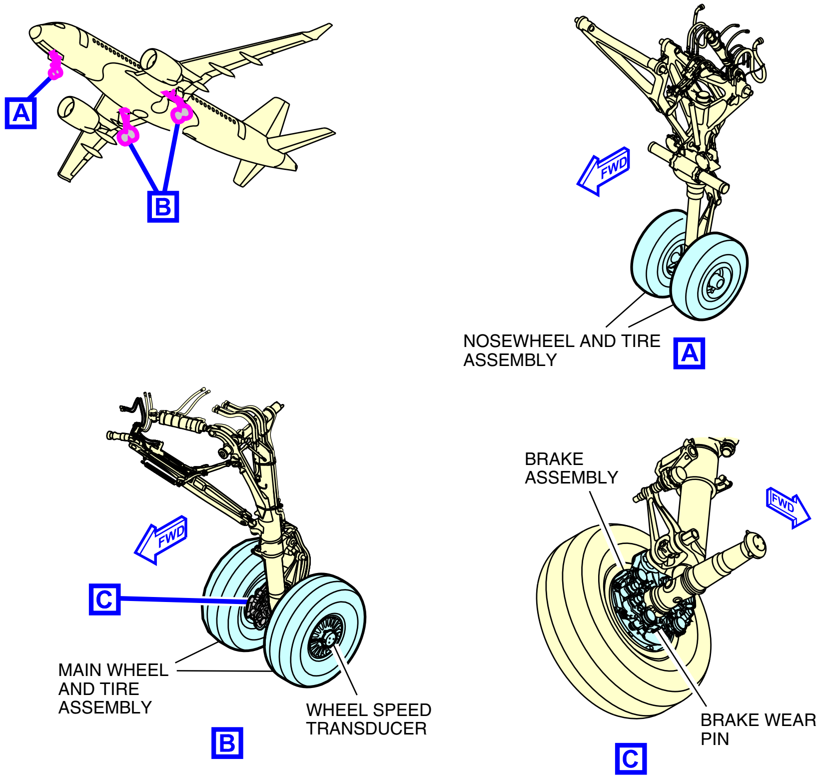
WHEELS, TIRES, AND BRAKES – OVERVIEW

There are two wheel and tire assemblies on each landing gear (refer to Figure 14–04–1). All landing gear wheels have a tire pressure monitoring system. The main landing gear wheel wells also have a brake temperature monitoring system and a landing gear bay overheat detection system. The main landing gear are equipped with brakes on each wheel. The electric brakes are activated by the brake function (toe) of the rudder pedals or by the AUTOBRAKE switch. The brakes also include a parking brake function. The brake assemblies incorporate an anti-skid system, Brake Temperature Monitoring System (BTMS), and wear sensors.

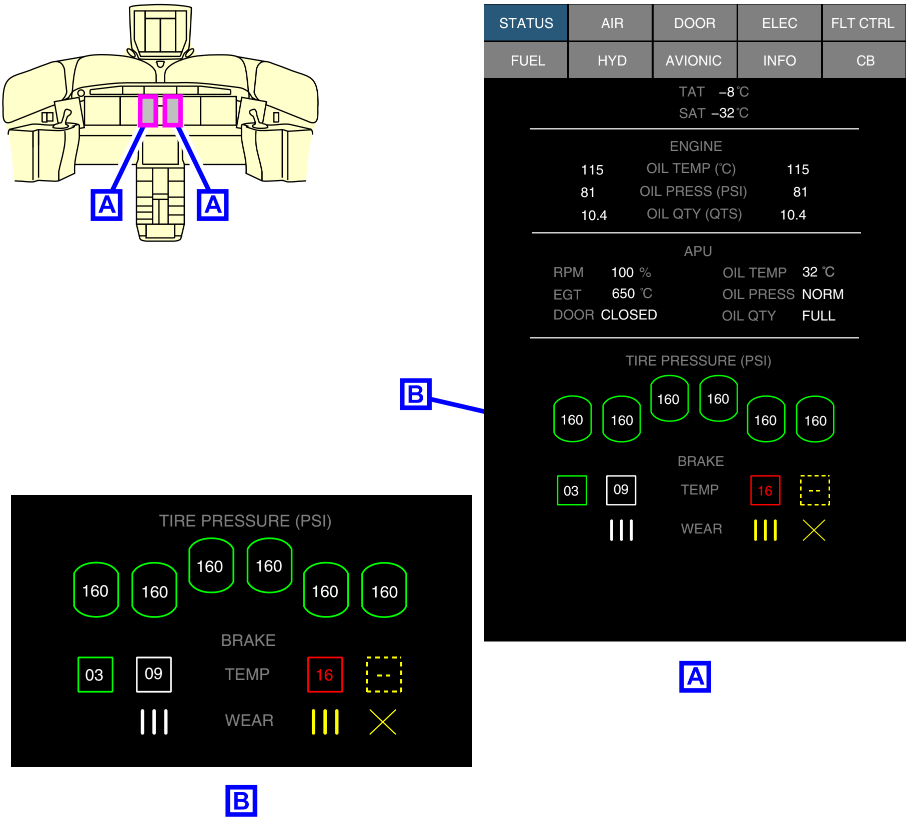
Tire pressure, brake temperatures, and wear data are transmitted to the STATUS synoptic page (refer to Figure 14–04–2).

NOTE

Wear data is only shown when there is less than 5% of brake life remaining (equivalent to less than 100 landings).



Wheel and tire assembly
Figure 14–04–1



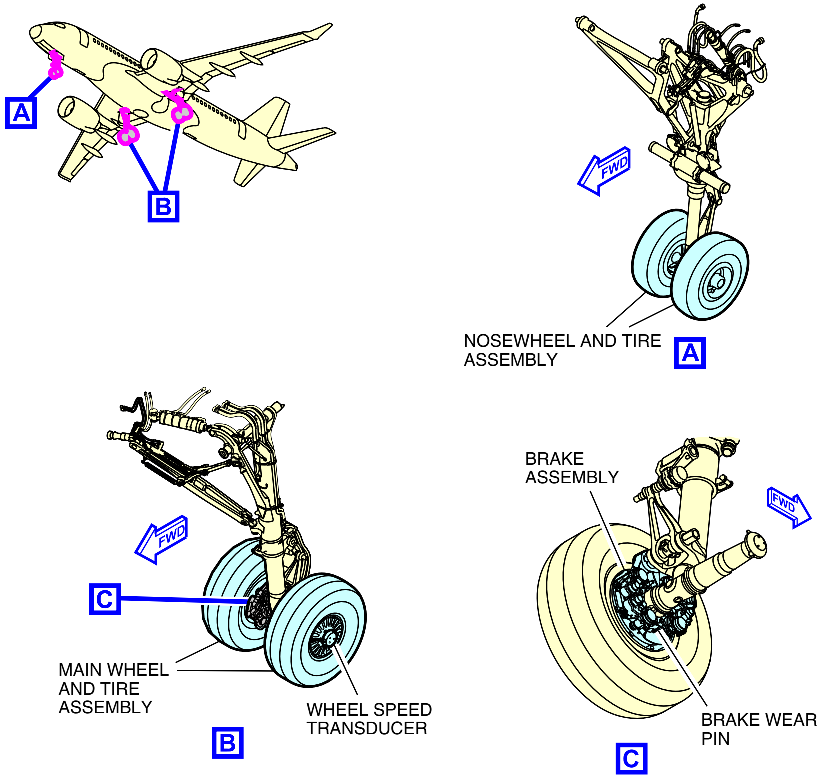
STATUS synoptic page – Indications
Figure 14–04–2

WHEELS, TIRES, AND BRAKES – DESCRIPTION AND OPERATION

A. Wheels, tires, and brakes

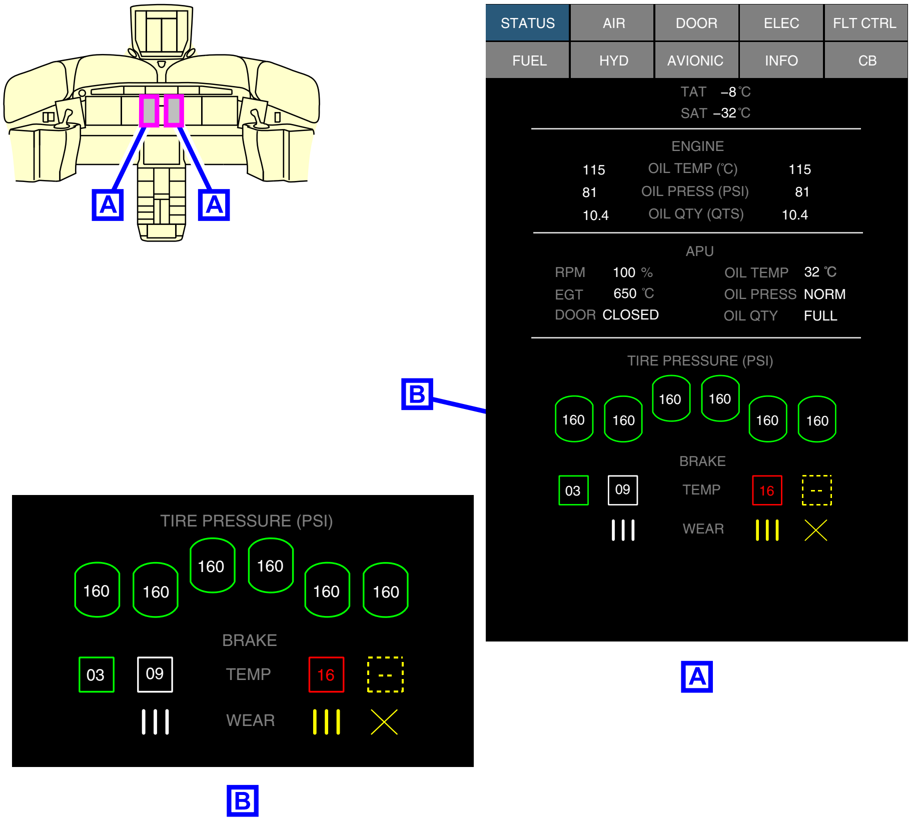
(1) Wheels and tires

There are two conventional split-hub wheel assemblies on each landing gear strut (refer to Figure 14–04–3). The main landing gear wheel assemblies have a wheel speed transducer to transmit wheel speed information for the operation of the anti-skid system and spoiler actuation. All wheels have an over-inflation protection plug to protect against overpressure (approximately 400 psi).



Wheel and tire assembly
Figure 14–04–3

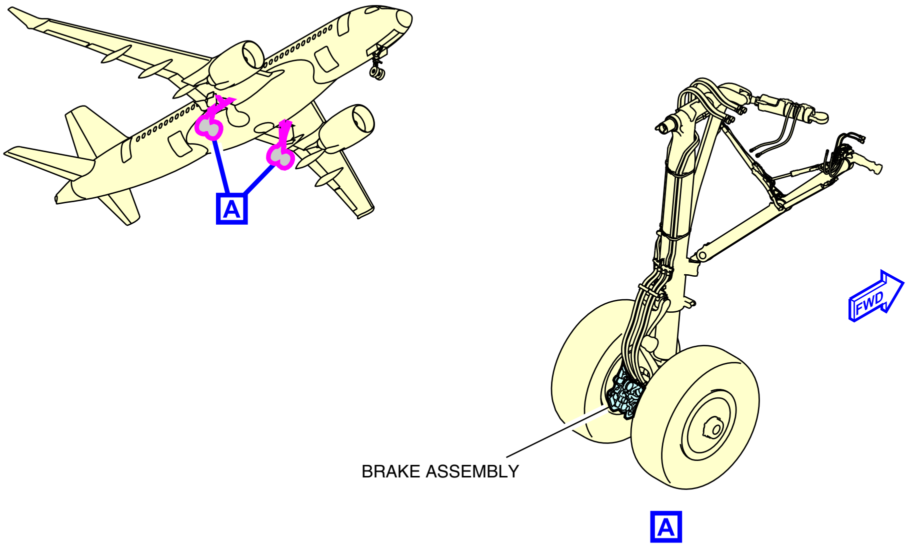
A tire pressure indicating system is installed to monitor and transmit tire pressure information to the STATUS synoptic page (refer to Figure 14–04–4). There are three fusible plugs installed on the brake side of each main wheel to release tire pressure when the wheel temperature exceeds approximately 200°C.



STATUS synoptic page – Indications
Figure 14–04–4

(1) Electric brakes

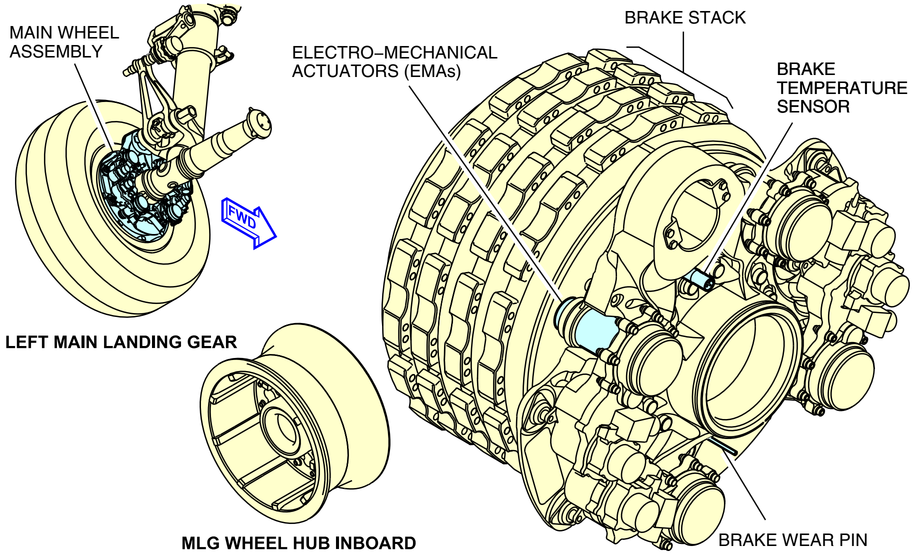
There is one brake assembly installed on each wheel of the main landing gear (refer to Figure 14–04–5).



Brake assembly
Figure 14–04–5

Each brake assembly is fitted with one carbon brake stack and four Electric Motor Actuators (EMAs) housed in a carrier plate (refer to Figure 14–04–6).

A brake temperature sensor is installed on each brake unit. Brake wear is computed by the EMAC controllers in relation to EMA travel. A brake wear pin is installed on each brake assembly for visual inspection.



Main wheel – Brake assembly and tire assembly
Figure 14–04–6

When commanded, the brake system uses 28 VDC from the DC ESS 1 and DC ESS 2 busses to energize the EMAs, thereby compressing the brake stacks and decelerating the aircraft. Brake temperature and wear are monitored and transmitted to the STATUS synoptic page by the Brake Data Concentrator Units (BDCUs) (refer to Figure 14–04–4).

B. Brake Data Concentrator Units (BDCUs)

Two Brake Data Concentrator Units (BDCUs) control and monitor the EMAs, brake temperature, wheel speed, and tire pressure. Internally, each BDCU has a NORMAL and an ALTERNATE module. Both BDCUs work simultaneously in tandem with no priority set-up. The BDCUs send command signals to each of the four Electric Motor Control Unit (EMCU). Each EMCU consists of two Electric Motor Actuator Controllers (EMACs). Each EMAC then sends signals to two of the four EMAs on one brake assembly, and to two other EMAs on a different brake assembly. Each brake assembly has four EMAs (two pairs). To provide safety and redundancy, each pair of EMAs receives command signals from a different EMAC, which is in turn controlled by a different EMCU.

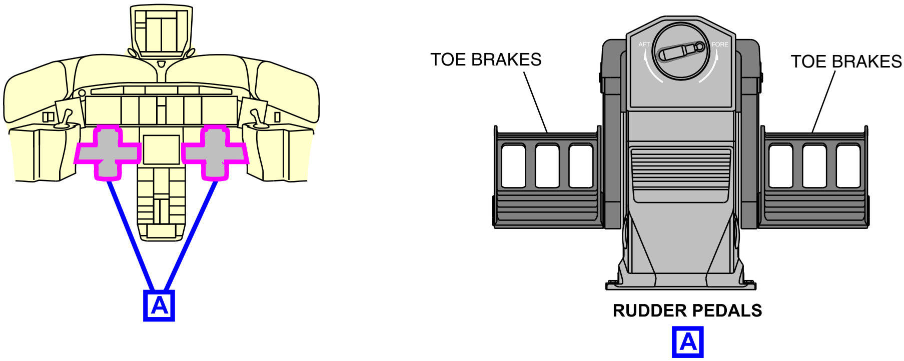
The BDCUs detect faults in the brake system and provide braking protection. They are bypassed if the parking brake or alternate braking is selected. The BDCUs send tire pressure and brake data to the STATUS synoptic page for display. The brake wear data displays on the STATUS synoptic page only when there is less than 5% of brake life remaining. If one BDCU fails, the other can take over and control the entire brake system.

C. Normal braking

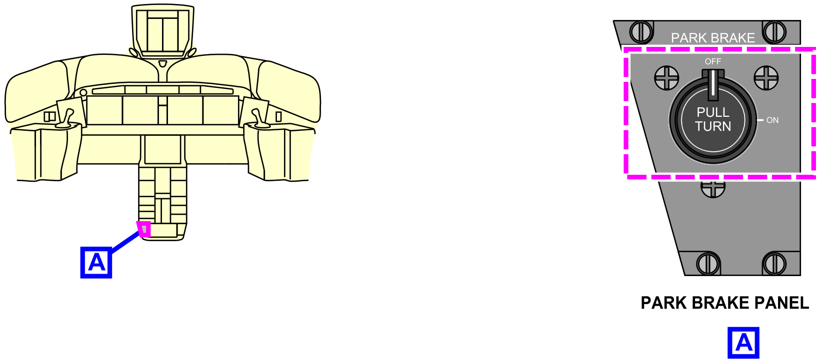
The brake system permits controlled speeds while taxiing, differential braking, and optimum deceleration rates during landing or rejected takeoff. The controls of the brake system are:

- The toe brakes (refer to Figure 14–04–7),
- The PARK BRAKE (refer to Figure 14–04–8), and
- The AUTOBRAKE switch (refer to Figure 14–04–9).

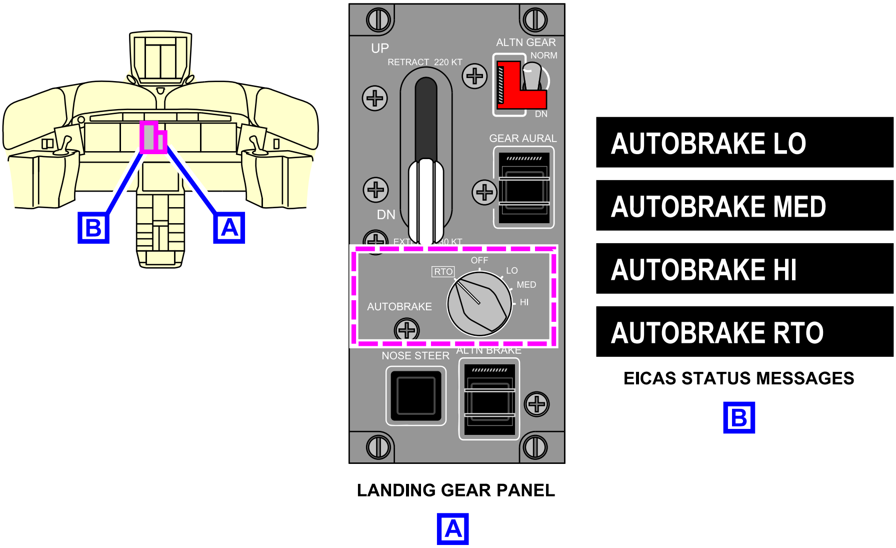
The BDCUs receive the command inputs, calculate the required pressure using the respective sensors, and transmit the appropriate braking signal to the brakes. The EMAC also protect the aircraft from wheel skidding or locking during normal braking.



Toe Brakes
Figure 14–04–7



Parking brake switch
Figure 14–04–8



AUTOBRAKE switch
Figure 14–04–9

D. Braking system protection

During normal braking mode, the EMAC provide the braking protection functions that follow:

- Anti-skid protection,
- Landing gear retraction braking
- Touchdown protection,
- Locked wheel protection, and
- De-rotation.

(1) Anti-skid protection

The anti-skid protection provides variable wheel speed control to eliminate deep skid at each individual brake to minimize stopping distance. Anti-skid is available at more than 204 knots. If the wheel speed is higher than 204 knots, the BCS will consider the wheel speed at 204 knots. It is deactivated below wheel speeds of 10 knots.

(2) Retraction braking

Landing gear retraction braking is activated when the landing gear control lever is selected up. The BDCUs transmit a braking signal to all brakes for 5 seconds, stopping the main wheels from rotating during landing gear retraction.

(3) Touchdown protection

The touchdown protection prevents brake actuation while the aircraft is in flight. This is to prevent any main wheel tire from bursting on landing due to a locked wheel (brakes applied).

(4) Lock wheel protection

The locked wheel protection releases the respective brake of a locked wheel when detected. When taxiing, to avoid braking command release during turning maneuvers, the locked wheel protection is inhibited with wheel speeds below 30 knots.

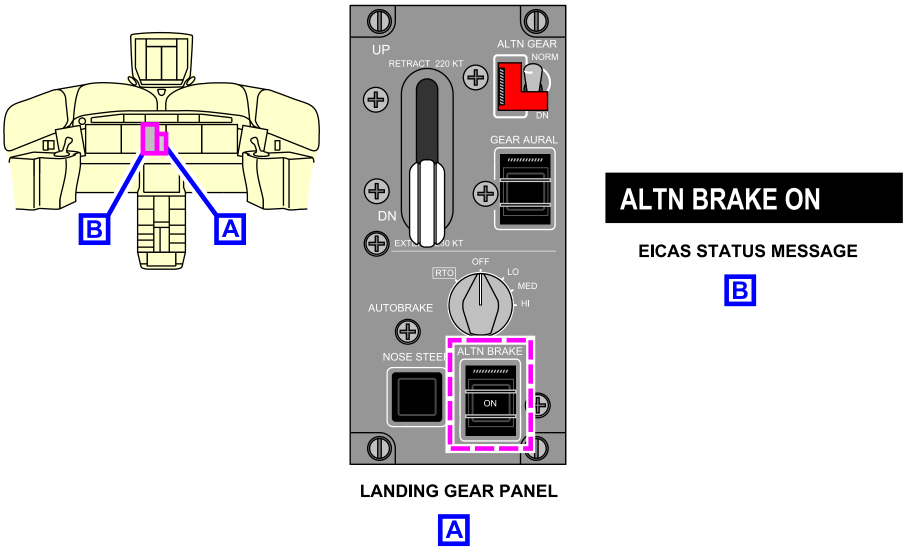
(5) De-rotation

The de-rotation function of the BDCUs is activated after main wheel touchdown with the nose landing gear still in the air. This limits the braking force which prevents abrupt nosewheel impact and improves stopping distances. It is disabled when any of the following conditions occur:

- Nose landing gear confirmed on ground (nose WOW),
- Nose pitch angle is less than 1.5 degrees, or
- Time delay of 5 seconds after main gear wheels spin up.

E. Alternate brake mode

In the event of a normal braking system malfunction, an alternate brake mode is available via the ALTN BRAKE guarded switch on the landing gear panel. This mode provides direct, proportional control from the rudder pedals' toe brakes to the EMAs on the wheels. There are no braking system protections available when the alternate brake mode is activated. When the alternate brake mode is selected, the ON light on the switch illuminates and the status message **ALTN BRAKE ON** is displayed on the EICAS synoptic page (refer to Figure 14–04–10).



ALTN BRAKE switch
Figure 14–04–10

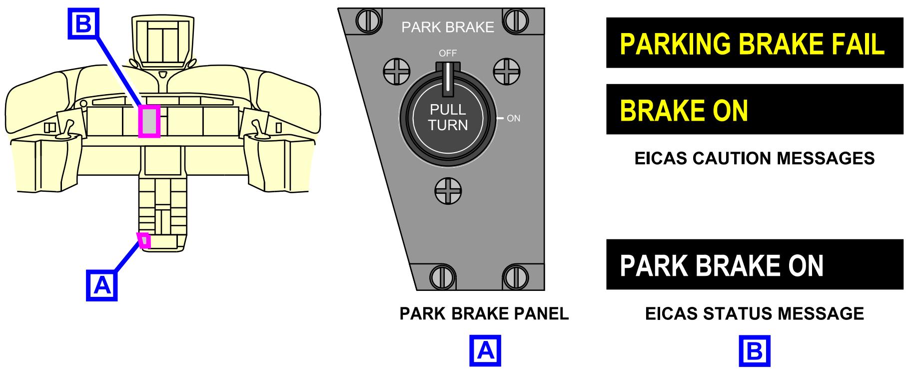
F. Parking brake

When the PARK BRAKE switch (refer to Figure 14–04–11) is selected ON (pulled and turned), the aircraft electric brakes lock in the braked position. An internal mechanism in the actuator will keep the brakes in the locked position without electrical power. The parking brake can be applied and removed when the aircraft is powered by 28 VDC power from the DC essential busses 1 and 2 (DC ESS 1 and DC ESS 2).

When the parking brake is applied, each Electromechanical Actuator (EMA) provides a variable parking brake force between 3000 and 11500 lb per EMA, depending on the position of the thrust levers. The status message **PARK BRAKE ON** is displayed on the EICAS page.

The parking brake system can be used to stop the aircraft when the normal and alternate braking systems have failed on ground. If parking brake is activated in air mode, the park brake is failed until system repowered on ground. There are no braking system protections available when using the parking brake for decelerating.

The caution message **PARKING BRAKE FAIL** is displayed on the EICAS page if the parking brake force is insufficient or the park brake has been selected in air mode. If an uncommanded parking force greater than 200 lb is detected, the caution message **BRAKE ON** is displayed on the EICAS page.

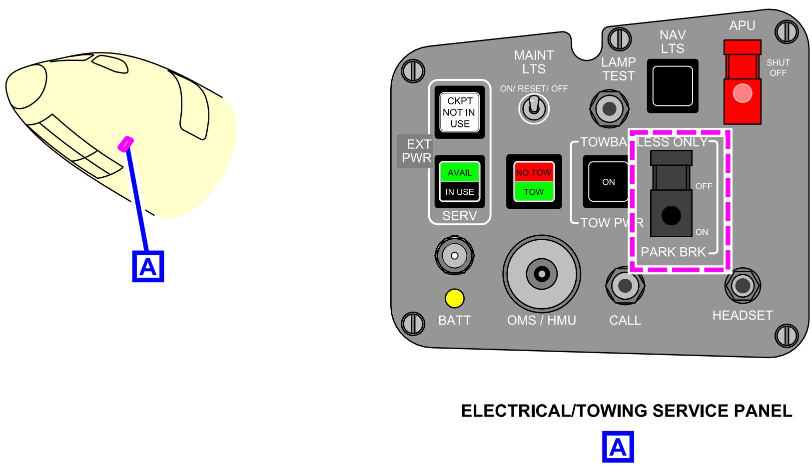


Parking brake operation
Figure 14–04–11

The parking brakes can also be applied by the ground crew from the electrical/towing service panel with the PARK BRK guarded switch, powered by the DC EMER BUS (refer to Figure 14–04–12). When the TOW PWR switch is selected ON, the PARK BRK guarded switch can be used to apply (ON) or remove (OFF) the parking brakes.

The flight deck PARK BRAKE switch has priority over the electrical/towing service panel PARK BRK switch. If any of the battery switches (BATT 1 or BATT 2) on the ELECTRICAL panel are selected to AUTO, the electrical/towing service panel PARK BRK switch is inhibited and the parking brakes are set to the flight deck PARK BRAKE switch position.

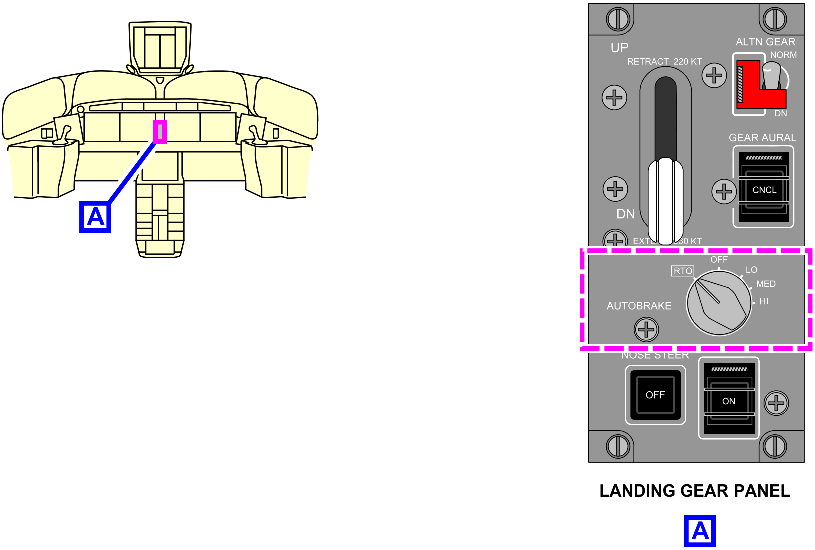
<Mod 240006> or <Post–SB BD500–240006>



External Parking Brake Control
Figure 14–04–12

G. Automatic braking

The braking system supplies automatic braking after landing or during a rejected takeoff. Automatic braking is controlled with the AUTOBRAKE switch on the landing gear panel (refer to Figure 14–04–13).



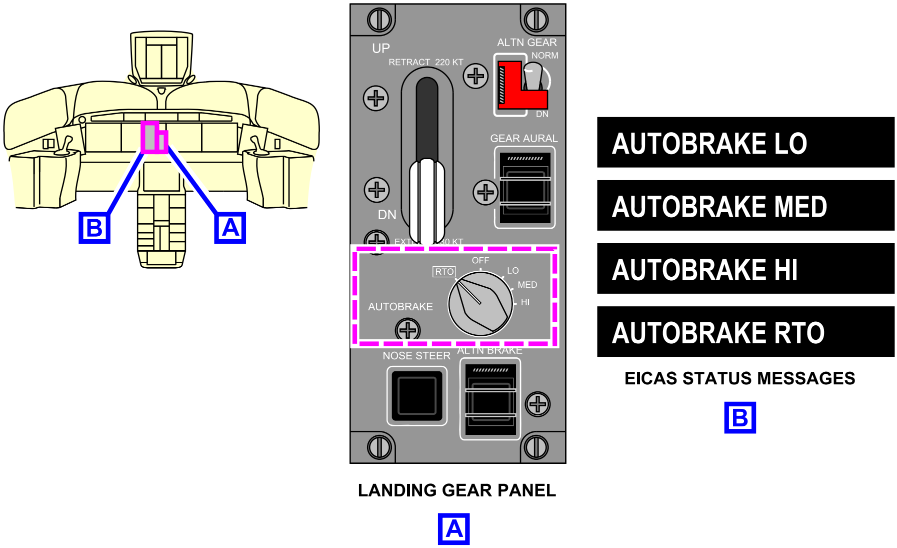
AUTOBRAKE switch
Figure 14–04–13

(1) Rejected takeoff

- Below 60 kt: If a takeoff is rejected at a ground speed less than 60 kt, manual braking is necessary to stop the aircraft, regardless of the AUTOBRAKE switch position.
- Above 60 kt: When the AUTOBRAKE switch is selected to RTO (Rejected Takeoff) and the throttle levers are moved to idle, the automatic braking system activates and optimum braking is applied to stop the aircraft using maximum possible deceleration force. When the switch is selected to RTO, the **AUTOBRAKE RTO** status message is displayed on the EICAS page. Refer to Figure 14–04–14.

(2) Landing

When the AUTOBRAKE switch is selected to LO, MED, or HI, the automatic braking system activates and provides a deceleration rate according to the selected intensity. These selections result in the respective **AUTOBRAKE LO**, **AUTOBRAKE MED** or **AUTOBRAKE HI** status message to be displayed on the EICAS page. Refer to Figure 14–04–14.



AUTOBRAKE switch
Figure 14–04–14

On ground, the automatic braking system will only allow RTO to be selected. In the air, only the selection of LO, MED and HI are possible.

The automatic braking system is deactivated when manual braking is applied (greater than 20%), or when the AUTOBRAKE switch is selected to OFF, or if the thrust levers are advanced above idle.

WHEELS, TIRES, AND BRAKES – CONTROLS AND INDICATIONS

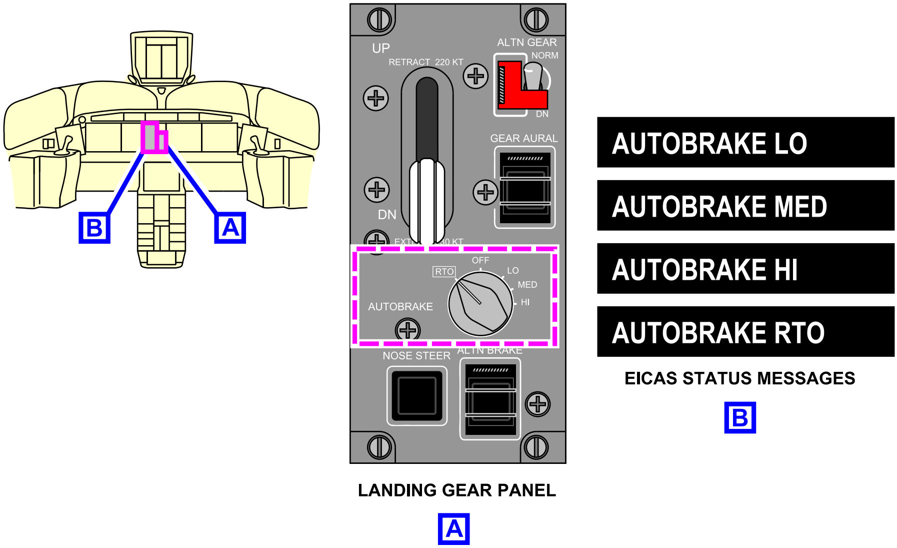
A. AUTOBRAKE switch

The autobrake function is used to maintain constant deceleration of the aircraft during landing and to stop the aircraft during a rejected takeoff. The switch is located on the landing gear panel and has a selection of different levels of deceleration from the Brake Data Concentration Units (BDCUs) (refer to Figure 14–04–15).

NOTE

The autobrake system has been shown to significantly reduce the number of brake applications required to slow the aircraft. The autobrake system also increases the life cycle of the carbon brakes.

- RTO: The status message **AUTOBRAKE RTO** displays on the EICAS page and the BDCUs arm the autobrake system to provide braking for the rejected takeoff according to the deceleration parameters that follow:
  - For a rejected takeoff below 70 kt ground speed, the deceleration rate is 8 ft/s^2 (2.44 m/s^2).
  - For a rejected takeoff above or equal to 70 kt ground speed, the maximal deceleration is applied.
- OFF: The autobrake function is deactivated.
- LO: The autobrake function is set for a low rate of deceleration of 6 ft/s^2 (1.83 m/s^2) and the status message **AUTOBRAKE LO** displays on the EICAS page.
- MED: The autobrake function is set for a medium rate of deceleration of 9 ft/s^2 (2.74 m/s^2) and the status message **AUTOBRAKE MED** displays on the EICAS page.
- HI: The autobrake function is set for the maximum deceleration and the status message **AUTOBRAKE HI** displays on the EICAS page.

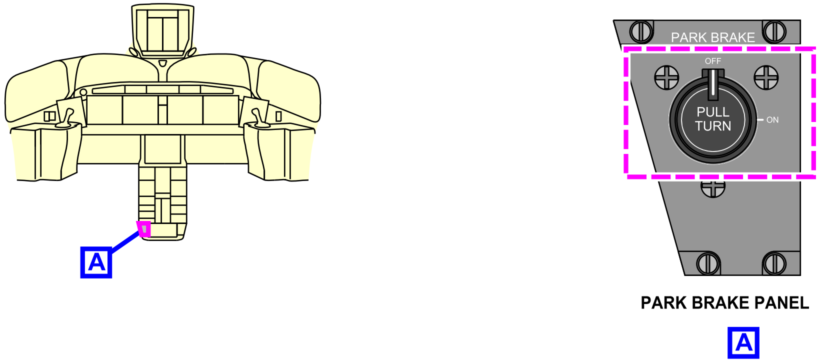


AUTOBRAKE switch
Figure 14–04–15

B. PARK BRAKE switch

The parking brake switch is located on the PARK BRAKE panel (refer to Figure 14–04–16) on the center pedestal. It is labeled PULL TURN. When selected to ON, the status message **PARK BRAKE ON** displays on the EICAS page.

- OFF: The parking brake system is deactivated.
- ON: The parking brake system is activated.

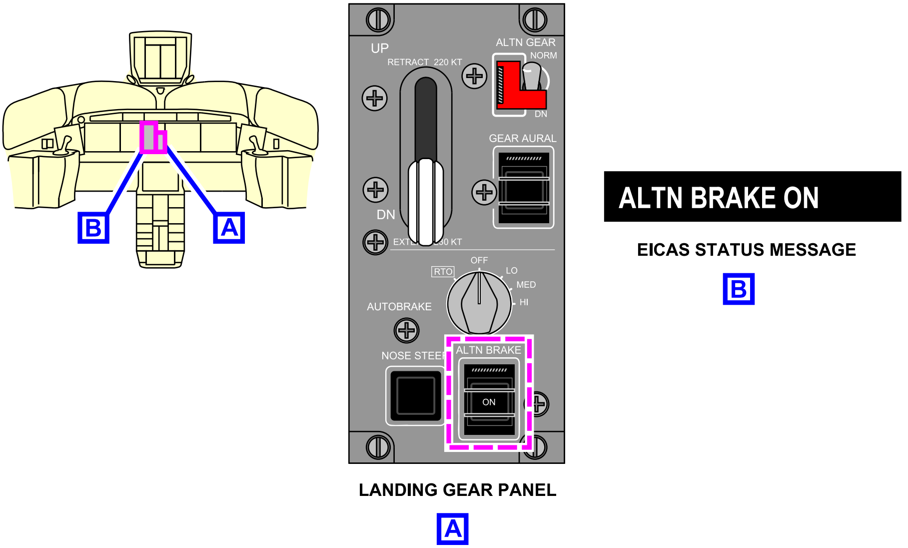


Parking brake switch
Figure 14–04–16

C. ALTN BRAKE switch

The ALTN BRAKE guarded switch (refer to Figure 14–04–17) is used to enable the alternate braking function during non-normal operation. When the switch is pushed in, the BDCUs are bypassed and the brakes are controlled directly by brake pedal actuation. The autobrake function and all normal brake protections are not available.

- ON: When the ALTN BRAKE switch is pushed, it latches and the ON label illuminates white to indicate that the alternate braking is activated. The status message **ALTN BRAKE ON** displays on the EICAS page.

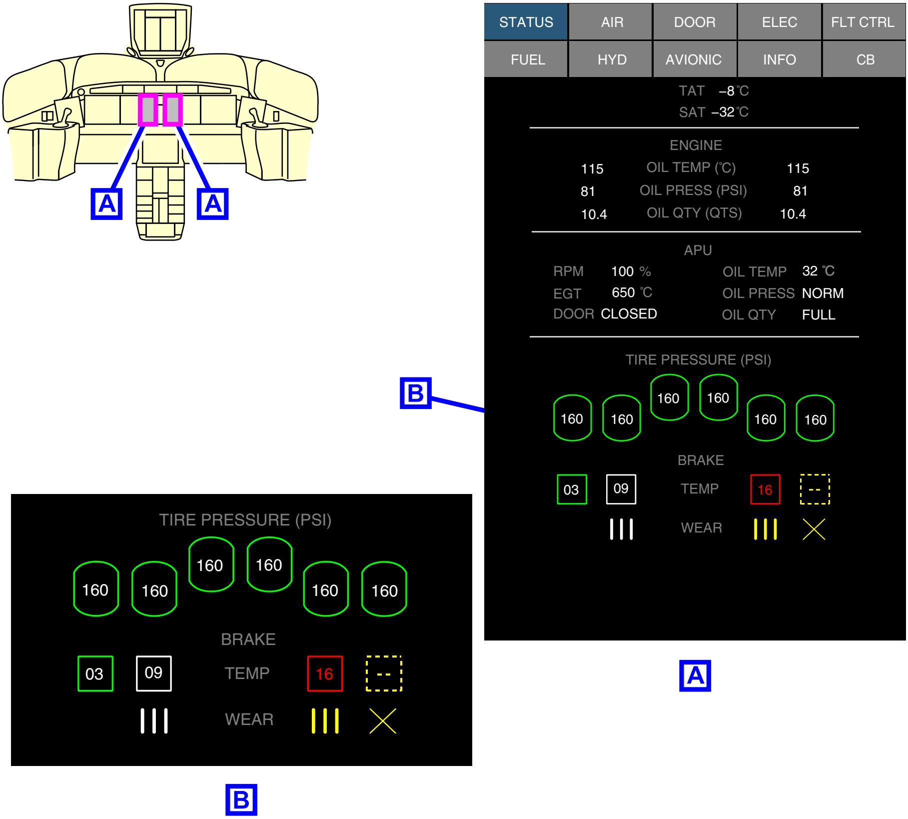


ALTN BRAKE switch
Figure 14–04–17

D. STATUS synoptic page

The STATUS synoptic page contains the gear and brake indications that follow (refer to Figure 14–04–18):

- Tire pressure (psi),
- Brake temperature (BRAKE TEMP), and
- Brake wear (BRAKE WEAR).



STATUS synoptic page – Indications
Figure 14–04–18

Figure 14–04–19 describes the tire and brake indications on the STATUS synoptic page.

TIRE PRESSURE (TIRE PRESSURE in grey)

Symbol	Color	Condition on ground	Condition in flight
160	GREEN	Pressure ≥ Nominal	Pressure ≥ 90% nominal
150	WHITE	90% nominal ≤ Pressure < nominal	70% nominal ≤ Pressure < 90% nominal
110	YELLOW	Pressure < 90% nominal	Pressure < 70% nominal
- - -	YELLOW	No data	No data

BRAKE TEMPERATURE (TEMP in grey)

Symbol	Color	Condition
03	GREEN	Temperature in green range (00 ≤ TEMP ≤ 06)
09	WHITE	Temperature in white range (07 ≤ TEMP ≤ 14)
16	RED	Overheat – Temperature in red range (15 ≤ TEMP ≤ 20)
- -	YELLOW	Temperature invalid

BRAKE WEAR (WEAR in grey)

Symbol	Color	Condition
	BLACK	Brake OK (no indication)
	WHITE	Brake to be replaced in less than 100 flights
	YELLOW	Brakes to be replaced immediately
	YELLOW	Brake wear indication invalid

STATUS synoptic page – Landing gear legend
Figure 14–04–19

The tire pressure of each wheel is displayed on the STATUS synoptic page using color-coded symbols and pressure numbers.

The temperature of each MLG wheel brake is displayed on the STATUS synoptic page as a number from 00 to 20. The number represents a range of brake temperatures where 00 is the coolest temperature and 20 is the hottest. A brake temperature from 00 to 06 is displayed in green. When a brake temperature is between 07 and 14, it is displayed in white and a BRAKE HI TEMP advisory message is displayed on the EICAS page. When a brake temperature is between 15 and 20, it is displayed in red and a BRAKE OVHT warning message is displayed on the EICAS page.

The brake wear indications are displayed on the STATUS synoptic page under each brake temperature number. The wear indications only appear when there is less than 5% of brake life remaining (equivalent to less than 100 landings).

WHEELS, TIRES AND BRAKES – EICAS MESSAGES

A. Warning messages

Message	Description	Aural	Inhibit
BRAKE OVHT	Any brake temperature reaches the temperature range of 15 or more.	None	TO
CONFIG BRAKE	Parking brake is applied when in takeoff mode.	CONFIG BRAKE	None

B. Caution messages

Message	Description	Inhibit
AUTOBRAKE FAIL	Failure of the autobrake system after being armed or autobrake function cannot be armed.	TO

Message	Description	Inhibit
BRAKE FAIL	Total loss of braking in the normal mode (NORM BRAKE FAIL) and the alternate mode (ALTN BRAKE FAIL).	TO
BRAKE ON	Detection of uncommanded brake force greater than 200 lb or parking brake is on in flight.	TO
CPLT BRAKE PEDAL FAIL	Normal and alternate modes for the copilot pedal braking are not available on the left and/or right copilot brake pedals.	TO
L BRAKE FAIL	Three or more EMAs on left landing gear are failed, or two EMAs adjacent to each other on left landing gear have failed, or at least one wheel speed transducer (both channels) on left landing gear wheels has failed.	TO
R BRAKE FAIL	Three or more EMAs on right landing gear are failed, or two EMAs adjacent to each other on right landing gear have failed, or at least one wheel speed transducer (both channels) on right landing gear wheels has failed.	TO
NORM BRAKE FAIL	Total loss of braking in the normal mode or communication failure from Brake Data Concentrator Units (BDCUs).	TO
NOSE TIRE LO PRESS	Nose tire pressure below 70% of nominal pressure in flight.	TO, LDG
PARK BRAKE FAIL	Failure to set parking brake or insufficient parking force available after commanding the function.	TO
PLT BRAKE PEDAL FAIL	Normal and alternate modes for the pilot pedal braking are not available on the left and/or right pilot brake pedals.	TO

C. Advisory messages

Message	Description	Inhibit
ALTN BRAKE FAIL	Failure of the alternate brake function or loss of a pilot and copilot brake pedal.	TO, LDG
BRAKE FAULT	Loss of redundant or non-critical function for the brake control system.	TO, LDG
BRAKE HI TEMP	Any brake temperature range reaches 7 or greater.	TO, LDG
L BRAKE DEGRADED	Partial loss of functionality on left brake.	TO, LDG
R BRAKE DEGRADED	Partial loss of functionality on right brake.	TO, LDG
TIRE LO PRESS	On ground, any tire < 90 % of nominal pressure. In flight, main tire < 70% of tire pressure.	TO, LDG
TIRE PRESS FAULT	One or more sensors failed on tire (info collector).	TBD

D. Status messages

Message	Description	Inhibit
ALTN BRAKE ON	ALTN BRAKE switch has been selected ON and confirmed on.	None
AUTOBRAKE HI	AUTOBRAKE switch is in the HI position and arming conditions are acceptable.	None
AUTOBRAKE LO	AUTOBRAKE switch is in the LO position and arming conditions are acceptable.	None
AUTOBRAKE MED	AUTOBRAKE switch is in the MED position and arming conditions are acceptable.	None

Message	Description	Inhibit
AUTOBRAKE RTO	AUTOBRAKE switch is in the RTO position and arming conditions are acceptable.	None
PARK BRAKE ON	PARK BRAKE switch has been selected to ON and parking brake on.	None

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CHAPTER 15 – LIGHTING

EXTERNAL LIGHTING SYSTEM

CARGO, SERVICE, AND MAINTENANCE LIGHTING

EMERGENCY LIGHTING SYSTEM

List of figures

INTERNAL LIGHTING SYSTEM

EXTERNAL LIGHTING SYSTEM

CARGO, SERVICE, AND MAINTENANCE LIGHTING

EMERGENCY LIGHTING SYSTEM

LIGHTING – CONTROLS AND INDICATIONS

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LIGHTING SYSTEM – OVERVIEW

The lighting system provides internal and external illumination for operational visibility and safety. In addition, lighting provides guidance and information to passengers and crew during normal flight conditions as well as emergency situations.

The lighting system consists of:

- Flight deck lights,
- External lights,
- Internal lights,
- Cargo, service, and maintenance lights, and
- Emergency lights.

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INTERNAL LIGHTING – OVERVIEW

The internal lighting is divided into two major areas, the flight compartment and the cabin.

The flight compartment lighting areas are illuminated by two sub-systems: the integral lighting systems and the miscellaneous lighting systems.

The cabin lighting systems are controlled by the Cabin Management System (CMS). The cabin lighting systems include:

- Main cabin lights,
- Flight attendant lights, and
- Passenger lights.

The main cabin lighting includes the ceiling lights and the sidewall lights.

The flight attendant zones include:

- Cabin entrance/boarding lights,
- Reading lights,
- Flight attendant lights and
- Cabin advisory light.

The passenger lights include the Passenger Service Unit (PSU) and the lavatory lights.

FLIGHT DECK LIGHTING – DESCRIPTION AND OPERATION

A. Description

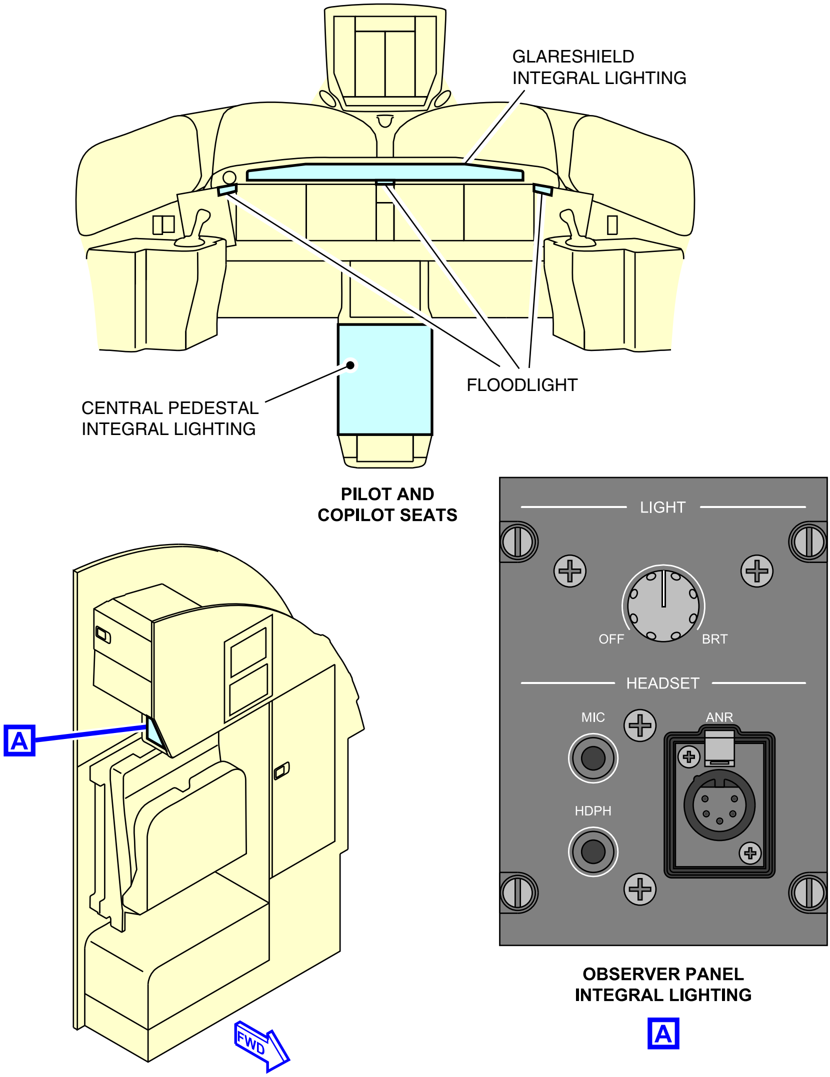
The flight deck lighting includes the areas that follow:

- Instrument panel, center pedestal, and observer seat lights,
- Overhead panel, circuit breaker panels, and compass lights,
- Reading and maps lights,
- Side console, bag stowage lights, and foot lights,
- Entrance and dome lights, and
- Passenger signs.

The integral lighting panel has a potentiometer to control the intensity of the integral lights. For more information, refer to section 06: Lighting controls and indication.

B. Instrument panel, pedestal, and observer seat lights

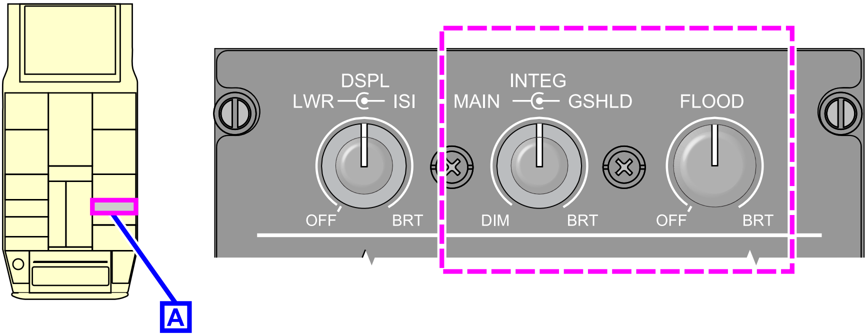
Integral lighting illuminates the glareshield, instrument panel, center pedestal, and the observer seat panel. Three floodlights, located beneath the glareshield, also illuminate the instrument panel. Refer to Figure 15–02–1.



Instrument panel and pedestal lights
Figure 15–02–1

(1) Controls

The control panel for integral lighting is located on the right side of the center console. Refer to Figure 15–02–2.



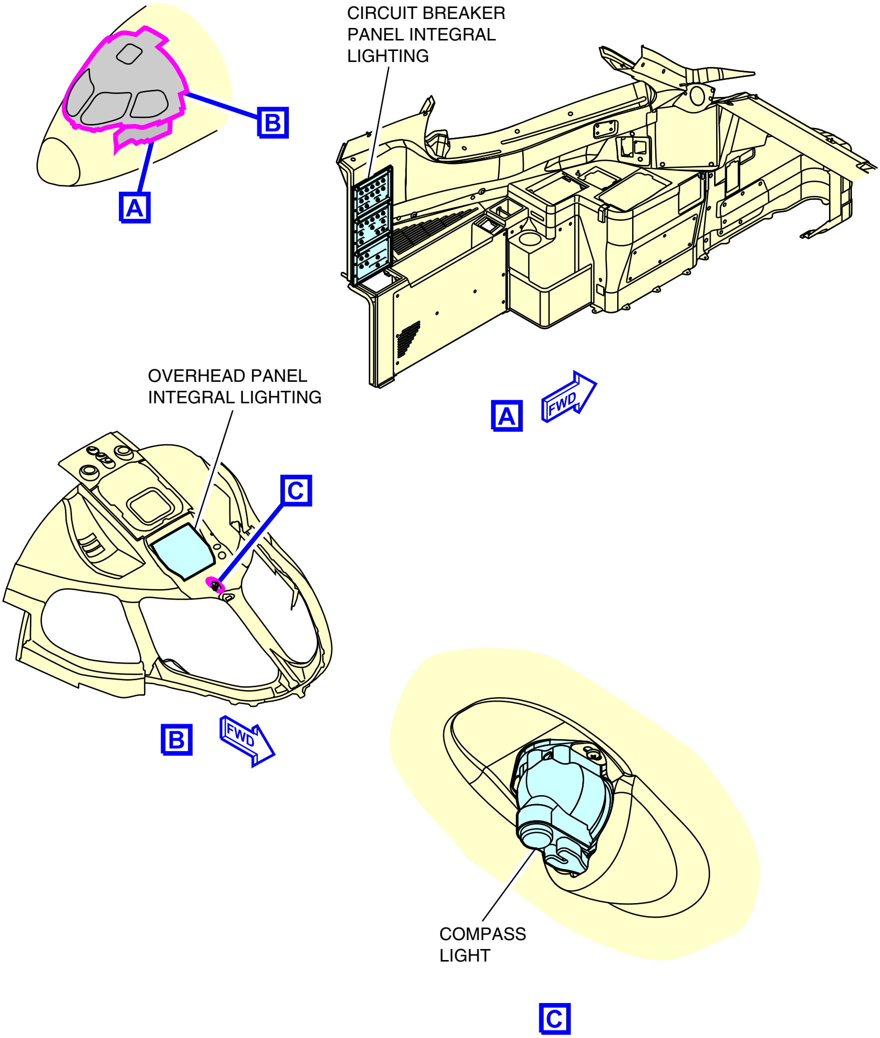
Integral lighting and floodlights controls
Figure 15–02–2

The INTEG double-stacked knob controls integral lighting. The MAIN outer knob controls the brightness of the main instrument panel, center pedestal, and observer seat panel integral lighting. The GSHLD inner knob controls the brightness of the glareshield integral lighting.

The FLOOD knob controls the brightness of the main instrument panel floodlights.

C. Overhead panel, circuit breaker panels, and compass lights

Integral lighting is installed in the overhead panel, the circuit breaker panels, and the compass. Refer to Figure 15–02–3.



Overhead panel, circuit breaker panels, and compass lights
Figure 15–02–3

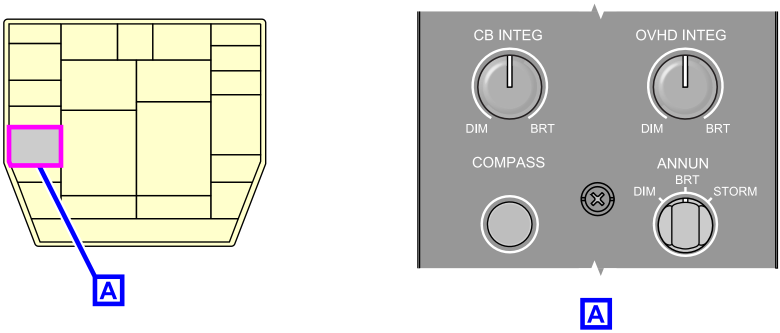
(1) Controls

Controls on the overhead panel adjust the brightness of these lights. Refer to Figure 15–02–4.

The CB INTEG switch controls the brightness of the left and right circuit breaker panels. The OVHD INTEG switch controls the brightness of the overhead panel. The COMPASS switch toggles the compass light.

The three-position ANNUN rotary switch controls the brightness of the overhead panel, pedestal switch/lights, and Multifunction Keyboard (MKP):

- DIM sets the switch/lights and MKP light to minimum brightness.
- BRT sets the switch/lights and MKP light to full brightness.
- STORM sets the switch/lights and MKP light to full brightness, integral lighting of all panels to full brightness, and turns on the dome lights.

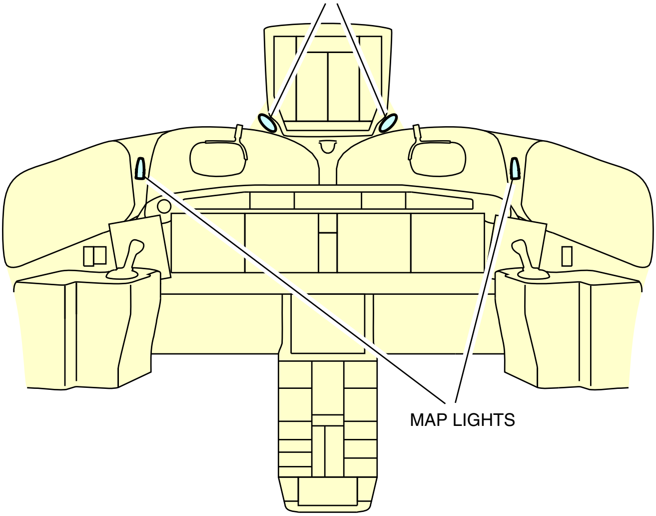


Overhead panel, circuit breaker panels, and compass lights controls
Figure 15–02–4

D. Reading and map lights

There are two reading lights located on each side of the overhead panel, and one near the entrance ceiling light. They illuminate the pilot, copilot, and observer seat areas.

Map lights are installed on the left and right windshield side posts. Refer to Figure 15–02–5.

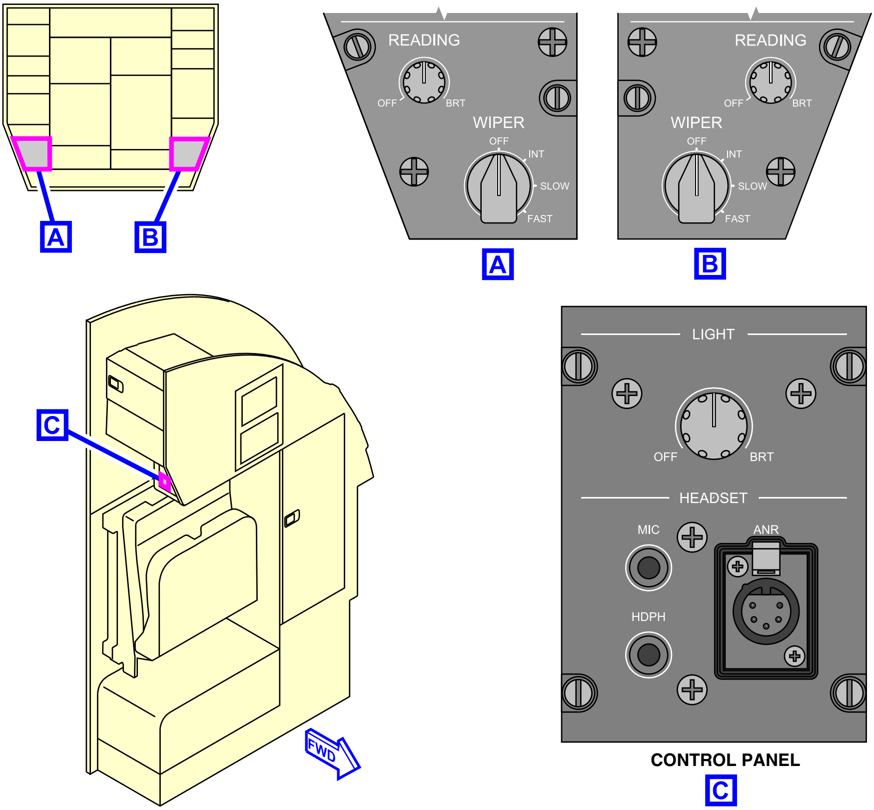


Reading and map lights
Figure 15–02–5

(1) Controls

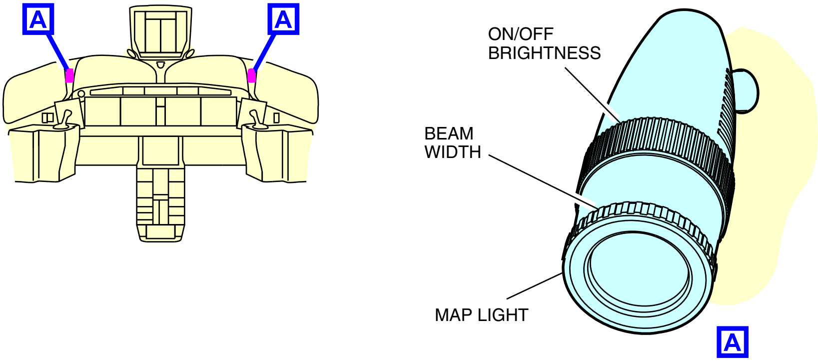
The READING switch on the overhead panels control the brightness of the flight deck reading lights.

The LIGHT switch on the observer seat panel controls the brightness of the observer seat reading light. Refer to Figure 15–02–6.



Reading lights controls
Figure 15–02–6

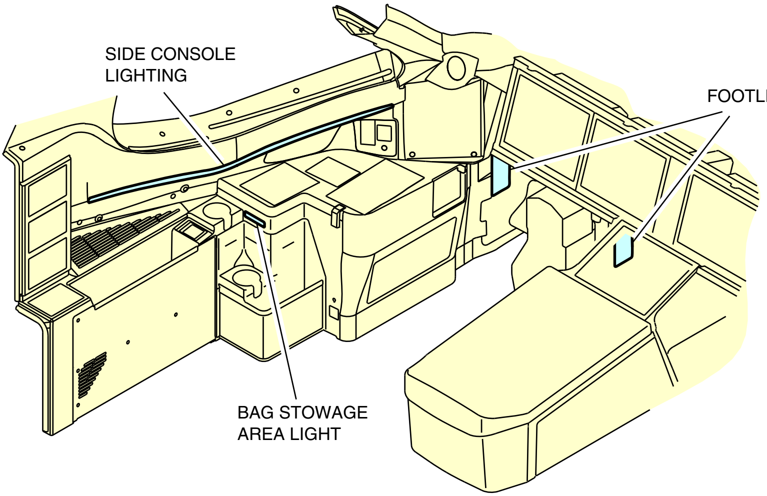
On the maps lights, the bezel closest to the lens controls the beam width. The ring in the center of the light selects the light on and controls the brightness. Refer to Figure 15–02–7.



Map reading lights
Figure 15–02–7

E. Side console, bag stowage area, and foot lights

Each pilot position is equipped with side console lights, a bag stowage area light, and foot lights. Refer to Figure 15–02–8.

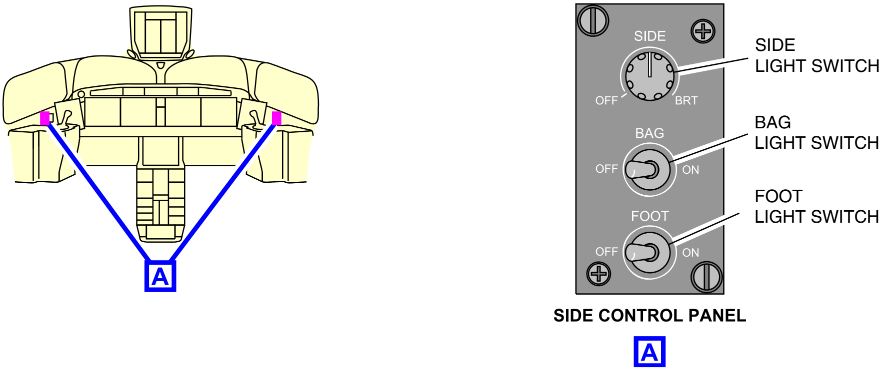


Side console, bag stowage area, and footlights
Figure 15–02–8

(1) Controls

Two identical control panels are located on the left and right side of the main instrument panel. Each control panel has the three switches that follow(refer to Figure 15–02–9):

- The SIDE switch controls the brightness of the floodlights on the side console.
- The BAG switch controls the bag stowage area light located on the aft face of the side console.
- The FOOT switch controls the foot lights on both sides of the rudder pedals.



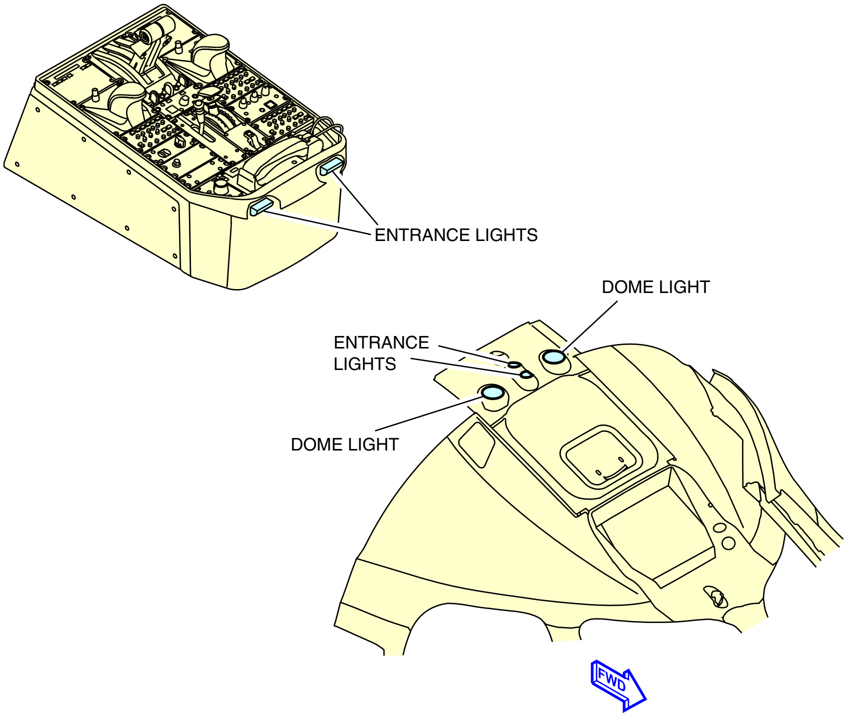
Side console, bag stowage area, and footlights contols
Figure 15–02–9

F. Entrance and dome lights

There are three flight deck entrance lights at the locations that follow (refer to Figure 15–02–10):

- One light in the flight deck ceiling behind the overhead panel, and
- Two lights at the rear of the center pedestal.

Two dome lights are located aft of the flight deck overhead emergency exit.



Entrance ceiling and dome lights
Figure 15–02–10

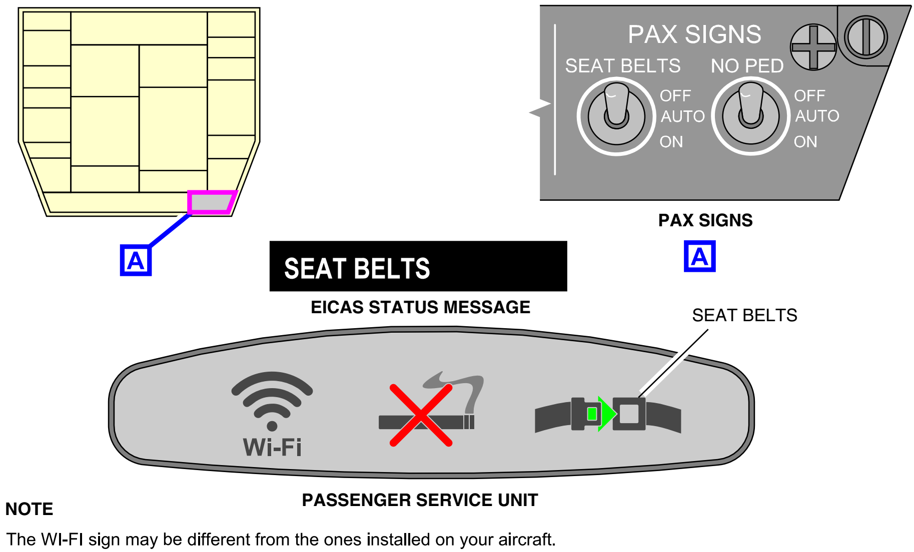
G. Passenger signs <33200010C>

The seat belt signs on the Passenger Services Unit (PSU) are located above each passenger seat. They are controlled with the SEAT BELTS switch on the overhead PAX SIGNS panel. The NO PED switch is deactivated. The SEAT BELTS switch has three positions:

- OFF – Signs are off (unless overridden by the CMS).

- AUTO – Signs come on and stay illuminated until altitude of 10000 feet is reached. Signs do not come on above 10000 feet unless overridden by the CMS.
- ON – Signs come on and stay illuminated.

When the seat belt signs come on, a chime sounds and the status message SEAT BELTS is displayed on the EICAS page. Refer to Figure 15–02–11.



Wi–Fi and FSB sign
Figure 15–02–11

H. Flight deck lighting (lamp test)

The AVIO tab of the AVIONIC synoptic page is used to initiate a lamp test by operating a LAMP test soft switch using the Cursor Control Panel (CCP) trackball. This soft switch initiates a group of tests to verify the functionality of the flight deck lamps.

When the LAMP test soft switch is selected, all lights in the flight deck illuminate for 20 seconds (including the master WARNING/CAUTION switch).

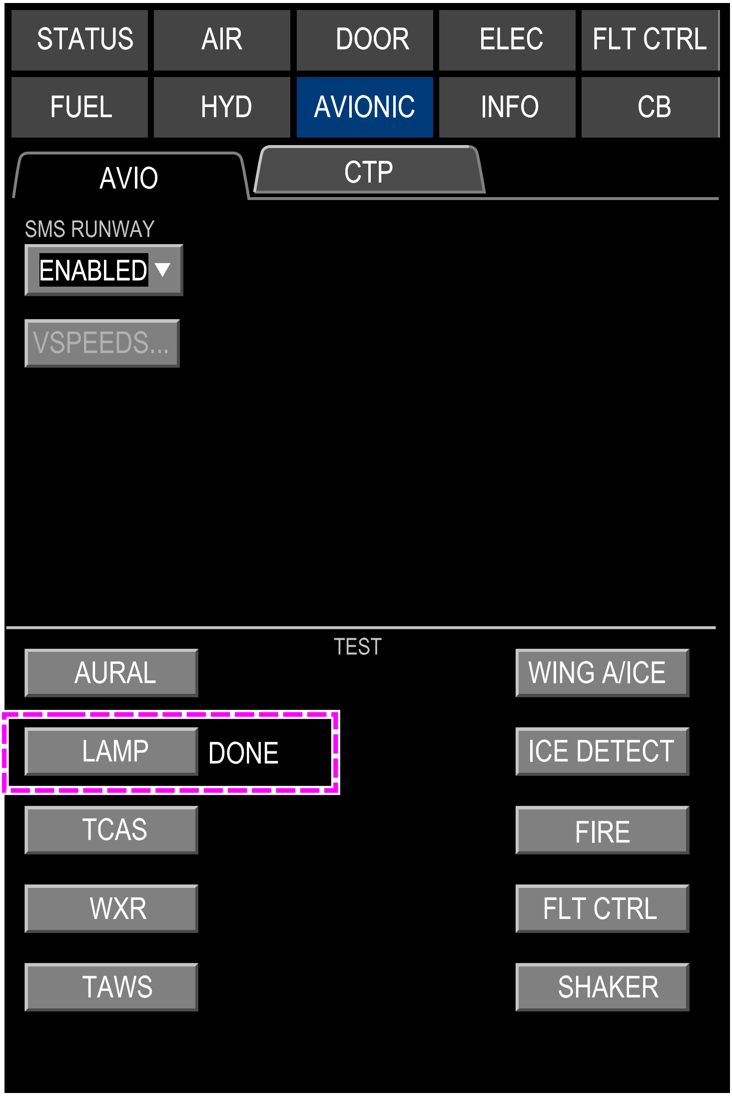
The indications that follow display:

- IN PROG (in cyan.)
- DONE (in white) after test completion.

NOTE

If a failure occurs during the test, a **caution** or **advisory** message shows on the EICAS page.

Figure 15–02–12 shows the AVIONIC/AVIO (lamp test) synoptic page.

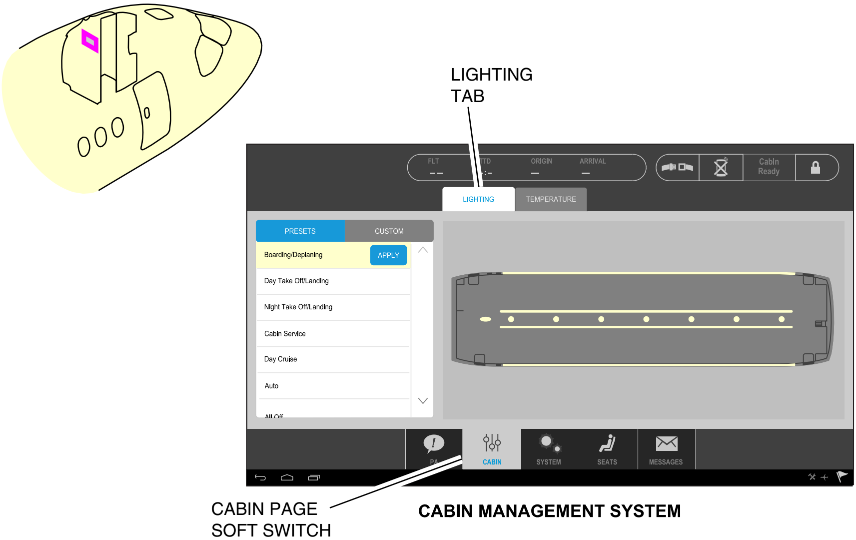


AVIONIC/AVIO (Lamp test) page
Figure 15–02–12

CABIN LIGHTING – DESCRIPTION AND OPERATION

A. Cabin Management System (CMS)

The Cabin Management System (CMS) is located above the flight attendant jump seats, near the forward passenger DOOR 1L. The CMS consists of a 15-inch LCD touchscreen. Refer to Figure 15–02–13.



Cabin management system
Figure 15–02–13

The cabin lighting page of the CMS controls the main cabin lights, the cabin entrance light, and the reading lights in the Passengers System Units (PSU).

The settings for intensity (and color) are pre-set in the Crew Management System (CMS). The cabin lighting can also be operated from more than one panel. The individual flight attendant panels can override the cabin lighting setting from the CMS.

For more information on all the functions of the CMS refer to Chapter 01 – General – CMS

B. Main cabin lights

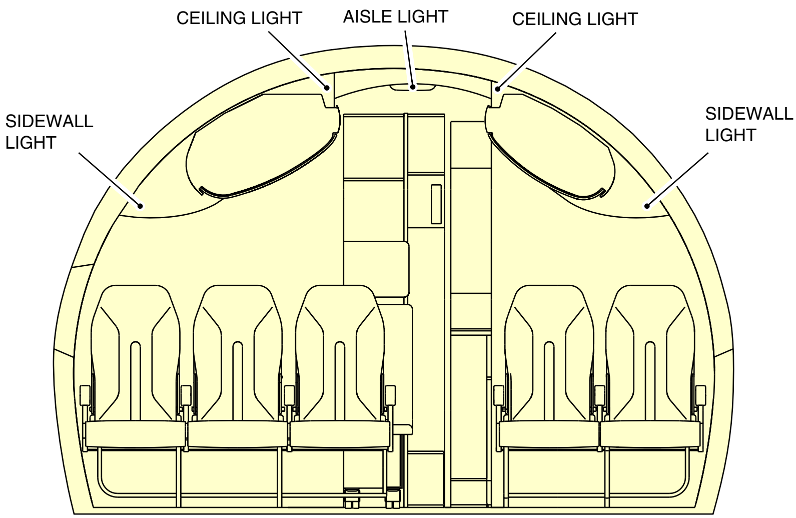
The main cabin illumination is generated by the ceiling lights and the sidewall lights. The ceiling light assemblies are mounted on the overhead stowage bins.

The aisle ceiling lights are fitted on the centerline of the ceiling to provide accent lighting along the aisle. They also provide minimum illumination when primary power is not available.

The aisle lights are powered by two power supplies, the ESS BUS and the Emergency Power Supply Unit (EPSU). If the DC ESS BUS voltage level falls below 28 VDC, the aisle lights begin to dim.

Operation of the lights is controlled from the CMS and the forward flight attendant panel. If a CMS failure occurs, the lights will turn off. If a main power failure occurs, the lights will revert to 50% intensity.

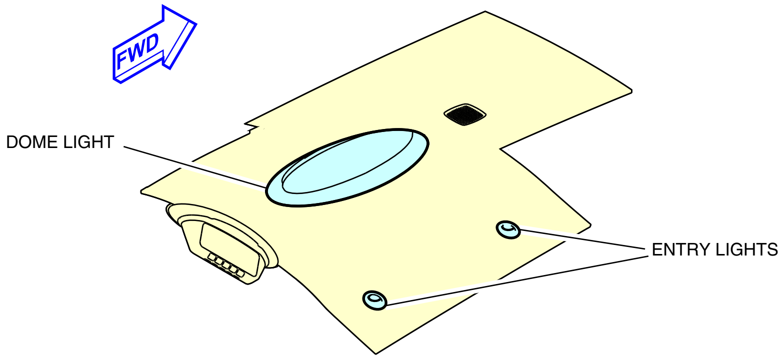
Figure 15–02–14 shows the main cabin lights.



Cabin lighting cross section
Figure 15–02–14

C. Cabin entrance/galley lights

The cabin entrance dome light is a multifunction light installed in the ceiling above the entry area (refer to Figure 15–02–15). Its primary function is to illuminate the entry area. A secondary function is to illuminate a path to the flight deck for initial crew entry when the aircraft is unpowered.

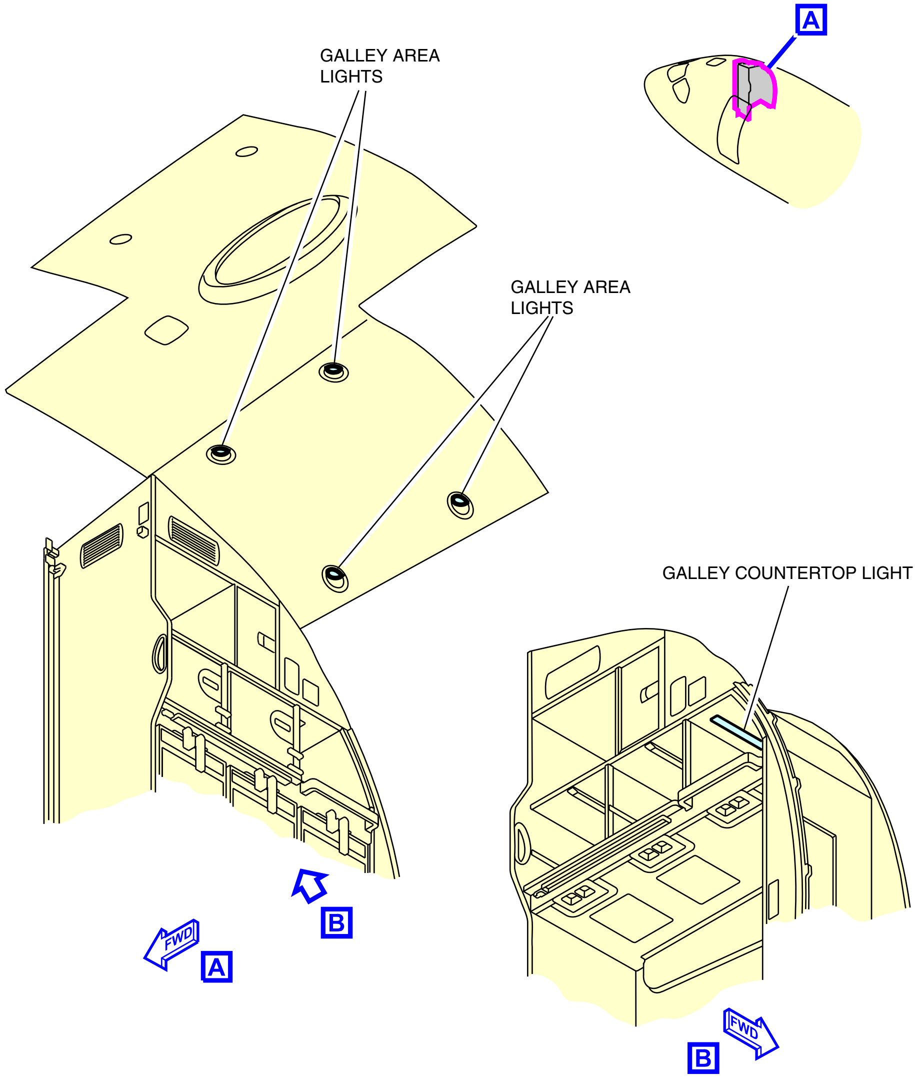


Entrance lights
Figure 15–02–15

The cabin entrance dome light is controlled by the CMS and the flight attendant panels. When it is turned on, while the aircraft is on battery power only, the timer function is activated for a defined period (20 minutes). The timer function turns off the cabin entrance dome light after the time delay has expired to conserve power drawn from the aircraft batteries.

Entry spot lights are installed in the forward and aft entrance areas to provide adequate light for boarding and de-boarding. When selected on the ground with no power, they activate the illumination of the DOME finder light for 20 minutes.

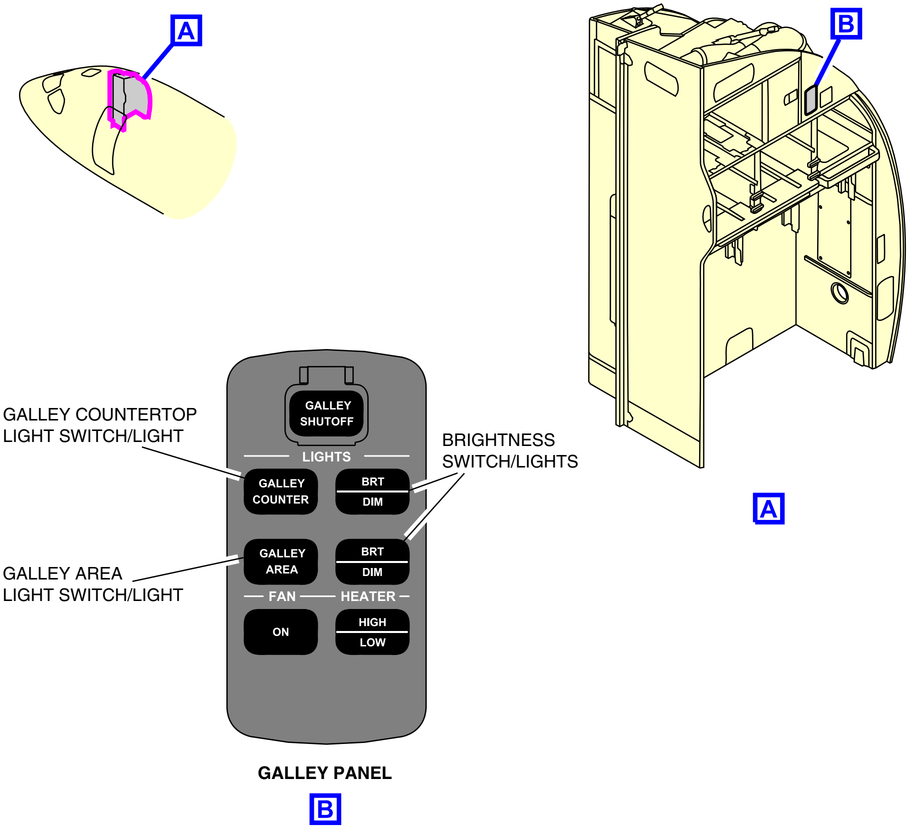
Entry spot lights are controlled from the CMS and the flight attendant panels. They use the same scenarios as the main cabin lights. If there is a power interruption, the entry spot light will revert to 50% intensity. Refer to Figure 15–02–16.



Galley lights
Figure 15–02–16

The galley lighting consists of four spotlights in the galley area and a countertop light that illuminates the galley work space.

Galley lights are controlled in the galley from the galley panel. Refer to Figure 15–02–17.



Galley panel
Figure 15–02–17

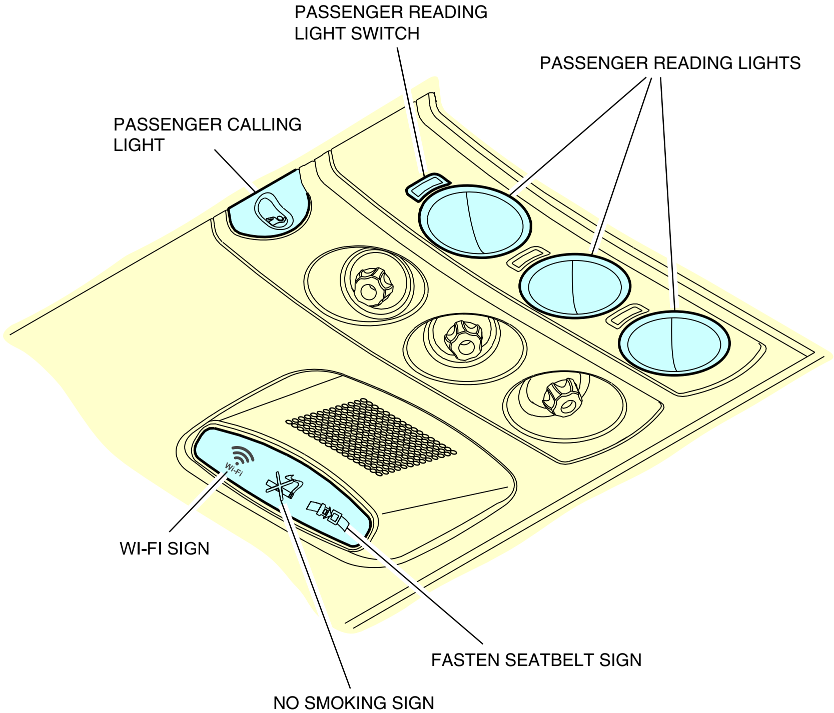
The GALLEY COUNTER switch controls the countertop light, and the GALLEY AREA switch controls the galley area lights. Brightness is controlled by the respective BRT/DIM switch.

D. Passenger Service Unit (PSU) <33200010C>

The Passenger Service Units (PSUs) are located above the seat rows. Each PSU includes:

- Reading lights,
- Gaspers,
- Speaker,
- Wi–Fi sign,
- No Smoking sign,
- Fasten Seat Belt (FSB) sign, and
- Flight attendant call switch.

Figure 15–02–18 shows the Passenger Service Unit (PSU).



NOTE

The WI-FI sign may be different from the ones installed on your aircraft.

Passenger Service Unit (PSU) <33200010C>
Figure 15–02–18

NOTE

The Cabin Management System (CMS) overrides passenger selection.

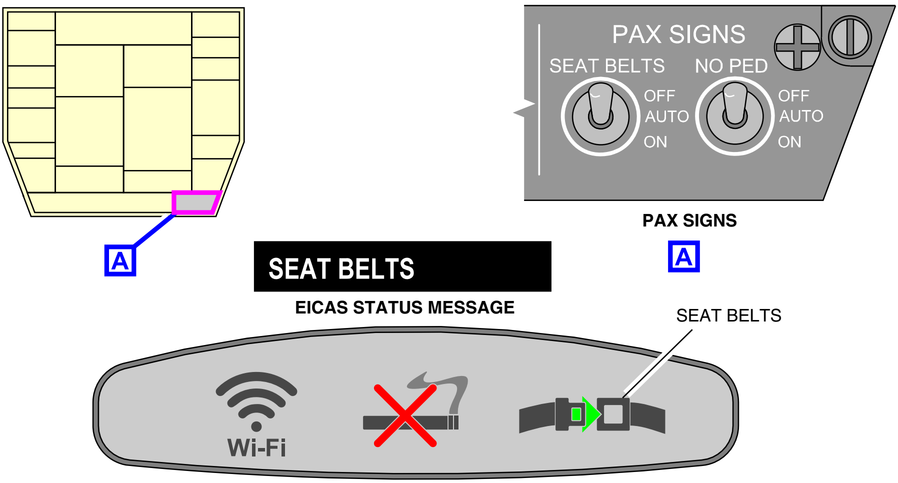
Each PSU can have up to three reading lights with control switches. The reading lights are fixed and not adjustable.

When a flight attendant call switch is pushed, the light in the PSU will come on. The CMS shows when and where the flight attendant call switch light was selected. The flight attendant call light is cancelled when the call switch is pushed again or from the CMS.

The FSB signs inform the passengers when seat belts must be fastened. It is operated by the flight crew from the flight deck overhead panel (PAX SIGNS).

When the FSB sign is illuminated, the associated EICAS status message **SEAT BELTS** is shown on the EICAS page.

Figure 15–02–19 shows the FSB sign.



NOTE

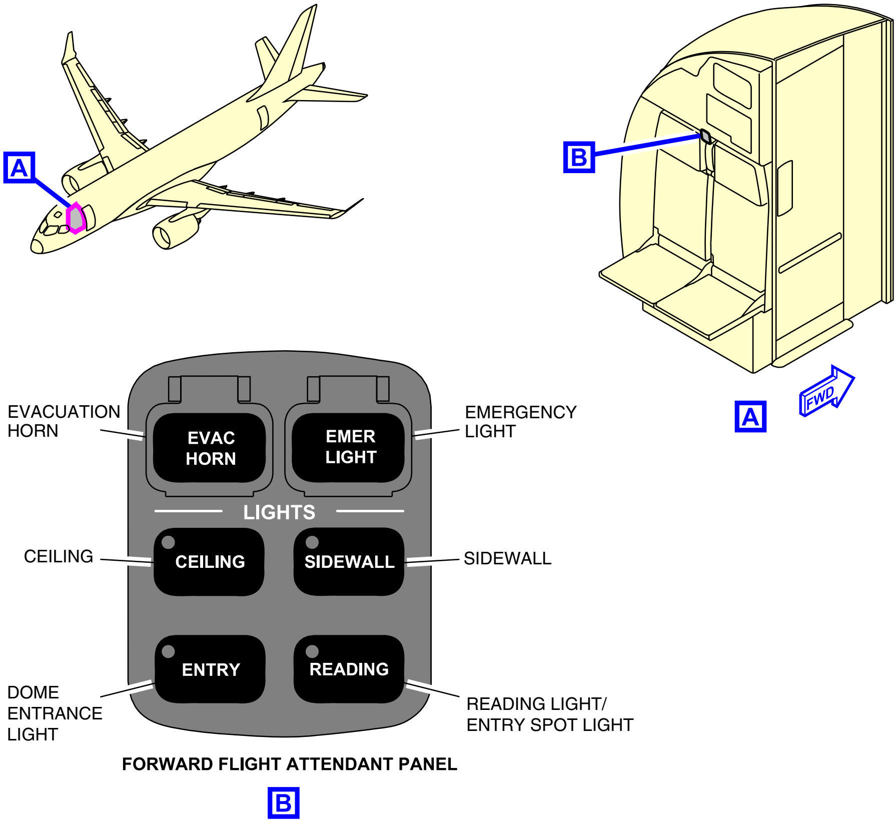
The WI-FI sign may be different from the ones installed on your aircraft.

Wi–Fi and FSB sign <33200010C>
Figure 15–02–19

E. Flight attendant lights

The forward and aft flight attendant stations have two different panels. They control the lights in the main cabin and the flight attendant work zone. The flight attendant panels can override the CMS lighting selection.

Figure 15–02–20 shows the forward flight attendant panel and its location.

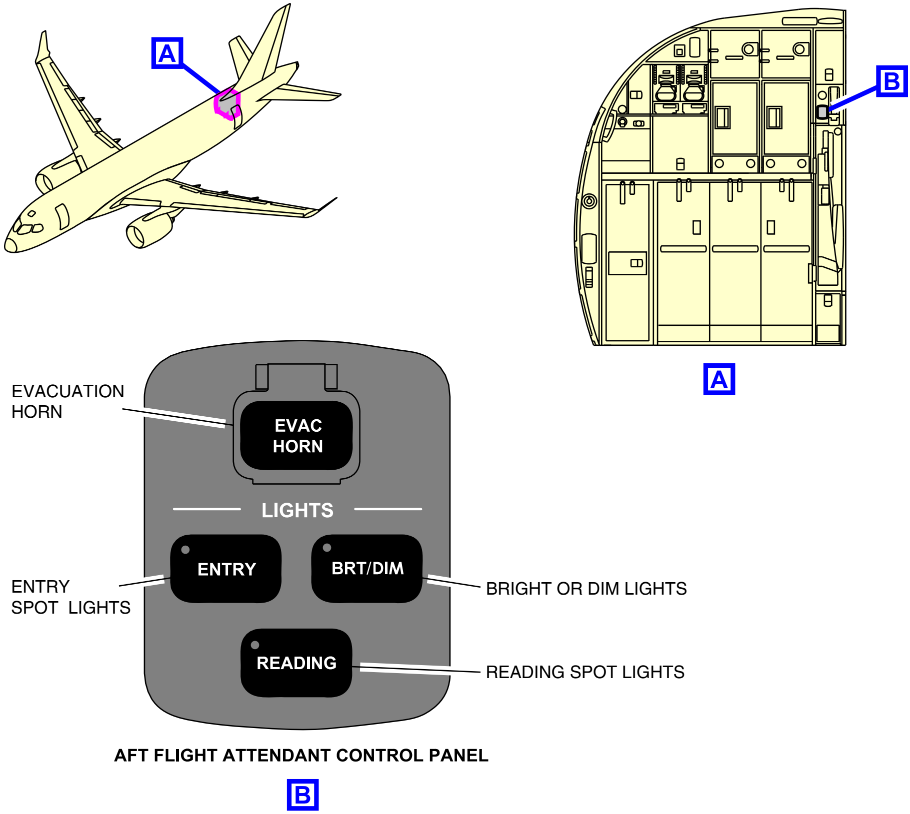


Forward flight attendant panel and location
Figure 15–02–20

The forward flight attendant panel is located between the flight attendant jump seats. It includes five switches that control lights in the cabin. The switches are:

- CEILING (controls ceiling light),
- SIDEWALL (controls sidewall light),
- ENTRY (controls the entry spot lights at all times and the dome light when the aircraft is unpowered),
- READING (controls reading lights and one of entry spot light), and
- EMER LIGHTS (controls all the emergency lights).

Figure 15–02–21 shows the aft flight attendant panel and its location.



Aft Flight attendant panel
Figure 15–02–21

The aft flight attendant panel is located next to the aft flight attendant jump seat. It controls the aft entry spotlights and jump seat reading light. It includes three switches that control lights in the cabin. The three switches are:

- ENTRY (controls four entry spot lights),
- READING (controls one reading spot light), and
- BRT/DIM (controls the bright and dim entry spot lights).

All the switches in the forward and aft flight attendant panels can be selected by pushing on the labelled switch directly.

The galley lighting consists of direct light to illuminate floor and wall panels. The entry spot lights of the galley illuminate the forward and aft galley area zones and aft service door. The counter top light illuminates workbench areas in the galley.

The closet light illuminates the interior of the closet. These lights are controlled by a switch located in the closet door.

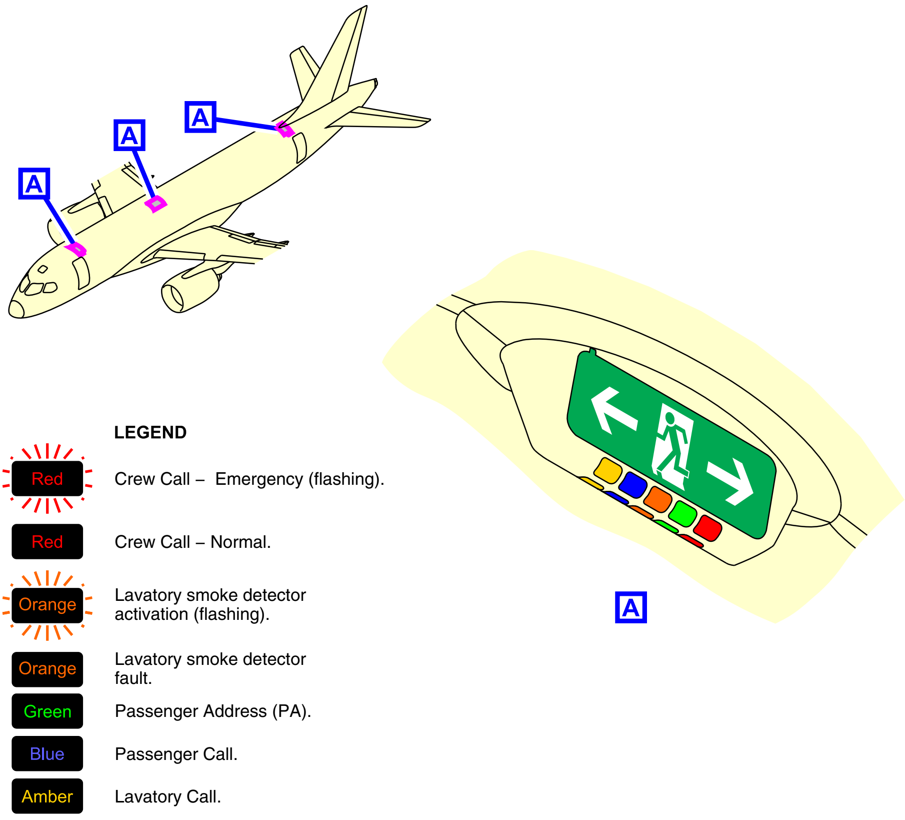
F. Cabin advisory lights

The cabin advisory lights on the bottom of the exit locator signs are located in the ceiling at the forward, mid, and aft positions in the cabin. They provide flight attendants with a visual alert of calls from passengers, other crew members, and other types of alerts (example: Smoke Detector Activation).

The cabin advisory lights are a series of five Light-Emitting Diode (LED) lights that identify the source of incoming calls:

- Red – Crew call light,
- Red (flashing light) – Emergency crew call,
- Orange – Lavatory smoke detector fault,
- Orange (flashing light) – Lavatory smoke,
- Amber – Lavatory call light,
- Blue – Passenger call light, and
- Green – PA announcement.

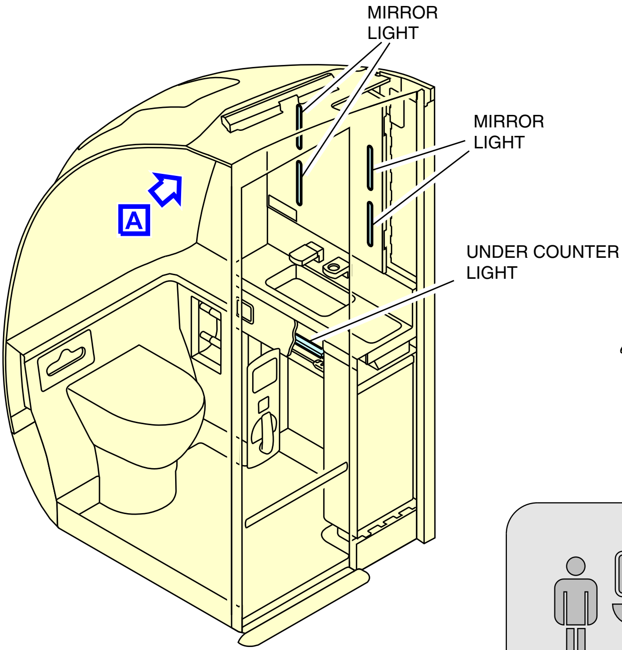
Figure 15–02–22 shows the cabin advisory lights and their location.



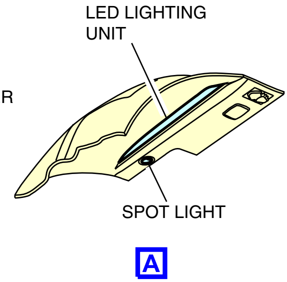
Cabin advisory lights and locations
Figure 15–02–22

G. Lavatory lights

The lavatory lights consist of an entry spot light on the ceiling and light strips to illuminate the mirror. They are automatic, based on the door locked/unlocked position. Outside the lavatory, a lavatory occupied sign is installed to indicate the occupied status, and a lavatory call light indicates a call from a person inside the lavatory. Refer to Figure 15–02–23.



LAVATORY LIGHTS



VACANT

Lavatory lights
Figure 15–02–23

When the lavatory door is unlocked, the lavatory light strips dim to a pre-selected value and the lavatory occupied sign goes off. When the lavatory door is locked, the lights automatically get brighter and the lavatory occupied sign is shown.

In cleaning mode with an unlocked door, the white lights will go bright and the lavatory occupied sign stays off. <33201001D>

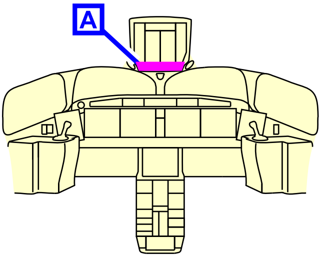
Lavatory passenger service units are installed in the lavatories to inform passengers if they need to return to their seats or to allow them to call for assistance from the flight attendant. If the flight attendant call switch is activated, a white ring around the icon will illuminate.

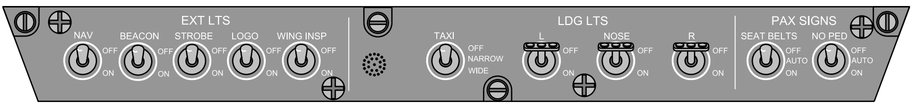
When the lavatory call light is activated, a steady orange light on the cabin advisory lights and the lavatory call light illuminate. The call can be deactivated by another push of the call switch in the lavatory or on the CMS page.

EXTERNAL LIGHTING – OVERVIEW

External lights provide external visibility of the aircraft to the flight crew of other aircraft, ground crews, and air traffic controllers. They are controlled by the EXT LTS (External Lights) and LDG LTS (Landing Lights) control panels on the eyebrow overhead module.

Figure 15–03–1 shows the eyebrow overhead module and its location.





EYEBROW OVERHEAD MODULE

A

External lights (EXT LTS), landing lights (LDG LTS) and SEAT BELTS/NO PED (PAX SIGNS) panels
Figure 15–03–1

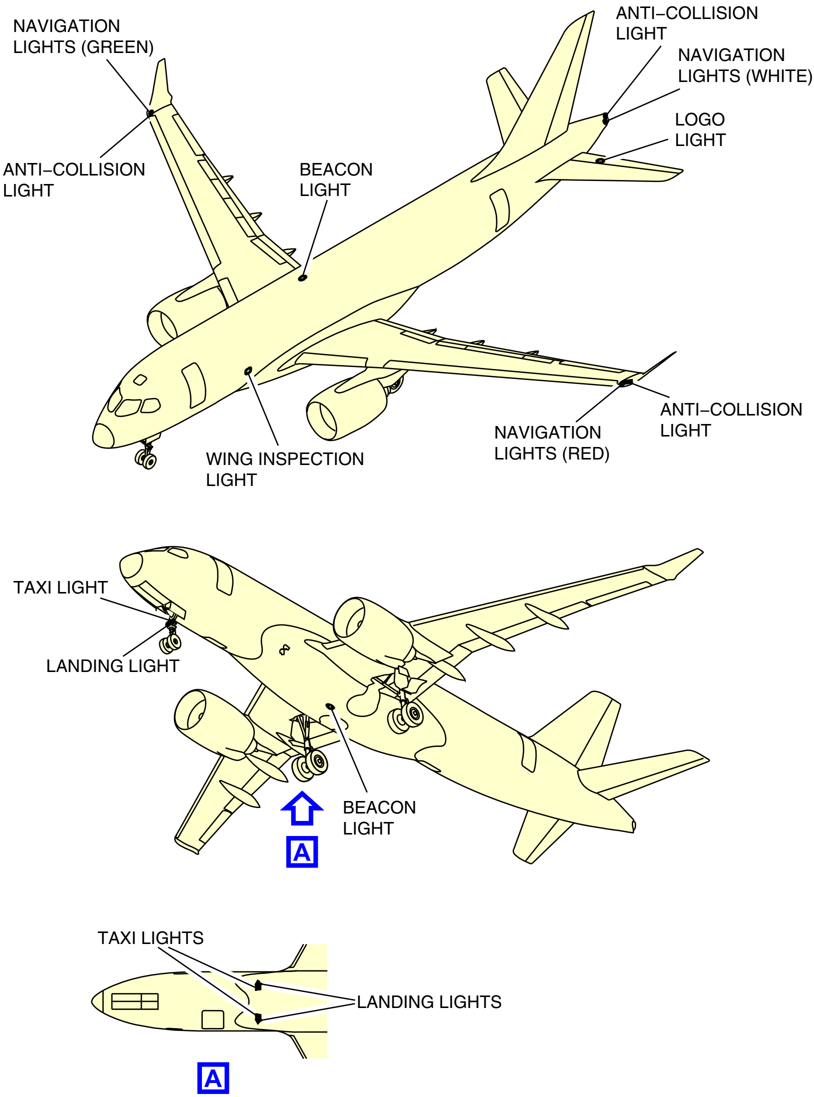
The EXT LTS control panel includes the controls for the lights that follow:

- Navigation lights (NAV),
- Beacon lights (BEACON),
- Logo lights (LOGO),
- Anti-collision strobe lights (STROBE), and
- Wing inspection lights (WING INSP).

The Landing Lights (LDG LTS) control panel includes the following lights:

- Taxi (TAXI) lights,
- Left (L) landing light,
- Nose (NOSE) landing light, and
- Right (R) landing light.

Figure 15–03–2 shows the external light locations.



External lights
Figure 15–03–2

EXTERNAL LIGHTING – DESCRIPTION AND OPERATION

A. Navigation lights

The navigation lights are controlled by the NAV switch on the EXT LTS panel. They are installed in pairs for redundancy, with two green lights in the right wing tip, two red lights in the left wing tip and two white lights on the tail. The wing tip lights are enclosed as a pair within clear wing tip lenses. A built-in thermal sensor automatically reduces power to the wing tip lights during ground operations to protect the lenses from heat damage.

Figure 15–03–2 shows the navigation lights and their locations.

B. Beacon lights

The beacon lights are controlled by the BEACON switch on the EXT LTS panel. They are two flashing red anti-collision lights, one located on the upper fuselage and another on the bottom of the belly fairing. The beacon light system is synchronized to flash both lights simultaneously, and is designed to flash at a lower intensity when an aircraft is on the ground to minimize crew distraction. They have separate power supplies, independent of each another.

Figure 15–03–2 shows the beacon lights and their locations.

C. Anti-collision (strobe) lights

The anti-collision (strobe) lights are controlled by the STROBE switch on the EXT LTS panel. These lights are three flashing white Xenon flash tube lights, one located on each wing tip and one on the tail cone.

Figure 15–03–2 shows the anti-collision (strobe) lights and their locations.

D. Logo lights

The logo lights are controlled by the LOGO switch on the EXT LTS panel. The logo lights are two flood lamps, one located on the top of each horizontal stabilizer. They illuminate the airline logo on each side of the tail.

Figure 15–03–2 shows the logo lights and their locations.

E. Wing inspection lights

The wing inspection lights are controlled by the WING INSP switch on the EXT LTS panel. The wing inspection lights are two flood lamps, one on each side of the fuselage. Each one illuminates its respective wing leading edge, nacelle, and upper wing surface. They provide increased visibility of the wing areas to allow personnel to detect any contamination.

Figure 15–03–2 shows the wing inspection light locations.

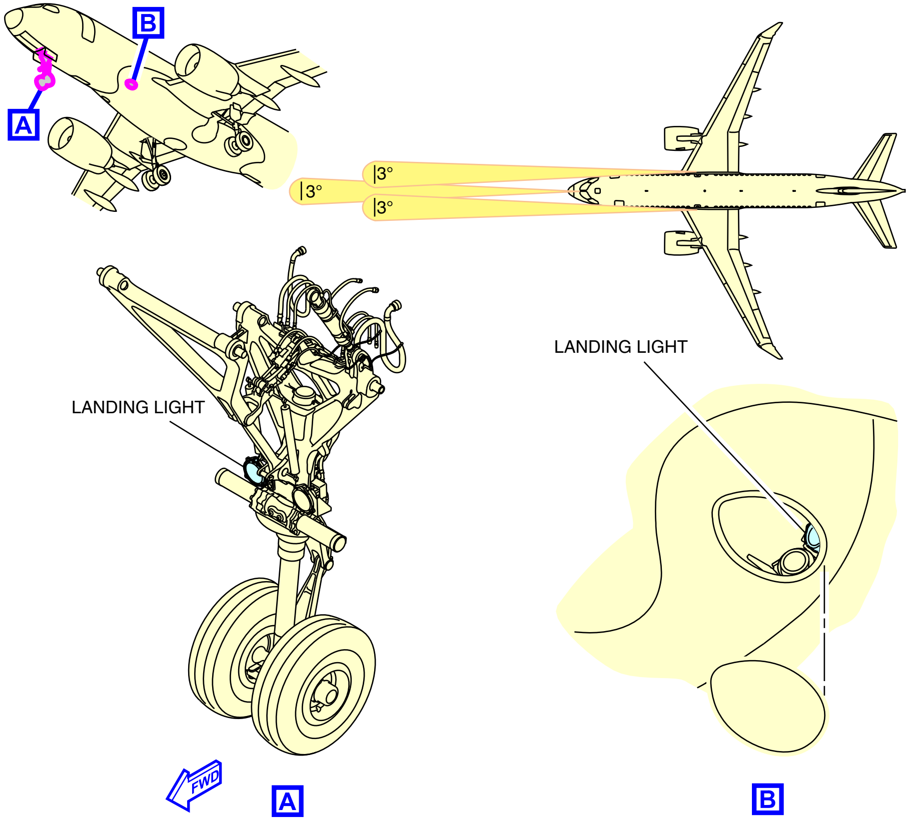
F. Landing lights

The landing lights are controlled by the L, NOSE, and R landing light switches on the LDG LTS panel. The landing lights provide illumination for landing. They produce intense narrow beams of light that illuminate the runway during takeoff and landing. The landing lights are located on the left and right wing-to-body fairing and on the nose landing gear.

NOTE

Nose landing light will not come on unless the nose gear is down and locked.

Figure 15–03–3 shows the landing light locations.



Landing lights
Figure 15–03–3

G. Taxi lights

The taxi lights are controlled by the TAXI switch. They are used during aircraft maneuvers on the ground. The taxi lights provide wide, diffused beams of light which illuminate the maneuvering area in front and along the sides of the aircraft. The taxi lights are installed on the left and right wing-to-body fairing and on the nose landing gear.

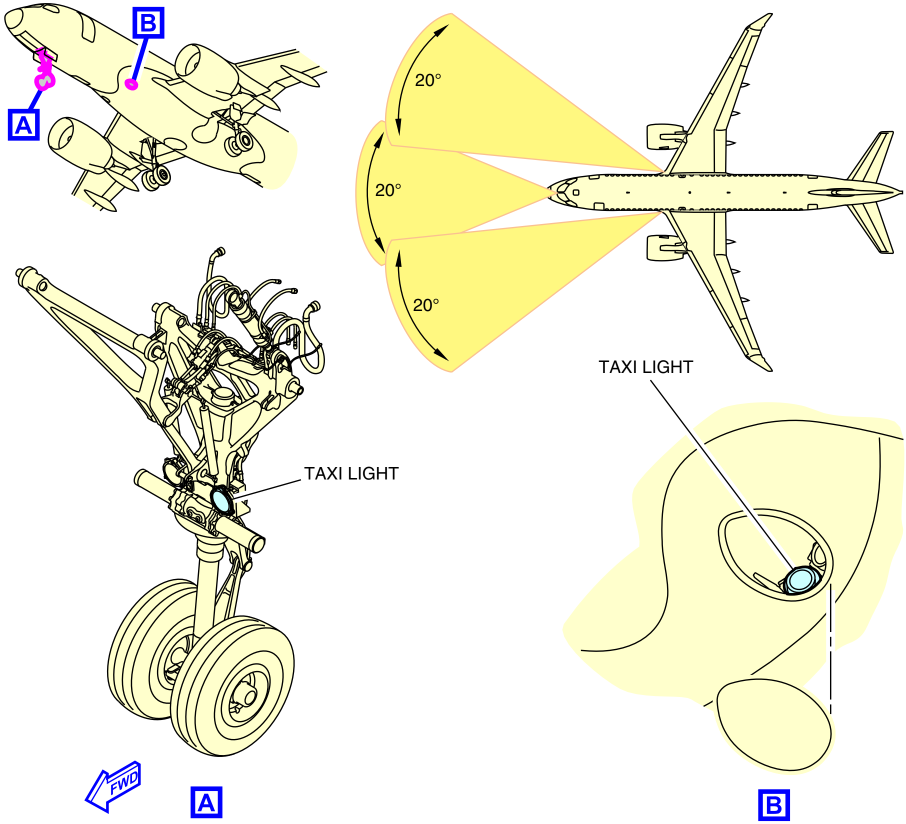
The TAXI switch has three positions:

- OFF – all three taxi lights are off
- NARROW – only the nose taxi light is on
- WIDE – all three taxi lights are on

NOTE

The taxi lights on the nose gear will not illuminate unless the nose gear is down and locked.

Figure 15–03–4 shows the taxi lights.



Taxi lighting area
Figure 15–03–4

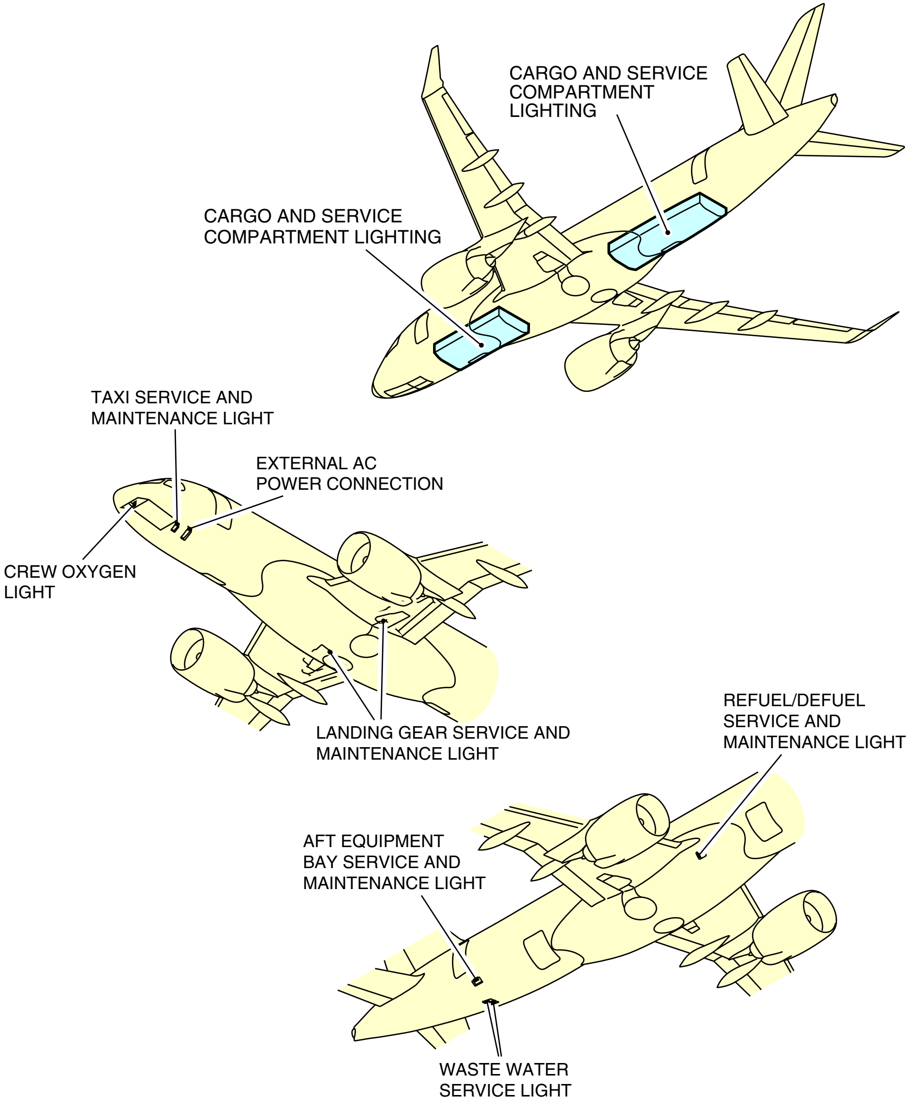
CARGO, SERVICE, AND MAINTENANCE LIGHTING – OVERVIEW

The cargo lights illuminate the cargo compartments and the cargo loading areas.

Service and maintenance lighting provides illumination of the specific areas of the aircraft for general servicing, maintenance, and inspection purposes. These areas include:

- External service panels,
- Landing gear wheel wells,
- Equipment bays (forward, mid and aft), and
- APU compartment.

Figure 15–04–1 shows the cargo, service, and maintenance lighting.



Cargo, service and maintenance lighting
Figure 15–04–1

CARGO LIGHTS – DESCRIPTION AND OPERATION

A. Cargo lights

The forward and aft cargo compartments each have three lights in the cargo compartment ceiling and one light in each cargo door for the cargo loading area.

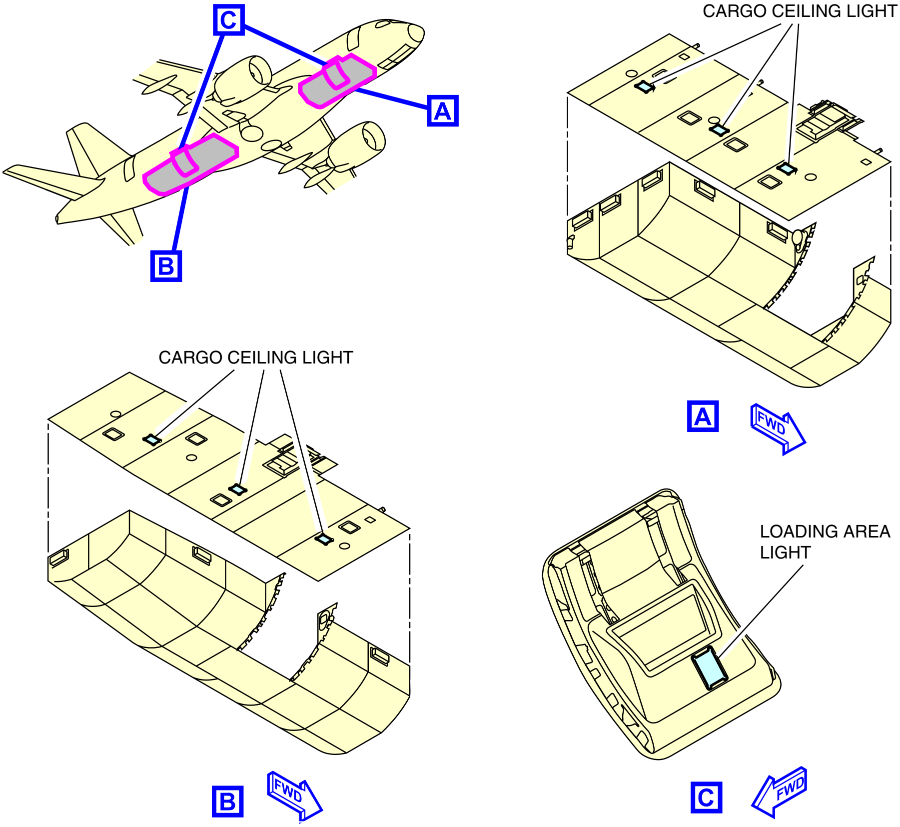
(1) Cargo loading area lights

The cargo loading area light switches are located on the panel to the left side of each cargo door. The switch is only active when the door is fully open. When the switch is pressed, the loading area lights illuminate for 30 minutes. The lights automatically shut off when the cargo door is closed or the switch is pressed again.

(2) Cargo compartment lights

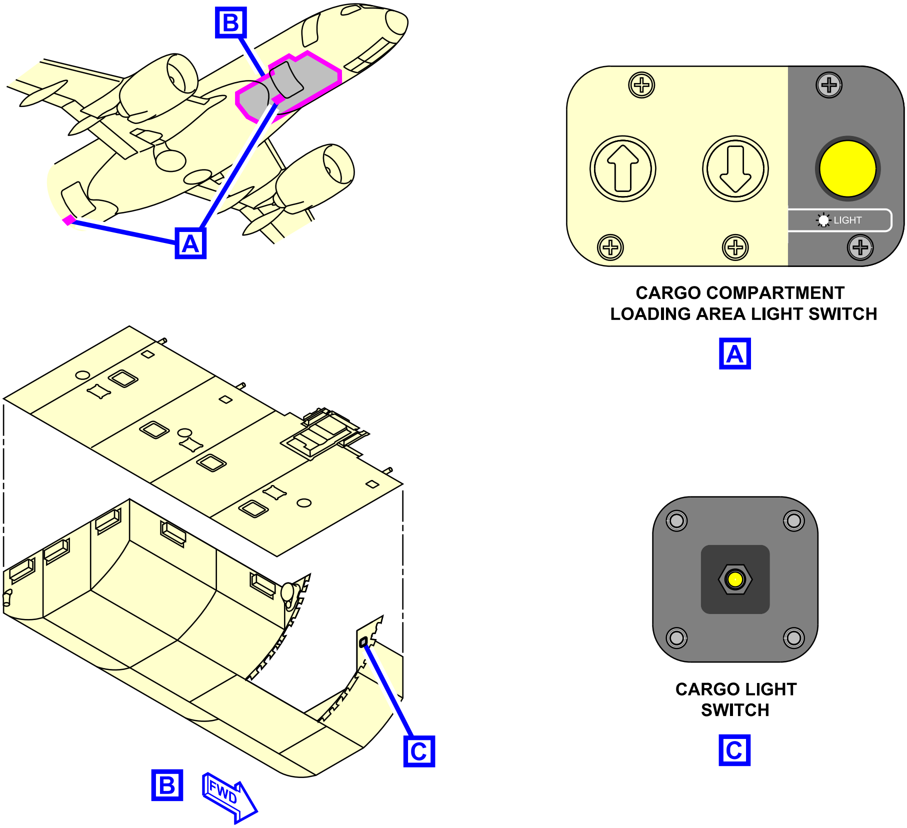
Cargo compartment light switches are located inside each cargo compartment. When the switch is pressed, the cargo compartment lights illuminate for 30 minutes. The lights go off when the door is closed or when the switch is pressed again.

Figure 15–04–2 shows the cargo light locations.



Cargo light locations
Figure 15–04–2

Figure 15–04–3 shows the cargo light switches.



Cargo light switches
Figure 15–04–3

SERVICE AND MAINTENANCE LIGHTING – DESCRIPTION AND OPERATION

A. Service and maintenance lighting

The service and maintenance light switches are located in:

- Nose Landing Gear (NLG) bay,
- Main Landing Gear (MLG) bay,

- Electrical/towing service panel,
- Oxygen service panel,
- Forward equipment bay,
- Mid equipment bay,
- Aft equipment bay,
- Refuel/defuel service panel,
- Auxiliary Power Unit (APU) compartment,
- Water service panel, and
- Waste service panel.

The service and maintenance lights are powered by either DC BUS 1 or BATT DIR BUS 1, depending on the availability of external power to the aircraft. Each service and maintenance area has a spring-loaded switch with a timer function that activates the lights for 20 minutes on DC BUS 1 or BATT DIR BUS 1.

Each service and maintenance panel light switch has three functions:

ON: When pushed, it illuminates the associated light(s),

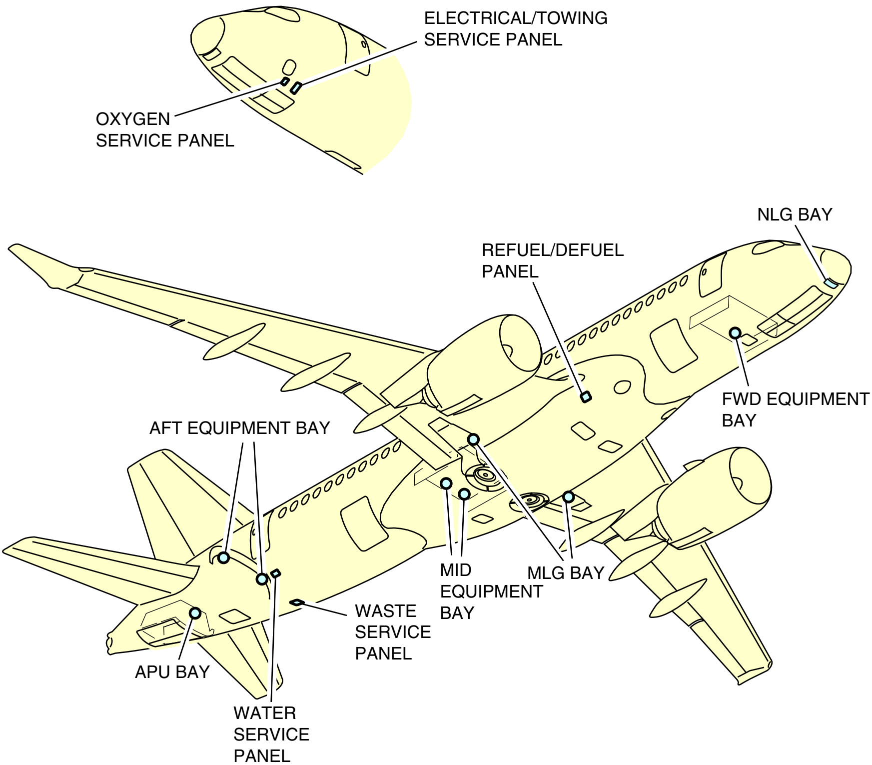
RESET: If pushed a second time, it resets the timer for an additional 20 minutes before the lights go off, and

OFF: If pushed a third time, it turns off the associated light(s).

NOTE

After 15 minutes of illumination in an unpowered aircraft, the service and maintenance lights will flash off and on for approximately 10 seconds. This notifies personnel that there are only 5 minutes of illumination remaining if the switches are not activated a second time.

Figure 15–04–4 shows the service and maintenance lighting locations.



Service and maintenance lighting locations
Figure 15–04–4

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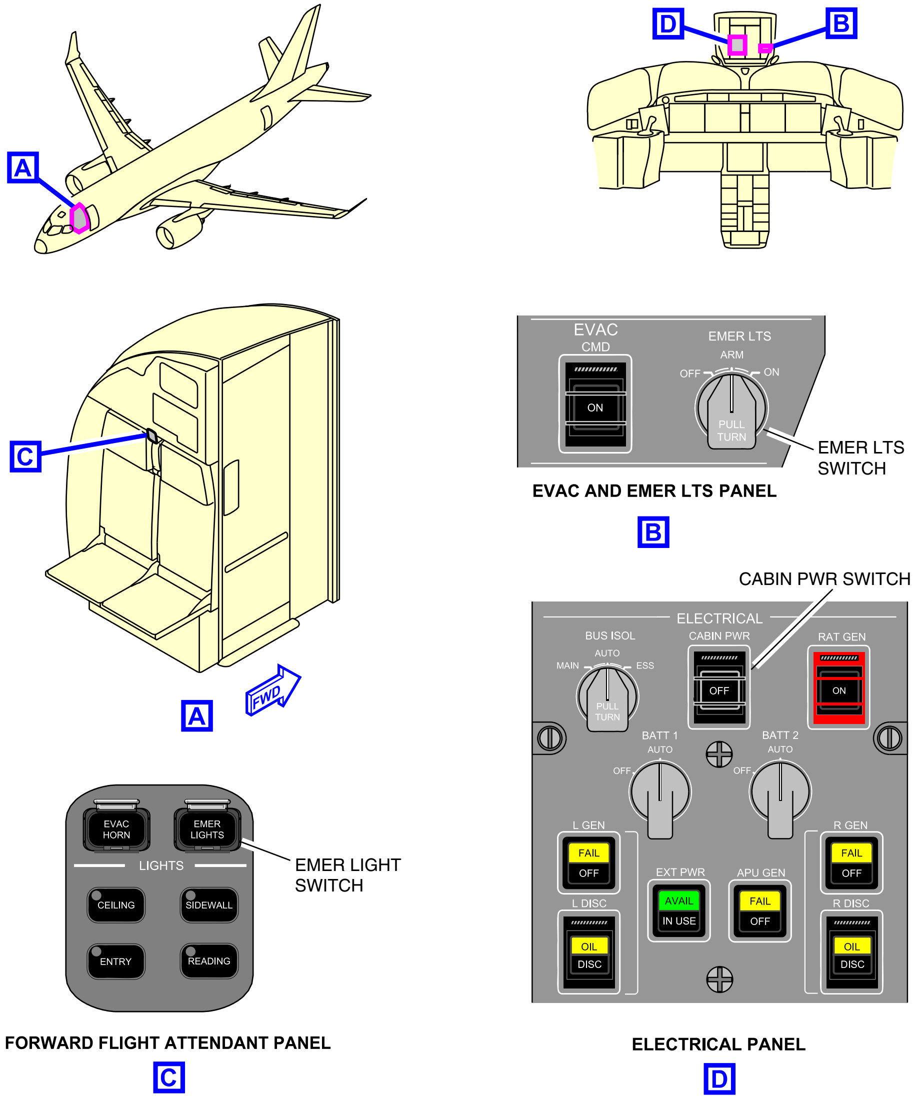
EMERGENCY LIGHTING – OVERVIEW

The emergency lights are controlled by the EMER LTS switch located on the flight deck overhead panel and/or the guarded EMER LIGHT switch on the forward flight attendant panel. The flight deck EMER LTS switch is used to arm or disarm the emergency lights. Refer to Figure 15–05–1. The pilot can use the guarded EMER LTS switch to manually select the emergency lights to ON. The guarded EMER LIGHT switch in the cabin, it is the secondary control for the emergency lighting system.

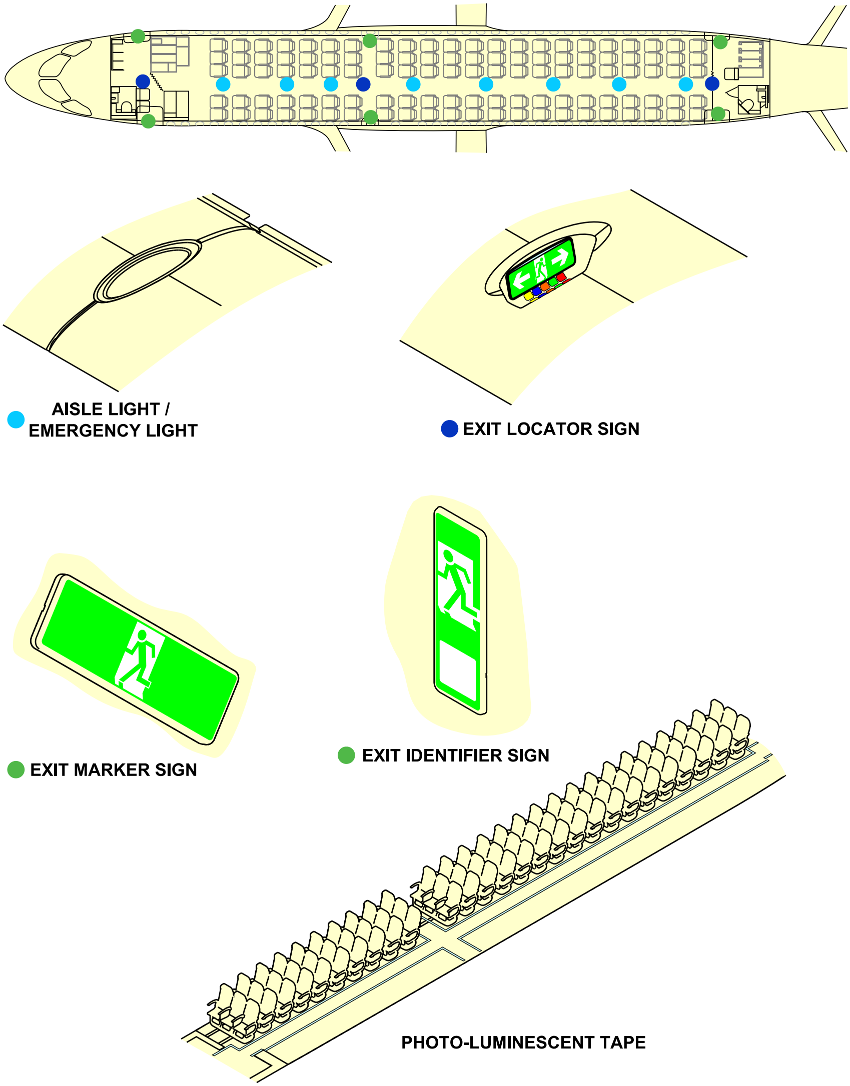


Emergency lighting control panels
Figure 15–05–1

The emergency lighting system illuminates the emergency escape path markings and signage.

The emergency lighting system (refer to Figure 15–05–2) consists of:

- Exit marker signs,
- Exit locator signs,
- Exit identifier signs,
- Emergency part of aisle lights,
- Floor track photo-luminescent tape, and
- External emergency lights.



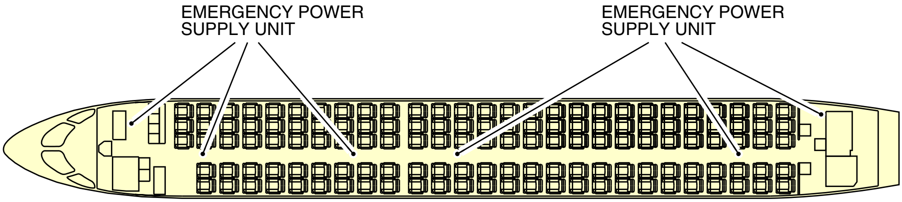
Interior emergency lighting
Figure 15–05–2

INTERNAL EMERGENCY LIGHTING – DESCRIPTION AND OPERATION

A. Emergency Power Supply Unit (EPSU)

The Emergency Power Supply Units (EPSUs) provide power to emergency lights and exit signs. The emergency power supply system includes six EPSUs that are integral battery packs. The EPSUs allow the emergency lighting system to operate for a minimum of 10 minutes after all other sources of power have been lost. The EPSUs are charged by 28 VDC. Each EPSU has a quick-charge feature which allows a 1-hour recharge period if the EPSU has been fully discharged.

Figure 15–05–3 shows the EPSU locations.



Emergency power supply units (EPSU) location
Figure 15–05–3

B. Emergency exit signs

The emergency exit signs include:

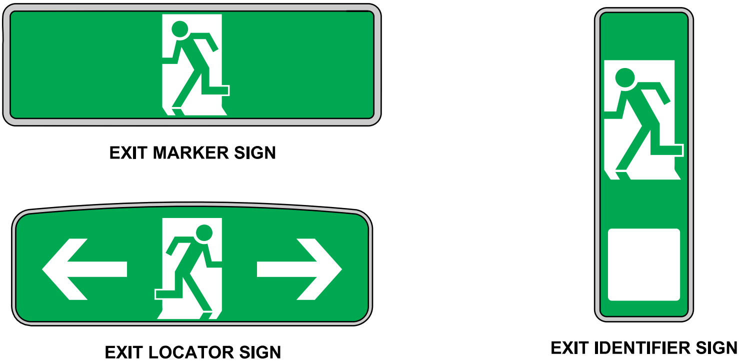
- Six exit marker signs,
- Three exit locator signs, and
- Six exit identifier signs.

The exit marker signs are installed near the exit to identify the emergency exits.

The exit locator signs are installed on the aisle ceiling panels to show the location of emergency exits.

The exit identifier signs are adjacent to each exit door. They help passengers identify each exit from the emergency escape path.

Figure 15–05–4 shows the emergency exit signs.



Emergency exit signs
Figure 15–05–4

C. Cabin emergency lights

The internal emergency lighting system includes six overhead emergency lights and eight aisle emergency lights.

The overhead emergency lights illuminate the emergency exits and the passageway in front of the exits during an evacuation. They are installed on the ceiling panels near the exit doors.

The aisle lights are installed on the ceiling along the passenger aisle. They have two functions. The primary function is to accent the ceiling illumination. The secondary function is to illuminate the aisle so that the passengers can find the nearest exit door. Aisle lights are powered by the EPSU when normal aircraft power is not available.

The flight attendants can push the EMER LIGHT switch on the forward flight attendant panel and turn on the emergency lights no matter what the selection of the pilot EMER LTS switch is. They can also push the EMER LIGHT switch to test the system for a time that is sufficient to allow inspection of the lights and signs. This emergency lights system test is normally done daily before the first flight of the day.

To safely deactivate the cabin emergency lighting system when the aircraft is normally powered, use the steps that follow:

- The EMER LIGHT switch on the forward flight attendant panel is in the off position, and
- The EMER LTS switch in the flight deck is in the OFF position.

NOTE

The flight deck EMER LTS switch must be selected to the OFF position before power is removed from the aircraft, or the emergency lights will illuminate.

To avoid inadvertent emergency light reactivation, the cabin power should be removed before the aircraft power.

D. Floor photo-luminescent tape exit markers

The emergency exit markers are strips of photo-luminescent tape on the cabin floor along each side of the passenger compartment aisle. They lead toward all emergency exits and will provide up to 10 hours of illumination with a 15-minute charging period, with the cabin lights on full bright.

EXTERNAL EMERGENCY LIGHTING – DESCRIPTION AND OPERATION

A. Emergency exit door lighting

The external emergency lighting system provides illumination of the ground contact areas and of the overwing areas.

This lighting system has eight lights:

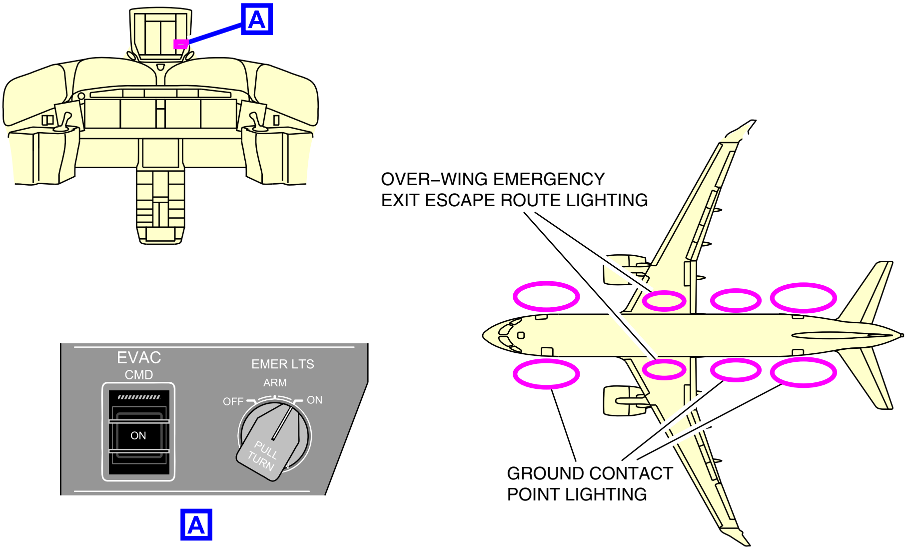
- Two forward emergency lights,

- Four overwing emergency lights (two on each side), and
- Two aft emergency lights.

There are two emergency light switches:

- EMER LTS switch located in the flight deck, on the overhead panel, and
- EMER LIGHT switch located on the forward flight attendant panel.

Figure 15–05–5 shows the emergency exit door lighting.



Emergency exit doors lighting
Figure 15–05–5

FLIGHT DECK LIGHTING– CONTROLS AND INDICATIONS

A. Controls

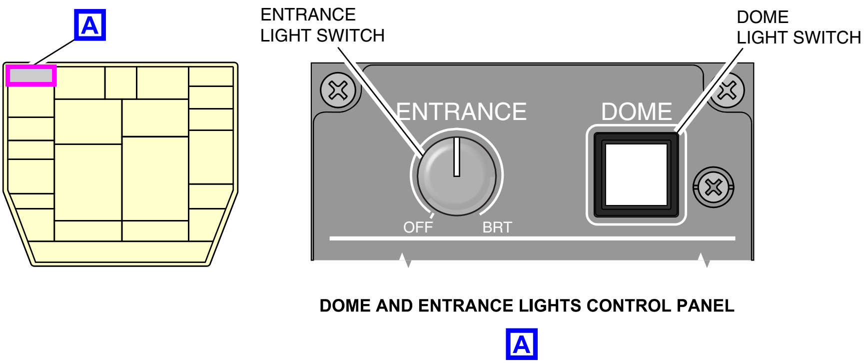
The flight deck lighting system controls are located on:

- ENTRANCE and DOME light panel,
- Left and right light panels,
- Lighting and cockpit door panel,
- Miscellaneous lights panel,
- DOOR LIGHT panel,
- Reading light and wiper panels,
- Observer reading light panel, and
- Map reading lights.

B. ENTRANCE and DOME light panel

The ENTRANCE and DOME light panel controls the intensity of the entrance light. It also has a switch for the dome light. The panel is located at the top of the left outboard overhead module and includes the DOME switch and the ENTRANCE switch.

Figure 15–06–1 shows the ENTRANCE and DOME light panel.



DOME and ENTRANCE light control panel
Figure 15–06–1

(1) DOME light switch

The DOME light switch is an illuminated switch that controls the two dome lights in the ceiling of the flight compartment. The DOME finder light illuminates only on the ground when there is no power on the aircraft and the cabin ENTRY lights are turned on.

- To activate: Push the switch once to turn on the dome light.
- To deactivate: Push the switch again to turn off the dome light.

NOTE

When the cabin ENTRY light switch is turned on and the aircraft is unpowered, the timer function illuminates the DOME finder light for 20 minutes or until the DOME light switch is activated. If after 20 minutes, the aircraft is still on battery power, the DOME lights will go out, or the DOME finder light will go out.

(2) ENTRANCE light switch

The ENTRANCE light switch is used to select and control the intensity of the flight compartment entrance light and the floor lights.

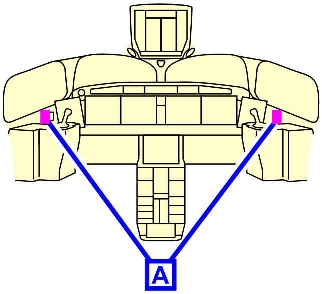
- OFF: The floor and entrance lights go off.
- BRT: Turned half way, will turn on the floor lights to maximum intensity. Turned past the half way, will turn on the overhead light to maximum intensity.

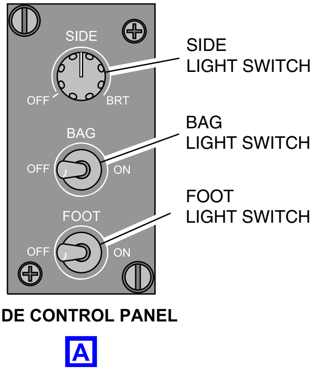
C. Left and right light panels

The left and right light panels are located on each side of the flight deck, next to the Electronic Flight Bag (EFB). Each panel includes the three switches that follow:

- SIDE light switch,
- BAG light switch, and
- FOOT light switch.

Figure 15–06–2 shows the left and right light panels.





Side console, bag stowage area, and footlights contols
Figure 15–06–2

(1) SIDE light switch

The SIDE light switch is used to control the intensity of the side lights of the side console.

- OFF: The side lights go off.
- BRT: The side lights illuminate the side console area with the maximum intensity.

(2) BAG light switch

The BAG light switch is used to select the flight bag light in the flight compartment. The flight bag light is located on the aft face of the pilot and copilot side consoles.

- OFF: The flight bag light goes off.
- ON: The flight bag light comes on.

(3) FOOT light switch

The FOOT light switch is used to select the foot lights in the flight compartment. The foot lights, located within the pilot and copilot rudder pedal well, illuminate the floor area between the rudder pedals and the seat of each pilot.

- OFF: The foot lights go off.

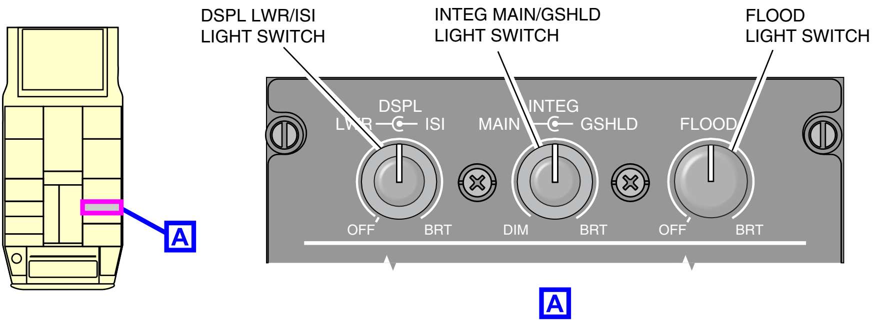
- BRT: The foot lights come on.

D. Lighting and cockpit door panel

The lighting and cockpit door panel is used to control the integral light intensity of the center pedestal console, main instrument panel, and glareshield, and also the flood lights. This panel is located on the right side of the center pedestal. It has three switches:

- DSPL LWR/ISI switch,
- INTEG MAIN/GSHLD switch, and
- FLOOD switch.

Figure 15–06–3 shows the lighting and cockpit door panel.



Lighting and cockpit door panel
Figure 15–06–3

(1) DSPL LWR/ISI light switch

Outer knob (LWR)

- OFF: Turned fully counterclockwise (to the OFF position), DU5 is selected off.
- BRT: Turned clockwise, DU5 illuminates gradually from dim to full bright (BRT).

Inner knob (ISI)

- OFF: Turned fully counterclockwise (towards OFF), the ISI lights are dimmed.
- BRT: Turned clockwise, the ISI illuminates gradually from dim to full bright (BRT).

NOTE

If the dimming potentiometer fails, the integral lighting defaults to 80% intensity.

(2) INTEG MAIN/GSHLD light switch

The INTEG MAIN/GSHLD switch has an outer knob, marked MAIN, and an inner knob, marked GSHLD. The outer knob controls the intensity of the integral lighting of the center pedestal, main instrument panel, and the observer panel. The inner knob controls the intensity of the integral lighting of the glareshield. The intensity varies gradually from dim (DIM) to bright (BRT). There is no off position on the knob.

Outer knob (MAIN)

- DIM: Turned fully counterclockwise, the integral lights of the center pedestal, the main instrument panel, and the observer panel are turned to minimum intensity.
- BRT: Turned clockwise, the integral lights of the center pedestal, the main instrument panel, and the observer panel increase gradually from dim (DIM) to full bright (BRT).

INNER knob (GSHLD)

- DIM: Turned fully counterclockwise, the glareshield integral lighting goes to minimum intensity (DIM).
- BRT: Turned clockwise, the glareshield integral lights vary gradually from dim (DIM) to full bright (BRT).

(3) FLOOD light switch

The FLOOD switch is used to control the three flood lights mounted below the glareshield. One is oriented toward the main instrument panel, and the two outboard lights illuminate the side panels.

- OFF: Turned fully counterclockwise to OFF, the three flood lights go off.
- BRT: Turned clockwise, the three flood lights come on and their intensity increases gradually to full bright at BRT.

NOTE

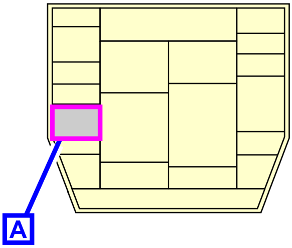
If the dimming potentiometer fails, the flood lighting defaults to 50% intensity.

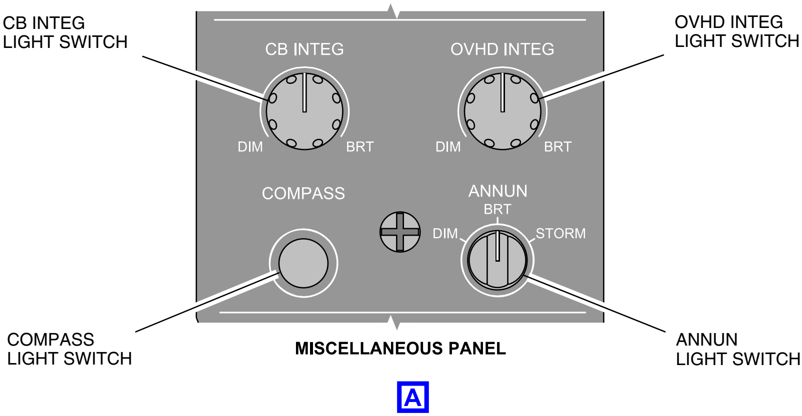
E. Miscellaneous lights panel

The miscellaneous lights panel is used to control the intensity of the integral lighting of the overhead console, circuit breaker panel, and annunciators, and to illuminate the compass. This panel is located on the left outboard overhead panel. It has four switches:

- CB INTEG switch,
- OVHD INTEG switch,
- ANNUN switch, and
- COMPASS switch.

Figure 15–06–4 shows the miscellaneous lights panel.





Miscellaneous lights panel
Figure 15–06–4

(1) CB INTEG light switch

The CB INTEG switch controls the intensity of the integral lighting of the left and right Circuit Breaker (CB) panels. The intensity varies gradually from dim to full bright. The switch does not have an off position.

- DIM: Turned fully counterclockwise, the CB panel integrated lights illuminate at minimum intensity.

- BRT: Turned clockwise, the CB panel integrated lights illuminate gradually from dim (DIM) to full bright (BRT).

(2) OVHD INTEG light switch

The OVHD INTEG switch controls the intensity of the integral lighting of the overhead panels. The intensity varies gradually from dim (DIM) to full bright (BRT). The switch does not have an off position.

The integral lights of the overhead panel illuminate with minimum to maximum intensity.

- DIM: Turned fully counterclockwise, the integral lights illuminate the overhead panel at minimum intensity.
- BRT: Turned clockwise, the integral lights illuminate the overhead panel gradually from dim (DIM) to full bright (BRT).

(3) ANNUN light switch

The ANNUN light switch is a three-position rotary switch. The switch positions control the lighting in the areas that follow:

- DIM: The center pedestal, main instrument panel, observer panel, overhead panel, eyebrow overhead module, Push Button Annunciators (PBAs), and Multifunction Keyboard Panel (MKP) illuminate with the minimum intensity.
- BRT: The center pedestal, main instrument panel, observer panel, overhead panel, eyebrow overhead module, PBAs, and MKP illuminate with maximum intensity.
- STORM: The complete flight deck, the PBAs, the panels, and the DOME lights illuminate at maximum intensity.

(4) COMPASS light switch

The COMPASS switch controls the illumination of the compass and increases the visibility of the magnetic heading.

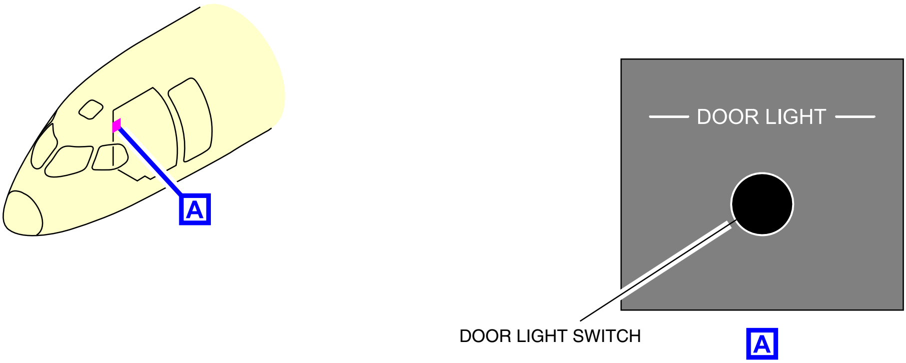
- To activate: Push the switch once to turn on the compass light.
- To deactivate: Push the switch again to turn off the compass light.

F. DOOR LIGHT panel

A flight compartment door light, located outside the flight compartment, illuminates the door area and is used when the pilot looks through the peephole to identify persons trying to get access. The DOOR LIGHT switch is located on the left side of the flight deck door.

- To activate: Push the switch once to turn on the door light.
- To deactivate: Push the switch again to turn off the door light.

Figure 15–06–5 shows the flight deck DOOR LIGHT switch and its location.



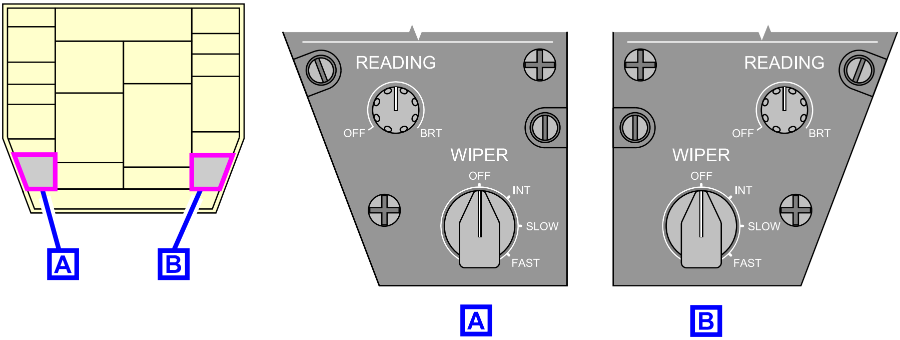
Flight deck DOOR LIGHT switch
Figure 15–06–5

G. Reading light and wiper panel

The READING rotary switch is used to control the intensity of the reading lights. Two reading light switches are located on the left and right outboard overhead panel. The intensity of the reading light varies gradually from off (OFF) to full bright (BRT).

- OFF: Turned fully counterclockwise, the reading light goes off.
- BRT: Turned clockwise, the reading light illuminates gradually from off (OFF) to full bright (BRT).

Figure 15–06–6 shows the reading light switches and their locations.



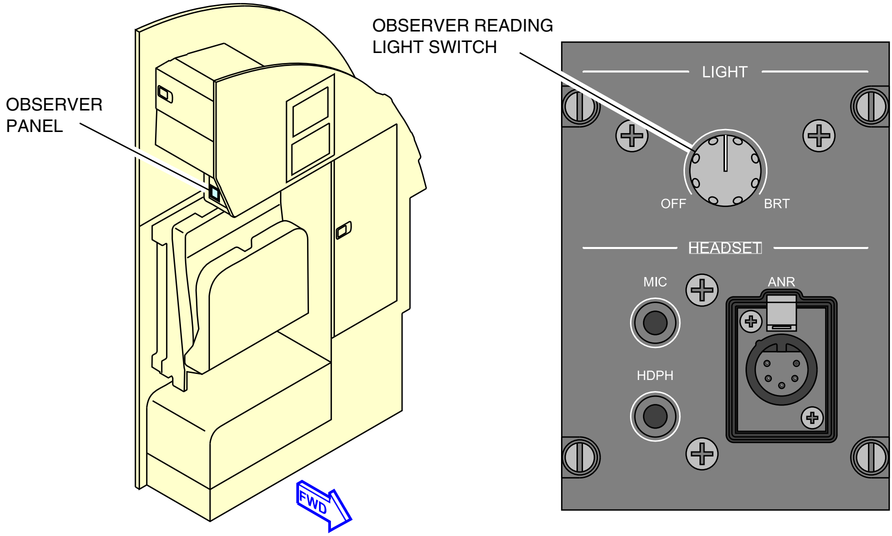
Reading light switches
Figure 15–06–6

H. Observer reading light panel

The observer reading light switch is used to control the intensity of the observer reading light. This LIGHT switch is located on the observer reading light panel above the observer seat near the observer oxygen mask. The intensity varies gradually from (DIM to BRT).

- OFF: Turned fully counterclockwise, the reading light goes off.
- BRT: Turned clockwise, the reading light illuminates gradually from dim (DIM) to full bright (BRT).

Figure 15–06–7 shows the observer reading light panel and its location.



Observer's reading light
Figure 15–06–7

CABIN LIGHTING – CONTROLS AND INDICATIONS

A. Cabin Management System (CMS)

The CMS-controlled lights are:

- Cabin entrance lights,
- Main cabin lights (controlled by the CDC and CMS),
- Call advisory lights (ON/OFF/FLASH),
- Reading lights in the Passenger Service Units (PSUs), and
- Galley area lights.

The galley area lights are normally controlled by the CMS, but can be overridden by the local control switches.

Each galley worktop has a Countertop Light (CTL). Each CTL has a worktop switch which controls its on or off (ON/OFF) and intensity (BRT/DIM) condition.

Also, lighting in some areas can be controlled locally with the flight attendant switches.

B. Cabin signs panel <33200010C>

The ordinance lights are controlled from the PAX SIGNS panel. The PAX SIGNS panel is located in the flight compartment, on the bottom right side of the overhead panel. It includes the SEAT BELTS and NO PED light switches.

Figure 15–06–8 shows the PAX SIGNS panel.

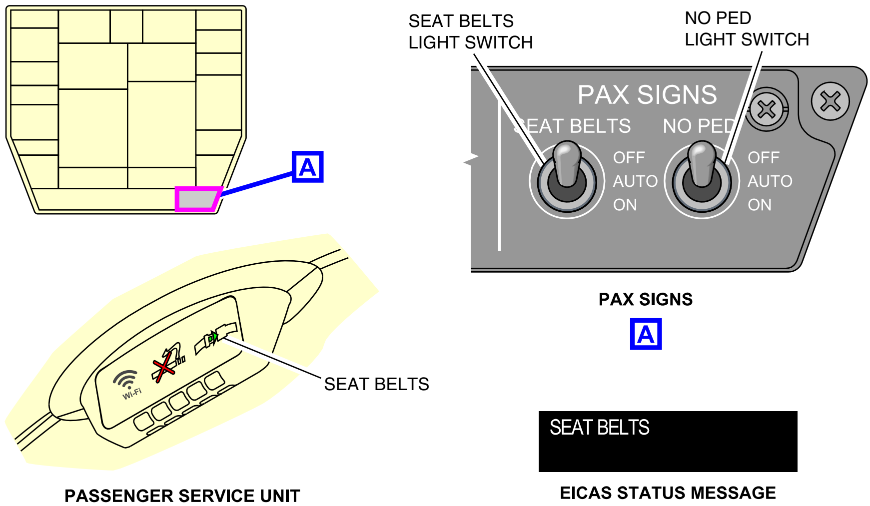
(1) SEAT BELTS light switch

The SEAT BELTS switch has three positions: OFF, AUTO and ON.

- OFF: The SEAT BELTS signs go off.
- AUTO: The SEAT BELTS signs automatically come on and the **SEAT BELTS** status message shows on the EICAS page when the conditions programmed by the operator are met.
- ON: The SEAT BELTS signs come on and the **SEAT BELTS** status message shows on the EICAS page.

(2) NO PED light switch

The NO PED switch is deactivated.



Passenger signs control panel (PAX SIGNS) <33200010C>
Figure 15–06–8

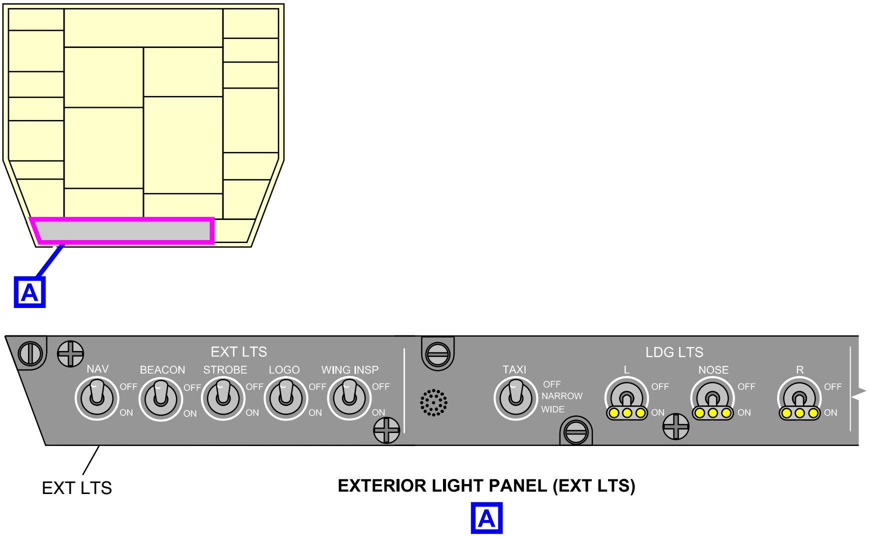
EXTERNAL LIGHTS (EXT LTS) – CONTROLS AND INDICATIONS

A. External lights (EXT LTS) panel

The EXT LTS panel includes the controls for the external lights that follow:

- NAV,
- BEACON,
- STROBE,
- LOGO (option), and
- WING INSP.

Figure 15–06–9 shows the external lights panel.



Exterior lights control panel (EXT LTS)
Figure 15–06–9

(1) NAV switch

The NAV (navigation lights) switch has the settings that follow:

- OFF: The navigation lights go off.
- ON: The navigation lights come on.

(2) BEACON switch

The BEACON switch has the settings that follow:

- OFF: The beacon lights go off.
- ON: The beacon lights come on.

(3) STROBE switch

The STROBE switch has the settings that follow:

- OFF: The strobe lights go off.
- ON: The strobe lights come on.

(4) LOGO switch

The LOGO switch has the settings that follow (option):

- OFF: The logo lights go off.
- ON: The logo lights come on.

(5) WING INSP switch

The WING INSP (wing inspection lights) switch has the settings that follow:

- OFF: The wing inspection lights go off.
- ON: The wing inspection lights come on.

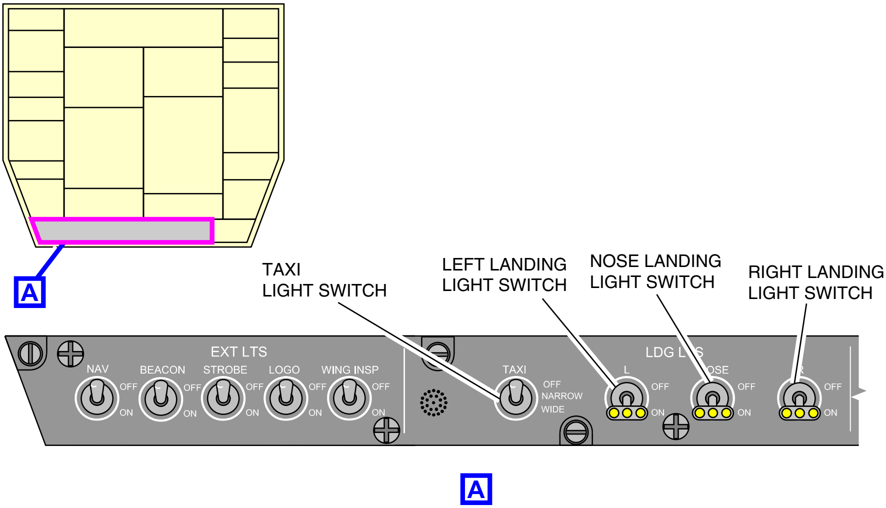
B. Landing Lights (LDG LTS) panel

LDG LTS panel

The Landing Lights (LDG LTS) panel includes the controls for the external lights that follow:

- Taxi lights (TAXI),
- Left landing light (L),
- Nose landing light (NOSE), and
- Right landing light (R).

Figure 15–06–10 shows the Landing Lights (LDG LTS) panel.



Landing lights panel (LDG LTS)
Figure 15–06–10

(1) TAXI switch

The TAXI switch has the settings that follow:

- OFF: All the taxi lights go off.
- NARROW: ONLY the taxi light located on the nose landing gear comes on.
- WIDE: The three taxi lights come on.

(2) LDG (L, NOSE, R) switches

The L, NOSE, and R light switches have the settings that follow:

- OFF: The landing lights go off.
- ON: The landing lights come on.

EMERGENCY LIGHTS (EMER LTS) – CONTROLS AND INDICATIONS

A. Evacuation and Emergency Lights panel

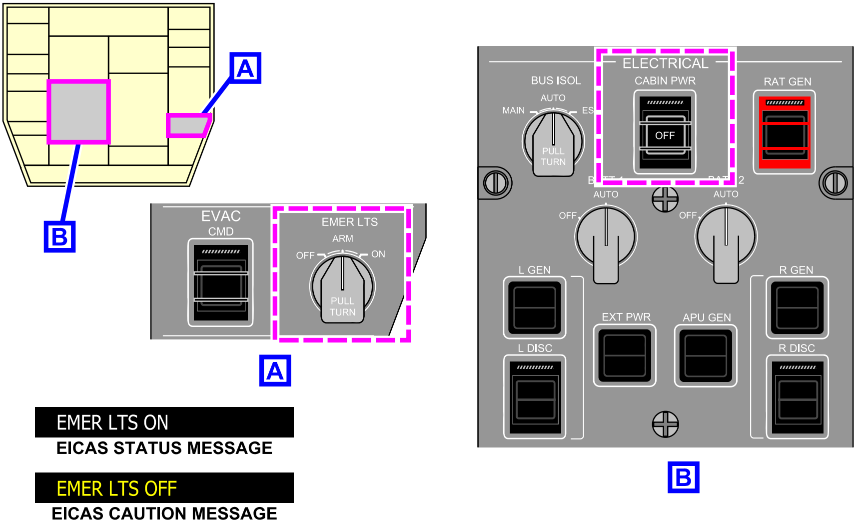
The EMER LTS pull-to-turn switch is used to select the emergency lights of the overwing emergency exit escape route area and the emergency exits for the passengers and the flight crews. This switch is visible in low lighting environments. It has OFF, ARM and ON selections. The details of the switch positions are as follows:

- OFF: The emergency lights stay off regardless of the system condition. When selected, the emergency lights go off and the **EMER LTS OFF** caution message is shown on the EICAS page.
- ARM: The emergency lights automatically come on when the aircraft is not powered. When the aircraft is powered, the emergency lights stay armed with no EICAS message. When the main bus power is lost, the emergency lights illuminate automatically and an **EMER LTS ON** status message is shown on the EICAS page.
- ON: The emergency lights come on and the **EMER LTS ON** status message is shown on the EICAS page.

NOTE

The flight deck Emergency Lights (EMER LTS) switch is powered by the DC ESS BUS.

Figure 15–06–11 shows the Emergency Lights (EMER LTS) switch location.



Cabin Power (CABIN PWR) and Emergency Lts (EMER LTS)
Figure 15–06–11

B. Flight attendant Emergency Light (EMER LIGHT) switch

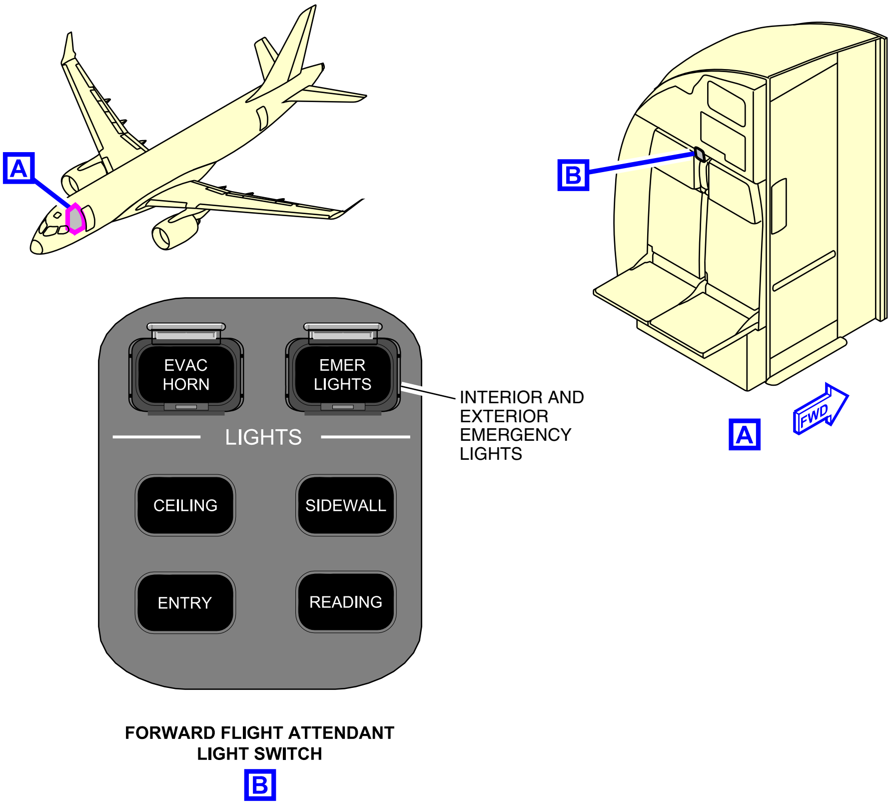
The flight attendant Emergency Light (EMER LIGHT) switch has no effect on the emergency light system when the pilot EMER LTS switch is selected to ON.

When the flight attendant EMER LIGHT switch is pushed, the emergency lights come on, even if the pilot EMER LTS switch is set to ARM or OFF.

NOTE

The flight attendant Emergency Light EMER LIGHT switch is powered directly by the DC ESS BUS.

Figure 15–06–12 shows the location of the flight attendant Emergency Light (EMER LIGHT).



Forward flight attendant emergency light switch
Figure 15–06–12

LIGHTING – EICAS MESSAGES

A. Warning messages

None

B. Caution messages

Message	Description	Inhibit
EMER LTS OFF	The emergency light switch is selected to OFF.	TO, LDG

C. Advisory messages

None

D. Status messages

Message	Description	Inhibit
CABIN PWR OFF	The cabin power switch is selected to OFF on the electrical control panel.	None
EMER LTS ON	The emergency lights are on.	None
SEAT BELTS	Seat belts signs activated (Auto or manual) in the cabin.	None

CHAPTER 16 – NAVIGATION

GENERAL

INERTIAL REFERENCE SYSTEM (IRS)

TERRAIN AWARENESS AND WARNING SYSTEM (TAWS)

WEATHER RADAR (WXR) SYSTEM

List of figures

INERTIAL REFERENCE SYSTEM (IRS)

GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS)

TRAFFIC SURVEILLANCE SYSTEM (TSS)

TERRAIN AWARENESS AND WARNING SYSTEM (TAWS)

NAVIGATION SYSTEM – OVERVIEW

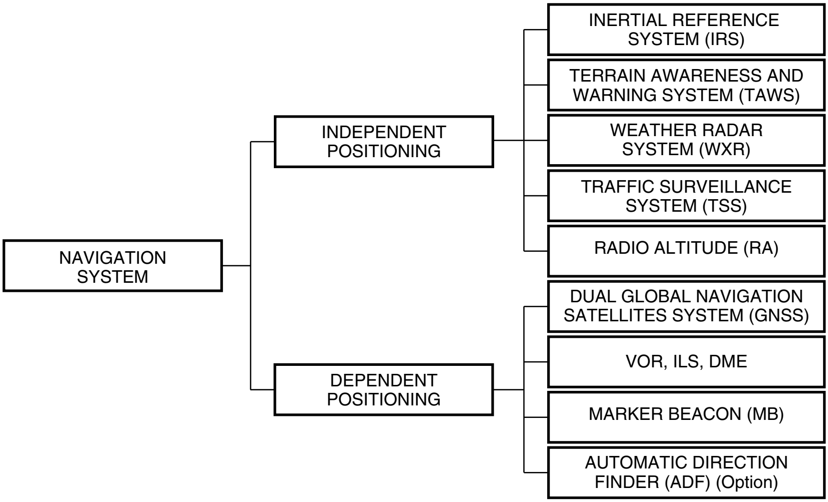
The navigation system is divided into two subgroups: independent and dependent positioning systems (refer to Figure 16–01–1).

The independent positioning system refers to navigation aids that do not need any exterior reference to support aircraft navigation. It consists of:

- Inertial Reference System (IRS),
- Terrain Awareness and Warning System (TAWS),
- Traffic Surveillance System (TSS) including Traffic Alert and Collision avoidance System (TCAS),
- Weather Radar System (WXR), and
- Radio Altitude (RA) (refer to Chapter 08 – Electronic display).

The dependent positioning system refers to navigation aids that use exterior references (ground stations and satellites) to support aircraft navigation. It consists of:

- Dual Global Navigation Satellite Systems (GNSS), and
- Radio navigation,
  - VHF NAV (VOR, ILS, LOC)
  - Distance Measuring equipment (DME), and
  - Marker Beacon (MB).



Navigation system
Figure 16–01–1

The Flight Management System (FMS) provides:

- Flight planning,
- Flight management,
- Lateral Navigation (LNAV) and Vertical Navigation (VNAV),
- Aircraft position calculation and monitoring, and
- Performance planning.

The Air Data System (ADS) interacts directly with the navigation system through the FMS and TAWS.

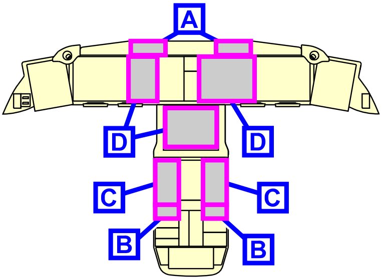
Navigation controls are located on the:

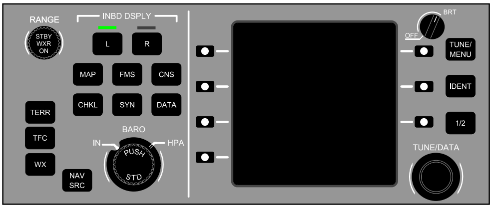
- Control Tuning Panel (CTP),
- Communication, Navigation and Surveillance (CNS) – TUNE page,
- Multifunction Keyboard Panel (MKP),

- Cursor Control Panel (CCP),
- Audio Control Panel (ACP), and
- MAP page.

System status and faults are reported on the:

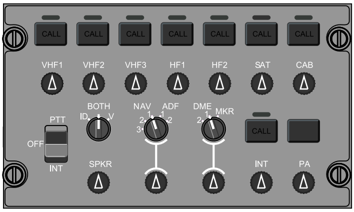
- EICAS page,
- Primary Flight Display (PFD),
- MAP page, and
- Integrated Standby Instrument (ISI).





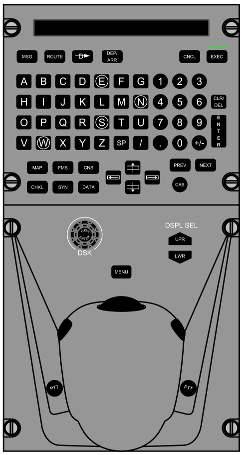
CONTROL TUNING PANEL (CTP)

A



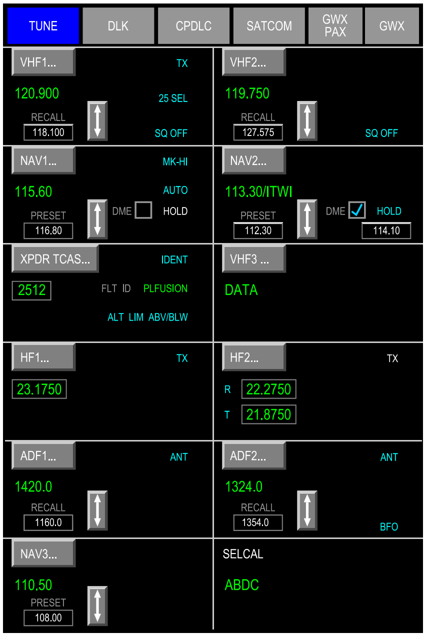
1 AUDIO CONTROL PANEL (ACP)

B



MULTIFUNCTION KEYBOARD PANEL (MKP)
AND CURSOR CONTROL PANEL (CCP)

C



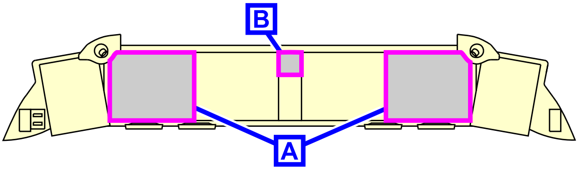
1 COMMUNICATION, NAVIGATION
AND SURVEILLANCE (CNS) - TUNE PAGE

D

NOTE

1 This view shows options that may not be installed on your aircraft.

Navigation system controls
Figure 16–01–2



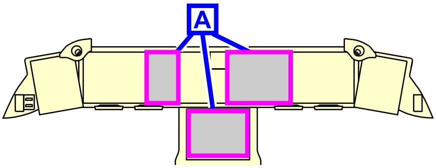
PFD - HORIZONTAL SITUATION INDICATOR (HSI)

A

INTEGRATED STANDBY
INSTRUMENTS (ISI)

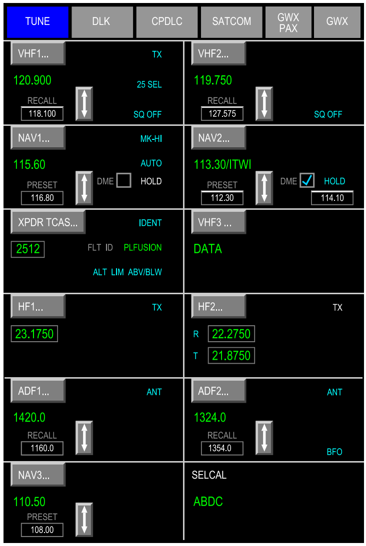
B

Navigation system indications (part 1)
Figure 16–01–3



MAP PAGE

A



1 COMMUNICATION, NAVIGATION AND SURVEILLANCE (CNS) - TUNE PAGE

A

NOTE

1 This view shows options that may not be installed on your aircraft.

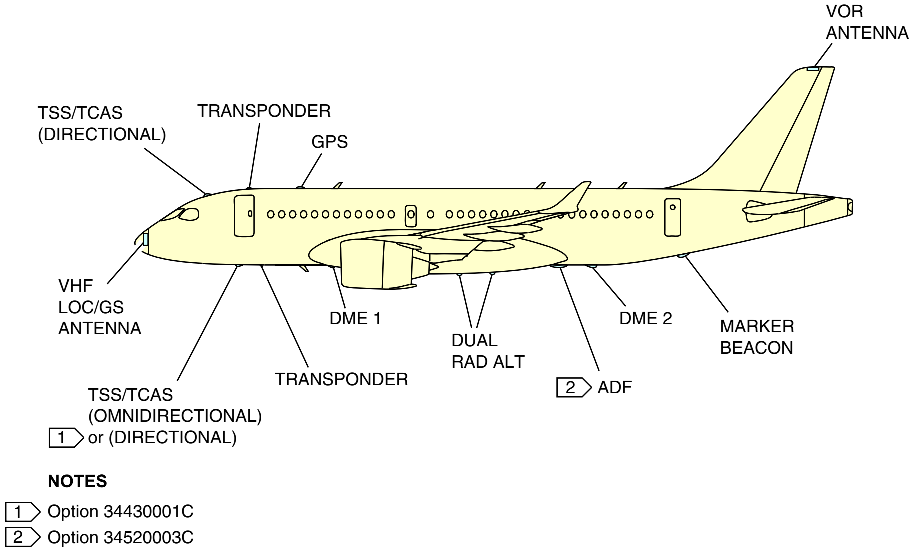
Navigation system indications (part 2)
Figure 16–01–4

NAVIGATION DISPLAY

The aircraft is equipped with:

- VHF navigation receivers,
- DME transceivers, and
- Marker Beacon (MB).

The antennas of the radio navigation equipment are located on the top and bottom of the fuselage. Refer to Figure 16–01–5

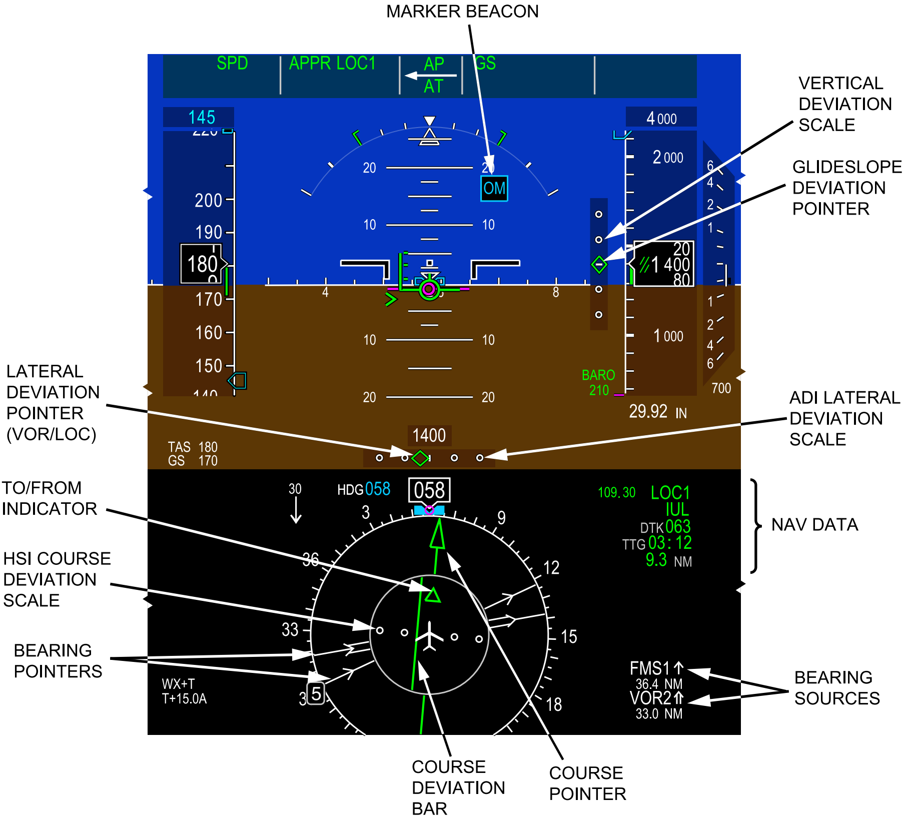


Navigation antennas
Figure 16–01–5

(1) Navigation display

VHF-NAV radio indications display on the PFD (refer to Figure 16–01–6) and include:

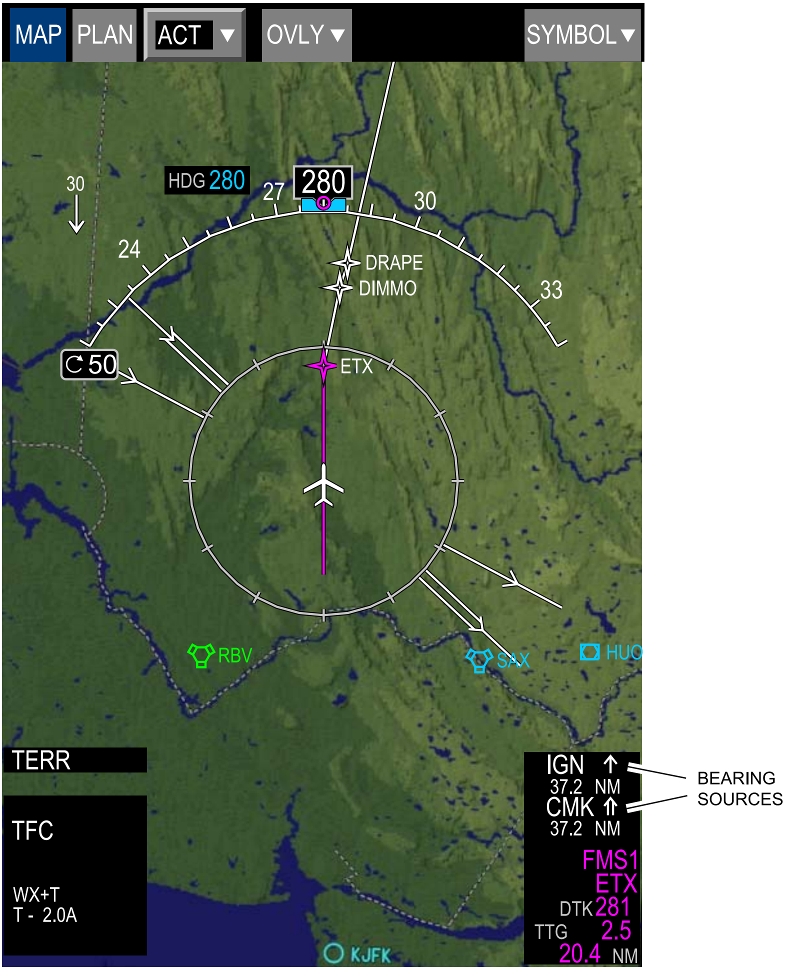
- NAV data: NAV frequency and identification, course, and Time To Go (TTG),
- Course pointer and course deviation bar,
- TO/FROM indicator,
- Lateral deviation scale and pointer,
- Vertical deviation scales and glideslope deviation pointer,
- MB,
- Bearing pointers and source.



PFD – VHF navigation radio indications
Figure 16–01–6

VHF-NAV radio navigation indications also display on the MAP page (refer to Figure 16–01–7) and include:

- Bearing pointers,
- NAVAID symbols and identifications, and
- Bearing pointers sources and distance (if available).

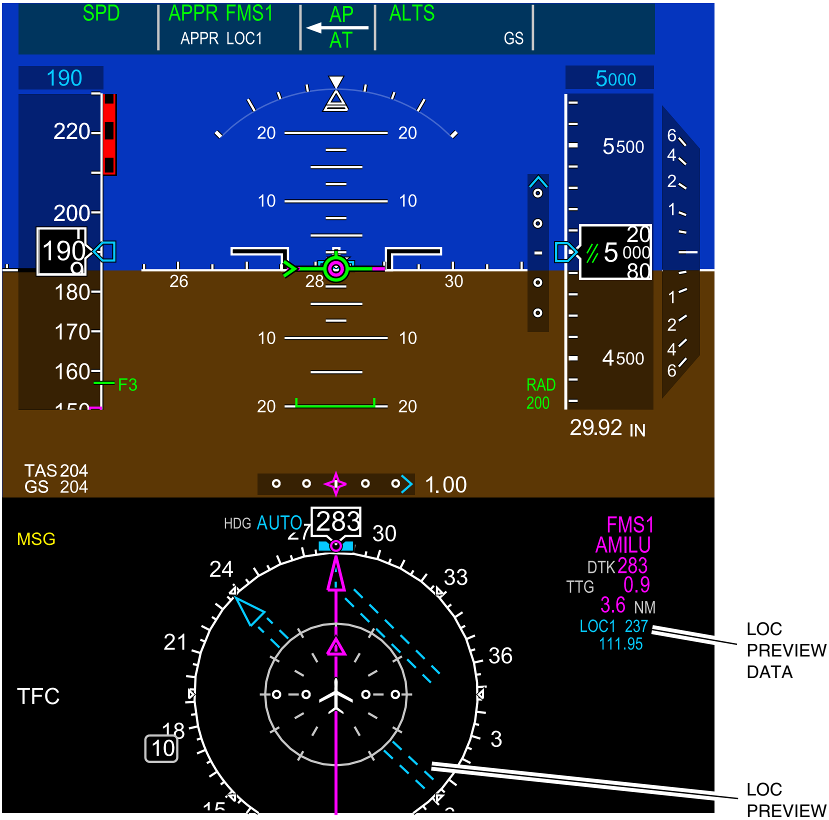


VHF – NAV radio indications on MAP
Figure 16–01–7

A. NAV-to-NAV preview

The NAV-to-NAV preview function displays localizer data and indications on the HSI when a localizer-based approach (for the destination airport) is selected in the FMS, and the aircraft is within 31 nm of destination airport.

Localizer preview indications display as a cyan dashed-lines, double-bar course pointer and deviation bar. Localizer preview data also displays the localizer frequency and the course readout in cyan. Refer to Figure 16–01–8.



NAV–to–NAV preview indications
Figure 16–01–8

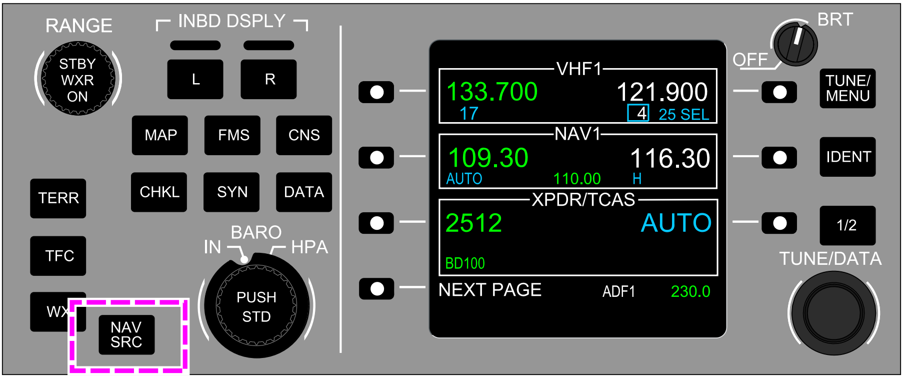
B. Failure indications

VOR, LOC, and GS failure flags display on the PFD in the event of a failure (refer to Figure 16–01–9). Course pointers and deviation bar are removed from the PFDs.

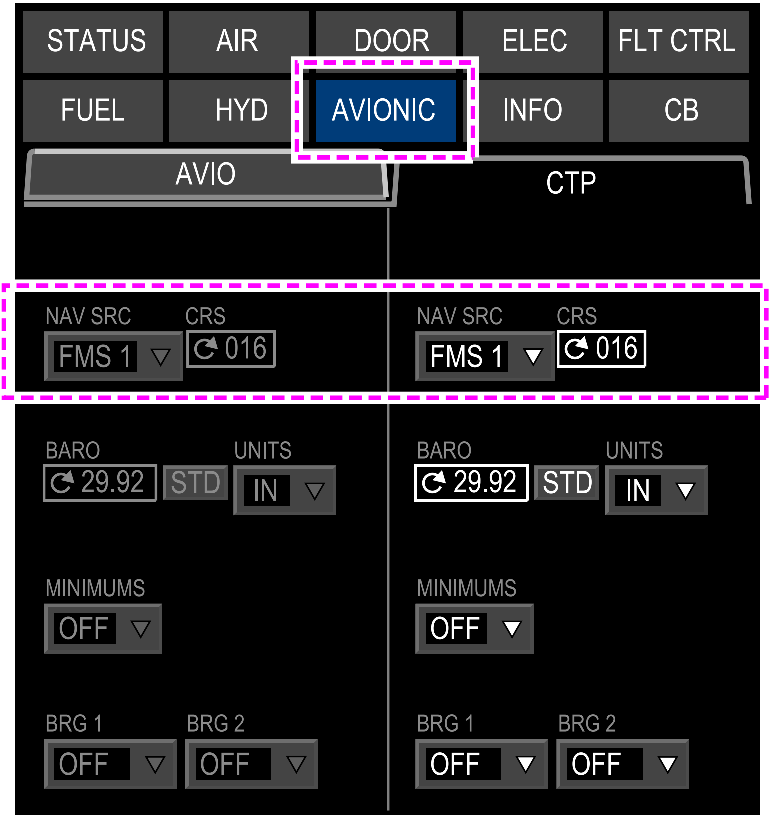
Failure indications
Figure 16–01–9

C. Navigation source selection

Navigation source is selected by pressing the NAV SRC switch on the CTP (refer to Figure 16–01–10) or by selecting the navigation source on the CTP tab on the AVIONIC synoptic page (CTP tab) (refer to Figure 16–01–11).



VHF navigation source selection – CTP
Figure 16–01–10



VHF navigation source selection – AVIONIC synoptic page
Figure 16–01–11

NOTE

Onside FMS is the default navigation source at power-up.

(1) CTP – Navigation source selection

Pressing the NAV SRC switch on the left CTP cycles through FMS1, NAV1, FMS2, NAV2. Pressing the NAV SRC switch on the right CTP cycles through FMS2, NAV2, FMS1, NAV1.

(2) AVIONIC synoptic page – Navigation source selection

The NAV SRC drop-down list on the left side selects the navigation sources that follow on the pilot side:

- FMS1, NAV1, and
- FMS2, NAV2.

The NAV SRC drop-down list on the right side selects the navigation sources that follow on the co-pilot side:

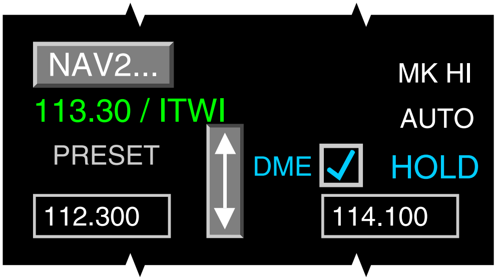
- FMS2, NAV2, and
- FMS1, NAV1.

(3) Distance Measuring Equipment (DME) system

The Distance Measuring Equipment (DME) system calculates the distance between the aircraft and a selected ground station. It has two antennas and two transceivers.

The DME antennas are located on the wing-to-body fairing and on the aft fuselage near the aft cargo compartment door. The transceivers are located in the forward and mid equipment bays.

The DME transceivers are three-channel units. The first channel is paired with the VOR, except when DME hold function (refer to Figure 16–01–12) is selected, and it is tuned when the flight crew selects a VOR/LOC station. The second and third channels are automatically selected by the Flight Management System (FMS) when auto tuning is selected.

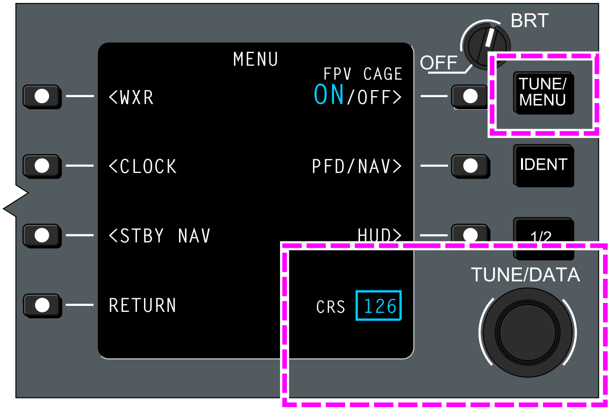


CNS – DME hold function
Figure 16–01–12

The DME hold function allows the flight crew to select a new VOR frequency separately from the first DME channel. The hold function is selected on the Control Tuning Panel (CTP) or on the Communication, Navigation and Surveillance (CNS) – TUNE page.

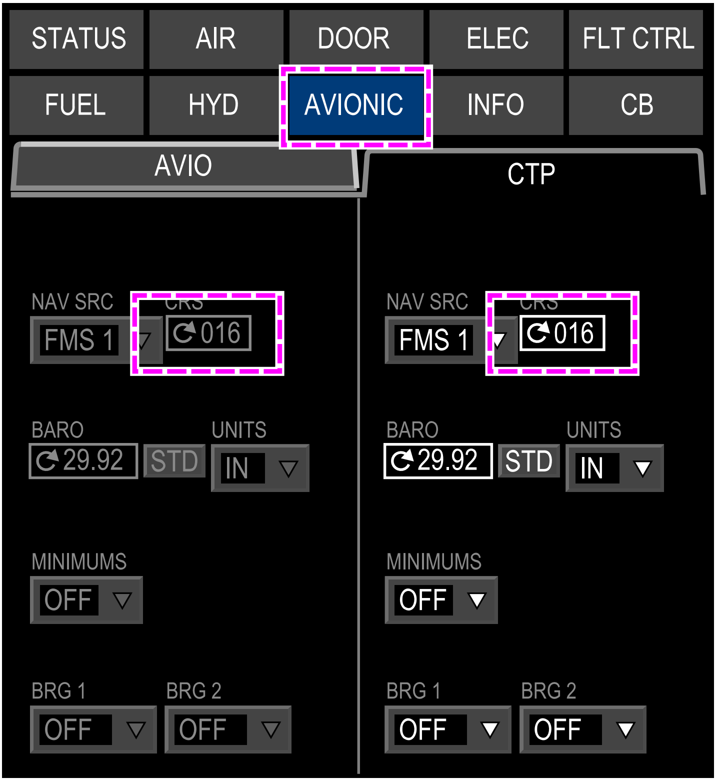
D. Course (CRS) selection

Course (CRS) selection is set on the CTP MENU page. The TUNE/DATA switch is used to select the desired course (refer to Figure 16–01–13). The selected course displays in a cyan box left of the TUNE/DATA switch and on the PFD course readout. The left CTP sets the course on the pilot side while the right CTP sets the course on the copilot side.



CTP course selection
Figure 16–01–13

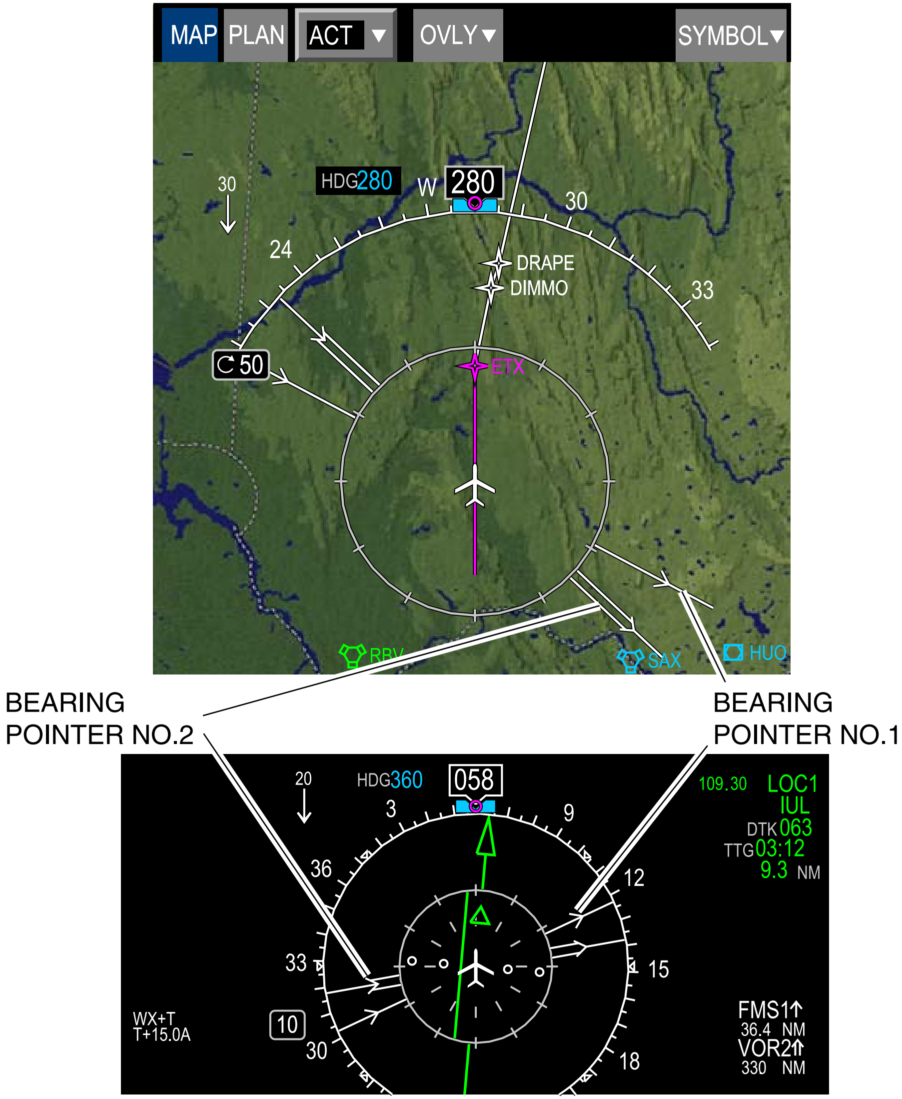
Course selection can also be set on the AVIONIC synoptic page (CTP tab) (refer to Figure 16–01–14). The CRS field is selected with the cursor and the DSK switch selects the desired course. The left CRS sets course for the pilot side while the right CRS sets course for the copilot side.



Multifunction window course selection
Figure 16–01–14

E. Bearing (BRG) pointers

Two bearing pointers display bearing information on the HSIs and MAP page (refer to Figure 16–01–15). Bearing pointer 1 displays as a single white arrow, bearing pointer 2 displays as double-bar white course pointer arrow.



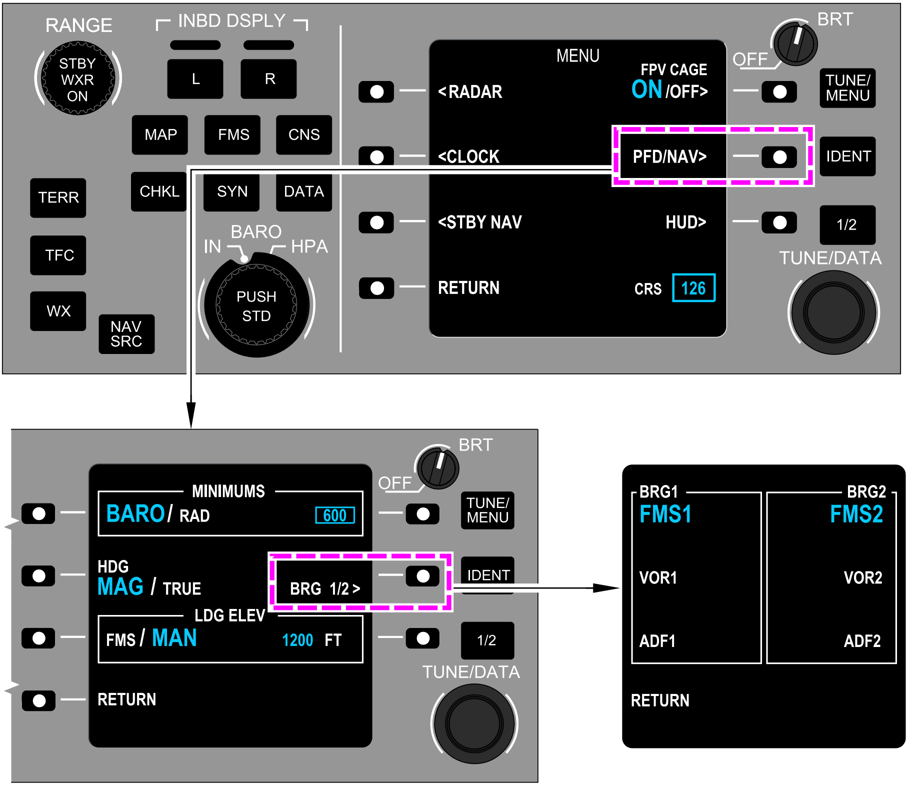
Bearing pointers
Figure 16–01–15

The bearing source is selected from the CTP or the AVIONIC synoptic page (CTP tab).

(1) CTP – Bearing selection

When using the CTP (refer to Figure 16–01–16), the bearing source is set by selecting the PFD/NAV page then the BRG 1/2 page. The BRG 1/2 page is used to select bearing 1 (BRG 1) and bearing (BRG 2) sources including:

- FMS, and
- VOR.



CTP – Bearing (BRG) pointer selection
Figure 16–01–16

(2) AVIONIC synoptic page – Bearing selection

When using the AVIONIC synoptic page, the bearing source is set from the CTP tab. Four drop-down lists display (refer to Figure 16–01–17) to select the source for bearing pointer 1 and 2 of the left and right HSI.

AVIONIC synoptic page
Figure 16–01–17

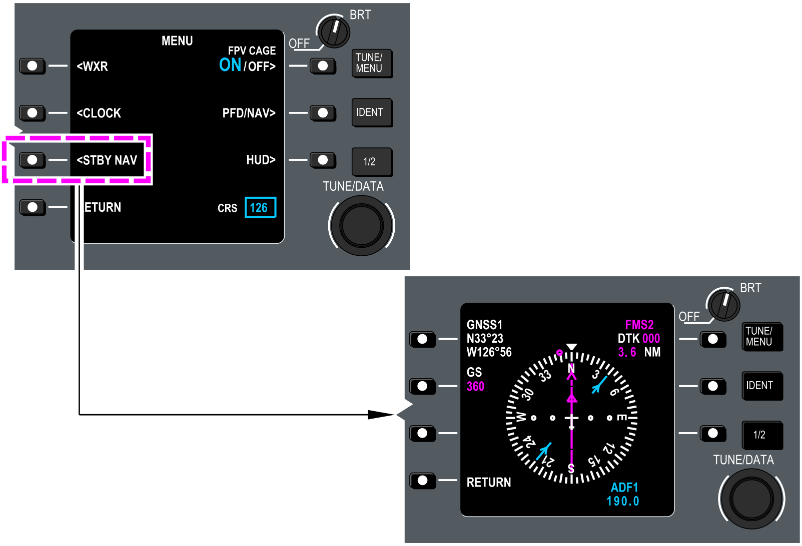
F. STBY NAV format

The CTP has a STBY NAV (Standby Navigation) format to cover failure scenarios in cases where all displays are failed. STBY NAV is accessed through the MENU page of the CTP. When selected, the STBY NAV display remains in view until another selection is made on the CTP.

The onside FMS is the default navigation source. The cross-side FMS is used if the onside FMS is not available. Manual selection of the navigation source is not possible. The onside Inertial Reference System (IRS) provides compass data. IRS 3 or cross-side provides reference data if onside IRS is not available.

The STBY NAV format displays (refer to Figure 16–01–18) the information that follows:

- GNSS position (360-degree compass),
- Ground Speed (GS),
- FMS source (onside or cross-side FMS),
- Desired track (DTK),
- Distance to waypoint (NM),
- Heading pointer,
- Drift bug,
- Course pointer,
- Course deviation bar,
- Lateral deviation scale,
- Aircraft symbol, and
- To/From indicator.



Standby navigation display
Figure 16–01–18

NAVIGATION RADIO TUNING

Tuning and control of the navigation radios is performed using either the:

- CTPs,
- Communications, Navigation, and Surveillance (CNS) page, and
- Graphical tuning function.

A. CTP tuning

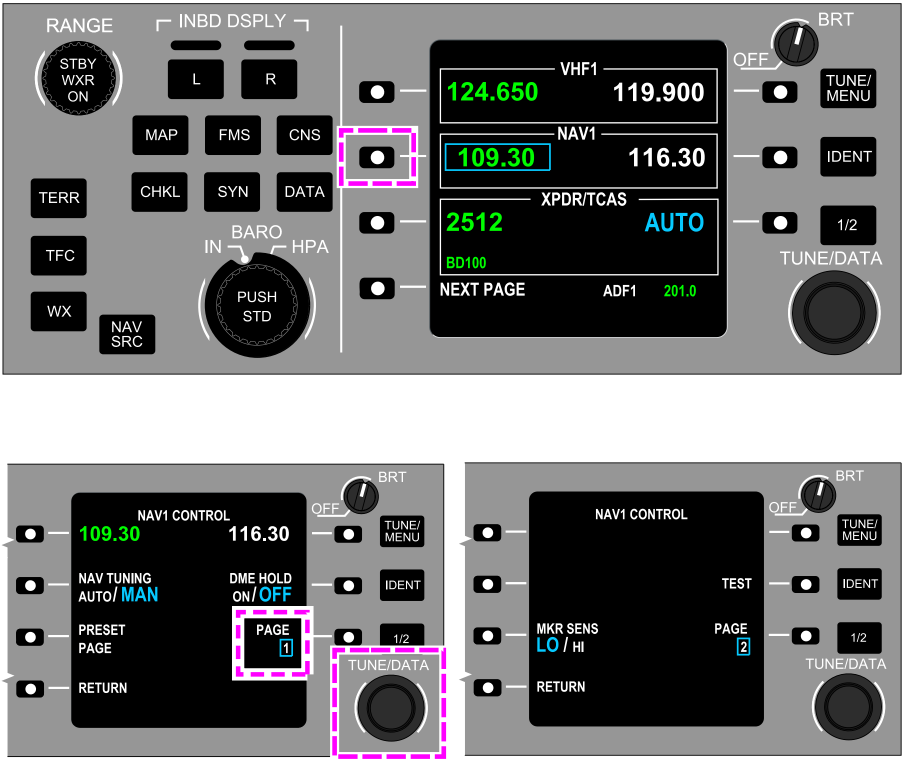
Tuning of navigation radios is very similar to the communication radios. The standby frequency is tuned by pressing the adjacent line select key (LSK) to position the focus indicator over the frequency, and using the TUNE/DATA switch to set the frequency (refer to). The standby and active frequencies may then be swapped by pressing on the LSK a second time.

The active frequency can be directly tuned by pressing the LSK adjacent to the active frequency (to position the focus indicator on the frequency), and using the TUNE/DATA switch to set the new frequency.

(1) VHF-NAV control

The VHF-NAV radios are controlled from the NAV CONTROL pages (refer to Figure 16–01–19) that are accessed by a double press of the LSK, adjacent to the active navigation frequency.

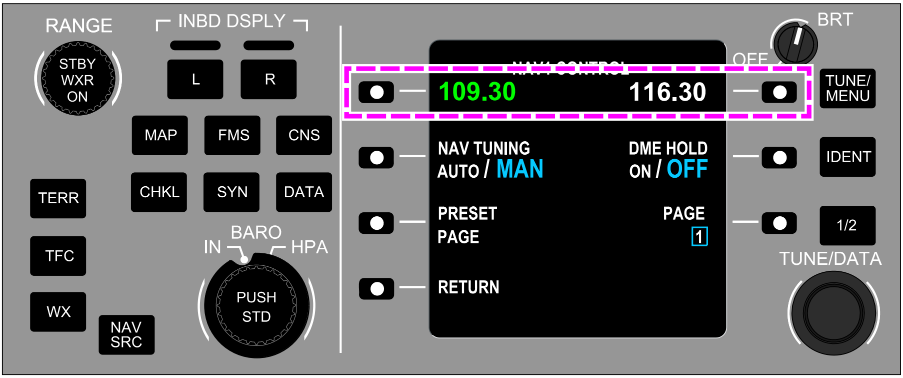
Pages are changed by pressing the LSK adjacent to PAGE, and using the TUNE/DATA switch.



CTP – NAV CONTROL pages
Figure 16–01–19

The NAV CONTROL pages include the VHF-NAV TUNING (refer to Figure 16–01–20) for the control of the tuning selection.

For standby or direct tuning of the VHF-NAV radios.

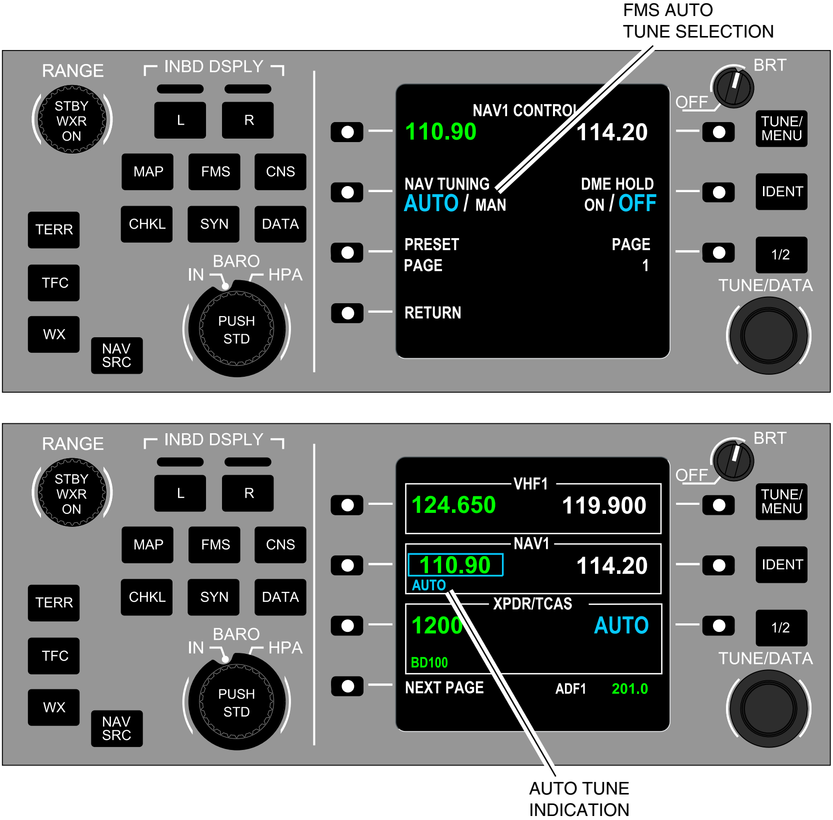


CTP – VHF – NAV tuning
Figure 16–01–20

(2) NAV TUNING MODE

When NAV TUNING is set to MAN, the FMS automatically uses DME channel 2 and channel 3 to calculate the aircraft position.

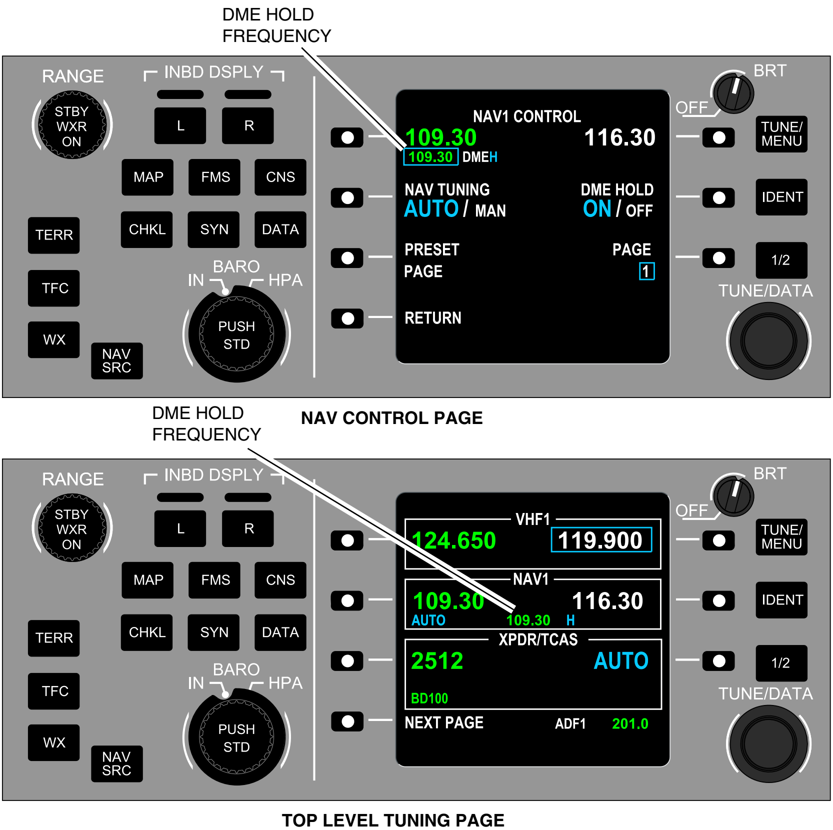
When the NAV TUNING is set to AUTO, the FMS still uses DME channel 2 and channel 3, but adds DME channel 1 and the VOR radial to calculate the aircraft position. The AUTO selection is only available when the FMS is the navigation source. It is removed when the VHF navigation radio is the navigation source. When AUTO is selected, AUTO displays in cyan, below the active frequency on the CTP top level page (refer to Figure 16–01–21).



CTP – NAV CONTROL page – AUTO tuning
Figure 16–01–21

(3) DME HOLD

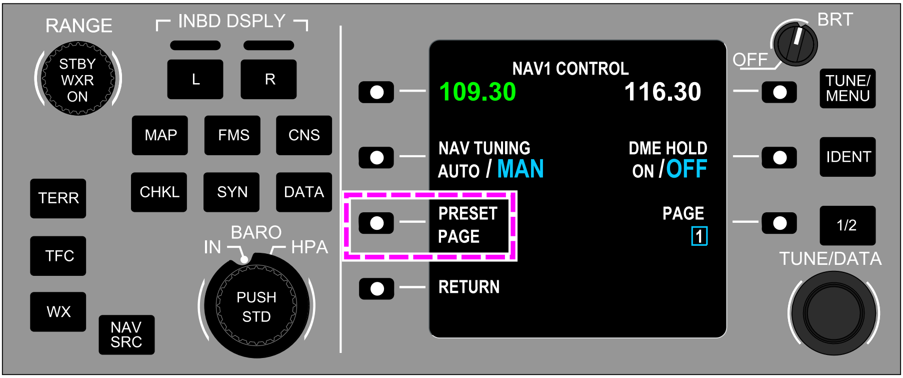
When DME HOLD is selected to ON, the DME frequency, followed by a cyan H display in a sub-window on the NAV CONTROL page and on the top level tuning page (refer to Figure 16–01–22). The DME hold frequency can be changed directly by pressing the adjacent LSK to move the focus indicator on the DME HOLD frequency, and set the new frequency using the TUNE/DATA switch.



CTP – NAV CONTROL page – DME HOLD
Figure 16–01–22

(4) PRESET PAGE

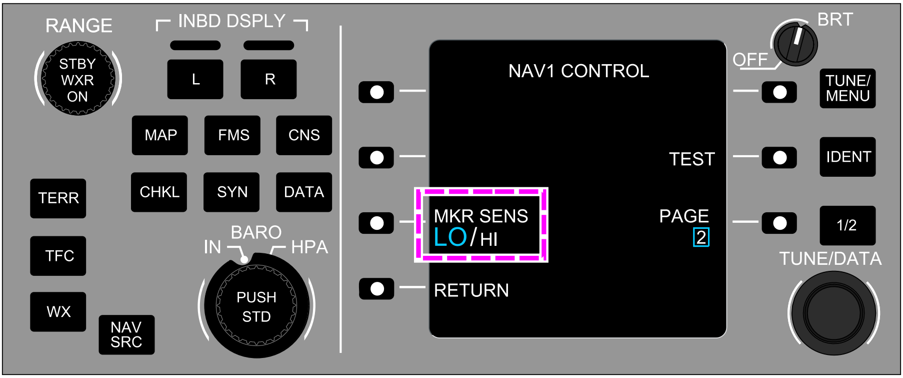
The PRESET PAGE selection accesses the NAV PRESET pages which allow storage or editing of VHF-NAV frequencies (refer to Figure 16–01–23).



CTP – NAV CONTROL page – PRESET PAGE selection
Figure 16–01–23

(5) MRK SENS

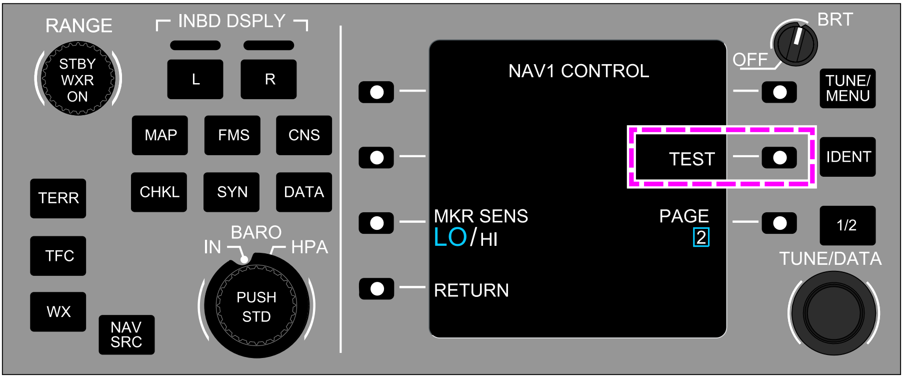
The MKR SENS selection displays on NAV CONTROL page 2 (refer to Figure 16–01–24). It is used to select the marker beacon sensitivity to low (LO) or high (HI).



CTP – NAV CONTROL page – MKR SENS selection
Figure 16–01–24

(6) TEST

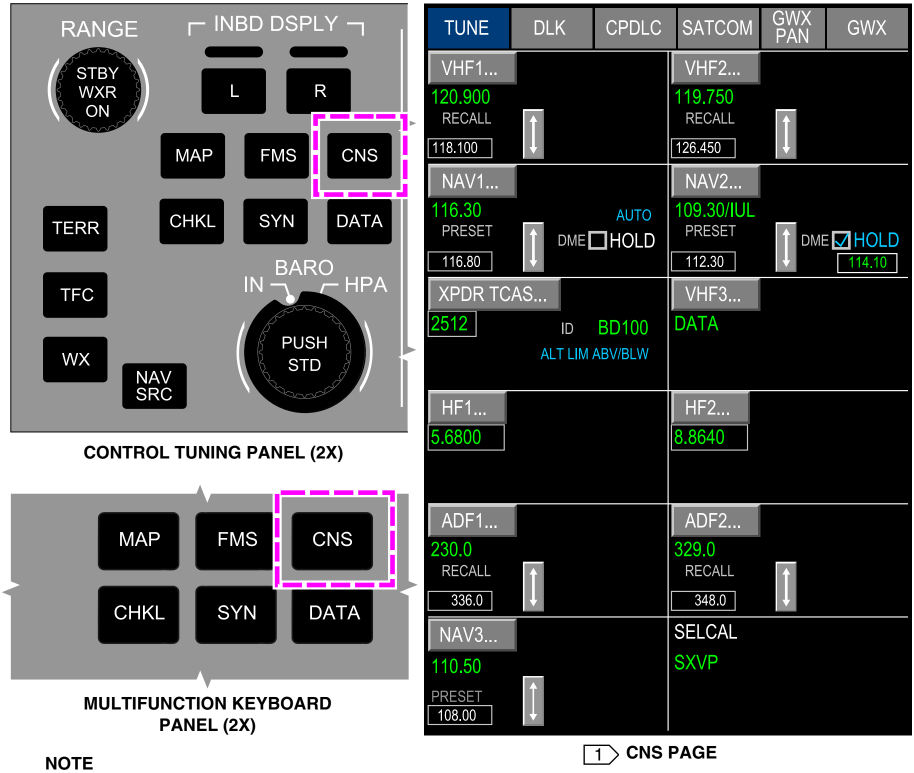
The TEST selection allows to test the VHF-NAV radios. When the adjacent LSK is pressed (refer to Figure 16–01–25), the test mode is activated for approximately 10 seconds (on ground only), during which TEST displays in cyan. A single beep sounds to indicate a pass, and a double beep sounds to indicate a fail.



CTP – NAV CONTROL page – TEST
Figure 16–01–25

B. Display tuning

Display tuning provides radio tuning and control using the TUNE page on the multifunction window (MFW). The TUNE page can be displayed by pressing either the CNS switch on the CTP or the CNS QAK on the MKP, then selecting the TUNE soft tile (refer to Figure 16–01–26 <34521003C>).

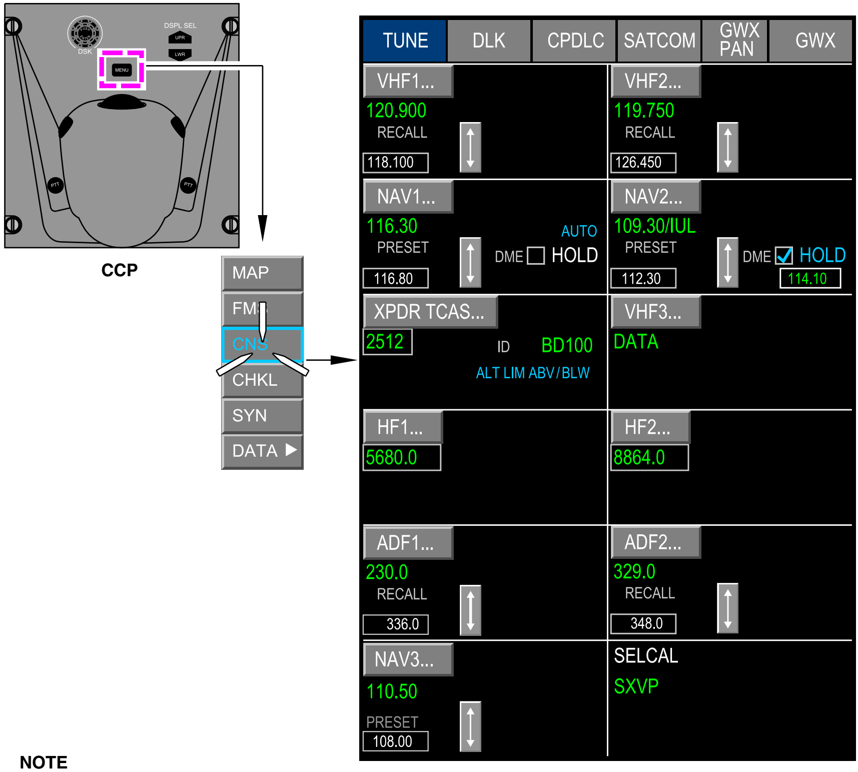


NOTE

1 This view shows options that may not be installed on your aircraft.

TUNE page via CTP or MKP <34521003C>
Figure 16–01–26

The TUNE page can also be accessed by pressing the MENU switch on the CCP (refer to Figure 16–01–27 <34521003C>), selecting CNS on the drop-down menu, then selecting the TUNE soft tile.



NOTE

1 This view shows options that may not be installed on your aircraft.

1 **CNS PAGE**

TUNE page via CCP <34521003C>
Figure 16–01–27

(1) TUNE window

Each navigation radio (VHF, ADF) displays in its own section of the TUNE page with its active and standby frequencies, control soft switch, and swap soft switch (refer to Figure 16–01–28). <34521003C>

The active frequencies display in green, the standby frequencies display in white. They display amber when there is a system tuning fault. The cursors are used to select soft switches and highlight data to be changed or modified.

NOTE

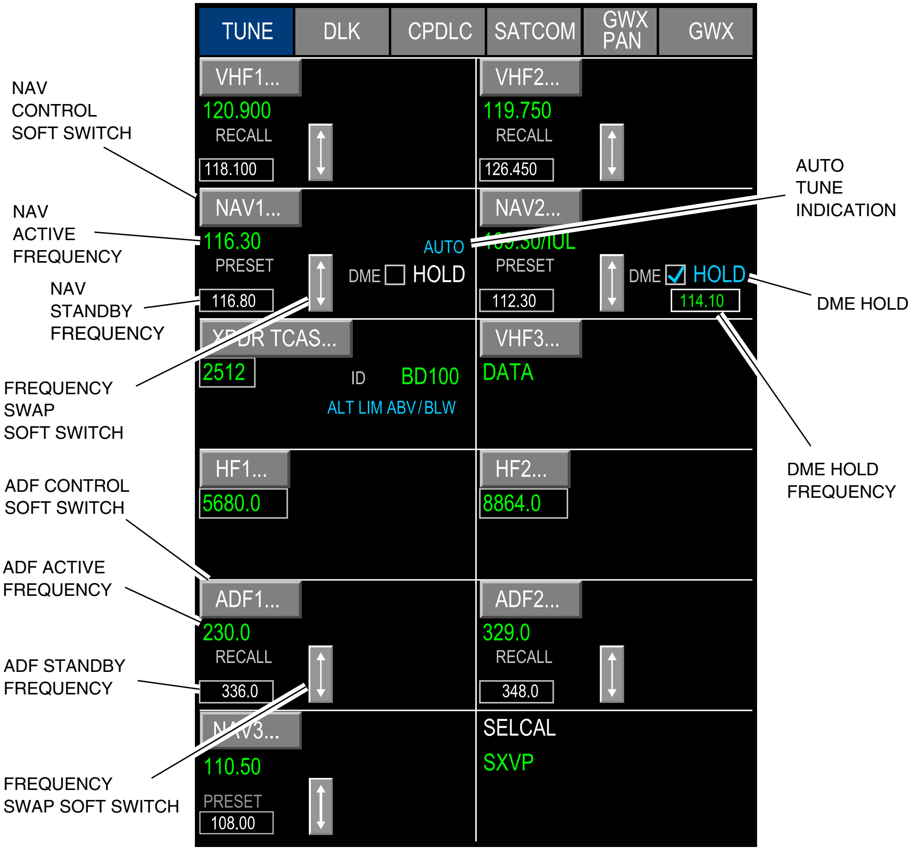
This view shows options that may not be installed on your aircraft.

CNS – NAV/ADF – TUNE page <34521003C>
Figure 16–01–28

(2) NAV radio tuning

NAV radios are tuned using the MKP or the CCP to position the focus indicator on the standby frequency (either VHF or ADF) and enter a new frequency. Selecting the frequency swap soft switch swaps the active and standby frequencies. Refer to Figure 16–01–29. <34521003C>

When the DME HOLD box is checked, HOLD displays in cyan and the DME hold frequency window displays to set the DME frequency.



NOTE

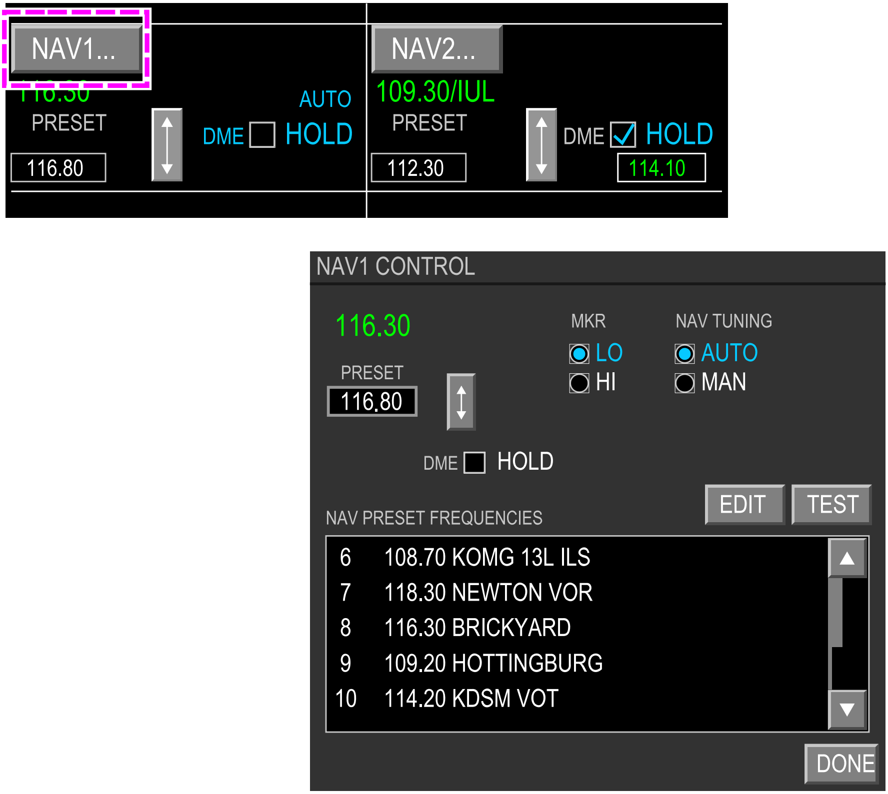
This view shows options that may not be installed on your aircraft.

CNS – NAV window – Tuning and Control <34521003C>
Figure 16–01–29

(3) VHF-NAV control

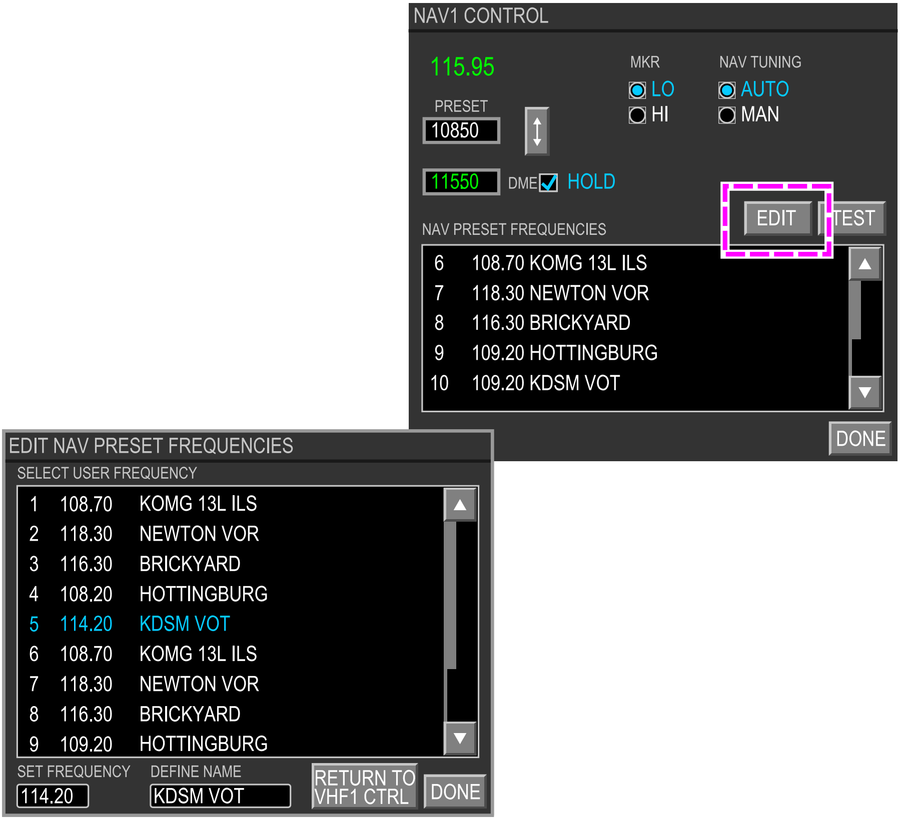
Selection of the NAV1(2) soft switch displays the NAV1(2) CONTROL window (refer to Figure 16–01–30), which includes the following:

- Standby frequency tuning and frequency swap,
- DME HOLD check box,
- MKR SENS selection,
- NAV TUNING when FMS is the navigation source,
- TEST, and
- EDIT.



CNS – TUNE page – VHF–NAV Control
Figure 16–01–30

The EDIT soft switch opens the EDIT NAV PRESET FREQUENCIES window where preset frequencies may be changed or added. Refer to Figure 16–01–31.



CNS – TUNE page – VHF – EDIT NAV PRESET FREQUENCIES window
Figure 16–01–31

(4) ADF control <34521003C>

Selection of the ADF1(2) soft switch displays the ADF1(2) CONTROL page. The cursor is used for tuning and control functions similar to the CTP. This includes:

- Active and preset frequency tuning,
- ADF/ANT MODE selection,
- BFO ON/OFF selection,

- ADF TEST, and
- Editing of stored preset frequencies

The EDIT soft switch provides access to the ADF PRESET FREQUENCIES window containing a list of 20 user defined ADF preset frequencies. Refer to Figure 16–01–32.

CNS – TUNE page – ADF CONTROL window <34521003C>
Figure 16–01–32

C. Graphical navigation tuning

Navigation radio tuning can be done using the cursor and the graphic map displayed on the MFW (refer to Figure 16–01–33).

Each navigation radio (VOR, VOR/DME, TACAN, NDB) displayed on the map can be selected. <34521003C>

When selected, a drop-down list containing tuning options for the VHF-NAV radios or ADF receiver is displayed. When TUNE NAV or TUNE ADF is selected from the list, the corresponding VHF or ADF frequency is automatically tuned, and displays as the active frequency on the associated CTP. <34521003C>

Graphical navigation tuning
Figure 16–01–33

IRS – OVERVIEW

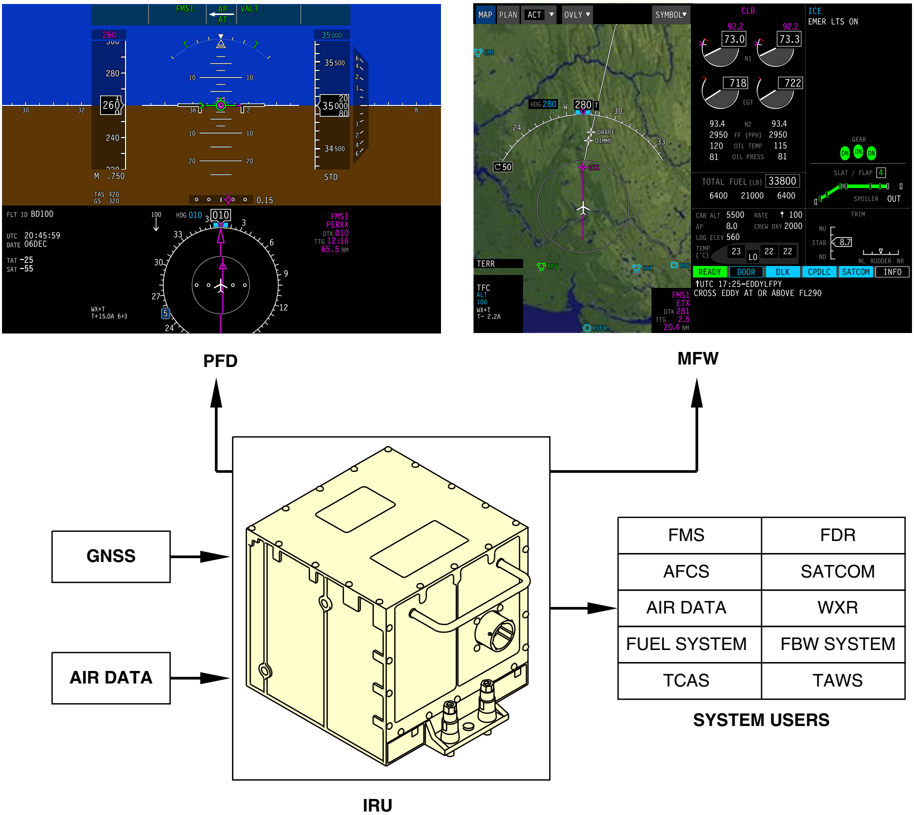
The aircraft is equipped with an Inertial Reference System (IRS) that includes three Inertial Reference Units (IRUs) and an Aircraft Personality Module (APM). The APM includes the aircraft configuration and mounting tray alignment data for each IRU installation. Each IRU contains accelerometers and laser gyros to measure inertial motion. The IRU receives system initialization data from the Global Navigation Satellite System (GNSS) and Air Data Computer (ADC) for alignment and position calculation.

IRU 1 and IRU 3 are located in the left side console and IRU 2 is located in the right side console. Each IRU receives power from multiple sources to ensure constant availability, regardless of the electrical power configuration.

The IRUs provides data to the Primary Flight Display (PFD) and other systems requiring IRU data that follow:

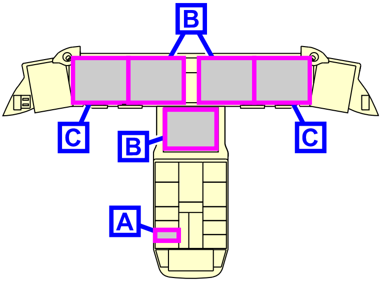
- Aircraft attitude (roll and pitch),
- Heading,
- Wind speed and direction, and
- Aircraft flight path.

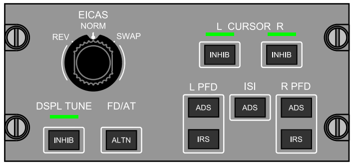
Figure 16–02–1 shows an overview of the IRS.



IRS
Figure 16–02–1

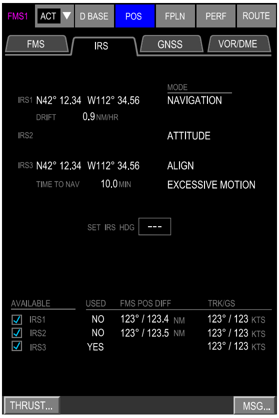
Operational information is available on the IRS tab of the POS page in the Flight Management System (FMS) (refer to Chapter 22: Flight Management System). The IRS status and faults are reported on the EICAS page and on the Flight Mode Annunciator (FMA) on the PFD. Controls are located on the Reversion Switch Panel (RSP) (refer to Figure 16–02–2).

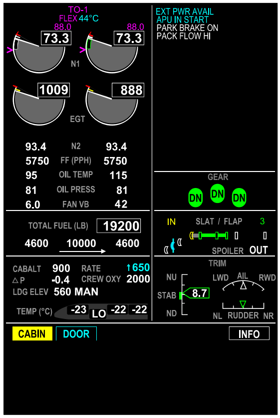




REVERSION SWITCH PANEL (RSP)

A



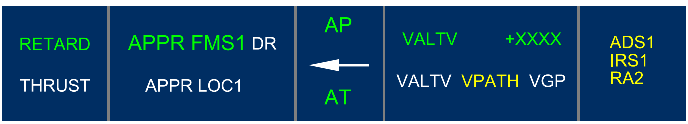


FMS POS PAGE - IRS TAB

B

EICAS PAGE - EICAS MESSAGES

B



PFD - FLIGHT MODE ANNUNCIATOR (FMA)

C

IRS controls and indications
Figure 16–02–2

IRS ALIGNMENT MODES – OPERATION

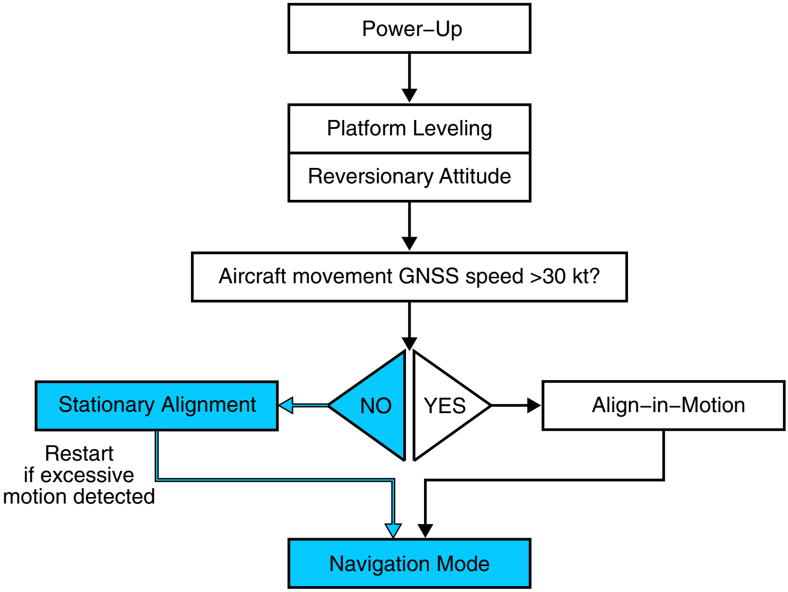
A. IRS alignment

The IRS startup alignment is completely automatic with no required action. An Align-In-Motion (AIM) feature provides automatic in-flight alignment when required.

At power-up or when the IRS is reset, it enters a power-up mode. During this mode, the IRS checks its configuration. Following the power-mode, a platform leveling function is done on each IRU. Then the IRUs enter the reversionary attitude mode to provide pitch and roll attitudes, magnetic heading, rotational rates, and linear accelerations.

While in the reversionary attitude mode, the IRUs enter the stationary alignment mode or the AIM mode, depending on the aircraft motion.

Figure 16–02–3 shows the IRS alignment operation.



IRS alignment operation
Figure 16–02–3

B. Stationary Alignment (SA) mode

The IRUs enter the Stationary Alignment (SA) mode on ground with no excessive aircraft movement (aircraft speed less than 30 kt). The SA mode does the actions that follow:

- Aligns with local vertical,
- Estimates the current latitude,
- Finds the true north, and

- Counts down the remaining time to the navigation mode.

After successful alignment, the IRU transfers to navigation mode.

The time required for an SA mode is dependent on the aircraft latitude. Alignment time ranges from 5 minutes at 0 degrees latitude to approximately 10 minutes between 60 degrees and 70 degrees latitude, and extending up to 17 minutes above 70 degrees latitude.

NOTE

On-ground, the stationary alignment mode is not affected by normal ramp activity such as fueling or loading. However, excessive motion, push-back or taxiing may cause the IRS to restart the full alignment. This will only occur 30 seconds after motion stops.

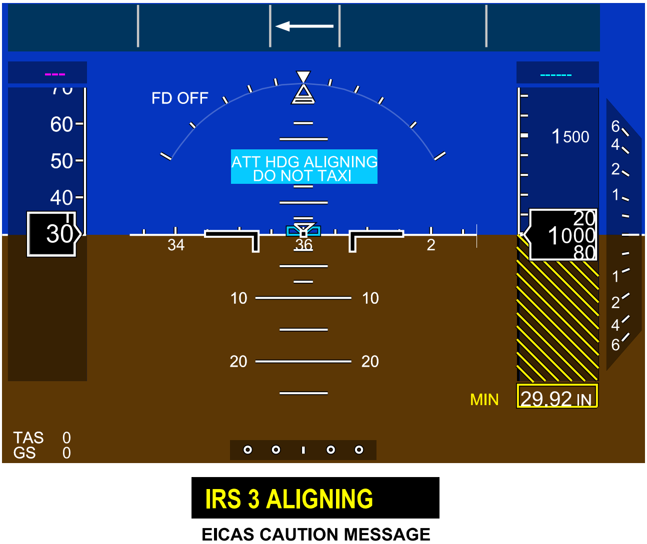
During the SA mode, the IRS uses the GNSS position data as an automatic source for position entry. It can also use a position entered by the flight crew in the FMS as a valid source. In the FMS tab, when the POS soft switch is selected, the flight crew can enter the position data that follow (refer to Figure 16–02–4):

- The airport (on ground),
- The NAVAID (in flight), or
- The reference point.

After the flight crew enters the position data and selects the LOAD soft switch, the GNSS data is ignored. Because the flight crew data entry is subject to errors, the IRS does a position comparison test with the last navigation position recorded by the IRS.

Position initialization
Figure 16–02–4

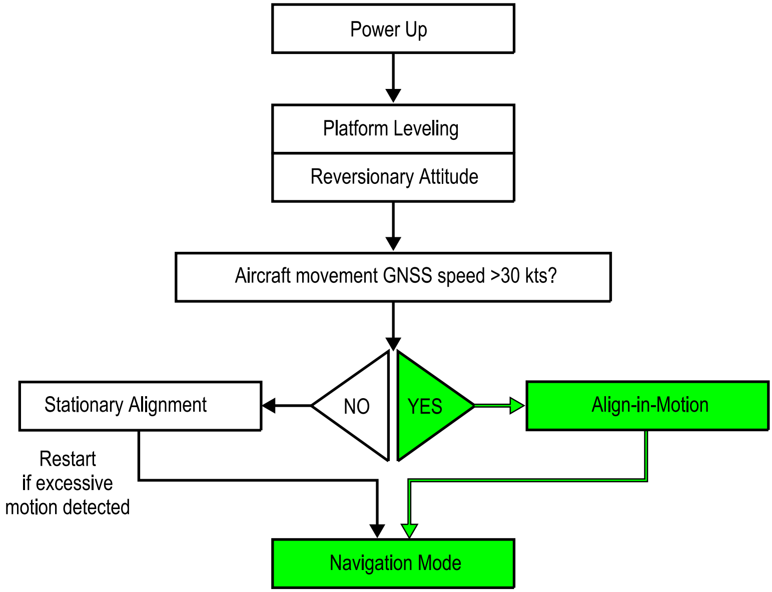
An ATT/HDG ALIGNING – DO NOT TAXI message is provided on each PFD while IRS 1 and IRS 2 are aligning. During the alignment of IRS 3, the caution message IRS 3 ALIGNING is displayed on the EICAS page (refer to Figure 16–02–5). The message is removed after a successful alignment and transition to the navigation mode.



IRS alignment indications
Figure 16–02–5

C. Align-In-Motion (AIM) mode

The Align-In-Motion (AIM) mode is used for alignment while the aircraft is in motion (aircraft speed is above 30 knots), allowing the IRUs to recover full navigation capability in the event of an in-flight power interruption. Refer to Figure 16–02–6.



AIM Alignment Process
Figure 16–02–6

In navigation mode, the AIM function uses GNSS and altitude data to recover the full capability of the IRU. During AIM alignment, an ATT/HDG ALIGNING message displays on the PFD. The message is removed when the IRU is in navigation mode.

Following a power loss, the reversionary attitude mode provides quick recovery of attitudes and accelerations. This mode occurs when the conditions that follow are met:

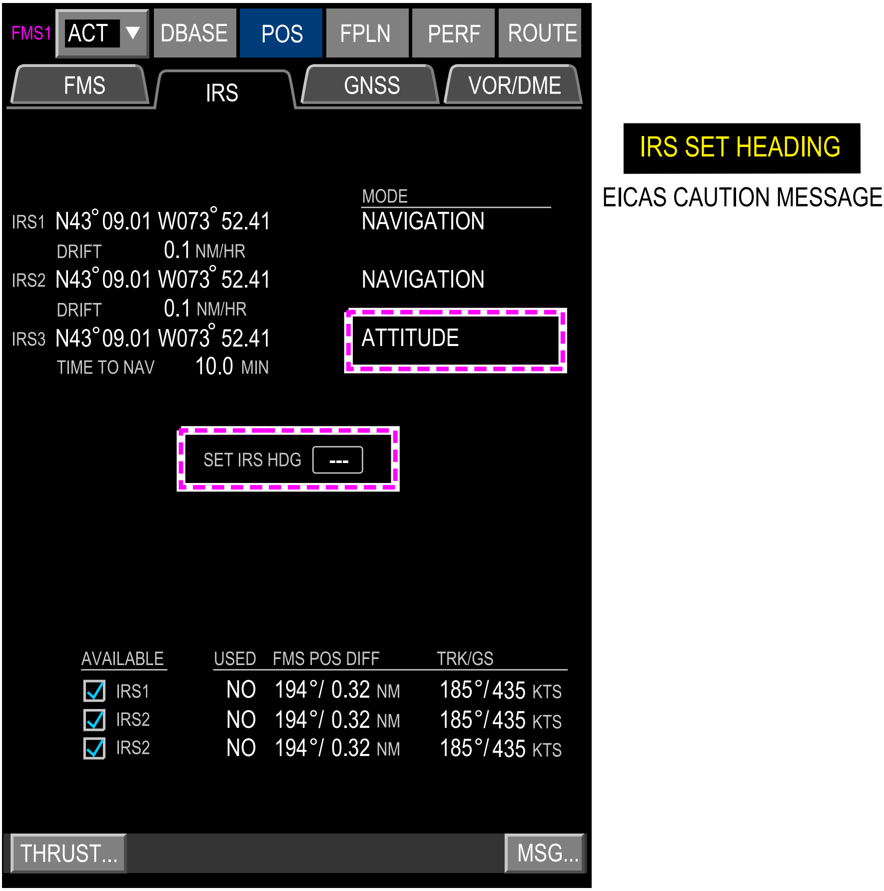
- IRS is reset during flight, or
- Pressure altitude is valid, and
- GNSS data is valid, and
- Ground Speed (GS) is greater than 30 kt.

The time period of the AIM varies from 15 minutes to 25 minutes, depending on the flight dynamic conditions (rate of change in heading and acceleration, etc.). Flight with no heading and acceleration changes may cause the time to exceed 25 minutes. Aircraft maneuvers with changes in heading and acceleration may reduce alignment time to 15 minutes or less.

D. Attitude mode

If air data and GNSS inputs are not available, the IRS stays in the reversionary attitude mode, providing attitude and heading information only.

During AIM, when a manual entry of the magnetic heading is necessary to recover heading information, the caution message **IRS SET HEADING** appears on the EICAS page. The magnetic heading is entered in the FMS page, in the IRS tab when the POS soft switch is selected. Refer to Figure 16–02–7.



POS soft switch – IFS tab – Magnetic heading input
Figure 16–02–7

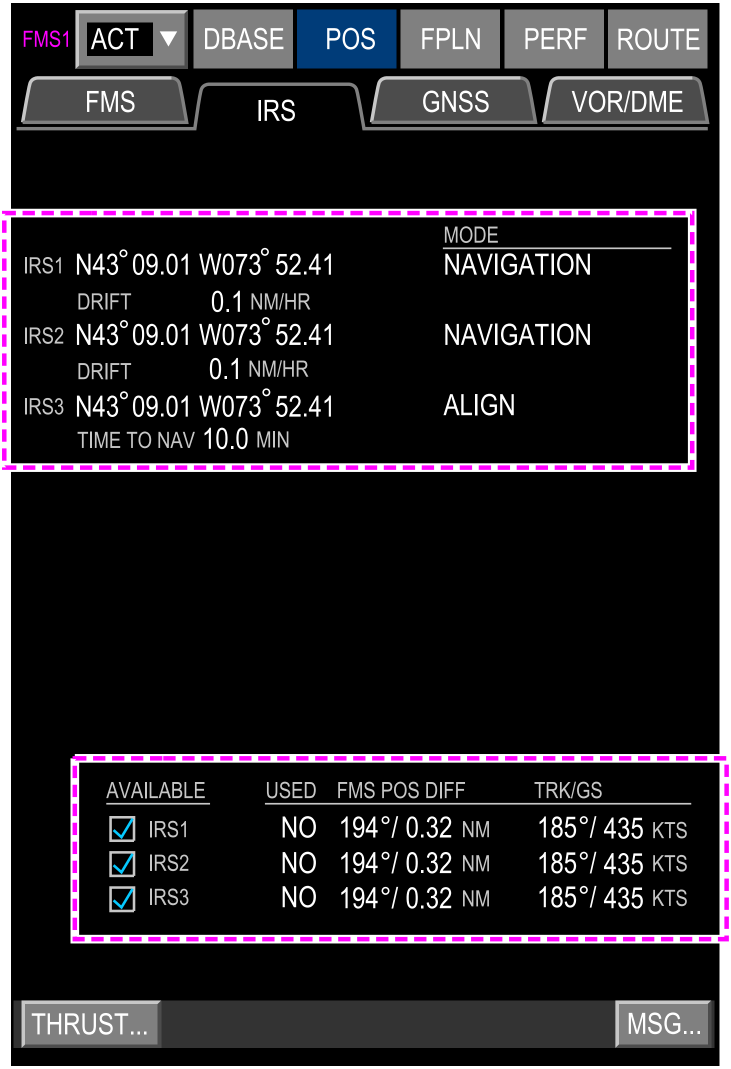
The caution message is removed when the IRU is in navigation mode.

E. IRS indications

The IRS operational information (operating modes and position data) displays on the IRS tab of the FMS when the POS soft switch is selected.

For each IRS, the IRS tab displays the data that follow (refer to Figure 16–02–8):

- The position (aircraft position calculated by the IRS),
- The IRS drift (DRIFT) or the time to navigation (TIME TO NAV) during an alignment mode, and
- The operating mode and messages that follow:
  - NAVIGATION, this is the normal operation mode, the IRS is fully operational,
  - ALIGN, the IRS is in alignment mode,
  - ATTITUDE, the IRS provides the attitude and the heading information only (no position), and
  - EXCESSIVE MOTION, the alignment is restarted because of an excessive motion.



POS soft switch – IRS tab – IRS display
Figure 16–02–8

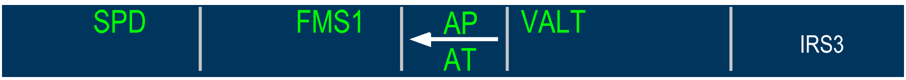
At the bottom of the page, three check boxes are used to select or deselect the IRSs for use. By default, all three IRSs are selected. For each IRS, information that follow display:

- USED, indicates if the FMS uses the IRS calculated position for navigation (YES) or not (NO),
- FMS POS DIFF, indicates the direction and distance (nm) of the FMS position from the calculated IRS position, and
- TRK/GS, indicates the aircraft track and groundspeed calculated by the IRS.

F. IRS reversion

IRS 1 provides data to the pilot side and IRS 2 provides data to the copilot side. IRS 3 is an alternate for either side.

IRS 3 automatically takes over a failed IRS and is displayed as a white IRS 3 message on the FMA. An advisory message also displays to indicate which IRS has failed (refer to Figure 16–02–9).

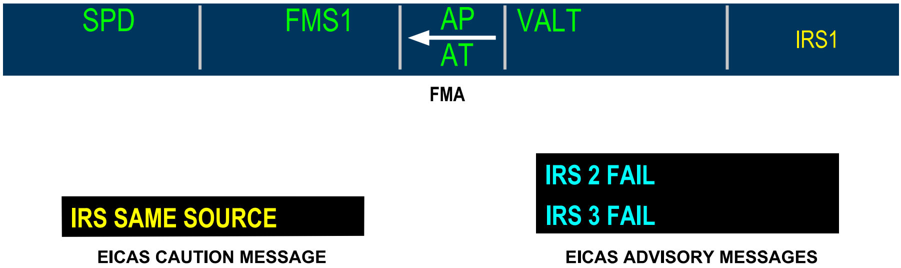


PFD - FLIGHT MODE ANNUNCIATOR (FMA)

EICAS ADVISORY MESSAGE

Single IRS failure
Figure 16–02–9

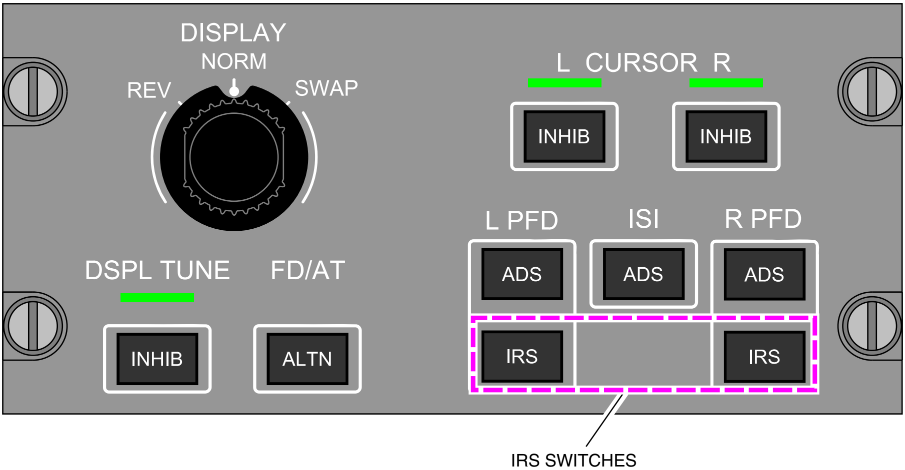
If a dual IRS failure occurs (including IRS 3), the remaining IRS displays in amber on the FMA. At the same time, the EICAS page displays an **IRS SAME SOURCE** caution message and two advisory messages corresponding to the failed IRS (refer to Figure 16–02–10).



Single Source IRS
Figure 16–02–10

There is no message on the FMAs when an IRS provide data to its respective side.

Manual reversion is also available by using the reversion switch panel (refer to Figure 16–02–11). Pressing the left IRS switch cycles the IRS source of the left PFD from IRS 1 to IRS 3 then IRS 2. Subsequent pressing of the IRS switch repeats the cycle. Similarly, pressing the right IRS switch cycles the IRS source of the right PFD from IRS 2 to IRS 3 then IRS 1.



Reversion switch panel
Figure 16–02–11

The table that follows describes the normal and reversion configurations:

	Primary	Secondary	Backup
Left PFD	IRS 1	IRS 3	IRS 2
Right PFD	IRS 2	IRS 3	IRS 1

IRS – EICAS MESSAGES

A. Warning messages

None.

B. Caution messages

Message	Description	Inhibit
IRS SAME SOURCE	Two of the three IRS failed.	TO, LDG

Message	Description	Inhibit
IRS SET HEADING	Heading manual entry is required.	TO, LDG

C. Advisory messages

Message	Description	Inhibit
IRS 1 FAIL	IRS 1 failure reported.	TO, LDG
IRS 2 FAIL	IRS 2 failure reported.	TO, LDG
IRS 3 FAIL	IRS 3 failure reported.	TO, LDG
IRS 1 PWR FAULT	The IRS 1 is operating on auxiliary power or auxiliary power is not available to the IRS.	TO, LDG

D. Status message

There is no EICAS status message related to IRS operation.

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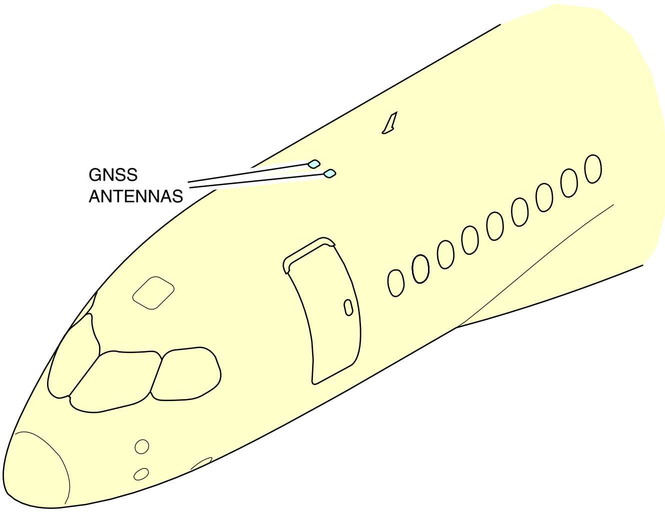
GNSS – OVERVIEW AND OPERATION

A. Satellite-Based Augmentation System (SBAS)

The Global Navigation Satellite System (GNSS) includes two receivers (GPS) located in the forward equipment bay and two antennas (refer to Figure 16–03–1). The receivers require a minimum of four satellites for a 3D position solution. The system is automatically active when the aircraft has electrical power.



GNSS antenna
Figure 16–03–1

The GNSS receivers interface with the Inertial Reference System (IRS), the Flight Management System (FMS), and the Terrain Awareness and Warning System (TAWS) to provide the outputs that follow:

- The position,
- The velocity, and
- The time data.

The GNSS position and status display on the FMS and GNSS tabs of the POS page.

The system provides Receiver Autonomous Integrity Monitoring (RAIM) for non-precision approach (five satellites are required for RAIM). The GNSS receivers support all Satellite Based Augmentation System (SBAS) operations, including Localizer Performance with Vertical Guidance (LPV) approaches.

The SBAS enhances and ensures the integrity of GPS signals and improves accuracy and availability of the indicated position of the aircraft for all phases of flight.

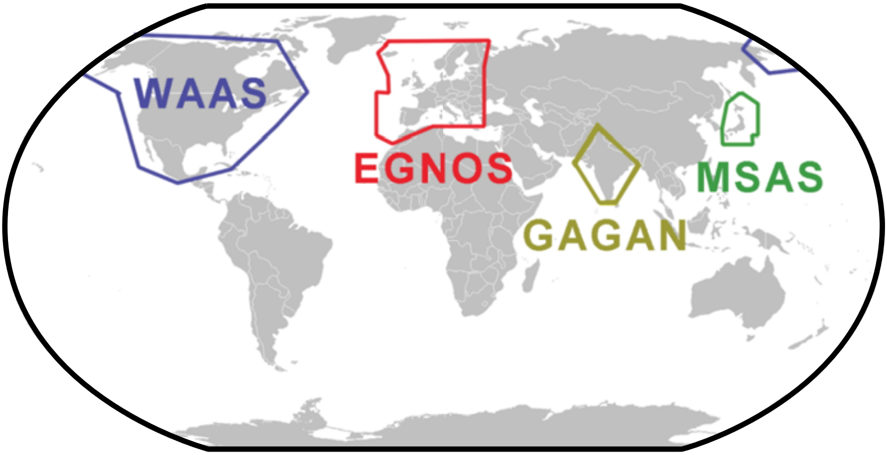
The SBAS consists of the items that follow:

- The ground reference stations,
- The master stations,
- The uplink stations, and
- The geostationary communication satellites.

The ground reference stations are surveyed accurately and compare their known location with the received GNSS satellite signals to detect errors. Data collected results in a corrective augmentation message sent to SBAS communication satellites. The satellites correction data is then sent to GNSS receivers.

The GNSS is designed to operate with signals from any SBAS that follow (refer to Figure 16–03–2):

- Wide Area Augmentation System (WAAS), in almost all the North American area,
- European Geostationary Navigation Overlay System (EGNOS), in Europe,
- GPS Aided Geo-Augmented Navigation (GAGAN), in India, and
- Multifunctional Satellite Augmentation System (MSAS), in Japan.



Satellite – Based Augmentation Systems (SBAS)
Figure 16–03–2

B. Receiver Autonomous Integrity Monitoring (RAIM)

The Receiver Autonomous Integrity Monitoring (RAIM) function of each GNSS compares the Horizontal Protection Level (HPL), and the Horizontal Alert Limit (HAL) for the current flight phase. The required HAL level is automatically set and is equivalent to the Required Navigation Performance (RNP) value relative to the flight phase as listed below:

- Oceanic/remote is 4.0 nm,
- Enroute is 2.0 nm,
- Terminal is 1.0 nm, and
- Approach is 0.3 – 0.1 nm.

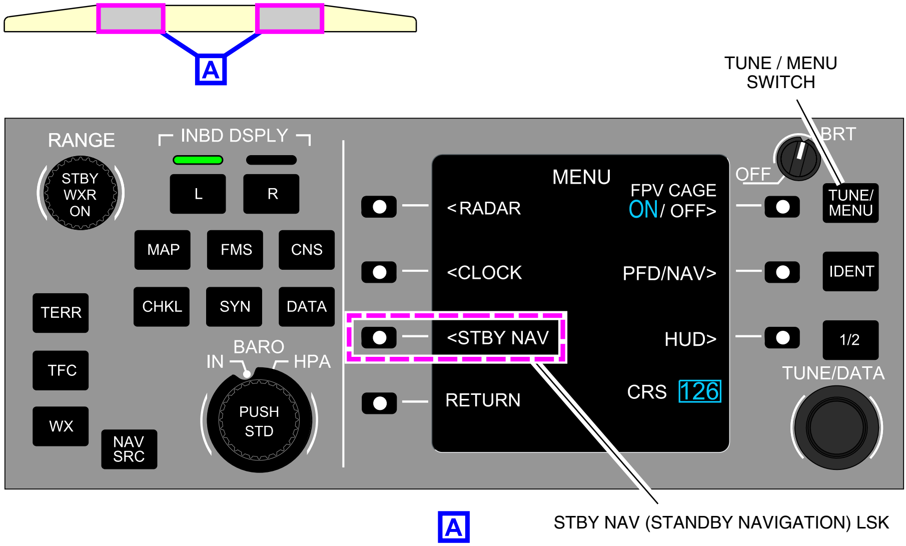
A NO APPR or NO RNP message displays on the PFD when the HPL value exceeds the current HAL.

The SBAS performs integrity monitoring when the aircraft is operating in SBAS coverage areas and the GNSS is operating in SBAS mode. When the SBAS position is available, the predictive RAIM check is not required.

GNSS – INDICATIONS

A. Control Tuning Panel (CTP)

The STBY NAV function on the Control Tuning Panel (CTP) displays the aircraft position calculated by the GNSS. The function is accessible through the TUNE/MENU switch on the CTP (refer to Figure 16–03–3).



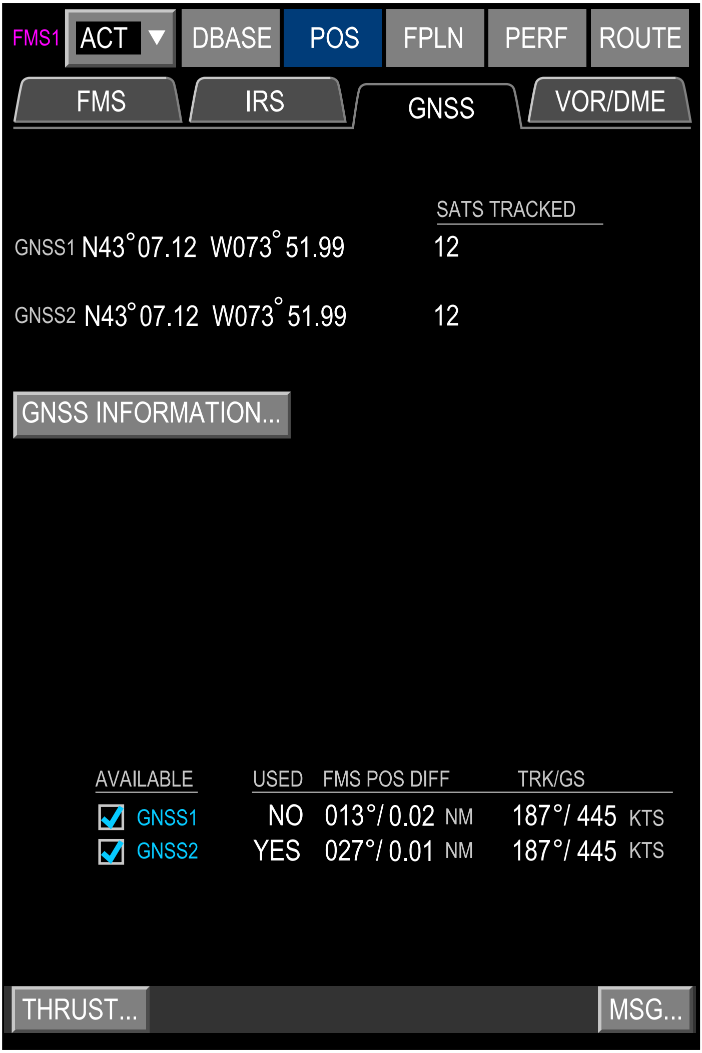
CTP – STBY NAV (Standby Navigation) function
Figure 16–03–3

The FMS page is accessed by selecting FMS from the MFW menu, or by pressing the FMS switch on the MKP or the CTP.

B. FMS – POS (position) page – GNSS tab

The data from the GNSS receivers is used by the Flight Management System (FMS) to compute an accurate aircraft position. All GNSS data is accessed through the POS page on the GNSS tab. The GNSS tab displays the GNSS 1 and GNSS 2 positions, along with the number of satellites used to calculate position.

At the bottom of the page, two check boxes are used to select or deselect the GNSS to use. By default, both GNSSs are selected. Refer to Figure 16–03–4.



POS soft switch – GNSS Tab
Figure 16–03–4

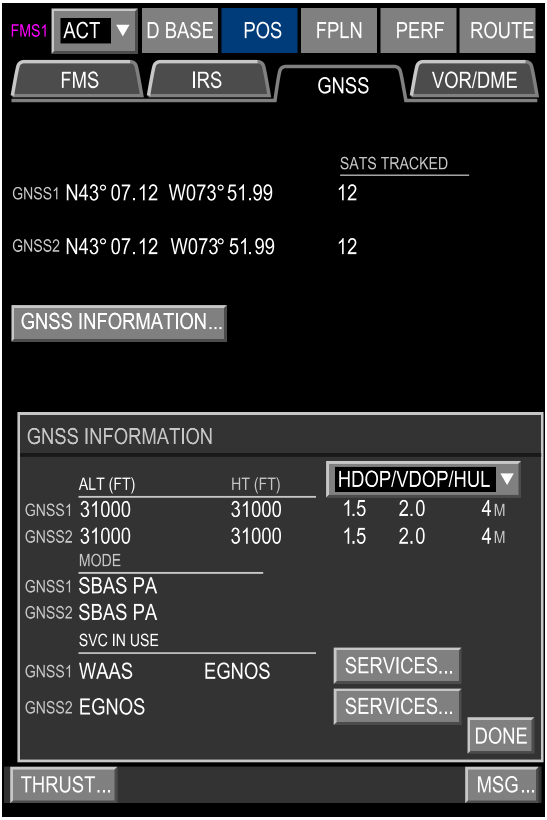
For each GNSS, the information that follows is displayed:

- Usage, indicates if the FMS uses the GNSS calculated position for navigation (YES) or not (NO),
- FMS POS DIFF, indicates the direction and distance (in nm) of the FMS position from the calculated GNSS position, and
- TRK/GS, indicates the aircraft track and ground speed calculated by the GNSS.

(1) GNSS information

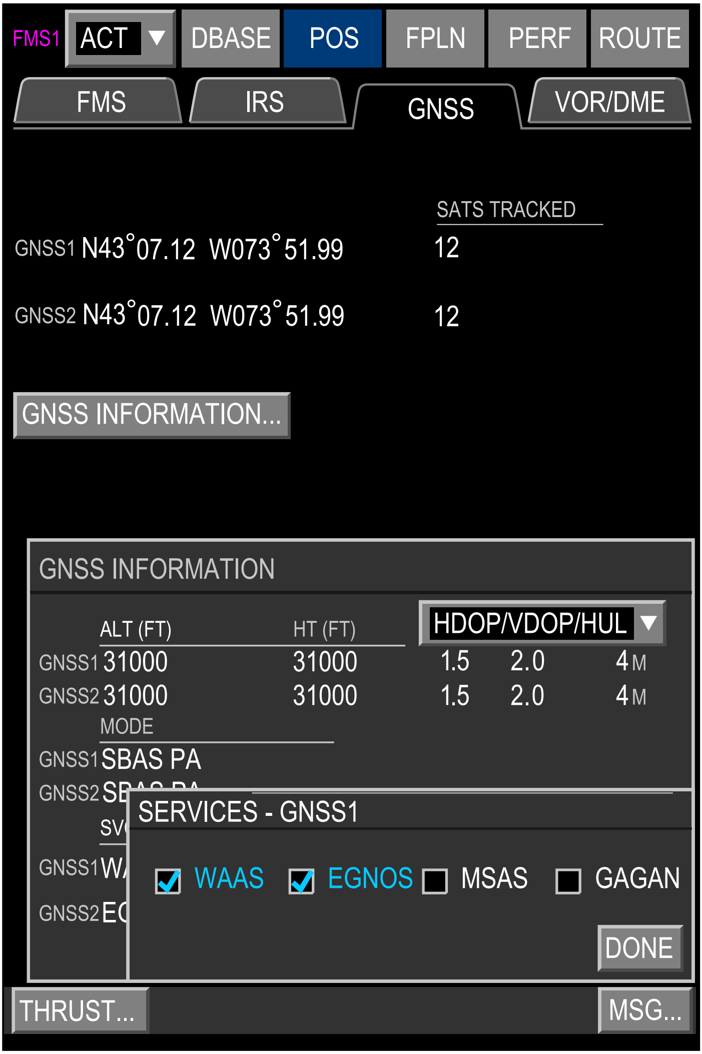
Selecting the GNSS INFORMATION soft switch displays the GNSS INFORMATION window which indicates (refer to Figure 16–03–5):

- GNSS sensed altitude and height,
- Drop-down menu to select HDOP/VDOP/HUL data, and
- SBAS status and network used.



POS soft switch – GNSS Tab – GNSS INFORMATION window
Figure 16–03–5

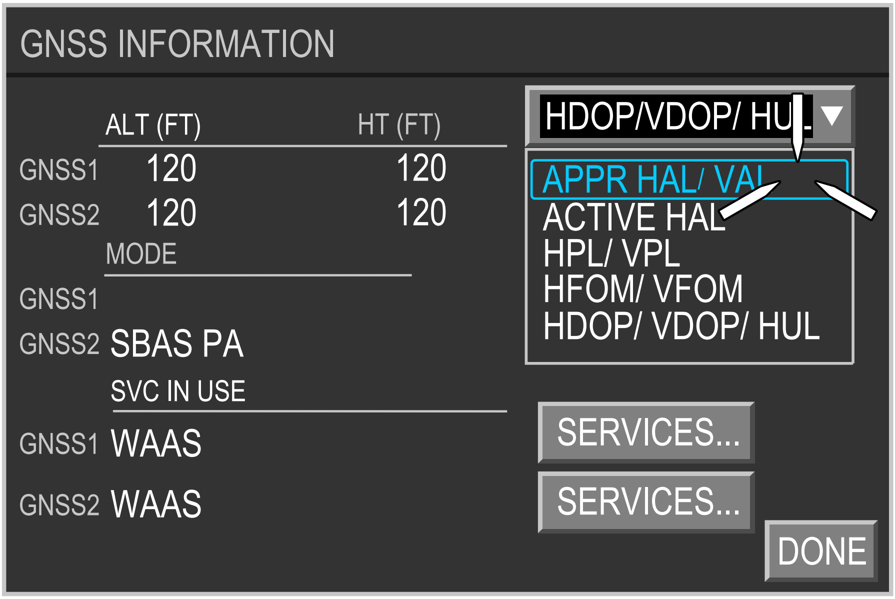
The SERVICE soft switches are used to select SBAS services for GNSS 1 and GNSS 2. Refer to Figure 16–03–6.



POS soft switch – GNSS Tab – SERVICE GNSS window
Figure 16–03–6

GNSS performance is monitored for accuracy and integrity of the computed solution. The drop-down list on the GNSS INFORMATION window is used to display the GNSS data that follow (refer to Figure 16–03–7):

- The accuracy measurements,
- The alert limits, and
- The protection levels.



GNSS INFORMATION drop–down list
Figure 16–03–7

LIST	DEFINITION	DESCRIPTION
APPR HAL/VAL	Approach Horizontal Alert Limit/Vertical Alert Limit	Displays position accuracy requirements for the selected LPV or LNAV/VNAV approach using SBAS. Results are shown in meters and nautical miles.
ACTIVE HAL	Active Horizontal Alert Limit	Displays active horizontal alert limit for the current phase of flight. Results are shown in meters and nautical miles.
HPL/VPL	Horizontal Protection Level/Vertical Protection Level	A measure of the integrity in the position, represented as the smallest radial position error that GNSS can guarantee at a given instant. HPL is shown in meters and nautical miles. VAL is shown in meters.
HFOM/VFOM	Horizontal Figure of Merit/Vertical Figure of Merit	Represents a measure of accuracy of the horizontal and vertical position with 95% confidence. HFOM is shown in meters and nautical miles. VFOM is shown in meters.
HDOP/VDOP/ HUL	Horizontal Dilution of Precision/Vertical Dilution of Precision/Horizontal Uncertainty Limit	Represents geometric strength of satellite configuration. Wider satellite separation provides better accuracy (lower number DOP). HUL indicates current estimate of position error shown in meters.

C. FMS – POS (position) page – FMS tab

The FMS tab includes the data that follow (refer to Figure 16–03–8):

- The sensor type used for navigation,
- The position difference between the sensor and the FMS, and
- The sensor-computed track and groundspeed.

POS soft switch – FMS tab
Figure 16–03–8

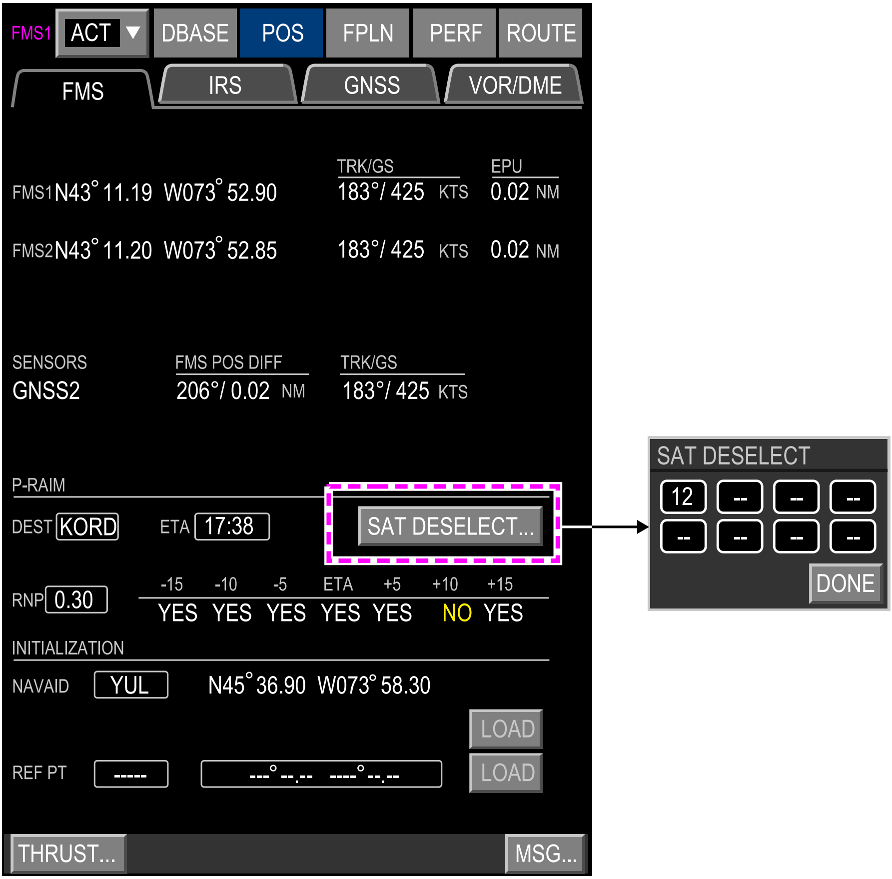
Predictive RAIM function (P-RAIM) determines if sufficient GNSS coverage is available to support a GNSS-based approach at the destination or alternate airport at the planned arrival time.

The P-RAIM calculations are based on the FMS destination airport and calculated ETA, already filled in the respective fields. Airport and ETA can also be manually entered.

The P-RAIM results display a YES, indicating sufficient RAIM, or NO indicating insufficient RAIM at 5 minutes intervals, starting 15 minutes before the ETA to 15 minutes after the ETA (7 results).

During calculation, a white REQUEST PENDING message displays under the ETA scale.

Selecting the SAT DESELECT soft switch opens the SAT DESELECT window used to exclude up to eigh GNSS satellites from P-RAIM calculations. Refer to Figure 16–03–9.



POS soft switch – FMS tab – SAT DESELECT window
Figure 16–03–9

D. GNSS/SBAS messages

The following messages related to GNSS operation display in the FMS message lines on the PFD:

MESSAGE	COLOR	DESCRIPTION
GNSS NOT AVAILABLE	Amber	FMS is not using GNSS position or GNSS is not available in the terminal or approach environment.
GNSS REVERTED	Amber	Both GNSS enabled, however FMS is using cross-side GNSS rather than onside.

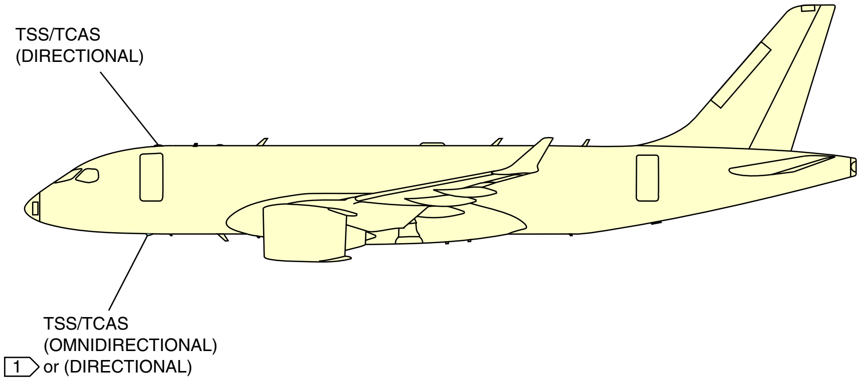
(1) EICAS messages

MESSAGE	DESCRIPTION	INHIBIT
GNSS NOT AVAIL	GNSS sensors not available	TO, LDG
UNABLE RNP	Loss of integrity condition, unable to maintain RNP	TO

TRANSPONDER/TRAFFIC ALERT AND COLLISION AVOIDANCE (TCAS)

The Traffic Surveillance System (TSS) is an airborne system that interrogates other aircraft transponders to identify and display potential collision threats.

The TSS/Traffic Collision Avoidance System (TCAS) computer integrates the function of TCAS and mode S transponder. It is powered by DC BUS 2. The upper and lower TSS antennas are directly connected to the TSS/TCAS computer (refer to Figure 16–04–1).



NOTE

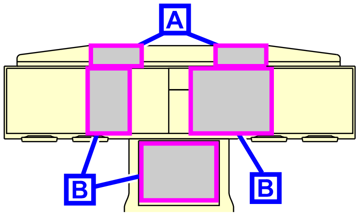
1 Option 34430001C

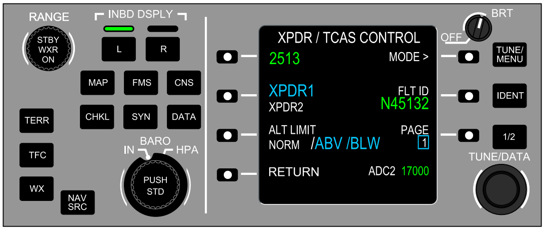
Traffic Surveillance System (TSS) antennas
Figure 16–04–1

The upper TSS directional antenna detects traffic and provides Traffic Advisories (TA) and Resolution Advisory (RA) with bearing information. The lower TSS omnidirectional antenna provides traffic without bearing information.

Both TSS directional antennas improve en-route monitoring of the traffic above and below by providing TA and RA with bearing information. <34430001C>

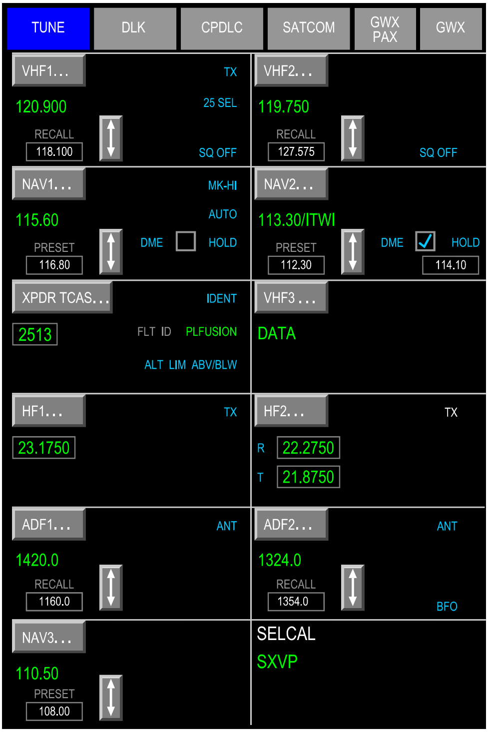
The TSS monitors a spherical protective zone around the aircraft and gives aural and visual alerts when an intruding aircraft penetrates this protected zone. The TCAS monitors a radius of approximately 5 to 40 NM around the aircraft. System controls are located on the Control Tuning Panel (CTP) and on the Communication Navigation System (CNS). Refer to Figure 16–04–2.





CONTROL TUNING PANEL (CTP)

A



1 CNS – TUNE PAGE – (XPDR TCAS ...) CONTROL

B

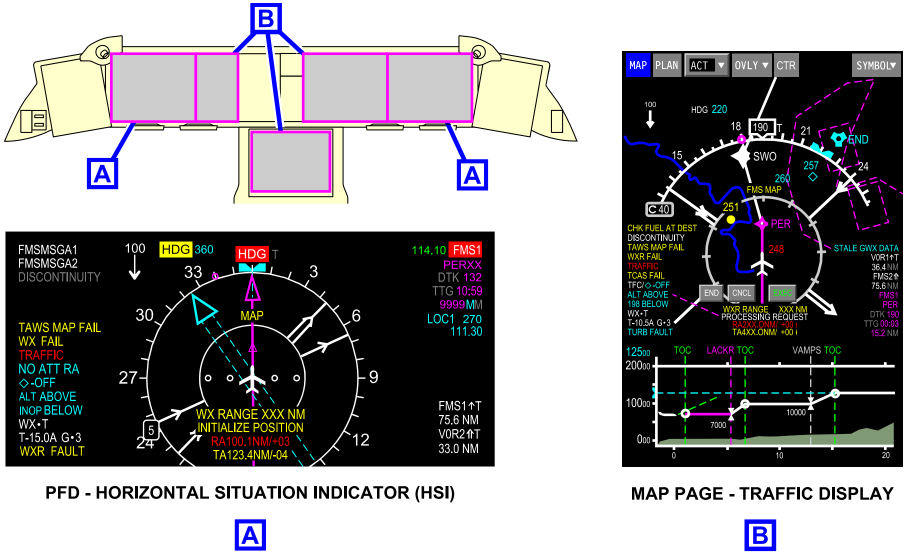
NOTE

1 This view shows options that may not be installed on your aircraft.

TCAS controls
Figure 16–04–2

The selection of XPDR1 or XPDR2 has no impact on the TCAS functions due to the continuous data exchange between the transponder computer and the TSS/TCAS computer.

The Traffic data indications (TA and RA) are displayed on the Horizontal Situation Indicator (HSI), the PFD, and the MAP page (refer to Figure 16–04–3).

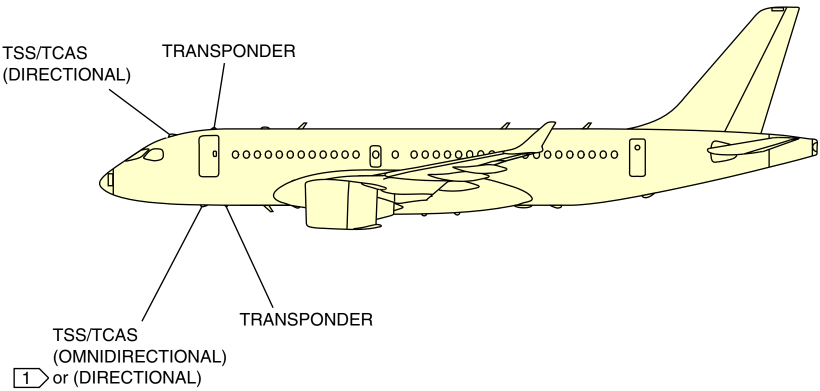


TCAS indications
Figure 16–04–3

A. Transponder

The mode-S transponder function can be provided by either the transponder computer or the transponder function in the TSS/TCAS computer. It operates in the Air Traffic Control (ATC) environment as a cooperative surveillance and communication system providing identification of transponder-equipped aircraft to both ground-based or airborne interrogations.

The transponder computer is powered by DC ESS BUS 3. The upper and lower transponder antennas (refer to Figure 16–04–4) are directly connected to the transponder computer.



NOTE

1 Option 34430001C

Transponder antennas
Figure 16–04–4

The TSS/TCAS computer is powered by DC BUS 2. The upper and lower transponder antennas are directly connected to the TSS/TCAS computer.

The diversity transponder installation permits the capability to discriminate between the upper and the lower antennas and determine which antennas, upper or lower, will be used to receive interrogations and transmit replies. On the ground, the lower antennas are de-selected automatically and the upper antennas are transmitting only if they are interrogated.

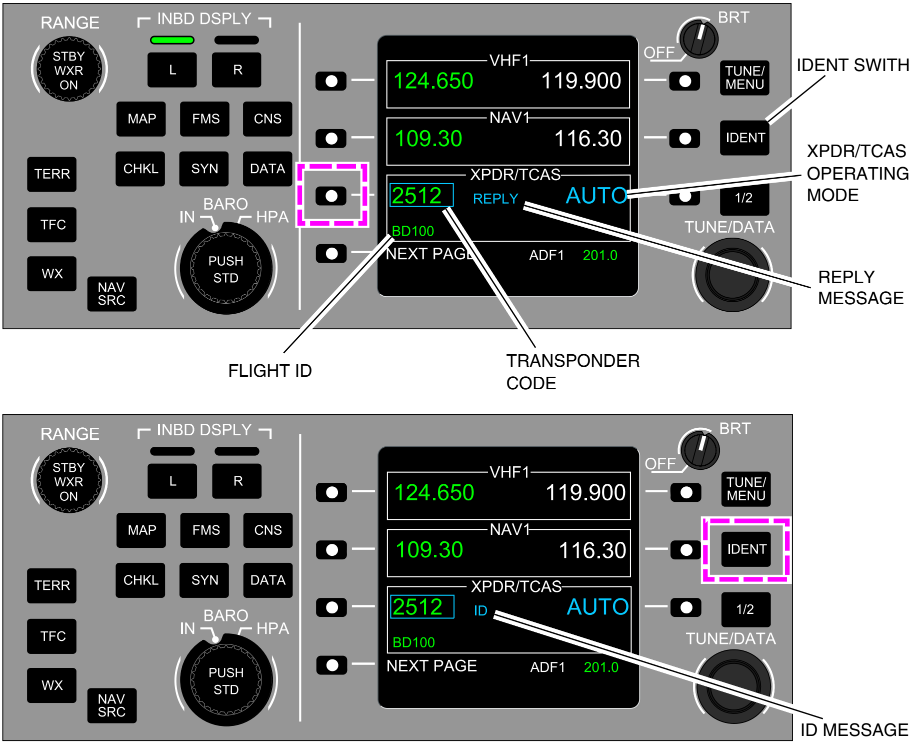
Only one transponder can be active at a time, with the other in standby.

XPDR1 (in cyan) in the Control Tuning Panel (CTP), or selected in the Communication Navigation System (CNS), will activate the transponder computer and put the TSS/TCAS computer is standby.

XPDR2 (in cyan) in the CTP, or selected in the CNS, will activate the TSS/TCAS computer and put the transponder computer on standby.

The top level page of the CTP displays the transponder code, flight identification, and the XPDR/TCAS operating mode. When the transponder is replying to an interrogation, a cyan REPLY message displays briefly next to the transponder code (refer to Figure 16–04–5).

The assigned transponder code is set using the TUNE/DATA switch. The IDENT switch is located on the right side of the CTP. When pressed, REPLY is replaced by a cyan ID message for approximately 18 seconds.

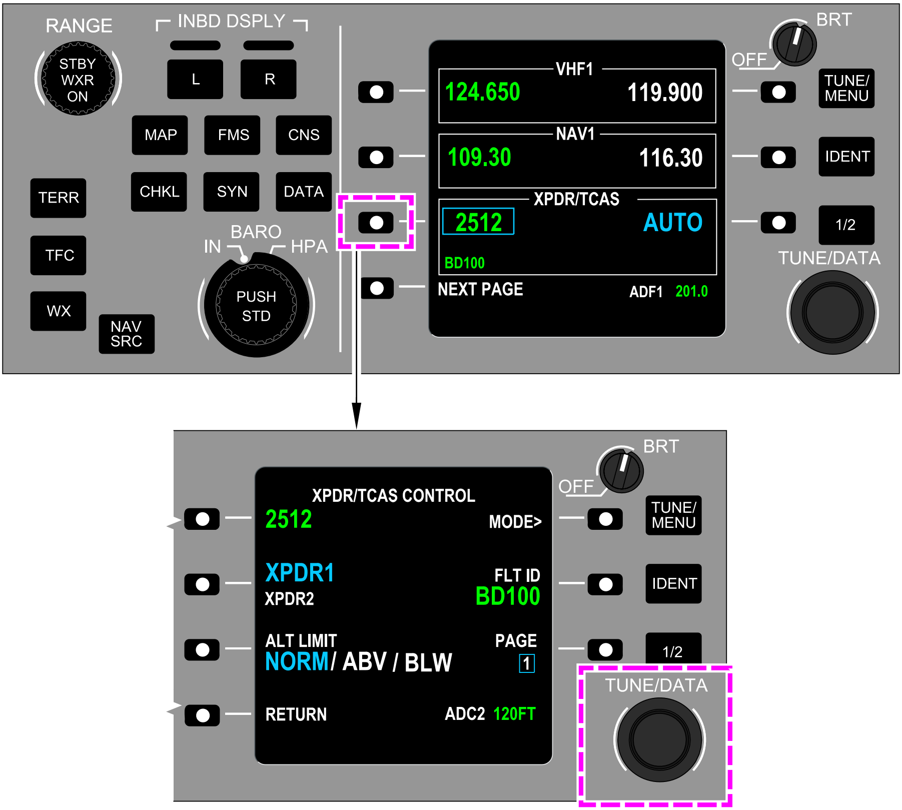


CTP – Transponder display
Figure 16–04–5

In the event of a transponder failure, an amber XPDR FAIL message displays below the transponder code.

(1) Transponder control

The transponder is controlled from the XPDR/TCAS CONTROL page 1 (refer to Figure 16–04–6), accessed by double-pressing the LSK adjacent to the transponder code.



CTP – XPDR/TCAS CONTROL page view
Figure 16–04–6

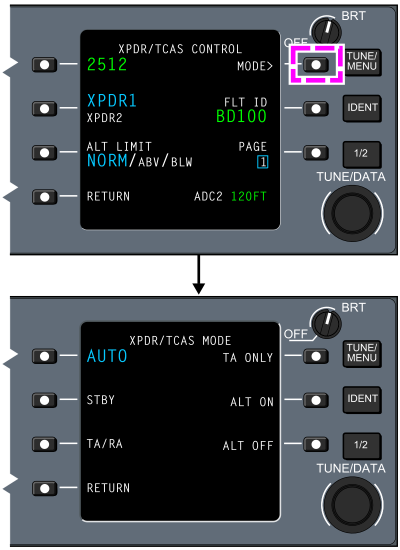
The XPDR/TCAS CONTROL page 1 displays the following selections:

- Transponder code: Set the transponder code by pressing the adjacent LSK and enter the code using the TUNE/DATA switch,
- Transponder selection: Select the active transponder (XPDR1 or XPDR2) by pressing the adjacent LSK, and

- FLT ID: Set the flight identification by pressing the adjacent LSK and enter the flight identification using the TUNE/DATA switch.

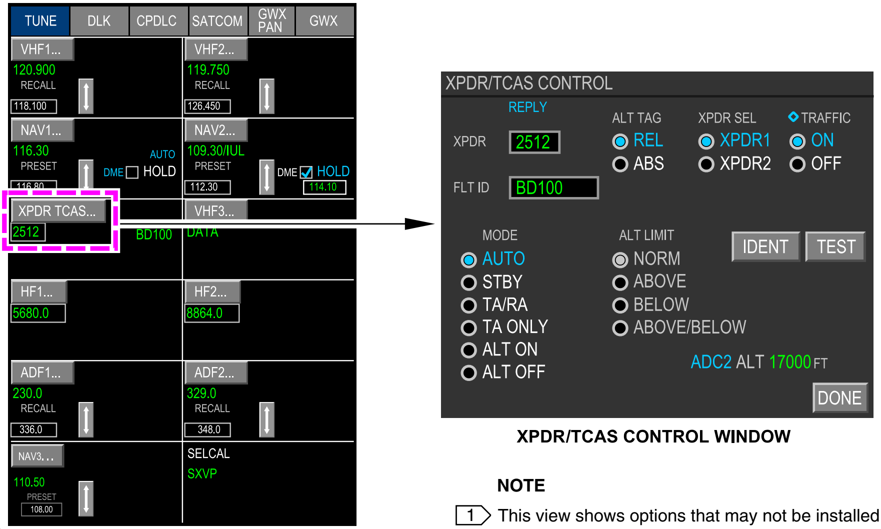
When the LSK adjacent to MODE is pressed, the XPDR/TCAS MODE page is displayed with the following selectable transponder modes (refer to Figure 16–04–7):

- AUTO: On ground, the transponder does not transmit but responds to airport ground surface management systems (ASDX, MDS). When airborne, mode S is activated,
- STBY: Transponder is in standby mode,
- ALT ON: Transponder is operating in mode S, and
- ALT OFF: Transponder is operating in mode A.
- TA: Transponder is operating in mode S.
- TA/RA: Transponder is operating in mode S.



CTP – XPDR/TCAS MODE page
Figure 16–04–7

Transponder control is also available by selecting the TUNE page of the CNS page, then selecting the XPDR TCAS soft switch. The XPDR/TCAS CONTROL window displays allowing the same transponder setting as the CTP. Refer to Figure 16–04–8.



XPDR/TCAS CONTROL WINDOW

1 **CNS - TUNE PAGE - (XPDR TCAS...) CONTROL**

NOTE

1 This view shows options that may not be installed on your aircraft.

CNS – TUNE page – XPDR/TCAS CONTROL window
Figure 16–04–8

TCAS – OPERATION AND MODES

The traffic alert and collision avoidance system (TCAS) displays transponder-equipped aircraft located within a maximum 40 nm range. TCAS provides surveillance, threat detection, and conflict resolution.

The TCAS computes the following data from aircraft equipped with mode C or mode S transponders:

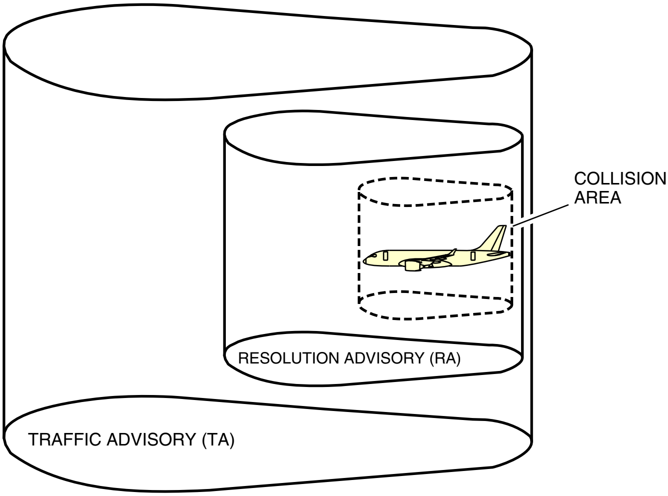
- The relative bearing,
- The range and horizontal closure rate, and
- The relative altitude and vertical closure rate.

The TCAS issues visual and aural alerts to ensure vertical separation.

The system provides two types of advisories:

- Traffic Advisory (TA), and
- Resolution Advisory (RA).

Figure 16–04–9 shows the TA and RA alert envelopes.



Traffic Advisory (TA) and Resolution Advisory (RA) alert envelopes
Figure 16–04–9

A TA is issued when an intruding aircraft may become a collision threat.

A RA is issued when a conflicting aircraft is considered a collision threat. The RA provides aural and visual cues to avoid collision.

When the intruder aircraft is equipped with a functioning Mode S transponder, the TCAS uses the transponder to transmit collision-avoidance data to that aircraft. Mode S allows the two TCAS to coordinate conflict resolution. An intruder with a Mode A transponder causes only a TA alert but no RA alert since the intruder altitude is unknown.

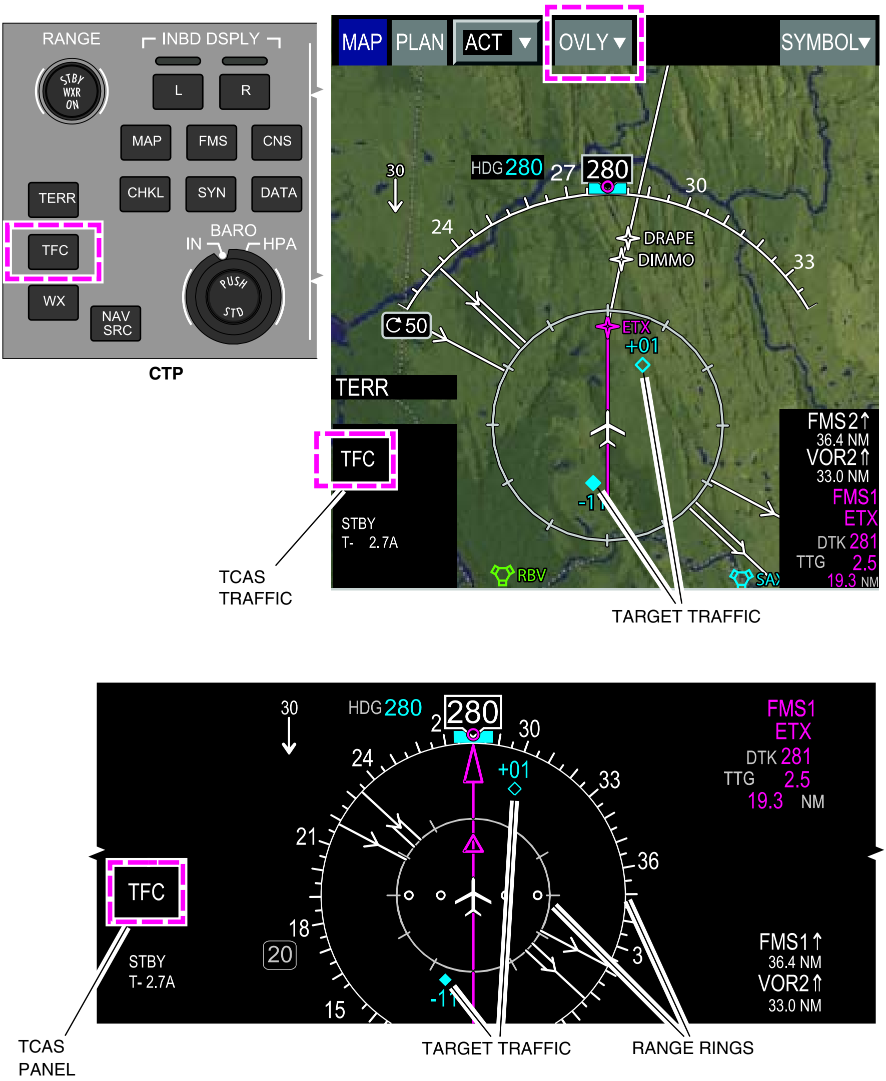
A. TCAS display

The TCAS information and alerts are displayed on the:

- HSI,
- PFD, and
- MAP format.

The traffic information displayed on the HSI and the MAP is selectable through (refer to Figure 16–04–10):

- The TFC selection on the OVLY menu of the MAP page and
- The TFC switch on the CTP.



TCAS display
Figure 16–04–10

TFC message displays on the left of the HSI and the MAP page with TCAS status and setting messages.

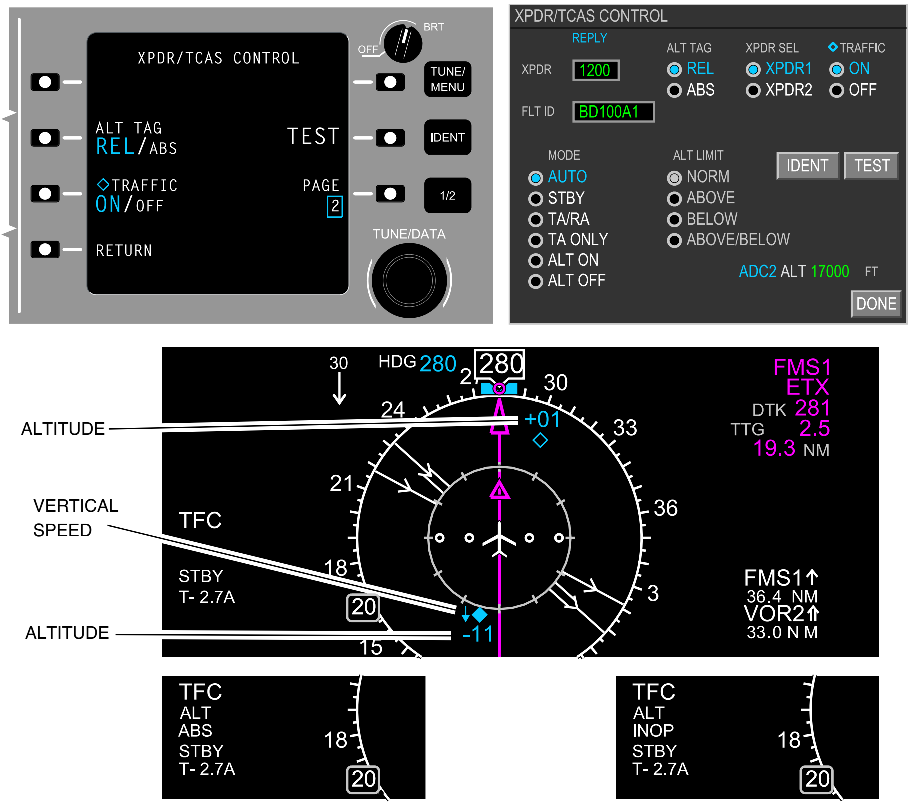
Range rings display on both displays with clock-hour position marks. A 3 nm range inner ring displays when the selected range is less than 20 nm.

TCAS display range is selectable from 5 to 40 NM around the aircraft. In normal operation, the HSI displays only the traffic alerts while the MAP format displays all the traffic information. However, if there is a display failure, the HSI can display the traffic information. In a Traffic Alert (TA) situation, the MAP range will be set automatically to 10 NM.

The traffic altitude displays in hundreds of feet above the traffic target symbol if the it is higher than the aircraft, or below symbol if the traffic is lower than the aircraft.

The traffic altitude display is selected through (refer to Figure 16–04–11):

- The ALT TAG on page 2 of the XPDR/TCAS CONTROL on the CTP or
- The XPDR/TCAS CONTROL window of the TUNE page.



Traffic altitude display
Figure 16–04–11

When the ABS is selected, the traffic altitude above sea level displays and ALT ABS displays under TFC in the TCAS section of the HSI.

When the REL is selected, the traffic height above the aircraft displays with a plus sign (+), and traffic height below the aircraft displays with the minus sign (–).

When the traffic altitude cannot be determined, ALT INOP displays under TFC in the TCAS section.

Arrows associated with indicators show that the traffic is climbing or descending with a climb rate or descent rate of at least 500 feet/minute. The absence of an arrow may indicate:

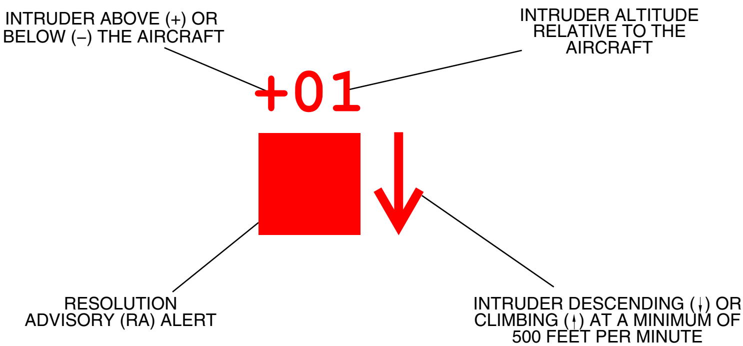
- Intruder is at the same altitude as the aircraft, or
- The rate of climb or descend is low, or
- The vertical data is unavailable.

(2) Traffic target

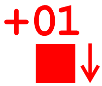
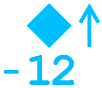
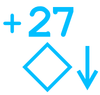
Each traffic target displays relative to the heading of the aircraft. The target shape and color identify the level of threat. There are four types of traffic targets represented:

- Other traffic.
- Proximity,
- Traffic advisory,
- Resolution advisory, and

The table that follows shows the traffic alert symbology (refer to Figure 16–04–12 and Figure 16–04–13).



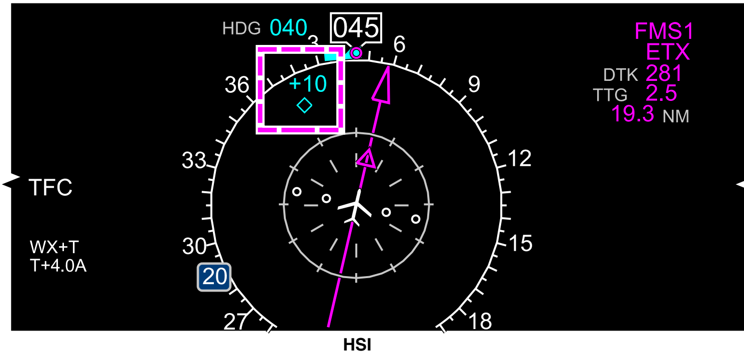
Resolution Advisory (RA) visual alert description
Figure 16–04–12

	RA ISSUED FOR INTRUDING AIRCRAFT THAT IS 100 FT ABOVE AND DESCENDING AT LEAST 500 FPM.
	TA ISSUED FOR INTRUDER AIRCRAFT THAT IS AT THE SAME ALTITUDE OF THE PROTECTED AIRCRAFT AND IS NOT CLIMBING OR DESCENDING.
	PT DISPLAYING TRAFFIC THAT IS 1200 FT BELOW AND CLIMBING AT LEAST 500 FPM.
	OT DISPLAYING TRAFFIC THAT IS 2700 FT ABOVE AND DESCENDING AT LEAST 500 FPM.

Traffic visual alerts description
Figure 16–04–13

(3) Other Traffic (OT)

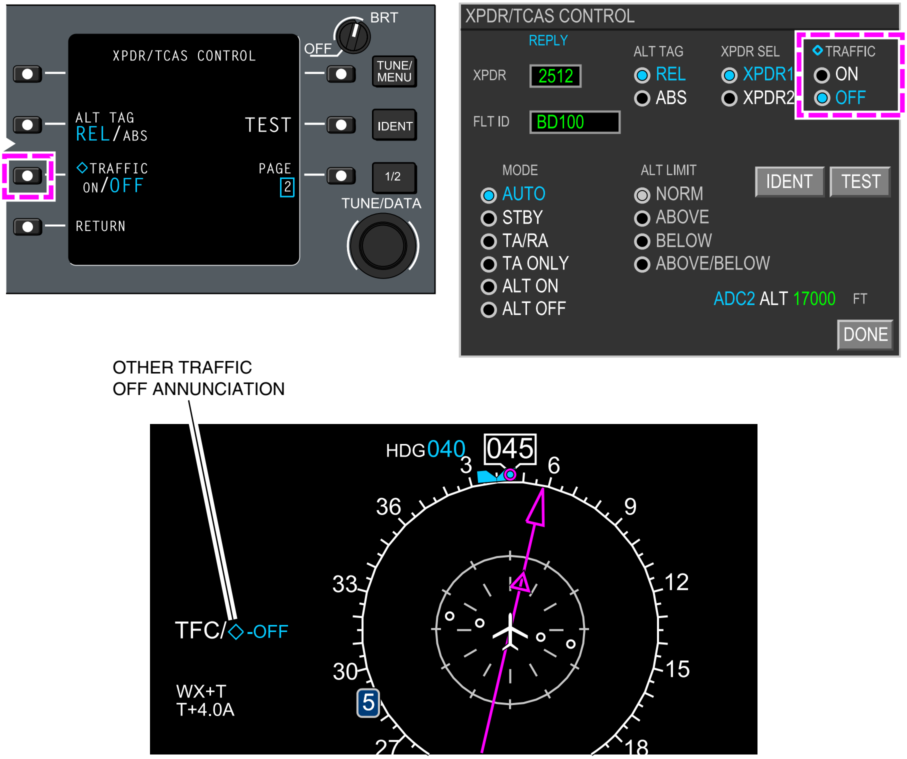
The other traffic indicator shows the traffic that is outside the proximate traffic range and up to 40 nm. This indicator is a diamond with a cyan outline (refer to Figure 16–04–14).



HSI – Other traffic
Figure 16–04–14

The OT target display is controlled from: (refer to Figure 16–04–15):

- The XPDR/TCAS CONTROL page on the CTP or
- The XPDR/TCAS CONTROL window of the TUNE page.

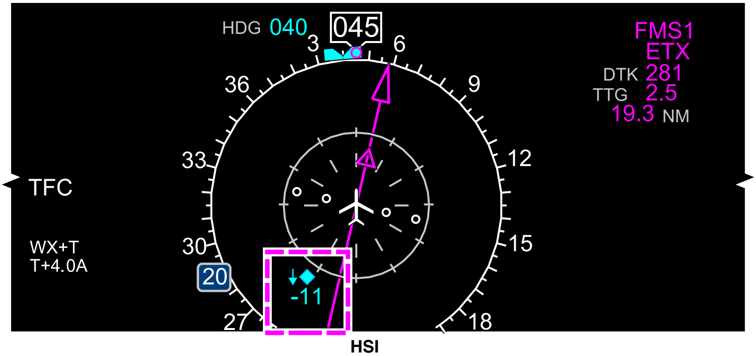


Other traffic selection
Figure 16–04–15

When selected OFF, the OT targets do not display and an OFF message displays on the left of the HSI, next to TFC.

(4) Proximate Traffic (PT)

The proximate traffic indicator appears when an aircraft is approaching but is not considered a threat. This indicator is a solid cyan diamond within 6.5 nm horizontally and 1200 ft vertically (refer to Figure 16–04–16). There is no associated aural alert.



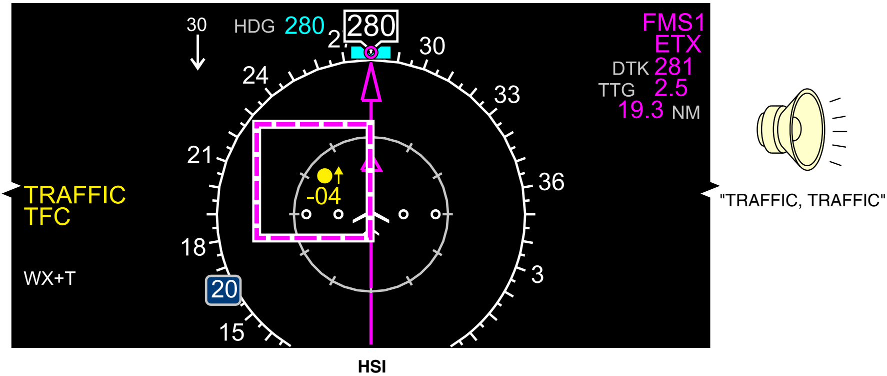
HSI – Proximity traffic indication
Figure 16–04–16

(5) Traffic Advisory (TA)

The TA appears when the target is predicted to enter the protected zone within 45 seconds. The TA target displays as a solid amber circle (refer to Figure 16–04–17).

Amber TRAFFIC and TFC messages display on the HSI and MAP page, and

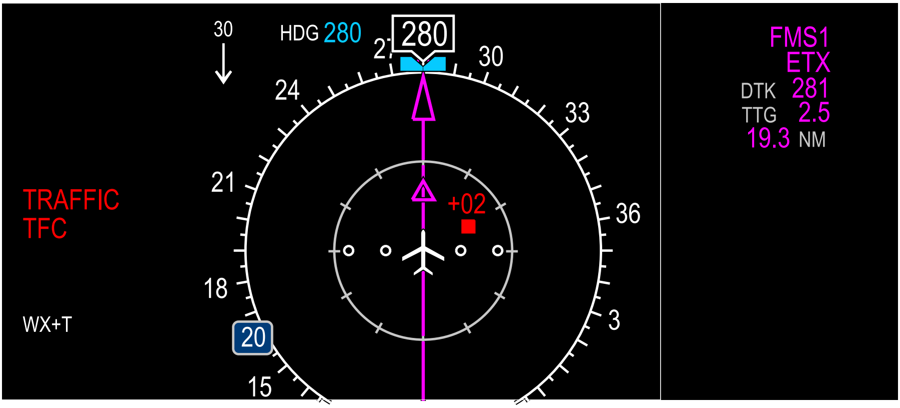
A “TRAFFIC, TRAFFIC” aural message sounds.



HSI – Traffic Advisory (TA) indications
Figure 16–04–17

(6) Resolution Advisory (RA)

The RA appears when the target is predicted to impact in less than 30 seconds. The advisory is represented by a solid red square and red TRAFFIC and TFC messages display on the HSI and the MAP page. Refer to Figure 16–04–18.



HSI – Resolution advisory
Figure 16–04–18

B. Resolution Advisory (RA)

When both aircraft are TCAS-equipped, they communicate with each other to coordinate the Resolution Advisory (RA) commands. The information is communicated to other aircraft as well as ATC.

A RA is categorized as follows:

- Corrective RA, (CLIMB, DESCEND, or adjust vertical speed command) and
- Preventive RA (restrict or maintain a vertical speed command).

The TCAS command displays as a green rectangular box on the PFD where the Flight Path Vector (FPV) should be maintained.

Red lines, bordering either side of the box, indicate the no-fly zones. During preventive RA, no-fly zones display above and below the green box.

The FPV displays green when inside the box and red when in the no-fly zones.

When a TCAS RA is active, the Flight Director (FD) and FMS V/S indicator are temporarily removed until the TCAS RA threat is cleared.

When RA pitch cues cannot be computed, a NO ATT RA visual alert is displayed in the TCAS data field.

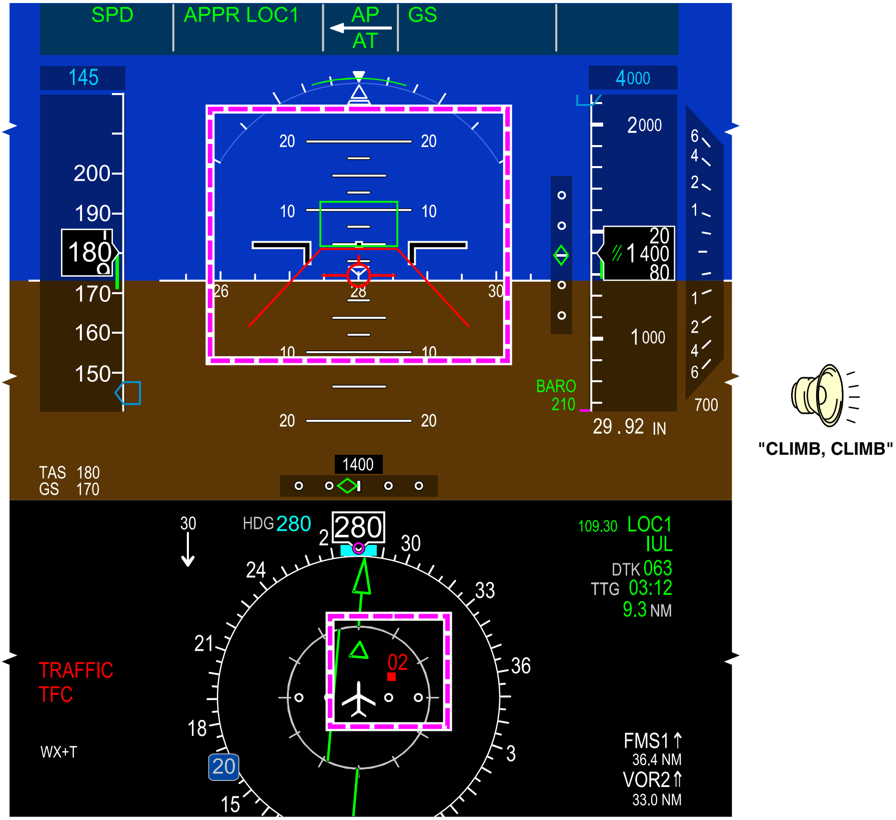
NOTE

If an aircraft is not TCAS-equipped, RA responsibility is assumed by the TCAS-equipped aircraft.

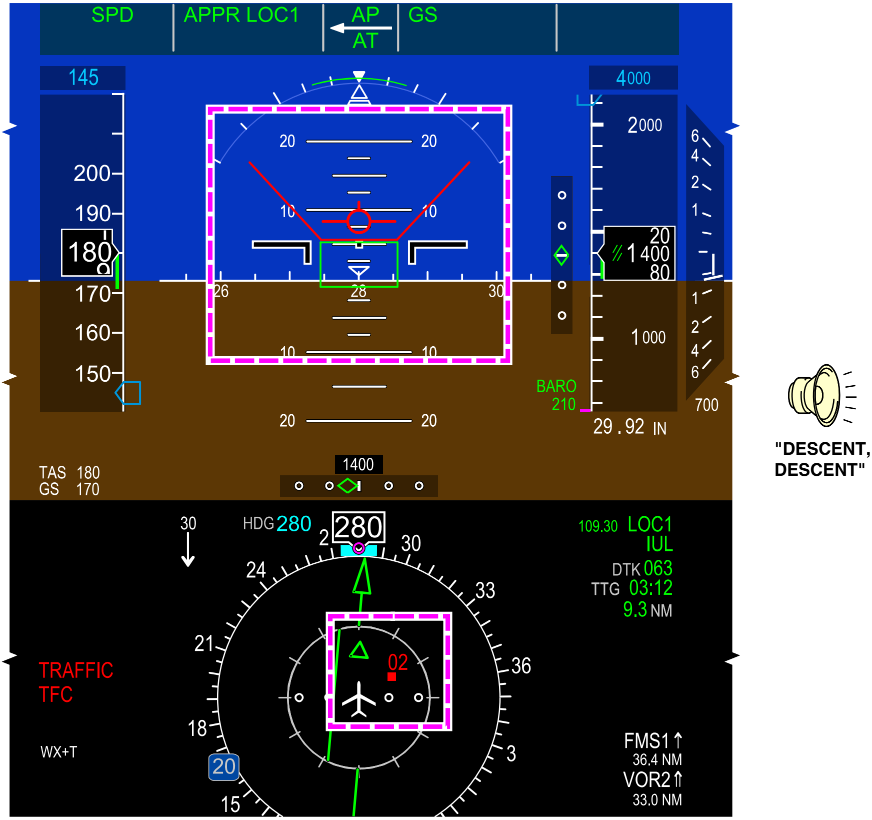
Climb command is not issued if it takes the aircraft above 40,000 ft.

(1) Corrective RA

When it is corrective and immediate action must be taken by the flight crew, there is an aural alert of “CLIMB, CLIMB” (refer to Figure 16–04–19) or “DESCEND, DESCEND” (refer to Figure 16–04–20) or “ADJUST VERTICAL SPEED”, depending on the situation.



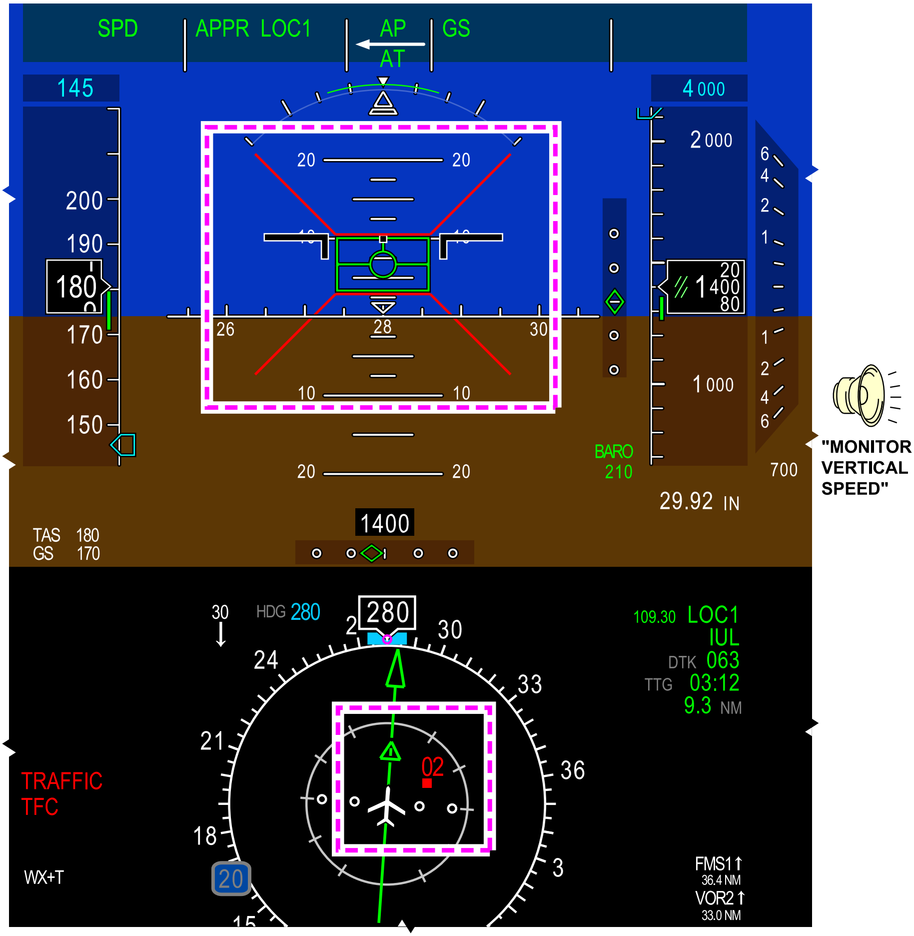
PFD – RA corrective action indication – Climb
Figure 16–04–19



PFD – RA corrective action indication – Descent
Figure 16–04–20

(2) Preventive RA

When it is preventive, the visual alert is a red square and the aural alert is “MONITOR VERTICAL SPEED” (refer to Figure 16–04–21).

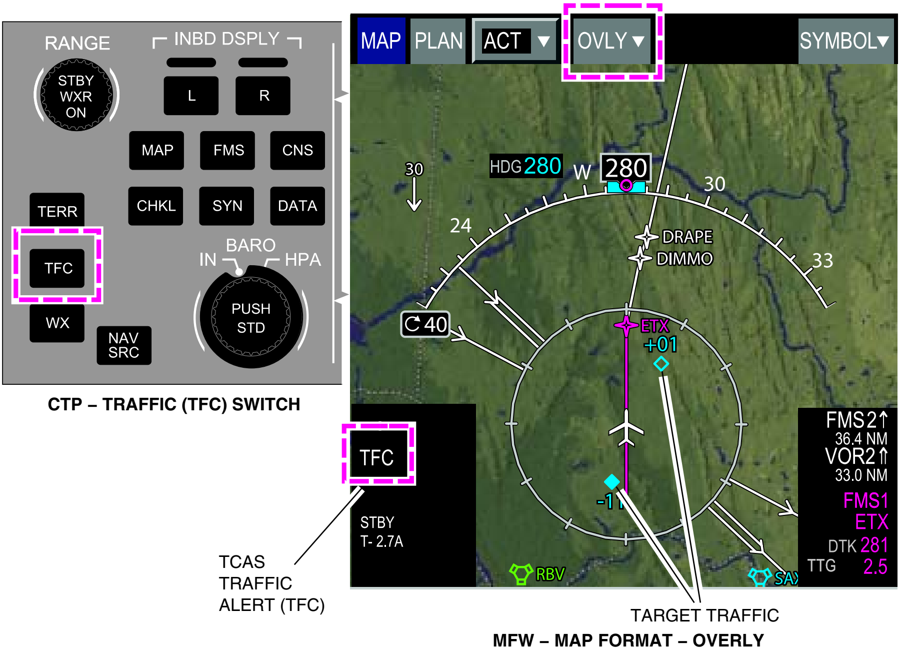


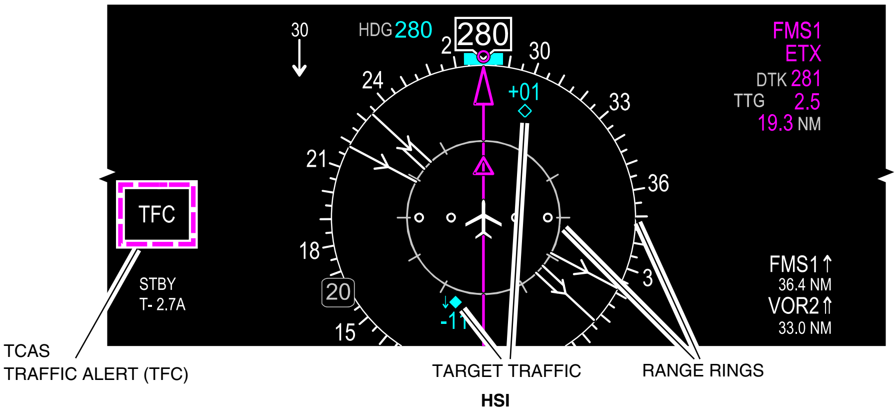
PFD – RA preventive indication
Figure 16–04–21

C. Transponder/TCAS operating modes

The ATC/TCAS MODE page on the Control Tuning Panel (CTP) allows the flight crew to select the different modes of the TCAS.

The TCAS traffic displays at the bottom of the Primary Flight Display (PFD) and on the MAP page when the TRAFFIC (TFC) switch is pressed on the CTP. Refer to Figure 16–04–22.

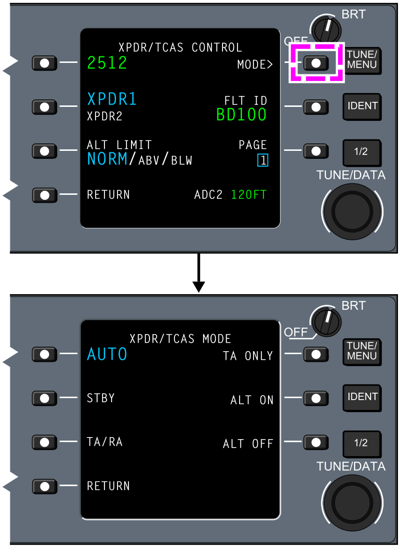




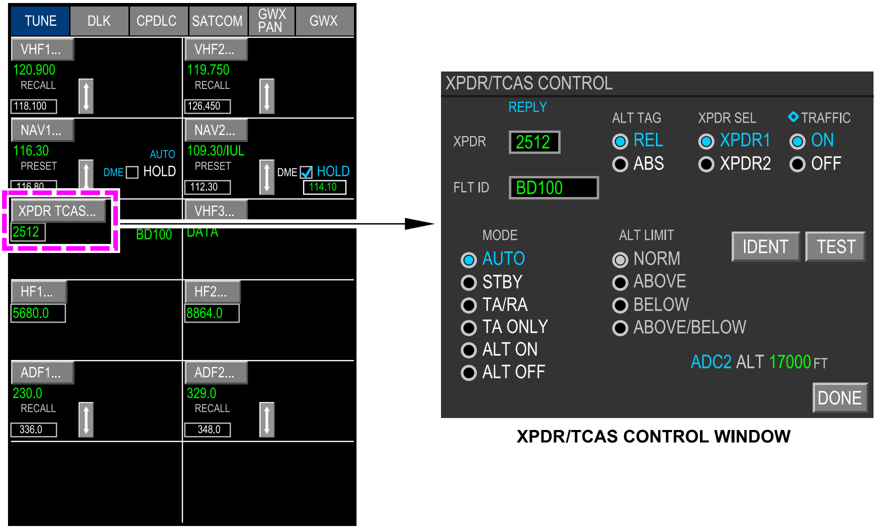
TCAS display
Figure 16–04–22

TCAS modes are selectable through the controls that follow:

- The XPDR/TCAS MODE page on the CTP (refer to Figure 16–04–23), or
- The XDPR/TCAS CONTROL window on the CNS TUNE page (refer to Figure 16–04–24.



CTP – XPDR/TCAS MODE page
Figure 16–04–23



XPDR/TCAS CONTROL WINDOW

CNS - TUNE PAGE - (XPDR TCAS...) CONTROL

CNS – TUNE page – XPDR/TCAS CONTROL window
Figure 16–04–24

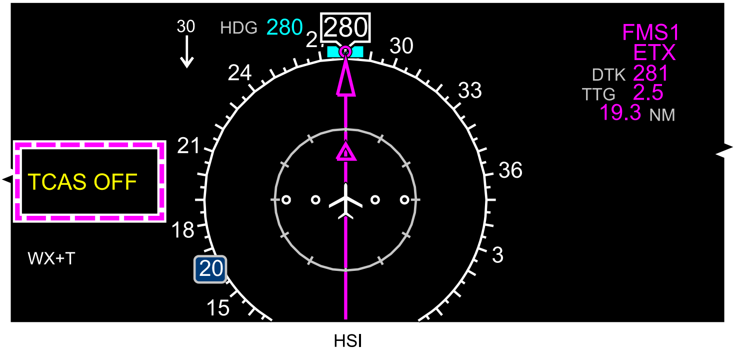
The transponder and TCAS operates in the six different modes that follow:

- AUTO,
- STBY,
- TA/RA (Traffic Advisory/Resolution Advisory),
- TA ONLY,
- ALT ON, and
- ALT OFF.

At power-up, the operating mode is AUTO.

(1) AUTO mode

On ground, the ATC transponder is ON for surface surveillance while TCAS is set to OFF. A TCAS OFF message displays in amber on the TCAS section of the HSI. Refer to Figure 16–04–25.



HSI – TCAS OFF mode annunciation
Figure 16–04–25

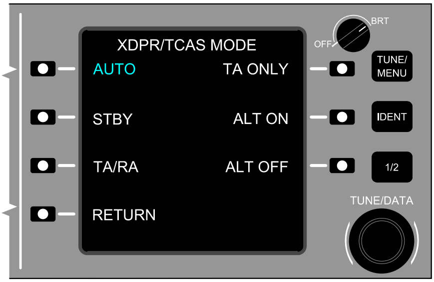
After takeoff, the TCAS provides traffic advisories only, preventing an RA at low altitude. A TA ONLY message displays on the TCAS section of the HSI.

Upon reaching 1100 ft AGL, the TCAS provides TA and RA as required. No message displays during TA/RA operation.

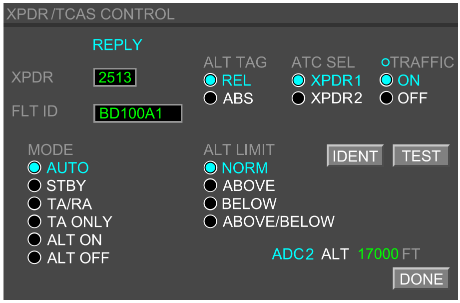
When descending below 1100 ft AGL, the TCAS returns to in-traffic advisories only and a TA ONLY message displays on the TCAS section. After landing, the TCAS automatically turns off and a TCAS OFF message displays.

The altitude limits do not display in AUTO mode. Manual altitude limit setting disabled.

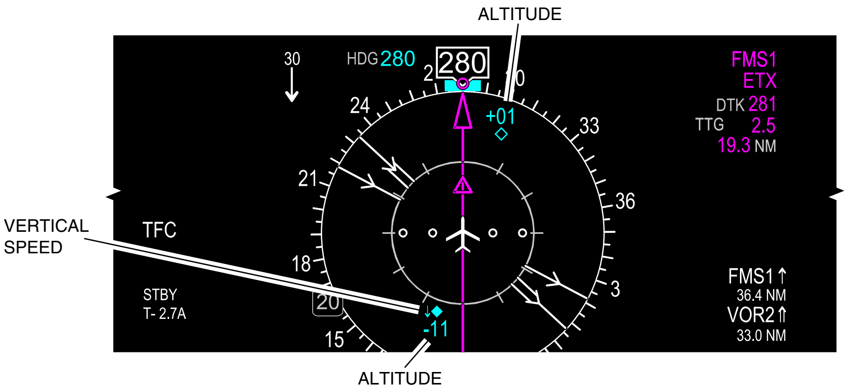
Figure 16–04–26 shows the TCAS – AUTO mode.



CTP – XPDR/TCAS MODE PAGE



CNS – TUNE PAGE – XPDR/TCAS CONTROL WINDOW

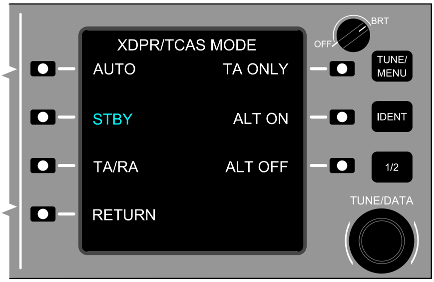


HSI

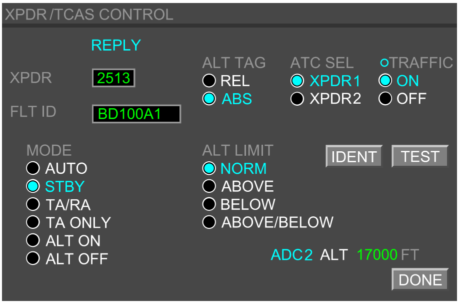
TCAS – Mode AUTO
Figure 16–04–26

(2) STBY mode

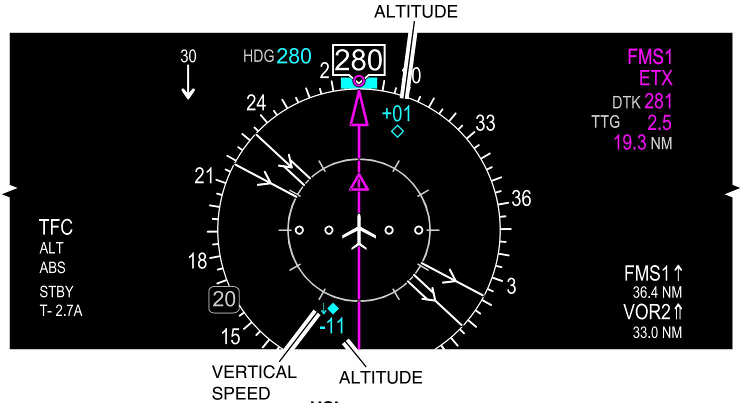
When the standby mode (STBY) is selected (refer to Figure 16–04–27), the transponder is in standby mode and the TCAS is off. A TCAS OFF message displays in amber on the TCAS section of the HSI.



CTP – XPDR/TCAS MODE PAGE



CNS – TUNE PAGE – XPDR/TCAS CONTROL WINDOW

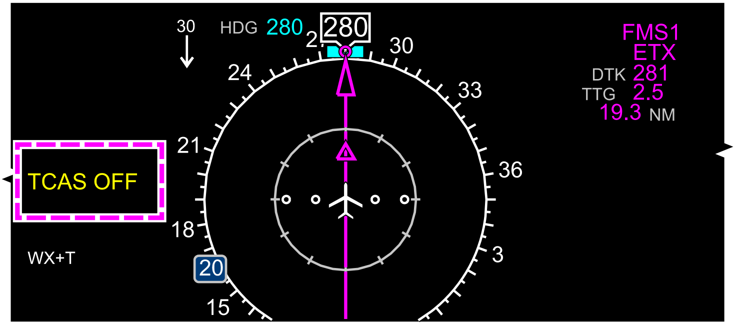


HSI

TCAS – Mode standby (STBY)
Figure 16–04–27

(3) ALT ON/ALT OFF mode

When the altitude off (ALT OFF) or altitude on (ALT ON) mode is selected, the TCAS is off. Only the transponder is on, using mode-C (ALT OFF) or mode-S (ALT ON). In either mode, a TCAS OFF message displays in amber on the TCAS section of the HSI. Refer to Figure 16–04–28.

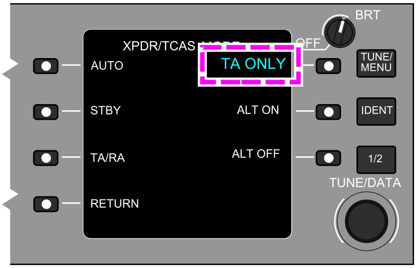


HSI

HSI – TCAS OFF mode annunciation
Figure 16–04–28

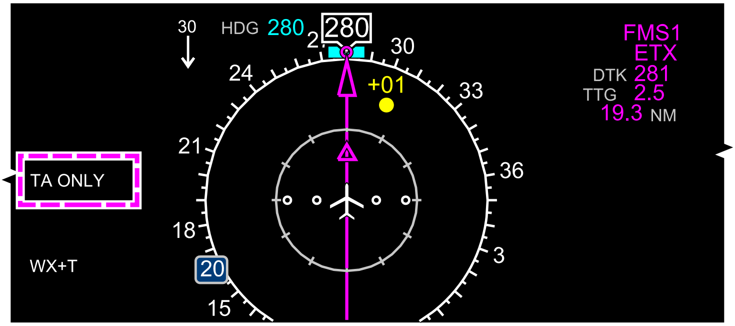
(4) TA ONLY mode

When the Traffic Advisory Only (TA ONLY) is selected, the transponder and the TCAS are on but only the traffic advisory is provided (RA inhibited). A white TA ONLY message displays on the TCAS section of the HSI. Refer to Figure 16–04–29.



CTP – XPDR/TCAS CONTROL PAGE

CNS – XPDR/TCAS CONTROL WINDOW



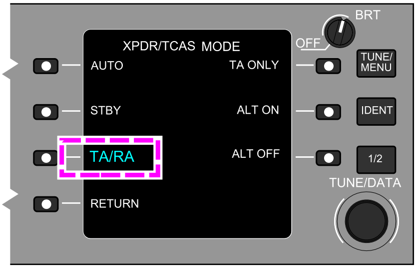
HSI

HSI – TA ONLY mode annunciation
Figure 16–04–29

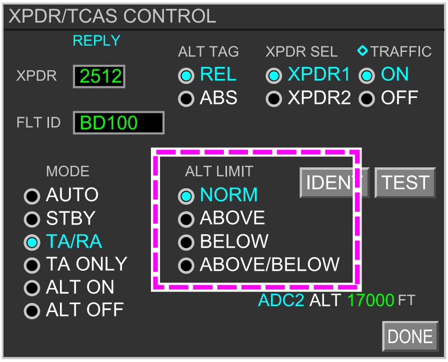
When a traffic advisory is detected (TA target), TA ONLY displays amber an flashes for 5 seconds.

(5) TA/RA mode

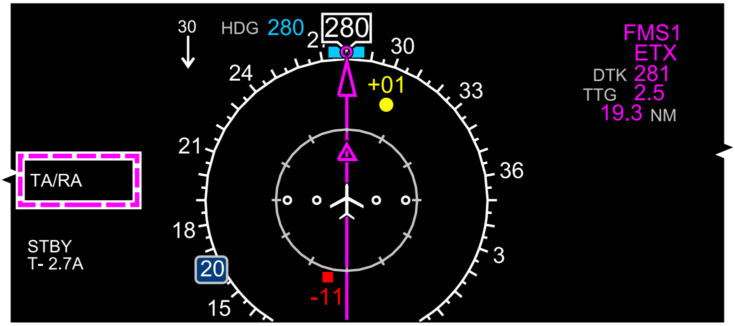
When the Traffic Advisory and Resolution Advisory mode (TA/RA) is selected, both the transponder and TCAS are on and operational. No message displays on the TCAS section of the HSI when TA/RA mode is active. Refer to Figure 16–04–30.



CTP – XPDR/TCAS CONTROL PAGE



CNS – XPDR/TCAS CONTROL WINDOW



HSI

HSI – TA/RA mode annunciation
Figure 16–04–30

(6) TCAS altitude limits

When the TCAS is not in AUTO mode, the ALT LIMIT control allows the flight crew to choose the range of the traffic detection around the aircraft. Cycling through the ALT LIMIT switch on the XPDR/TCAS CONTROL page allows the selections that follow:

- NORM,
- ABV (above),

- BLW (below), and
- ABV and BLW.

The NORM selection displays all the traffic detected within an altitude range of ±2700 ft around the aircraft.

The ABV selection displays all the traffic detected between 2700 ft below the aircraft altitude and 9900 ft above the aircraft altitude.

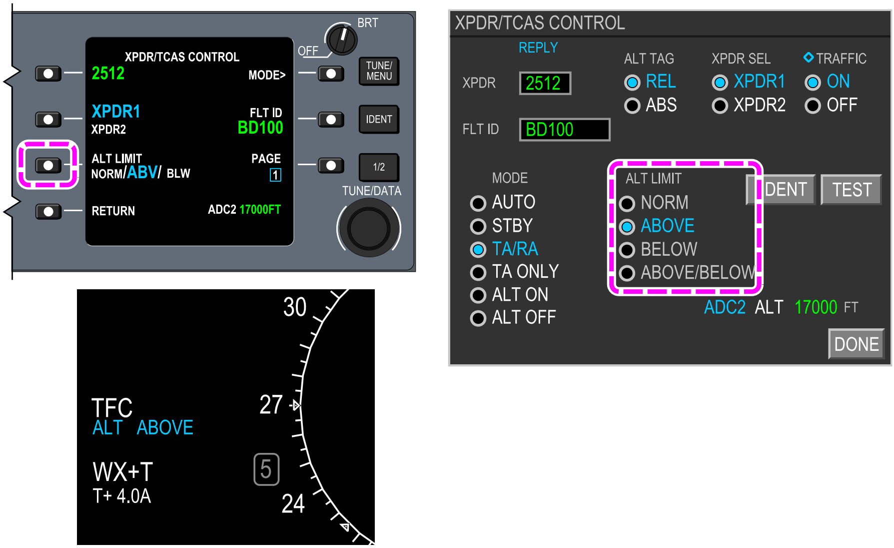
If BLW is selected, the TCAS will show all the traffic between 9900 ft below the aircraft altitude and 2700 ft above the aircraft altitude.

The ABV and BLW selection displays all the traffic detected within ±9900 ft around the aircraft altitude.

The selected altitude limit displays on the TCAS section of the HSI but no indication displays for the NORM selection.

In AUTO mode, the altitude limits are automatically set, based on the aircraft rate of climb (refer to Figure 16–04–31):

- NORM, when the rate of climb or descent is within 300 ft/min: 2700 ft above and below the aircraft.
- ABOVE, when the rate of climb is above 300 ft/min: 9900 ft above to 2700 ft below the aircraft.
- BELOW, when the rate of descent is below 300 ft/min: 2700 ft above to 9900 ft below the aircraft.



Surveillance altitude limits – Setting and indication
Figure 16–04–31

D. TCAS aural alerts

When a resolution advisory is activated, the TCAS produces aural alerts to advise of incoming traffic or command a change in the aircraft trajectory. The aural alerts cannot be muted or reduced in volume. Only STALL warning and TAWS windshear aural alerts have priority over TCAS alerts.

TYPE	COMMAND/ MESSAGE	AURAL ALERT
N/A	Clear of conflict	“CLEAR OF CONFLICT.”
TA	TA initial alert	“TRAFFIC. TRAFFIC.”
N/A – Test	TCAS test	“TCAS SYSTEM TEST OK” or “TCAS SYSTEM TEST FAIL”

TYPE	COMMAND/ MESSAGE	AURAL ALERT
Corrective RA	Descend	“DESCEND, DESCEND NOW. DESCEND, DESCEND NOW.”
Corrective RA	Climb	“CLIMB, CLIMB NOW. CLIMB, CLIMB NOW.”
Corrective RA	Increase descend	“INCREASE DESCENT. INCREASE DESCENT.”
Corrective RA	Increase climb	“INCREASE CLIMB. INCREASE CLIMB.”
Corrective RA	Descend	“DESCEND. DESCEND.”
Corrective RA	Altitude crossing descend	“DESCEND, CROSSING DESCEND. DESCEND, CROSSING DESCEND.”
Corrective RA	Altitude crossing climb	“CLIMB, CROSSING CLIMB. CLIMB, CROSSING CLIMB.”
Corrective RA	Climb	“CLIMB. CLIMB”
Corrective RA	Multi-aircraft encounter (issued while climbing)	“LEVEL OFF. LEVEL OFF”
Corrective/Preventive RA	Multi-aircraft encounter (maintain existing VS)	“MAINTAIN VERTICAL SPEED. MAINTAIN.”
Corrective RA	Altitude crossing maintain rate (maintain climb rate)	“MAINTAIN VERTICAL SPEED, CROSSING, MAINTAIN.”
Preventive RA	Limit climb (do not climb)	“MONITOR VERTICAL SPEED.”
N/A	TCAS test	“TCAS SYSTEM TEST OK”

TYPE	COMMAND/ MESSAGE	AURAL ALERT
N/A	TCAS TEST	"TCAS SYSTEM TEST FAIL"

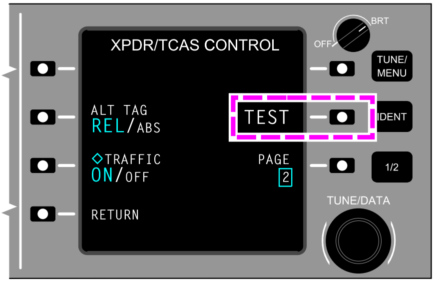
Some aural alerts are inhibited below certain radio altitudes.

COMMAND	ALTITUDE LIMITS
Increased descent	Prevented below 1550 ft AGL during a climb and 1450 ft AGL during a descent.
Descend	Prevented below 1000 ft AGL during a descent and below 1200 ft AGL during a climb.
All RA commands	Prevented below 1100 ft AGL during a climb and below 900 ft AGL during a descent. TCAS automatically changes to the TA ONLY mode.
TA initial alert	Prevented below 500 ft AGL during a climb and below 400 ft AGL during a descent.

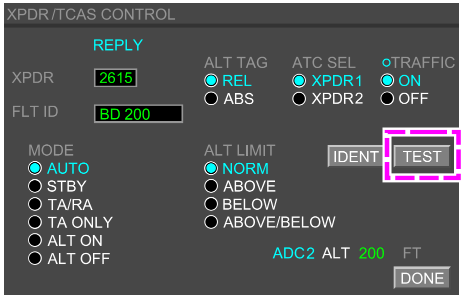
E. TCAS test

The TCAS system test can be done through one of the controls that follow (refer to Figure 16–04–32):

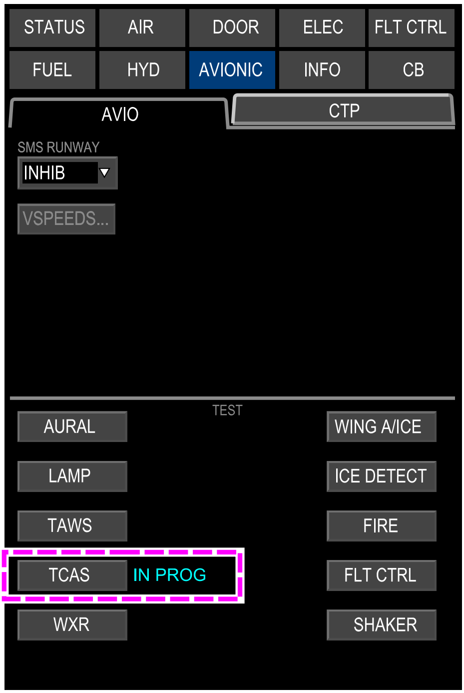
- On the XPDR/TCAS CONTROL page of the CTP, the LSK adjacent to TEST is pressed,
- On the XPDR/TCAS CONTROL window of the Communication, Navigation and Surveillance (CNS) the TEST soft switch is selected, or
- On the AVIO tab, of the AVIONIC synoptic page, the TEST soft switch is selected.



CONTROL TUNING PANEL (CTP) – TEST LSK



CNS – TUNE PAGE – XPDS/TCAS CONTROL WINDOW



AVIONIC SYNOPTIC PAGE – AVIO TAB

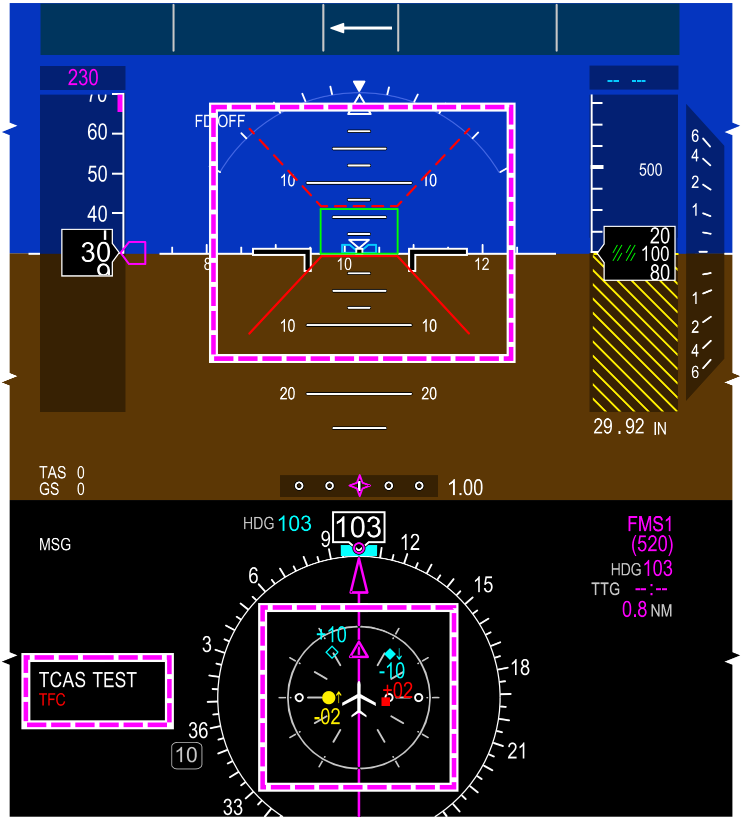
TCAS test
Figure 16–04–32

When the test is started, there is an aural message of “TCAS TEST”).

During the TCAS test, TEST displays in a larger font on the CTP, and an IN PROG message displays in cyan on the AVIONIC page.

During the TCAS test, the PFD displays the data that follow (refer to Figure 16–04–33):

- Fly-to and the fly-away zones on the ADI,
- A white TCAS TEST message and a flashing red TFC message on the TCAS section of the HSI, and
- Traffic targets on the HSI as follows:
    - RA traffic at the 3 o'clock position, 2 nm and 200 ft above,
    - TA traffic at the 9 o'clock position, 2 nm and 200 ft below and climbing,
    - PT approximately at the 1 o'clock position, 1000 ft below, descending, and
    - OT approximately at the 11 o'clock position, 1000 ft above , level flight.



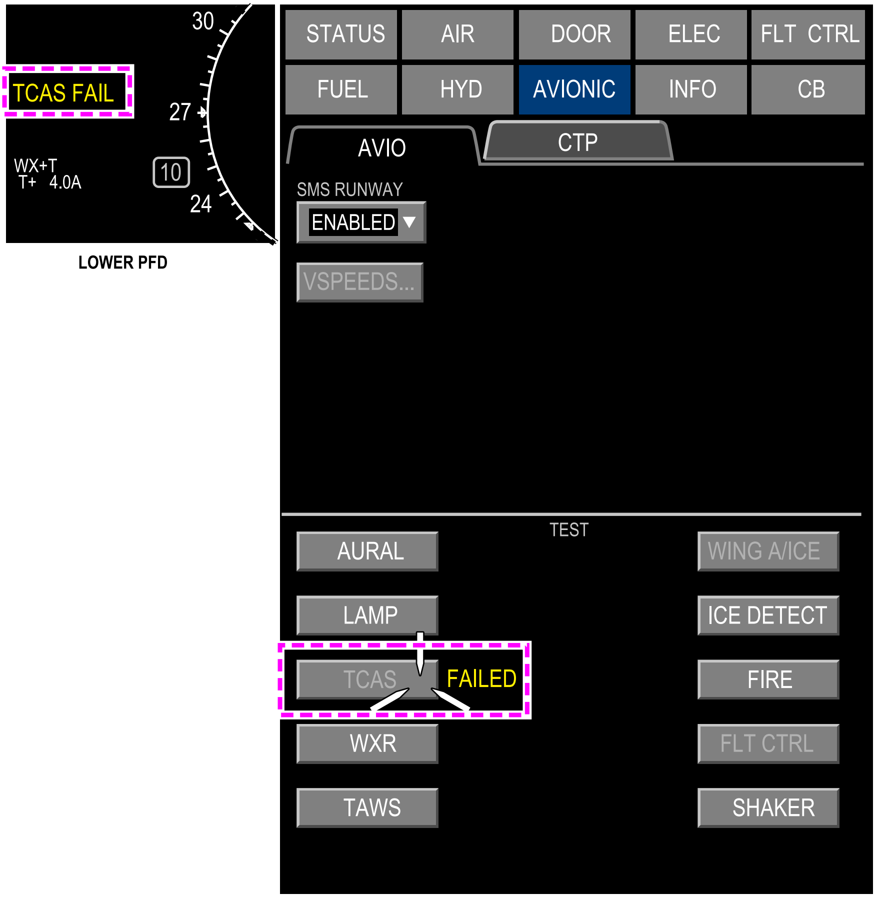
PFD – TCAS test indications
Figure 16–04–33

After a successful test, an aural message "TCAS SYSTEM TEST OK" sounds.

After a failed test, indications that follow occur (refer to Figure 16–04–34):

- "TCAS SYSTEM TEST FAIL"aural message,
- TCAS FAIL message on the lower PFD (TCAS test removed), and

- FAILED next to the TCAS soft switch on the AVIO tab of the AVIONIC page.



AVIONIC synoptic page – TCAS Test FAIL indications
Figure 16–04–34

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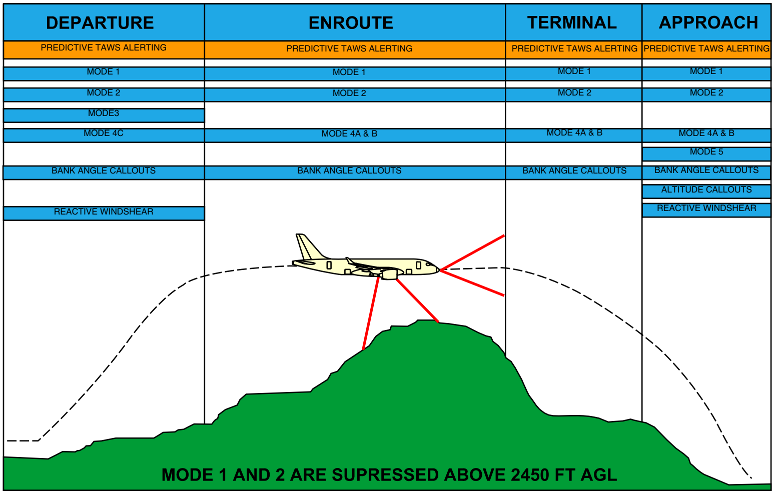
TAWS – OVERVIEW

The Terrain Awareness and Warning System (TAWS) contains a worldwide database of terrain and obstacle heights and airport elevations to avoid situation that may lead to Controlled Flight Into Terrain (CFIT). TAWS provides the functions that follow:

- Terrain threat detection,
- Aural and visual alerts (cautions and warnings),
- Aircraft misconfiguration when close to the ground,
- Bank angle alerts,
- Altitude callouts, and
- Advance windshear detection.

The TAWS computer function includes the Enhanced Ground Proximity Warning System (EGPWS) and alerting and awareness operating modes that follow (refer to Figure 16–05–1):

- Mode 1: Excessive descent rate,
- Mode 2: Excessive terrain closure rate,
- Mode 3: Altitude loss after takeoff,
- Mode 4: Unsafe terrain clearance,
- Mode 5: Excessive deviation below Glideslope (GS),
- Mode 6: Advisory callouts, bank angle, and attitude,
- Mode 7: Windshear detection and alerting.
- Terrain Clearance Floor (TCF),
- Forward looking ahead/obstacle,
- Terrain and obstacle awareness.



Flight phases with active modes
Figure 16–05–1

The TAWS indications consist of:

- Alert annunciations displayed on the Attitude Direction Indicator (ADI) portion of the PFD (refer to Figure 16–05–2) ,
- Status and fault annunciations displayed on the MAP page,
- Terrain pop-up alerts (cautions and warnings) displayed on the MAP page,
- Terrain display on the Vertical Situation Display (VSD) in the lower portion of the MAP page, and
- EICAS messages.

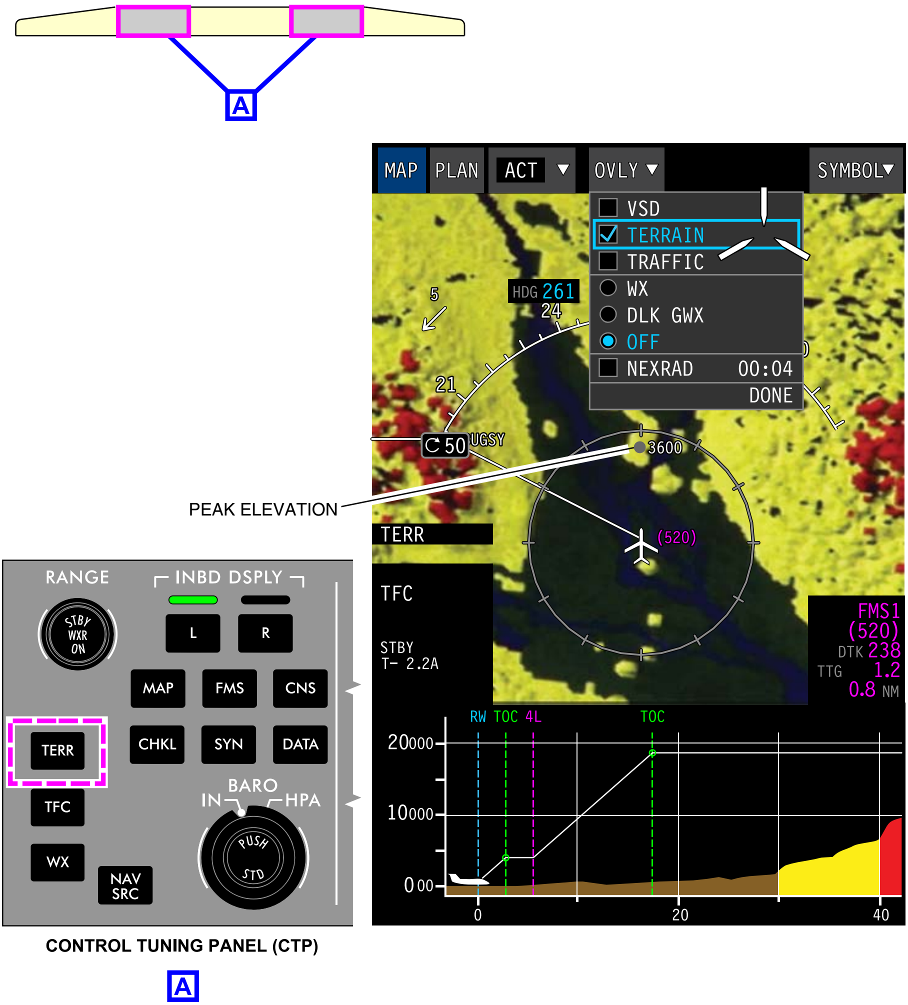
TAWS operation is automatic and requires no selections or actions.

ADI – TAWS caution alert
Figure 16–05–2

A. Terrain/Obstacle display

The internal terrain database has the ability to scan ahead of the aircraft and detect terrain or obstacle conflicts with greater alerting time.

Terrain topographic relief is presented on the MAP page by selecting TERRAIN from the overlay (OVLY) drop-down menu. Refer to Figure 16–05–3.



TAWS controls and indications
Figure 16–05–3

The graphical display depicts a top down view of terrain with respect to either aircraft position or a map reference point, using a color pattern to indicate relative terrain height above sea level. The highest terrain elevation (peak) within the half-range ring, also displays on the MAP or PLAN page as a gray dot with the elevation in feet. The peak displays if it is higher than 1000 ft ASL.

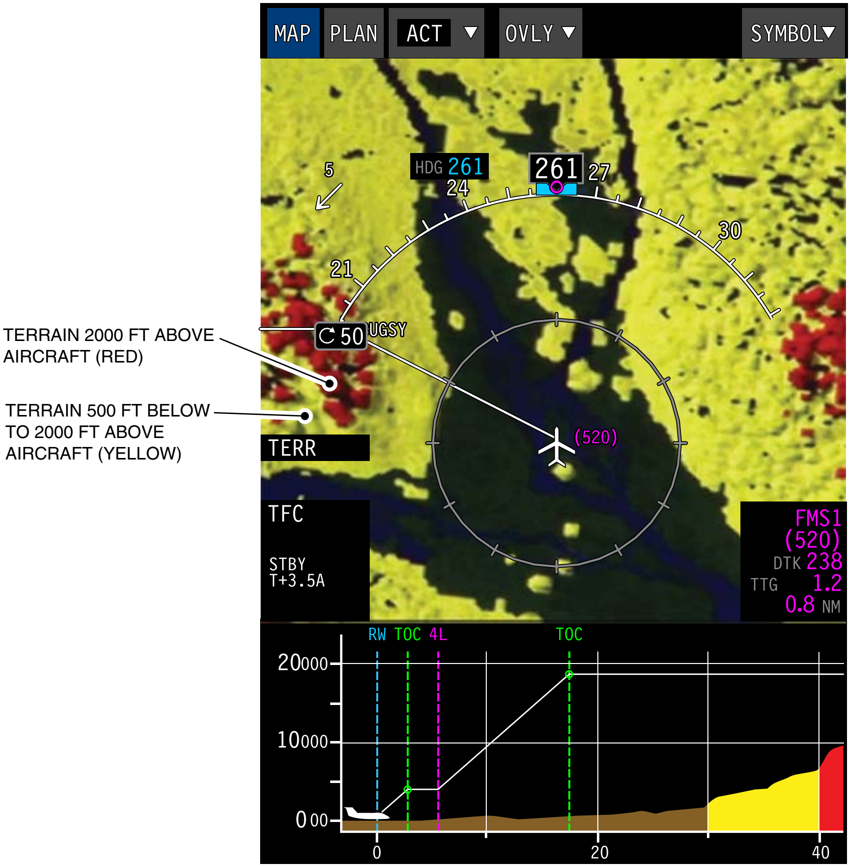
Figure 16–05–4 shows the terrain elevation colors code.

ELEVATION RANGES (MSL)	
FEET (<)	COLOR
500	
1000	
2000	
3000	
4000	
5000	
6000	
7000	
8000	
9000	
10000	
11000	
12000	
13000	
15000	
17000	
19000	
21000	
33000	
Unknown Terrain	

Terrain elevation colors
Figure 16–05–4

B. Terrain alert

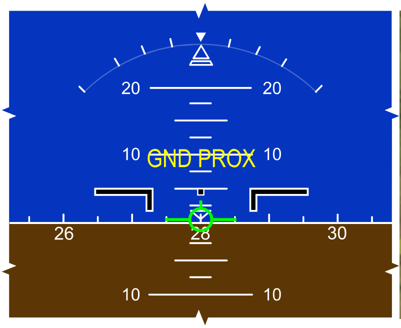
When the terrain elevation surrounding the aircraft is between 500 ft below and 2000 ft above the aircraft, it displays in yellow (refer to Figure 16–05–5). When the terrain elevation exceeds 2000 ft above the aircraft, it displays in red.



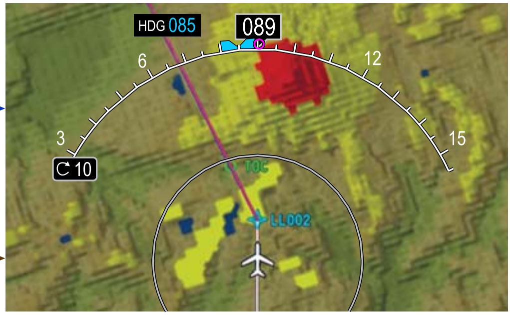
Terrain alert
Figure 16–05–5

When the aircraft enters the terrain caution range, a TAWS caution alert (refer to Figure 16–05–6) is initiated as follows:

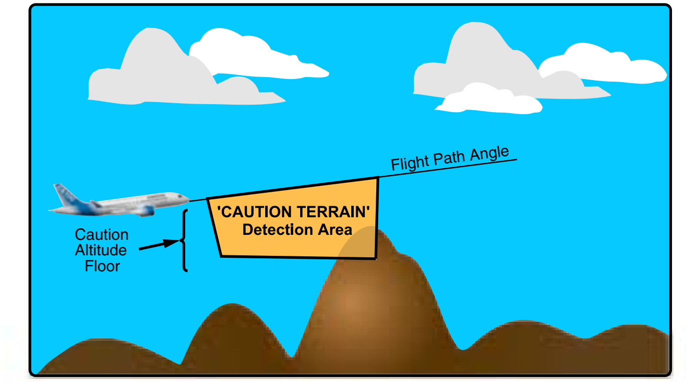
- The map does the following:
  - The PLAN display automatically switches to MAP display with a TERRAIN overlay,
  - The map range is automatically set to 10 NM,
  - The Weather Radar (WXR) display is automatically cancelled on the map format,
  - The displayed area is shown in flashing high intensity amber on the MAP page,
  - The Horizontal Situation Indicator (HSI) has a terrain display (unavailable in normal operation), and
  - The MAP page displays on the Multifunction Window (MFW) on Display Unit 2 (DU2) and DU3, if not already displayed.
- An amber GND PROX visual alert displays on the PFD, and
- A "CAUTION TERRAIN, CAUTION TERRAIN" or "CAUTION OBSTACLE, CAUTION OBSTACLE" alert sounds 60 seconds before the terrain/obstacle conflict can occur and is repeated every seven seconds while the aircraft remains within the conflict caution area.



PFD - ADI



MFW - MAP PAGE - OVERLY



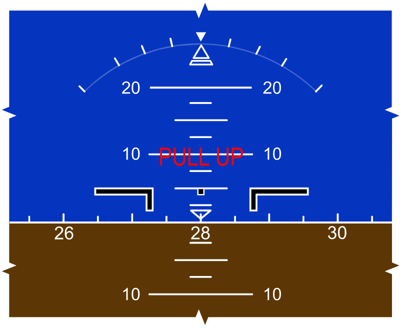
VERTICAL SITUATION DISPLAY (VSD)

Terrain caution alert
Figure 16–05–6

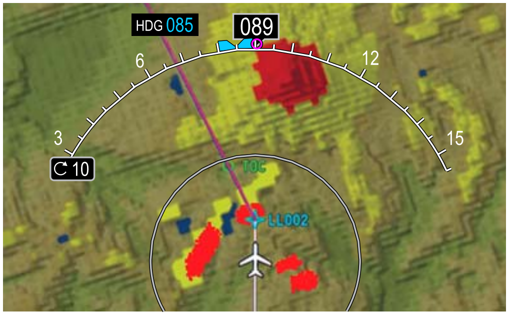
When the aircraft enters the terrain warning range, a TAWS warning alert (refer to Figure 16–05–7) is initiated as follows:

- The map does the following:
  - The PLAN display automatically switches to MAP display with a TERRAIN overlay,
  - The map range is automatically set to 10 NM,

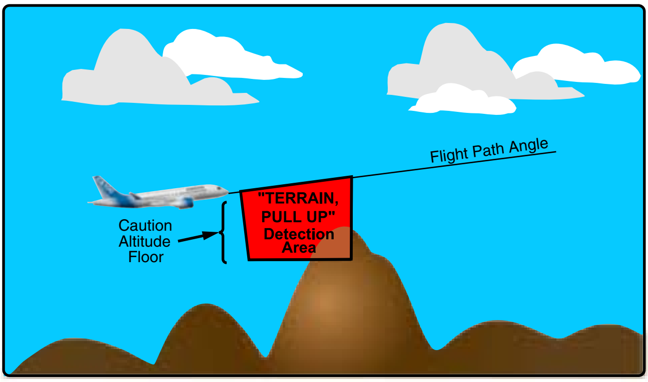
  - The Weather Radar (WXR) display is automatically cancelled on the map format,
  - The displayed area is shown in flashing high intensity red on the MAP page,
  - The Horizontal Situation Indicator (HSI) has a terrain display (unavailable in normal operation), and
  - The MAP page displays on the Multifunction Window (MFW) on Display Unit 2 (DU2) and DU3, if not already displayed.
- A red PULL UP visual alert displays on the PFD, and
- A “TERRAIN, TERRAIN, PULL UP, PULL UP” or “OBSTACLE, OBSTACLE, PULL UP, PULL UP” alert sounds 30 seconds before the terrain/obstacle conflict can occur.



PFD - ADI



MFW - MAP PAGE - OVERLY



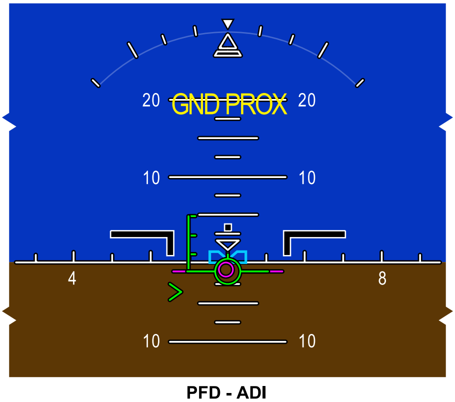
VERTICAL SITUATION DISPLAY (VSD)

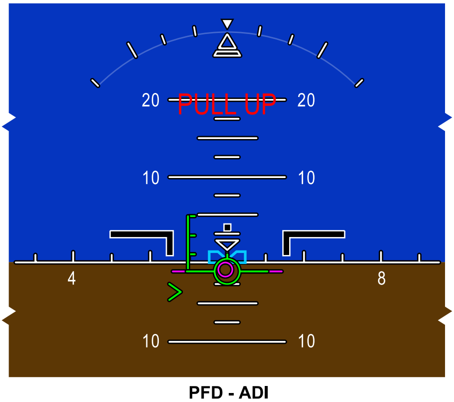
Terrain warning alert
Figure 16–05–7

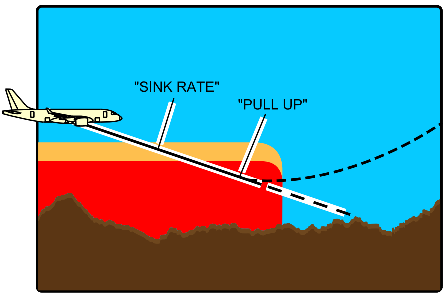
TAWS – OPERATION (MODES)

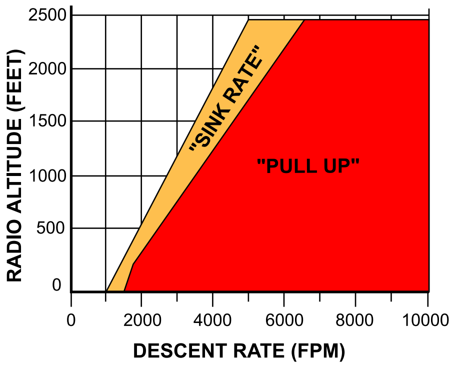
A. Mode 1: Excessive descent rate

Mode 1 (refer to Figure 16–05–8) applies to excessive descent rate with respect to terrain clearance. This mode is independent of landing gear and flap position. It will generate aural and visual alerts when the rate of descent is excessive for the current altitude.









Mode 1 alert envelopes
Figure 16–05–8

The Mode 1 alert envelope is divided into two zones: the initial zone, which corresponds to the SINK RATE zone, and the inner warning zone, which corresponds to the PULL UP zone. When the aircraft enters the SINK RATE zone, the TAWS generates the aural alert "SINK RATE" and an amber GND PROX visual alert on the Attitude Direction Indication (ADI). The entry into the PULL UP zone generates the aural alert "PULL UP" and a red PULL UP visual alert on the ADI. The aural is annunciated continuously until the condition no longer exists

The alert envelope limits are defined by the aircraft vertical speed and radio altitude.

B. Mode 2: Excessive terrain closure rate

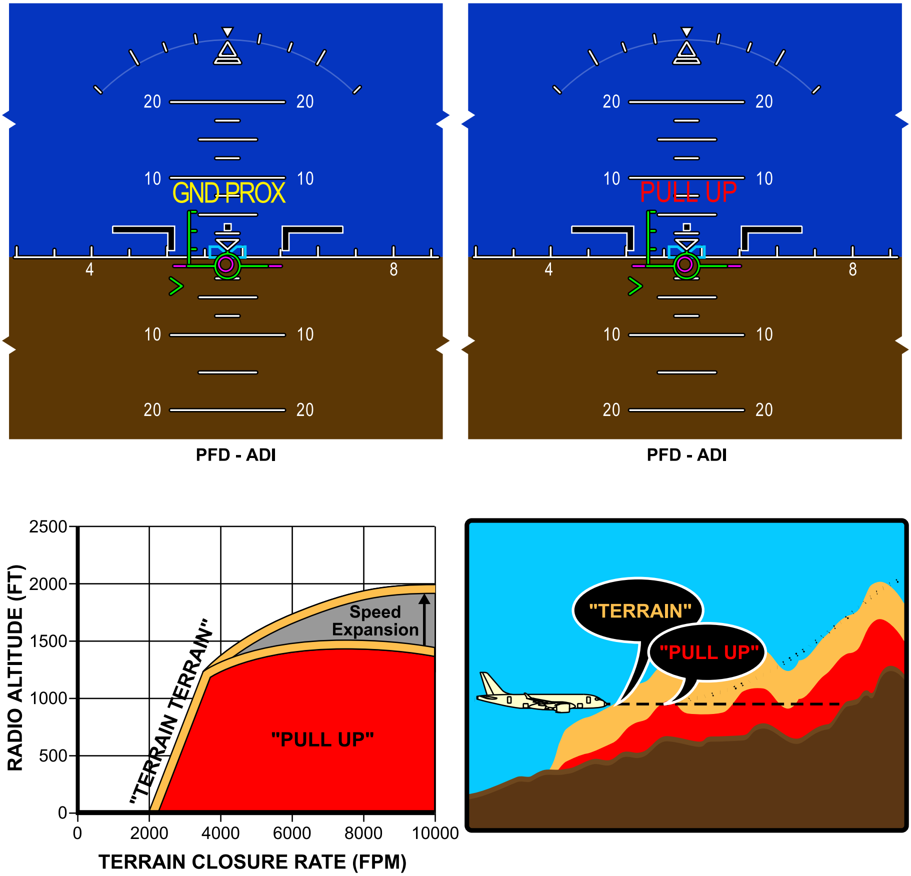
Mode 2 is available during all flight phases. Calculations are carried out using radio altitude and vertical speed.

Mode 2 is comprised of two submodes (2A, 2B) that provide aural and visual alerts when an excessive closure rate to terrain is detected. Mode 2A is enabled when the conditions for mode 2B are not satisfied.

(1) Mode 2A

The Mode 2A envelope (refer to Figure 16–05–9) is divided into two zones: the penetration zone and the warning zone. The entry into the penetration zone generates a "TERRAIN, TERRAIN" aural alert and a GND PROX visual alert is displayed on the ADI. Entry into the warning zone generates a "PULL UP" aural alert and a PULL UP message on the ADI.

The upper boundary of the mode 2A envelope varies as a function of the aircraft airspeed and the availability of the terrain awareness function.



Mode 2A alert envelopes
Figure 16–05–9

When the aircraft leaves the warning zone, due to either terrain drop-off or a pull-up maneuver, the altitude gain function is activated. The warnings continue until the aircraft achieved one of the condition that follow:

- Gained 300 ft of barometric altitude, or
- 45 seconds has elapsed, or
- The radio altimeter loses track.

If the aircraft penetrates the envelope with both gear and flaps in the landing gear configuration, the “PULL UP” aural alert is inhibited and is replaced by the aural alert “TERRAIN, TERRAIN” which is repeated until the aircraft exists the envelope.

(2) Mode 2B

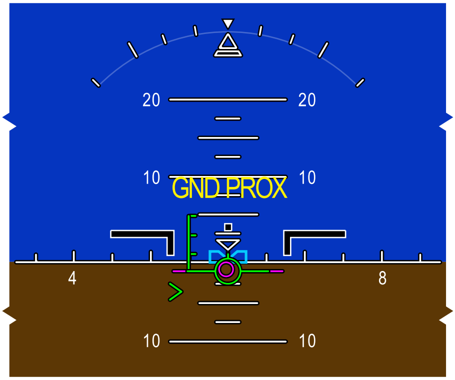
Mode 2B (refer to Figure 16–05–10) has similar alerts to Mode 2A but the envelope is adapted to prevent nuisance alerts during a normal approach. This mode is active during:

- Whenever flaps are selected to the landing position, or
- The aircraft is performing an ILS approach and is within two dots of both localizer and glideslope centerlines, or
- The aircraft is within 10 NM and 3500 ft of the destination runway, or
- For the first 60 seconds after takeoff.

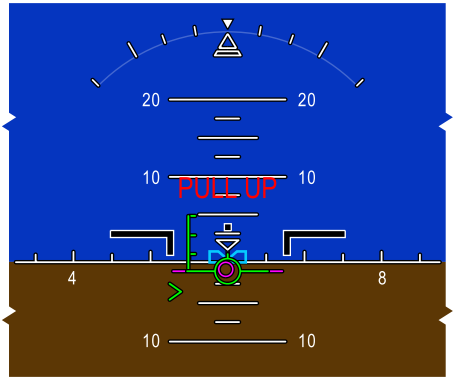
In this mode, when the terrain closure rate and the radio altitude are in the caution envelope and the gear or flaps are not in the landing configuration, a “TERRAIN, TERRAIN” aural alert sounds.

If in the warning envelope, a continuous “PULL UP” aural alert sounds. If in the caution envelope with the gear and flaps in the landing configuration, only the “TERRAIN, TERRAIN” aural alert sounds.

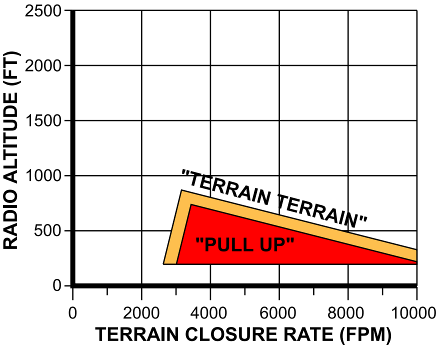
If the aircraft penetrates the mode 2B envelope with both gear and flaps in landing configuration, the voice aural “TERRAIN, TERRAIN” is repeated until the envelope is exited.

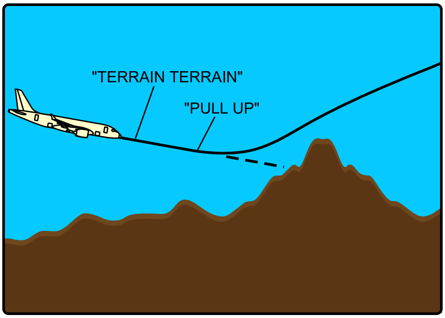


PFD - ADI



PFD - ADI

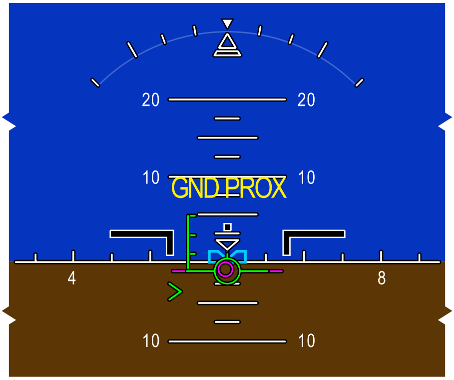




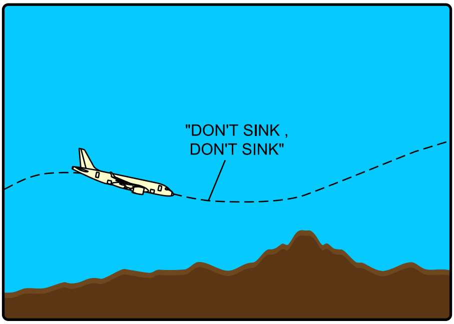
Mode 2B alert envelopes
Figure 16–05–10

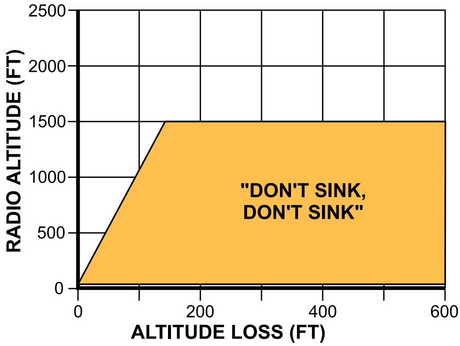
C. Mode 3: Altitude loss after takeoff

Mode 3 (refer to Figure 16–05–11) is active when the aircraft loses a significant amount of altitude immediately after takeoff or go-around. This mode compares the radio altitude and barometric altitude with the rate of altitude loss to generate the aural alert "DON'T SINK, DON'T SINK" and a GND PROX visual alert on the ADI. The GND PROX visual alert remains active until a positive rate of climb is restablished.



PFD - ADI





Mode 3 – Alert envelope
Figure 16–05–11

To monitor altitude loss, Mode 3 records the aircraft altitude when a descent occurs after a takeoff, and compares it with the successive altitude data to generate the alert.

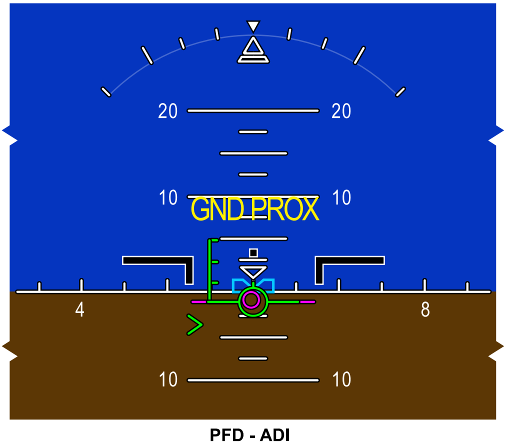
The alert is triggered once, then silenced, but triggered again if altitude degrades an additional 20%. The alert remains active until the aircraft has gained sufficient altitude, indicating that it is no longer in the takeoff phase.

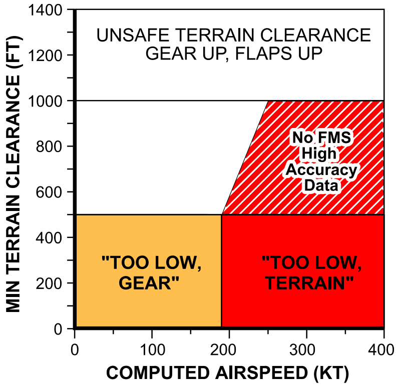
D. Mode 4: Unsafe terrain clearance

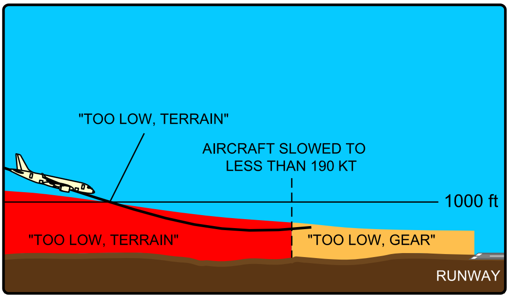
Mode 4 has three sub-modes: Mode 4A, 4B and 4C, based on detection of unsafe terrain clearance relative to flight phase and airspeed.

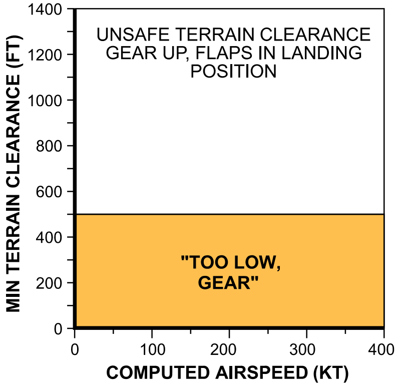
(1) Mode 4A – Gear up

The Mode 4A (refer to Figure 16–05–12) warning area is dependent on altitude and airspeed. Penetration of the warning area with gear not down triggers an aural alert "TOO LOW, TERRAIN" and a GND PROX visual alert is displayed on the ADI. The terrain clearance limit of the warning area increases with airspeed when high accuracy FMS data is not available. Below 500 ft AGL and 190 kt, the aural alert "TOO LOW, GEAR" is enabled.





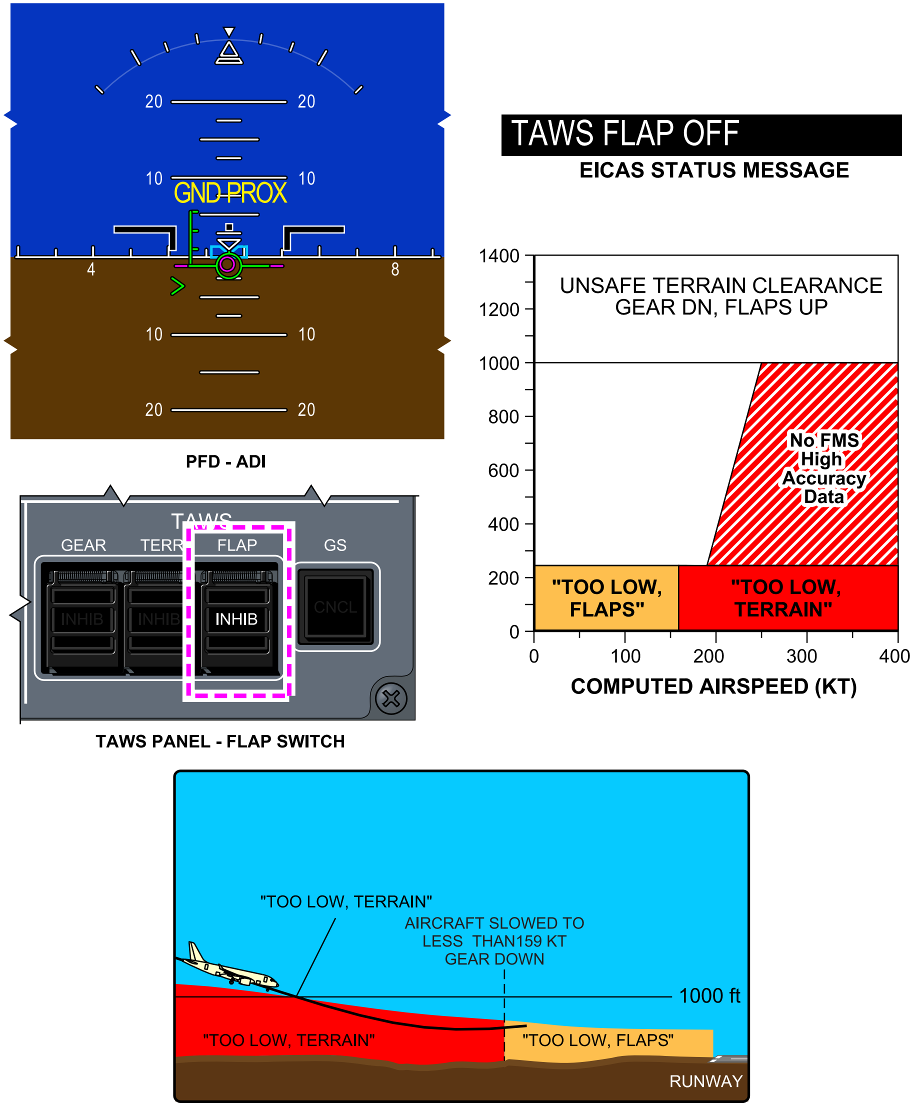




Mode 4A – Unsafe terrain clearance – Approach (gear not down)
Figure 16–05–12

(2) Mode 4B – Flap up

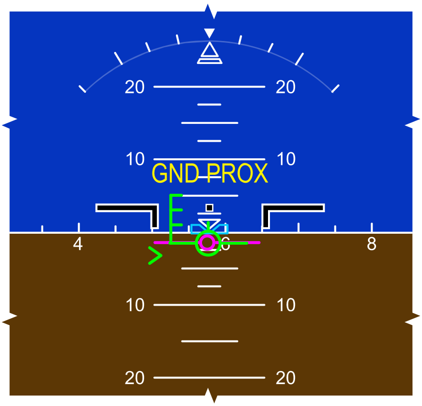
Mode 4B (refer to Figure 16–05–13) is active while the aircraft is in cruise or approach phase with the landing gear down and flaps not in landing configuration. Penetration of the warning area terrain clearance limit with the flaps not in landing configuration triggers an aural alert "TOO LOW, TERRAIN" and a GND PROX visual alert is displayed on the ADI. The terrain clearance limit of the warning area increases with airspeed when high accuracy FMS data is not available. Penetration of the caution area with the flaps not in landing configuration and landing gear down triggers a "TOO LOW, FLAPS" aural alert. This alert may be muted by selecting the FLAPS switch/light on the TAWS panel. Selection is accompanied by a **TAWS FLAPS OFF** EICAS status message on the EICAS page.



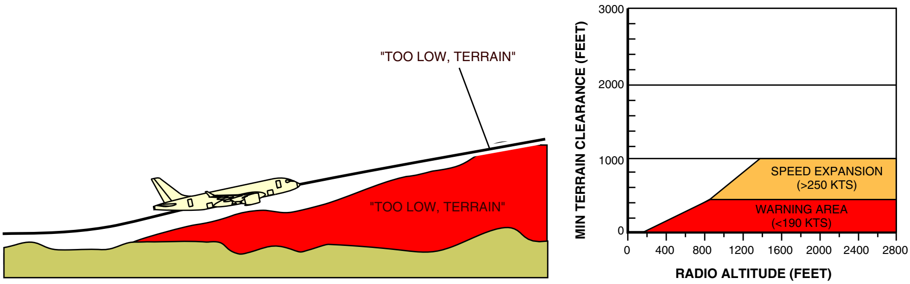
Mode 4B – Unsafe terrain clearance – Approach (gear down)
Figure 16–05–13

(3) Mode 4C – At takeoff

Mode 4C (refer to Figure 16–05–14) is intended for takeoff or go-around, should the terrain rise faster than the aircraft climb rate. Operation is based on the minimum terrain clearance floor, radio altitude, and airspeed. Any decrease in altitude below the floor triggers an amber GND PROX visual alert is displayed on the ADI, and TOO LOW, TERRAIN sounds.



PFD – ADI

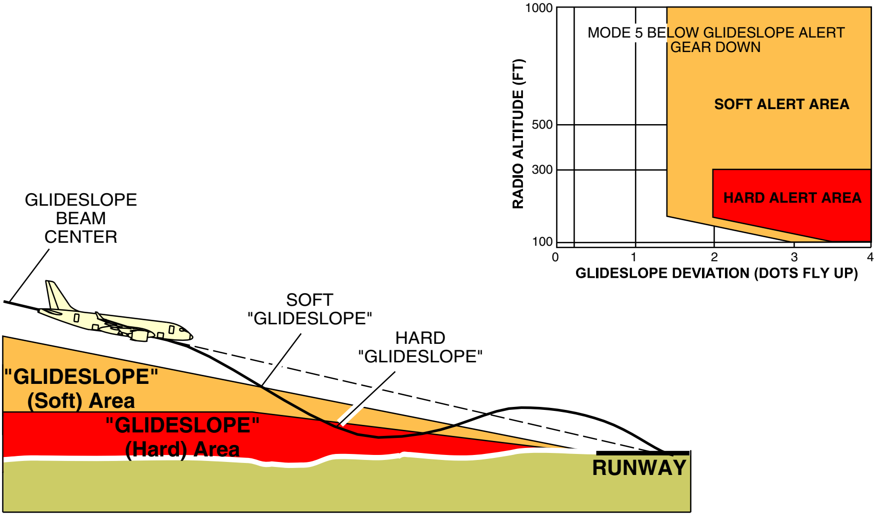


Mode 4C – Unsafe terrain clearance – Takeoff and go–around
Figure 16–05–14

E. Mode 5: Descent below Glideslope (GS)

Mode 5 provides two levels of alerting when the aircraft is between 1000 and 300 ft RA and the aircraft flight path descends below the glideslope beam on front-course ILS approaches or for excessive downward deviation during Localizer Performance with Vertical guidance (LPV) approaches

Refer to Figure 16–05–15.

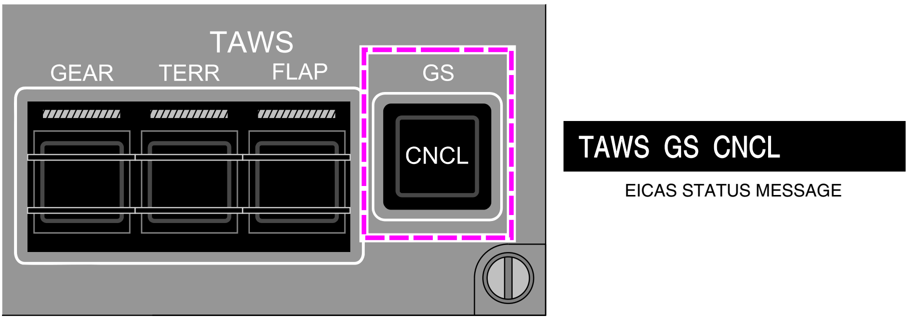


Mode 5 – Excessive deviation below Glideslope (GS)
Figure 16–05–15

When the glideslope exceeds 1.3 dots (0.46 degrees), the GLIDESLOPE visual alert is displays on the ADI and the aural alert **"**GLIDESLOPE**"** is given once.

The second alert level occurs when the aircraft is below 300 ft RA with greater than two dots of deviation below the glideslope (0.7). In this case, a hard (louder) **"**GLIDESLOPE**"** aural message sounds. In both alert cases, an amber GND PROX visual alert is displayed on the ADI.

To inhibit the "GLIDESLOPE" aural alert, the flight crew must press the GS switch on the TAWS panel. The CNCL label on the switch illuminates white and a **TAWS GS CNCL** EICAS status message displays on the EICAS page. Refer to Figure 16–05–16.



TAWS panel – Glideslope (GS) cancel switch
Figure 16–05–16

F. Mode 6: Advisory callouts and bank angle

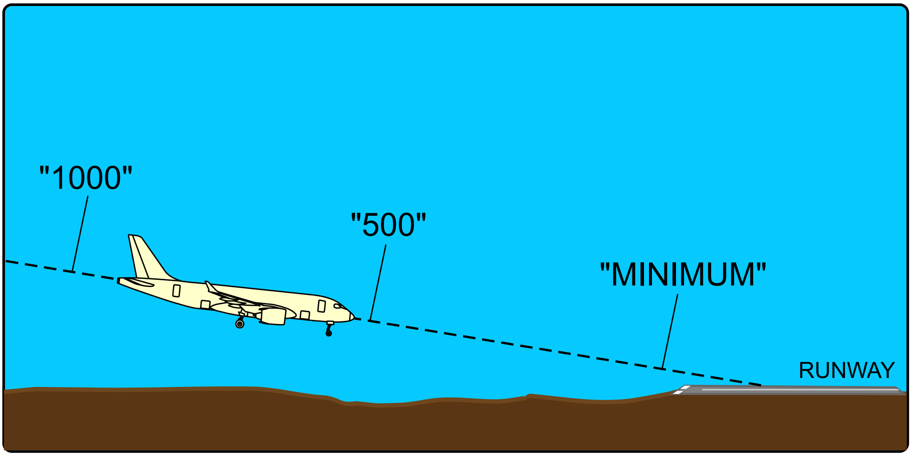
Mode 6 provides aural alerts (such as "DECISION HEIGHT", "MINIMUMS", "APPROACHING MINIMUMS", etc.) for descent below predefined altitudes (if a minimum is entered in the DH window).

(1) Mode 6: Altitude callouts

Mode 6 provides aural alerts and altitude callouts for descent below predefined altitudes, approaching minimums (optional), and minimums (refer to Figure 16–05–17). Mode 6 produces aural alerts only (no messages on the ADI). AGL altitude callouts sound at 1000 ft and 500 ft.

The 500 ft callout will only sound when a non-precision approach is performed, or a glideslope or localizer deviation exceeds two dots.

The "MINIMUM" aural message sounds when the aircraft descends below the minimums setting, either radio-altitude DH or barometric MDA depending on the BARO/RAD selection on the CTP.

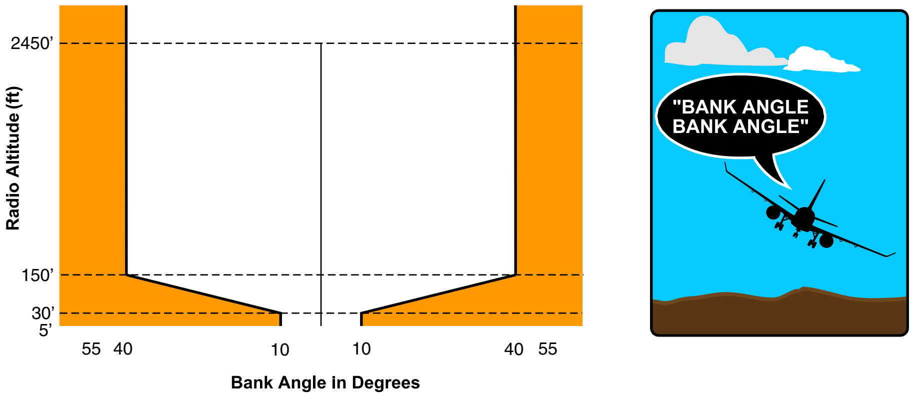


Mode 6 call–outs
Figure 16–05–17

(2) Mode 6: Bank angle

Mode 6 also includes alerts for excessive bank angle, with respect to radio altitude. Bank angles exceeding the envelope generate the aural alert “BANK ANGLE, BANK ANGLE”. Refer to Figure 16–05–18.

The bank angle aural alerts are issued twice and then suppressed unless the roll angle increases by an additional 20%.



Excessive bank angle alerts
Figure 16–05–18

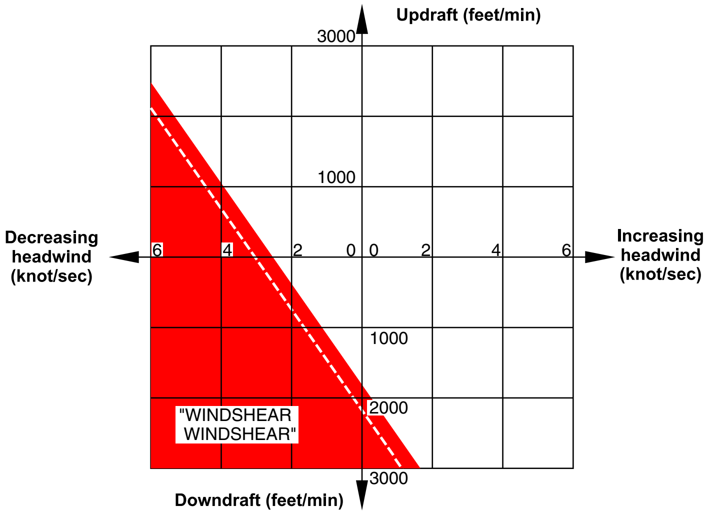
G. Mode 7: Windshear warning

Mode 7 provides reactive windshear detection during initial takeoff and final approach phases of flight.

The windshear warning annunciation is displayed on the PFD when windshear conditions are encountered (reactive).

The reactive windshear function uses flight data inputs. The reactive windshear detection is active between 10 and 1500 ft AGL, during the initial takeoff and final approach.

Reactive windshear warning alerts are given for decreasing head wind (or increasing tail wind) and severe vertical down drafts (refer to Figure 16–05–19).

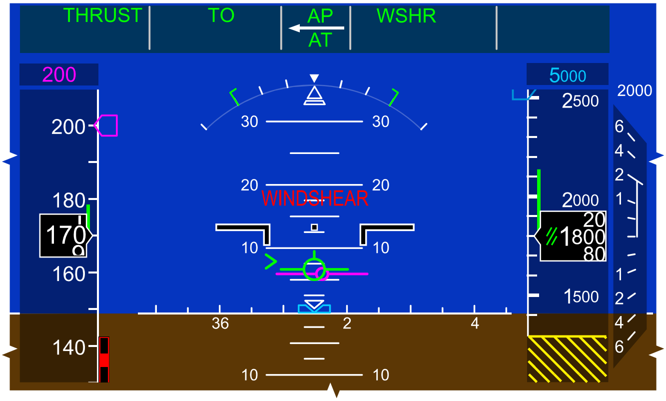


Windshear alert envelopes
Figure 16–05–19

When an decreasing performance windshear is detected, it provides a visual message and the aural message (refer to Figure 16–05–20) that follows:

- A “ WINDSHEAR, WINDSHEAR, WINDSHEAR” sounds, and
- a red WINDSHEAR message displays on the ADI.

"WINDSHEAR, WINDSHEAR, WINDSHEAR."



PFD – ADI

Mode 7 – Windshear warning alert
Figure 16–05–20

NOTE

Windshear aural alerts have priority over all other ground proximity aural alerts.

The reactive windshear caution from the TAWS mode 7 is deactivated on the aircraft. Windshear cautions are provided exclusively by the predictive windshear function of the radar.

TERRAIN AND OBSTACLE AWARNESS

A. Terrain and obstacle awareness

Terrain and obstacle awareness detects potential conflicts between the aircraft flight path and the terrain. Alerts for conflicting flight path and terrain obstacles are shown on the Vertical Situation Display (VSD) at the bottom of the MAP page. This mode includes:

- Aircraft geographic position,

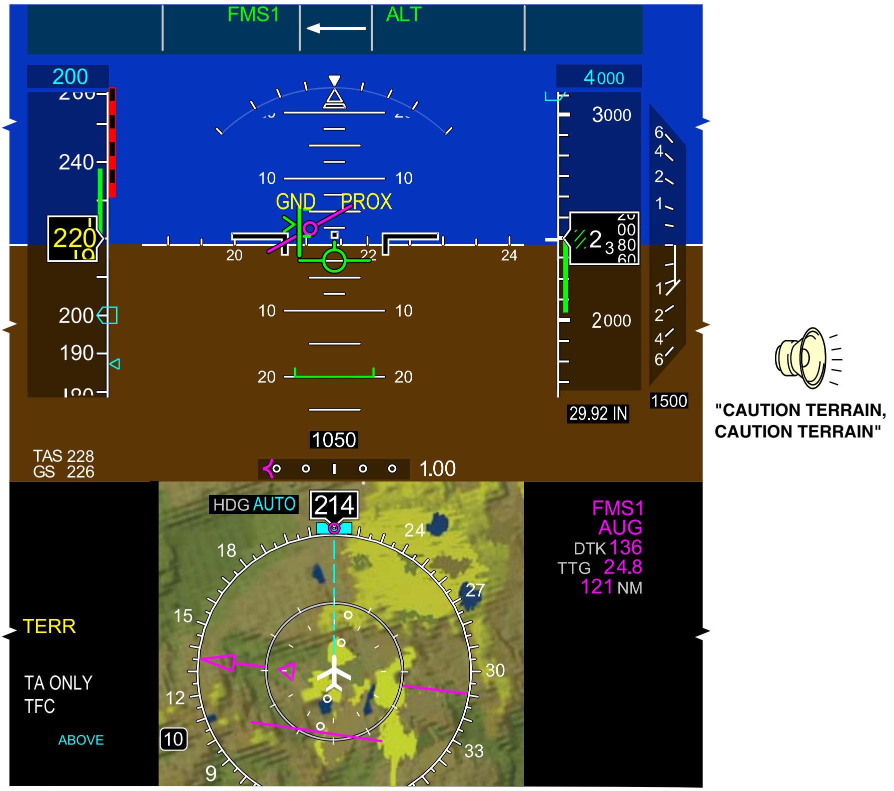
- Aircraft altitude, and
- Terrain and obstacle database.

The terrain and obstacle awareness mode computes two levels of alerts:

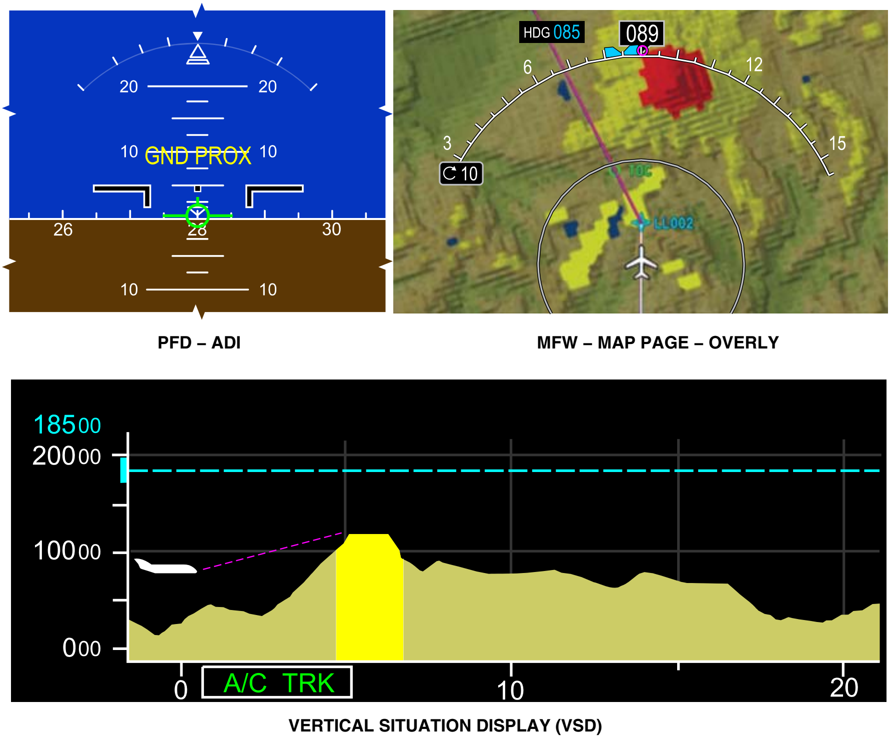
- The terrain/caution alert level, and
- The terrain/warning alert level.

If the aircraft penetrates the terrain/caution alert zone:

- An aural alert "CAUTION TERRAIN, CAUTION TERRAIN" sounds (refer to Figure 16–05–21), and
- The terrain areas corresponding to the caution alert are shown in solid amber on the VSD (refer to Figure 16–05–22).



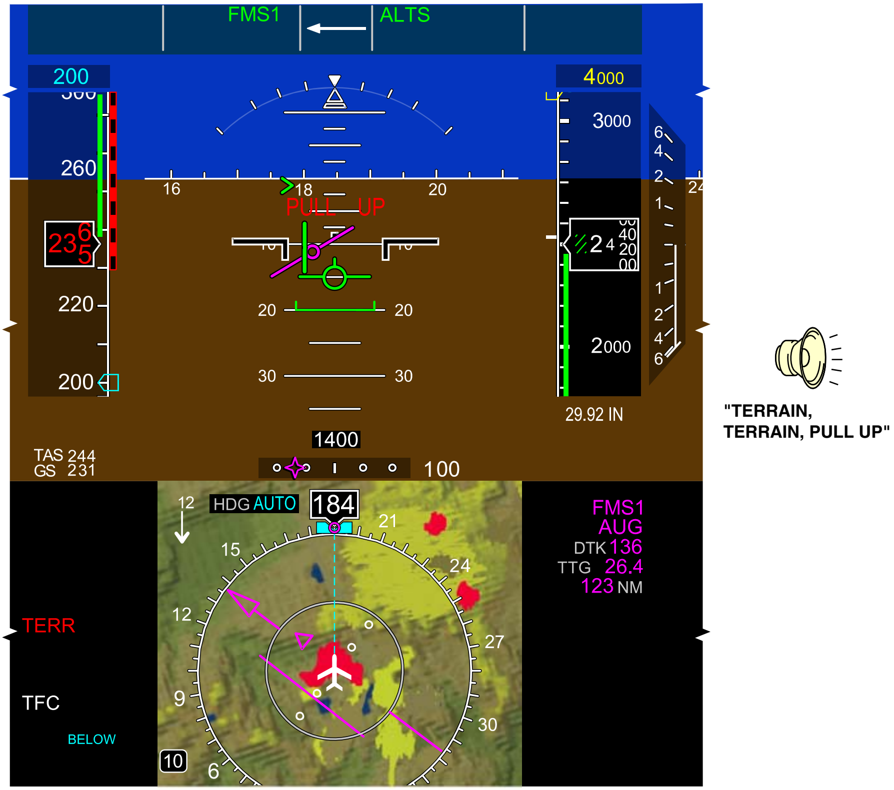
PFD – Ground proximity (GND PROX) indication
Figure 16–05–21



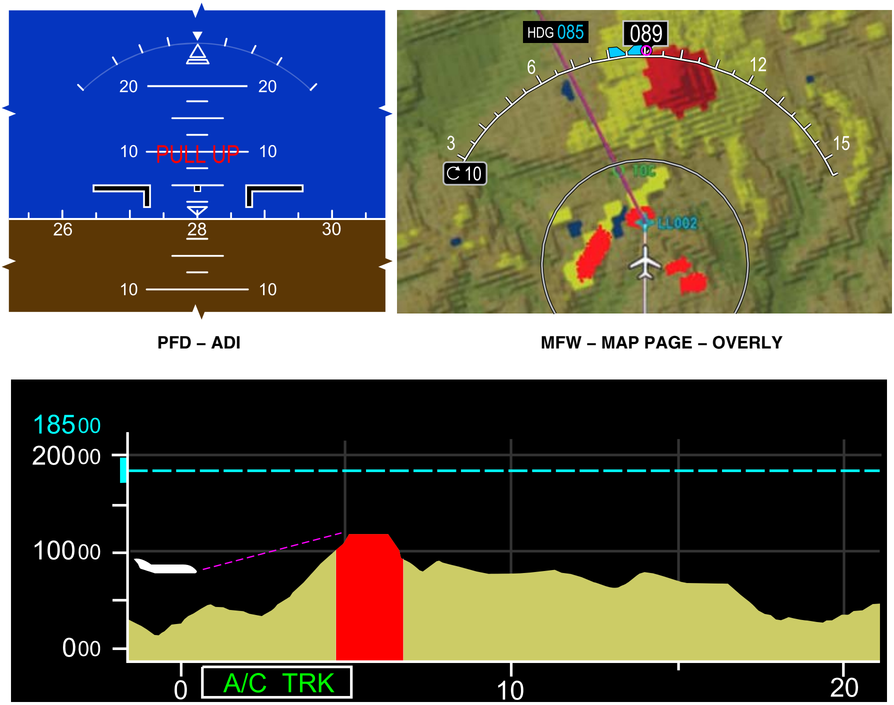
VSD – Terrain caution alert
Figure 16–05–22

If the aircraft penetrates the terrain/warning alert zone:

- An aural alert "TERRAIN, TERRAIN, PULL UP" sounds (refer to Figure 16–05–23), and
- The terrain areas corresponding to the warning alert are shown in solid red on the VSD (refer to Figure 16–05–24).



PFD – PULL UP indications
Figure 16–05–23

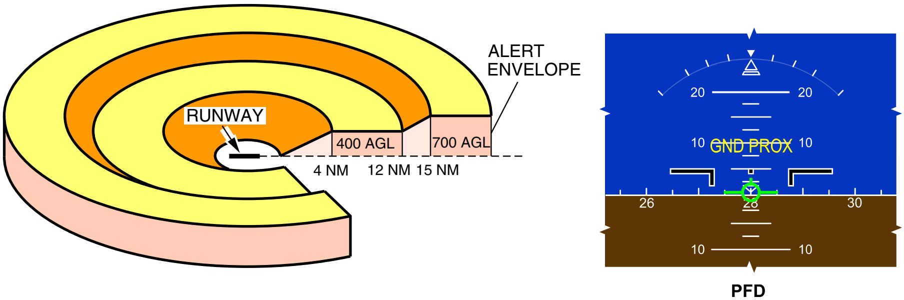


VSD – Terrain warning alert
Figure 16–05–24

B. Terrain Clearance Floor (TCF)

The Terrain Clearance Floor (TCF) creates an increasing terrain clearance envelope around the intended airport runway, related to the distance from the runway (refer to Figure 16–05–25). The TCF database, which is included in the TAWS database, contains information for all hard-surfaced runways of 3500 ft or greater.

This alert mode complements existing Mode 4 protection by providing an alert based on insufficient clearance even when in landing configuration.



Terrain Floor Clearance (TFC) – Alert envelope
Figure 16–05–25

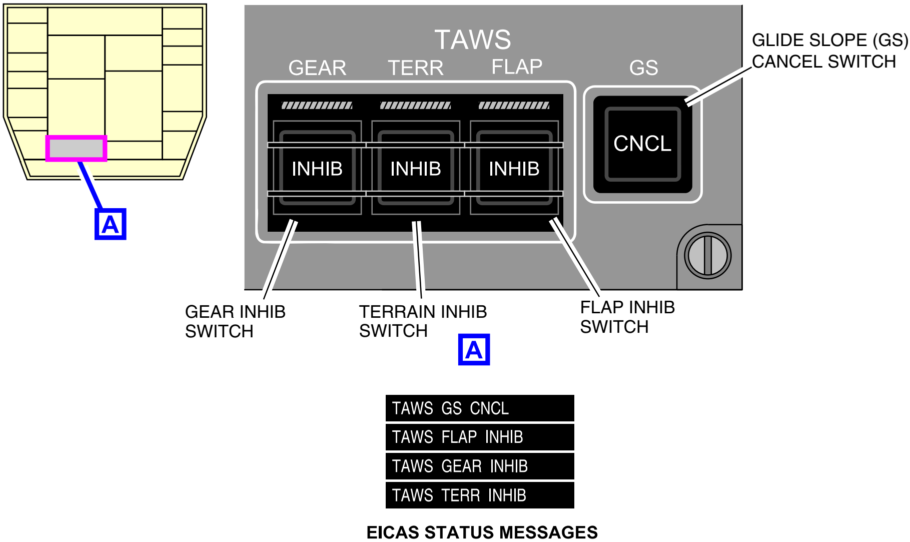
When the aircraft penetrates the TCF alert envelope, there is an aural alert of **"**TOO LOW, TERRAIN**"** and an amber GND PROX message displays on the PFD. The aural alert is issued once when the initial envelope penetration occurs, and one time for each 20% of degradation in Radio Altitude (RA).

TAWS – CONTROLS AND INDICATIONS

Although the TAWS is automatic, the TAWS panel on the overhead panel includes the three guarded switch/lights that follow (refer to Figure 16–05–26):

- GEAR, to inhibit TAWS aural alerts associated with landing gear,
- TERR, to inhibit TAWS aural alerts associated with terrain, and
- FLAP, to inhibit TAWS aural alerts associated with flap.

The TAWS includes also one switch/light to inhibit aural alert associated with Glideslope (GS).



TAWS panel
Figure 16–05–26

When the GEAR INHIB guarded switch is pressed in:

- The INHIB label on the switch is illuminated white.
- The “TOO LOW GEAR” aural alert is inhibited.
- The **TAWS GEAR INHIB** status message displays on the EICAS page.
- When pressed in again, it restores the “TOO LOW GEAR”alert function.

When the TERR INHIB guarded switch is pressed in:

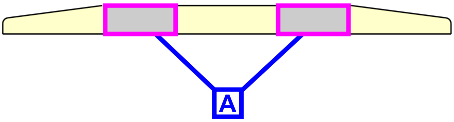
- The INHIB label on the switch is illuminated white.
- The “TOO LOW TERRAIN” alert is inhibited.
- The TAWS TERRAIN OFF alert displays on the MAP page.
- When pressed in again, it restores the “TOO LOW TERRAIN” alert function.

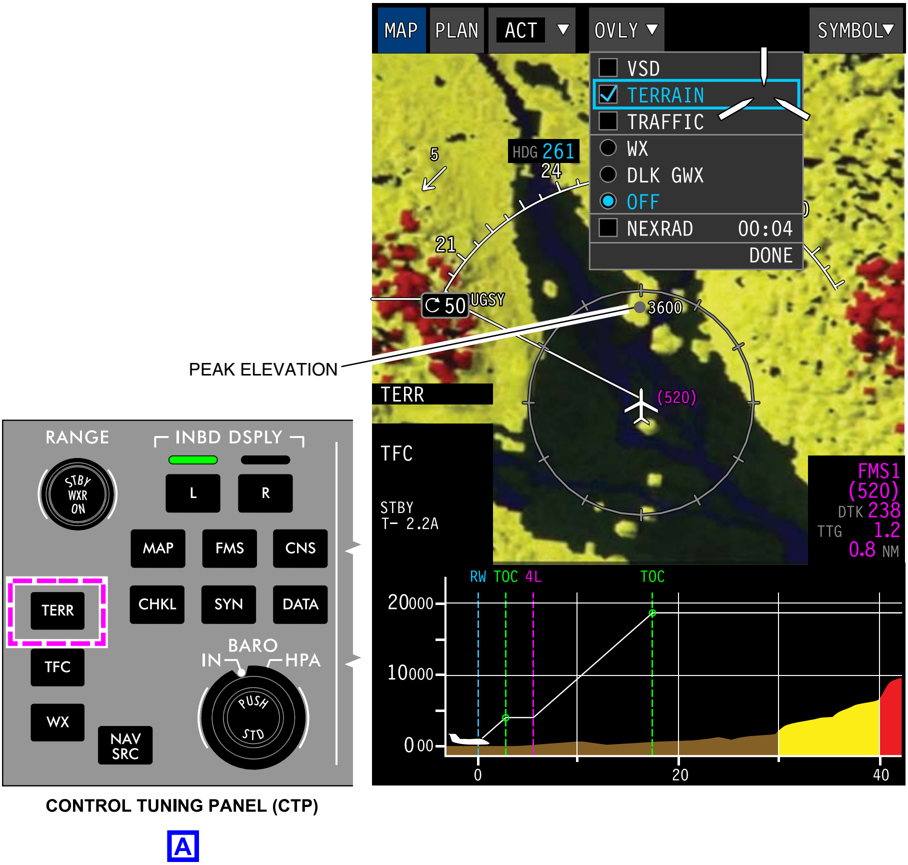
When the FLAP INHIB guarded switch is pressed in:

- The INHIB label on the switch is illuminated white.
- “TOO LOW FLAPS” alert is inhibited.
- The **TAWS FLAP INHIB** status message displays on the EICAS page.
- When pressed in again, it restores the “TOO LOW FLAPS” alert function.

When a switch/light is pressed, the associated aural alert are inhibited and a white INHiB or CNCL legend illuminates. An associated EICAS status message displays when each switch/light is pressed.

The terrain display on the MAP page is selected using the TERR switch on the CTP or the terrain OVLY (overlay) menu on the MAP page (refer to Figure 16–05–27). The OVLY menu selection will display absolute and relative TAWS alerting.



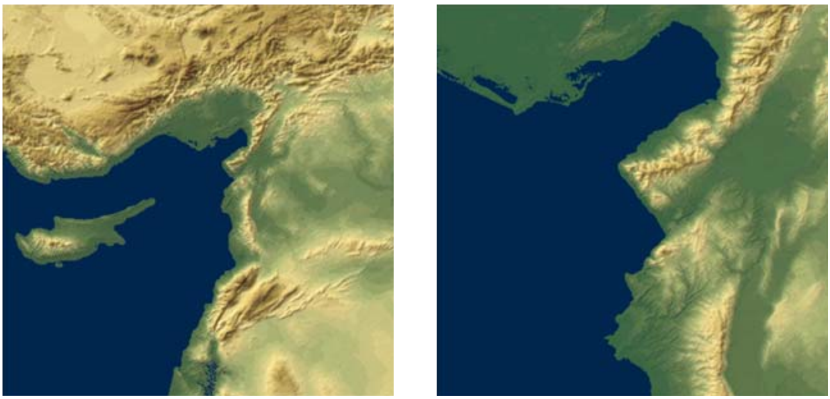


TAWS controls and indications
Figure 16–05–27

The terrain display has three presentations:

- Absolute terrain: Topographic terrain (always displayed when TERRAIN is selected on the OVLY menu).
- Relative terrain: TERRAIN display selection shaded red and amber relative to aircraft position.
- Alerting terrain: Red and amber terrain alerts.

The absolute terrain is displayed in browns and greens, and water is displayed in blue (refer to Figure 16–05–28). Absolute terrain can be displayed with WXR. Weather or terrain are removed during alerts (TAWS modes or windshear) and are automatically restored once the alert condition has cleared.



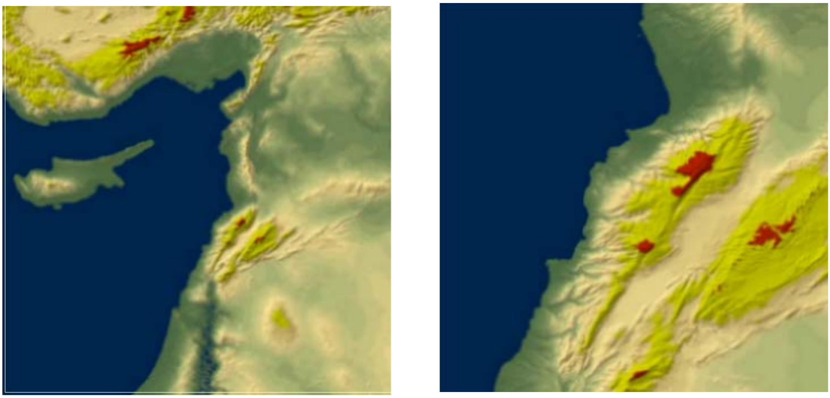
100 NM DISPLAY SETTING   25 NM DISPLAY SETTING

NOTE

1. Absolute terrain displayed in greens and browns.

Absolute terrain display
Figure 16–05–28

The relative terrain is displayed using the same color and elevation rules as defined for the displays of relative terrain on the MAP page (refer to Figure 16–05–29).



100 NM DISPLAY SETTING

MEDIUM INTENSITY YELLOW FOR TERRAIN ≤ 500 FEET BELOW TO < 2000 FEET ABOVE AIRCRAFT ALTITUDE.

25 NM DISPLAY SETTING

MEDIUM INTENSITY RED FOR TERRAIN ≥ 2000 FEET ABOVE AIRCRAFT ALTITUDE.

NOTE

1. Relative terrain displayed in medium intensity reds and yellows.

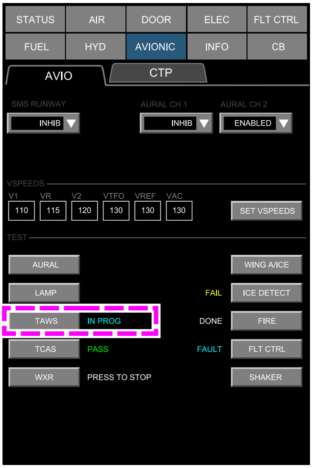
Relative terrain display
Figure 16–05–29

The terrain alerts are displayed using the same color rules as defined for the display of relative terrain on the lateral MAP page (refer to Figure 16–05–29). When a terrain alert is active, the terrain display on the VSD associated with the alerts appears solid and filled with the terrain alert color. This is so the alert is clearly visible.

A. TAWS test

The TAWS pilot-initiated test function is done through the AVIONIC synoptic page (AVIO tab) (refer to Figure 16–05–30). During the test, a test pattern displays on the MFW and HSI, and all the aural alerts sound. The test takes 2.5 minutes to complete.

The TAWS test function is a self-running test and it is inhibited in flight.



AVIONIC PAGE (AVIO TAB) - TAWS TEST FUNCTION

TAWS FAIL

EICAS CAUTION MESSAGE

TAWS MAP FAIL

EICAS ADVISORY MESSAGE

TAWS test function
Figure 16–05–30

The table that follows describes the different test statuses for the TAWS:

Status	Description
PASS (Green)	Test completed successfully.
FAIL (Amber)	Test failure.
FAULT (Cyan)	Test uncompleted due to a failure.
IN PROG (Cyan)	Test in progress.
DONE (White)	Test sequence completed.
PRESS TO STOP (White)	White, test to be stopped by the user.
–––––– (Amber dash)	Test invalid.

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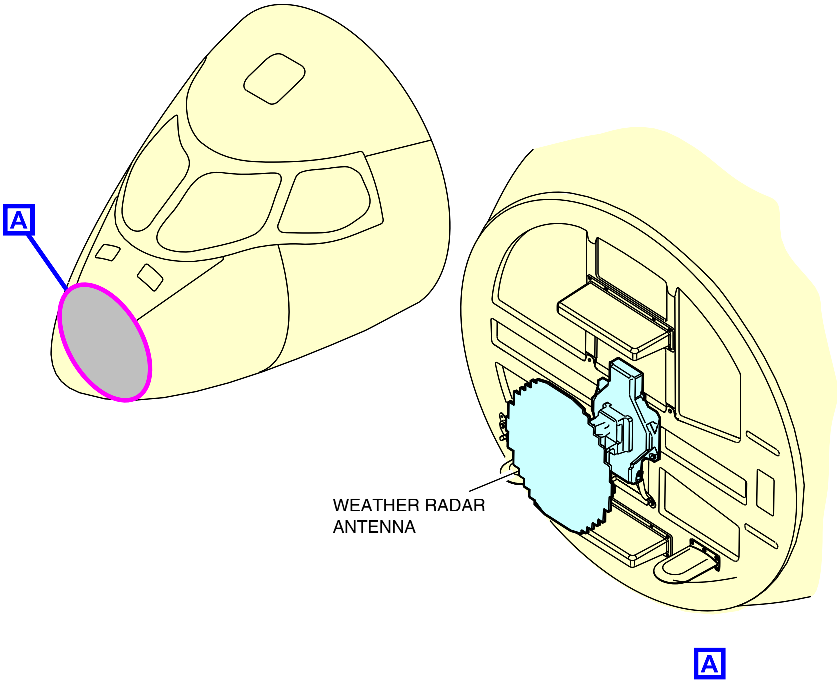
WXR SYSTEM – OVERVIEW

The Weather Radar (WXR) system has an integrated receiver/transmitter/antenna unit mounted on the forward bulkhead in the nose radome. Refer to Figure 16–06–1.



MultiScan weather radar antenna
Figure 16–06–1

The weather radar system (WXR) provides weather information for a range of 320 nm. The system has the characteristics that follow:

- 18-inch antenna,

- 320 nm range,
- 120-degree scan,
- 40 degrees/second scan rate, and
- A tilt angle of ±15 degrees.

When the WXR is turned on, the antenna makes an initial sweep to detect weather in front of the aircraft. The second sweep will be at a relatively low tilt angle from which significant ground clutter may be visible. When the initialization process is completed, the flight crew receives an optimized weather picture with minimal ground clutter for any range selected.

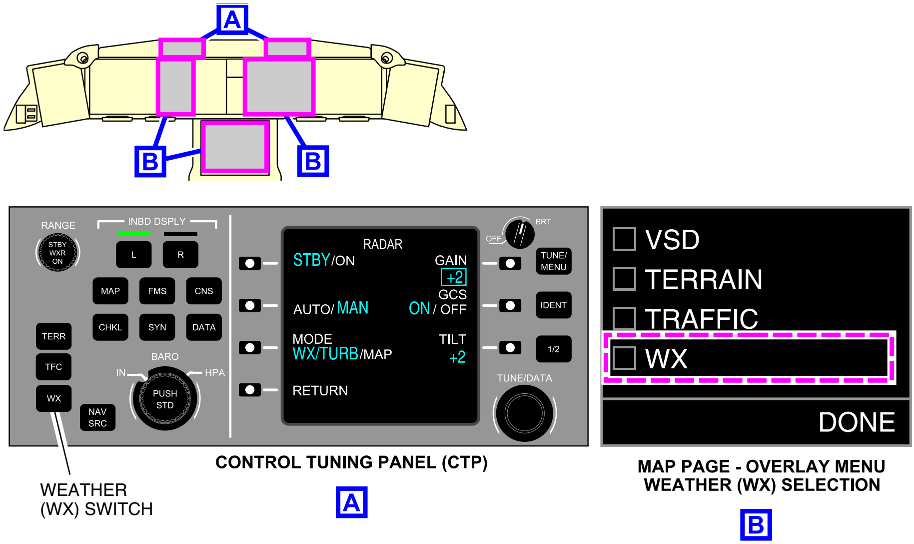
The presented image is the result of multiple radar scans at different tilt angles. The system stores the scanned images in memory in order to construct and display a complete weather image. Other features include:

- Independent (pilot/copilot) inputs and outputs,
- Enhanced Ground Clutter Suppression (GCS),
- Variable temperature-based gain control,
- Thunderstorm cell top protection,
- Path Attenuation Correction (PAC) alert,
- Geographic (oceanic/continental) weather correlation,
- Optimized weather depiction during turns,
- Predictive windshear function,
- Ground mapping for major geographical features, and
- Turbulence detection to a range of 40 nm.

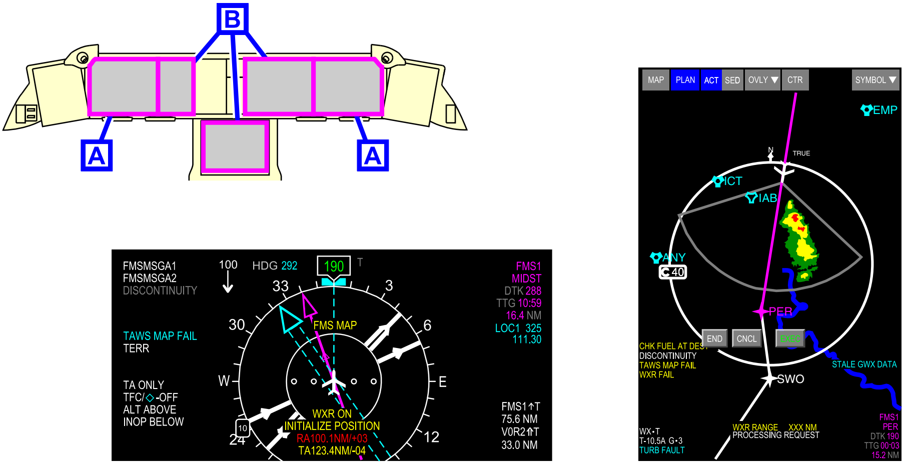
The WXR system is designed to work in automatic mode (AUTO) at all times. The manual mode (MAN) is used as a backup. The WXR has a geographic weather correlation and auto-temperature gain database. This provides a more accurate picture of the displayed weather.

The WXR settings can be adjusted with the controls located on the Control Tuning Panel (CTP) and in the MAP page (refer to Figure 16–06–2).

Indications are displayed on the Multifunction Windows (MFWs) and on the Horizontal Situation Indicator (HSI) (refer to Figure 16–06–3).



WXR system controls
Figure 16–06–2



PFD - HORIZONTAL SITUATION INDICATOR (HSI)

MAP PAGE

A

B

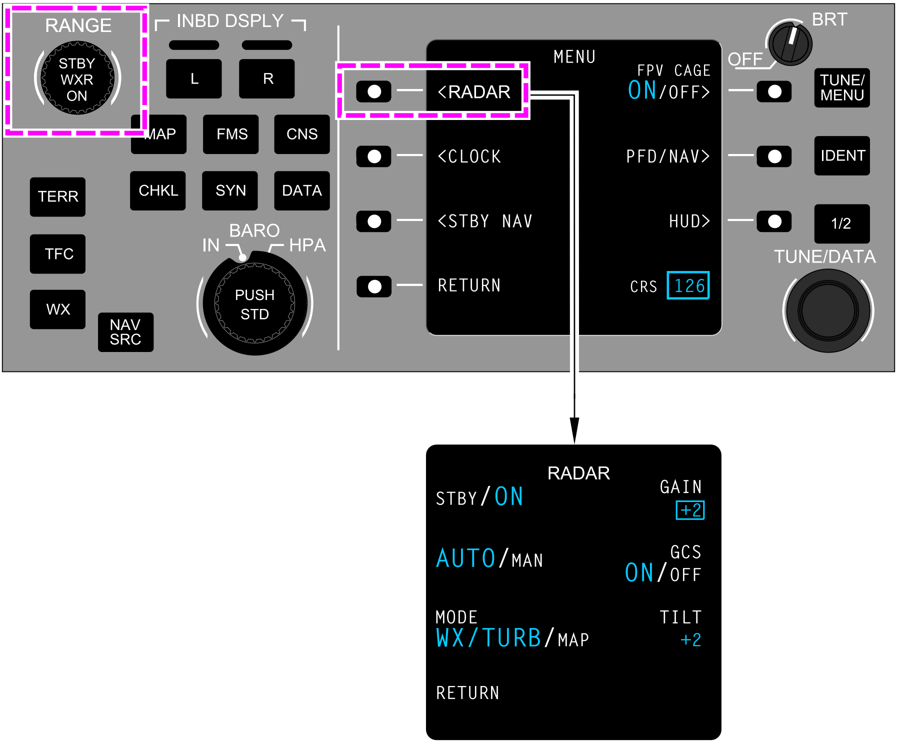
WXR system indications
Figure 16–06–3

WXR RADAR OPERATING MODES

The WXR can be operated in automatic or manual mode as follows:

- The automatic operating mode is used for normal operation, and
- The manual operating mode is available as an alternate or backup mode.

Pressing the LSK, adjacent to AUTO/MAN, selects automatic (AUTO) or manual (MAN) operation of the WXR. The selection displays in cyan. Refer to Figure 16–06–4.



CTP – Weather radar page
Figure 16–06–4

A. Automatic operation

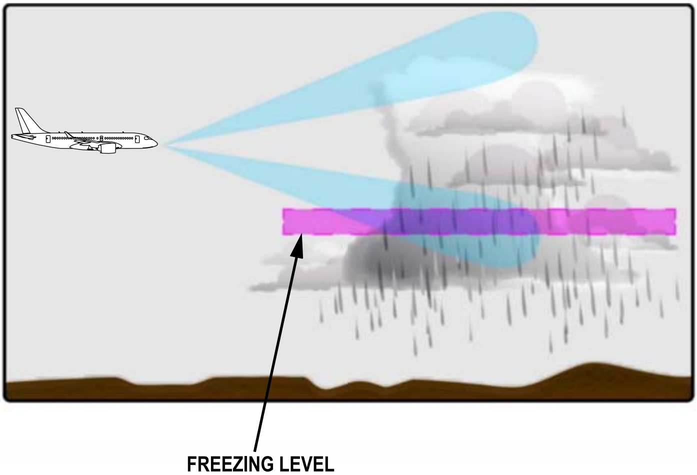
The AUTO mode is the default mode of operation. During the AUTO mode, the system continuously scans and adjusts the tilt angle and gain to provide an optimum weather picture to the flight crew. Gain adjustment by the flight crew is available during AUTO mode while the tilt adjustment is disabled. If the AUTO mode is selected on either side, then both sides are selected for automatic operation.

Operation in AUTO mode includes the functions that follow:

- The MultiScan^{TM},
- The Ground Clutter Suppression (GCS),
- The overflight protection,
- The Path Attenuation Correction (PAC), and
- The temperature-based/geographic-based gain.

(1) MultiScan

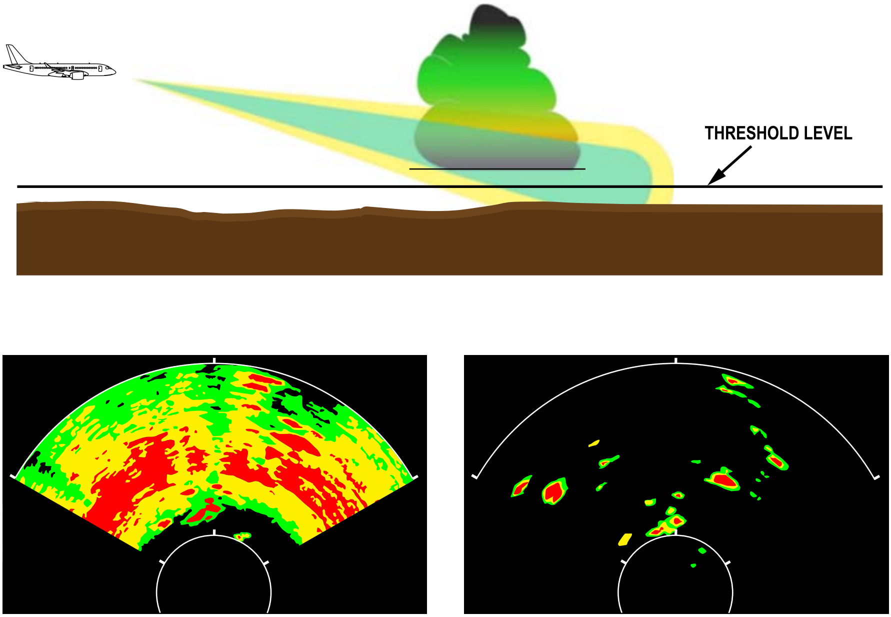
The MultiScan™ function combines multiple radar scans at various antenna tilt angles to detect short, medium, and long-range weather. Radar scan data is stored in memory and retrieved when a range selection is made, to display an accurate eather image regardless of aircraft altitude. Refer to Figure 16–06–5.



MultiScan function
Figure 16–06–5

(2) Ground Clutter Suppression (GCS)

The Ground Clutter Suppression (GCS) system function removes approximately 98% of the ground returns when the tilt angle of the radar antenna is below a predetermined threshold level. Refer to Figure 16–06–6.

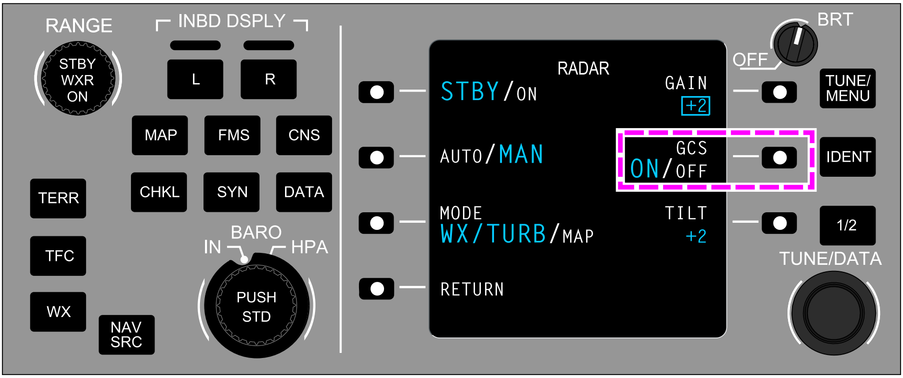


Ground clutter suppression
Figure 16–06–6

NOTE

The GCS function is only available when in automatic operating mode.

The GCS can be turned on by pressing the LSK switch related GCS on the Control Tuning Panel (CTP) (refer to Figure 16–06–7).



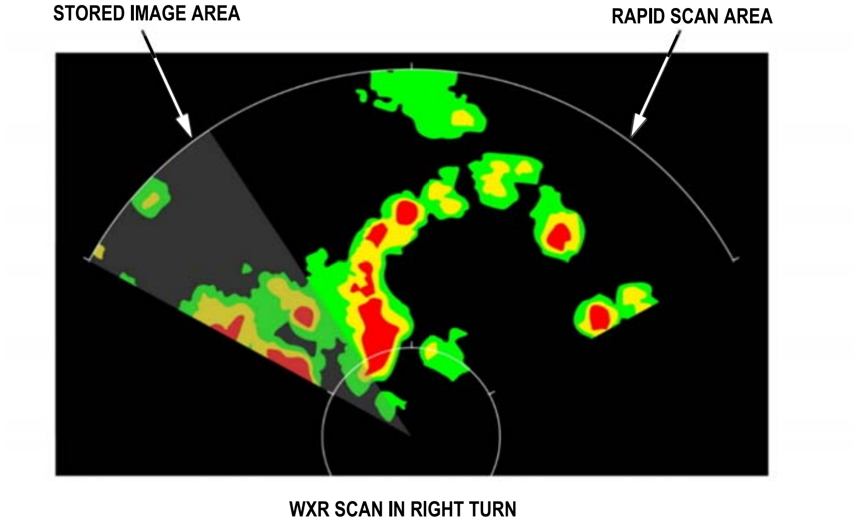
CTP – Ground Clutter Suppression (GCS) control LSK
Figure 16–06–7

The default GCS setting is ON in AUTO mode.

(3) Weather display in turns

During turns with the SmartScan™, the steps that follow occur (refer to Figure 16–06–8):

- The scan rate is decreased in the direction of the turn to provide smooth and rapid weather updates,
- Updates rates in the turn are faster, allowing for better depiction of the weather ahead of the aircraft and in the direction of the turn, and
- The opposite direction of the turn is not actively scan but a stored image of the weather are displayed prior to starting the turn.

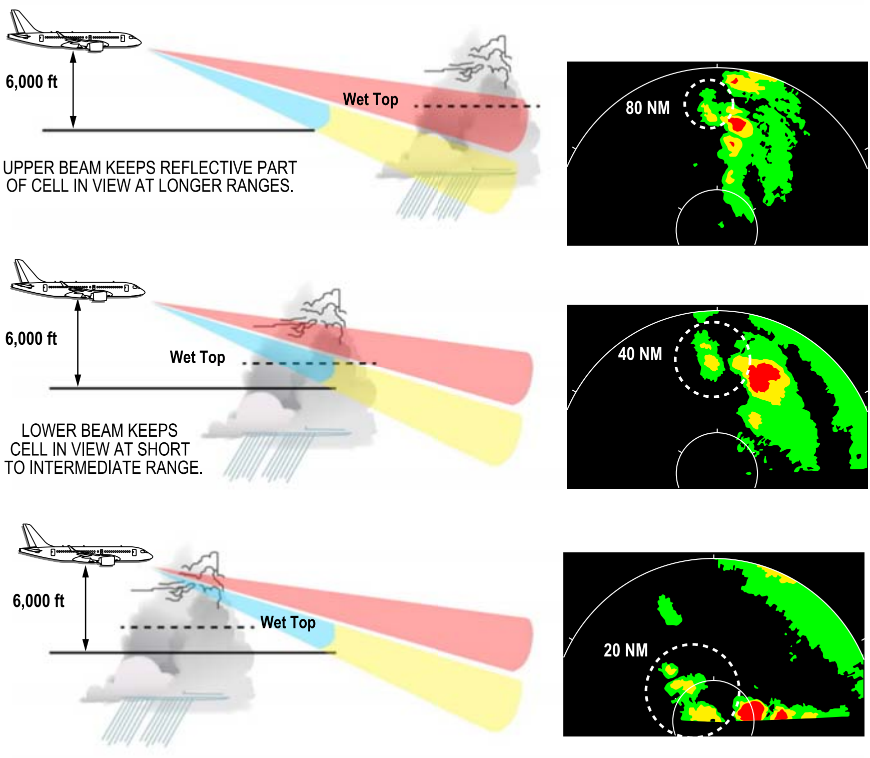


WXR display in turns
Figure 16–06–8

(4) Overflight protection

Above 22,000 ft, the overflight protection function activates to prevent detected storm cells from disappearing from the display as they approach the aircraft during high altitude cruise.

As the cells begin to move below the upper radar beam, the system uses the data collected down to 6000 ft below the aircraft to keep the reflective part of the cells in view (refer to Figure 16−06−9). As the aircraft is within approximately 15 nm of the cells, the radar compares the stored digital image with the latest scan data and displays the more intense returns so the cells remain in view until they move behind the aircraft.

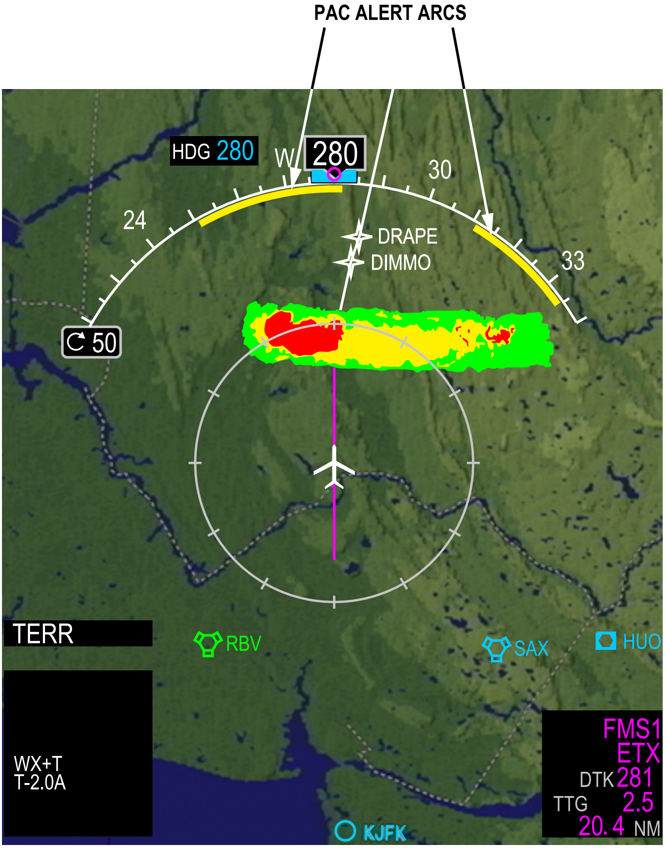


Overflight protection
Figure 16–06–9

(5) Path Attenuation Correction (PAC)

The Path Attenuation Correction (PAC) alert displays when high intensity weather is detected (up to 80 nm ahead of the aircraft) and requires an attenuation correction.

The PAC alert shows an amber arc that appears at the edge of the outer heading range (refer to Figure 16–06–10) when is at limits. It displayed the area where the radar may not display precipitation correctly or not at all. The PAC is available in automatic operating mode only.



PAC alert
Figure 16–06–10

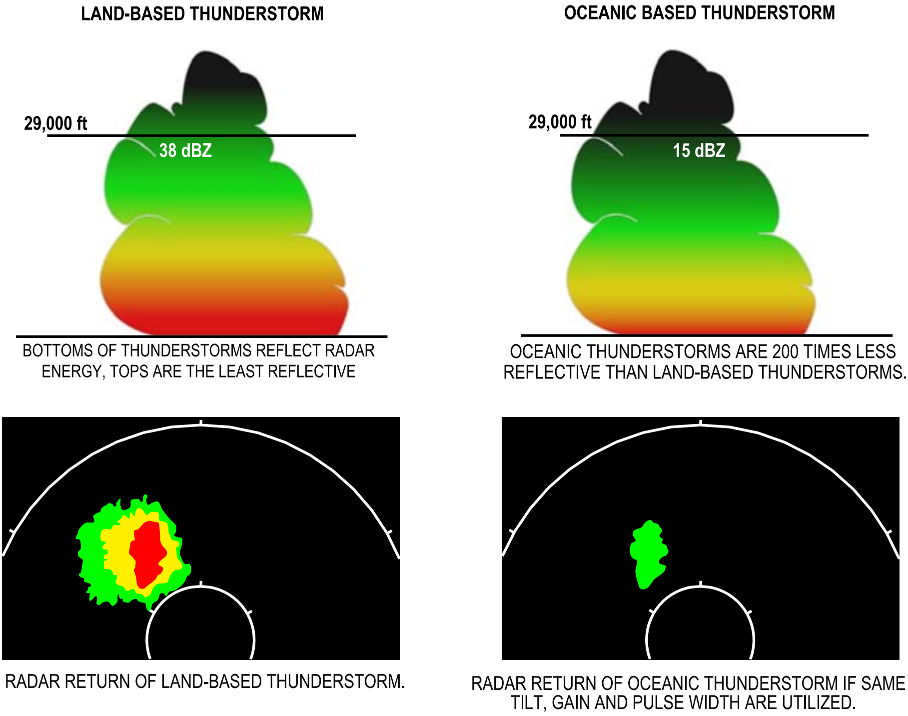
The PAC alert informs the flight crew that the radar beam in the direction of the alert is severely attenuated and the area behind it is dangerous and may contain significant precipitation. The PAC alert arc identifies potentially dangerous precipitation conditions and is available in automatic operating mode only.

(6) Temperature-based/geographic-based gain

During automatic operating mode, to optimize gain settings and weather returns in all phases of flight, the WXR system compensates the data that follow:

- The variations in temperature,
- The geographic location,
- The time of day, and
- The altitude.

Oceanic weather cells tend to have less mass and reflectivity than continental thunderstorms of equivalent height (refer to Figure 16–06–11). The WXR automatically adjusts gain and tilt in oceanic regions to more accurately depict weather cells.



Continental/Oceanic weather
Figure 16–06–11

B. Manual operation

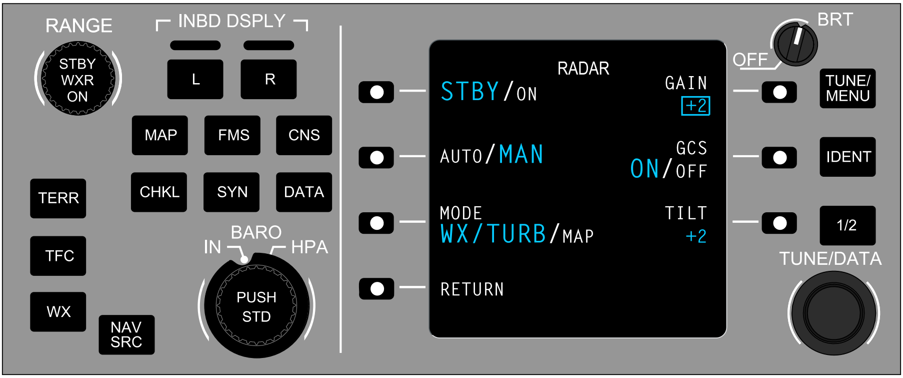
The manual operating mode is the alternate or backup mode of the WXR system, in case of failure or fault. In manual operating mode, the WXR scans as a set gain and antenna tilt angle. It does not include any signal conditioning functions available in automatic mode.

To activate the manual operating mode, the LSK adjacent to the AUTO/MAN selection on the both CTPs must be pressed to select MAN mode.

C. Weather radar selection

During automatic or manual WXR operation, the weather radar selections that follow are available on the CTP (refer to Figure 16–06–12):

- STBY (standby)/on mode,
- WX (Weather) mode,
- WX/TURB (Weather and Turbulence) mode,
- TURB (Turbulence) mode, and
- MAP mode.



CTP – Mode selection
Figure 16–06–12

The modes that follow can be selected individually for each side (pilot and copilot):

- WX mode,
- WX/TURB mode,
- TURB mode, and
- MAP mode.

The selected mode and any failures of the system are indicated beside the HSI portion of the PFD, and at the bottom of the MFW.

(1) STBY mode

The STBY mode is the default mode at system power-up. After landing, the weather radar switches automatically to STBY mode to prevent injury to ground personnel. When STBY mode is selected on either side, both sides are selected to STBY operation.

If STBY mode is selected when the aircraft is below 2300 ft RA or during takeoff, the windshear detection function is automatically turned on.

(2) ON mode

The WRX can be manually selected ON at any time. When the WXR is selected ON while on the ground, WRX ON message displays in amber on the HSI.

NOTE

The WRX is automatically on when the aircraft is WOFFW.

(3) WX mode

The WX mode is the normal mode. This mode cannot detect windshear, clouds, or lightning, but it can detect returns related to precipitation intensity and type as follows:

- Rain,
- Wet hail,
- Snow, and
- Possible icing conditions.

(4) TURB mode

The TURB mode shows only the turbulence associated with precipitation. Only detected turbulence within a 40 nm range displays, regardless of the selected WXR range. This mode is useful to isolate zones that have been identified with the WX/TURB mode. The system remains in TURB mode for 30 seconds, then reverts to WX/TURB mode.

The WX/TURB mode shows the same weather picture as the WX mode, plus the turbulence associated with precipitation. The turbulence zone display is limited to 40 nm on the MAP page, regardless of the range selected.

(5) WX/TURB mode

The WX/TURB mode shows the same weather picture as the WX mode, plus the turbulence associated with precipitation. The turbulence zone display is limited to 40 nm on the MAP page, regardless of the range selected.

NOTE

This mode cannot detect Clear-Air Turbulence (CAT).

(6) MAP mode

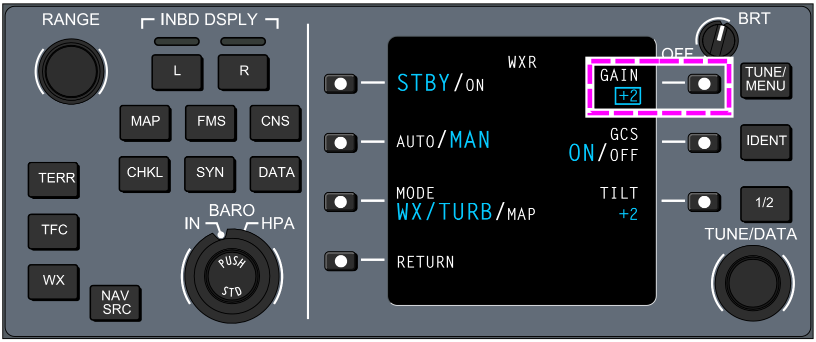
The MAP mode enables display of both terrain and weather returns. The Ground Clutter Suppression (GCS) is disabled in MAP mode. The MAP mode displays the ground returns when there is no significant weather in the area. Receiver sensitivity is decreased to accommodate terrain characteristics. The mode enables identification of terrain features such as:

- The mountains,
- The coastlines, and
- The bodies of water.

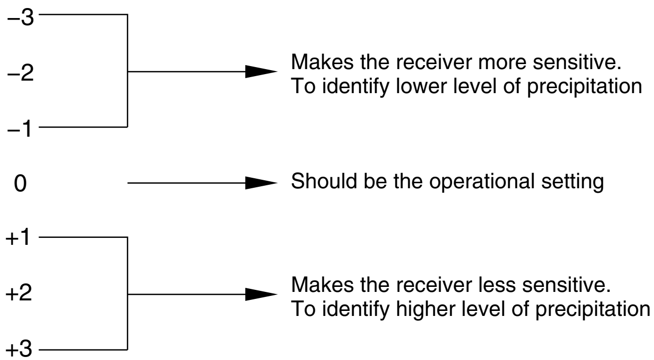
(7) GAIN control

The GAIN control function allows the flight crew to set the intensity of the weather display. This function is available in AUTO mode and in MAN mode. The GAIN control is done through the GAIN switch on the CTP (refer to Figure 16–06–13).

The setting are: −1, −2, −3, 0, +1, +2, and +3 (refer to Figure 16–06–14). When in the automatic mode, the gain should be set to 0.



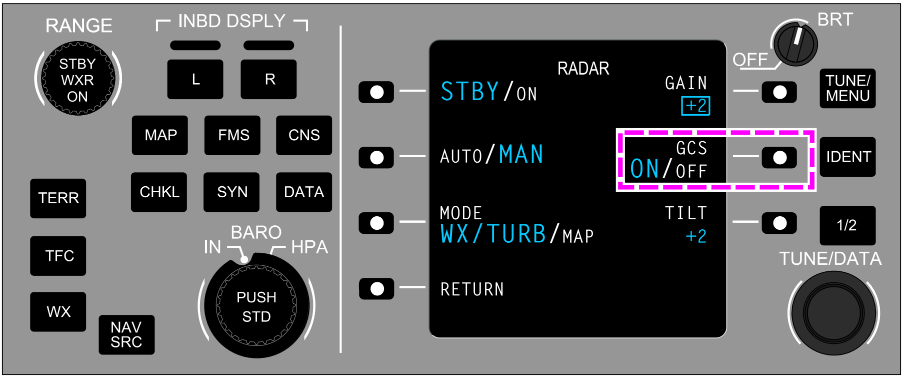
CTP – Gain control LSK
Figure 16–06–13



Radar gain control setting
Figure 16–06–14

(8) Ground Clutter Suppression (GCS)

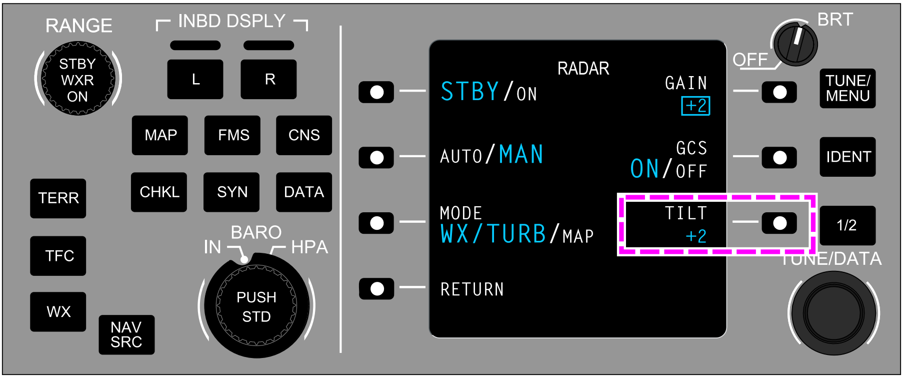
The GCS system function removes approximately 98% of the ground returns when the tilt angle of the radar antenna is below a threshold angle. The GCS can be turned on by pressing the GCS switch on the Control Tuning Panel (CTP) (refer Figure 16–06–15). The default setting is ON and can be ON in automatic mode only, but can be selected OFF.



CTP – Ground Clutter Suppression (GCS) control LSK
Figure 16–06–15

(9) TILT control

The tilt control allows the flight crew to have a better picture of the size, height, and relative direction of the storm cell. This function is not selectable in AUTO mode but is controlled automatically. The tilt angle is controllable by the flight crew in MAN mode through the TILT switch on the CTP (refer to Figure 16–06–16). The tilt angle range varies from –15 to +15 degrees.



CTP – TILT control LSK
Figure 16–06–16

WEATHER RADAR OPERATION

When operated in automatic mode, the WXR settings are optimized to provide the best weather imagery adapted for the phases of flight that follow:

- Takeoff,
- Climb,
- Cruise, and
- Descent and landing.

A. Takeoff

During takeoff, the WXR antenna is set to approximately 4 degree to 7 degree up and uses multiple beams at different tilt settings, along with ground clutter suppression and PAC to produce a clutter-free display prior to takeoff.

Weather radar operation on the ground is optimized to display hazardous weather within approximately 50 nm. If a longer range view is required, manual operating mode can be set to increase the tilt control to view farther range weather. The operating mode is changed back to automatic prior to takeoff.

B. Climb

During climb, the antenna tilt angle is automatically decreased. A radar beam detects high-altitude thunderstorms. A second beam is set at a lower tilt angle to detect weather at extended ranges and prevent over-scanning of weather with turbulence threat in the vicinity of the aircraft. When the aircraft is above 22,000 ft MSL, overflight protection becomes active.

C. Cruise

During cruise, the WXR displays significant weather at the current aircraft altitude. The functions that follow are active:

- Variable temperature-based gain,
- Overflight protection, and
- PAC.

D. Descent and landing

During descent, the antenna tilt angle is automatically increased. A radar beam detects high-altitude thunderstorms, and a second beam is set at a lower tilt angle to detect weather at extended ranges and prevent over-scanning of weather with turbulence threat in the vicinity of the aircraft. Once the aircraft is below 22,000 ft MSL, the overflight protection deactivates. The WXR continues to increase the tilt angle to maintain weather within view until landing.

WXR SYSTEM – CONTROLS AND INDICATIONS

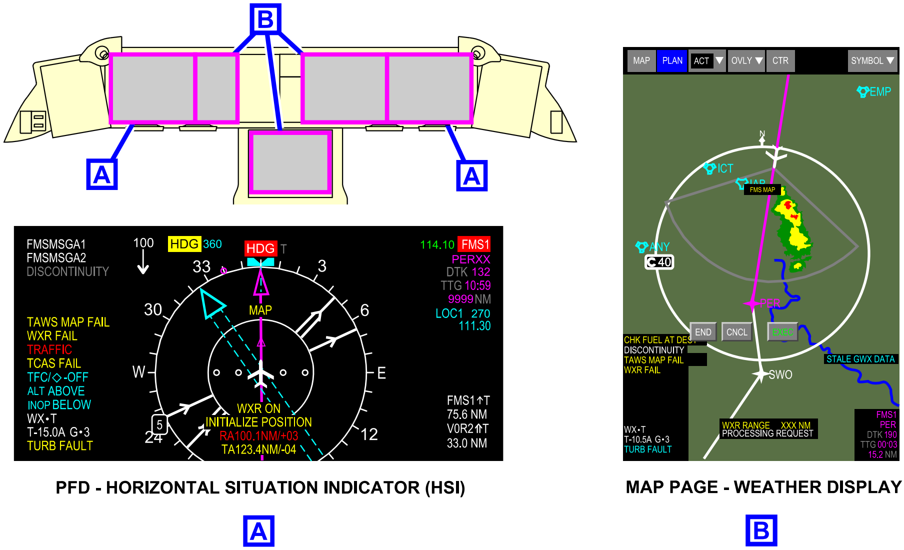
A. Weather radar display

The weather radar display selection is done through the WX switch on the CTP or through the OVLY (overlay) menu selection on the MAP display and the PLAN display. Refer to Figure 16–06–17.

Radar display
Figure 16–06–17

A maximum of four independent radar images can be displayed simultaneously, two on each side. The weather display feature allows uploaded weather imagery from satellite and/or data link to be displayed on the MFW.

The weather radar picture is displayed on the Multifunction Window (MFW), or on the Horizontal Situation Indicator (HSI) section of the PFD if an on-side display failure occurs (refer to Figure 16–06–18).



WXR system display
Figure 16–06–18

During a TAWS or a TCAS alert, the WXR image is removed.

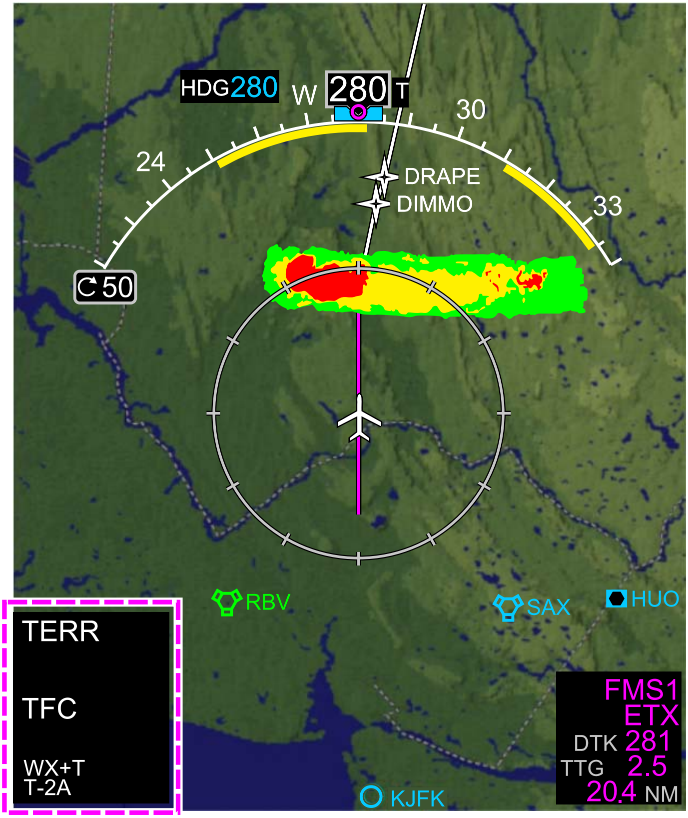
After a TAWS alert, the weather image is automatically restored. However, after a TCAS alert the crew must select WX on the CTP or from the OVLY tab to display the weather image again.

The WXR section on the HSI and MAP displays system status and mode selections. The top line indicates the WXR mode status including:

- STBY, the system is in standby mode and not transmitting,
- WX, the system is in normal weather mode,

- WX + T, the system is in weather mode with turbulence detection (40 nm limit),
- TURB, the system is in turbulence mode detection only, and
- MAP, the system is in ground mapping mode.

The second line indicates Tilt (T) setting followed by Gain (G) setting. Gain displays only in manual operation. If a system fault occurs, the third line displays the system fault. Refer to Figure 16–06–19.



WXR section
Figure 16–06–19

The Data Link Graphical Weather (DLK GWX) may be displayed on a MFW. This imagery is enabled by selecting WXR on the CTP MENU page or from the OVLY drop-down list on the MAP page.

B. WXR control

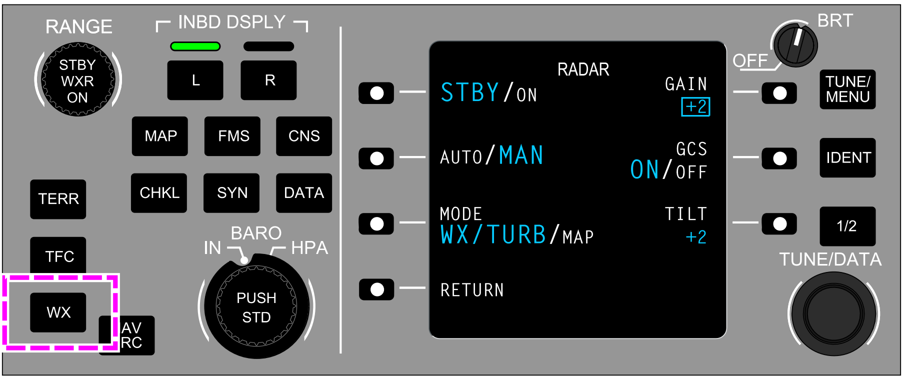
The WXR system range is coupled to the MAP range and is limited to 320 nm. For MAP range greater than the radar range, the weather display will be limited to the maximum radar range. The range is controlled by the RANGE switch on the CTP (refer to Figure 16–06–20) and it is scaled as follows: 5, 10, 25, 50, 100, 200, and 300 nm.

CTP – RANGE switch
Figure 16–06–20

The WXR is controlled from either CTP, as each side has independent WXR control.

On the CTP, the WXR page is accessed by selecting the LSK adjacent to WXR on the MENU page and includes the following selections (refer to Figure 16–06–21):

- STBY/ON, Standby or ON,
- AUTO/MAN, Automatic or Manual mode,
- WX/TURB/MAP, Weather, Turbulence, or Map mode,
- GAIN, Gain control setting,
- GCS, Ground Clutter Suppression, and
- TILT, Tilt control.



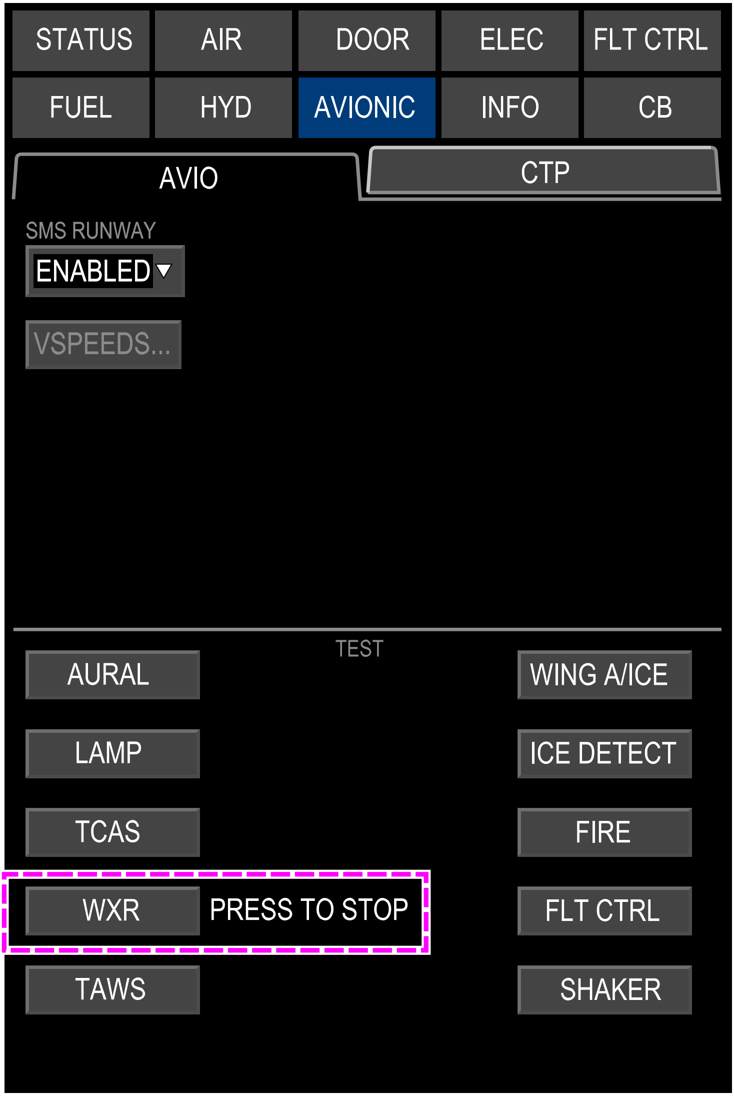
CTP – Weather radar (WX) switch
Figure 16–06–21

NOTE

AUTO mode is set when selected on either CTP.

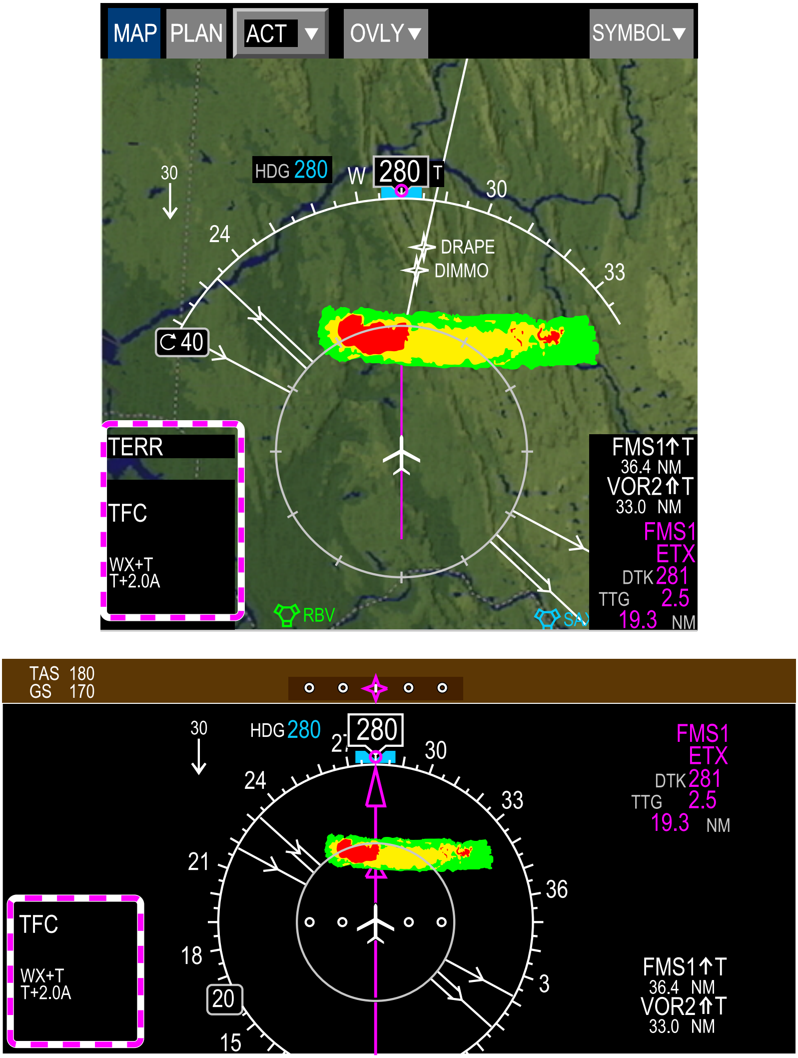
C. WXR test

The WXR test is initiated on the AVIONIC synoptic page (AVIO tab) (refer to Figure 16–06–22). The test can be done at any time. When the test in progress, the radar antenna stops transmitting.



WXR system test function
Figure 16–06–22

The selected mode and any failures in the system display beside the HSI portion of the PFD and at the bottom of the MFW. Refer to Figure 16–06–23.



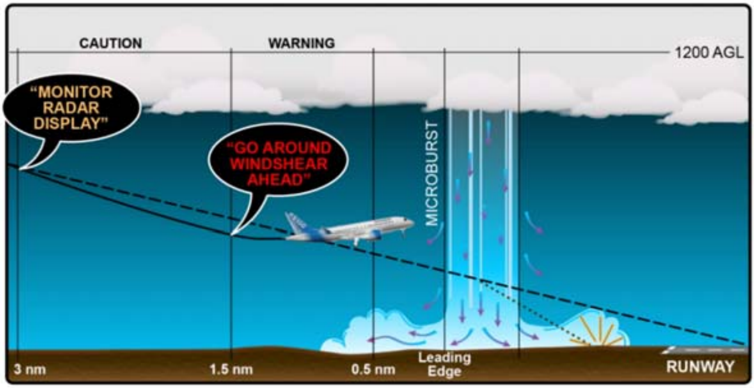
Weather mode display on HSI and MFW
Figure 16–06–23

D. Predictive windshear function

The predictive windshear function uses weather radar information to predict windshear conditions during takeoff and approach. Windshear detection is active when the weather radar is operating, in STBY, or in TEST mode.

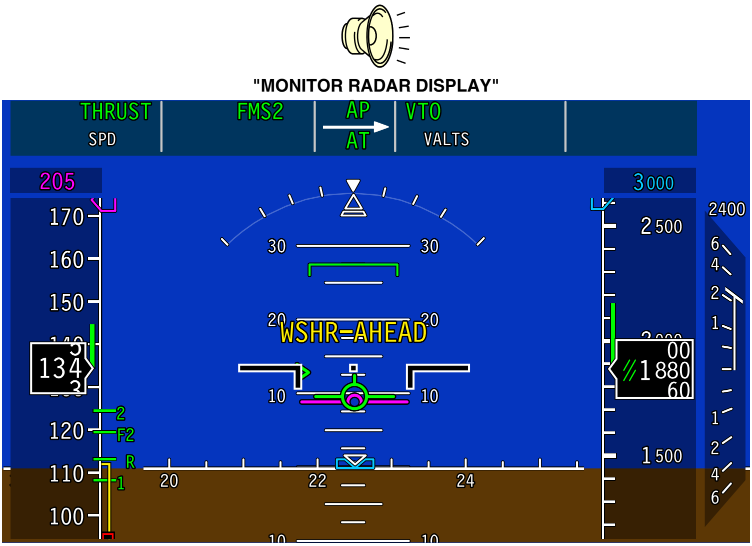
The predictive windshear annunciation on the HUD is inhibited when the **TAWS FAIL** caution message displays on the EICAS page.

Alerts are given when the level of windshear exceeds predetermined threshold values (refer to Figure 16–06–24).

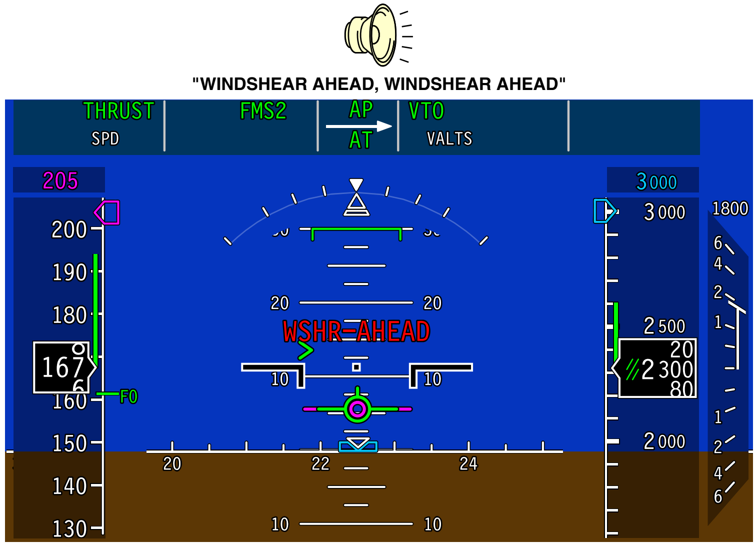


Predictive windshear alerts
Figure 16–06–24

On takeoff, if the weather radar detects windshear conditions (wind shift variance around cells), a “MONITOR RADAR DISPLAY” caution aural alert sounds. An amber WSHR AHEAD message is displayed on the ADI (refer to Figure 16–06–25). If the detection continues when the aircraft is in the warning area, a “WINDSHEAR AHEAD, WINDSHEAR AHEAD” aural warning alert sounds. A red WSHR AHEAD message is displayed on the ADI (refer to Figure 16–06–26).

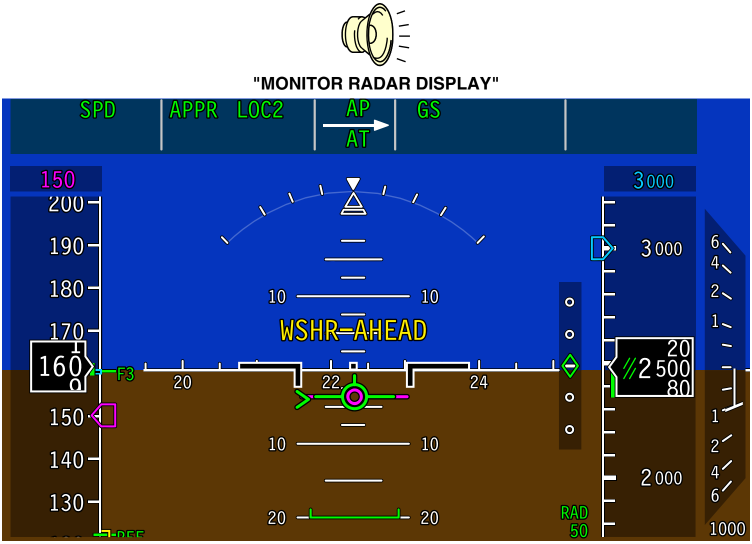


Predictive windshear caution alert – Takeoff
Figure 16–06–25

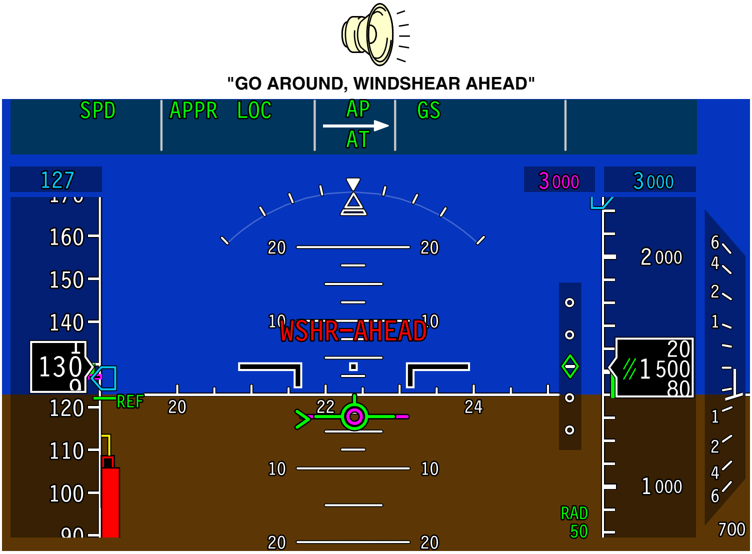


Predictive windshear warning alert – Takeoff
Figure 16–06–26

On approach, when windshear is detected and the aircraft is in the caution area, a "MONITOR RADAR DISPLAY" caution aural alert sounds. An amber WSHR AHEAD message is displayed on the ADI (refer to Figure 16–06–27). If the detection occurs or continues when the aircraft is in the warning area, a "GO AROUND, WINDSHEAR AHEAD" warning aural alert sounds. A red WSHR AHEAD message is displayed on the ADI (refer to Figure 16–06–28).



Predictive windshear caution alert – Approach
Figure 16–06–27



Predictive windshear warning alert – Approach
Figure 16–06–28

NOTE

When predictive windshear is detected and the radar is in ground mapping or test mode, the weather mode is activated.

The windshear aural alert has priority over all other ground proximity aural messages.

NAVIGATION – EICAS MESSAGES

A. Warning messages

None

B. Caution messages

Message	Description	Inhibit
GNSS NOT AVAIL	Shows when the FMS is not using GNSS position data as part of its calculations to determine position. Shows if either of the conditions that follow is true: • All GNSS sensors are not available and at least one sensor is enabled, or • At least one sensor is disabled and one sensor is enabled and no enabled sensor is available.	TO, LDG
IRS SAME SOURCE	Two of the three IRS failed.	TO, LDG
IRS SET HEADING	Alignment In Motion (AIM) occurs but not in AIM attitude mode or excessive motion in reversion attitude mode.	TO, LDG
TAWS FAIL	Terrain Awareness and Warning System (TAWS) failed.	TO, LDG
TCAS FAIL	Traffic Alert and Collision Avoidance System (TCAS) failed.	TO, LDG
TCAS OFF	TCAS in the standby mode. One or more display is reporting TCAS in standby and aircraft is in-air and TCAS is not failed.	None
WXR ON	Weather radar is transmitting while air-craft is on ground and no engine is running.	TO, LDG
XPDR 1 FAIL	Transponder 1 is active and has failed.	TO, LDG

Message	Description	Inhibit
XPDR 2 FAIL	Transponder 2 is active and has failed.	TO, LDG

C. Advisory messages

Message	Description	Inhibit
IRS 1 FAIL	IRS 1 failure reported.	TO, LDG
IRS 2 FAIL	IRS 2 failure reported.	TO, LDG
IRS 3 FAIL	IRS 3 failure reported.	TO, LDG
IRS 1 PWR FAULT	The IRS is operating on auxiliary power or if auxiliary power is not available to the IRS.	TO, LDG
TAWS GPWS FAIL	TAWS mode 1–6 not available and the other TAWS functions are working.	TO, LDG
TAWS MAP FAIL	Absolute terrain map function of TAWS not available and the other TAWS functions are working.	TO, LDG
TAWS TERR FAIL	Terrain awareness function inoperative or not available and the other TAWS functions are working.	TO, LDG
TAWS WINDSHEAR FAIL	TAWS mode 7 not available and the other TAWS functions are working.	TO, LDG
WXR AUTO FAULT	WXR is reporting an autotilt mode fault and other WXR functions are working.	TO, LDG
WXR CTRL FAULT	Both WXR controls have faults.	TO, LDG
WXR FAIL	WXR transceiver inoperative.	TO, LDG
WXR FAULT	WXR minor failure.	TO, LDG
WXR PWS FAIL	WXR is reporting a PWS failure and other WXR functions are working.	TO, LDG

Message	Description	Inhibit
WXR TURB FAULT	WXR is reporting a turbulence mode fault and other WXR functions are working.	TO, LDG

D. Status messages

Message	Description	Inhibit
CTP OVERRIDE	Left or right Control Tuning Panel (CTP) override through AVIONIC synoptic page (CTP tab).	None
CURSOR INHIB	Left or right (CCP) cursor inhibited.	None
TAWS FLAP INHIB	TAWS flap alerts inhibited by the flight crew.	None
TAWS GEAR INHIB	TAWS gear alerts inhibited by the flight crew.	None
TAWS GS CNCL	TAWS Glideslope (GS) alerts cancelled by the flight crew.	None
TAWS TERR INHIB	TAWS terrain alerts inhibited by the flight crew.	None

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CHAPTER 17 – OXYGEN AND EMERGENCY EQUIPMENT

List of figures

GENERAL

FLIGHT COMPARTMENT AND CABIN OXYGEN SYSTEM

EMERGENCY EQUIPMENT SYSTEM

EMERGENCY LOCATOR TRANSMITTER (ELT)

OXYGEN AND EMERGENCY EQUIPMENT – OVERVIEW

The oxygen and emergency equipment system includes all the interior installations necessary for the flight and cabin crews to respond to emergency situations.

The oxygen system consists of:

- Flight compartment oxygen system,
- Cabin oxygen system, and
- Portable oxygen system.

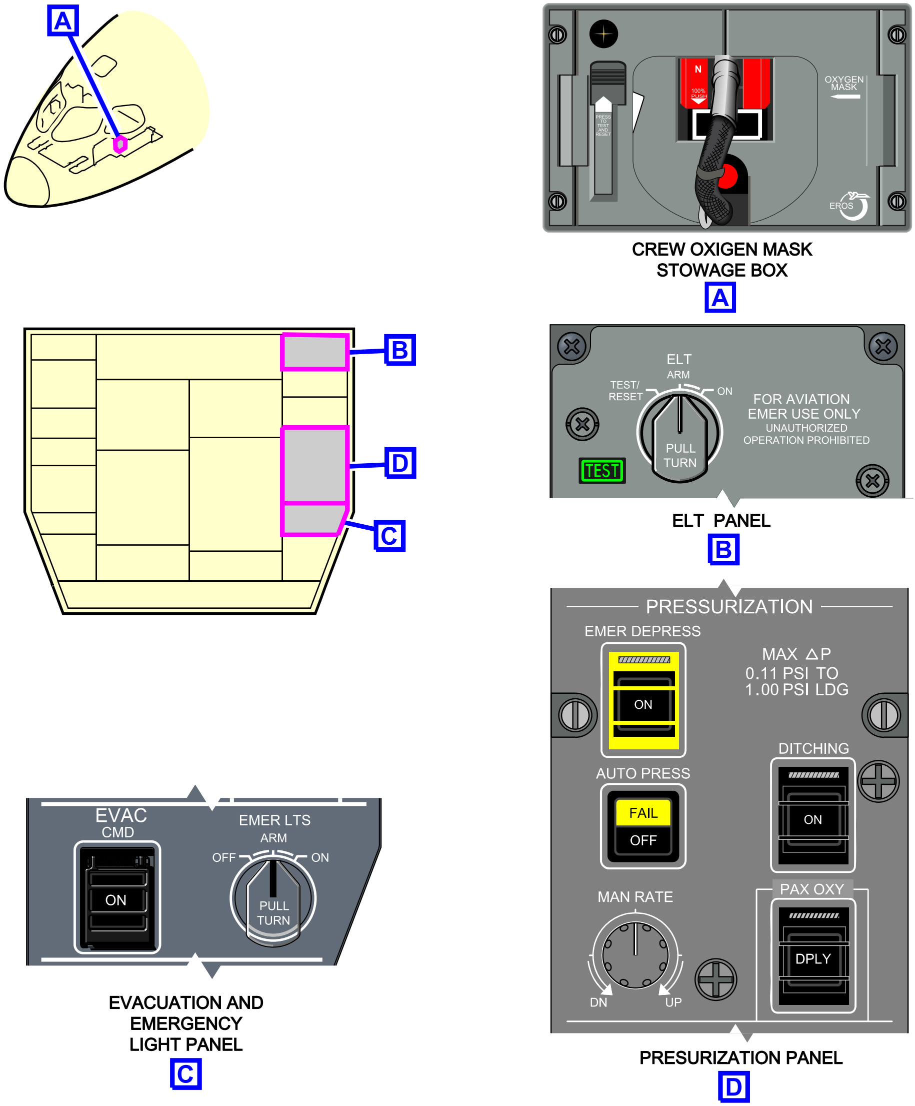
The emergency equipment consists of:

- Fire-fighting equipment,
- Overwater emergency equipment,
- Emergency exit slides,
- Emergency Locator Transmitter (ELT), and
- Other emergency equipment.

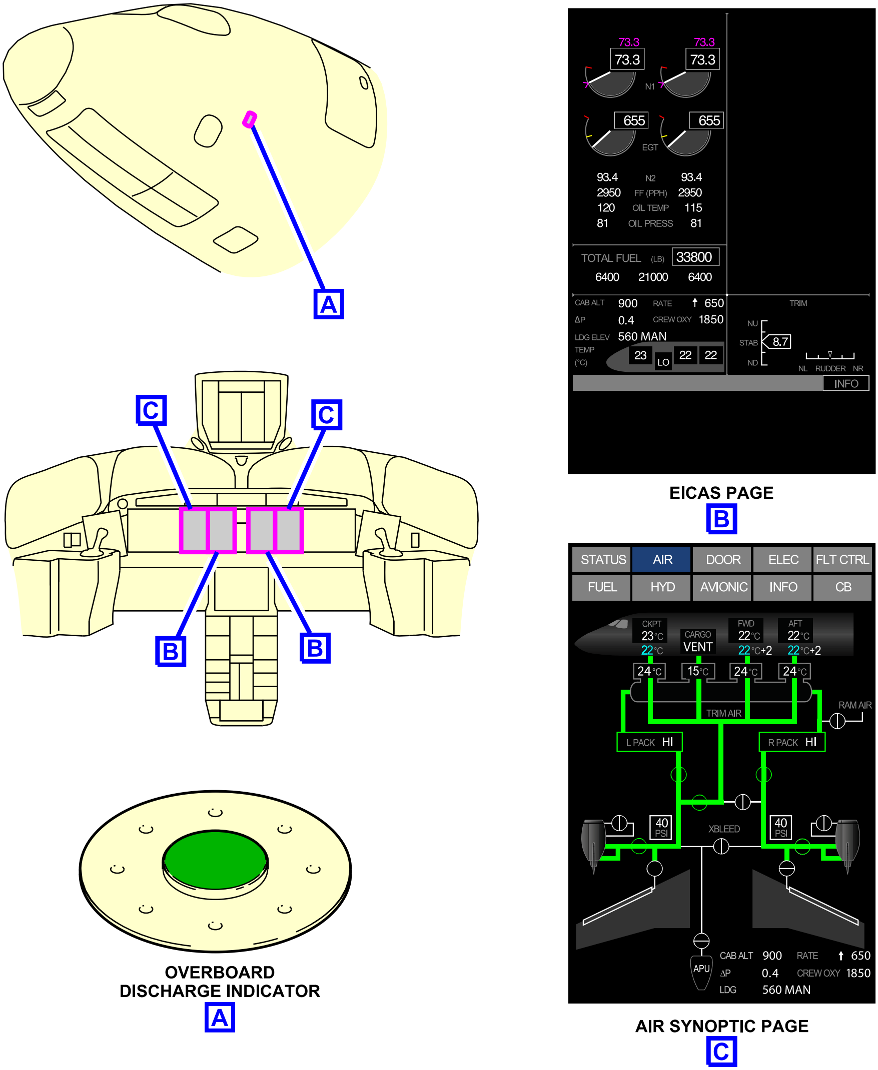
The oxygen and emergency equipment controls are located on (refer to Figure 17–01–1):

- The flight crew oxygen mask stowage boxes,
- The ELT panel,
- The PRESSURIZATION panel, and
- The evacuation and emergency light panel.

System indications are displayed on the AIR synoptic page and EICAS page. System status and fault messages are reported on the EICAS page. Refer to Figure 17–01–2.



Oxygen and emergency equipment system – Controls
Figure 17–01–1



Oxygen and emergency equipment system – Indications
Figure 17–01–2

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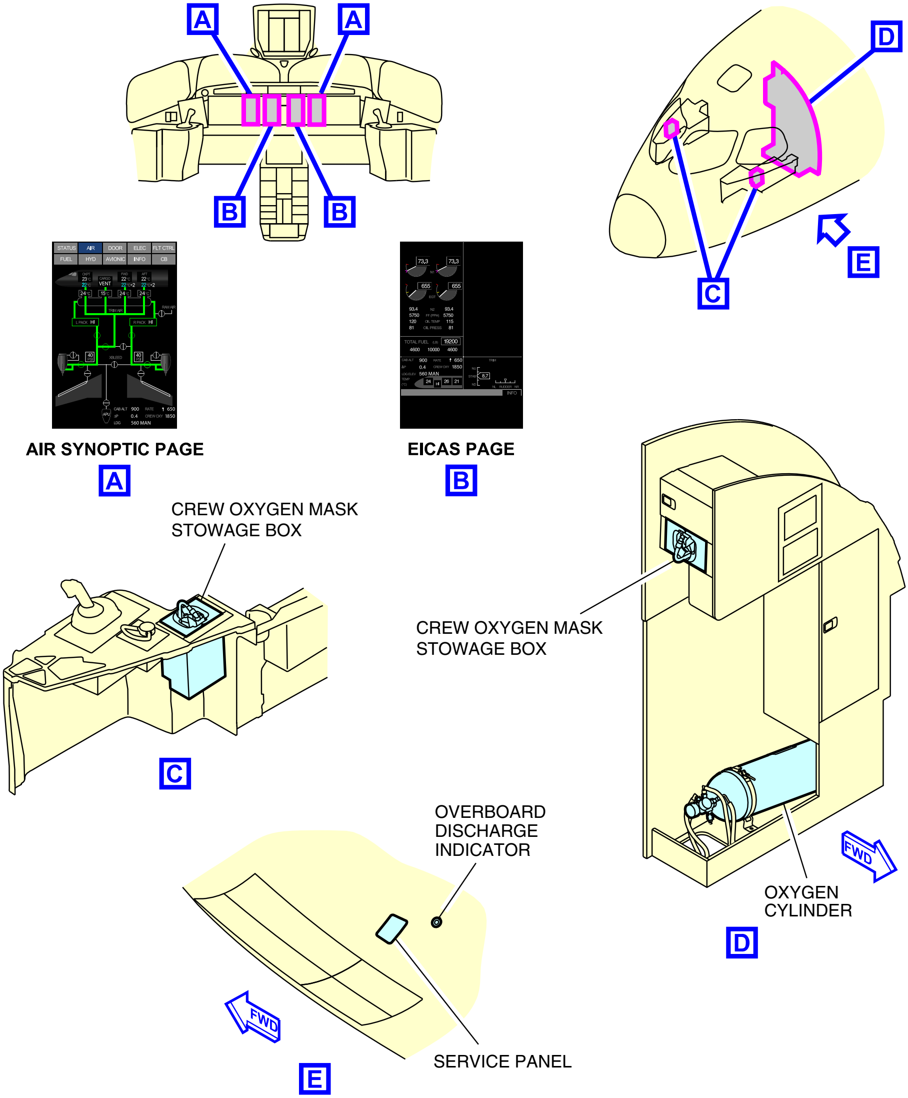
FLIGHT COMPARTMENT OXYGEN SYSTEM

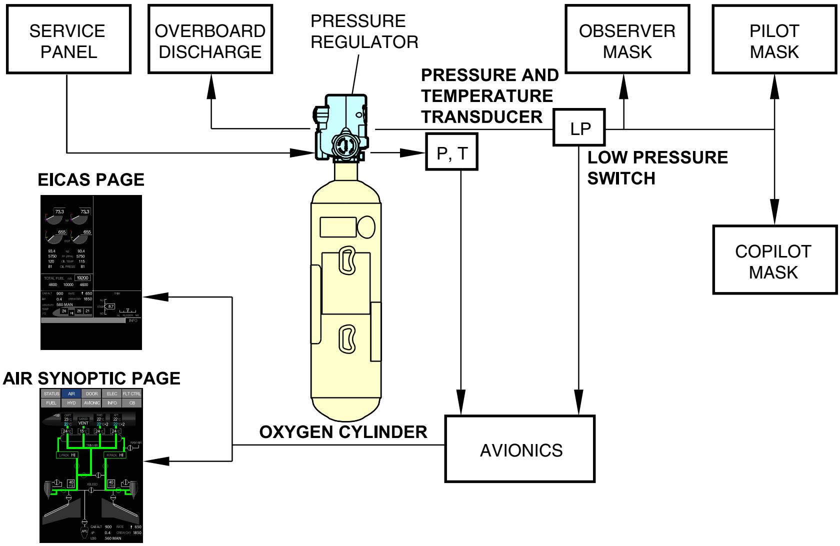
The flight compartment oxygen system supplies the pilots with oxygen during cabin depressurization, smoke or toxic gas contamination, and other emergencies. The system includes the main components that follow (refer to Figure 17–02–1):

- Oxygen cylinder,
- Pressure and temperature transducer,
- Pressure regulator,
- Overpressure safety system,
- Three stowage boxes and oxygen masks, and
- Overboard discharge indicator.



Crew oxygen system – Overview
Figure 17–02–1

The system has a service panel located on the lower left side of the forward fuselage. It is used by maintenance personnel to replenish the oxygen cylinder through a filler valve. Refer to Figure 17–02–2. The panel also includes a pressure gauge and a servicing chart.



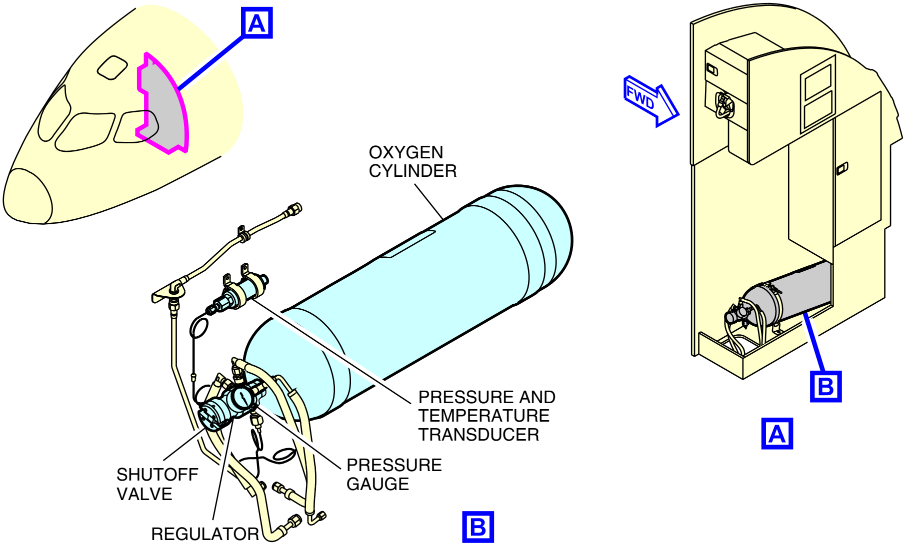
Crew oxygen system – Schematic
Figure 17–02–2

The system status is displayed on the AIR synoptic page and on the EICAS page. Status and fault messages are reported on the EICAS page.

A. Oxygen cylinder

The oxygen cylinder supplies oxygen to all three masks in the flight compartment. It is stored in a compartment under the observer seat (refer to Figure 17–02–3). The compartment is equipped with an access panel for maintenance and a ventilation screen to avoid high gaseous oxygen concentration if there is a cylinder leak.

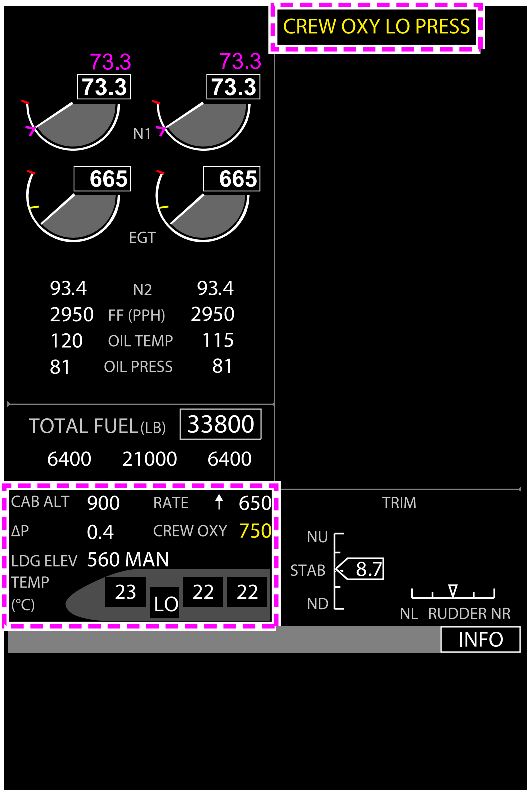
The oxygen cylinder is charged to a pressure of 1850 psig. It has a pressure regulator that reduces the pressure going to the masks, and two overpressure safety mechanisms that vent oxygen overboard. The pressure gauge installed on the cylinder head indicates the oxygen cylinder pressure.



Crew oxygen cylinder
Figure 17–02–3

B. Pressure and temperature transducer

The pressure and temperature transducer senses the pressure and temperature of the oxygen available in the cylinder. The information is then displayed on the EICAS page (refer to Figure 17–02–4). A fully charged oxygen cylinder will show approximately 1850 psig. If the pressure decreases to less than 1000 psig, the **CREW OXY LO PRESS** caution message is displayed on the EICAS page and the CREW OXY (crew oxygen) pressure indication becomes amber.



EICAS PAGE

Flight deck oxygen indications – EICAS page
Figure 17–02–4

The output pressure of the cylinder is regulated by a pressure regulator, which supplies 70 ±10 psi to the flight crew oxygen masks. If the pressure decreases to less than 45 psi, the **CREW OXY LO PRESS** caution message is displayed on the EICAS page and the digital readout will be 0.

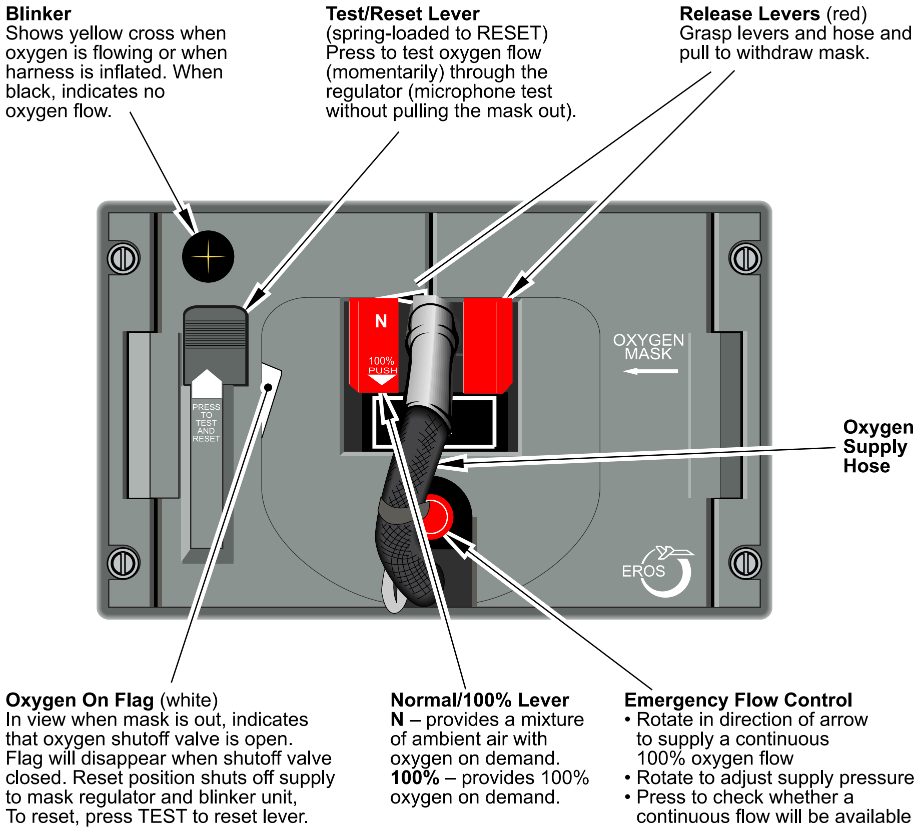
C. Stowage box and flight crew oxygen mask

There are three stowage boxes, one each in the pilot and copilot side consoles, and one above the observer seat. Each stowage box contains the components that follow (refer to Figure 17–02–5):

- Oxygen mask,
- Pneumatic blinker,
- PRESS TO TEST AND RESET switch,
- Oxygen flag, and
- Audio connector.

NOTE

The microphone in the flight crew oxygen mask is automatically enabled when the mask is put on. The headset and headset microphones are inhibited when the mask stowage box is opened.



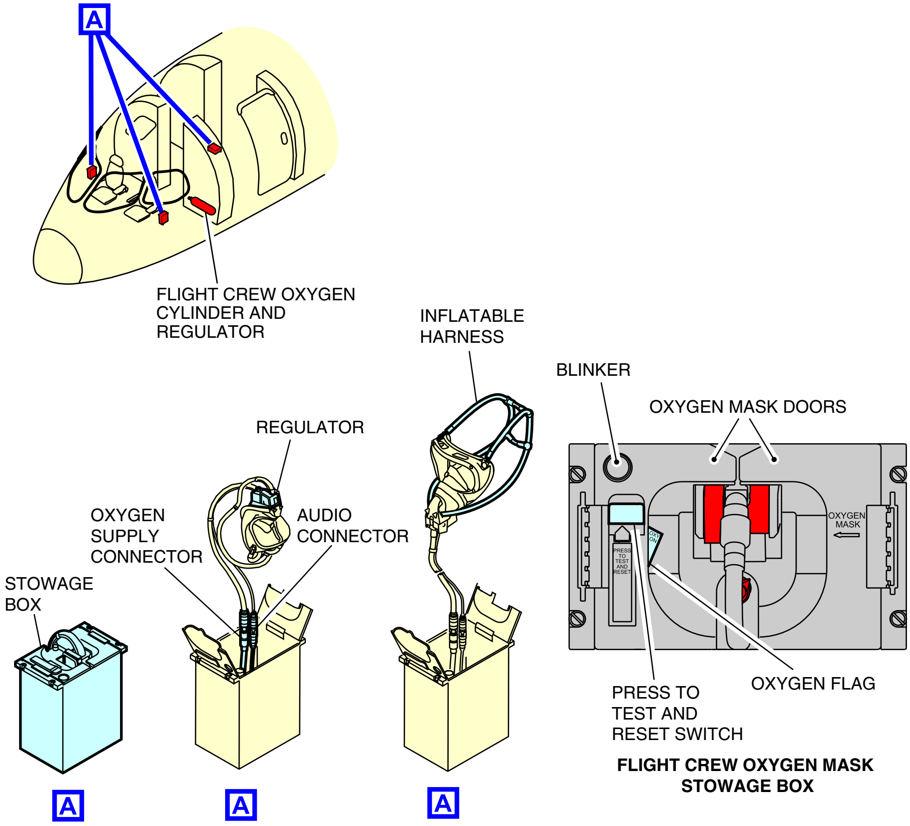
Stowage box controls and indicators
Figure 17–02–5

(1) Flight crew oxygen mask

The flight crew oxygen mask is a full-face type for smoke protection. It has the components that follow:

- Inflatable harness,
- Control tabs,
- Flow regulator, and
- Built-in microphone.

The inflatable harness allows the flight crew and the observer to fit the harness on the head (refer to Figure 17–02–6). The flow regulator controls the air-oxygen mixture depending on the flow mode selected (normal, 100%, and emergency).



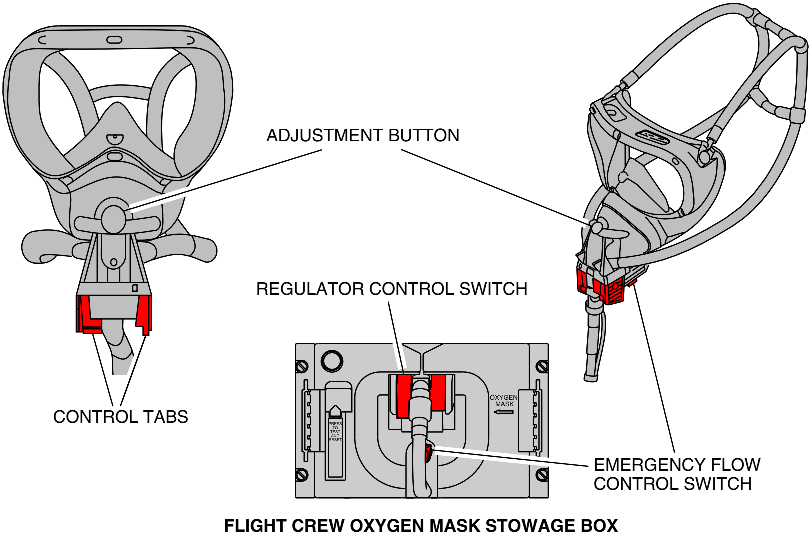
Stowage box and flight crew oxygen mask
Figure 17–02–6

The built-in microphone is activated automatically by a microswitch when the doors of the oxygen mask stowage box are opened. It allows communication between the flight crew, observer, Air Traffic Control (ATC), cabin crew, and passengers.

D. Flight crew oxygen mask operation

To use the flight crew oxygen mask, the two red control tabs must be squeezed together (until the harness is fully inflated) while the mask is pulled out completely from the stowage box (refer to Figure 17–02–7). To don the mask, the harness must be put over the head and the mask on the face while the control tabs are kept squeezed together. When the mask is in place, the control tabs must be released to deflate the harness and to secure the mask on the face. When the mask is donned, the flight crew must make sure that the doors of the oxygen mask stowage boxes stay opened so that the built-in microphones stay active. The built-in microphones are deactivated when the stowage box doors are closed.

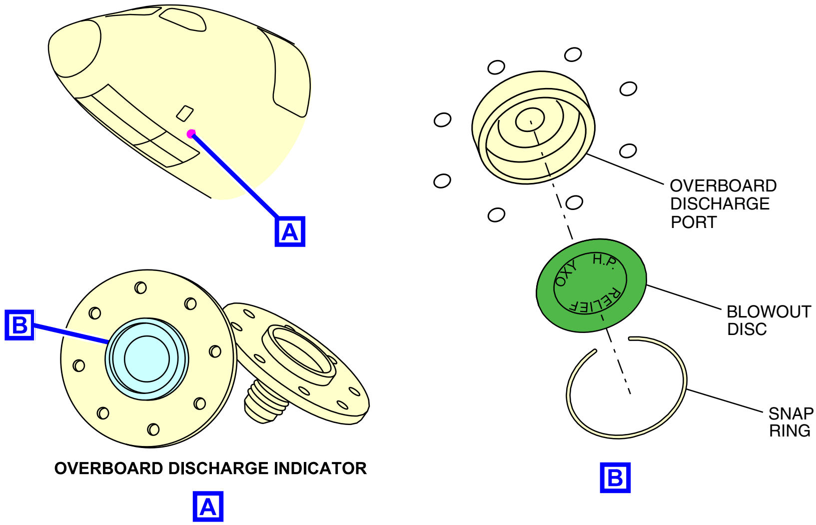
The air-oxygen mixture is adjusted with the flow regulator. Three oxygen flow modes are available: normal mode, 100% mode, and emergency mode. The normal (N) mode is selected when the N/100% selector is pushed up. In the N mode, the flight crew breathes a mixture of ambient air and oxygen. This dilution ratio changes with altitude, but above 35000 feet the flow is 100% oxygen. The 100% mode is selected when the N/100% toggle switch is pushed down. In the 100% mode, the flight crew breathes 100% oxygen at all altitudes. The emergency mode is activated when the emergency flow control switch is turned clockwise. During emergency mode, the flight crew breathes 100% oxygen with a positive pressure for protection from smoke and toxic fumes.



Flight crew oxygen mask – Operation
Figure 17–02–7

E. Overboard discharge indicator

If the oxygen bottle pressure becomes excessive, the overpressure safety system will discharge the overpressure oxygen through the overboard discharge indicator (refer to Figure 17–02–8). The indicator is a green, snap-in disc that pops out when oxygen gas is discharged overboard. It is located on the forward left side of the fuselage, beside the flight crew oxygen service panel.



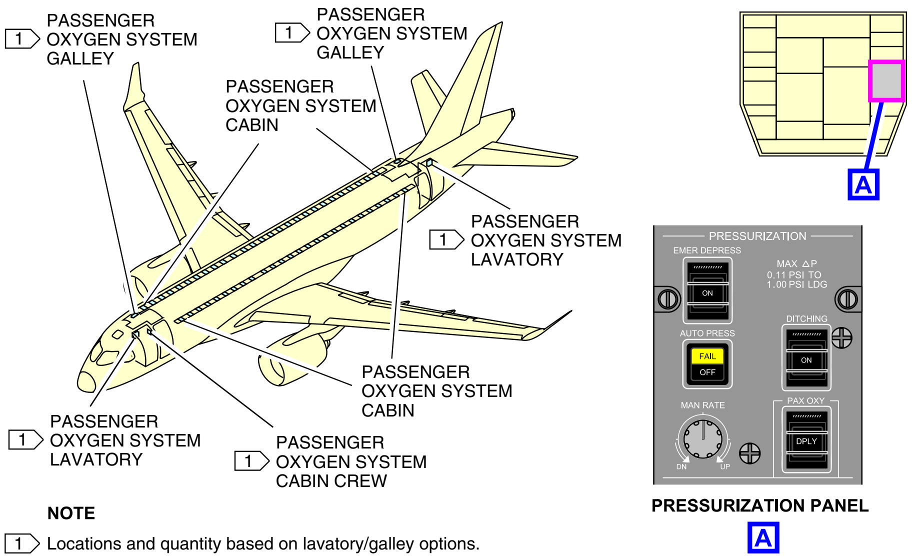
Overboard discharge indicator
Figure 17–02–8

CABIN OXYGEN SYSTEM – DESCRIPTION AND OPERATION

In the cabin, the chemical oxygen generator system and the oxygen cylinders activate automatically if there is cabin depressurization. It can also be manually activated by the PAX OXY switch on the PRESSURIZATION panel (refer to Figure 17–02–9). The Oxygen Dispensing Units (ODUs) supply oxygen from the chemical generator system through drop-down masks for the passengers and flight attendants.

Each chemical generator supplies a group of three or four masks.

In the lavatory, the dispensing unit uses an oxygen cylinder instead of the chemical generator.



Cabin oxygen system overview
Figure 17–02–9

In the cabin, oxygen masks are available at the locations that follow:

- All the passengers seats,
- The lavatory A,
- The aft flight attendant station,
- The forward galley area ceiling,
- The aft galley area ceiling, and
- The lavatory E.

A. Oxygen Dispensing Unit (ODU)

In the cabin, the oxygen system has ODUs that are installed as part of the Passenger Service Units (PSUs).

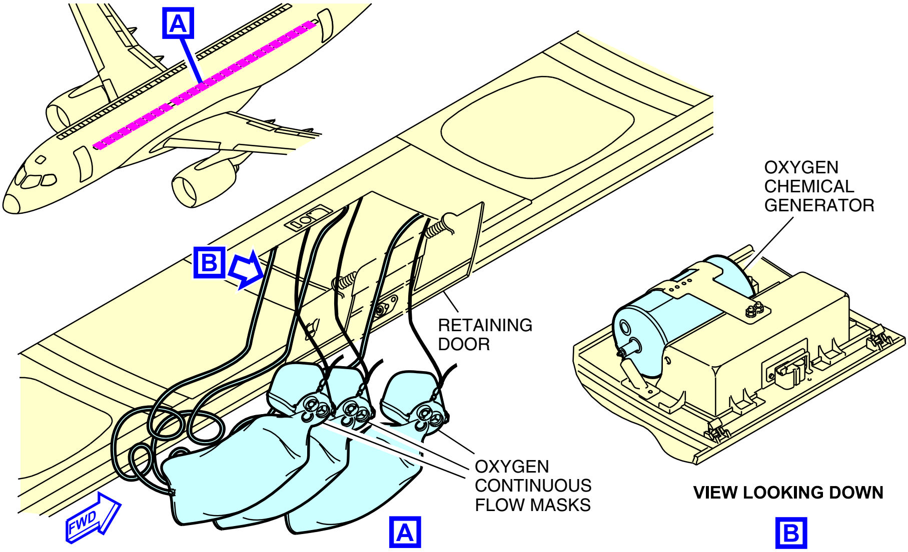
Each ODU includes one chemical oxygen generator that generates 13 minutes of oxygen (or 22 minutes optional).

The masks are kept inside each ODU by retaining doors that are released by an electrical latch.

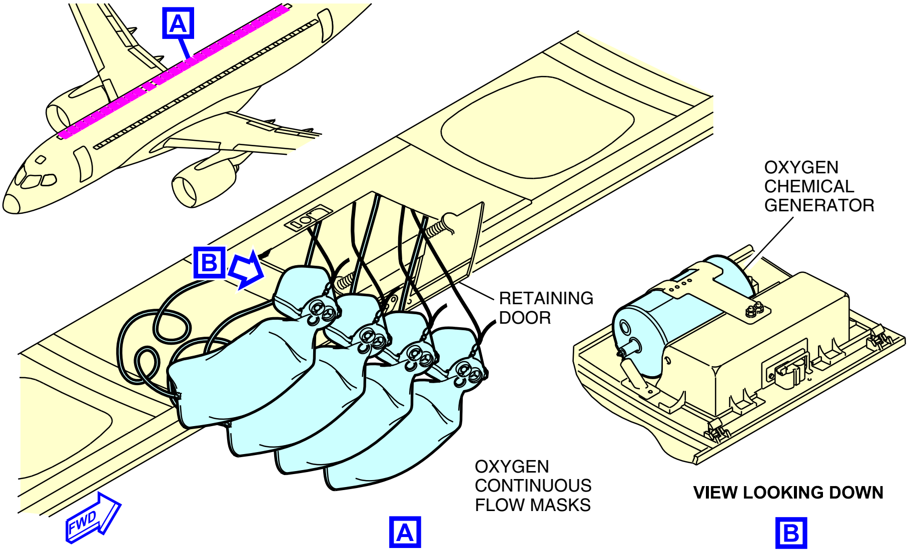
The number of the masks inside each ODU is as follows:

- Three masks for the left-side passenger seating (refer to Figure 17–02–10),
- Three masks (or four masks optional) for the right-side passenger seating (4 masks shown in Figure 17–02–11),
- Two masks in lavatory A,
- Two masks in lavatory E,
- Two masks aft of the flight attendant station,
- Two masks forward of the flight attendant station, and
- Three masks aft of the galley area ceiling.

The electrical latches of the ODU doors are powered by the 28 VDC DC ESS 1 bus and DC ESS 2 bus. Either bus can deploy all masks.



Oxygen dispensing unit (ODU) – Three masks
Figure 17–02–10



Oxygen dispensing unit (ODU) – Four masks
Figure 17–02–11

B. Chemical oxygen generator

Each ODU has a one-time use chemical oxygen generator that supplies breathable oxygen to all the masks in the ODUs.

The chemical oxygen generator is activated by a firing pin when the masks are pulled for donning. When activated, the oxygen flow is continuous, and flows to all masks in the ODU. The chemical reaction releases an odor similar to scorched cloth and increases the cabin temperature. The odor does not affect the purity of the oxygen.

C. Continuous-flow mask

The continuous-flow mask has an amber silicone rubber face-piece assembly attached to a vinyl reservoir bag. On this reservoir bag, there are instructions on how to put on the mask. Each mask is connected to a firing pin that activates the chemical oxygen generator to produce oxygen. Because the mask is not always a perfect fit, ambient air may be mixed with the pure oxygen from the generator.

D. Cabin oxygen system operation

The cabin oxygen masks can be deployed automatically or manually.

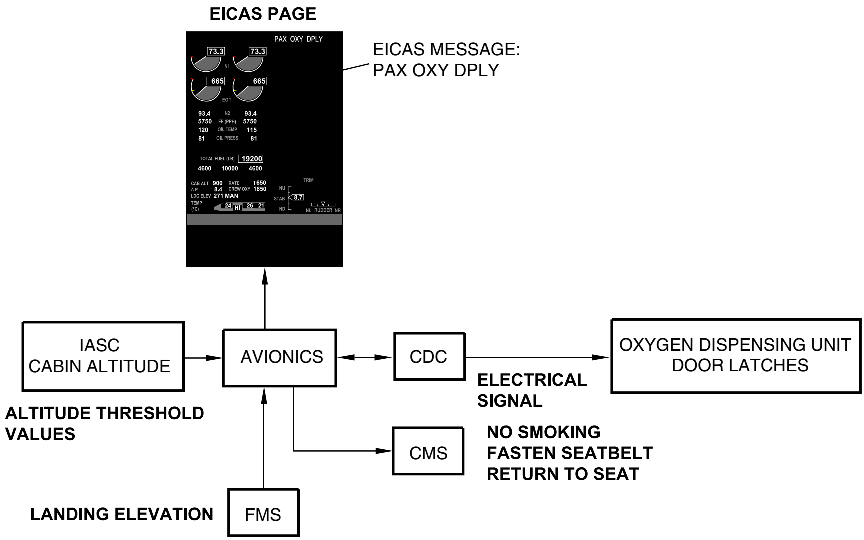
(1) Automatic deployment

When the cabin altitude is more than 14500 feet (refer to Figure 17–02–12 <33200010C>):

- The ODU doors unlatch to drop the oxygen masks,
- The **PAX OXY DPLY** status message is displayed on the EICAS page,
- The DPLY (Deployed) label on the PAX OXY switch is illuminated white, and
- The NO SMOKING, FASTEN SEAT BELT, and RETURN TO SEAT signs are displayed in the cabin. <33200010C>

NOTE

The light in the DPLY switch does not go off when the PAX OXY guarded switch is pushed.

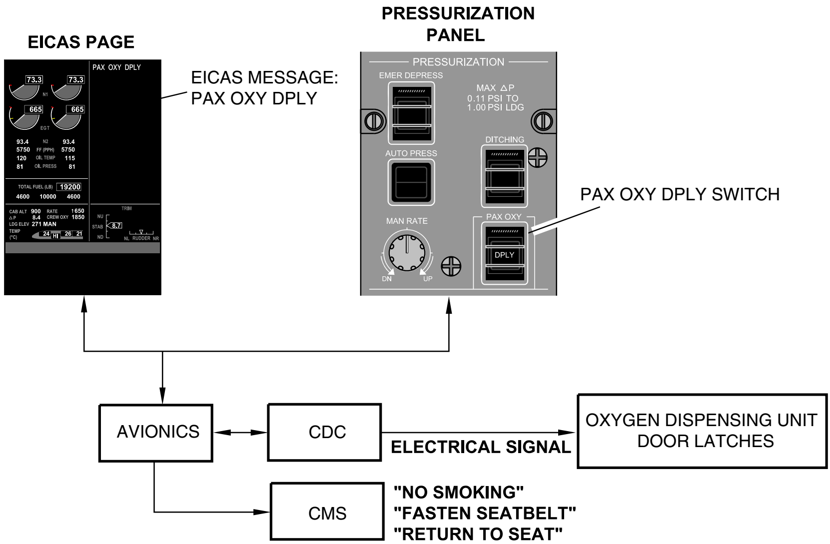


Automatic deployment schematic <33200010C>
Figure 17–02–12

(2) Manual deployment

When the flight crew pushes the PAX OXY guarded switch on the PRESSURIZATION panel (refer to Figure 17–02–13 <33200010C>):

- The DPLY (Deployed) label on the switch is illuminated,
- The ODU doors unlatch to drop the masks,
- The **PAX OXY DPLY** status message is displayed on the EICAS page, and
- The NO SMOKING, FASTEN SEAT BELT, and RETURN TO SEAT signs are displayed in the cabin. <33200010C>



Manual deployment schematic <33200010C>
Figure 17–02–13

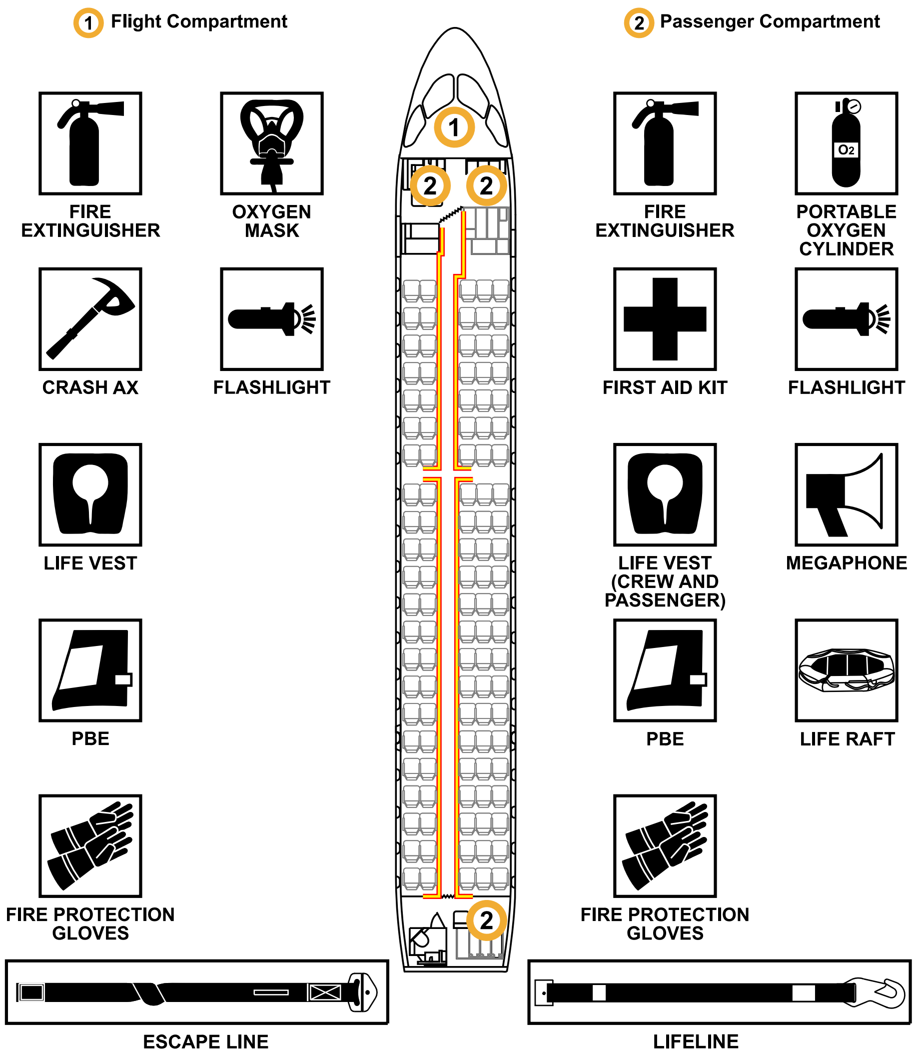
EMERGENCY EQUIPMENT

A. Overview

The table that follows lists the emergency equipment available in the aircraft:

Emergency equipment	Quantity in the flight compartment	Quantity in the cabin
Portable oxygen cylinders	0	3
Clean-agent portable fire extinguishers	1	3
Portable water fire extinguisher	0	Depends on aircraft interior configuration
Portable Breathing Equipment (PBE)	1	3
Fire protection gloves	0	Depends on aircraft interior configuration
Life vests for crew	3	3
Life vests for passengers	0	Depends on aircraft interior configuration
Life rafts	0	Depends on aircraft interior configuration
Flashlights	2	3
Crash axe	1	0
First aid kits	0	2
Megaphones	0	2
Escape line	1	0
Lifeline	0	Depends on aircraft interior configuration

Symbols are used to identify the emergency equipment (refer to Figure 17–03–1). The aircraft is also equipped with an Emergency Locator Transmitter (ELT).

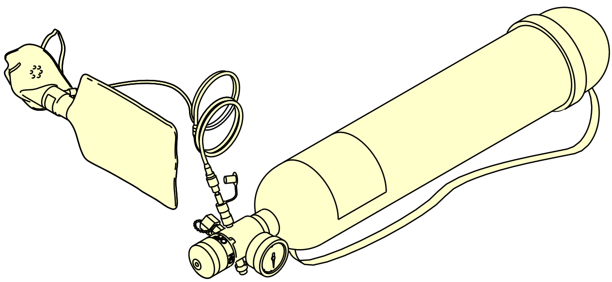


Emergency equipment and locations
Figure 17–03–1

B. Portable oxygen cylinders

The portable oxygen cylinders are used by the cabin crew during first aid situations and to help passengers during cabin decompression (refer to Figure 17–03–2). There are two portable oxygen cylinders in the forward galley and one in the aft galley. Each oxygen cylinder has two regulator outlets that are color-coded and preset to supply the necessary flow rates. The cylinders are equipped with a pressure gauge to monitor the pressure. It indicates fully charged when the needle on the pressure gauge is between 1800 psig and 2000 psig.

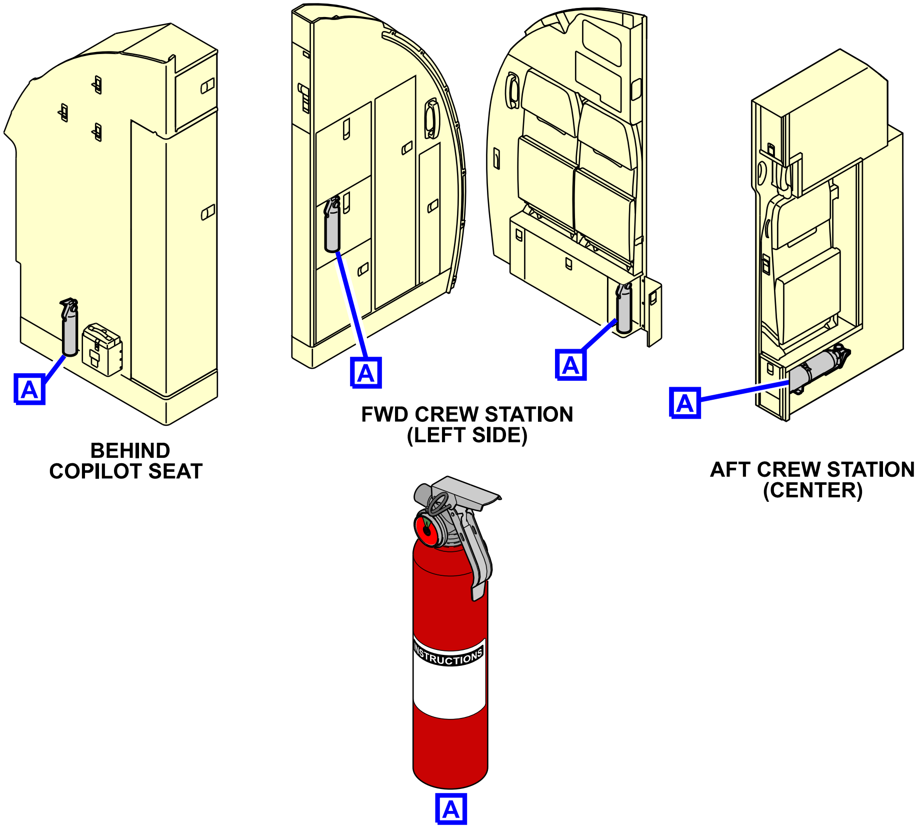
The masks are kept inside bags and consist of an amber silicone-rubber face-piece mask. Each mask has a reservoir with donning instructions printed on it and a flow indicator that becomes green when there is oxygen flow.



Portable oxygen cylinders and masks
Figure 17–03–2

C. Clean-agent portable fire extinguisher

There are normally four portable fire extinguishers, which contain halon or halon-free agent, in the aircraft. Refer to Figure 17–03–3.



Clean–agent portable fire extinguisher and locations
Figure 17–03–3

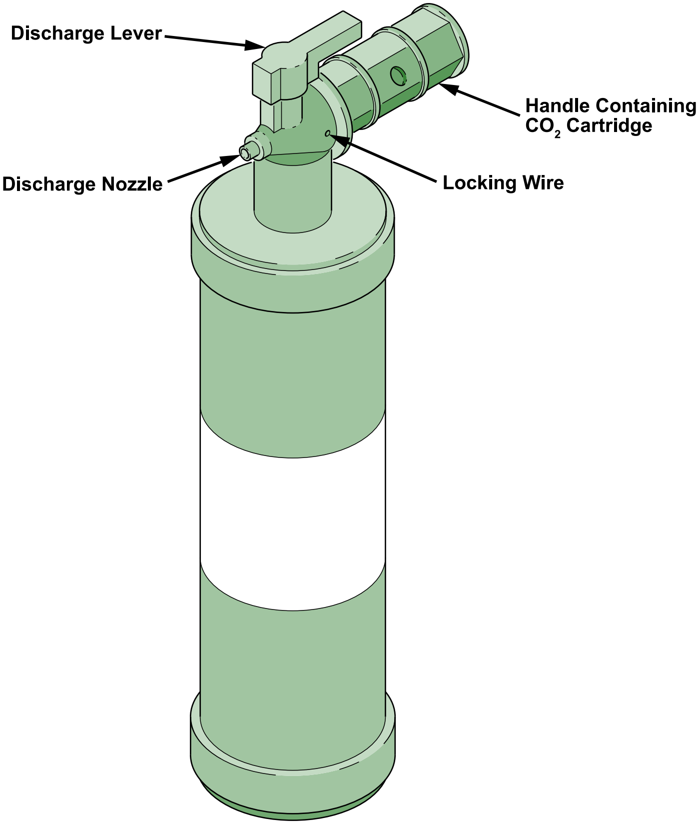
They are used to fight the types of fires that follow:

- Class A – Combustible,
- Class B – Flammable liquids, and
- Class C – Electrical.

The clean-agent portable fire extinguisher discharges for approximately 15 to 20 seconds, and has a range of approximately 4.6 meters (15 feet).

D. Portable water fire extinguisher (Option)

A portable water fire extinguisher is located in the aft bulkhead and is used for class A (combustible) fires only (refer to Figure 17–03–4). This extinguisher discharges for approximately 30 to 45 seconds, and has a range of approximately 6 meters (19 feet).

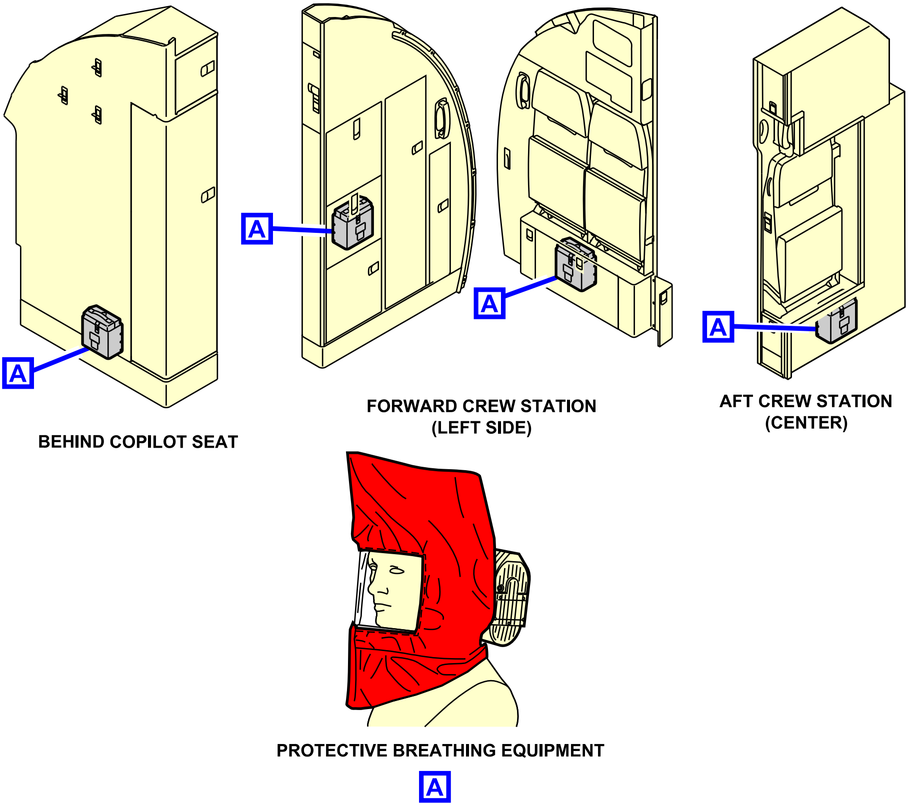


Portable water fire extinguisher
Figure 17–03–4

E. Protective Breathing Equipment (PBE)

The Protective Breathing Equipment (PBE) protects the cabin crew from smoke and noxious fumes during fire extinguishing (refer to Figure 17–03–5). There are four PBEs in the aircraft, at the locations that follow:

- One in the flight compartment,
- Two in the forward crew station (left side), and
- One in the aft crew station.



Protective Breathing Equipment (PBE) and locations
Figure 17–03–5

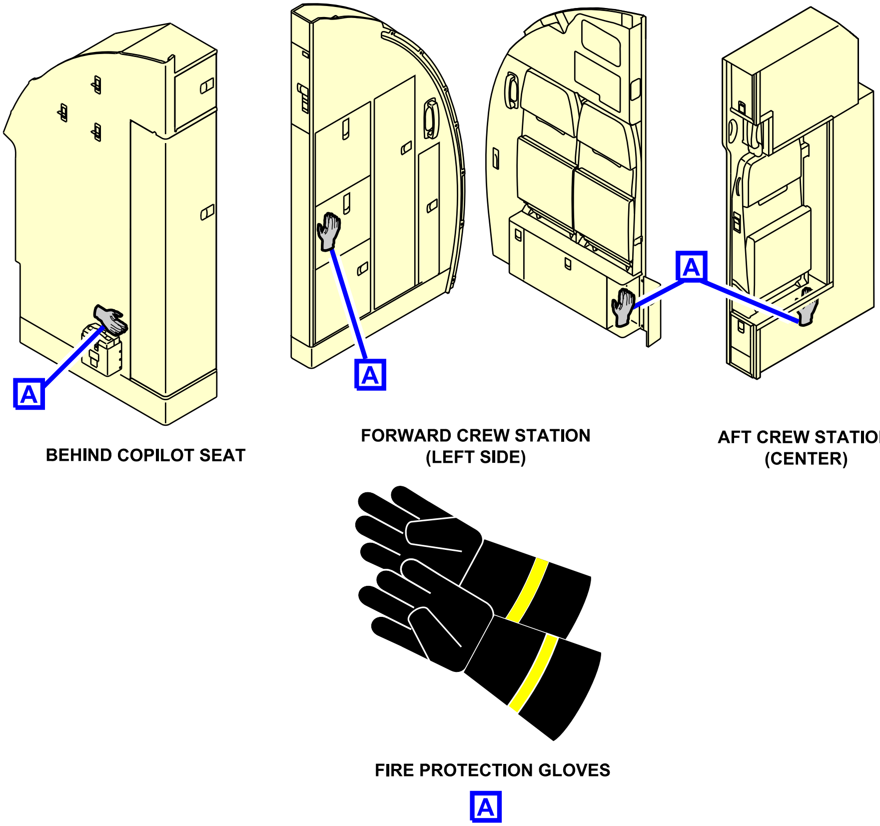
Each PBE contains a chemical generator that supplies oxygen to the user for approximately 15 minutes. There is one PBE near each portable fire extinguisher. During fire fighting, the cabin crew breathes oxygen supplied by the chemical generator in a sealed hood that protects against smoke and toxic fumes. The hood is equipped with a CO_2 absorption system that gives protection for 15 minutes.

NOTE

There are different types of PBE that could be installed in the aircraft.

F. Fire protection gloves

There are usually four pairs of fire protection gloves kept near each clean-agent portable fire extinguisher (refer to Figure 17–03–6). They can be used to handle hot or sharp objects. They also protect against evaporative cooling of the fire extinguisher nozzle during discharge.



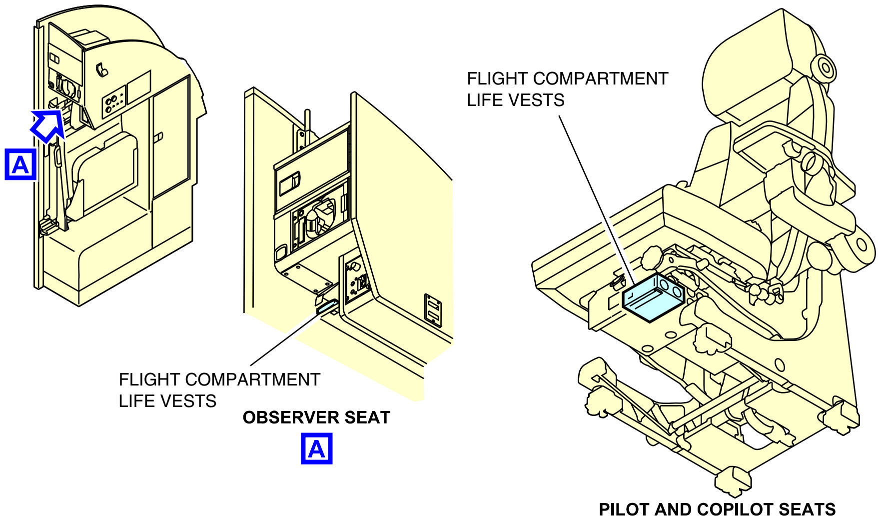
Fire protection gloves and locations
Figure 17–03–6

G. Overwater emergency equipment

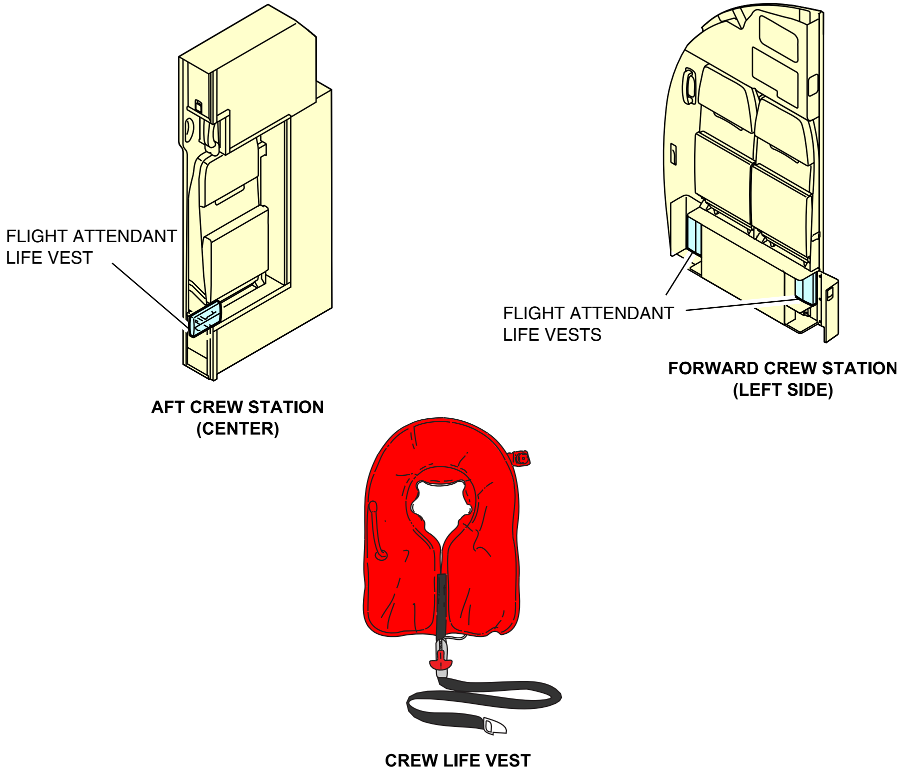
The overwater emergency equipment includes:

- Life vests for flight and cabin crew,
- Life vests for passengers, and
- Life rafts.

Life vests for the flight crew and cabin crew are located under each seat in the flight compartment and the cabin crew stations (refer to Figure 17–03–7 and Figure 17–03–8).

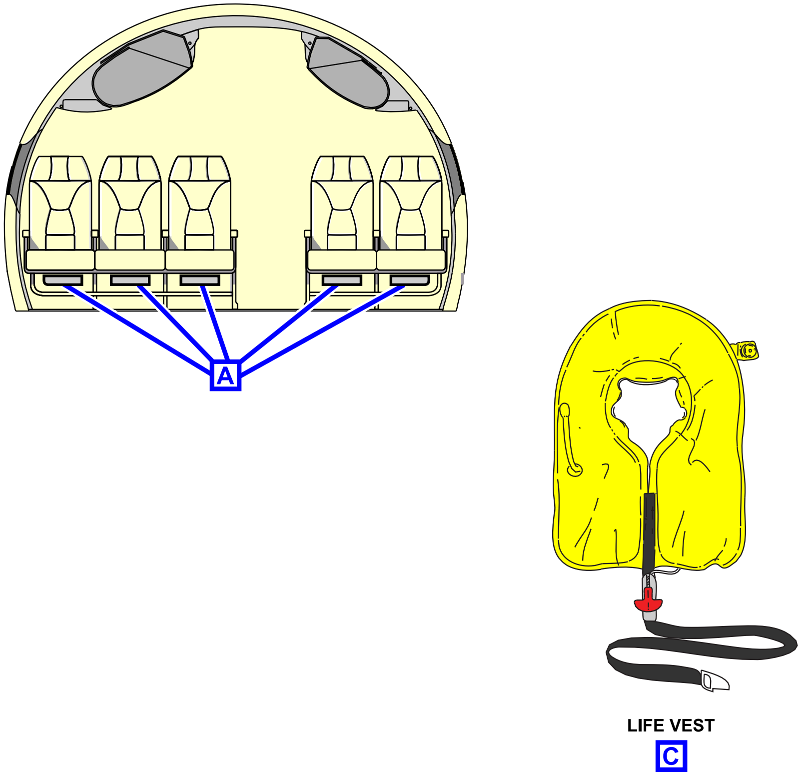


Flight compartment – Location of life vests
Figure 17–03–7



Flight attendant life vests and locations
Figure 17–03–8

Life vests for passengers are located under each passenger seat and are similar in design to the crew life vests (refer to Figure 17–03–9). Quantity and location of life rafts depend on the aircraft configuration.



Passenger life vests and locations
Figure 17–03–9

H. Escape slide system

For details, refer to Chapter 6 – Doors – Main door evacuation slides and Overwing emergency doors section.

I. Flight crew escape line

A flight crew escape line is stowed in the headliner, behind the pilot seat in the flight compartment. <34320001D>

The flight crew escape line is a knotted webbing with plastic discs spaced 12 inches apart.

During an emergency evacuation, the escape line can be deployed through the open emergency escape hatch. It is used to help the flight crew to lower themselves down to the ground. The full length of the escape line is deployed when the last red disc is visible.

For details, refer to Chapter 6 – Doors – Flight crew emergency exit hatch.

J. Other emergency equipment

The other emergency equipment includes:

- Flashlights,
- Crash axe,
- Lifelines,
- First aid kits, and
- Megaphones.

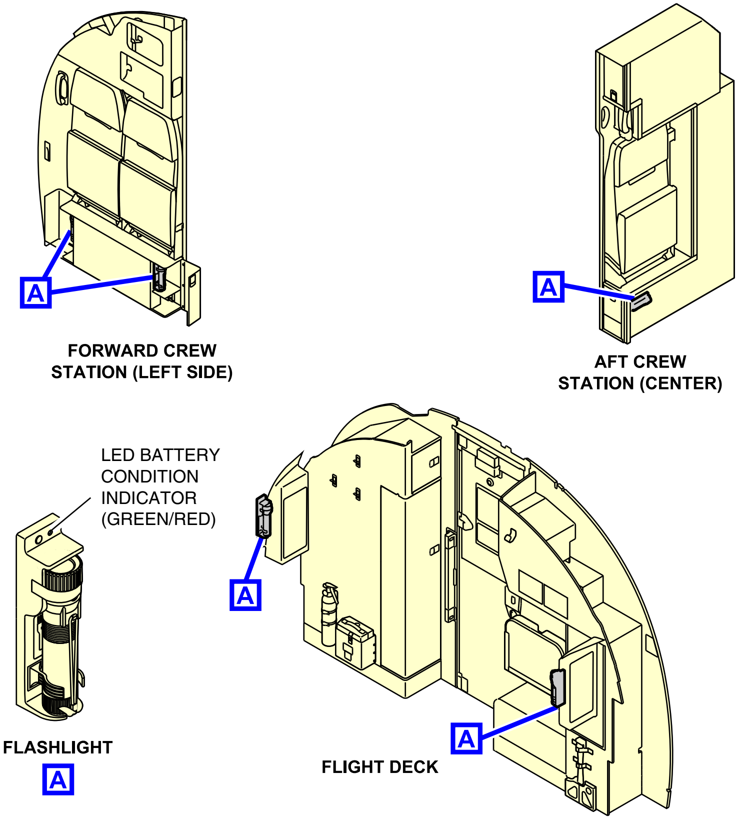
(1) Flashlights

Depending on customer option, either standard flashlights or rechargeable flashlights are installed in the aircraft at the locations that follow (refer to Figure 17–03–10):

- Two in the flight compartment,
- Two in the forward cabin crew station, and
- One in the aft cabin crew station.

The standard flashlights have a battery pack monitoring circuit in the mounting bracket. There is also a push-to-test button with an LED that comes on red or green to show the battery status.

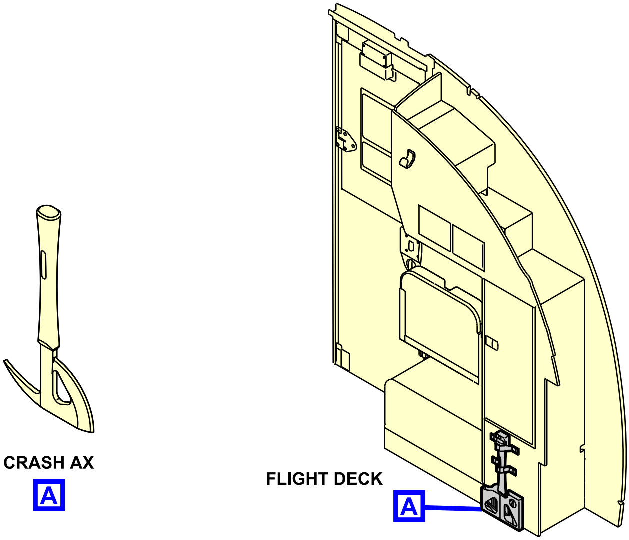
The rechargeable flashlights are charged automatically when they are in their stowed position. An illuminated LED light shows that the battery pack is charging.



Flashlight and locations
Figure 17–03–10

(2) Crash axe

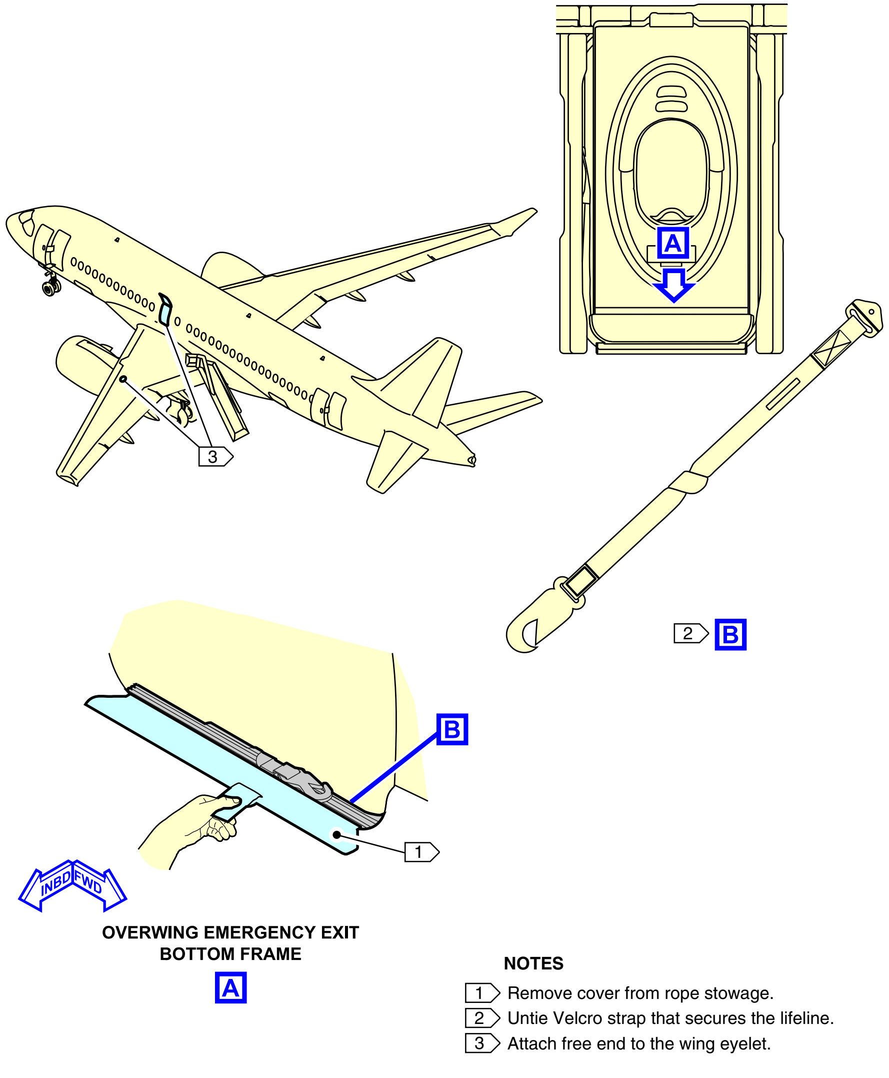
There is one crash axe installed in the flight compartment, behind the pilot seat. The crash axe handle is insulated to protect against electrical shock. Refer to Figure 17–03–11.



Crash ax location
Figure 17–03–11

(3) Lifelines

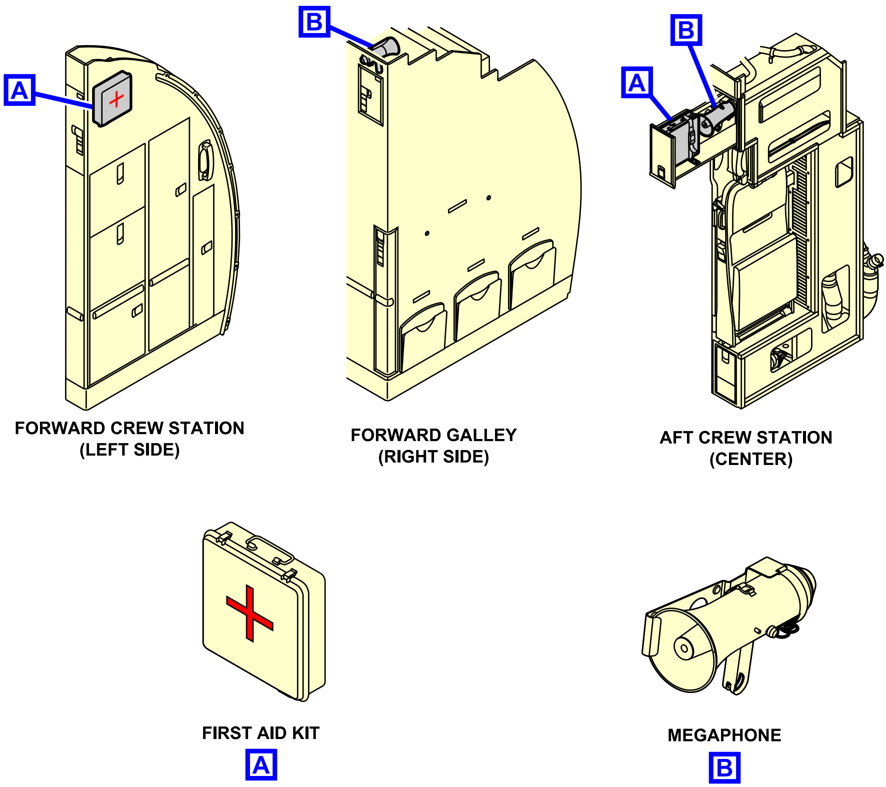
There is a lifeline at each overwing emergency exit door to help during an evacuation after an emergency landing on water (ditching). To open the exit from inside the aircraft, an internal cover is removed that exposes the handle. The lifeline, located in the bottom of the frame, is accessible when the overwing exit is open. Refer to Figure 17–03–12.



Lifeline
Figure 17–03–12

(4) First aid kits

There are usually two first aid kits installed in the aircraft, one located in the forward crew station (left side) and one in the aft crew station (center) (refer to Figure 17–03–13). The aircraft can also be equipped with a medical kit to be used by qualified medical personnel only.



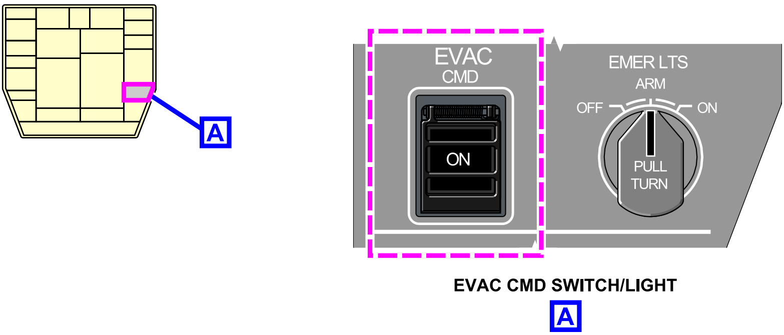
First aid kit and megaphone locations
Figure 17–03–13

(5) Megaphones

There are usually two megaphones onboard, one in the forward galley (right side) and one in the aft crew station (center) (refer to Figure 17–03–13). Each has a range of approximately 230 meters (250 yards). The battery life is approximately six hours on voice and one hour on siren.

K. Evacuation command

The EVAC CMD (Evacuation Command) guarded switch is located on the overhead panel (refer to Figure 17–03–14).



EVAC CMD (Evacuation Command) guarded switch
Figure 17–03–14

The EVAC CMD guarded switch activates and deactivates the evacuation horn. When the EVAC CMD guarded switch is pushed, the evacuation horn sounds and the white ON legend on the switch is illuminated white.

Depending on the aircraft configuration, the cabin crew can activate and deactivate the evacuation horn in the forward and aft attendant stations.

NOTE

The evacuation horn audio is independent of the flight compartment aural warning system.

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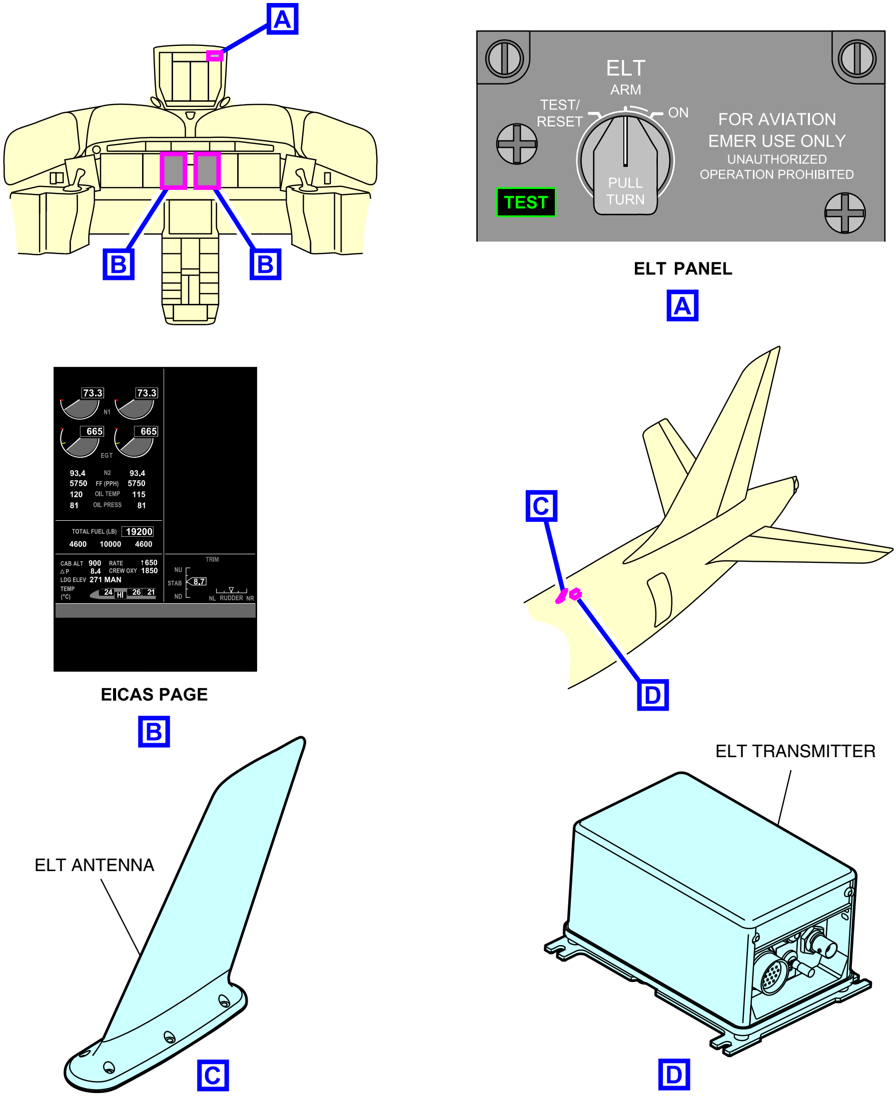
EMERGENCY LOCATOR TRANSMITTER (ELT)

A. Overview

The Emergency Locator Transmitter (ELT) system has:

- An antenna,
- A transmitter, and
- A battery.

The ELT system operates on its own power. It is a two-frequency (121.5 MHz and 406.040 MHz) automatic type ELT beacon. The ELT transmitter and antenna are located in the rear section of the aircraft, just in front of the vertical stabilizer. The ELT controls are located on the ELT panel, on the right outboard overhead module. ELT status is reported on the EICAS page. Refer to Figure 17–04–1.



ELT – Overview
Figure 17–04–1

B. ELT operation

The ELT is automatically activated by the deceleration force of the aircraft during high impact. It can also be activated manually with the ELT switch on the ELT panel. The switch has three positions:

- ON,
- ARM, and
- TEST/RESET.

(1) ON

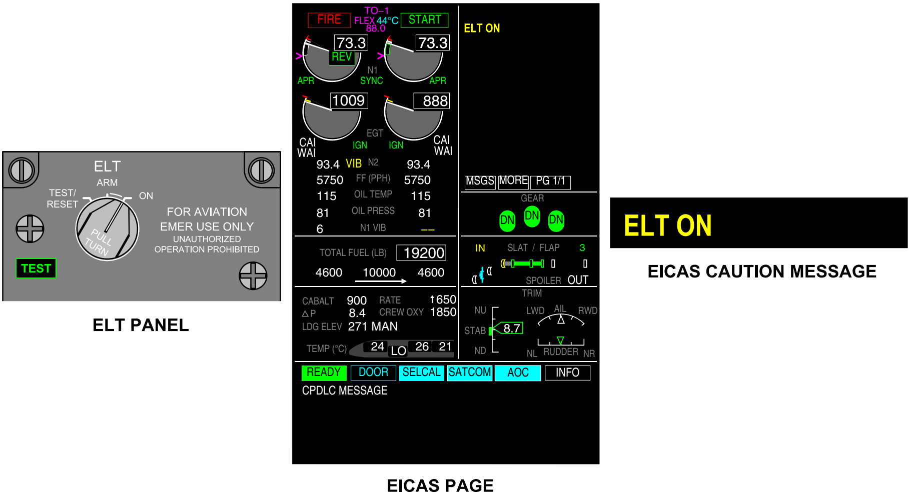
When the ELT rotary switch is selected to ON, the ELT is activated and an **ELT ON** caution message is displayed on the EICAS page.

(2) ARM

When the switch is selected to the ARM position, the ELT is ready to activate automatically on high impact. Upon activation, the **ELT ON** caution message is displayed on the EICAS page.

(3) TEST/RESET

To test the ELT or reset the ELT after it has been activated automatically, the switch is selected to TEST/RESET, then back to ARM. After this action, the **ELT ON** caution message disappears from the EICAS page.



ELT controls and indications
Figure 17–04–2

C. ELT test

To test the ELT, the switch must be set to the TEST/RESET position and then back to the ARM position rapidly (in less than 3 seconds). The TEST indicator on the control panel flashes once and an audible tone is heard on VHF frequency 121.5 MHz.

OXYGEN AND EMERGENCY EQUIPMENT – CONTROLS

A. PRESSURIZATION panel – PAX OXY guarded switch

When the PAX OXY guarded switch is pushed:

- The DPLY (deployed) label on the switch is illuminated white,
- The ODU doors unlatch to drop the masks,
- **The PAX OXY DPLY** status message is displayed on the EICAS page, and
- The NO SMOKING/NO PED, FASTEN SEAT BELT, and RETURN TO SEAT signs are displayed in the cabin.

B. ELT panel

The control panel has a three-position switch and a TEST indicator:

(1) ARM

Activates the automatic mode.

(2) ON

- Activates the ELT,
- Emergency signal is transmitted, and
- **ELT ON** caution message is displayed on the EICAS page.

(3) TEST/RESET

Tests the ELT operation or deactivates and resets the ELT for further automatic operation (ARM).

(4) TEST indication

Flashes during test.

CREW OXYGEN SYSTEM INDICATIONS

The table that follows describes the crew oxygen system indications of the air section of the EICAS page and on the AIR synoptic page.

OXYGEN AND EMERGENCY EQUIPMENT – EICAS MESSAGES

A. Warning messages

None

B. Caution messages

Message	Description	Inhibit
CREW OXY LO PRESS	Flight crew oxygen low pressure.	TO, LDG
ELT ON	ELT is transmitting	TO, LDG

C. Advisory messages

None

D. Status messages

Message	Description	Inhibit
PAX OXY DPLY	Cabin oxygen masks deployed automatically or manually.	None

CHAPTER 18 – POWER PLANT

GENERAL

NACELLE SYSTEM

ENGINE

ENGINE SUBSYSTEM

ENGINE FUEL SYSTEM

ENGINE IGNITION SYSTEM

ENGINE OIL SYSTEM

ENGINE BLEED AIR SYSTEM

List of figures

ENGINE SUBSYSTEM

ENGINE FUEL SYSTEM

ENGINE IGNITION SYSTEM

ENGINE OIL SYSTEM

ENGINE BLEED AIR SYSTEM

POWER PLANT – CONTROLS AND INDICATIONS

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POWER PLANT SYSTEM – OVERVIEW

The PW1500G engines are a series of axial flow, geared fan, concentric twin-spool, FADEC controlled, and ultra-high bypass ratio turbofan engines.

The engine models installed on the aircraft have the thrust ratings that follow:

Engine options	Engine models	Uninstalled thrust rating (lbf)	Installed thrust rating (lbf)
<72211001D>	PW1521G-3	21970	20760

The uninstalled thrust rating represents the maximum takeoff thrust available for the uninstalled engines as inscribed on the engine identification plate and indicated on the Type Certification Data Sheet (TCDS).The installed thrust rating represents the maximum takeoff thrust available after the engine is installed on the aircraft.

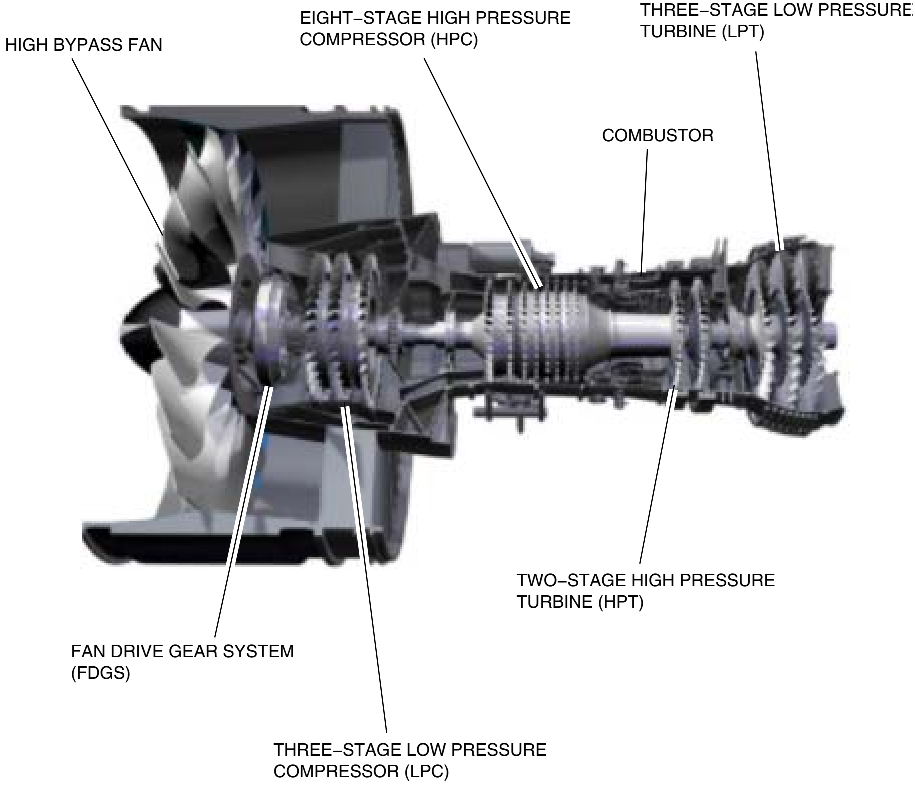
All models of the PW1500 series engine incorporate a cascade-type thrust reverser system.

The main feature of the PW1500G series is a relatively large diameter fan rotor that is rotated at a reduced speed by a Fan Drive Gear System (FDGS). The geared fan rotor configuration allows the fan to turn more slowly than the N1 shaft, thus increasing efficiency by allowing both sections to rotate at their optimum speeds. The relatively higher N1 shaft speed also reduces the number of stages required to generate power, thereby reducing parts and thus total engine weight.

The low pressure spool, or N1 shaft, drives the FDGS (which drives the fan) and consists of a three-stage Low Pressure Compressor (LPC) powered by a three-stage Low Pressure Turbine (LPT). The high pressure spool, or N2 shaft, powered by a two-stage High Pressure Turbine (HPT), drives an eight-stage High Pressure Compressor (HPC) and the engine Main Gearbox (MGB), which in turn drives the auxiliary systems. The N1 shaft rotates concentrically inside the N2 shaft but they are mechanically independent.

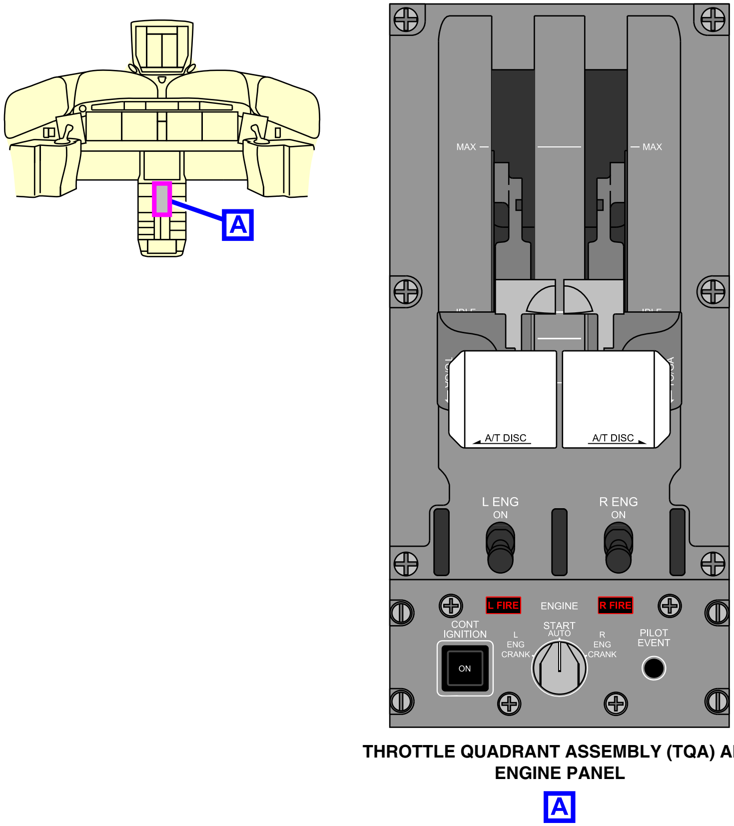
Other engine improvements include variable geometry compressor inlet guide vanes, an advanced compressor bleed air system, improved combustion chamber design, turbine blades that are cooled internally, and active turbine-to-case clearance control. The Full Authority Digital Engine Control (FADEC) manages all aspects of engine control, monitoring, and performance.

Figure 18–01–1 shows the main sections of the engine.

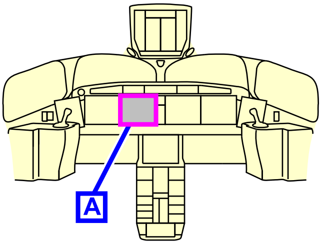


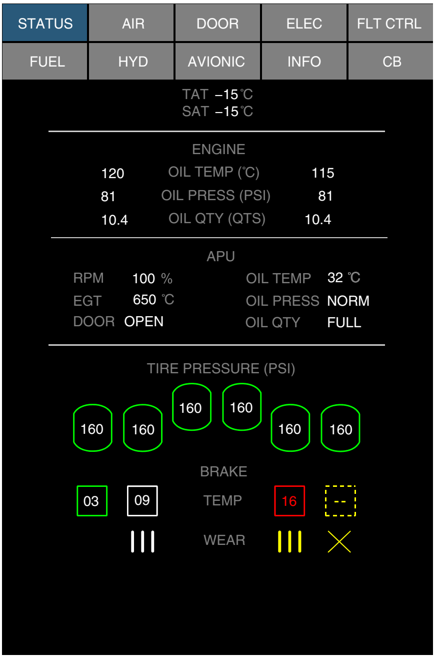
Power plant overview
Figure 18–01–1

The flight crew controls are located in the center pedestal and consist of a Throttle Quadrant Assembly (TQA) and an ENGINE panel. The engine parameters, status, and EICAS messages are reported on the EICAS page and STATUS synoptic page (refer to Figure 18–01–2 and Figure 18–01–3).

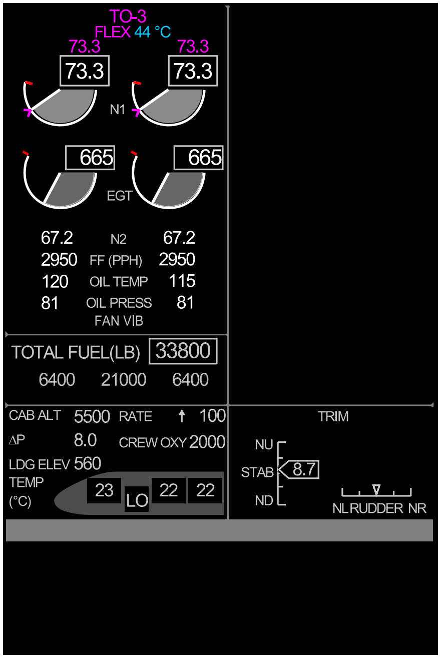


Power plant system controls
Figure 18–01–2





STATUS SYNOPTIC PAGE
A



EICAS PAGE
A

Power plant system indications
Figure 18–01–3

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NACELLE SYSTEM – OVERVIEW

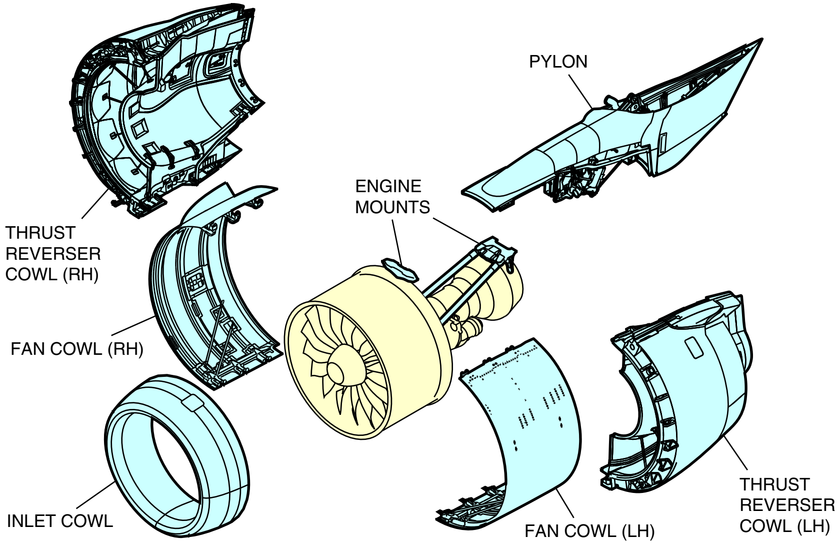
The nacelle system provides an aerodynamic and protective enclosure for the engine. It also transfers some loads to the pylon.

The main components of the nacelle system are:

- The inlet cowl,
- The fan cowls,
- The thrust reverser cowls,
- The engine mounts, and
- The drain system.

The inlet cowl directs the airflow that enters the engine. The fan cowls give access to the Electronic Engine Control (EEC), Prognostics and Health Management Unit (PHMU), and the fan case. The thrust reverser cowls give access to the thrust reverser system components. The engine mounts and thrust links transfer the engine loads to the pylon. The drain system evacuates the potential leaks (from the hydraulic, oil and fuel system, as well as the pylon wet bay) through the engine drain masts.

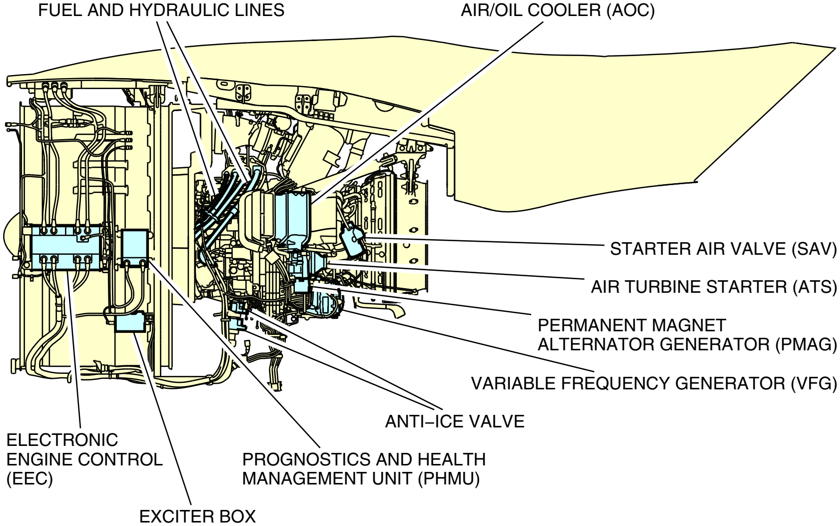
Figure 18–02–1 shows the nacelle system components.



Nacelle system
Figure 18−02−1

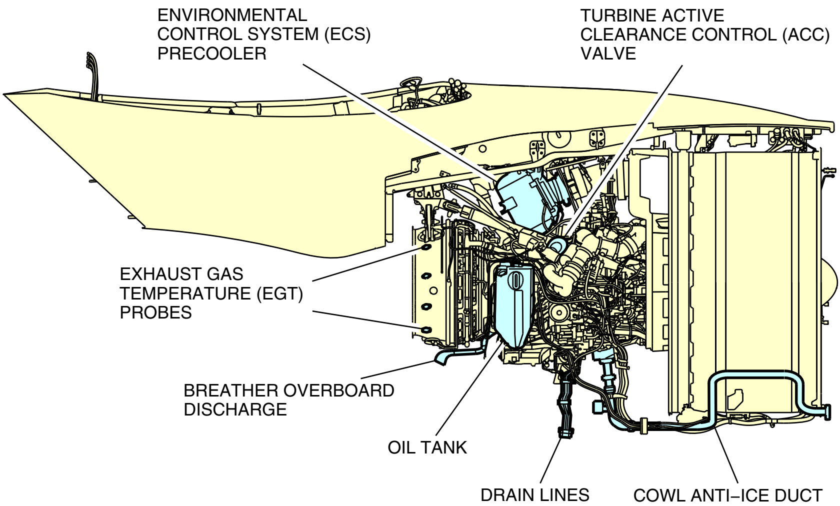
A. Power plant accessible components

(1) Left side view



Engine accessible components (left side)
Figure 18–02–2

(2) Right side view



Engine accessible components (right side)
Figure 18–02–3

THRUST REVERSER SYSTEM

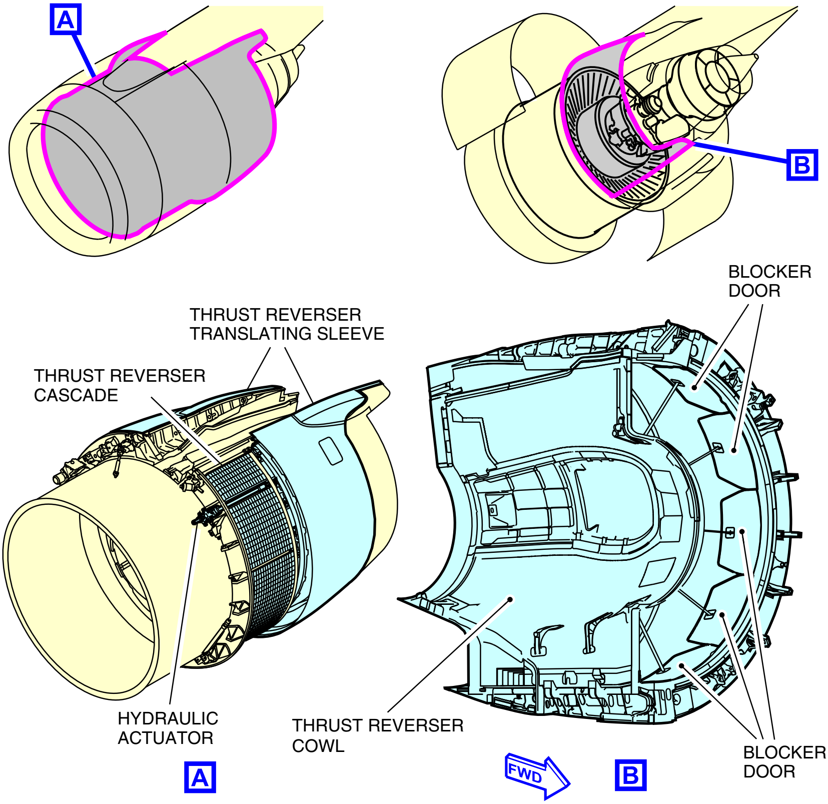
A. Thrust reverser system – Overview

The thrust reversers are translating sleeve/fixed cascade type and consist of:

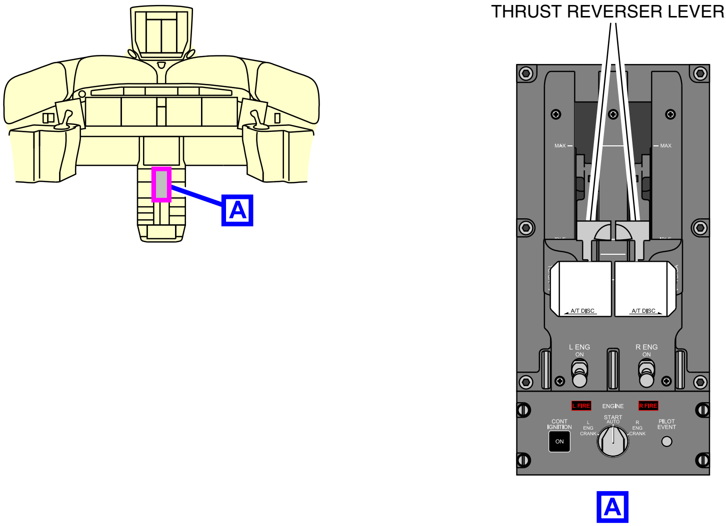
- Translating sleeves,
- Synchronized hydraulic actuators,
- Hydraulic Control Unit (HCU),
- Blocker doors,
- Thrust reverser cascades, and
- Manual drive.

The thrust reverser levers (refer to Figure 18–02–5) control their respective thrust reversers.

Figure 18–02–4 shows the thrust reverser system components.



Thrust reversers
Figure 18–02–4



Thrust reverser levers
Figure 18–02–5

B. Thrust reverser system – Operation

When deployed, the synchronized hydraulic actuators move the translating sleeves aft, which causes the blocker doors to rotate. This redirects the fan airflow through the cascades and provides reverse thrust. The actuators have a locking mechanism, position feedback sensors, and proximity switches for lock engagement status.

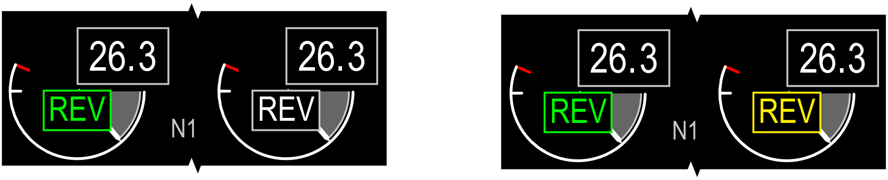
C. Thrust reverser system – Baulk function

The baulk mechanism will provide the flight crew with a tactile feedback to indicate thrust reverser state during deployment or stowage cycles. The mechanism can be overridden when a significant amount of force is applied to the thrust reverser levers.

During deployment, the baulk mechanism blocks the thrust levers in the idle position until thrust reverser deployment is confirmed. After deployment, the mechanism allows the thrust levers to enter in the reverse thrust range.

During stowage, the baulk mechanism blocks the thrust levers in the forward idle position until thrust reverser stowage is confirmed and securely closed and locked.

Figure 18–02–6 shows different thrust reverser indications.



LEFT THRUST REVERSER DEPLOYED.

RIGHT THRUST REVERSER IN TRANSIT.

LEFT THRUST REVERSER DEPLOYED.

RIGHT THRUST REVERSER FAILED OR NOT AVAILABLE. DO NOT USE FOR LANDING.

THROTTLE IN REVERSE

L REVERSER UNLOCK

R REVERSER UNLOCK

L REVERSER FAIL

R REVERSER FAIL

EICAS CAUTION MESSAGES

Thrust reversers deployment malfunctions
Figure 18–02–6

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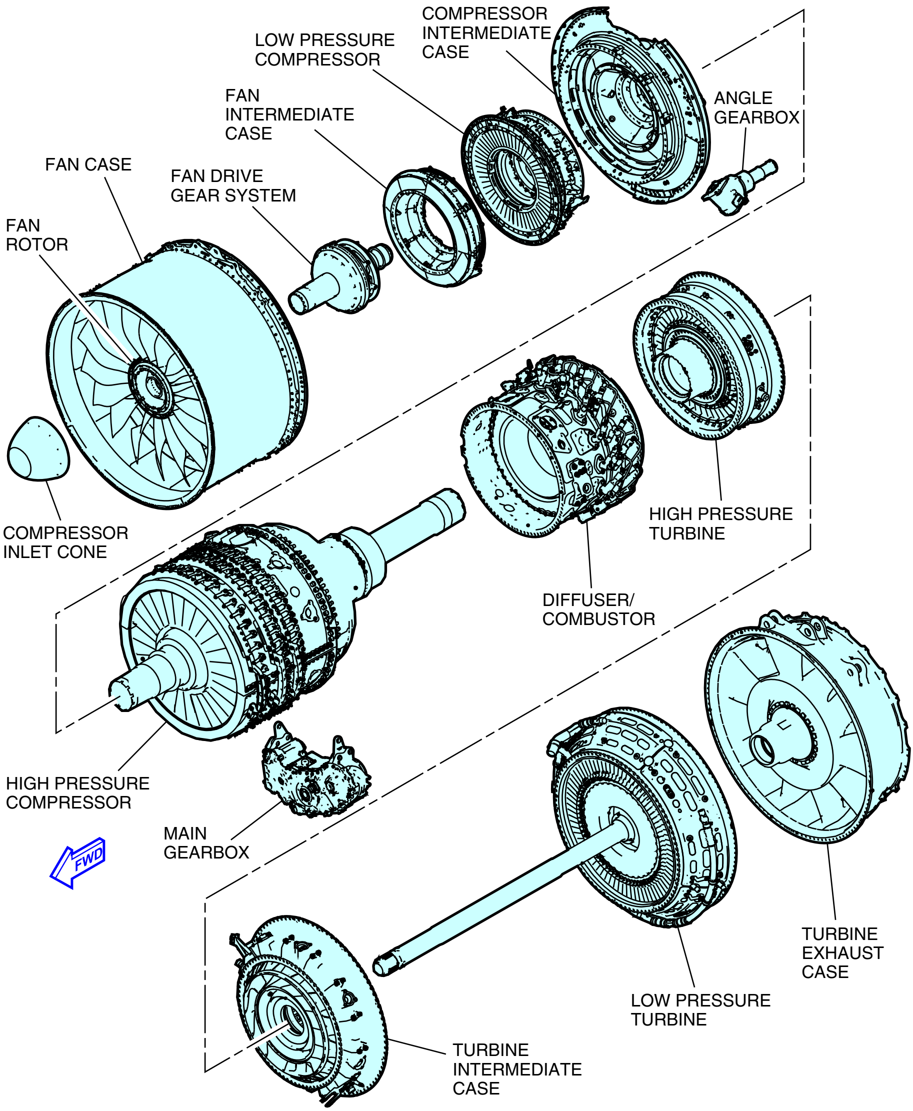
ENGINE – OVERVIEW

The engine is divided into the sections (refer to Figure 18–03–1) that follow:

- Compressor inlet cone and fan blades,
- Fan Drive Gear System (FDGS),
- Low Pressure Compressor (LPC),
- High Pressure Compressor (HPC),
- Combustor,
- High Pressure Turbine (HPT),
- Low Pressure Turbine (LPT), and
- Angle Gearbox (AGB) and Main Gearbox (MGB).



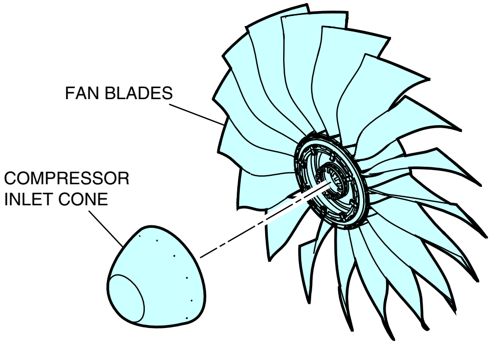
Engine module description
Figure 18–03–1

ENGINE – DESCRIPTION AND OPERATION

A. Compressor inlet cone and fan blades

The compressor inlet cone smooths the airflow that enters the fan blades (refer to Figure 18–03–2). The cone is made of composite material and it is automatically and constantly de-iced by the engine bleed air.

The fan blades draw air into the Low Pressure Compressor (LPC) for the gas-path flow and for the bypass flow that provides 80% of the engine thrust. The fan is rotated by the FDGS.

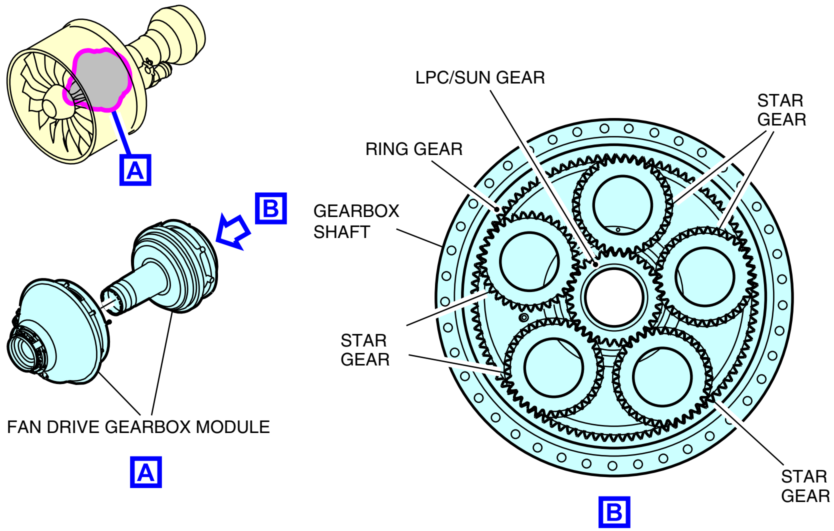


Compressor inlet cone and fan blades
Figure 18–03–2

B. Fan Drive Gear System (FDGS)

The Fan Drive Gear System (FDGS) allows the fan to spin three times slower than the Low Pressure Compressor (LPC) shaft. The FDGS is a sun gear type reduction gearbox with five star gears and an outer ring gear that rotates the fan. The reduction ratio is fixed.

Figure 18–03–3 shows the FDGS components.

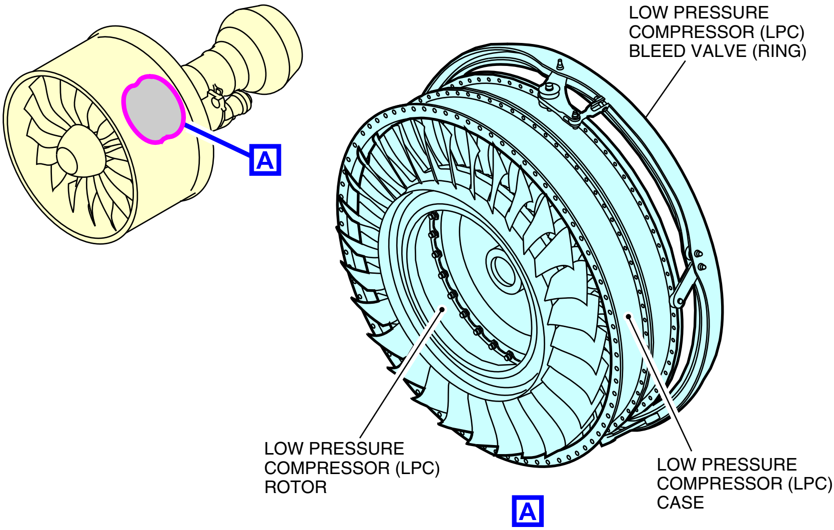


Fan Drive Gear System (FDGS) module
Figure 18–03–3

By using the FDGS, geared fan speed and N1 are optimized for cruise. The reduced fan load allows the Low Pressure Compressor (LPC) shaft to spin faster than conventional engines, thereby increasing the pressure change per stage. This results in fewer compressor and turbine stages being needed, reducing the engine weight, fuel consumption, and noise.

C. Low Pressure Compressor (LPC)

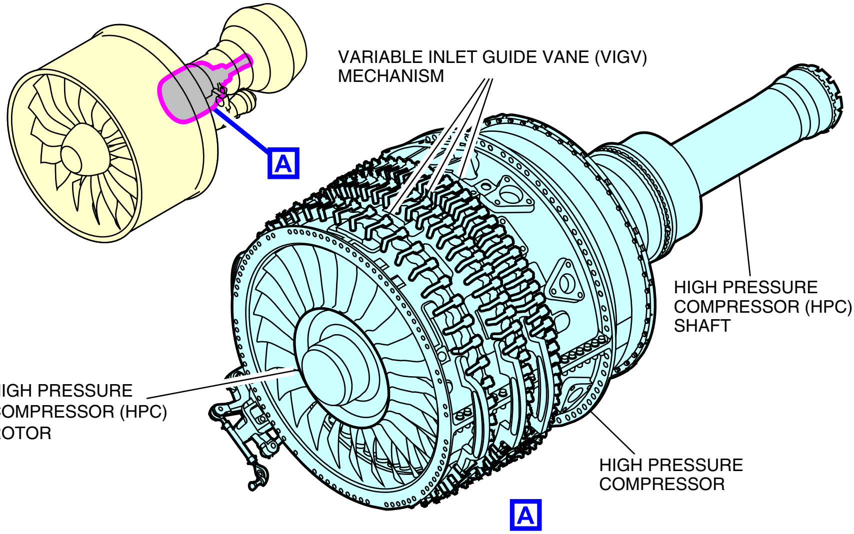
The Low Pressure Compressor (LPC) (refer to Figure 18–03–4) is a three-stage compressor, driven by the Low Pressure Turbine (LPT), that increases the air pressure being fed into the High Pressure Compressor (HPC). The LPC has a Variable Inlet Guide Vane (VIGV) mechanism that optimizes the engine airflow, and a bleed valve (bleed ring), that ensures compressor airflow stability.



Low Pressure Compressor (LPC)
Figure 18–03–4

D. High Pressure Compressor (HPC)

The High Pressure Compressor (HPC) (refer to Figure 18–03–5) is an eight-stage compressor driven by the High Pressure Turbine (HPT). The HPC increases the pressure and the speed of the airflow before it goes into the diffuser and the combustor. The HPC has a Variable Inlet Guide Vane (VIGV) mechanism that optimizes the engine airflow and an HPC bleed valve that bleeds air from the HPC during start.

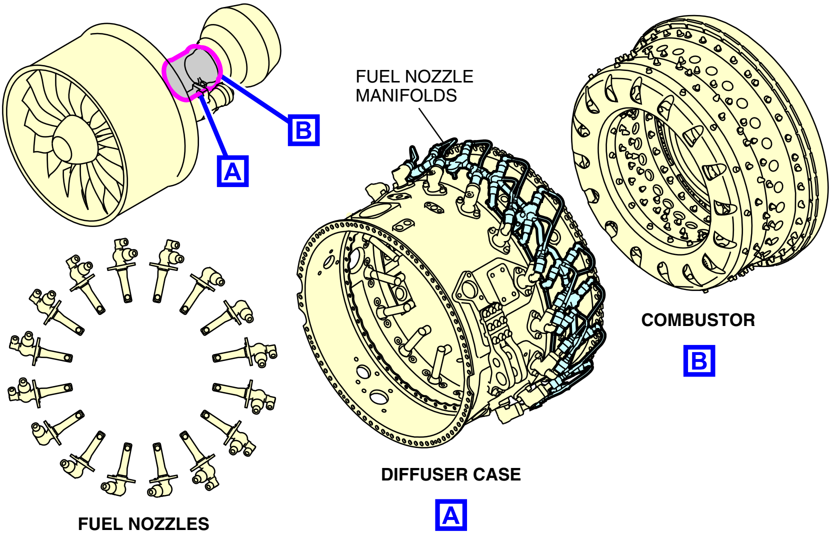


High Pressure Compressor (HPC)
Figure 18–03–5

E. Combustor

The combustor is a single-annular type chamber where the air/fuel mixture is ignited and burned. It has 16 fuel nozzles and 2 igniters. The combustor receives air from the diffuser at a reduced velocity.

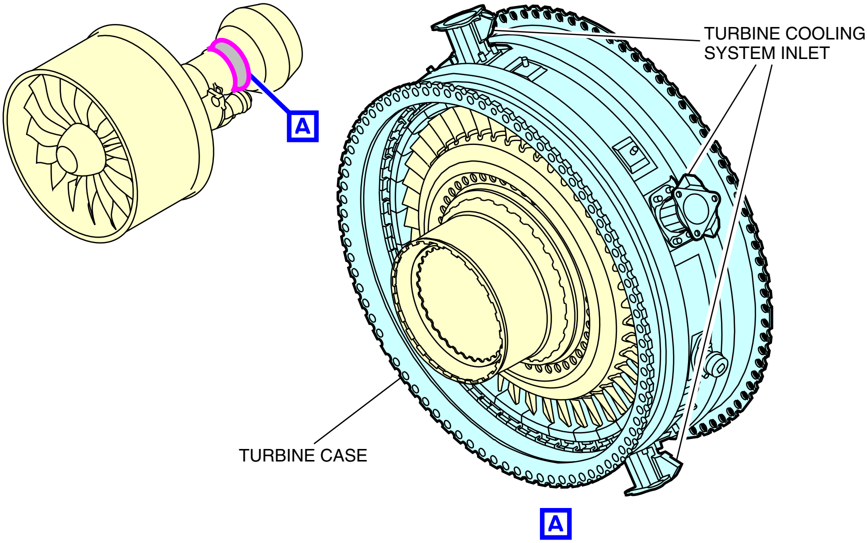
Figure 18–03–6 shows the combustor with the fuel nozzles and the diffuser.



Diffuser and combustor
Figure 18–03–6

F. High Pressure Turbine (HPT)

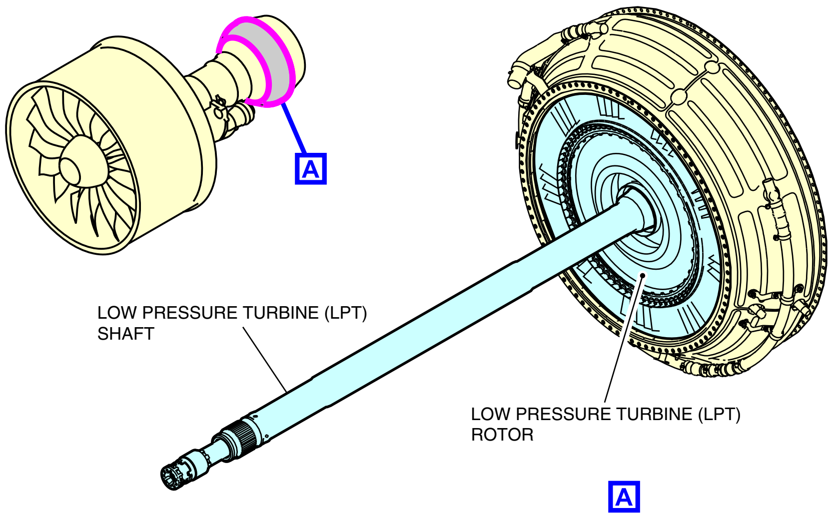
The passage of the high temperature and high velocity gas exhaust through the High Pressure Turbine (HPT) (refer to Figure 18–03–7) provides the rotational forces to directly drive the HPT and indirectly drive the HPC. Each turbine blade of the HPT has a thermal coating and internal cavities, which combined with the turbine cooling system, help the blades to resist high temperatures and to increase their durability.



High Pressure Turbine (HPT)
Figure 18–03–7

G. Low Pressure Turbine (LPT)

The Low Pressure Turbine (LPT) (refer to Figure 18–03–8) is a three-stage rotor that drives the LPC.



Low Pressure Turbine (LPT)
Figure 18–03–8

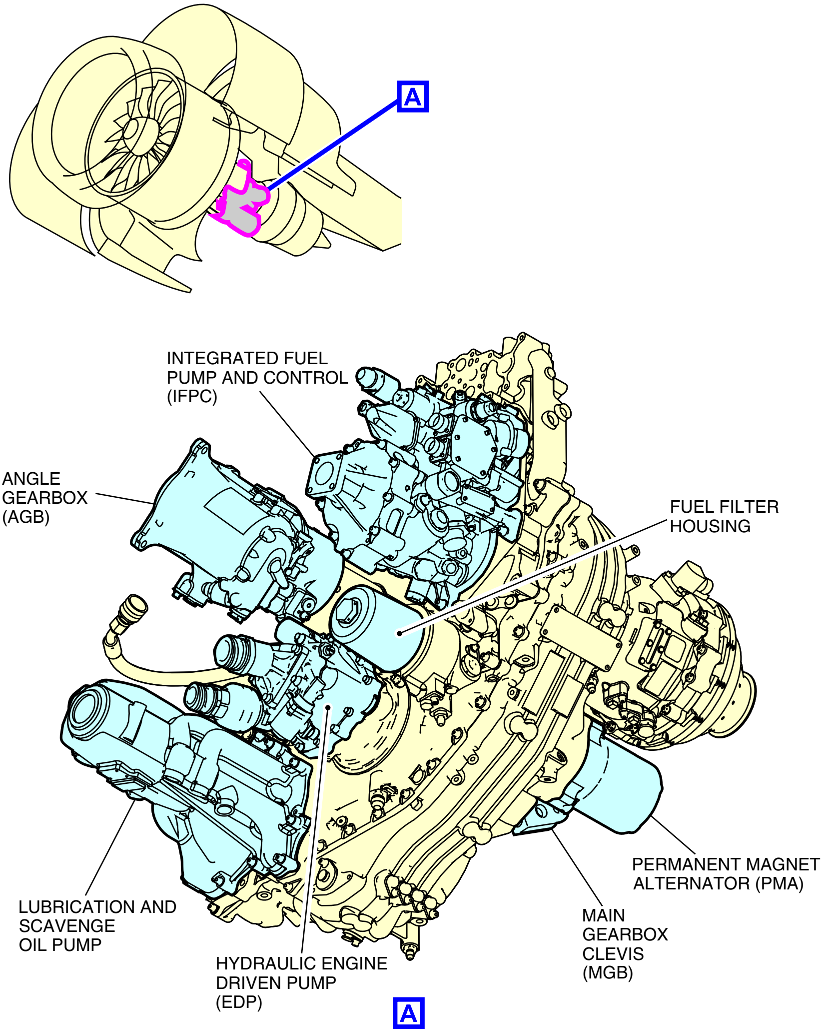
H. Main Gearbox (MGB)

Main Gearbox (MGB) (refer to Figure 18–03–9) uses the torque produced by the HPC, through an Angle Gearbox (AGB), to drive the accessories that follow:

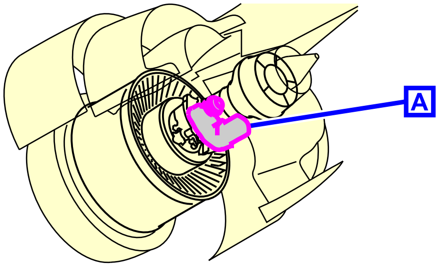
- Hydraulic Engine Driven Pump (EDP),
- Oil lubrication and scavenge pump,
- Variable Frequency Generator (VFG),
- Permanent Magnet Alternator Generator (PMAG), and
- Integrated Fuel Pump and Control (IFPC).

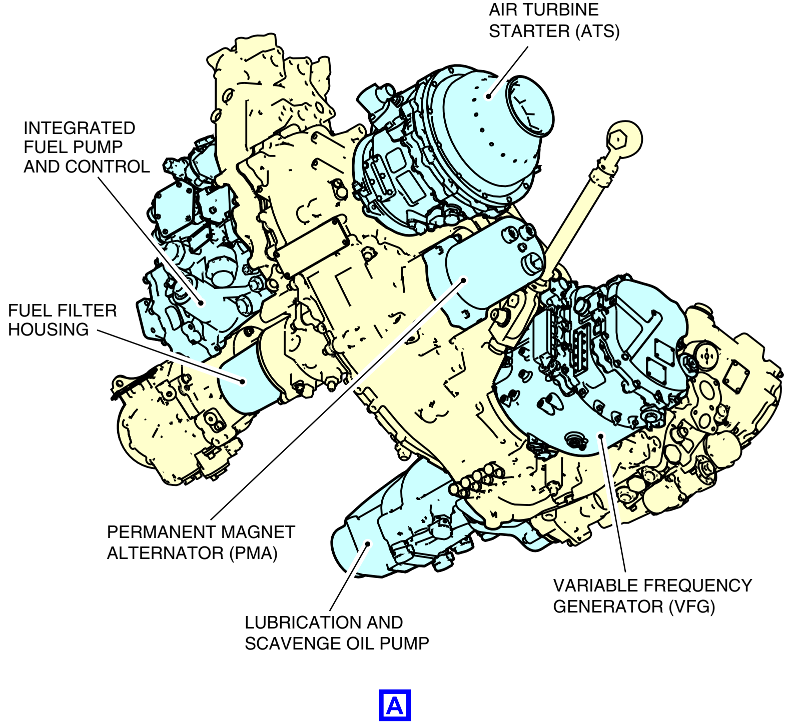
The MGB is also used to transfer the torque from the Air Turbine Starter (ATS) (refer to Figure 18–03–10) to crank the engine during start.

Figure 18–03–9 and Figure 18–03–10 show the accessories connected to the MGB.



Angle Gearbox (AGB) and Main Gearbox (MGB)
Figure 18–03–9





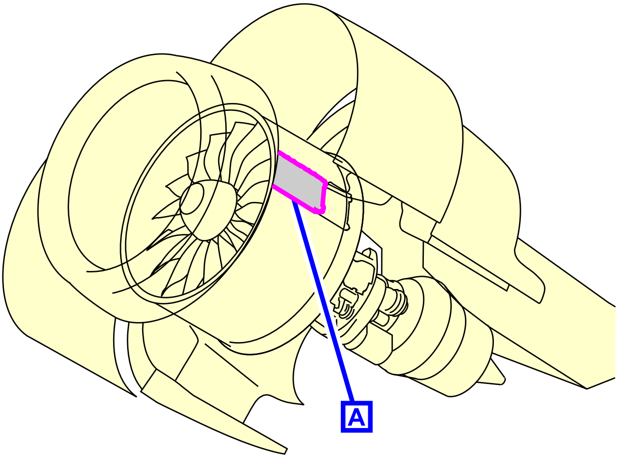
Main Gearbox (MGB)
Figure 18–03–10

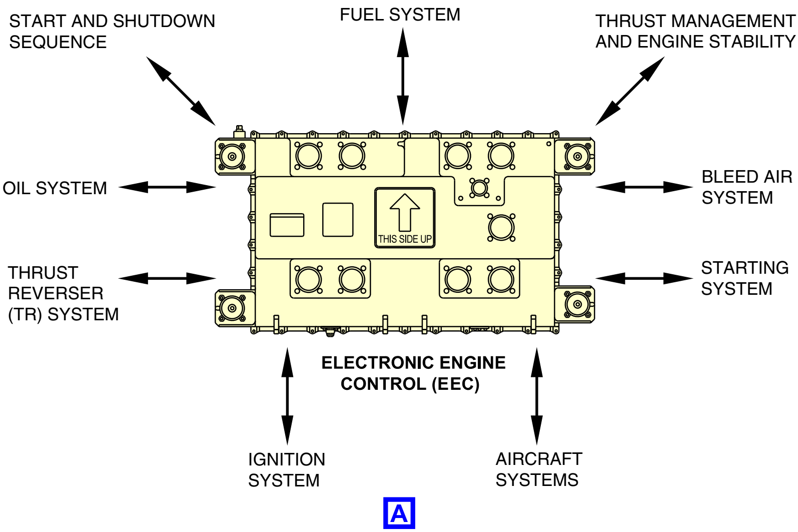
I. Full Authority Digital Engine Control (FADEC) / Electronic Engine Control (EEC)

The FADEC controls and monitors all the engine systems. The EEC (refer to Figure 18–03–11) is the core of the FADEC. It is a dual-channel unit installed on the left side of the fan case. One channel of the EEC is capable of complete system control and the other one is a backup if there is a failure. The EEC is mainly powered by the Permanent Magnet Alternator Generator (PMAG), which is driven by the Main Gearbox (MGB). N2 has to be greater than 10% to ensure adequate electrical power for the EEC. If PMAG power is unavailable, the DC essential bus powers the EEC.

The EEC protects the engine by maintaining the parameters (N1, N2, oil pressure and temperature, fuel temperature, and Exhaust Gas Temperature (EGT)) within the operational limits during all phases of flight. It receives inputs from the engine systems that follow:

- Fuel system,
- Ignition system,
- Bleed air system,
- Oil system,
- Thrust reverser system,
- Starting system,
- Start and shutdown sequence,
- Thrust management system, and
- Aircraft systems.





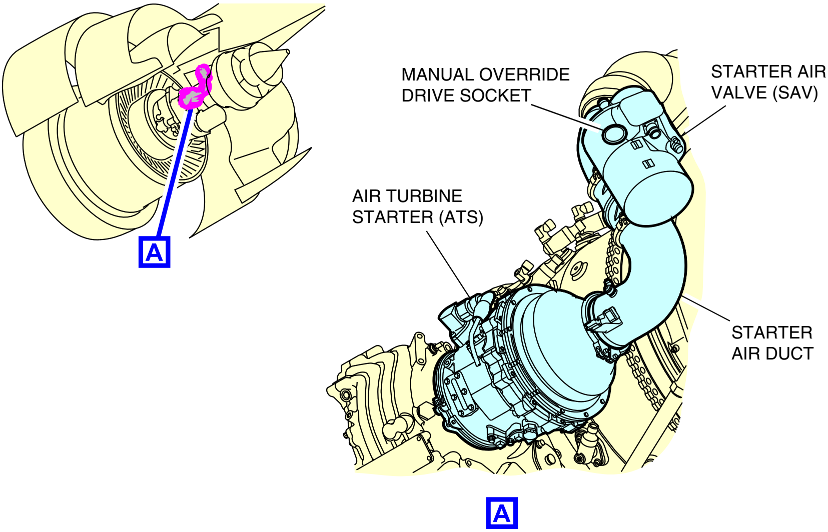
Electronic engine control (EEC) interaction
Figure 18–03–11

The inputs received by the EEC are monitored and processed for operation and maintenance reporting through the Engine Indication and Crew Alerting System (EICAS) and the Onboard Maintenance System (OMS).

The Prognostics and Health Monitoring Unit (PHMU) monitors and processes engine parameters such as vibration, oil debris, and performance for engine health monitoring and maintenance reporting. The unit is installed on the fan case adjacent to the EEC.

ENGINE STARTING SYSTEM – OVERVIEW

The engine starting system uses pneumatic pressure supplied by the Auxiliary Power Unit (APU), opposite engine bleed air, or a ground cart. The system is controlled by the EEC. The main components of the system are the Starter Air Valve (SAV) and the Air Turbine Starter (ATS) (refer to Figure 18–04–1).



Engine starting system
Figure 18–04–1

ENGINE STARTING SYSTEM – DESCRIPTION AND OPERATION

A. Starter Air Valve (SAV)

The SAV is a pneumatically-actuated valve controlled by the EEC. It sends compressed air from the aircraft pneumatic system to the Air Turbine Starter (ATS) to crank N2 for start. The valve has an external manual override drive socket that can be accessed without opening any engine nacelle doors.

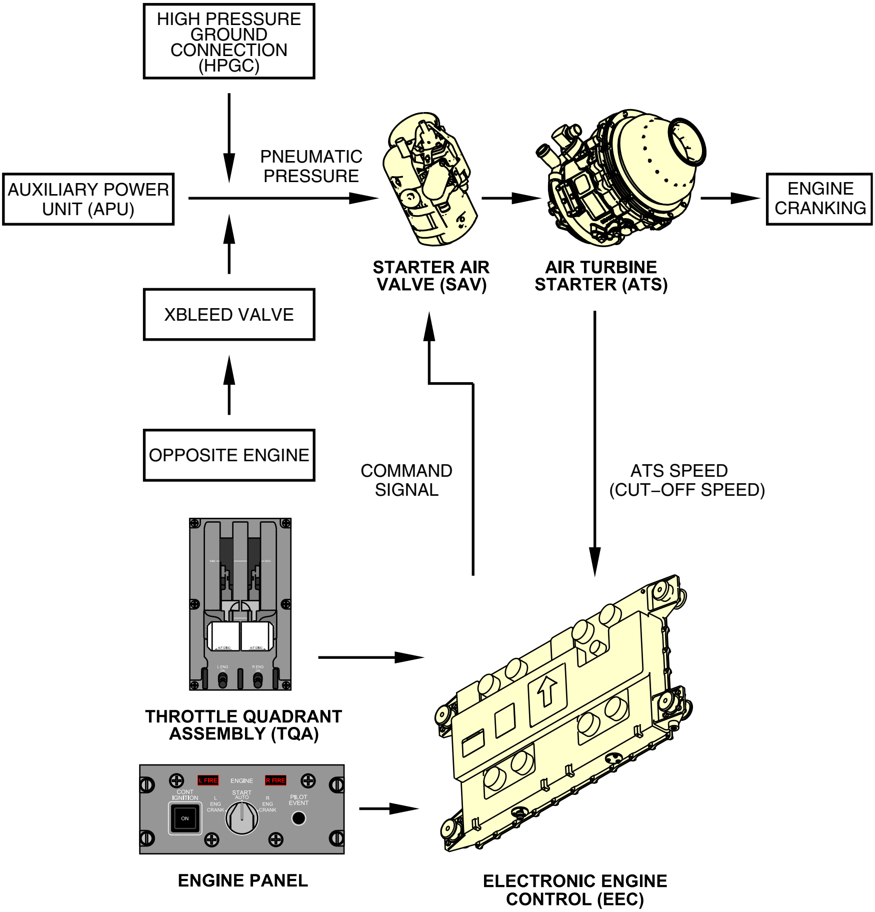
B. Air Turbine Starter (ATS)

The ATS converts pneumatic energy into torque to crank the engine through the Main Gearbox (MGB) and the Angle Gearbox (AGB). The starter has a speed sensor that sends the ATS speed signal to the EEC to control the ignition and start operation. It has a self-contained oil system that prevents cross contamination with the engine oil system.

C. Operation

During start, the EEC commands the SAV to supply pneumatic pressure to the ATS, which cranks the engine. ATS speed is monitored by the EEC, which disengages the ATS at approximately 51% N2.

Figure 18–04–2 shows an overview of the engine starting system operation.



Engine starting system operation
Figure 18–04–2

D. Automatic start

The automatic start gives the Electronic Engine Control (EEC) full control of the start sequence, depending on whether the aircraft is on the ground or in flight. For in flight starts, the starter assist is automatically commanded by the EEC at 250 KIAS and below, where windmilling airflow into the engine is insufficient for engine starting. The EEC automatically controls the Starter Air Valve (SAV), the ignition, and the fuel flow. The automatic start is initiated by ensuring that the thrust lever is at or greater than forward idle, that the CONT IGNITION switch is in the normal (dark) position, and by setting the START switch on the ENGINE panel to AUTO and moving the L/R ENG run switches to ON. During on-ground automatic start, the EEC will:

- Open the SAV,
- Turn on the igniters, and
- Turn on the fuel supply.

The igniters and SAV are automatically turned off by the EEC at approximately 51% N2.

The start will not initiate automatically unless:

- The thrust lever is at or greater than forward idle,
- The CONT IGNITION switch is in the normal (dark) position, and
- The N2 is less than starter cutout speed.

NOTE

If the thrust lever is not at the appropriate position for starting operation, the FADEC will generate a "THRUST LEVER" aural message.

E. Automatic start abort

An automatic start on ground is aborted by the EEC when one of the conditions that follow occurs:

- N1 locked rotor,

- Hot or hung start,
- Loss of Exhaust Gas Temperature (EGT) data,
- Igniter failure, or
- Fuel control failure.

Depending on the start malfunction, the EEC aborts the engine start by stopping the fuel supply, turning off the igniters and closing the SAV. The ability of the EEC to abort the start is inhibited above approximately 50% N2, on-ground and for all the in-flight conditions. Above this value, the flight crew must set the L ENG or R ENG run switch on the ENGINE panel to OFF to abort the automatic start.

Before a restart on the ground, the automatic start allows an engine motoring period of 30 seconds to clear fuel vapor and cool the engine components. The EEC then performs a single restart attempt when N2 is below 20%.

F. Manual start

During a manual start, the flight crew controls the start sequence and the EEC has limited control. The EEC continues to provide start and fault indications on the EICAS page but the automatic abort feature is disabled and pilot monitoring of the start parameters is required.

A manual start is commanded when the CONT IGNITION switch on the ENGINE panel is pressed to the ON position. This action sends a manual start request to the EEC, activates both igniters and displays IGN and the **ENG CONT IGNITION ON** status message on the EICAS page. The spring–loaded START switch on the ENGINE panel is then held in the L ENG CRANK or R ENG CRANK position to crank the corresponding engine by opening the appropriate SAV. The L ENG or R ENG run switch on the ENGINE panel are then set to ON between 18% and 20% N2 to allow the EEC to start the fuel flow.

The igniters and the ATS are turned off automatically by the EEC at approximately 51% N2 when the ATS reaches the cutout speed.

CAUTION

Before engine start, confirm that the thrust lever is set to idle. The engine will start regardless of the position of the thrust lever and thrust level will quickly increase to the thrust lever setting, which can cause a hazardous situation.

NOTE

The EEC will not automatically abort an abnormal manual start.

G. Manual start abort

The manual start is aborted by releasing the spring-loaded START switch to the AUTO position before the L or R ENG run switch is set to ON. This will disengage the starter. After the L or R ENG run switch is set to ON, it must be selected to OFF to abort the start (stops the fuel flow).

WARNING

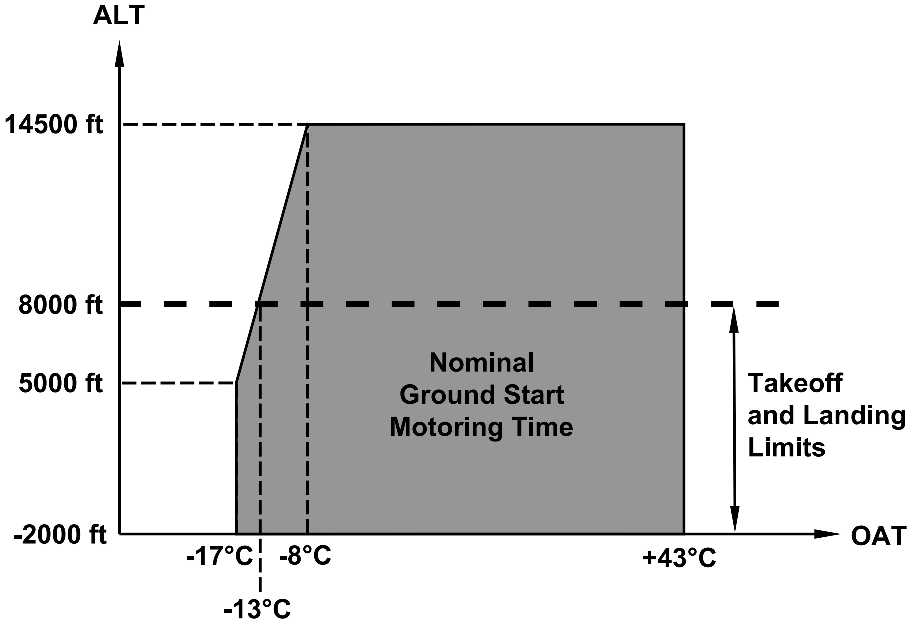
Always put the ENG run switch back to the OFF position after an abort of the start sequence. If you do not reset the ENG run switch to OFF, the FADEC system will not complete the ABORT. If you do not obey this instruction, the engine can start and this can cause injuries to persons.

NOTE

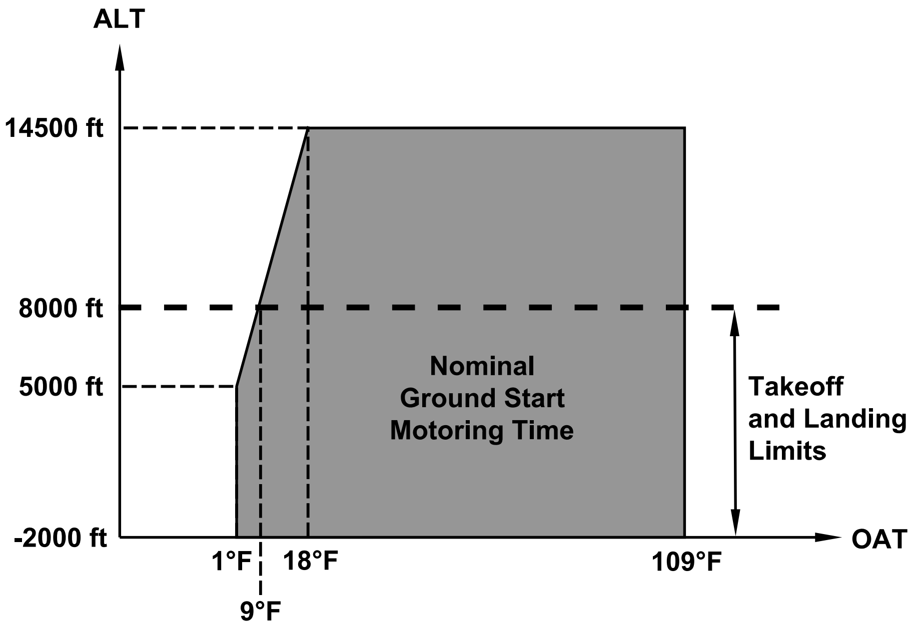
FADEC V2.9.5: To prevent the risk of a bowed rotor, upon initiation of an on-ground automatic or manual start command, the FADEC motors the engine before allowing the start to proceed and the **ENG START DELAY** EICAS advisory message displays on the EICAS page.

H. FADEC software V2.9.6.3

After FADEC software V2.9.6.3 is loaded, the advisory message **ENG START DELAY** will no longer be displayed on the EICAS page during all engine starts. The message will only be displayed after the engine RUN switch is selected to ON and the Outside Air Temperature (OAT) is outside the shaded area of the figure below (refer to Figure 18–04–3 or Figure 18–04–4).



FADEC V2.9.6.3 – ENG START DELAY
Figure 18–04–3



FADEC V2.9.6.3 – ENG START DELAY
Figure 18–04–4

For ambient conditions that require extended motoring, the motoring time will increase as a function of altitude and OAT.

The longest delay will be 62 seconds at 14000 feet with an OAT of –54°C (–65°F).

When **ENG START DELAY** is displayed on the EICAS page, the engine will motor at 12% N_2 for an extra 15 to 30 seconds (depending upon ambient conditions) as compared to a normal start (shaded area).

NOTE

The flight crews who used to operate engines equipped with FADEC V2.9.5 will observe a nominal ground start motoring time increase from 15 seconds to 30 seconds after the implementation of FADEC V2.9.6.3.

During the first engine start after the implementation of the FADEC software V2.9.6.3, the motoring time will be set by default to 69 seconds. Normal system behavior will resume after next engine start.

During the first engine start after the implementation of FADEC V2.9.6.3, the advisory message **ENG START DELAY** may be posted on the EICAS page throughout the entire motoring time.

During subsequent engine starts, the advisory message **ENG START DELAY** will be posted at start initiation only if the motoring time exceed 30 seconds.

Motoring time is counted from when the N_2 reaches 12%.

ENGINE FUEL SYSTEM – OVERVIEW

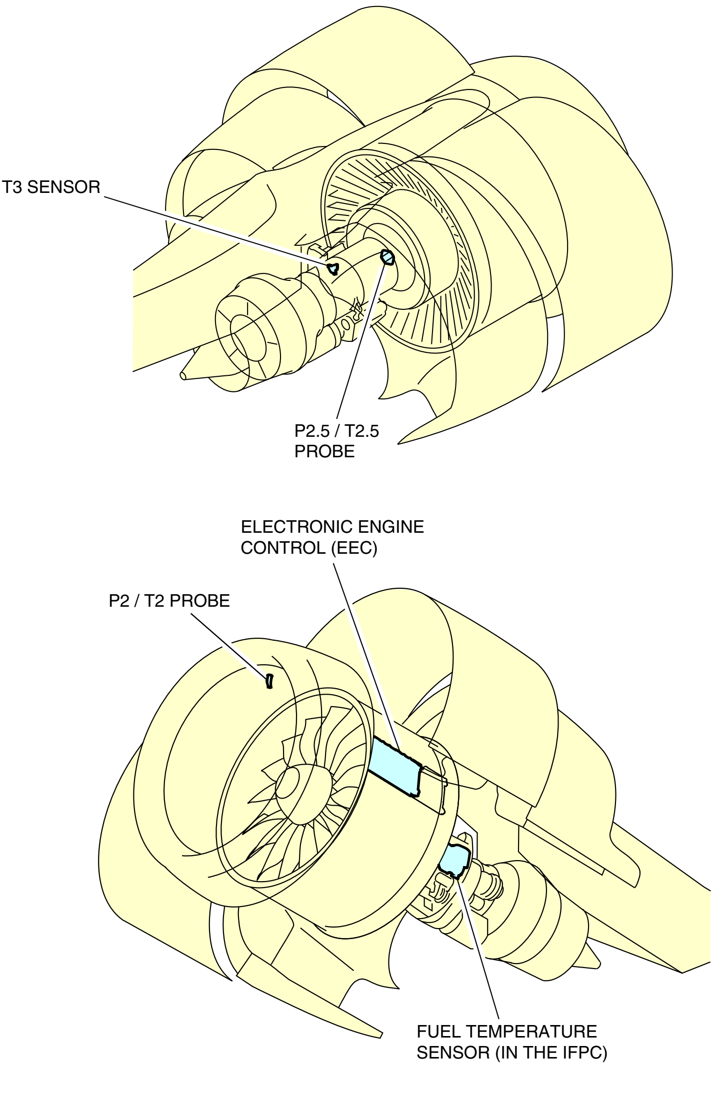
The engine fuel system supplies metered and pressurized fuel to the fuel nozzles and to the engine fuel-actuated valves and actuators. The fuel system can be divided into three subsystems:

- The fuel control system,
- The fuel distribution system, and
- The fuel indication system.

FUEL SYSTEM – DESCRIPTION AND OPERATION

A. Fuel control system

The fuel control system is managed by the Electronic Engine Control (EEC) to control the engine fuel flow and temperature, and to keep the engine within its operating limits. The EEC uses various sensors to manage the engine fuel system. Refer to Figure 18–05–1.



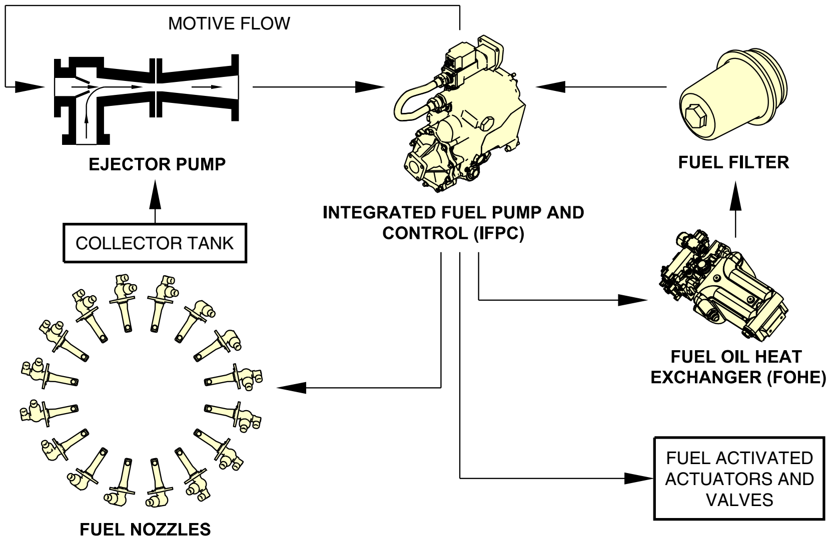
Engine fuel control system
Figure 18–05–1

The burner pressure sensor is used by the EEC for fuel scheduling, surge recovery, stall detection, and fuel topping. The fuel temperature sensor is used to monitor fuel temperature and is located in the Integrated Fuel Pump and Control (IFPC).

B. Fuel distribution system

The fuel distribution system supplies metered fuel to the nozzles and engine actuators at the necessary pressure (refer to Figure 18–05–2). It is controlled by the EEC and has the components that follow:

- Integrated Fuel Pump Control (IFPC),
- Fuel/Oil Heat Exchanger (FOHE),
- Fuel filter,
- Fuel manifolds and fuel nozzles,
- Compressor variable stator vane system, and
- Bleed valves and Active Clearance Control (ACC) valve.



Fuel distribution system (simplified)
Figure 18–05–2

C. Integrated Fuel Pump Control (IFPC)

The Integrated Fuel Pump and Control (IFPC) (refer to Figure 18–05–3) is driven by the engine Main Gearbox (MGB). The IFPC includes a two-stage pump and a fuel control unit. The first stage supplies fuel to the engine fuel distribution system components that follow:

- Fuel nozzles,
- FOHE,
- Fuel filter, and
- Fuel activated actuators and valves.

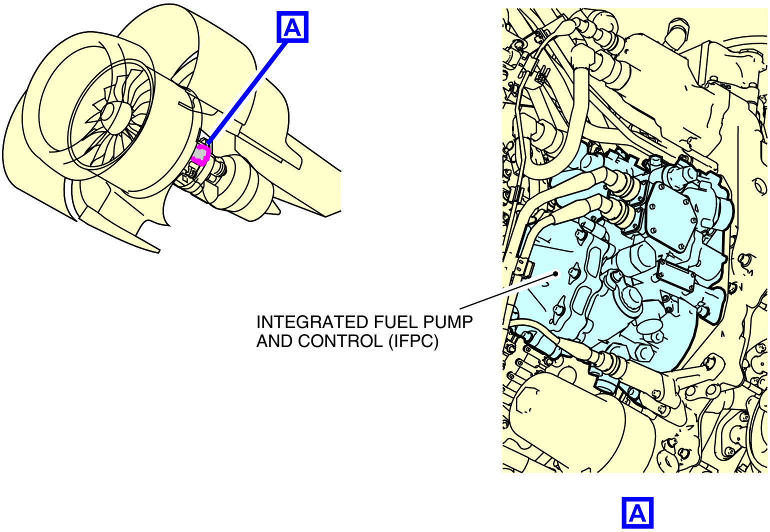
The second stage supplies motive fuel flow to the ejector pump.

The IFPC is also designed to:

- Shut off the fuel flow if there is an engine malfunction or fire,

- Help with engine oil cooling through the FOHE, and
- Supply fuel pressure to operate the HPC and LPC variable stator vanes and LPC bleed actuators.

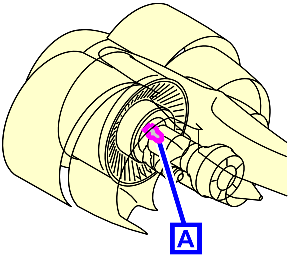
The IFPC temperature sensor and the flow meter send their data to the EEC for control and monitoring, and for display on the EICAS page.

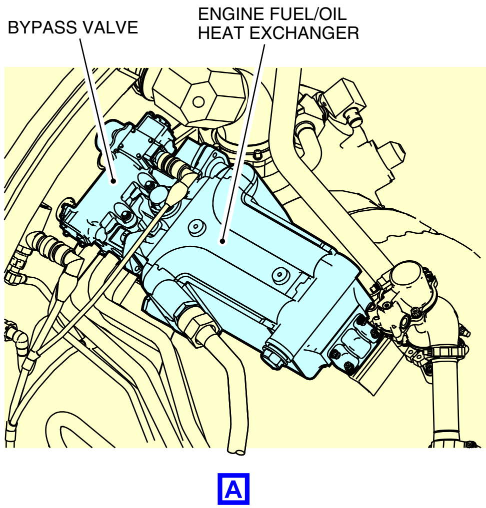


Integrated Fuel Pump and Control (IFPC)
Figure 18–05–3

D. Fuel/Oil Heat Exchanger (FOHE)

The Fuel/Oil Heat Exchanger (FOHE) heats the fuel to prevent ice formation (refer to Figure 18–05–4). The quantity of oil that flows through the FOHE to heat the fuel is controlled by the EEC and depends on the fuel temperature.

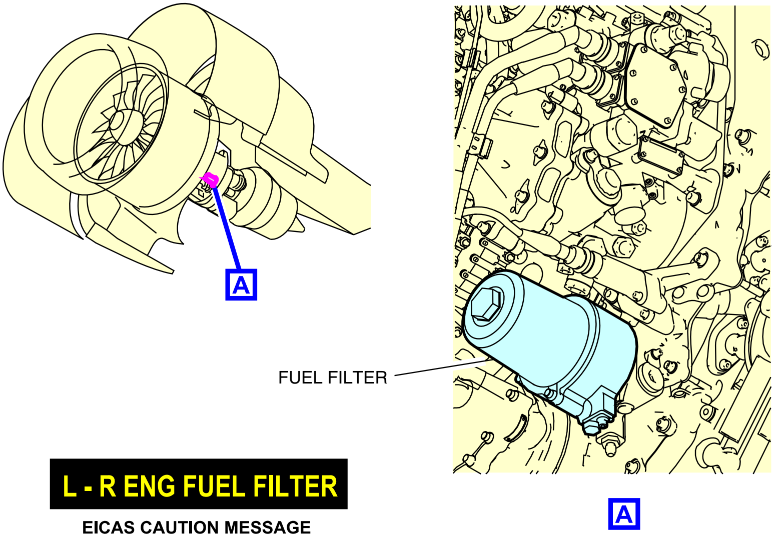




Fuel/Oil Heat Exchanger (FOHE)
Figure 18–05–4

E. Fuel filter

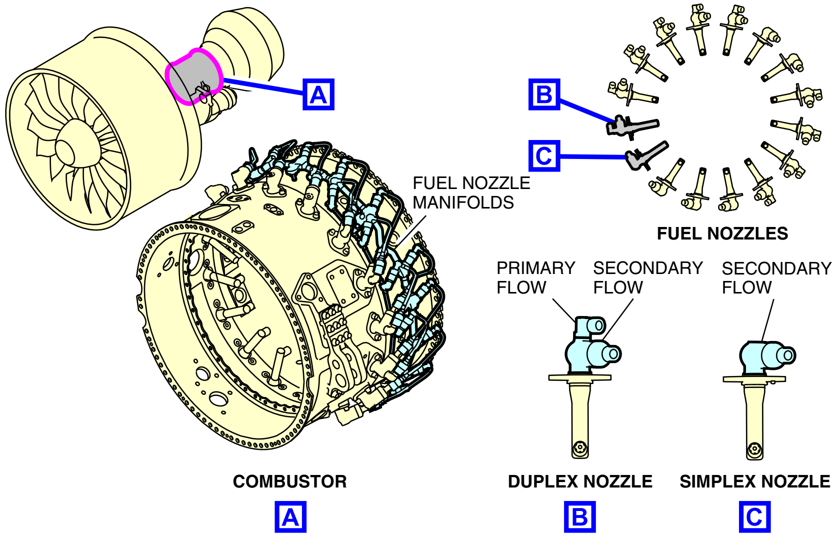
The fuel filter removes solid contaminants from the pressurized fuel that flows out of the IFPC (refer to Figure 18–05–5). The filter has a pressure differential switch to detect filter clogging. When the fuel filter is clogged, the fuel flows through the bypass valve and the caution message **L/R ENG FUEL FILTER** is displayed on the EICAS page.



Fuel filter
Figure 18–05–5

F. Fuel manifold and fuel nozzles

The fuel manifold goes from the collector tank to the IFPC and then to the fuel nozzles (refer to Figure 18–05–6). The fuel nozzles inject the atomized fuel inside the combustor and consist of duplex and simplex nozzles. The simplex nozzles supply the secondary fuel flow (for idle) and the duplex nozzles supply the primary and secondary fuel flow.

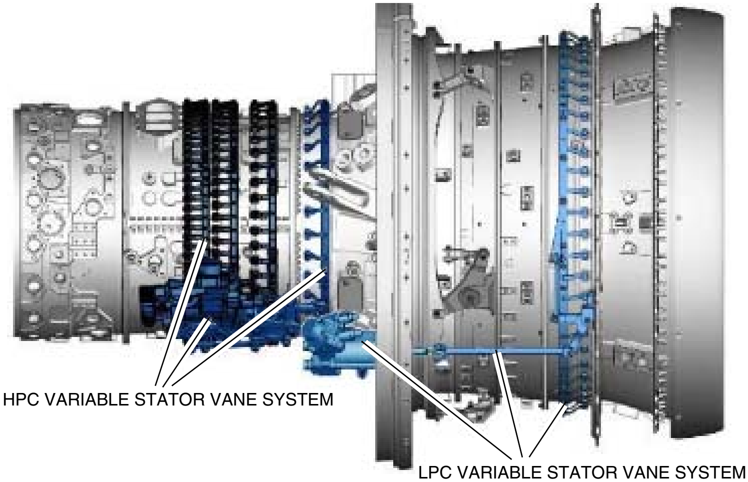


Fuel manifold and nozzles
Figure 18–05–6

G. Compressor variable stator vane system

The compressor variable stator vane system uses actuators to move the Low Pressure Compressor (LPC) and the High Pressure Compressor (HPC) stator vanes. The vanes adjust the direction of airflow for optimal engine operation.

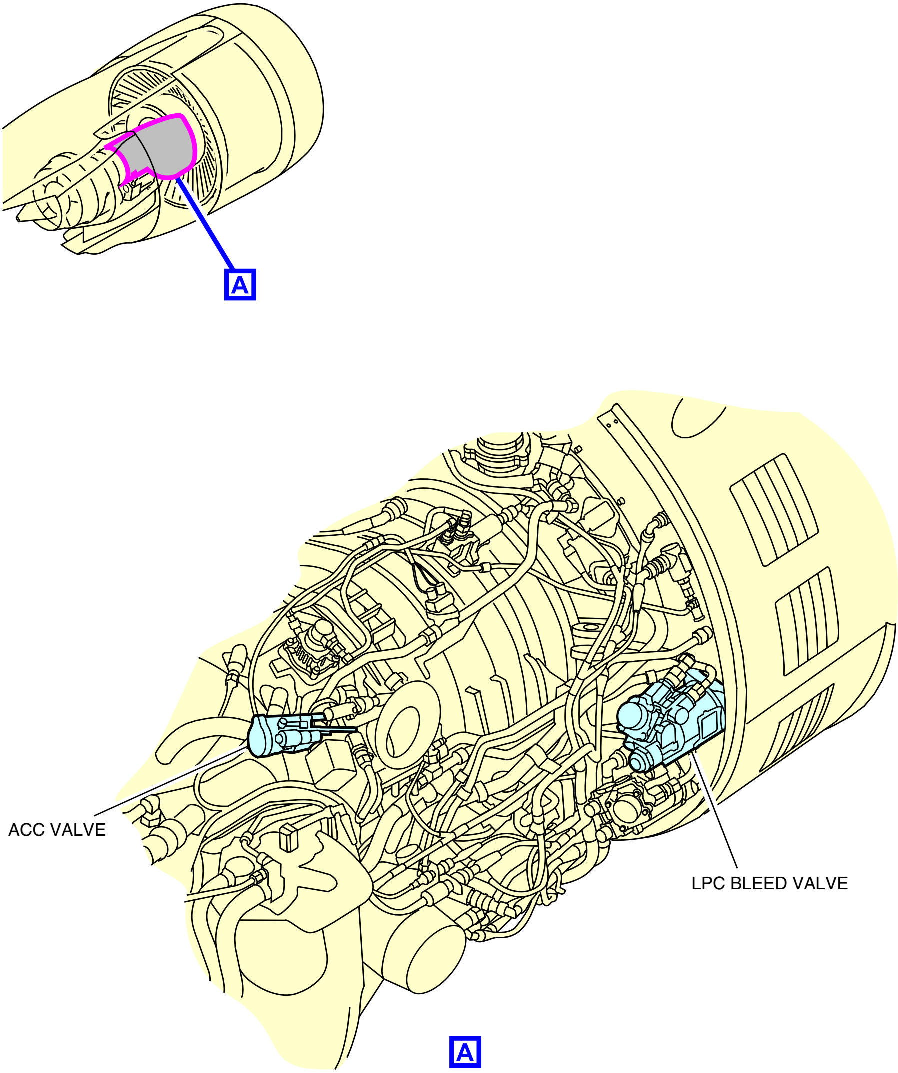
The actuators are moved by fuel pressure and commanded by the Electronic Engine Control (EEC), using schedules based on their respective engine N1 and N2 speeds.



Compressor variable stator vane system
Figure 18–05–7

H. Bleed valves and Active Clearance Control (ACC) valve

The LPC bleed valves and ACC valves are actuated by fuel pressure and are controlled by the EEC (refer to Figure 18–05–8).



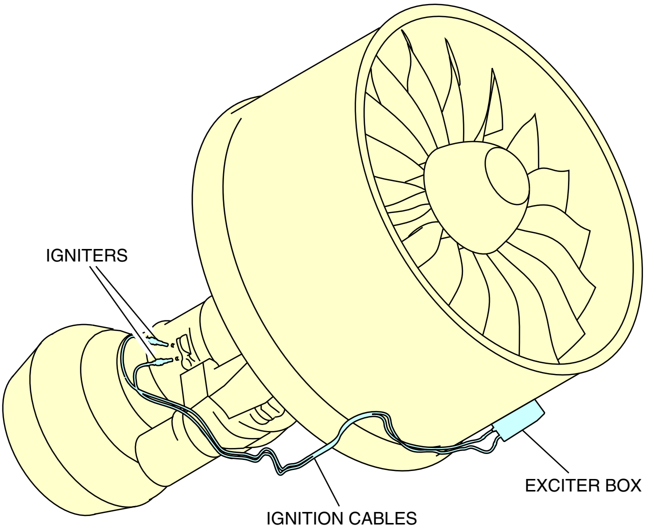
Bleed valves and Active Clearance Control (ACC) valve
Figure 18–05–8

ENGINE IGNITION SYSTEM – OVERVIEW

The ignition system is for start, relight, and flameout protection. It is controlled by the Electronic Engine Control (EEC) and consists of:

- One exciter box,
- Two ignition cables, and
- Two igniters.

Figure 18−06−1 shows the ignition system on the engine.



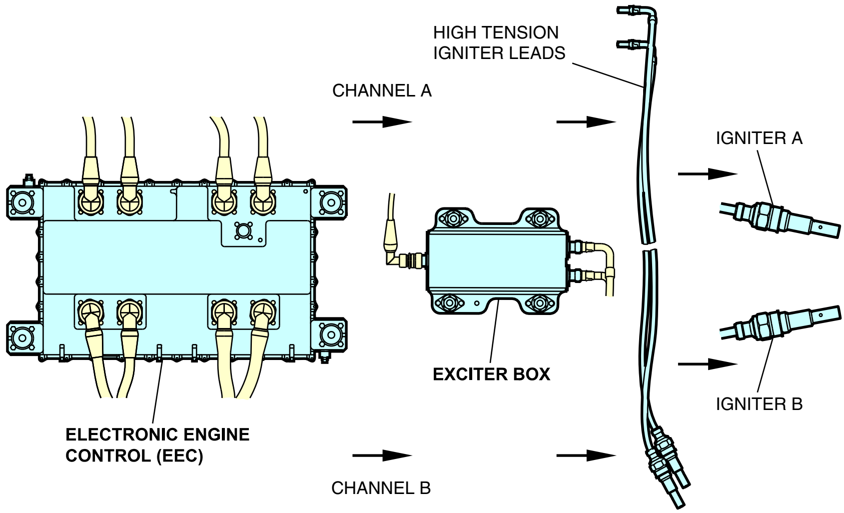
Ignition system
Figure 18−06−1

ENGINE IGNITION SYSTEM – OPERATION

Each engine has two electrically-independent ignition systems (refer to Figure 18–06–2). The exciter box converts low voltage into high voltage to ignite the fuel/air mixture in the combustor.

The ignition system receives power from the DC ESS BUSES, and is available during engine start, engine relight, or when environmental conditions require continuous ignition.

Each EEC channel controls one igniter. During the first automatic start attempt on-ground, the FADEC activates one igniter per engine. In subsequent automatic start attempts, the FADEC will alternate the igniter used in order to prolong ignitor life. During manual start attempts on-ground, the CONT IGNITION switch is selected to ON. During manual or automatic start attempts or in-flight, the EEC activates both igniters.



Ignition system operation
Figure 18–06–2

A. Continuous ignition

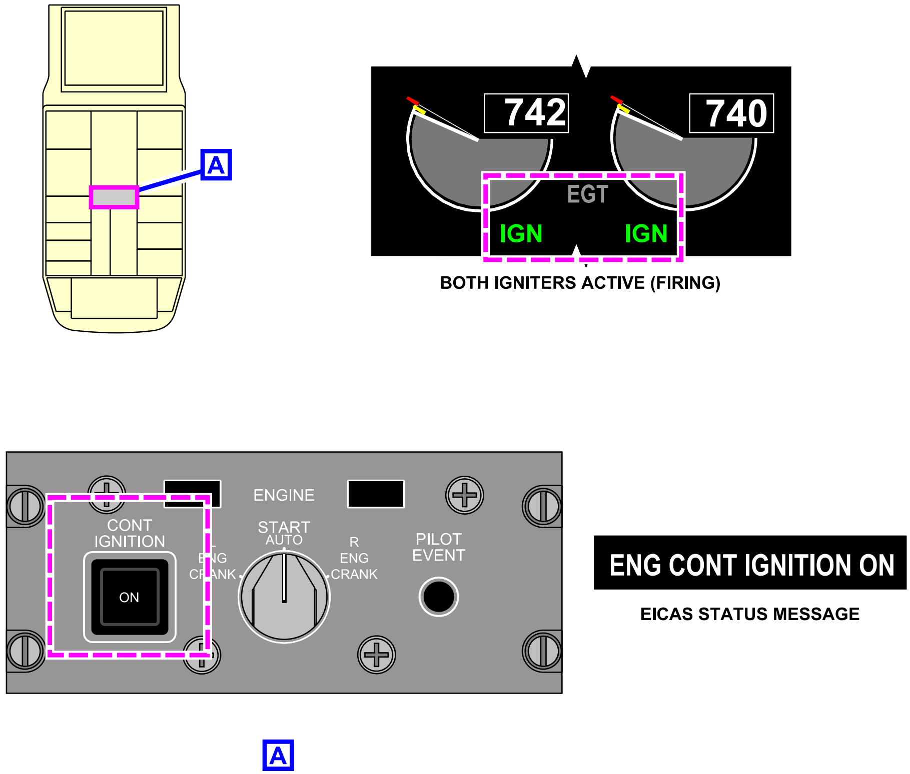
The continuous ignition system is activated automatically by the FADEC or manually by the flight crew.

The conditions that activate the continuous ignition system automatically are as follows:

- A second start attempt is required by the automatic start,
- During takeoff and landing phase, based on the Flight Management System (FMS) information,
- Cowl Anti-Ice System (CAIS) is turned on by automatic mode or manual mode,
- With the L ENG or R ENG run switch at ON and airspeed greater than 60 kt, engine flameout is detected within 2 seconds by the FADEC engine flameout protection logic, or
- Surge is detected in–flight or during takeoff.

The selection of the CONT IGNITION switch on the ENGINE panel (refer to Figure 18–06–3) manually activates the continuous ignition system. When the switch is pressed:

- A signal is sent to the EEC to activate the continuous ignition,
- The ON label on the switch illuminates white,
- The **ENG CONT IGNITION ON** status message is displayed on the EICAS page, and
- A green IGN flag is displayed under each Exhaust Gas Temperature (EGT) indication on the EICAS page.



Engine panel – CONT IGNITION (Continuous Ignition) switch ON
Figure 18–06–3

B. Dual ignition

Normally, the EEC alternates control channels after each subsequent start. The EEC automatically commands both igniter plugs to fire for the conditions that follow:

- Cowl anti-ice is selected,
- An engine flameout is detected,
- An in-flight start is attempted, or

- During takeoff, or if an in-flight surge is detected.

The FADEC automatic relight system energizes both igniters within 2 seconds of an engine flameout detection when the respective L ENG or R ENG switch is in the ON position and airspeed is greater than 60 kt.

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ENGINE OIL SYSTEM – OVERVIEW

The engine oil system cools, cleans, and lubricates the:

- Engine bearing compartments,
- Fan Drive Gear System (FDGS),
- Main Gearbox (MGB), and
- Angle Gearbox (AGB).

The oil system consists of:

- An oil tank,
- A lubrication and scavenge pump,
- An Oil Control Module (OCM),
- An Air/Oil Heat Exchanger (AOHE),
- A Fuel/Oil Heat Exchanger (FOHE), and
- An Oil/Oil Heat Exchanger (OOHE).

NOTE

The fan has a dedicated fan oil pump that isolates itself in certain conditions.

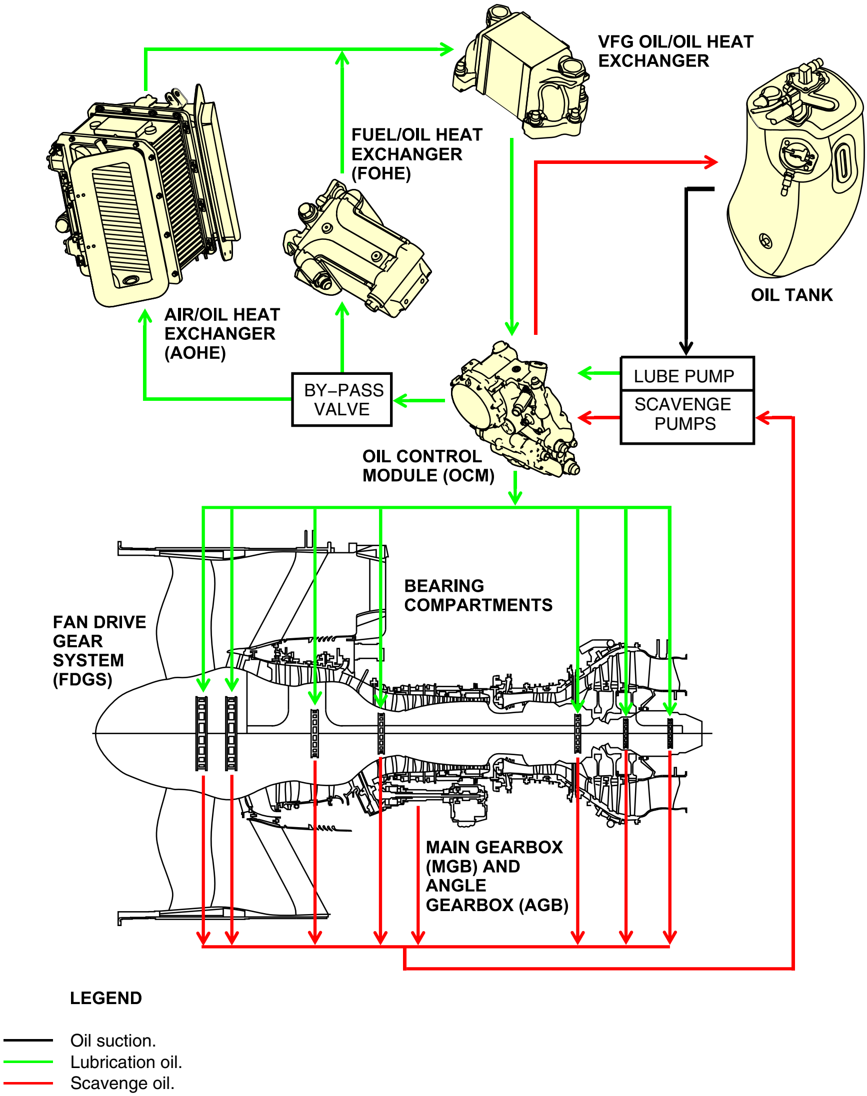
ENGINE OIL SYSTEM – DESCRIPTION AND OPERATION

A. Operation

Oil flows from the oil tank to the lubrication pump, where it is pressurized. Then it passes through the Oil Control Module (OCM) where it is filtered before being directed to the heat exchangers, and then through oil strainers, engine bearings, and gearboxes. The scavenge oil is returned to the tank by the scavenge side of the pump. Oil temperature, oil pressure, oil filtering, and debris monitoring functions are accomplished by the OCM.

A breather system releases the air/oil vapors from the system.

Figure 18–07–1 shows the oil distribution system.



Oil distribution system
Figure 18–07–1

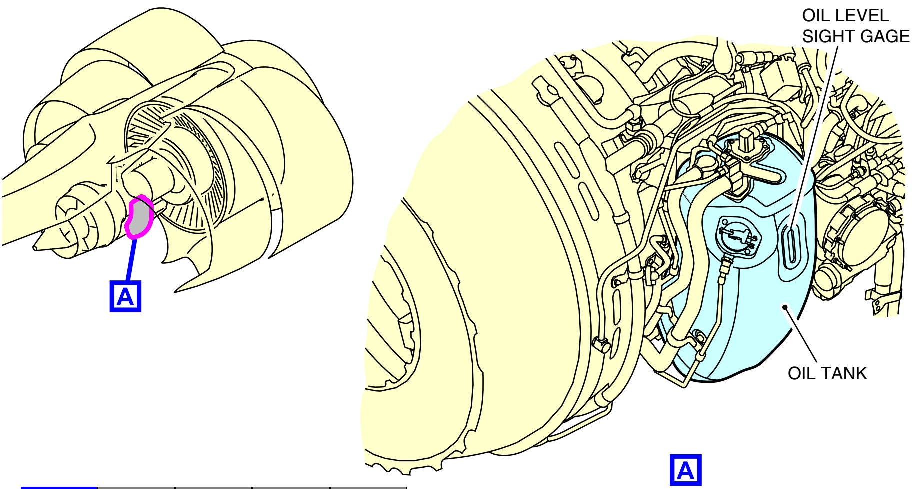
B. Oil tank

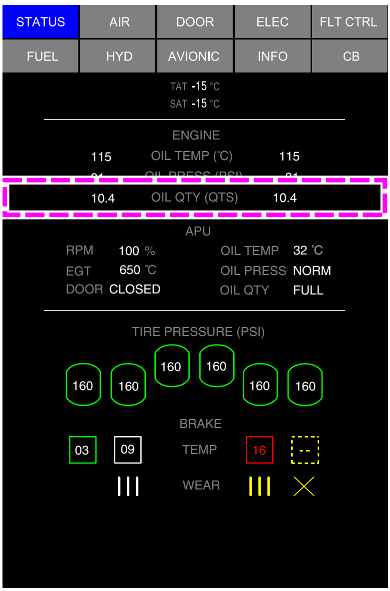
The oil tank is mounted on the right side of the engine and is accessible through an access panel. It has an oil level sensor, located in the tank, that transmits oil quantity to the STATUS synoptic page, and an oil level sight gauge, that allows a visual inspection.

The tank has a fill-to-spill quantity of 24.4 liters of oil and is pressurized. <Metric>

When low oil level is detected, a **L/R ENG OIL LO QTY** advisory message is displayed on the EICAS page (refer to Figure 18–07–2).

Figure 18–07–3 shows the engine oil indications legend.





STATUS PAGE

L ENG OIL LO QTY

R ENG OIL LO QTY

EICAS ADVISORY MESSAGES

Oil tank
Figure 18–07–2

OIL TEMPERATURE (OIL TEMP in grey)

Symbol	Color	Description
XX.X	WHITE	Oil temperature normal range
XX.X	YELLOW	Oil temperature above high oil temperature yellow line threshold.
XX.X	RED	Oil temperature above high oil temperature red line threshold
XX.X	YELLOW	Oil temperature below oil temperature threshold
---	YELLOW DASHED	Invalid oil temperature

OIL PRESSURE (OIL PRESS in grey)

Symbol	Color	Description
XX.X	WHITE	Oil press normal range
XX.X	YELLOW	Oil press above high oil press threshold
XX.X	RED	Oil press below low oil press threshold
---	YELLOW DASHED	Oil press invalid

OIL QUANTITY (OIL QTY in grey)

Symbol	Color	Description
XX.X	WHITE	Normal
XX.X	YELLOW	Below threshold
---	YELLOW DASHED	Invalid

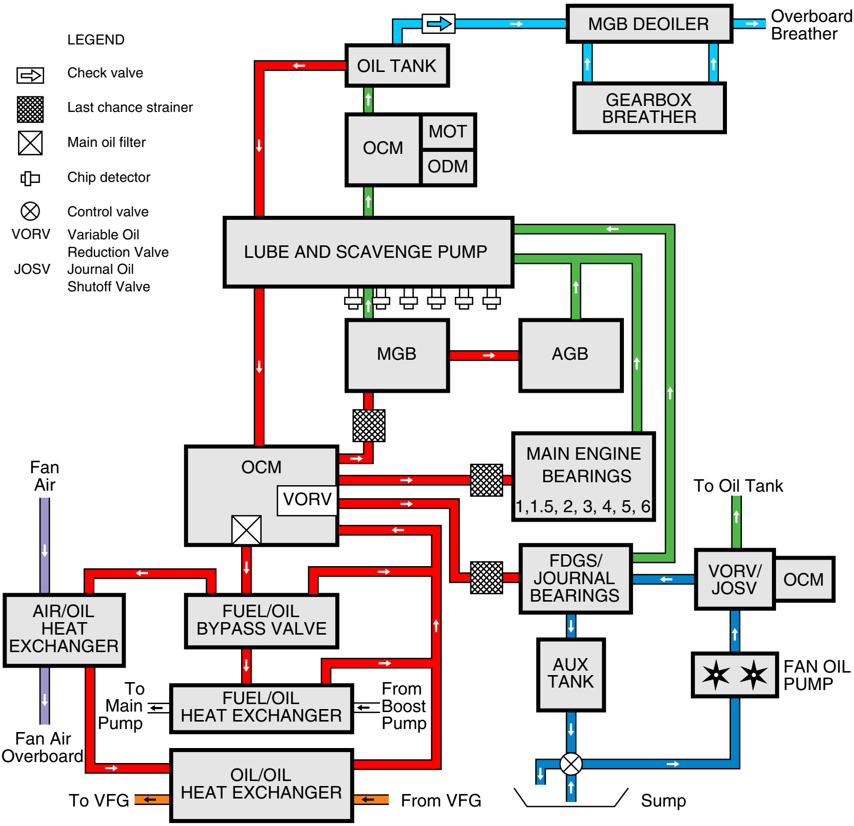
EICAS page and STATUS synoptic page – Engine oil indication legend
Figure 18–07–3

C. Lubrication and scavenge pump

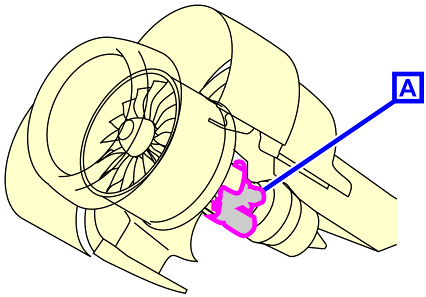
The oil system of each engine has one lubrication and scavenge oil pump with seven stages. Six stages remove scavenge oil and the seventh pressurizes. Oil from the tank is sent to the Oil Control Module (OCM) and to the components that follow (refer to Figure 18–07–4):

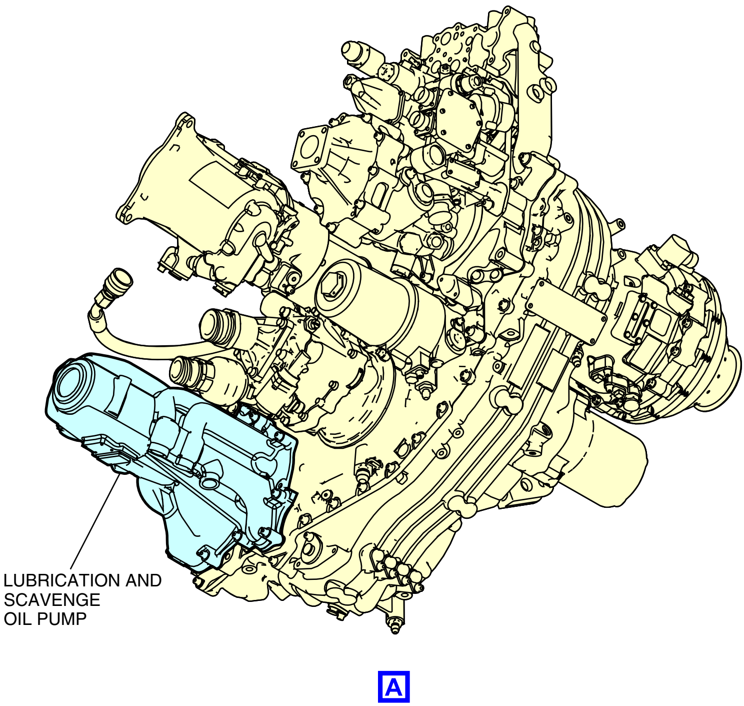
- The main engine bearings,
- The Fan Drive Gear System (FDGS),
- The Main Gearbox (MGB), and
- The Angle Gearbox (AGB).

The oil pump scavenge stages send the scavenged oil to the oil tank (refer to Figure 18–07–5). The return lines have magnetic chip detectors that provide indication of metallic particles in the oil.



Normal and auxiliary oil supply
Figure 18–07–4





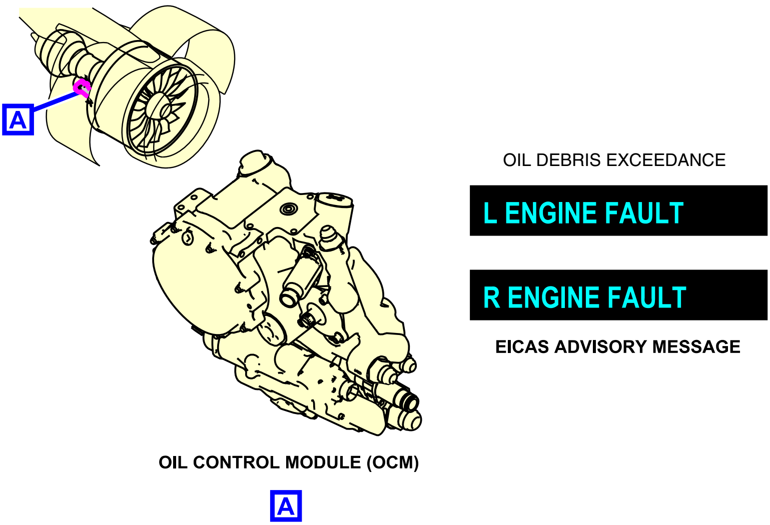
Main gearbox – Lubrication and scavenge oil pump
Figure 18–07–5

D. Oil Control Module (OCM) and oil debris monitoring function

The Oil Control Module (OCM) (refer to Figure 18–07–6) filters the oil, senses the oil pressure and temperature, monitors debris, and sends the oil to the engine bearings, Fan Drive Gear System (FDGS), Main Gearbox (MGB), Angle Gearbox (AGB), and to the heat exchangers. It contains:

- An oil filter,
- A pressure sensor,
- A temperature sensor, and
- An oil debris sensor.

When the debris count exceeds a certain threshold, an advisory message **L/R ENGINE FAULT** displays on the EICAS page.

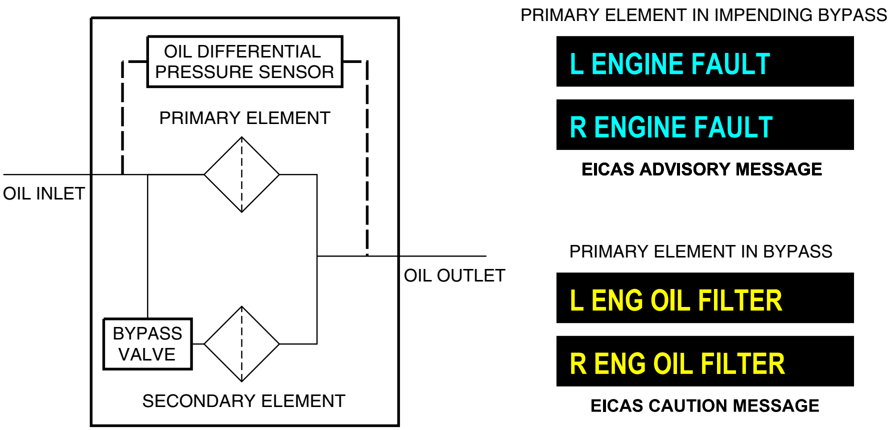


Oil Control Module (OCM)
Figure 18–07–6

(1) Oil filter

The oil filter removes contamination from the pressurized oil. It consists of a primary element, a secondary element, and a differential pressure sensor. When the differential pressure of the primary filter reaches a ΔP of 35 psi, an indication of an impending bypass is given by a **L/R ENGINE FAULT** advisory message on the EICAS page. When the differential pressure of the primary filter element exceeds a ΔP of 55 psi, the oil goes to the secondary filter element through the bypass valve and a **L/R ENG OIL FILTER** caution message displays on the EICAS page.

Figure 18–07–7 shows an overview of the oil filtering system.



Oil filter
Figure 18–07–7

(2) Oil pressure and temperature sensors

The pressure and temperature sensors measure and send data to the EEC for monitoring and EICAS display.

(3) Oil debris sensor

The oil debris sensor detects and sends debris count information to the Prognostics and Health Monitoring Unit (PHMU) for processing. When the debris count exceeds a specified threshold, the PHMU reports the data to the EEC to generate a **L/R ENGINE FAULT** advisory message.

E. Oil system heat exchangers

The engine oil system has three heat exchangers:

- A Fuel/Oil Heat Exchanger (FOHE),
- An Air/Oil Heat Exchanger (AOHE), and
- A Variable Frequency Generator (VFG) Oil/Oil Heat Exchanger (OOHE).

(1) Fuel/Oil Heat Exchanger (FOHE)

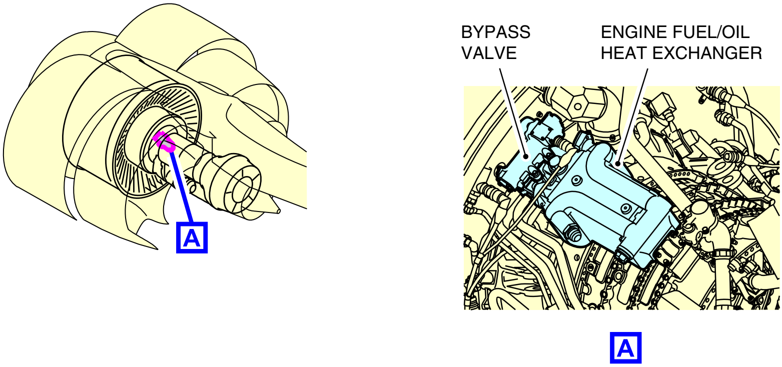
The FOHE heats the engine fuel with the engine oil. A part of the oil that flows from the OCM is routed to the FOHE, depending on the fuel temperature. The amount of oil flowing into the FOHE is controlled by the EEC through a bypass valve (refer to Figure 18–07–8).

(2) Air/Oil Heat Exchanger (AOHE)

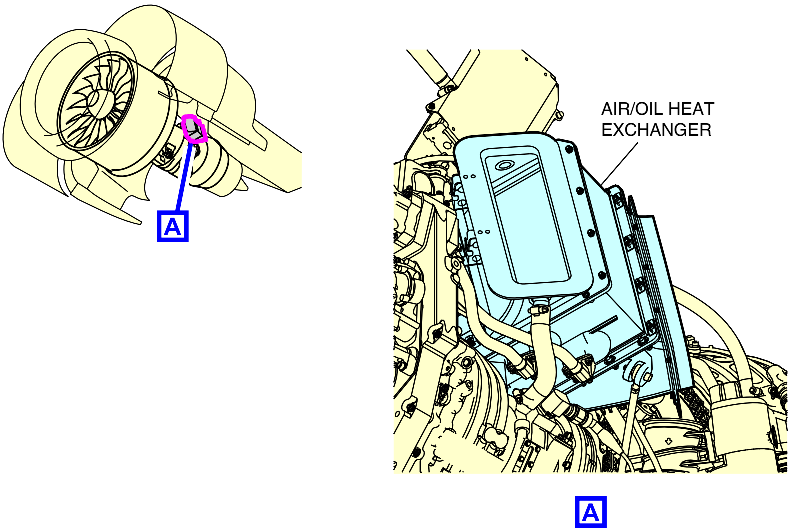
The AOHE cools the engine oil with the fan air. When the engine fuel temperature is higher than a specified value, heat transfer to the fuel is unnecessary. The EEC will then increase the oil flow through the AOHE and decrease the oil flow to the FOHE. The unit has a bypass valve that opens when the AOHE is clogged (refer to Figure 18–07–9).

(3) Variable Frequency Generator (VFG) Oil/Oil Heat Exchanger (OOHE)

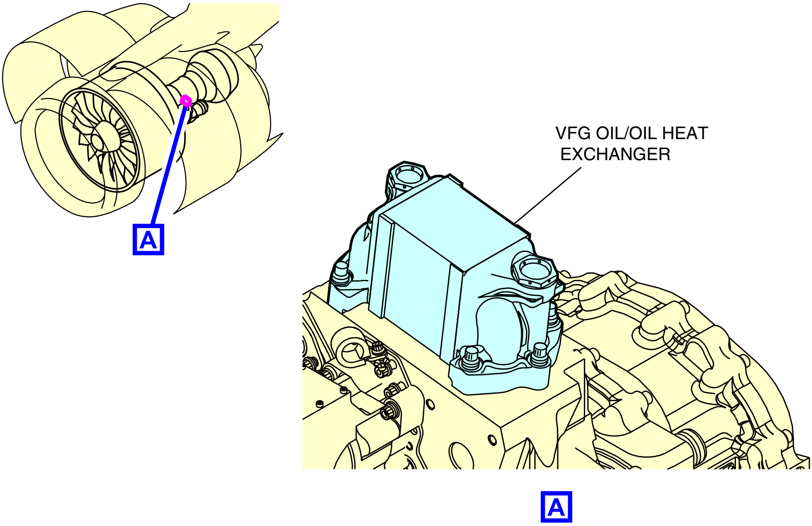
The oil from the AOHE goes to the VFG oil/oil heat exchanger to cool the VFG oil (refer to Figure 18–07–10).



Fuel/Oil Heat Exchange (FOHE)
Figure 18–07–8



Air/Oil Heat Exchanger (AOHE)
Figure 18–07–9

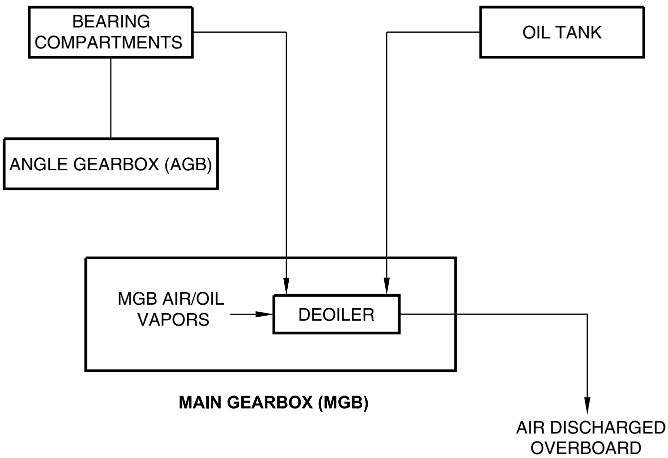


VFG Oil/Oil Heat Exchanger (OOHE)
Figure 18–07–10

F. Breather system

The pressurized oil vapors from the bearing compartments, Angle Gearbox (AGB), Main Gearbox (MGB), and the oil tank are released by the breather system. It consists of external tubes connected to a deoiler located in the MGB. The deoiler separates oil droplets from air and discharges the air overboard.

Figure 18–07–11 shows an overview of the breather system.



Breather system
Figure 18–07–11

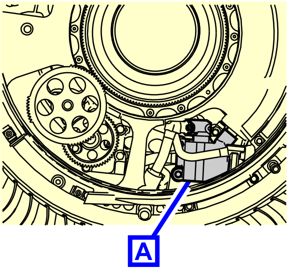
G. Auxiliary distribution system

The auxiliary distribution system lubricates the Fan Drive Gear System (FDGS) bearings and protects it from events that could cause oil supply loss. It consists of:

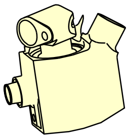
- One auxiliary oil tank,
- One fan-driven oil pump, and
- One gravity valve.

The system has two FDGS journal bearing oil supply modes. During normal conditions, oil flows back to the oil tank before returning to the FDGS. During low power, windmilling, or low G events, oil is directed straight back to the FDGS.

Figure 18–07–12 shows the location of the gravity valve and an overview of the auxiliary distribution system.

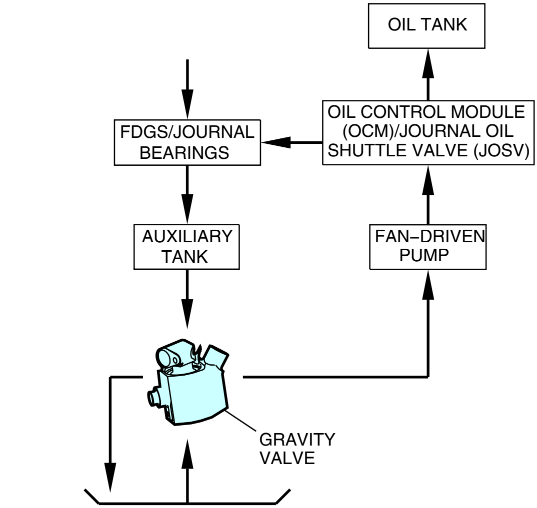


FRONT BEARING SUPPORT



GRAVITY VALVE

A



Auxiliary distribution system
Figure 18–07–12

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ENGINE BLEED AIR SYSTEM – OVERVIEW

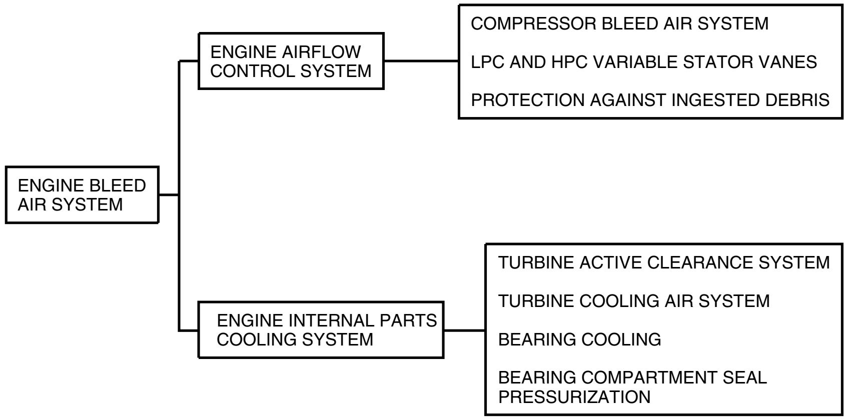
The engine bleed air system functions are:

- Engine airflow control,
- Engine parts cooling,
- Ingested debris removal, and
- Environmental control (refer to Chapter 02: Air-conditioning, bleed air, pressurization.

Engine airflow control removes the excess air and optimizes the airflow to improve engine stability during start, transient, and reverse thrust operation. Engine compartments are cooled to increase durability and performance. Ingested debris is removed from the Low Pressure Compressor (LPC) to prevent it from reaching the High Pressure Compressor (HPC). The engine bleed air system components consist of:

- Compressor bleed air system,
- Compressor variable stator vane system,
- Turbine cooling air system,
- Buffer air system (bearing cooling and seal pressurization system), and
- Turbine case Active Clearance Control (ACC) system.

Figure 18–08–1 shows an overview of the engine bleed air system.



Engine bleed air system overview
Figure 18–08–1

ENGINE BLEED AIR SYSTEM – DESCRIPTION AND OPERATION

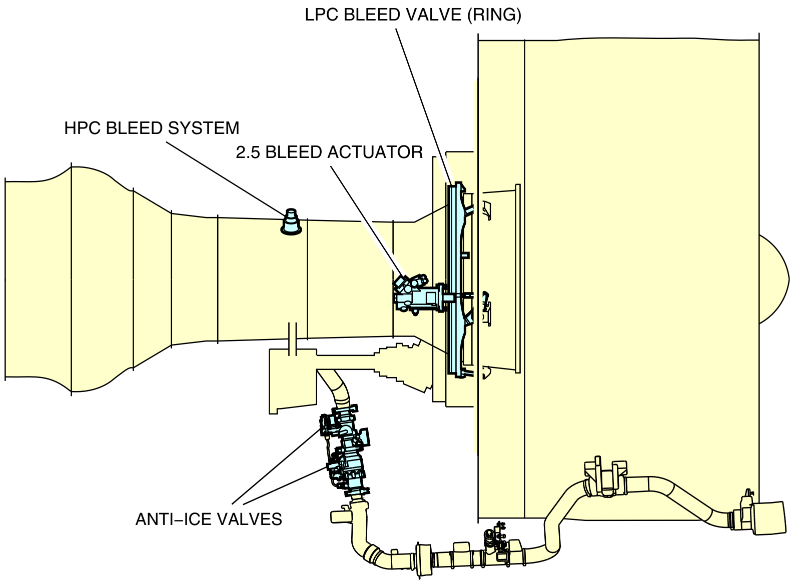
A. Compressor bleed air system

The compressor bleed air system removes excess air from the Low Pressure Compressor (LPC) and High Pressure Compressor (HPC) to prevent compressor stalls. This improves engine durability and stability. The system is controlled and monitored by the Electronic Engine Control (EEC). The main components are:

- The LPC bleed valve,
- The HPC bleed valve, and
- The Cowl Anti-Ice Valve (CAIV).

The LPC bleed valve (ring) removes excess air from the LPC for compressor stability. The valve is moved by a fuel-actuated actuator, which is controlled by the EEC based on several engine parameters.

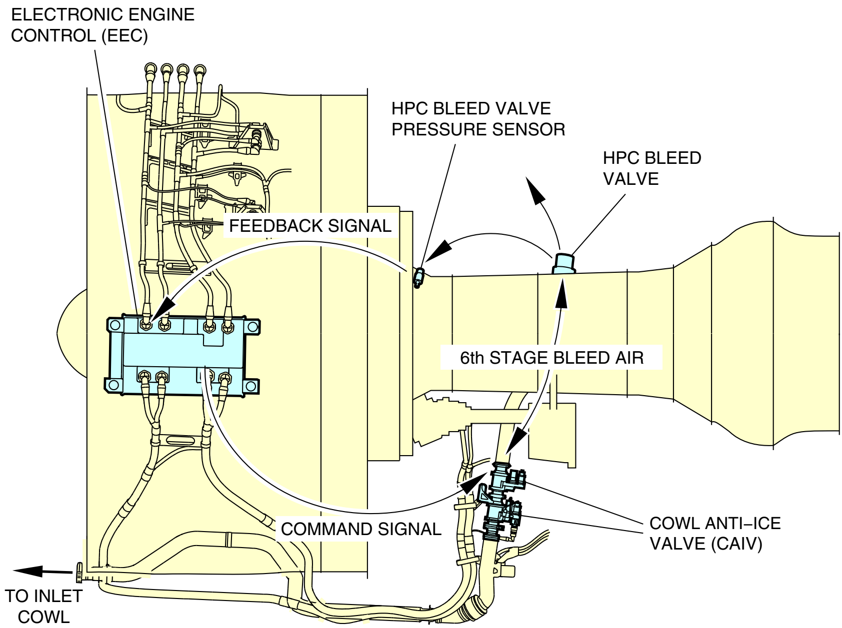
Figure 18–08–2 shows the location of the components of the compressor bleed air system.



LPC Compressor bleed air system
Figure 18–08–2

The HPC bleed valve is a passive valve that operates in conjunction with the CAIV during start to expel air from the HPC. It is monitored, but not controlled, by the EEC. When the engine is started, the EEC commands the CAIV to open and the HPC (6th stage) air is vented overboard through the HPC bleed valve and the CAIV. The HPC bleed valve is spring-loaded to the open position and closes when the air pressure is high enough to overcome the spring force of the valve.

Figure 18–08–3 shows the HPC bleed valve and the CAIV during start.



HPC bleed valve and CAIV operation during start
Figure 18–08–3

To prevent icing of the nacelle inlet cowl, the EEC controls two CAIV that regulate 6th stage bleed airflow. The valves are commanded open when the aircraft anti-ice system senses icing conditions when the L/R COWL switches on the ANTI-ICE panel are selected to AUTO, or when manually selected from the flight deck. Two temperature sensors in the fan cowl area monitor for CAI duct leaks.

Bleed air is also used to extract rain and ice from the gas path during flight operation, and to extract ingested debris during ground operations.

B. Compressor variable stator vane system

The compressor variable stator vane system controls the position of the LPC and the HPC stator vanes to optimize airflow and to increase engine performance during all phases of flight. The stator vanes are moved by fuel-actuated actuators controlled by the EEC. The EEC control is based on several engine parameters.

The table that follows describes the position of the LPC and HPC variable stator vanes during start, idle, and takeoff.

	Start	Idle	Takeoff
LPC variable stator vanes	Open	Closed	Open
HPC variable stator vanes	Closed	Closed	Open

C. Turbine air cooling system

The turbine air cooling system supplies continuous cooling air to the High Pressure Turbine (HPT) 2nd stage stator vanes, the Turbine Intermediate Case (TIC), the Low Pressure Turbine (LPT) case, and the LPT rotor. The air for the HPT comes from the High Pressure Compressor (HPC) 6th stage bleed air, while the rest comes from the HPC 4th stage bleed air.

D. Buffer air system

The buffer air system cools the main bearing compartments, and supplies sealing air to prevent oil leakage by taking air from the 4th or 6th stage of the HPC. The main components of the system are:

- Buffer Air Valve (BAV),
- Buffer air heat exchanger, and
- Buffer air temperature sensor.

E. Turbine Active Clearance Control (ACC) system

The turbine Active Clearance Control (ACC) system limits the thermal expansion of the turbine case by using fan air to maintain the blade tip clearance at a minimum, thus increasing turbine efficiency and reducing fuel consumption. The main component of the system is the ACC valve. The unit is a fuel-actuated valve controlled by the EEC based on the engine parameters and altitude.

F. Precooler exit door opening system

The precooler exit door supplies pressure relief for the precooler exhaust during high bleed demand. It is closed by the EEC based on aircraft bleed demand. If the door fails open, or is commanded open, a **L/R ENG PCE DOOR OPEN** advisory message is displayed on the EICAS page and high temperature bleed air is dumped into the engine nacelle.

G. Bleed air engine start

When the ENGINE START switch is set to AUTO, and the L (R) ENG switch is selected ON, the EEC senses that the HPC bleed valve is open. The inlet CAIV is commanded open to evacuate HPC bleed air and reduce load on the N2 for start.

After engine start, high-pressure air overcomes the HPC bleed valve spring force, and the valve closes.

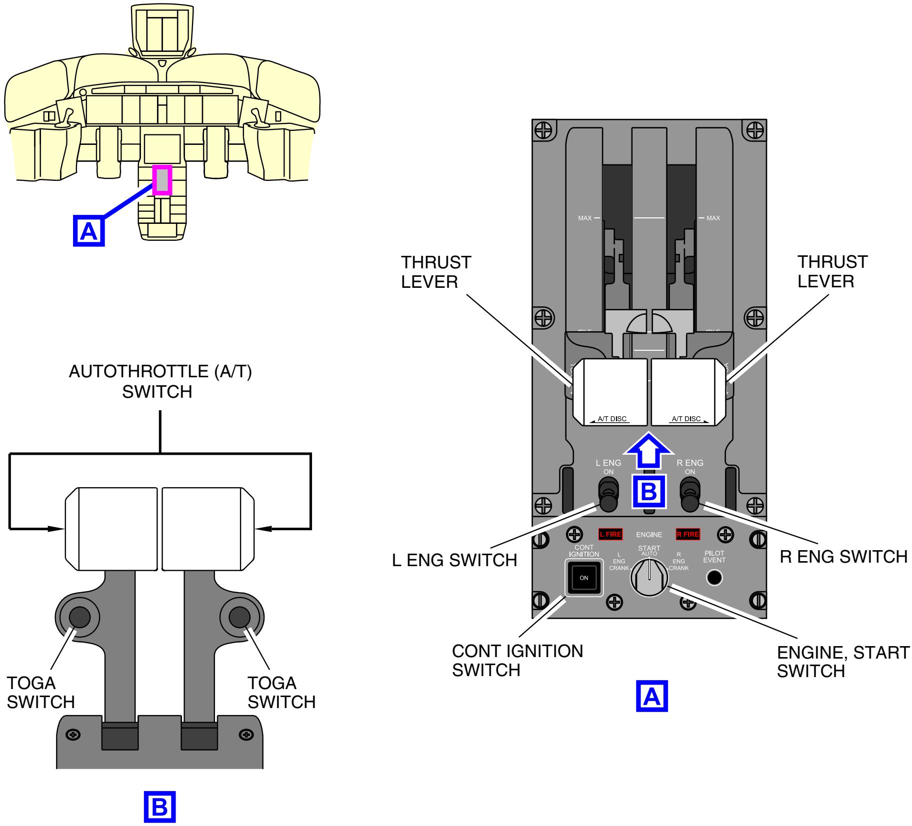
ENGINE CONTROLS

A. Throttle Quadrant Assembly (TQA) and ENGINE panel

The Throttle Quadrant Assembly (TQA) (refer to Figure 18–09–1) is located on the center pedestal and includes:

- Thrust levers,
- Thrust reverser levers,
- L ENG and R ENG run switches,
- A/T DISC switches, and
- TO/GA switches.

The thrust levers have stops at maximum (MAX) thrust, IDLE, and maximum reverse (MAX REV) thrust.



Throttle Quadrant Assembly (TQA) and ENGINE panel
Figure 18–09–1

(1) Thrust reverser levers

The thrust reverser system is actuated by raising the finger lifts on the front of the thrust levers and drawing the thrust levers aft into the reverse range. The landing maximum reverse and aborted takeoff are available when the thrust levers are at the MAX REV position. The maximum landing reverse thrust supports the landing maneuver from thrust reverser deployment down to a speed of 60 kt.

(2) L ENG and R ENG run switches

The switches have two positions:

- ON: With the START switch at AUTO, the ON position commands the Electronic Engine Control (EEC) to initiate the start sequence:
  - The Starter Air Valve (SAV) opens,
  - The igniters are energized, and
  - Fuel is automatically injected at 18% to 20% N2.

When the N2 reaches approximately 51%, the EEC closes the SAV and the igniters are de-energized.

- OFF: The engine cannot be started. But it can be cranked (no fuel and no ignition) when the START switch is selected to L ENG CRANK or R ENG CRANK.

(3) A/T DISC switches

When either of the switches are pressed, the Autothrottle (AT) system disconnects and a flashing AT (in amber) displays on the Flight Mode Annunciator (FMA) with an aural “AUTOTHROTTLE” alert. Pushing the switch again cancels the alert.

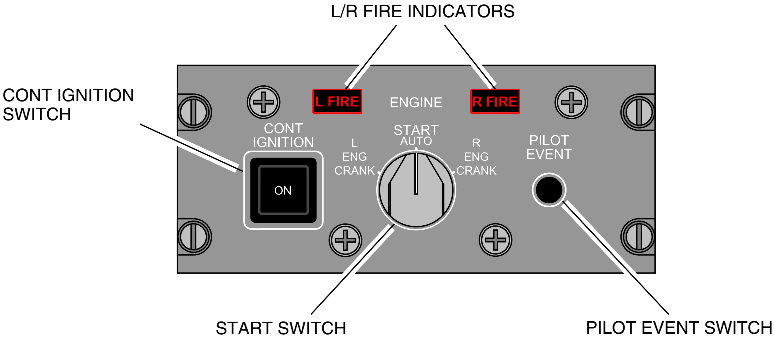
(4) TOGA switches

When either of the switches is pressed, the Take Off or Go-Around (TOGA) around mode is engaged. A TO (in green) or GA (in green) annunciation displays on the FMA depending on the phase of flight.

B. ENGINE panel

The ENGINE panel (refer to Figure 18–09–2) is on the center pedestal. It has three switches and two indicators:

- CONT IGNITION switch,
- L/R FIRE indicators,
- START switch, and
- PILOT EVENT switch.



Engine panel
Figure 18–09–2

(1) CONT IGNITION switch

When pressed in, the ON label on the switch illuminates white and provides continuous ignition if the engines are running. If the engines are not running, it provides a manual start request to the EEC.

(2) L/R FIRE indicators

The indicators are illuminated red if fire is detected in the corresponding engine.

(3) START switch

The switch has three positions:

- AUTO: When the switch is set to AUTO and the L/R ENG run switches are selected ON, the EEC initiates the start sequence.
- L or R ENG CRANK: Allows dry cranking of the engine with L/R ENG run switches set to OFF or begins engine cranking for a manual start.

(4) PILOT EVENT switch

When pressed in, the aircraft parameters recorded by the Flight Data Recorder (FDR) are marked for maintenance investigation.

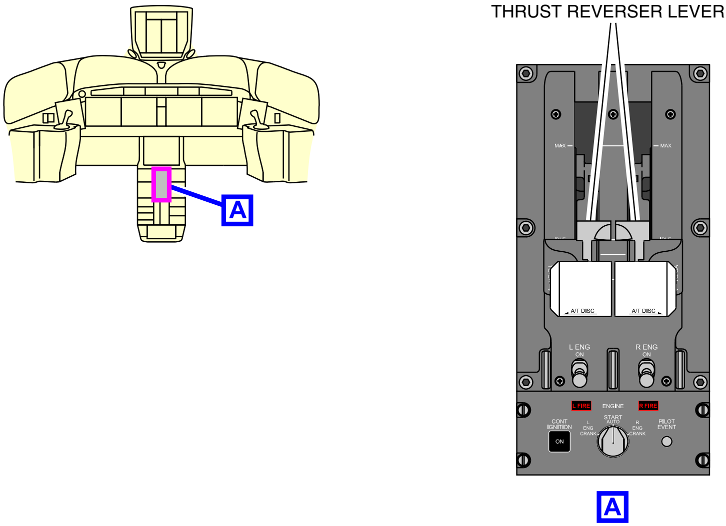
THRUST REVERSERS SYSTEM

The thrust reversers are translating-sleeve fixed-cascade type and have the components that follow:

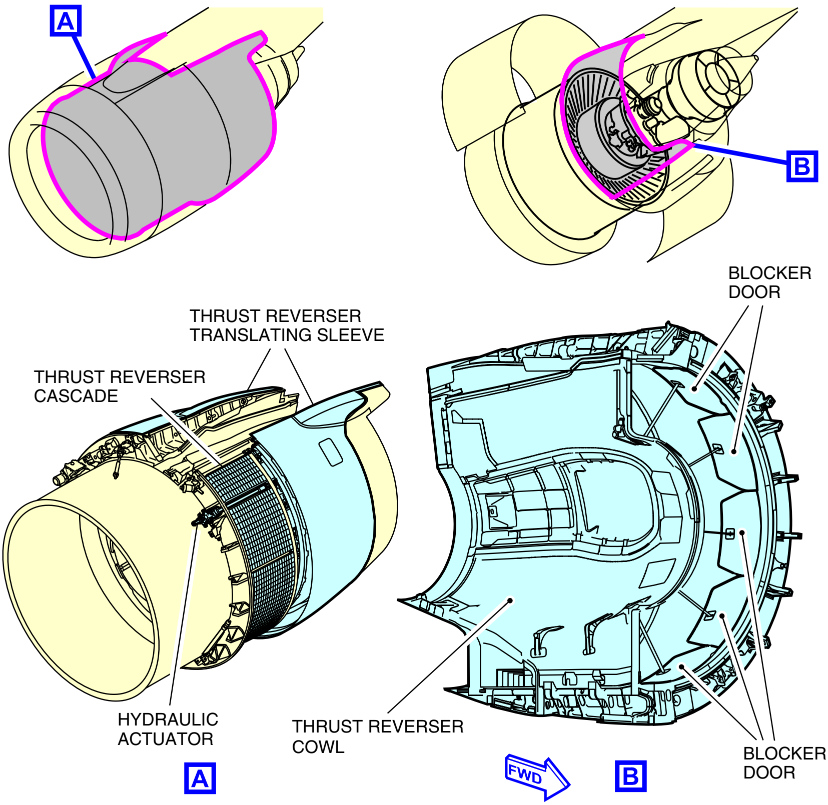
- Translating sleeves,
- Synchronized hydraulic actuators,
- Hydraulic Control Unit (HCU),
- Blocker doors,
- Thrust reverser cascades, and
- Manual drive.

The thrust reverser levers (refer to Figure 18–09–3) control their respective thrust reversers.

Figure 18–09–4 shows the thrust reverser system components.



Thrust reverser levers
Figure 18–09–3



Thrust reversers
Figure 18–09–4

A. Thrust reverser system – Operation

When deployed, the synchronized hydraulic actuators move the translating sleeves aft, which causes the blocker doors to rotate. This redirects the fan airflow through the cascades and provides reverse thrust. The actuators have a locking mechanism, position feedback sensors, and proximity switches for lock engagement status.

B. Thrust reverser system – Baulk function

The baulk mechanism will provide the flight crew with a tactile feedback to indicate thrust reverser state during deployment or stowage cycles. The mechanism can be overridden when a significant amount of force is applied to the thrust reverser levers.

During deployment, the baulk mechanism blocks the thrust levers in the idle position until thrust reverser deployment is confirmed. After deployment, the mechanism allows the thrust levers to enter in the reverse thrust range.

During stowage, the baulk mechanism blocks the thrust levers in the forward idle position until thrust reverser stowage is confirmed and securely closed and locked.

C. Thrust reverser indications

The REV icon is displayed inside the analogue engine N1 indicator on the EICAS page (refer to Figure 18–09–5). The color of the icon denotes the conditions that follow:

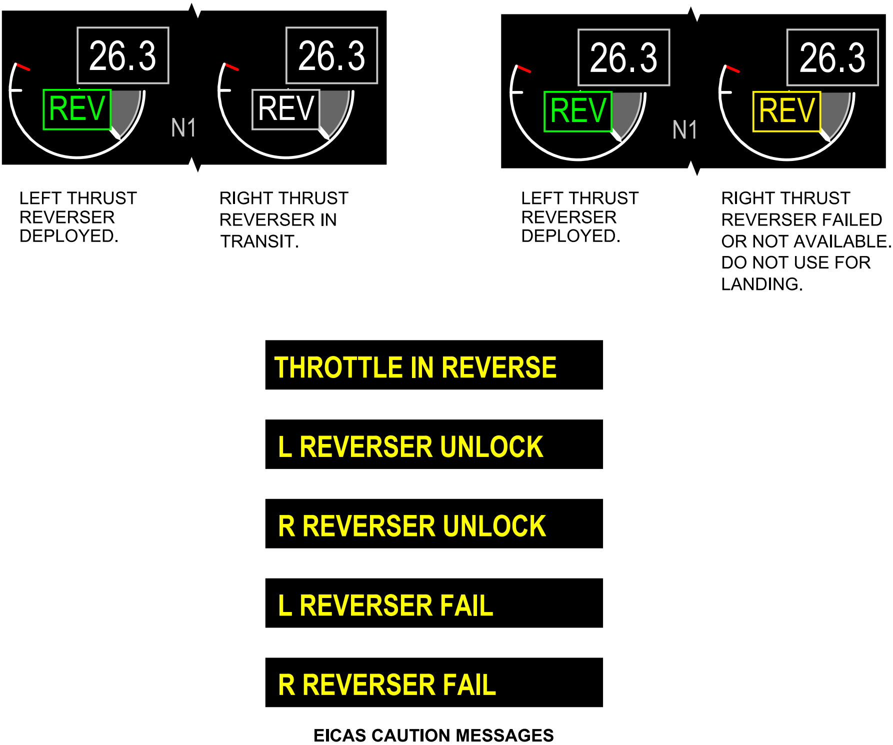
- Green: The reverser is fully deployed,
- White: The reverser is translating between the stowed and deployed position, or
- Amber: The reverser did not complete deployment or retraction command.

The thrust reverser system displays the EICAS messages that follow:

- The caution messages:
  - **L REVERSER UNLOCK** and **R REVERSER UNLOCK**: The thrust reverser has not been commanded but is unlocked and/or not stowed.
  - **L REVERSER FAIL** and **R REVERSER FAIL**: The thrust reverser has been commanded but failed or is unavailable.
  - **THROTTLE IN REVERSE**: The left or right throttle lever has been moved into the reverse thrust position on the Throttle Quadrant Assembly (TQA) in flight.

- The status messages:
  - **L REVERSER INHIBIT** and **R REVERSER INHIBIT**: The thrust reverser has been manually locked out through maintenance action.

.



Thrust reversers deployment malfunctions
Figure 18–09–5

THRUST MANAGEMENT SYSTEM

A. Thrust management system – Overview

The thrust management is monitored and controlled by the Electronic Engine Control (EEC) and the Flight Management System (FMS). It is available for all phases of flight and it consists of:

- Maximum Takeoff (MTO),
- Maximum Continuous Thrust (MCT),
- Derated takeoff thrust management,
- Reduced (FLEX) takeoff thrust management,
- Climb thrust management,
- Cruise thrust management,
- Idle thrust management, and
- Automatic Power Reserve (APR).

The EEC sets the maximum thrust available at the maximum thrust lever position inside the takeoff envelope and outside the takeoff envelope. The Maximum Takeoff (MTO) thrust is the maximum thrust available inside the takeoff (and go-around) envelope. It is always available at takeoff when the thrust levers are pushed to the MAX position. The Maximum Continuous Thrust (MCT) is the maximum thrust available outside the takeoff envelope and it is lower or equal to the MTO and higher or equal to the climb thrust (CLB).

When the Autothrottle (AT) system is engaged, the thrust lever is adjusted automatically to the position corresponding to the selected climb rating.

The thrust mode changes, from Takeoff (TO) to MCT or CLB to MCT, are commanded by the EEC in accordance with the active flight plan.

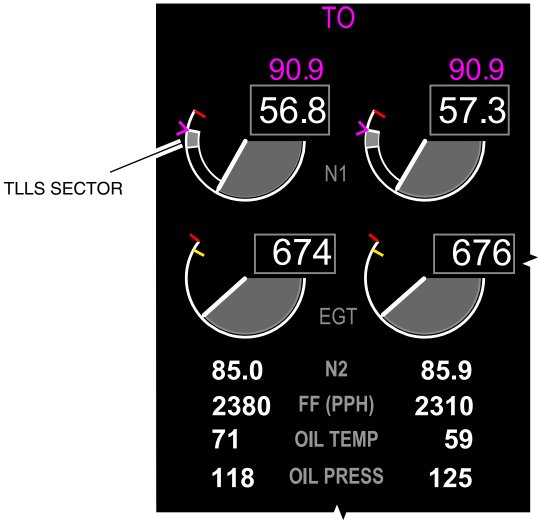
The EEC resets engine redline limits from TO to MCT after 5 minutes at TO for All Engines Operating (AEO) or after 10 minutes at TO for an One Engine Inoperative (OEI), or Opposite Engine Low–Thrust (OELT) event.

Once MCT redline limites are set by the EEC, and if go–around mode is activated, the redline limit increases from MCT to MTO for 5 minutes in AEO, or for 10 minutes for an OEI or OELT event.

B. Thrust Limitation at Low Speed (TLLS)

Thrust Limitation at Low Speed (TLLS) ensures that the nose landing gear is sufficiently loaded during the takeoff phase. The FADEC limits the thrust of the engines to about 60% of the takeoff power. As the aircraft accelerates in the takeoff run, thrust increases with airspeed and reaches full power at 80 kt.

The limits is indicated by a light gray sector on the N1 indications on the EICAS page. TLLS is disabled when the parking brake is set to allow full power run–ups. Refer to Figure 18–09–6.



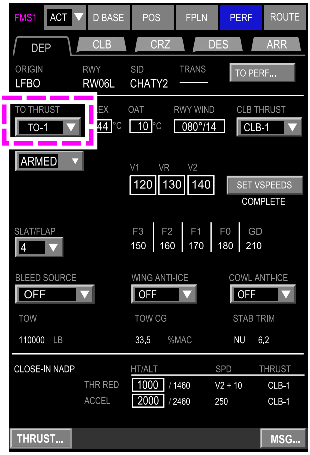
EICAS synoptic page – Engine section – TLLS indication
Figure 18–09–6

C. Derated takeoff thrust management

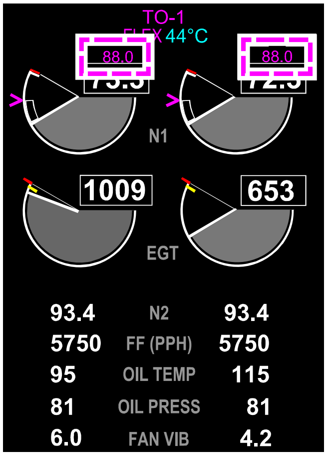
The derated takeoff thrust (refer to Figure 18–09–7) increases engine life and fuel economy. Derated takeoff thrust is selected through different ratings (TO, TO-1, TO-2, or TO-3) in the Flight Management System (FMS) PERF (Performance) page on the DEP (Departure) tab (refer to Figure 18–09–8). The selected mode is displayed at the top of the engine indications on the EICAS page.

The derated takeoff can be used in conjunction with reduced takeoff thrust (FLEX) and Automatic Power Reserve (APR). Derated takeoff can be conducted on contaminated runways.

Figure 18–09–9 shows the derated takeoff thrust entry on the FMS and on the EICAS page.

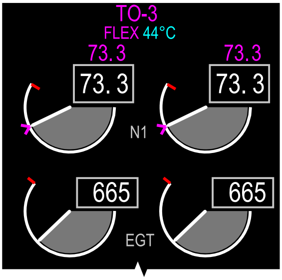


FLIGHT MANAGEMENT SYSTEM (FMS) - TAKEOFF THRUST MODE SELECTION



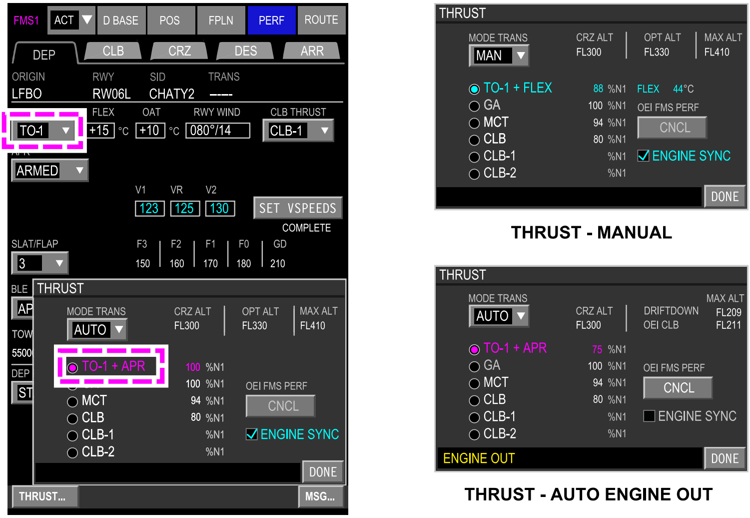
EICAS PAGE - N1 REFERENCE SPEED

Takeoff thrust management – Derated takeoff
Figure 18–09–7



Symbol	Description
>	FMS managed thrust reference value.
>	Manually entered thrust reference value.
TO-3 FLEX 44°C 73.3 73.3	First line displays the thrust mode. Second line displays the assumed temperature for FLEX XX°C and the digital thrust. Both symbols are always displayed together.
TO or TO TO-1 or TO-1 TO-2 or TO-2 TO-3 or TO-3 CLB or CLB CLB-1 or CLB-2 CLB-2 or CLB-2 MCT or MCT GA or GA FLEX 44°C 73.3 73.3 FLEX 44°C 73.3 73.3	The modes are displayed in: Magenta in AUTO (FMS managed) or Cyan in Manual (pilot entered).

Thrust management display
Figure 18–09–8



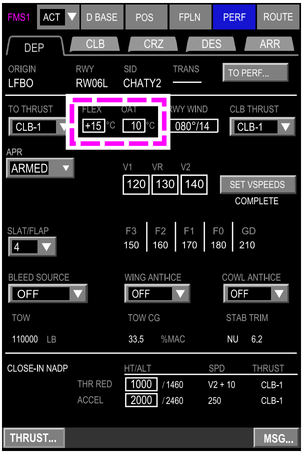
Derated takeoff entry
Figure 18–09–9

D. Reduced takeoff thrust (FLEX)

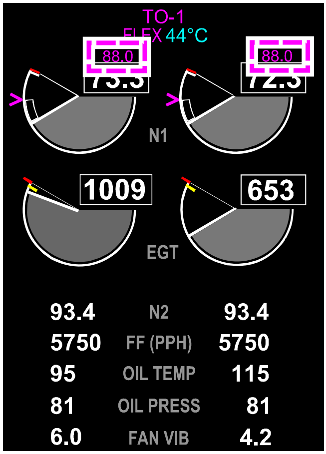
The FMS uses the assumed temperature method to calculate the reduced takeoff thrust (FLEX). The flight crew enters an assumed temperature in the FLEX box of the DEP (Departure) tab in the PERF (Performance) page of the FMS (refer to Figure 18–09–10). The assumed temperature has to be higher than the actual ambient temperature. If it is lower than the actual ambient temperature, the FLEX mode will be deactivated. The FLEX can be used with any takeoff thrust level (TO, TO-1, TO-2, or TO-3). The total thrust reduction between derate and FLEX is limited to 40% of Maximum Takeoff (MTO) thrust. FLEX takeoff is allowed on wet runways if performance data is available, but prohibited on contaminated runways, in the presence of windshear or thunderstorm activity.

The table that follows shows the thrust limitations for takeoff based on the engine type and the selected takeoff mode.

PW1521G-3 <72211001D>			
TO mode	TO thrust (lbf)	Max FLEX (% of TO)	Max FLEX (lbf)
MTO	21000	33	13980
TO-1	18900	26	13980
TO-2	17000	18	13980
TO-3	N/A	N/A	N/A



FLIGHT MANAGEMENT SYSTEM - FLIGHT CREW ASSUMED TEMPERATURE AND OUTSIDE AIR TEMPERATURE (OAT) SELECTION



EICAS PAGE - N1 REFERENCE SPEED

Takeoff thrust management – Flex takeoff
Figure 18–09–10

E. Climb thrust management

The climb thrust management is used to increase engine life. There are four options for the derated takeoff and for each of these the flight crew can select one of three climb derates:

- CLB (maximum climb thrust),
- CLB–1 (first level derated climb thrust), and

- CLB–2 (second level derated climb thrust).

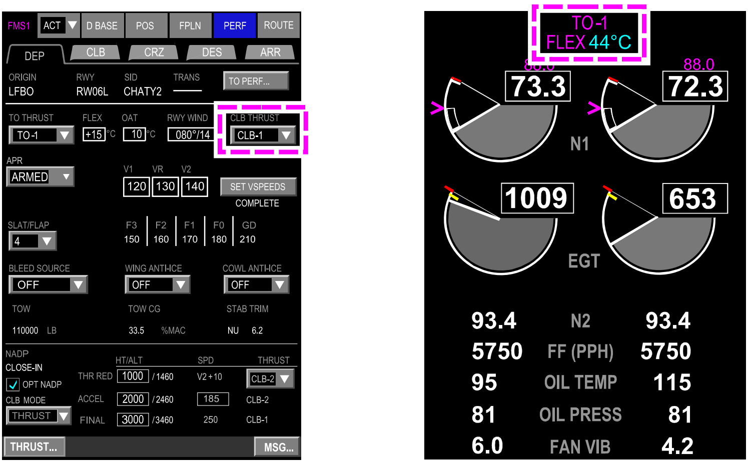
The climb thrust rating is selected on the DEP (Departure) tab in the PERF (Performance) page of the FMS.

The FMS calculates the N1 speed reference based on the aircraft configuration, takeoff thrust mode (TO, derate, or FLEX), and Outside Air Temperature (OAT). This speed displays on the top of the engine indications of the EICAS page.

If derated climb thrust is selected, a washout function (change over altitude) is implemented in order to recover maximum climb ceiling capability and optimal initial cruise altitude.

The washout function automatically and gradually increases the selected derated climb thrust (CLB-1 or CLB-2) to full CLB thrust by an altitude determined by the EEC.

Figure 18–09–11 shows the climb thrust management selection and indication.



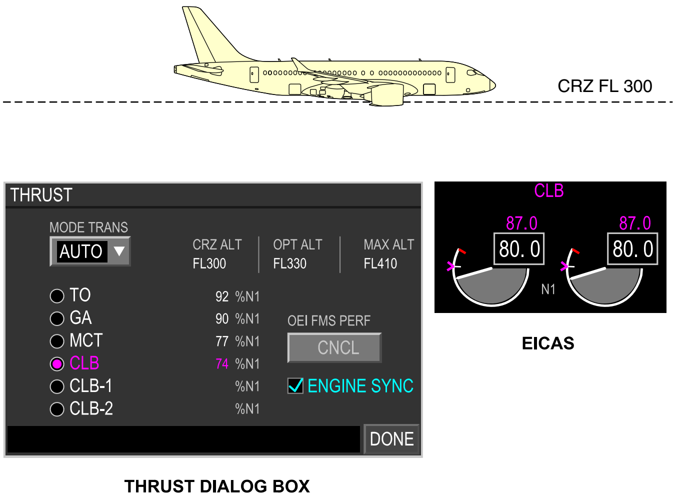
FLIGHT MANAGEMENT SYSTEM - CLIMB THRUST MODE SELECTION

EICAS PAGE - ENGINE SECTION - CLIMB THRUST MODE INDICATION

Climb thrust management
Figure 18–09–11

F. Cruise thrust management

When in cruise, the N1 reference (CLB) is still displayed above the N1 indications on the EICAS page. The white line gives the engine N1 limits (usually hidden by the N1 needle). The Thrust Reference Value (TRV) magenta arrows are suppressed, as the autothrottle is active in SPD mode. Refer to Figure 18–09–12.



Cruise (Climb) engine Limit
Figure 18–09–12

G. Idle thrust management

The idle thrust management is governed by the EEC. Idle RPM is dependent upon five different idle settings based on engine stability, bleed demand, and phase of flight:

- Minimum idle (ground and flight idle),
- Approach idle,
- Steep approach idle, and
- Reverse idle.

(1) Minimum idle (ground and flight idle)

The minimum idle on ground provides an engine speed that reduces the landing distance, brake wear, and landing gear wear during taxi.

The minimum idle in flight minimizes the fuel consumption when the flaps and landing gear are retracted. The flight idle N1 speed increases with altitude.

(2) Approach idle

The approach idle is intended to reduce spool-up time from idle to go-around thrust. It is selected in-flight with the selection of Flap 1 or when the landing gear is down.

Approach idle thrust is higher than minimum idle, and enables more rapid engine acceleration from idle to Go–Around (GA) thrust.

(3) Steep approach idle

The steep approach idle has to be lower than the normal approach idle while the air extraction from the engines is activated. It is lower than the normal approach idle, but will still allow the engines to achieve at least 80% of go-around thrust within 8 seconds of go-around thrust request. The steep approach mode is activated when:

- Steep approach mode selected in the FMS,
- Approach mode is engaged in the flight guidance system, and
- No windshear has been detected.

If these conditions are not met, the steep approach is disabled.

(4) Reverse idle

The reverse idle supports ground operation with the thrust reversers deployed. It is available with the thrust levers in the REV IDLE position.

When REV IDLE is automatically commanded, the landing maximum reverse thrust setting supports the landing maneuver from Thrust Reversers deployment down to a speed at 60 kt.

H. Automatic Power Reserve (APR)

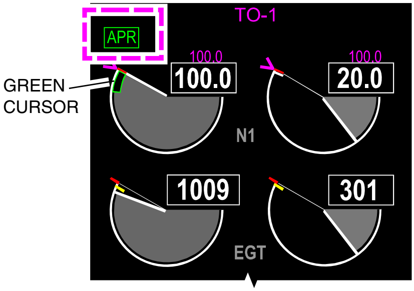
The APR function provides automatic, additional thrust when an Opposite Engine Low Thrust (OELT) condition exists during takeoff. When an OELT condition occurs, the FADEC will increase the N1 speed to the next level TO thrust. This function is automatically armed only during a derated takeoff or when FLEX takeoff power is selected. The APR can also be armed, or disarmed, manually by the flight crew before departure. This is done on the FMS PERF (Performance) page by selecting or deselecting the APR ARM checkbox on the DEP (Departure) tab.

When activated due to an OELT condition, the APR flag displays in green on the EICAS page below the N1 indication and a green cursor displays in the analog N1.

When disarmed in the FMS, the status message **APR DISARM** displays on the EICAS page.

Figure 18–09–13 shows the APR function selected on the FMS and the indication on the EICAS page.

FLIGHT MANAGEMENT SYSTEM - AUTOMATIC POWER RESERVE SELECTION



EICAS PAGE - ENGINE SECTION - APR DISPLAY

Automatic Power Reserve (APR)
Figure 18–09–13

(1) APR activation

When the APR is armed, the activation occurs under the conditions that follow:

- When an engine N1 is 15% lower than the opposite engine,
- A derate or derate/FLEX thrust combination is selected, and
- Thrust lever angle is higher than 20 degrees.

If both engines are operating at a lower thrust due to failures, and within 15% of each other, the APR function deactivates. This is because the EEC is already commanding the maximum fuel flow to recover engine thrust level.

(2) APR deactivation

The EEC deactivates the APR function when the aircraft is higher than 400 feet radio altitude and when any of the conditions that follow are met:

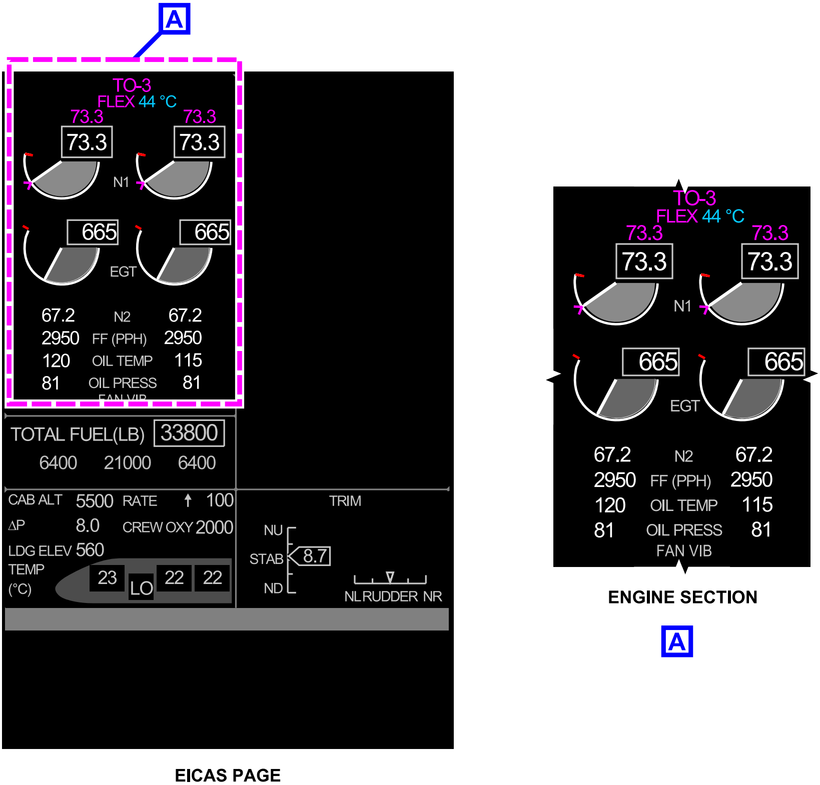
- APR status is set to DISARMED in the FMS.
- A successful in-flight engine relight, or
- When thrust is selected to another thrust mode.

After deactivation, the EEC returns to the nominal thrust.

ENGINE INDICATIONS

A. EICAS page – Primary and secondary parameter indications

The engine parameters, (refer to Figure 18–09–14) are displayed in the engine indications section of the EICAS page.



Engine Parameter Indications
Figure 18–09–14

The engine indications are divided into primary and secondary parameter indications.

(1) Primary parameter indications

- Thrust mode,
- FLEX mode with the assumed temperature (°C),
- N1 (%) reference speed (digital in magenta or cyan),

- Thrust reference value bug (magenta set via FMS, cyan set manually),
- N1 (%) actual speed (digital and analog), and
- Exhaust Gas Temperature (EGT °C) (digital and analog).

(2) Secondary parameter indications

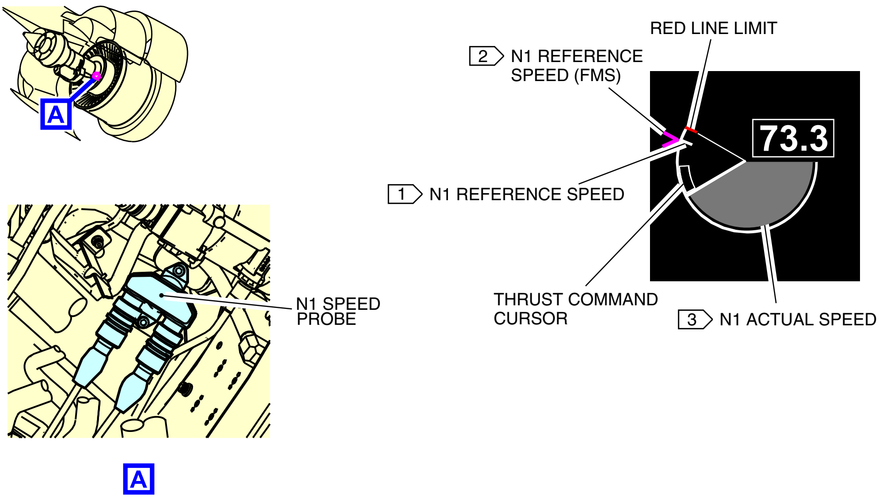
- N2 actual (%) speed and analog dial display,
- Fuel Flow (FF) (Pounds Per Hour (PPH) or Kilograms Per Hour (KPH)),
- Oil temperature (OIL TEMP °C),
- Oil pressure (OIL PRESS) (psi),
- N1 and N2 vibration, and
- Fan vibration (FAN VIB).

(3) N1 indication

The N1 speed is provided by a dual-channel probe that sends data to the Electronic Engine Control (EEC), which converts it for EICAS display to analog and digital format. The N1 overspeed limit is shown by a red line. When the red line is exceeded:

- The analog and digital displays change to red,
- The master WARNING/CAUTION light illuminates, and
- Single chime sounds.

Figure 18–09–15 describes the N1 display on the EICAS page.



Symbol	Color	Description
XX.X	White	N1 speed in the normal range.
XX.X or XXX	Red	N1 above red line limit. The decimal is removed once the N1 is over 99.9.
– – –	Amber, dashed	Invalid signal.

NOTES

1. Without flex or max climb when in climb phase.
2. Calculated by the FMS (magenta).
3. When the red line is reached, the digital value and analog value change to red.

N1 analog and digital display
Figure 18–09–15

(4) N1 synchronization

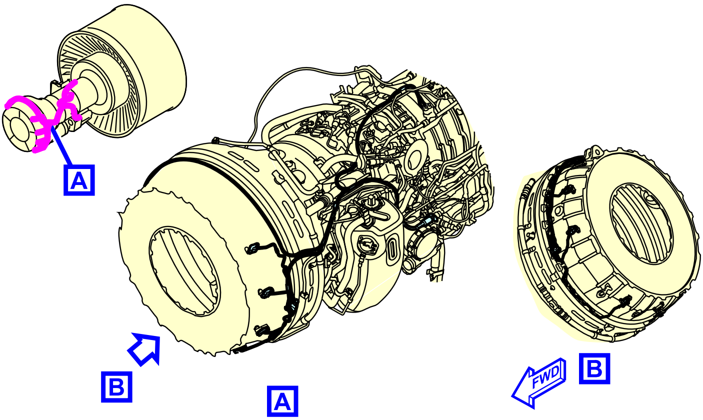
The N1 synchronization is an automatic function controlled by the EEC. It synchronizes the speed of the engines to minimize harmonic noise in the aircraft. The function uses the left engine speed as the master (reference) and the right engine speed as the slave. The synchronization is accomplished by fuel trimming on the slave engine.

The N1 synchronization operates in cruise and is indicated by a green SYNC indication below the N1 indication on the EICAS page.

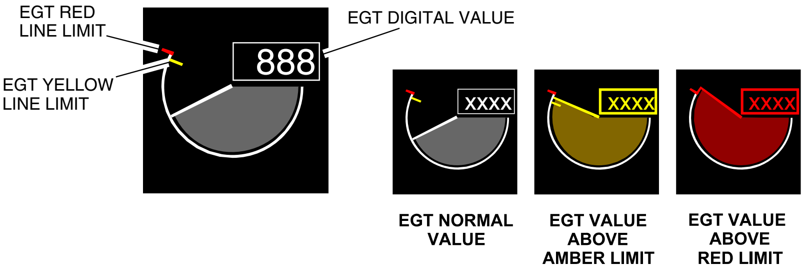
(5) Exhaust Gas Temperature (EGT) indication

The Exhaust Gas Temperature (EGT) is measured by thermocouple probes installed around the exhaust case. The data is sent to the EEC, which processes it and sends it for display on the EICAS page in analog and digital format (in °C). The established EGT threshold values are shown by an amber line and a red line. The amber line is the EGT limit during start and it is shown during the start sequence. The red line is a variable limit that indicates either the Max Takeoff (MTO) thrust EGT limit or the Max Continuous Thrust (MCT) EGT limit and is modified by the EEC, depending on the current flight thrust mode (e.g. TO−1, CLB, CRZ).

Figure 18−09−16 describes the EGT display and the start limit.



EXHAUST GAS TEMPERATURE (EGT) PROBES



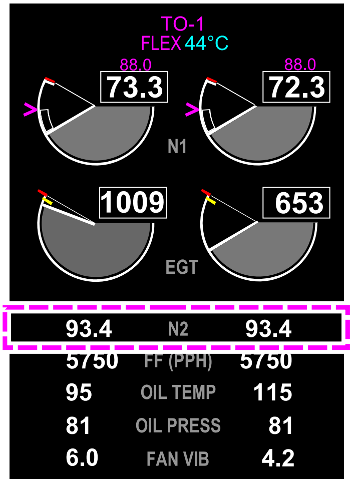
Symbol	Color	Description
XXXX	White	EGT in the normal range.
XXXX	Red	EGT above red line limit.
XXXX	Amber	EGT above yellow line limit.
----	Amber, dashed	Invalid signal.

Exhaust Gas Temperature (EGT) digital and analog display
Figure 18–09–16

(6) N2 indication

The N2 speed indications are provided by a dual-channel probe powered by the Permanent Magnet Alternator Generator (PMAG). The sensor signal is sent to the EEC, which processes it and displays it on the EICAS page in digital format (%). The EEC also uses the N2 data for starting, overspeed monitoring, shaft shear detection, and for other functions.

Figure 18–09–17 describes the N2 indications.



EICAS PAGE - ENGINE SECTION

Symbol	Color	Description
XX.X	White	N1 speed in the normal range.
XX.X or XXX	Red	N2 speed above threshold.
– – –	Yellow, dashed	Invalid.

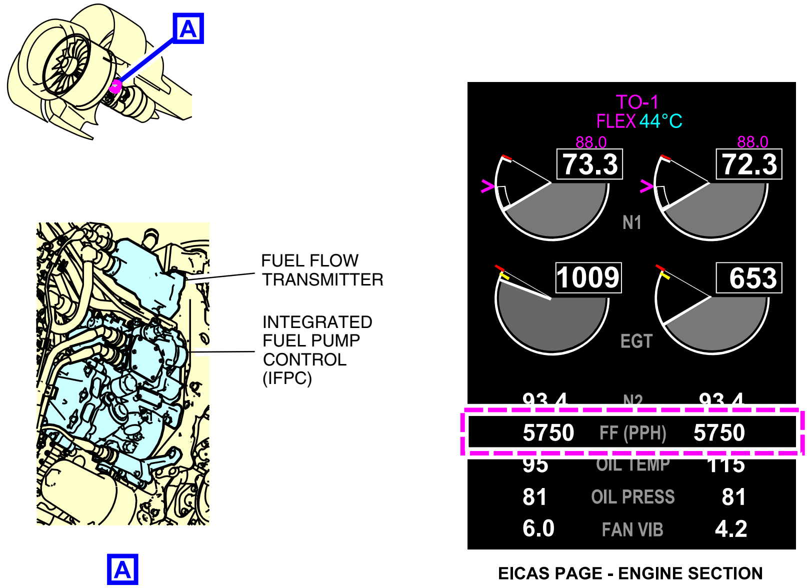
N2 DISPLAY

N2 indication
Figure 18–09–17

(7) Fuel Flow (FF) indication

The fuel flow is sensed by the flow meter. The signal from the flow meter is sent to the EEC for processing and is displayed on the EICAS page in Pounds Per Hour (PPH) or in Kilograms Per Hour (KPH).

Figure 18–09–18 describes the fuel flow indications.



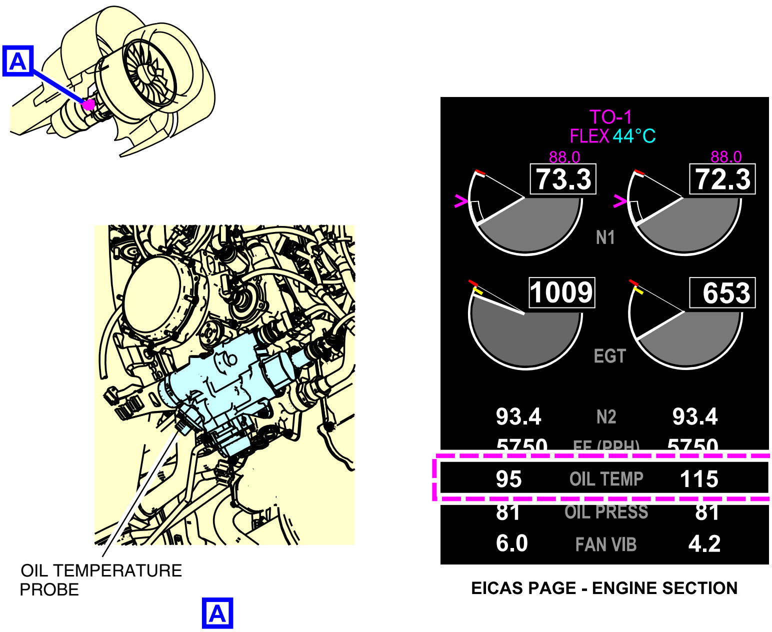
Symbol	Color	Description
XXXX	White	Fuel Flow (FF) in the normal range.
XXXX	Amber	Fuel Flow (FF) below threshold or above threshold.
----	Amber, dashed	Invalid signal.

Fuel Flow (FF) indication
Figure 18–09–18

(8) Oil temperature (OIL TEMP) indication

The scavenge oil temperature is measured by a sensor located in the Oil Control Module (OCM). The temperature signal is sent to the EEC for processing and oil monitoring, and then to the EICAS page for display in degrees Celsius (°C).

Figure 18–09–19 describes the oil temperature indications.



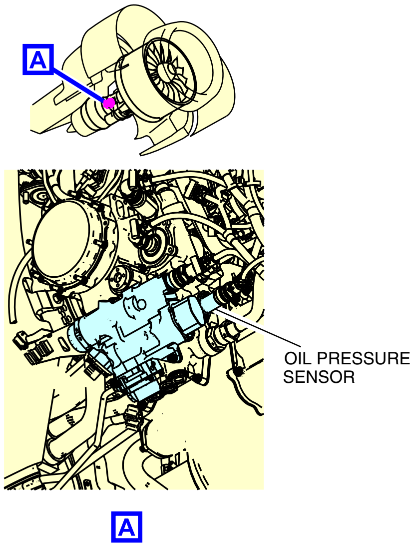
Symbol	Color	Description
XXXX	White	Oil temperature in the normal range.
XXXX	Amber	Oil temperature above high amber limit.
XXXX	Red	Oil temperature above high red limit.
XXXX	Amber	Oil temperature below low amber limit.
----	Amber, dashed	Invalid signal.

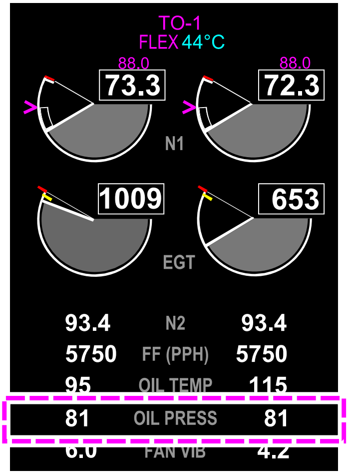
Oil temperature indication
Figure 18–09–19

(9) Oil pressure (OIL PRESS) indication

The oil pressure is measured by a sensor in the OCM. The pressure signal is sent to the EEC for processing and then to the EICAS page for display in Pounds per Square Inch (PSI).

Figure 18–09–20 describes the oil pressure indications.





EICAS PAGE - ENGINE SECTION
- OIL PRESSURE INDICATION

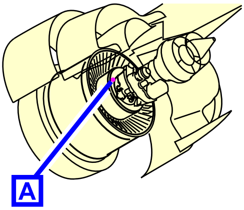
Symbol	Color	Description
XXX	White	Oil pressure in the normal range.
XXXX	Amber	Oil pressure above high limit.
XXXX	Red	Oil pressure below low limit.
----	Amber, dashed	Invalid signal.

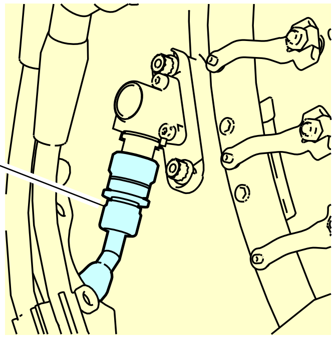
Oil pressure indication
Figure 18–09–20

(10) N1, N2 and fan vibration (FAN VIB) indications

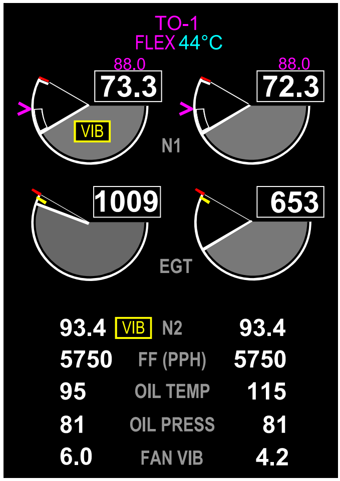
The vibrations of N1, N2, and the fan are measured by sensors (accelerometers). They provide vibration data to the Prognostics and Health Management Unit (PHMU) and to the EEC for display on the EICAS page.

When the N1 or N2 vibration exceeds the limit, the caution message **ENG VIBRATION** shows on the EICAS page with an amber VIB flag on the affected engine N1 or N2 indication. Refer to Figure 18–09–21





A



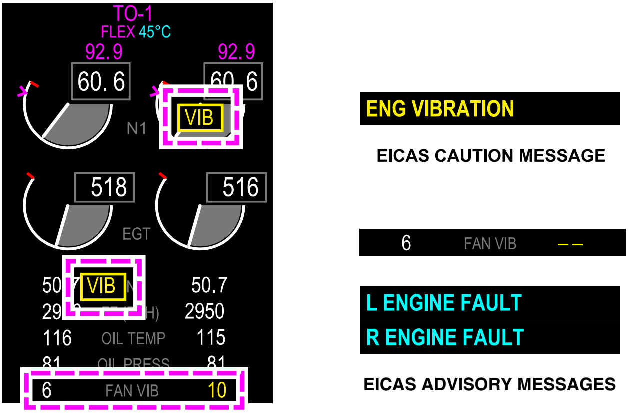
EICAS PAGE - ENGINE SECTION -
VIBRATION INDICATION

ENG VIBRATION

EICAS CAUTION MESSAGE

N1, N2 and vibration indications (VIB)
Figure 18–09–21

The fan vibration (FAN VIB) appears below the OIL PRESS indication on the EICAS page (refer to Figure 18–09–22). The vibration value is always displayed. When it exceeds the limit, the value changes to amber and the caution message **ENG VIBRATION** shows on the EICAS page. If both vibration monitors fail on one side, the FAN VIB digital is replaced by a dashed line, and an **L ENGINE FAULT** or **R ENGINE FAULT** EICAS advisory messages are displayed.



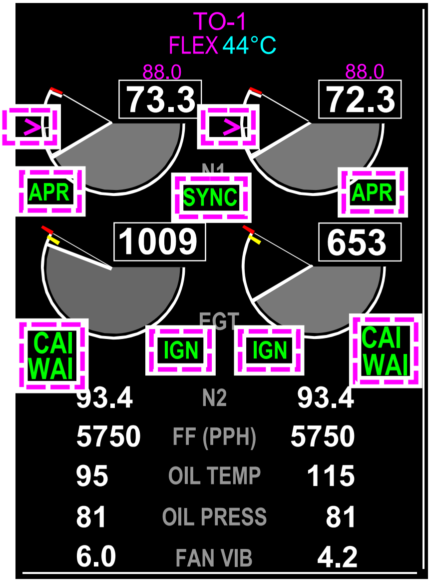
Engine vibration indications
Figure 18–09–22

B. Status and flag indications

Figure 18–09–23 shows the location of the status and flag indications on the EICAS page.

Figure 18–09–24 shows the status indications with a description.

Figure 18–09–25 shows the flag indications with a description.



EICAS PAGE - ENGINE SECTION

Status and flag indications
Figure 18–09–23

Symbol	Color	Description
FIRE	Red and white	Left or right engine fire indication.
START	Green	Left or right engine in start sequence.
RELIGHT	Green	Left or right engine automatic relight.
ATS	Cyan	Left or right engine below idle and aircraft within the air turbine start envelope.
WINDMILL	Cyan	Engine below idle and aircraft within windmill envelope.
SYNC	Green	Engine synchronization is active.

Status descriptions
Figure 18–09–24

Symbol	Color	Description
REV	Green	On ground: Thrust reverser in transition.
REV	White	On ground: Thrust reverser is deployed.
REV	Amber	On ground: Thrust reverser is not performing the commanded action.
APR	Green	Automatic Power Reserve (APR) is active.
CAI	Green	Cowl Anti–Ice System (CAIS) is on.
CAI	White	CAIS armed.
CAI	Amber	CAIS is failed.
WAI	Green	Wing Anti–Ice System (WAIS) is on.
WAI	White	WAIS is armed.
WAI	Amber	WAIS is failed with caution type or overheat.
WAI	Red	WAIS is failed with warning condition.
IGN	Green	Ignition is active.
IGN	White	Ignition selected but inhibited due to design constraints.
>	Magenta	Flight Management System (FMS) managed thrust reference value.
>	Cyan	Manually entered thrust reference value.
VIB	Amber	N1 vibration above high vibration threshold.
VIB	Amber	N2 vibration above high vibration threshold.

Flag descriptions
Figure 18–09–25

POWER PLANT – EICAS MESSAGES

A. Warning messages

Message	Description	Aural	Inhibit
DUAL ENG FAIL	Dual engine failure.	None	None
L ENG OIL PRESS	Left engine oil press below or above normal range.	None	TO, LDG
R ENG OIL PRESS	Right engine oil pressure below or above normal range.	None	TO, LDG

B. Caution messages

Message	Description	Inhibit
L COWL A/ICE FAIL	Left cowl anti–ice system failed (valves closed). This message is inhibited when the EICAS caution message L ENG OPER DEGRADED is displayed.	TO, LDG
R COWL A/ICE FAIL	Right cowl anti–ice system failed (valves closed). This message is inhibited when the EICAS caution message R ENG OPER DEGRADED is displayed.	TO, LDG
L COWL A/ICE FAIL ON	Left cowl anti–ice system failed (valves open). This message is inhibited when the EICAS caution message L ENG NACELLE OVHT is displayed.	TO, LDG
R COWL A/ICE FAIL ON	Right cowl anti–ice system failed (valves open). This message is inhibited when the EICAS message R ENG NACELLE OVHT is displayed.	TO, LDG
COWL A/ICE ON	Left or right cowl A/ICE manually selected ON while the OAT is above approximately 15 °C.	TO, LDG

Message	Description	Inhibit
ENG OIL LO TEMP	Either engine oil too cold to allow a high thrust being set.	TO, LDG
ENG SETTING MISMATCH	Thrust management data received/fed back by FADEC not matching (APR setting, N1 target, etc.).	TO, LDG
ENG VIBRATION	Left or right engine vibration (either fan, N1 or N2).	TO, LDG
L ENG EXCEED-ANCE	Left N1 or left N2 or left ITT or left oil temperature above threshold.	TO
R ENG EXCEED-ANCE	Right N1 or right N2 or right ITT or right Oil temperature above threshold.	TO
L ENG FAIL	Left engine sub-idle.	None
R ENG FAIL	Right engine sub-idle.	None
L ENG NACELLE OVHT	Left burst cowl anti-ice duct or left HPC valve failed open or buffer air shutoff valve failed open.	TO, LDG
R ENG NACELLE OVHT	Right burst cowl anti-ice duct or right HPC valve failed open or buffer air shut-off valve failed open.	TO, LDG
L-R ENG FUEL FILTER	Both engine fuel filters are bypassed (clogged filters). Likely fuel contamination.	TO, LDG
L ENG OIL FILTER	Left engine oil filter is bypassed (clogged filter).	TO, LDG
R ENG OIL FILTER	Right engine oil filter is bypassed (clogged filter).	TO, LDG
L ENG OPER DEGRADED	Uncertainty on T2/Total Air Temperature (TAT) (degraded or default value), or HPC stator vane actuator not tracking as it should.	TO

Message	Description	Inhibit
R ENG OPER DEGRADED	Uncertainty on T2/Total Air Temperature (TAT) (degraded or default value), or HPC stator vane actuator not tracking as it should.	TO
L ENG START ABORT	Left engine starting procedure has aborted.	None
R ENG START ABORT	Right engine starting procedure has aborted.	None
L ENG STARTER FAIL ON	Air Turbine Starter (ATS) is not disengaging or the left Starter Air Valve (SAV) failed open.	TO, LDG
R ENG STARTER FAIL ON	Air Turbine Starter (ATS) is not disengaging or the right Starter Air Valve (SAV) failed open.	TO, LDG
L REVERSER FAIL	Left thrust reverser failed or not available. Icon only shown if thrust reversers have been commanded.	TO
R REVERSER FAIL	Right thrust reverser failed or not available. Icon only shown if thrust reversers have been commanded.	TO
L REVERSER UNLOCK	Multiple left reverser locks unlocked.	TO
R REVERSER UNLOCK	Multiple right reverser locks unlocked.	TO
L THROTTLE FAIL	Left thrust lever position not recognized.	TO
R THROTTLE FAIL	Right thrust lever position not recognized.	TO
THROTTLE IN REVERSE	Left or right thrust reverser selected in flight.	TO

C. Advisory messages

Message	Description	Inhibit
L ENGINE FAULT	Loss of redundant or non-critical function for the left engine.	TO, LDG
R ENGINE FAULT	Loss of redundant or non-critical function for the right engine.	TO, LDG
L ENG FUEL FILTER	Left engine fuel filter is in impending bypass or is bypassed.	TO, LDG
R ENG FUEL FILTER	Right engine fuel filter is in impending bypass or is bypassed.	TO, LDG
ENG START DELAY FADEC V2.9.5	FADEC detects a risk of bowed rotor. Upon initiation of an on-ground start command motors the engine before allowing the start to proceed.	TO, LDG
ENG START DELAY FADEC V2.9.6.3	FADEC detects a risk of bowed rotor. The message will only be displayed for ambient conditions that require extended motoring. For more details, refer to Chapter 18 – ENGINE SUBSYSTEM – FADEC software V2.9.6.3).	TO, LDG
L FUEL FLOW DEGRADED	FADEC provides synthesized fuel flow instead of measured fuel flow. Displayed left fuel flow accuracy is degraded	TO, LDG
R FUEL FLOW DEGRADED	FADEC provides synthesized fuel flow instead of measured fuel flow. Displayed right fuel flow accuracy is degraded.	TO, LDG
L ENG OIL LO QTY	Left engine oil low quantity detected.	TO, LDG
R ENG OIL LO QTY	Right engine oil low quantity detected.	TO, LDG
L ENG PCE DOOR OPEN	Left Precooler Exhaust (PCE) door commanded open (due to precooler overtemperature condition).	TO, LDG

Message	Description	Inhibit
R ENG PCE DOOR OPEN	Right Precooler Exhaust (PCE) door commanded open (due to precooler overtemperature condition).	TO, LDG
L ENG STARTER OVHT	Left starter usage does not fulfill the duty cycle criteria: 30 minutes cool down time for 4 minutes (low N2) or 30 seconds (high N2).	TO, LDG
R ENG STARTER OVHT	Right starter usage does not fulfill the duty cycle criteria: 30 minutes cool down time for 4 minutes (low N2) or 30 seconds (high N2).	TO, LDG

D. Status messages

Message	Description	Inhibit
APR DISARM	Automatic Power Reserve (APR) is disarmed in the Flight Management System (FMS) and derated takeoff is being used.	None
ENG CONT IGNITION ON	At least one FADEC receives request from flight deck switch to have continuous ignition.	None
L COWL A/ICE ON	Left cowl anti–ice manually selected ON.	None
R COWL A/ICE ON	Right cowl anti–ice manually selected ON.	None
L–R COWL A/ICE ON	Left and right cowl anti–ice manually selected ON.	None
L COWL A/ICE OFF	Left cowl anti–ice manually selected OFF.	None
R COWL A/ICE OFF	Right cowl anti–ice manually selected OFF.	None

Message	Description	Inhibit
L–R COWL A/ICE OFF	Left and right cowl anti–ice manually selected OFF.	None
L ENG SHUTDOWN	In-flight pilot commanded engine shut-down (left engine run switch to OFF).	None
R ENG SHUTDOWN	In-flight pilot commanded engine shut-down (right engine run switch to OFF).	None
L REVERSER INHIBIT	Left thrust reverser manually inhibited, as per maintenance procedure.	None
R REVERSER INHIBIT	Right thrust reverser manually inhibited, as per maintenance procedure.	None

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CHAPTER 19 – RECORDING

List of figures

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RECORDING SYSTEM – OVERVIEW

The recording system digitally records communications, aircraft flight parameters, and aircraft systems data. It consists of:

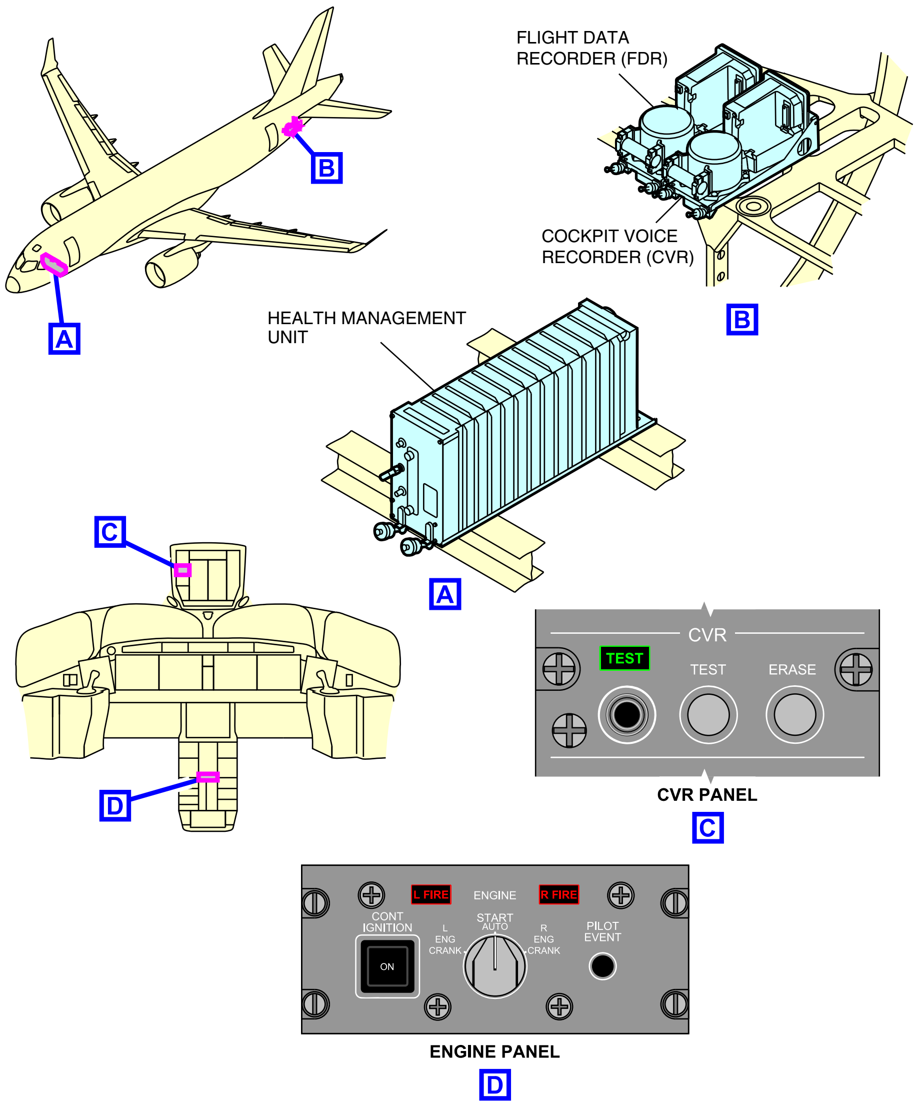
- A Cockpit Voice Recorder (CVR),
- A Flight Data Recorder (FDR), and
- An Aircraft Health Management System (AHMS).

The CVR records all audio communications, as well as all digital communications transmitted and received via the Aircraft Communication Addressing and Reporting System (ACARS).

The FDR records real-time aircraft flight parameters.

The AHMS records and monitors aircraft systems and engine conditions for preventive and corrective maintenance actions.

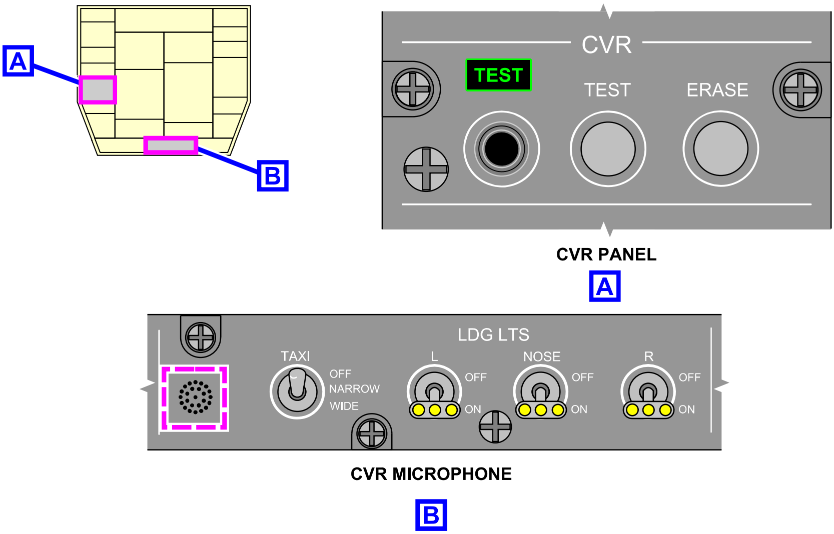
System status and fault messages are reported on the EICAS page. Controls are located on the CVR panel and ENGINE panel (refer to Figure 19–01–1).



Recording system location and controls
Figure 19–01–1

CVR – OVERVIEW

The CVR records all audio communications from the flight compartment, as well as all the communications passing through the Audio Control Panels (ACPs), including navaids, VHF, HF, SAT, cabin interphones, and Passenger Address (PA) system. Through a microphone located on the overhead panel, it also records all voices, alerts, and noises from the flight compartment environment. The CVR is located in the aft equipment bay, adjacent to the Flight Data Recorder (FDR), and has a battery-powered Underwater Locator Beacon (ULB) that emits a 37.5 kHz signal for 90 days when submerged. The controls are located on the CVR panel and system status is reported on the EICAS page (refer to Figure 19–02–1).



CVR controls and indications
Figure 19–02–1

CVR – OPERATION

The CVR records the last two hours of digital and voice communications, transmitted and received in the flight compartment in a Crash-Survivable Memory Unit (CSMU). When the memory is full, the most recent data overwrites the earliest.

The recorded data includes:

- Cockpit communications, noises and conversations,
- All voice communications passing through any Audio Control Panel (ACP), including nose and fuel service panels when the service intercom switch is activated, cockpit oxygen masks when activated, PA system, and aircraft interphone system,
- Aural alerts, and
- Digital communications (transmitted and received) via the ACARS.

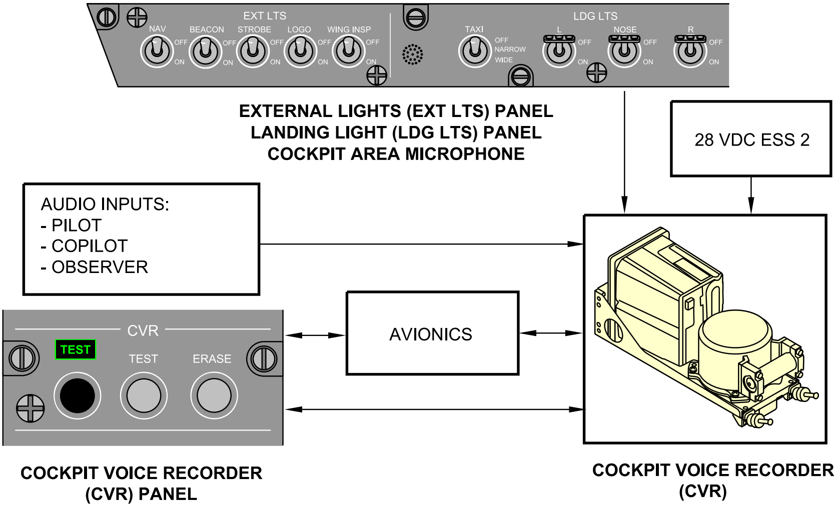
The CVR starts recording when the beacon or strobe lights are on or when the aircraft is Weight-Off-Wheels (WOFFW), regardless of the switch positions. It stops recording 10 minutes after the beacon and strobe lights are turned off on the ground.

Power will be removed to the CVR in a crash situation in order to avoid losing the recording should the power still be available. In that case, the power is removed when the conditions that follow occur:

- No weight-on-wheels,
- No airspeed, and
- No engine oil pressure detected in at least one engine.

The CVR is powered from the DC ESS BUS 2 and has a Recorder Independent Power Supply (RIPS) to ensure continued recording if a power loss occurs. It will power the CVR for an additional 10 minutes after the aircraft power source is lost.

Figure 19–02–2 shows an overview of the CVR operation.



Cockpit voice recorder (CVR) operation
Figure 19–02–2

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FDR – OVERVIEW

The FDR monitors and records the last 50 hours of operational data of real-time aircraft flight parameters and is designed to keep the last 25 hours of data in its Crash-Survivable Memory Unit (CSMU).

The FDR is located in the aft equipment bay, adjacent to the CVR, and has a battery-powered Underwater Locator Beacon (ULB) that emits a 37.5 kHz signal for 90 days when submerged.

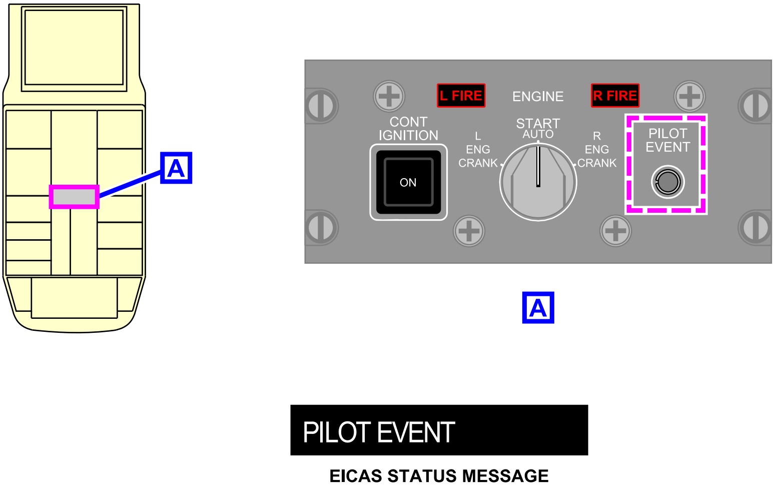
FDR – OPERATION

The FDR is powered from the DC ESS BUS 1. It begins recording when either the beacon or strobe lights switch is ON, or the first engine starts and stops when the aircraft is on the ground and the last engine stops.

Power will be removed to the FDR in a crash situation to avoid losing the recording should the power still be available. In that case, the power is removed when all the conditions that follow occur:

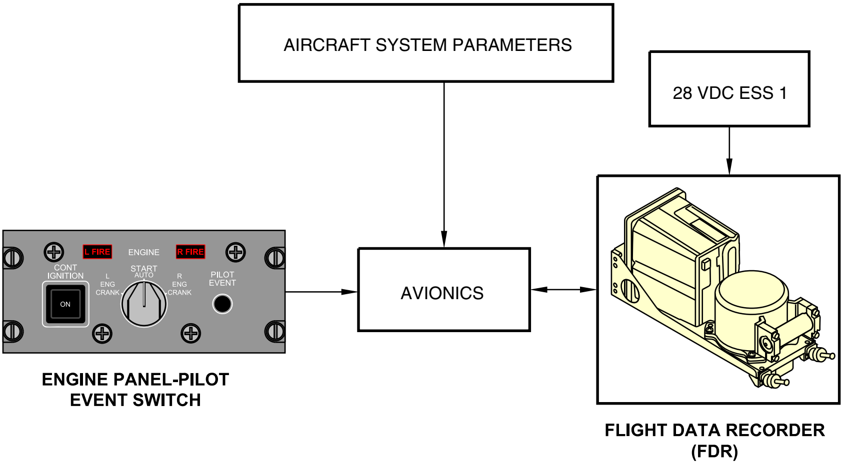
- No weight-on-wheels,
- No airspeed, and
- No engine oil pressure detected in at least one engine.

The PILOT EVENT switch on the ENGINE panel in the center pedestal (refer to Figure 19–03–1) sends a marker to the FDR. This function allows investigators to quickly find the flagged data.



ENGINE panel – PILOT EVENT switch
Figure 19–03–1

Figure 19–03–2 shows an overview of the FDR operation.



Flight data recorder (FDR) operation
Figure 19–03–2

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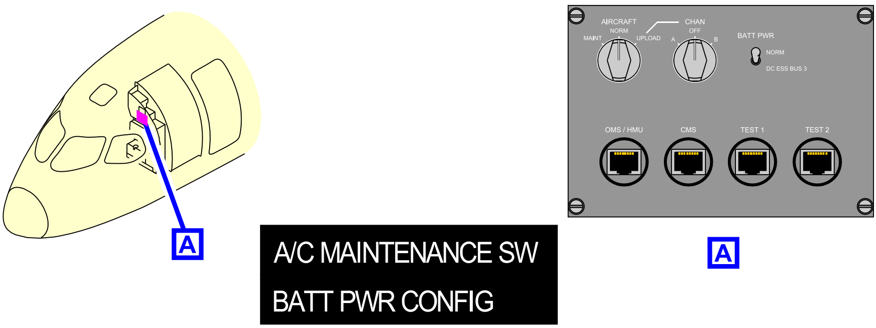
AHMS – OVERVIEW

The AHMS stores, manages, and provides access to maintenance data used for aircraft maintenance actions. It consists of:

- A Health Monitoring Unit (HMU),
- An Onboard Maintenance System (OMS), and
- An Information Management System (IMS).

The high-load event indication function monitors gust, heavy turbulence, and hard landing conditions. The system measures the acceleration severity in the airframe and compares the severity with thresholds of structural capacity. If a hard landing or a flight upset from gust or maneuver is detected, the HMU records the event and, if selected, transmits the event to the ground station. A **HIGH LOAD EVENT** advisory message is displayed on the EICAS page. <31340001C>

A maintenance panel located behind the pilot seat is also part of the AHMS (refer to Figure 19–04–1). If the AIRCRAFT switch on the maintenance panel is not in the NORM position before flight, the **A/C MAINTENANCE SW** status message displays on the EICAS page. If the BATT PWR switch is not in the NORM position before flight, the **BATT PWR CONFIG** status message displays on the EICAS page.



EICAS STATUS MESSAGES

Maintenance panel
Figure 19–04–1

The table that follows shows the AHMS functions.

HMU	OMS	IMS
High-Load Event Indication Function (HLEIF). Aircraft Condition Monitoring Function (ACMF). Aircraft Data Recording Function (ADRF), Aircraft data exchange function. Aircraft data management.	Real-time system data reporting. Maintenance messages and configuration reporting. Fault diagnostic and isolation. Aircraft condition monitoring.	Data loading integration. Printer integration. Wireless connectivity integration.

HEALTH MANAGEMENT UNIT (HMU) – OVERVIEW

The HMU is a dual-channel Line Replaceable Unit (LRU) located in the forward equipment bay.

The table that follows summarizes the HMU functions.

HMU function	Description
High-Load Event Indication Function (HLEIF)	Monitors the aircraft for severe turbulence and hard landing conditions.
Usage Based Monitoring Function (UBMF)	This function collects and records engine data to be transmitted to a ground station.
Aircraft Data Recording Function (ADRF)	The recorded data is configured by the operator, who chooses what and when to record.

HMU function	Description
Aircraft Condition Monitoring Function (ACMF)	This function records data from the engines for trend monitoring such as vibration, oil debris detection, etc. The data is stored and off-loaded for maintenance.
Aircraft data exchange function	This function manages file transfer and software uploading into the aircraft. When a file or software is uploaded, the HMU checks the data for integrity and transfer it to the corresponding system.
Aircraft data management	Allows the aircraft maintenance data to be off-loaded through the channels that follow: • ACARS, • Cellular connectivity, • Wi-Fi connectivity, • USB ports, and • Laptop.

ONBOARD MAINTENANCE SYSTEM (OMS) – OVERVIEW

The OMS is a software application that provides access to stored maintenance data. It performs the functions that follow:

- Maintenance messages and configuration reporting.
- Real-time system data reporting,
- Line Replaceable Unit (LRU) testing and rigging,
- Fault diagnostics and isolation, and
- Aircraft condition monitoring,

The table that follows summarizes the OMS functions.

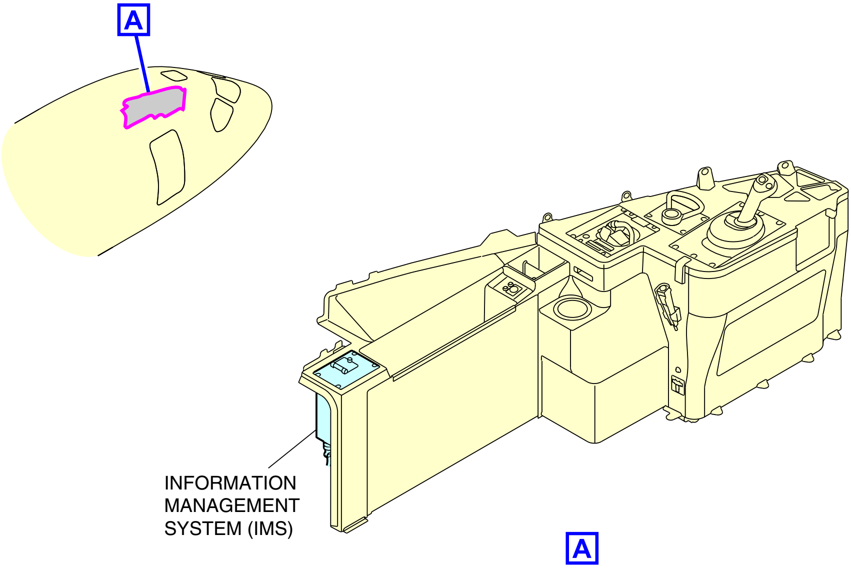
OMS function	Description
Maintenance messages and configuration reporting.	Reports maintenance messages with faults description, faults logic, and troubleshooting help text. It provides assistance in managing the aircraft configuration by monitoring and displaying the hardware and software part numbers.
Real-time system data reporting.	This function allows the maintenance crew to monitor real-time LRU parameters for each system (ex: valves position, sensors reading, brakes clamping force etc.).
LRU testing and rigging	The functions allows the maintenance crew to do Initiated Built-In Test (IBIT) and rigging of the LRUs.
Faults diagnostic and isolation	This function isolates and records faults when fault conditions are met, and links them to trouble-shooting pages.
Aircraft condition monitoring	It records and stores engine/APU/system trends, exceedances, and aircraft life cycle for preventive and maintenance actions.

The OMS pages display on the Multifunction Window (MFW). The controls are accessed through the Cursor Control Panel (CCP) and the Multifunction Keyboard Panel (MKP).

INFORMATION MANAGEMENT SYSTEM (IMS) – OVERVIEW

The IMS is a Line Replaceable Unit (LRU) installed in the pilot side console (refer to Figure 19–04–2). It manages the data exchange between the aircraft and ground stations through:

- Flight deck printer, <23220001C>
- Wireless connection, and
- Ethernet connection.



Information Management System (IMS) location
Figure 19–04–2

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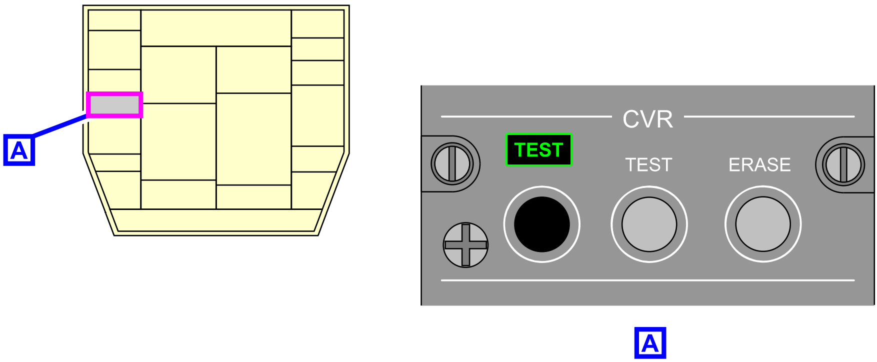
COCKPIT VOICE RECORDER (CVR) CONTROLS

A. CVR panel

The CVR panel (refer to Figure 19–05–1) consists of:

- A TEST switch,
- A TEST indicator,
- An ERASE switch, and
- A headset jack.



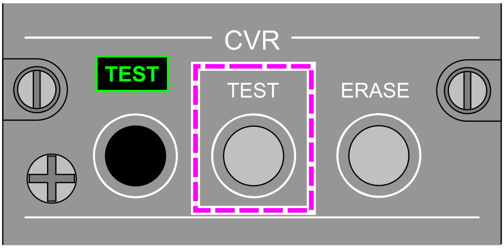
CVR panel
Figure 19–05–1

B. TEST switch

When the TEST switch (refer to Figure 19–05–2) is pressed and held, the CVR performs an internal test. If the test is successful, the TEST indicator illuminates.

NOTE

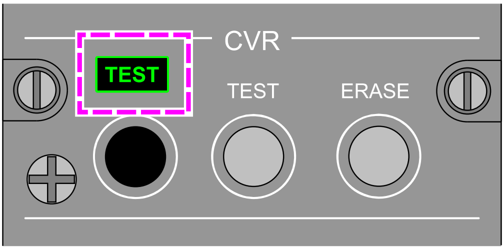
A CVR test failure soon after the aircraft is powered may indicate that the CVR battery is not adequately charged. Another test may be performed after 15 minutes.



CVR panel – TEST switch
Figure 19–05–2

C. TEST indicator

The TEST indicator (refer to Figure 19–05–3) illuminates when the CVR internal test is successful.



CVR panel – TEST indicator
Figure 19–05–3

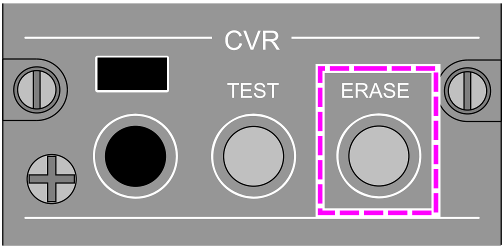
D. ERASE switch

When the ERASE switch (refer to Figure 19–05–4) is pressed for 2 seconds, the CVR deletes all the voice/digital recordings if:

- The aircraft is Weight-On-Wheels (WOW), and
- The PARK BRAKE switch is ON.

A confirmation tone sounds when a headset is plugged in the HEASDSET jack.

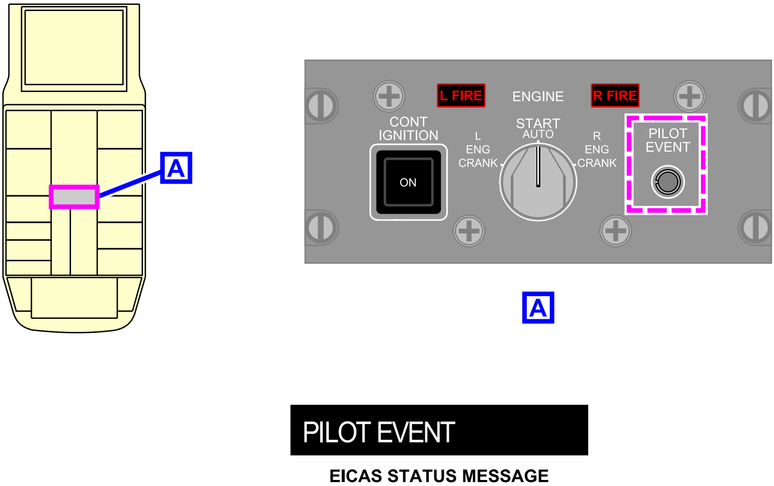
The 2-second delay is to ensure that the switch was not pressed accidentally.



CVR panel – ERASE switch
Figure 19–05–4

ENGINE PANEL – PILOT EVENT SWITCH

When the PILOT EVENT switch (refer to Figure 19–05–5) is pressed, a momentary **PILOT EVENT** status message displays on the EICAS page.



ENGINE panel – PILOT EVENT switch
Figure 19–05–5

RECORDING – EICAS MESSAGES

A. Warning messages

None

B. Caution messages

None

C. Advisory messages

Message	Description	Inhibit
CVR FAIL	CVR failure.	TO, LDG
FDR FAIL	FDR failure.	TO, LDG
HEALTH MGMT FAULT	Generic fault detected in the HMU.	TO, LDG

Message	Description	Inhibit
HI LOAD EVENT	A high-load event, either gust or hard landing has been detected.	TO, LDG
HI LOAD MONITOR FAIL	High load detection failed or unreliable.	TO, LDG
FDR ACCEL FAIL	Accelerometer declared failed if signal is not reading a reasonable acceleration.	TO, LDG

D. Status messages

Message	Description	Inhibit
A/C MAINTENANCE SW	Maintenance switch in UPLOAD or MAINT position.	None
PILOT EVENT	Momentary status message for confirmation of PILOT EVENT switch selection.	None
BATT PWR CONFIG	ELEC switch on the maintenance panel selected to DC ESS 3.	None

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CHAPTER 20 – WATER AND WASTE

List of figures

POTABLE WATER SYSTEM

WASTE SYSTEM

WATER AND WASTE – INDICATIONS

WATER AND WASTE SYSTEM – OVERVIEW

The potable water system provides potable water storage, distribution to the galleys and lavatories, temperature control, and water level indication. The vacuum waste system provides lavatory waste storage, level indication and system control for lavatory waste.

There are two external panels, one for the potable water and one for the disposal of the waste system.

The control and monitoring is done through the Cabin Management System (CMS) and Water and Waste System Controller (WWSC).

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POTABLE WATER SYSTEM – OVERVIEW

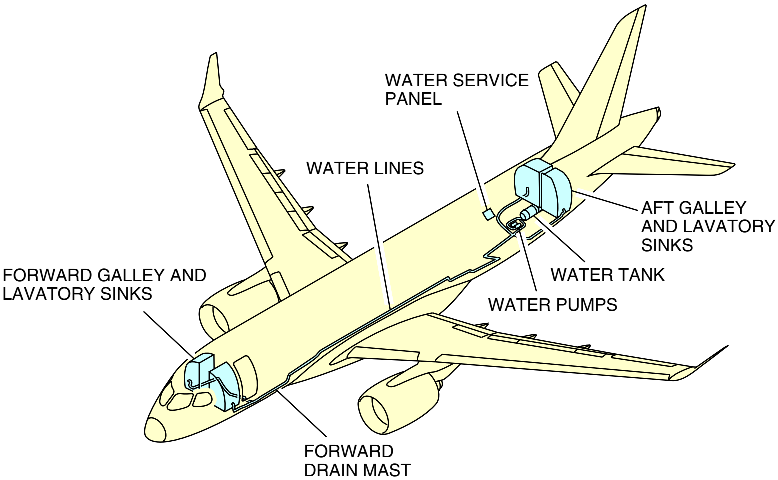
The potable water system (refer to Figure 20–02–1) supplies the galleys and lavatories. The system is pressurized, heated, and monitored by the pressure, temperature, and level sensors. After it is used, the water is evacuated through heated drain masts. The potable water system is automatically active when:

- Power is available,
- Water is in the tank, and
- Servicing panel door is closed.

The system consists of the main components that follow:

- A potable water tank,
- Two AC-powered water pumps,
- Water line heaters,
- Drain mast and drain valves, and
- A potable water servicing panel.

When certain conditions are met, the potable water can be purged in flight.



Potable water system overview
Figure 20–02–1

POTABLE WATER SYSTEM – DESCRIPTION AND OPERATION

A. Potable water tank

The potable water tank is installed behind the aft cargo compartment. It has a usable capacity of 159 liters (42 US gallons) and an extra unusable volume in case of water freezing. The unit consists of:

- A level sensor,
- Two hose connections consisting of one venting and one replenishing lines, and
- Heaters.

B. AC-powered water pumps

The potable water system is pressurized by two AC-powered water pumps installed next to the water tank. Only one pump runs during normal operation, with pump utilization alternating at each servicing. If the active pump fails in flight, the other pump automatically operates. When the tank is empty, the pump operation is inhibited.

When the water tank is empty, or both water pumps are faulty, the WATER SYSTEM INOPERATIVE message displays on the Cabin Management System (CMS).

C. Water line heaters

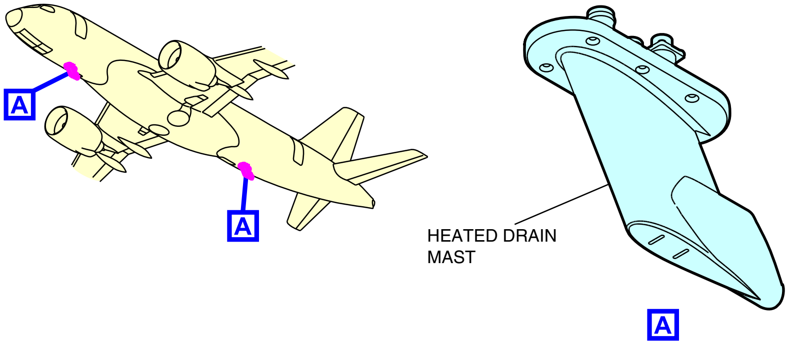
The water lines are electrically heated. The heaters are monitored by temperature sensors and controlled by the Water and Waste System Controller (WWSC).

Water heaters are installed in each lavatory beneath the sink to provide heated water to the sink faucet.

D. Drain mast and drain valves

The water is gravity-drained by two motor-operated drain valves and one motor-operated fill/drain valve. The forward and aft drain valves are used to drain the system, and the fill/drain valve is used to service the water tank. All three drain valves are heated.

The drained water is discharged overboard by heated drain masts (refer to Figure 20–02–2) located on the underside of the aircraft fuselage. If a drain mast heater is not powered, a FWD DRAIN MAST FAULT or AFT DRAIN MAST FAULT message displays on the CMS.

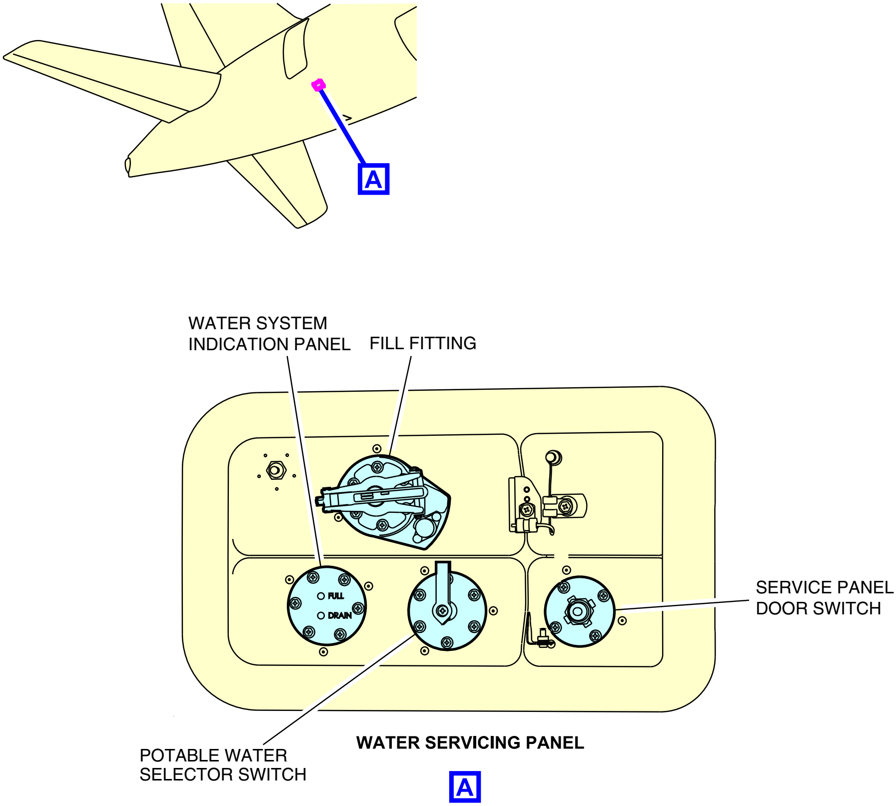


Heated drain mast locations
Figure 20–02–2

E. Potable water servicing panel

The potable water servicing panel (refer to Figure 20–02–3) is used to fill and drain the tank. It is located on the aft lower fuselage and includes:

- A selector switch,
- A fill fitting to fill and drain the water tank,
- Two FILL and DRAIN indicator lights, and
- A panel door switch to deactivate the water pumps when the servicing panel door is open.



Potable water servicing panel
Figure 20–02–3

F. Potable water purging

The cabin crew can purge the potable water from the water lines and from the water tank by using the water purge function on the LAVATORY screen in the CMS.

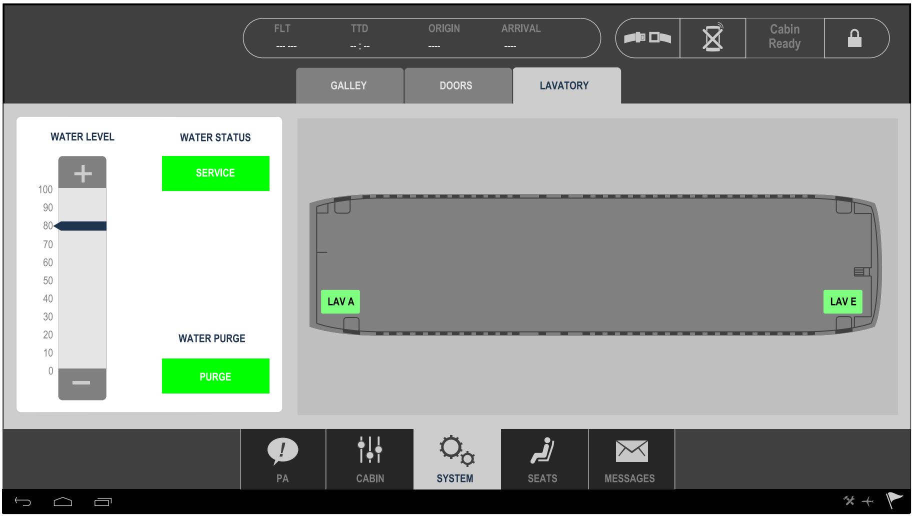
The purge function is active if the conditions that follow are met:

- Landing gear is up,
- Drain mast heaters are operative,

- WATER TANK PURGE soft switch is pressed on the LAVATORY page(refer to Figure 20–02–4), and
- Aircraft altitude below 10000 feet.

The IN FLIGHT PURGE INHIBIT message displays on the CMS if any of the above conditions are not met.

During water purging, the IN FLIGHT PURGE IN PROGRESS message displays on the CMS.



Water purge control on Cabin Management System (CMS)
Figure 20–02–4

WASTE SYSTEM – OVERVIEW

The waste system uses the differential pressure existing between the cabin and the outside atmosphere and a vacuum generator to transport waste from the lavatories to the waste tank. The waste system is automatically active when:

- AC power is available,
- Waste tank is not full, and
- Waste servicing panel door is closed.

The system comprises the main components that follow:

- A waste tank,
- An air/waste separator,
- A vacuum system, and
- A waste servicing panel.

WASTE SYSTEM – DESCRIPTION AND OPERATION

A. Waste tank

One waste tank stores all the waste from the lavatories. It has a usable capacity of 144 liters (38 US gallons) and it is located aft of the rear bulk cargo compartment. It has the components that follow:

- An air/waste separator,
- Level sensors at 75% and 100%,
- An inlet assembly, and
- Rinse nozzles.

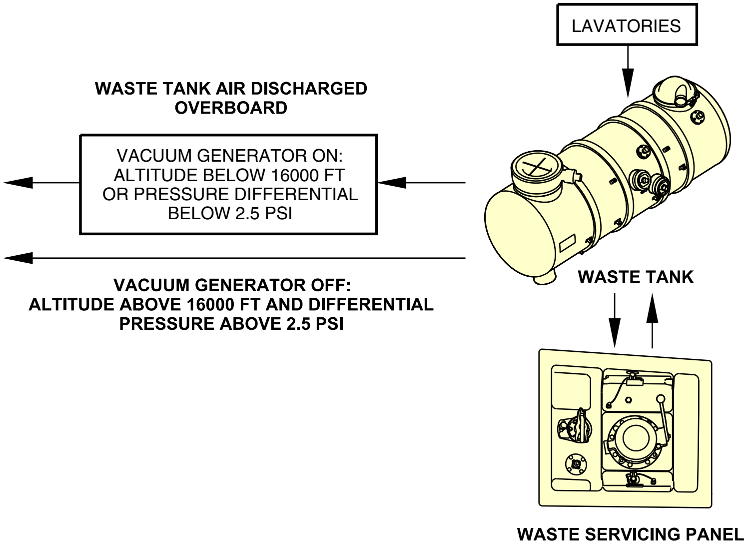
The air/waste separator expels air overboard from the waste tank during a flush sequence. Two sensors indicate when the waste tank has been filled to 75% and to its full usable capacity (100%). When the tank level reaches 100% capacity, a sensor triggers an automatic waste system shutdown. If the 100% sensor fails before reaching the 100% capacity, the system shuts down at 75% capacity.

The inlet assembly is connected to the tubing from the lavatories and the two rinse nozzles clean the interior of the tank during servicing.

B. Vacuum system

During ground and low-altitude operations, a vacuum generator creates the necessary pressure differential in the system to move the waste from the lavatories to the waste tank. Above 16000 feet (4877 meters), the system uses differential pressure between the cabin and the outside.

Figure 20–03–1 shows an overview of the waste system.



Waste system overview
Figure 20–03–1

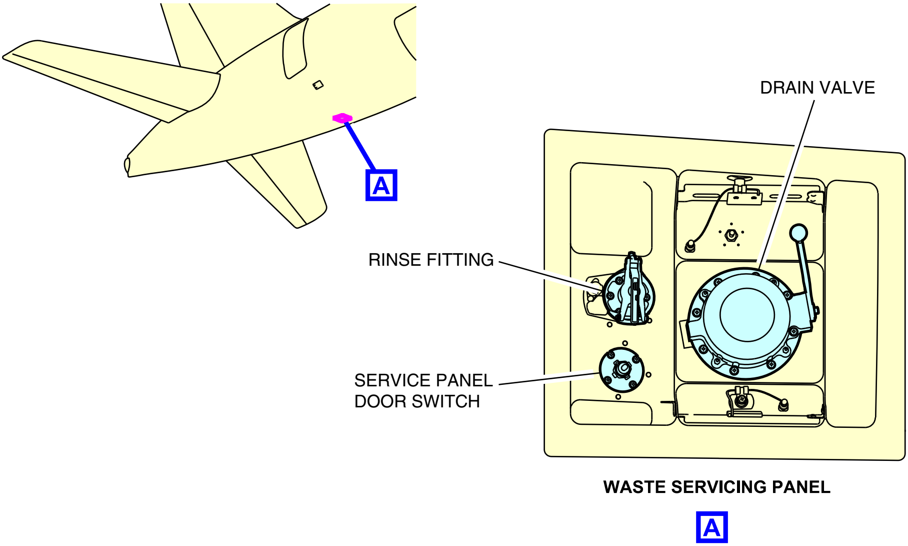
C. Waste servicing panel

The waste servicing panel (refer to Figure 20–03–2) is located in the aft lower section of the fuselage and includes:

- A drain valve,
- A waste tank rinse fitting, and

- A service panel door switch.

The drain valve is used to remove the waste material from the tank. The service panel door switch deactivates the vacuum generator during servicing.



Waste servicing panel location and components
Figure 20–03–2

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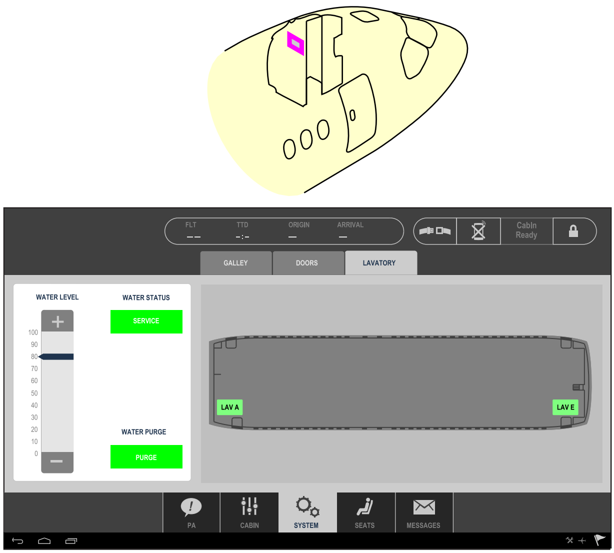
CABIN MANAGEMENT SYSTEM (CMS) INDICATIONS

Status and fault messages are reported on the Cabin Management System (CMS). It provides:

- Water level and waste status,
- Water quantity fill pre selection by increments of 10%, and
- In-flight water purging function.

Refer to Figure 20–04–1.



Cabin Management System (CMS) display
Figure 20–04–1

The table that follows shows the status and fault messages associated to the system. They are accompanied by a low chime.

Messages	Description
WASTE TANK 75%	Waste tank level at 75%.
WASTE TANK FULL	Waste tank level at 100%.

Messages	Description
WASTE SYSTEM INOP	Waste tank 100% full, or both waste level sensors inoperative, or all lavatories inoperative.
WATER QUANTITY	Transmission of water quantity in %, GAL, or liter.
IN-FLIGHT PURGE IN PROGRESS	In-flight purge is running.
IN-FLIGHT PURGE INHIBIT	In flight purge draining conditions are not met.
FWD DRAIN MAST FAULT	Forward drain mast is not heated.
AFT DRAIN MAST FAULT	Aft drain mast is not heated.
WASTE SERVICE DOOR OPEN	Waste servicing panel door open.
WATER SERVICE DOOR OPEN	Water servicing panel door open.
WATER SYSTEM INOPERATIVE	Water tank is empty, or both water pumps are faulty.

WATER AND WASTE – EICAS MESSAGES

There are no EICAS messages associated to the water and waste system.

CHAPTER 21 – ELECTRONIC CHECKLIST

ELECTRONIC CHECKLIST (ECL)

ELECTRONIC CHECKLIST – DESCRIPTION AND OPERATION

List of figures

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ELECTRONIC CHECKLIST (ECL)

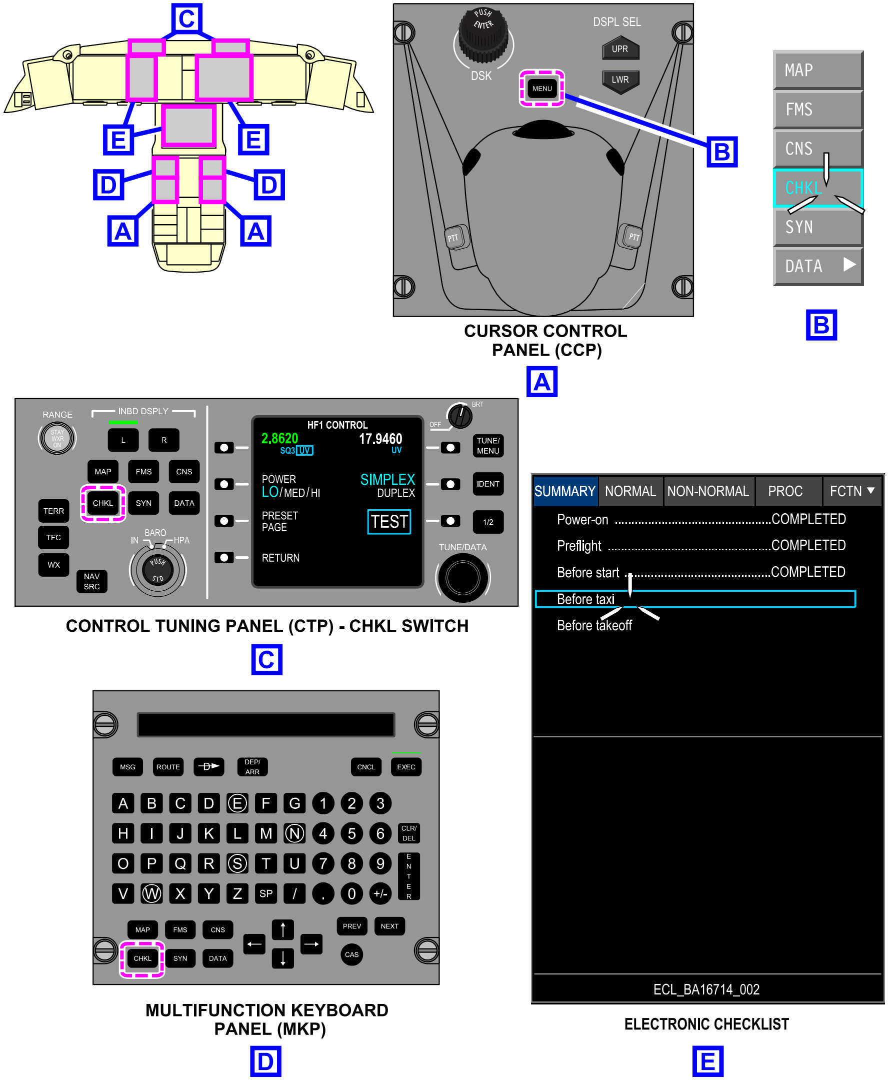
A. Overview

The Electronic Checklist (ECL) is displayed on the Multifunction Windows (MFWs) and is designed to reduce the flight crew workload. It gives access to the normal and non–normal procedures and checklists that are also available in the Electronic Flight Bag (EFB), iPad, or paper formats. The ECL, AFM, FCOM and QRH share the same content, with different formats.

The ECL is an interactive display with automatically sensed or manually selected items. The design of the ECL is efficient and helps the flight crews in regular and awareness situations.

The ECL controls (refer to Figure 21–01–1) include the panels that follow:

- Control Cursor Panel (CCP),
- Multifunction Keyboard Panel (MKP), and
- Control Tuning panel (CTP).



ECL – Controls
Figure 21–01–1

This document uses the action select or press to describe the manipulation of controls.

Select is used when it is necessary to move, turn, or choose the controls that follow:

- Hard switches,
- Levers,
- Control cursor line items, and
- Soft tile switches (as shown in the ECL).

Press is used when it is necessary to put pressure on hard switches.

The ECL does not open automatically. To select the ECL, the flight crew has to do one of the three procedures that follow:

- Pressing the CHKL switch on the left CTP displays the ECL on DU 2, and pressing the CHKL switch on the right CTP displays it on DU 3. The left (L) and right (R) INBD DSPL switches on the CTP are used to select in which DU partition the format will be displayed.
- Pressing the CHKL switch on the left MKP displays the ECL page on the left DU 5 partition. Pressing the CHKL switch on the right MKP displays it on the right DU 5 partition.
- The MENU switch on the CCP can be used as a backup to select the ECL page.

Two ECL pages can be displayed on the MFWs, and they are synchronized.

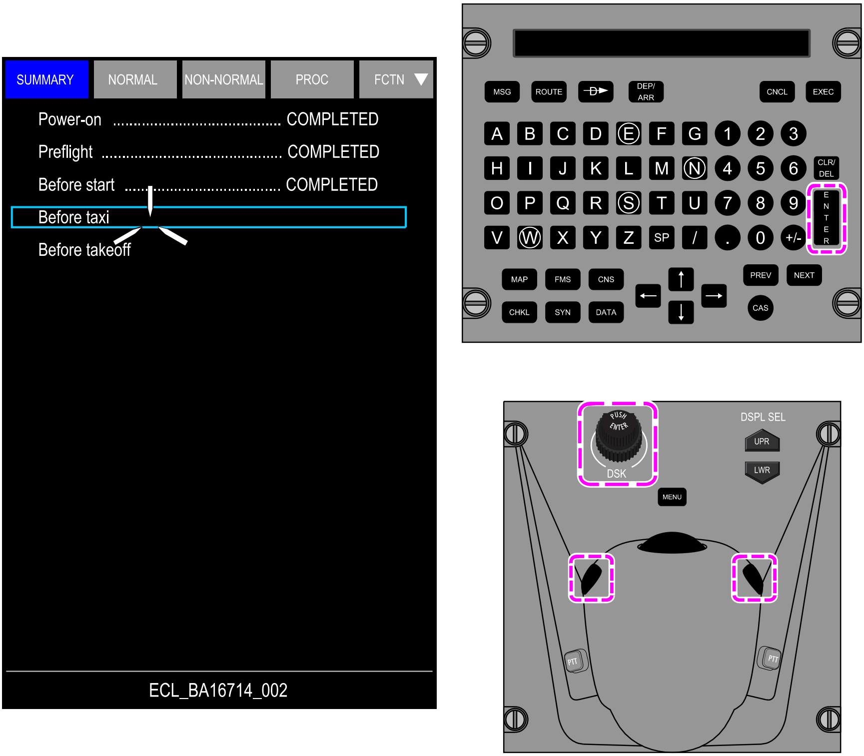
When the aircraft is on battery power, the ECL is available on DU 2 only. When the aircraft is fully powered, the ECL is available on DU 2, DU 3, and DU 5.

To navigate within the ECL, the cursor is used to position the focus indicator (cyan box). The selection is done with one of the switches that follow (refer to Figure 21–01–2):

- The left and right SELECT switches on the CCP,
- The ENTER switch on the MKP, and

- The inside of the DSK switch (PUSH ENTER).

The ENTER switch allows the flight crew to acknowledge the checklist items, with the exception of the sensed items.

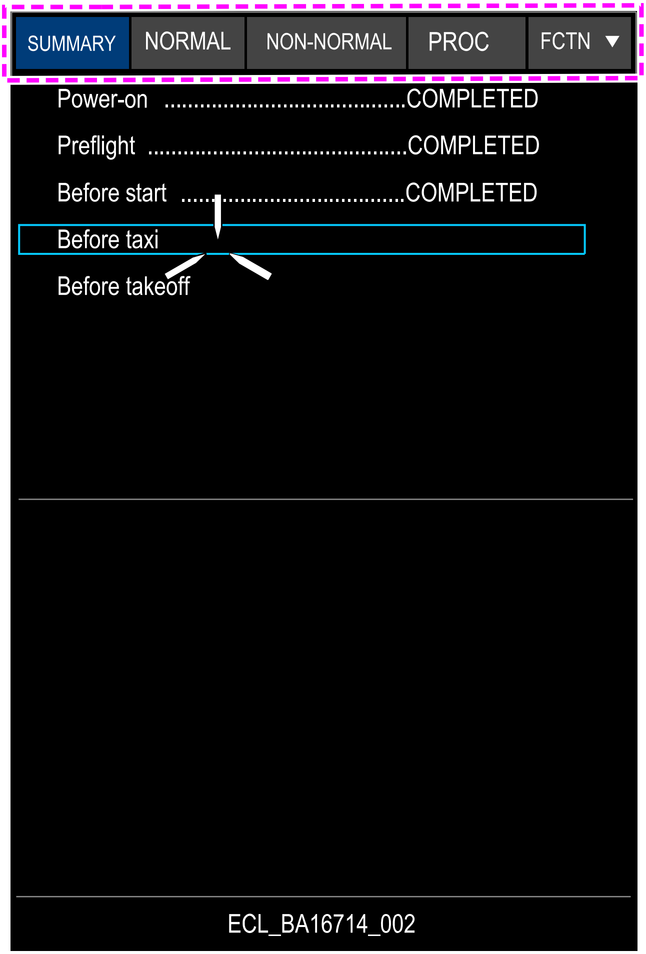


ECL – Navigation controls
Figure 21–01–2

The ECL has a menu bar (refer to Figure 21–01–3), which includes the soft tile switches that follow:

- SUMMARY,
- NORMAL,

- NON–NORMAL,
- PROC (procedure), and
- FCTN (function).



ECL – Menu bar
Figure 21–01–3

The part number of the ECL database is shown on the bottom of the SUMMARY page, until it is replaced with a COMPLETE, STARTED, LIMITATIONS, or COMPLETE W/DFRD status.

NOTE

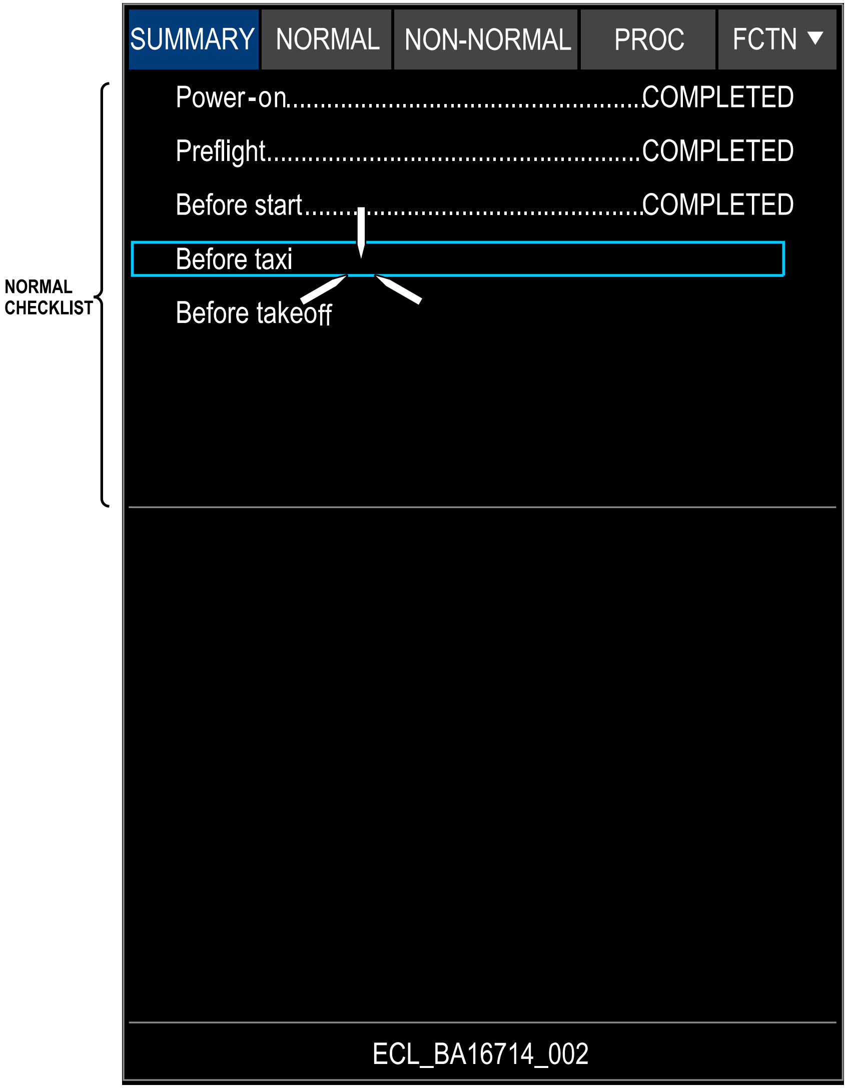
When an ECL database error is detected, it prevents the user from accessing the ECL content by annunciating the CHECKLIST NOT AVAILABLE message.

B. SUMMARY page

The SUMMARY page is the ECL default page. It will be displayed when any of the CHKL switches are pressed. The summary page is refreshed automatically, and updates automatically depending on the status of procedures and checklists.

The SUMMARY page is divided into 2 sections, an upper and a lower sections.

The upper section includes the normal checklist (refer to Figure 21–01–4). It displays the STARTED and COMPLETED checklists based on the current phase of flight (on ground prior to takeoff, in flight, and on ground after landing) determined by the Weight-Off-Wheels (WOFFW). On ground, the ECL only displays all ground related normal checklists. When a checklist is STARTED or COMPLETED, it is separated by a white dotted line in between the white title and the checklist status. When the checklist is not started, the dotted line will be hidden.



SUMMARY Page – ECL Upper Section
Figure 21–01–4

The lower section includes the active and the history subsections. Refer to Figure 21–01–5.

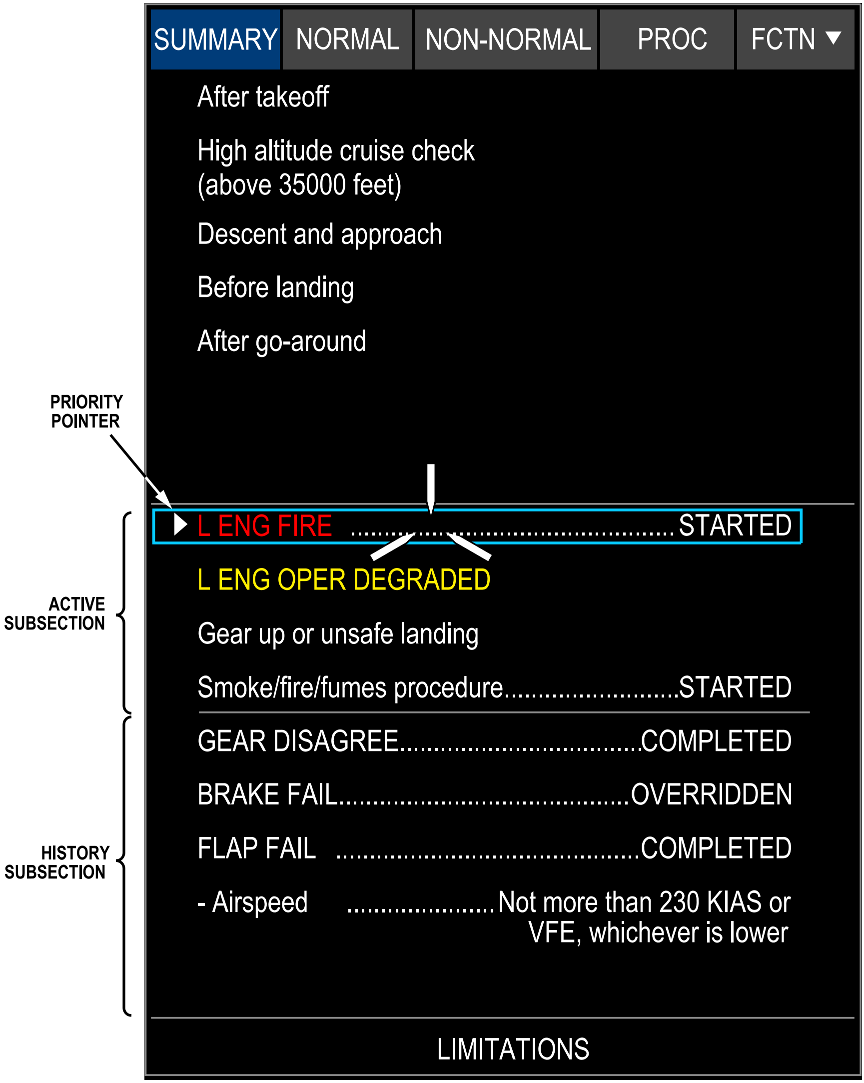
The active subsection displays:

- The non-normal warning (red) and caution (amber) checklists and procedures based on triggered EICAS messages,
- The procedures selected by the flight crew (not EICAS related), and
- The follow-on checklists.

The history section displays:

- The non-normal COMPLETE, COMPLETE W/DFRD (with deferred) and/or the OVERRIDDEN checklists/procedures, and
- The associated carried limitations (if any) at the bottom of the page.

When the soft switch SUMMARY tile is selected, the cursor is positioned on the top started or non-started checklist.



SUMMARY Page – ECL Lower Section
Figure 21–01–5

A priority pointer is displayed on the left side of the checklist that has the highest priority. When this checklist is completed, the priority pointer moves to the next priority checklist. The priory pointer is advisory only and doesn't show a priority for the normal checklists and the non-EICAS procedures.

C. NORMAL tile

The NORMAL page displays the normal procedure index (refer to Figure 21–01–6). The normal procedures are associated with one of the phases of flight that follow:

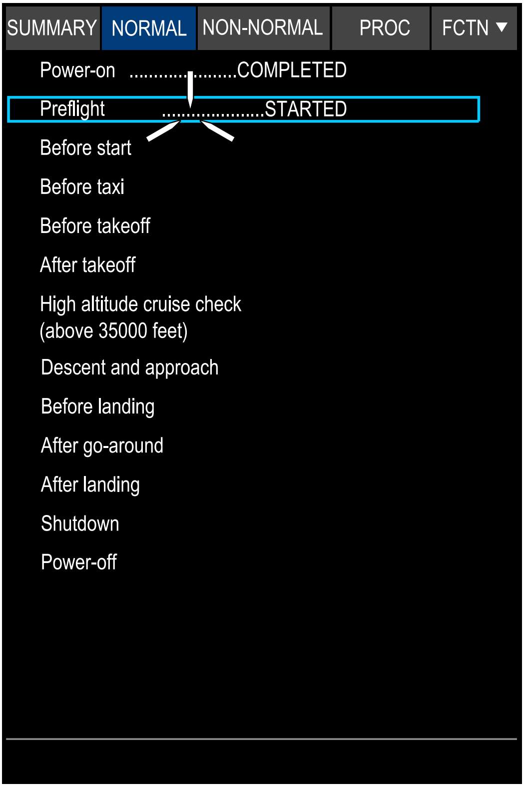
- Before flight (pre-flight),
- In flight (in-flight), and
- After flight (post flight).

The status of the procedure displays next to each started and/or completed procedure.

The user-defined procedures, if any, are grouped below the SUPPLEMENTARY title. They are displayed after the normal procedure index. It also contains the limitations, if any, at the bottom of the page.

The NORMAL page also contains the limitations, if any, at the bottom of the page.

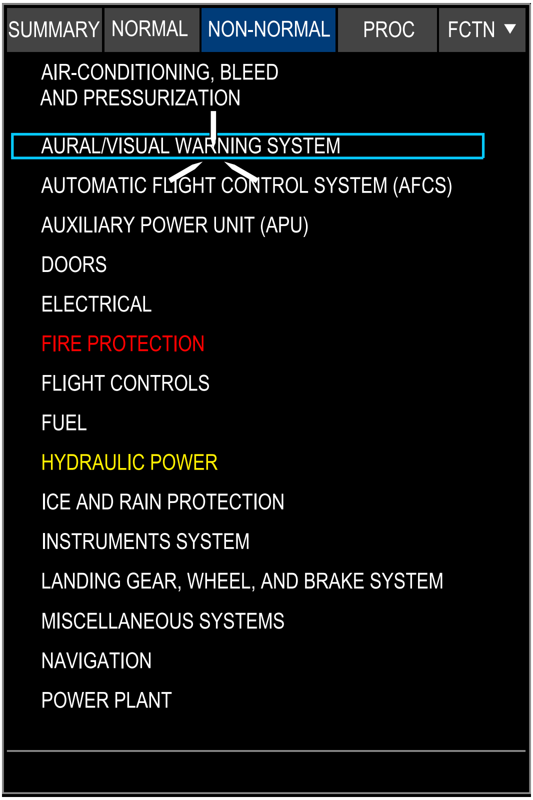
Any checklist on the NORMAL page can be selected, regardless of the phase of flight.



ECL – NORMAL page
Figure 21–01–6

D. NON-NORMAL tile

The NON–NORMAL page displays the list of systems that contain checklists with associated EICAS messages and the non EICAS related procedures. The system list is organized in alphabetical order. Clicking on a system title displays the corresponding subsystem titles (refer to Figure 21–01–7).

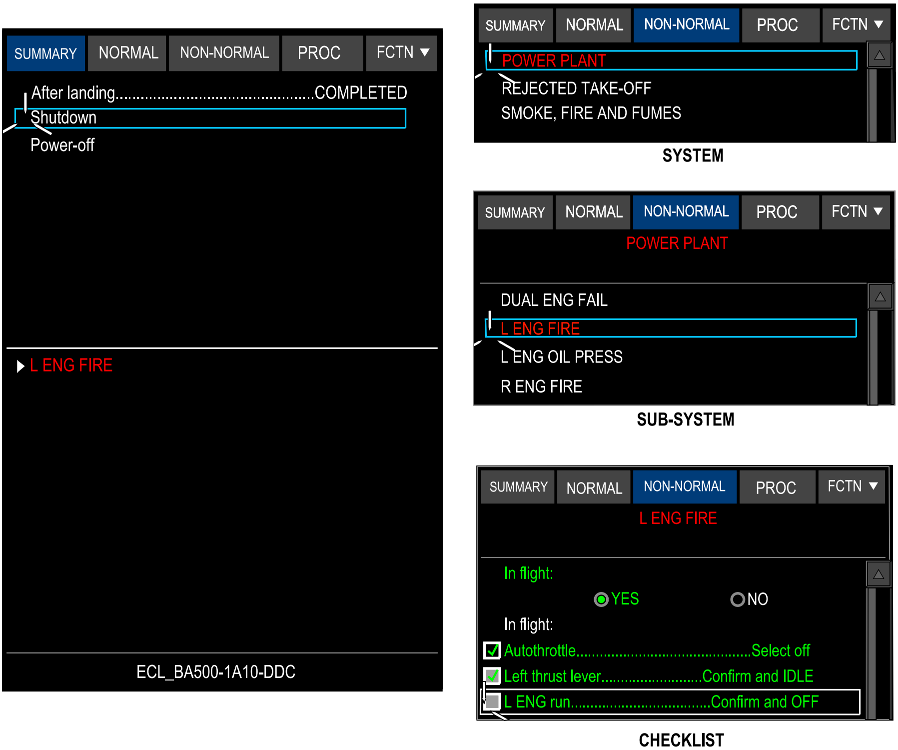


ECL – NON–NORMAL page
Figure 21–01–7

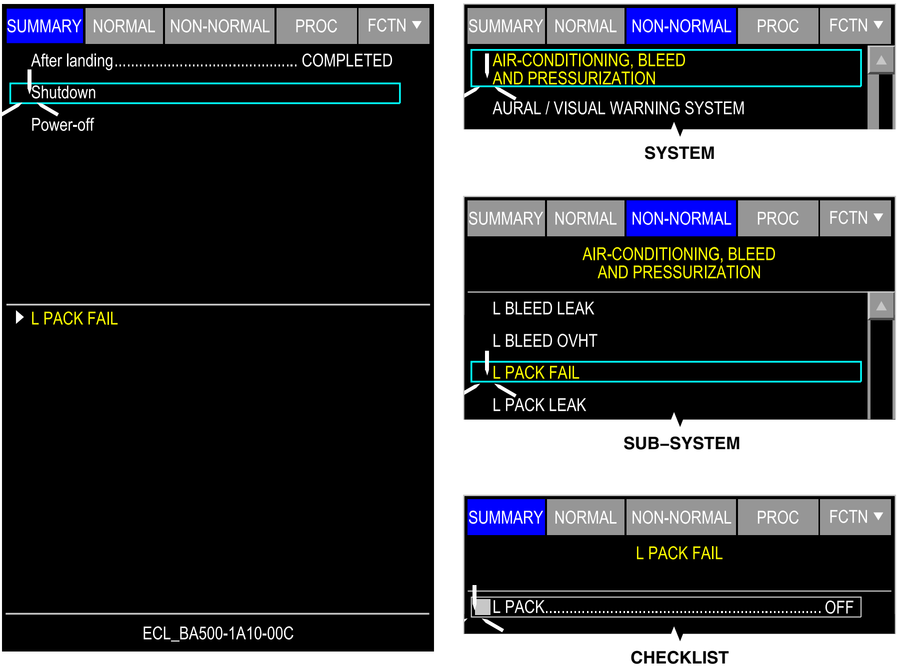
Clicking on a subsystem title displays the list of associated non-normal procedures. If the system does not contain any subsystems, it will display the system-associated non-normal checklist.

The non-normal checklists are grouped by EICAS message priority:

- WARNING associated EICAS messages (refer to Figure 21–01–8), and
- CAUTION associated EICAS messages (refer to Figure 21–01–9).



NON–NORMAL page – Warning checklist
Figure 21–01–8



NON–NORMAL page – Caution checklist
Figure 21–01–9

The categories are separated by a gray line.

The NON-NORMAL page can also display the limitations, if any, at the bottom of the page.

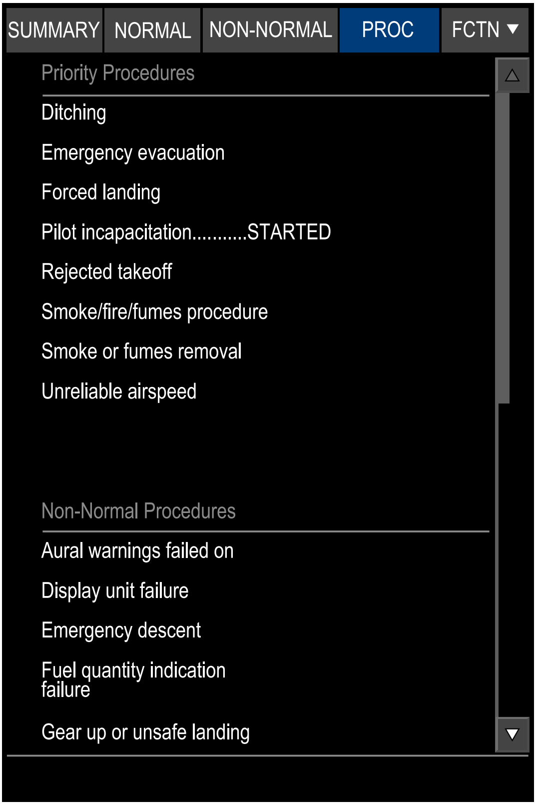
The non-normal procedures are displayed when the corresponding EICAS message is triggered on the EICAS page. The flight crew can also display a specific procedure by clicking on it.

Any checklist can be selected and used, regardless of the phase of the flight.

E. PROC tile

The PROC page displays the list of procedures not associated with an EICAS message and their related status (refer to Figure 21–01–10). It contains two lists separated by a gray line. The first list includes the titles of the priority procedures. The second list includes the other non-normal procedures.

Clicking on a procedure title displays the associated procedure. When selected, the procedure checklist displays, regardless of the phase of flight.



ECL – PROC page
Figure 21–01–10

F. FCTN tile

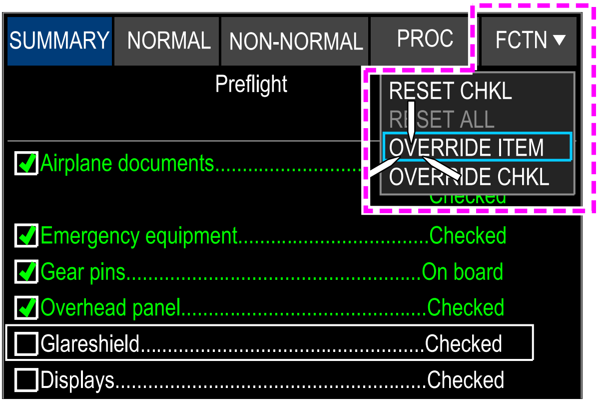
The FCTN (function) tile displays a drop-down menu (refer to Figure 21–01–11) to reset or override a checklist with the selections that follow:

- RESET CHKL: Resets the checked items and displays the first page of the checklist.

- RESET NORMALS (in flight only): Resets all normal checklists when the SUMMARY page is selected. This function cannot be applied on non-normal checklist or procedure.
- RESET ALL (on ground only): Removes the checklists or procedures from the summary page if the EICAS message is not triggered.
- OVERRIDE ITEM: Allows the pilot to override a checklist item (when item cannot be performed or sensing is not working).
- OVERRIDE CHKL: Allows the pilot to override a started or non-started checklist.

NOTE

All checklists are auto-reset on power up.



ECL – FCTN drop–down menu
Figure 21–01–11

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ECL ITEMS

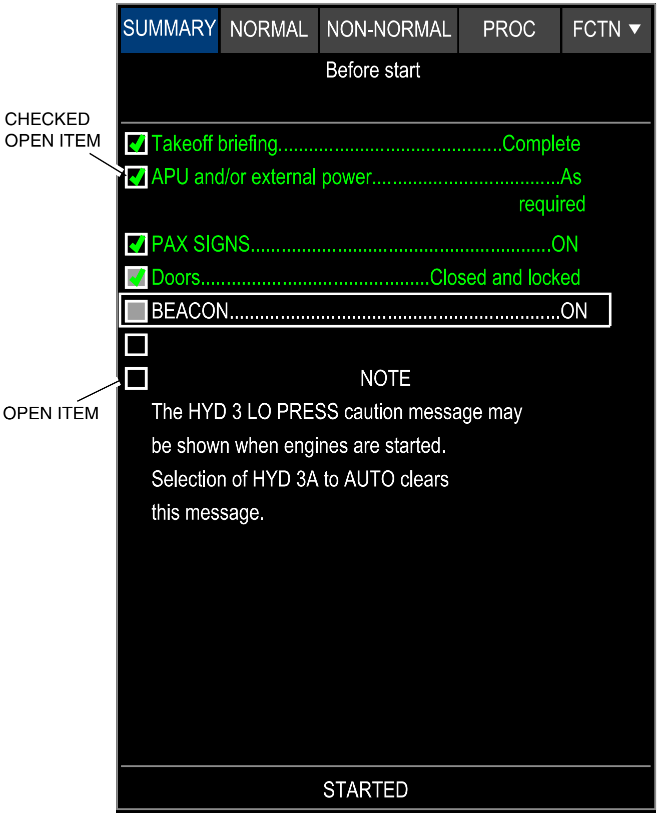
Each checklist includes items that must be actioned for the checklist to be completed. The checklist items are:

- Open item,
- Sensed item,
- Conditional item,
- Limitation item,
- Notification item,
- Deferred item,
- Follow-on item,
- Timed item,
- Free text item, and
- Override item.

A. Open item

An action item includes a challenge text and a response text.

The open items include an open white checkbox that is manually selected. When selected a green check displays in the checkbox. The items are displayed in green and the cursor and the focus indicator (white box) are automatically positioned on the next checklist item. Refer to Figure 21–02–1.



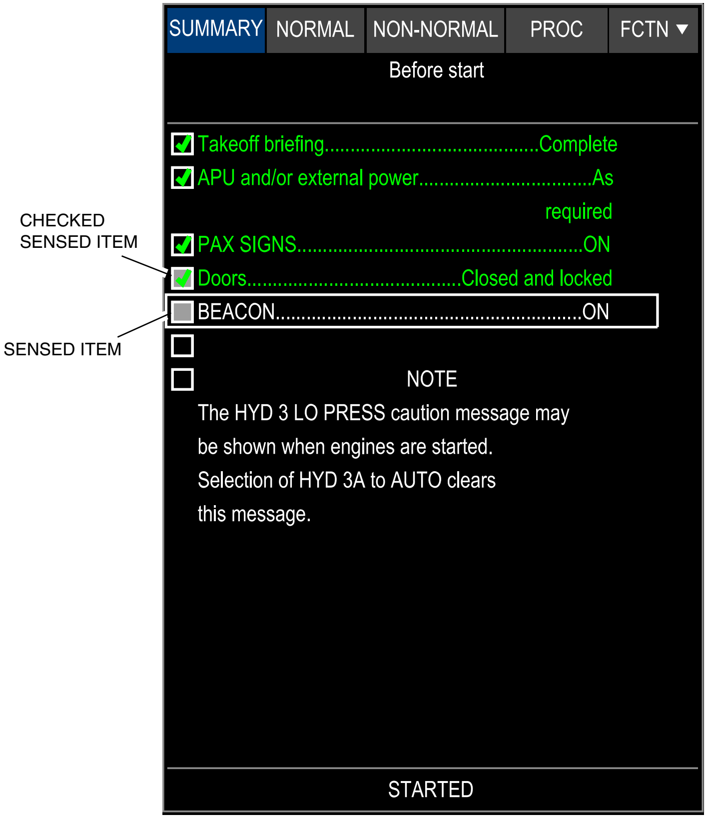
Open items
Figure 21–02–1

If a previously checked item is un-checked, the checkbox and the item are changed from green to white.

B. Sensed item

A sensed item is an item associated with a system status, a switch position, or a control position sensed by the ECL.

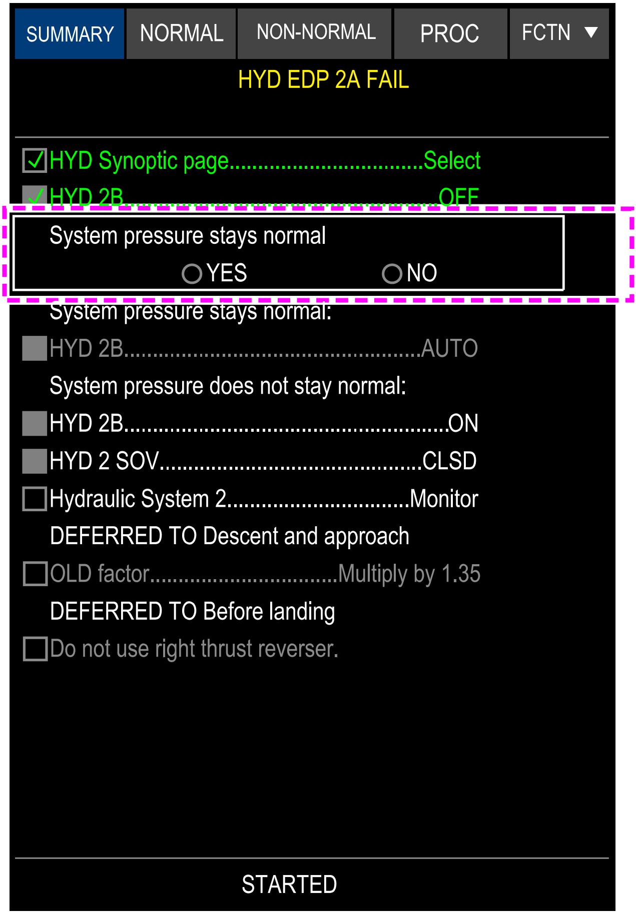
The sensed item checkboxes are filled-in gray. When the item control is at the position requested by the sensed checklist item, a green check displays in the checkbox. The checklist item displays in green and the cursor and the focus indicator automatically move to the next checklist item. Refer to Figure 21–02–2.



Sensed items
Figure 21–02–2

C. Conditional item

A conditional item has a question text, and two possible answers (YES or NO) (refer to Figure 21–02–3). The question is about operational conditions. When a selection is made, the cursor and focus indicator automatically move to the appropriate checklist item for the selection. The checklist items not required display in gray and are not considered.

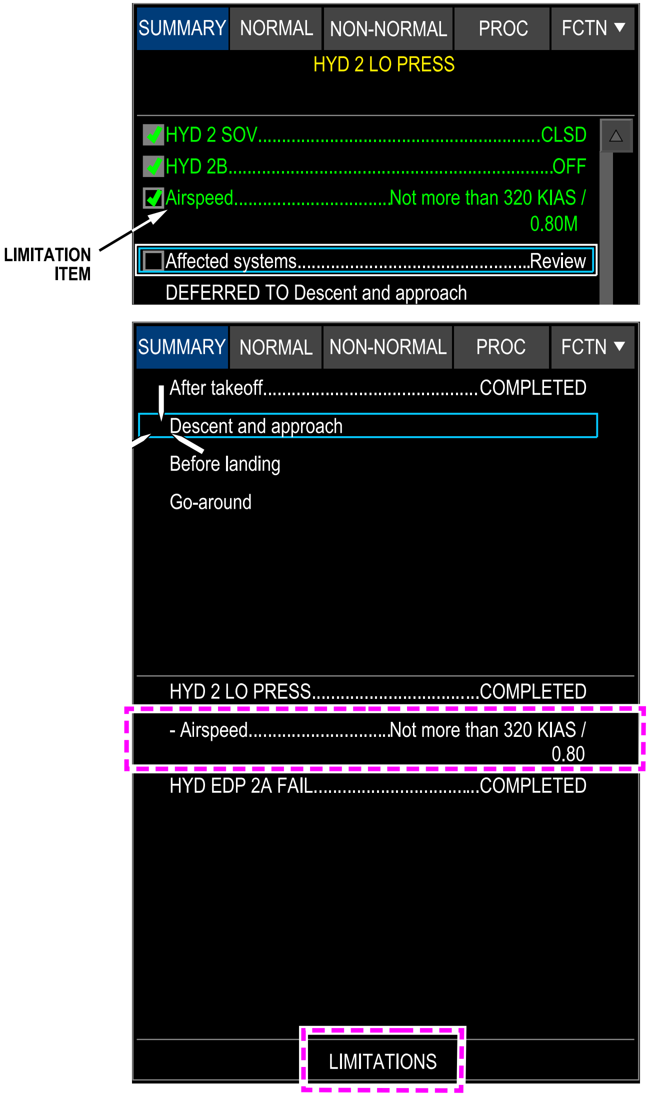


Conditional item
Figure 21–02–3

It is possible to change the answer of the condition item. The checklist items related to this new selection will display.

D. Limitation item

A limitation item contains the associated limitations. These are open checklist items used to define a limitation. When the limitation item is selected, it displays in green on the checklist. It is displayed in white at the lower section of the SUMMARY page (LIMITATIONS) only if the limitation items are checked and the checklist status is COMPLETE or COMPLETE W/DFRD (complete with deferred). Refer to Figure 21–02–4.



Limitation Item
Figure 21–02–4

E. Notification item

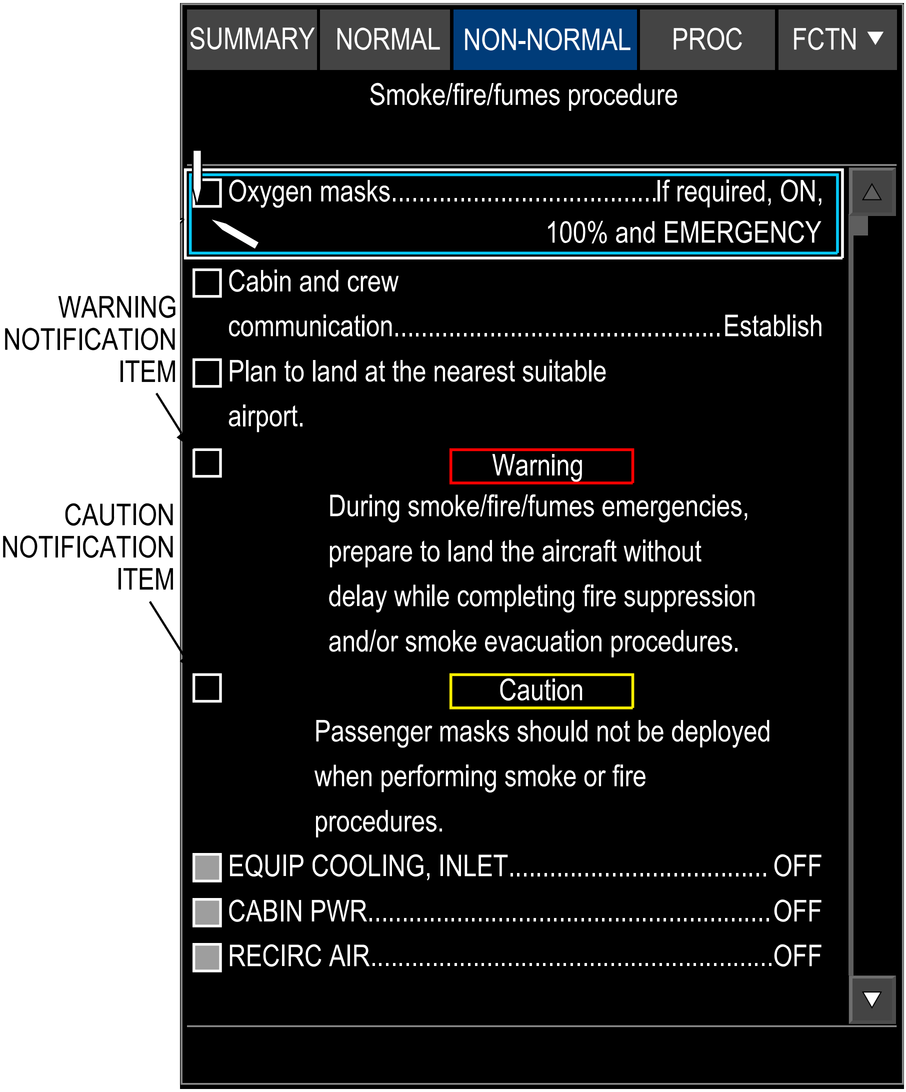
The ECL displays three types of checklist notifications:

- WARNING (surrounded by a red box),
- CAUTION (surrounded by an amber box), and
- NOTE (white text only).

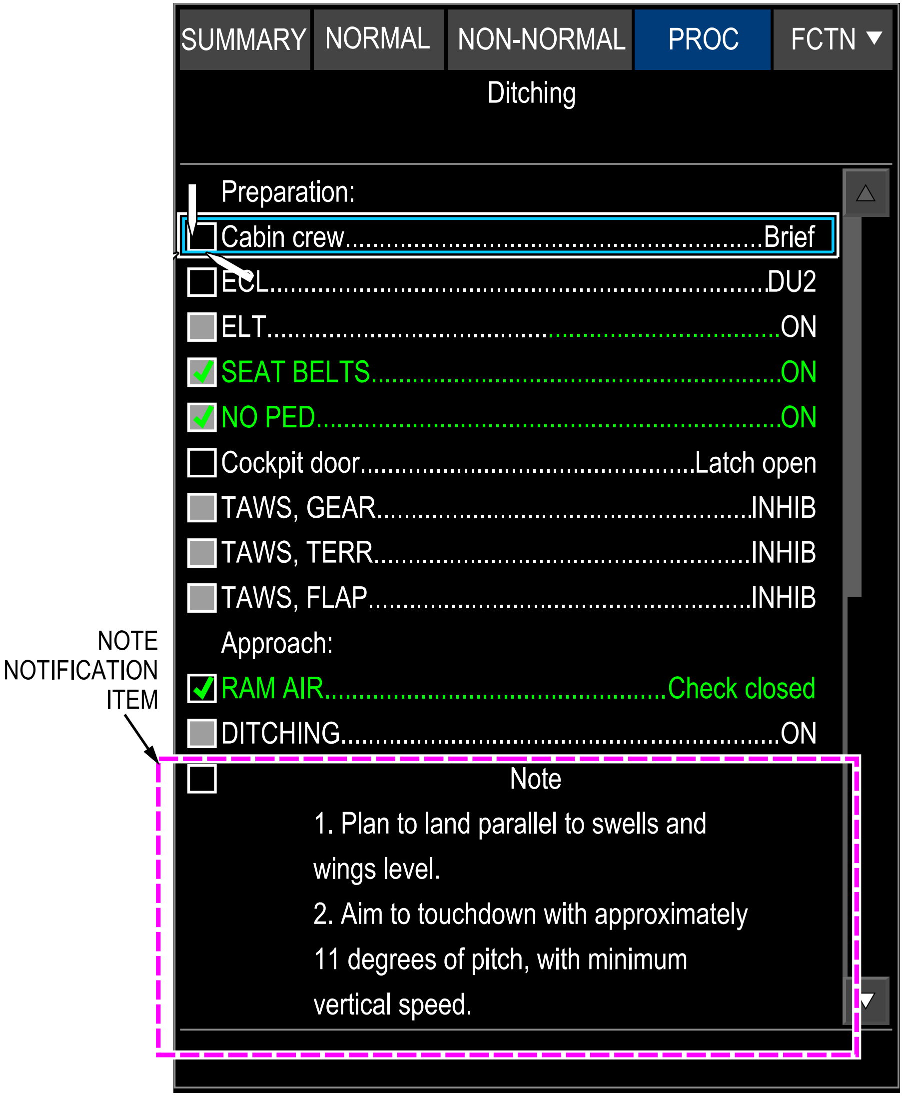
A note contains additional text to provide detailed information to the pilot. It must be acknowledged by the pilot.

An example of WARNING and CAUTION notification items are shown in Figure 21–02–5.

An example of NOTE notification item is shown in Figure 21–02–6.

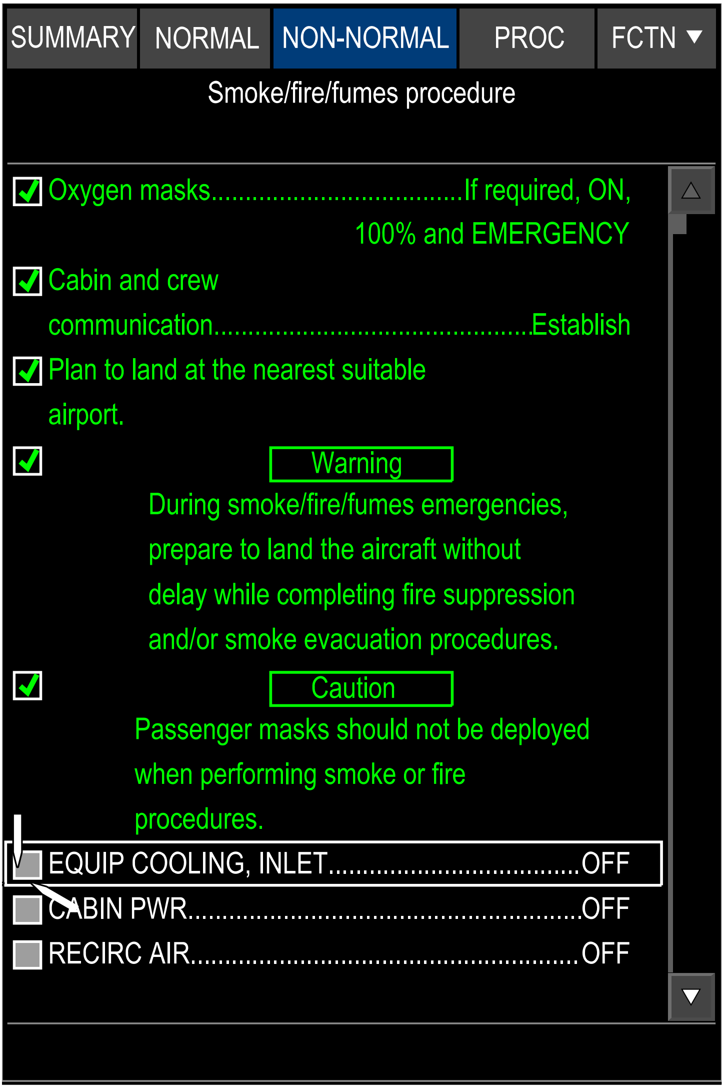


Warning and Caution Notification Items – Not Selected
Figure 21–02–5



Note Notification Item – Not Selected
Figure 21–02–6

When the checkbox is selected, the checkmark and that notification display in green (refer to Figure 21–02–7).



Notification Item – Selected
Figure 21–02–7

F. Deferred item

A deferred item is an action item that can be accomplished in a later phase of flight.

When non-normal checklists include items to be added to a later checklist, DEFERRED TO (checklist name) displays in white, followed by the items to be deferred in gray.

When the checklist is complete, the deferred items are automatically included in the appropriate checklist, and the COMPLETE W/DFRD soft switch displays at the bottom of the page (refer to Figure 21–02–8).

At the appropriate place in the checklist, DEFERRED FROM (non-normal checklist name) displays followed by the deferred items.

NOTE

When the source procedure or checklist is reset, the deferred items are removed from the checklist.

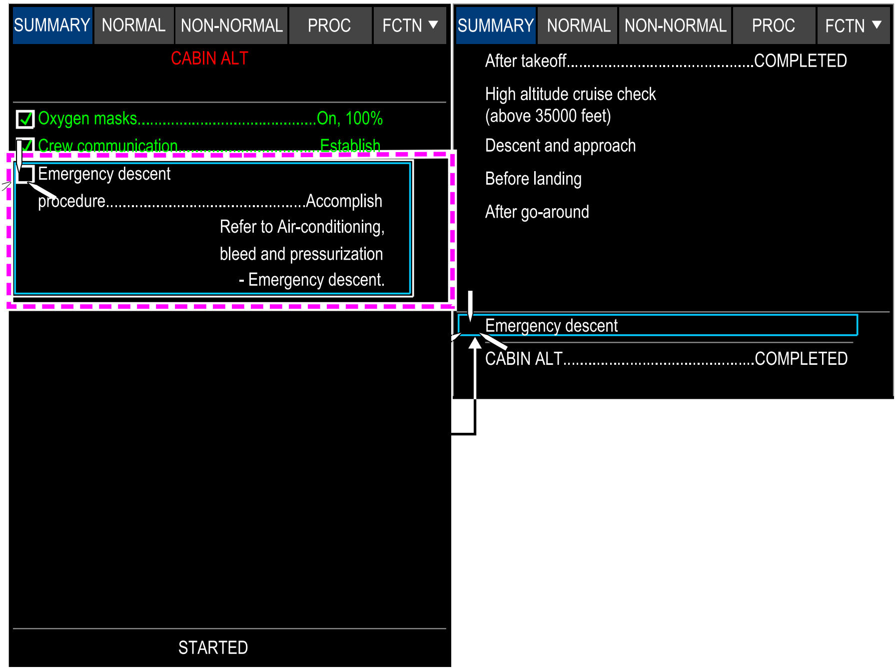
The DEFERRED ITEMS must be selected to complete the checklist.

Checklist deferred
Figure 21–02–8

G. Follow-on item

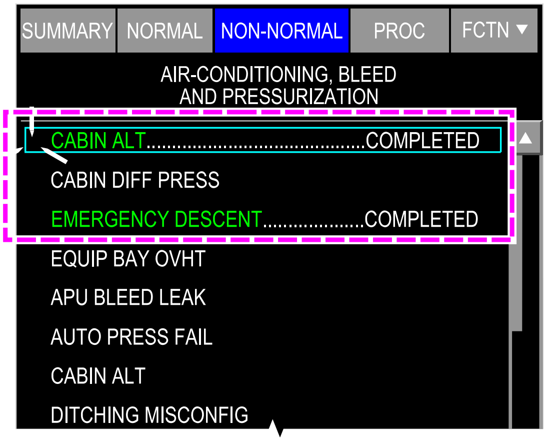
A follow-on item is an action item used to activate a procedure that the pilot will have to do later.

When another checklist or procedure is required at the completion of a non-normal checklist or procedure, the follow-on checklist or procedure is displayed on the SUMMARY page, when the non-normal checklist is completed. Refer to Figure 21–02–9 for an example of follow-on Emergency descent procedure after a CABIN ALT non-normal checklist. When the Emergency descent shown in the CABIN ALT checklist will be selected (and displayed in green), the status of the CABIN ALT checklist will changed from STARTED to COMPLETE status. Then, when the COMPLETE soft tile switch is selected, the history subsection of the SUMMARY page will display the completed CABIN ALT checklist below the follow-on Emergency descent non-normal procedure.



Follow–on item
Figure 21–02–9

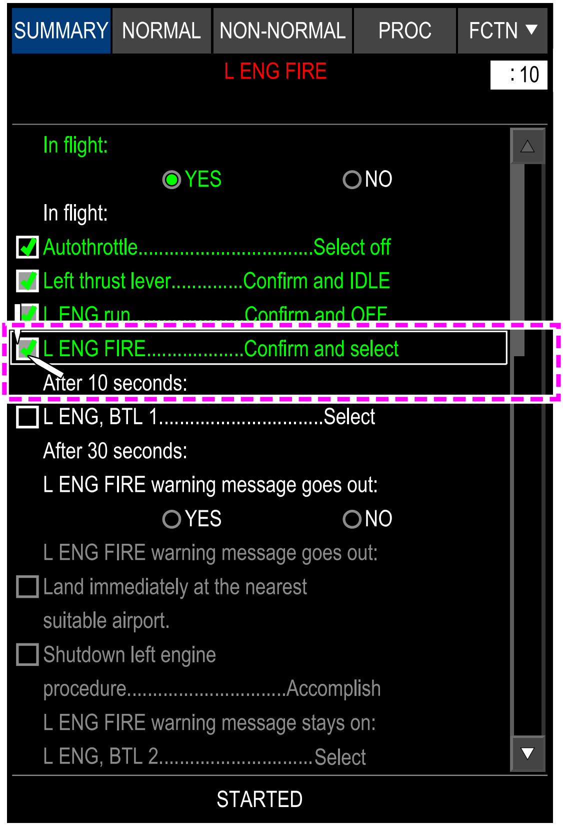
Also, when the follow-on checklist is COMPLETE, the procedure title is shown in green in the NON-NORMAL page (refer to Figure 21–02–10).



NON–NORMAL page – Follow–on item
Figure 21–02–10

H. Timed item

A timed item is an action item that has a defined time limit for completion. The ECL timer visual indication is displayed in reverse video with a white background and numbers in black. It is aligned with the right edge of the format (below the FCTN tile) and displays the time in minutes and seconds with two digits for each (00:00). The minutes portion of the visual indication is removed when the remaining time is less than one minute. Refer to Figure 21–02–11.



Timed item
Figure 21–02–11

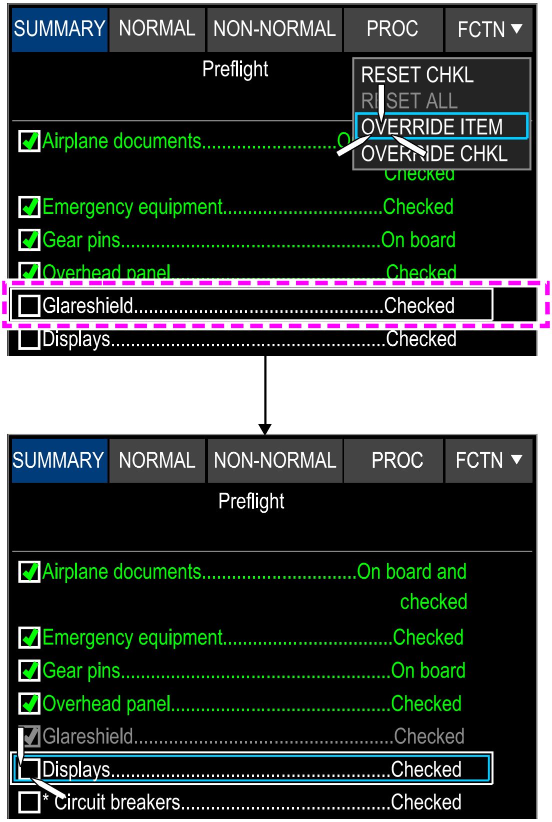
I. Free text item

A free text gives quick information to the pilot. It does not have to be acknowledged.

J. Override item

If a checklist item cannot be actioned, or if the sensing has failed, the item can be overridden so that the checklist can be completed.

When the item is in the focus indicator, selecting OVERRIDE ITEM in the FCTN tile drop-down menu overrides the item, and positions the focus indicator and the cursor to the next item. The overridden item is displayed in gray with a checkmark. Refer to Figure 21–02–12.



Override item
Figure 21–02–12

ECL – OPERATION

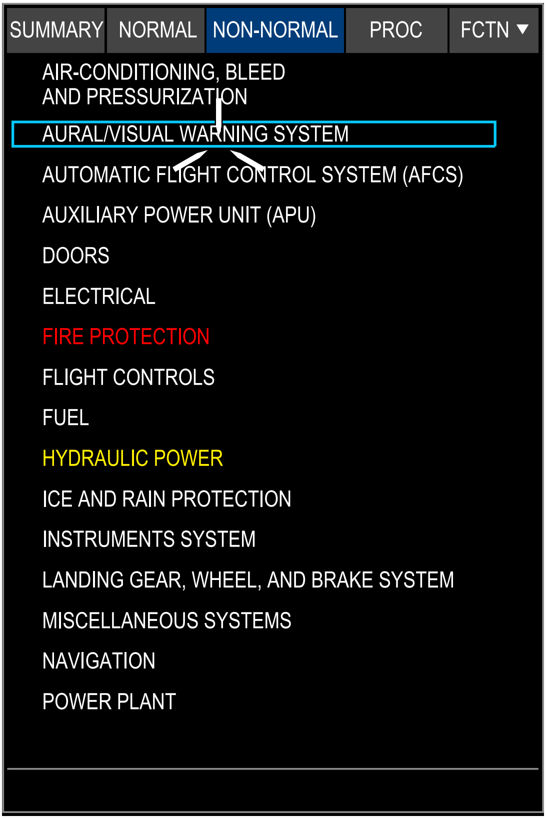
The normal procedures displayed are dependent on the status of the aircraft (WOW/WOFFW). The non-normal procedure associated with an EICAS message will be displayed when that EICAS message is triggered. The procedures not associated with an EICAS message must be selected by the flight crew. Once completed or overridden, the procedures are displayed in the history section.

The flight crew uses the cursor from the CCP and the keys on the MKP to interact with the ECL.

During an ECL procedure, the pilots interact with many items. An active item is displayed in white. When the checkbox is selected, the checkmark appears in the checkbox, and the item becomes green (text and checkmark). A sensed item becomes green and the checkmark appears when the corresponding input is sensed (switch is selected). A disabled item is displayed in gray.

Notes, warnings, cautions and advisory items must be acknowledged by the flight crew.

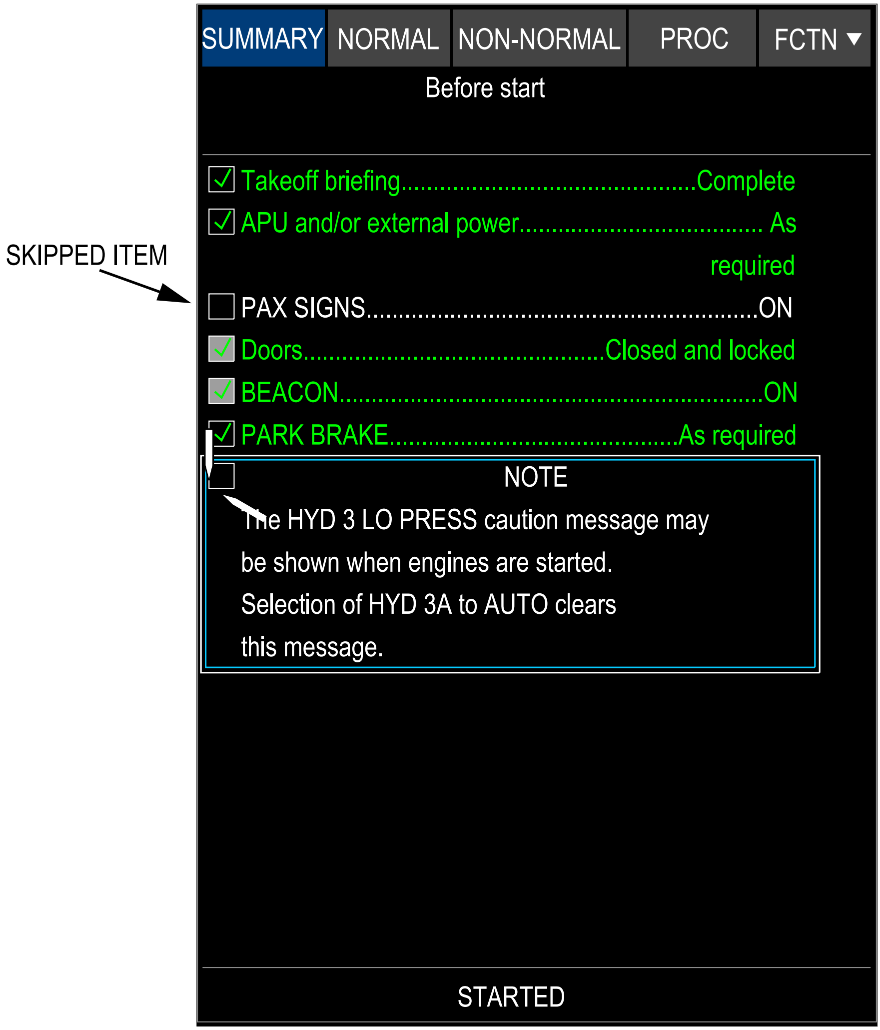
Figure 21–02–13 shows a non-normal checklist.



ECL – NON–NORMAL checklist
Figure 21–02–13

When the checklist is opened, the position of the cursor and the focus indicator are displayed on the first unchecked item and moved to the next one when the first one is selected.

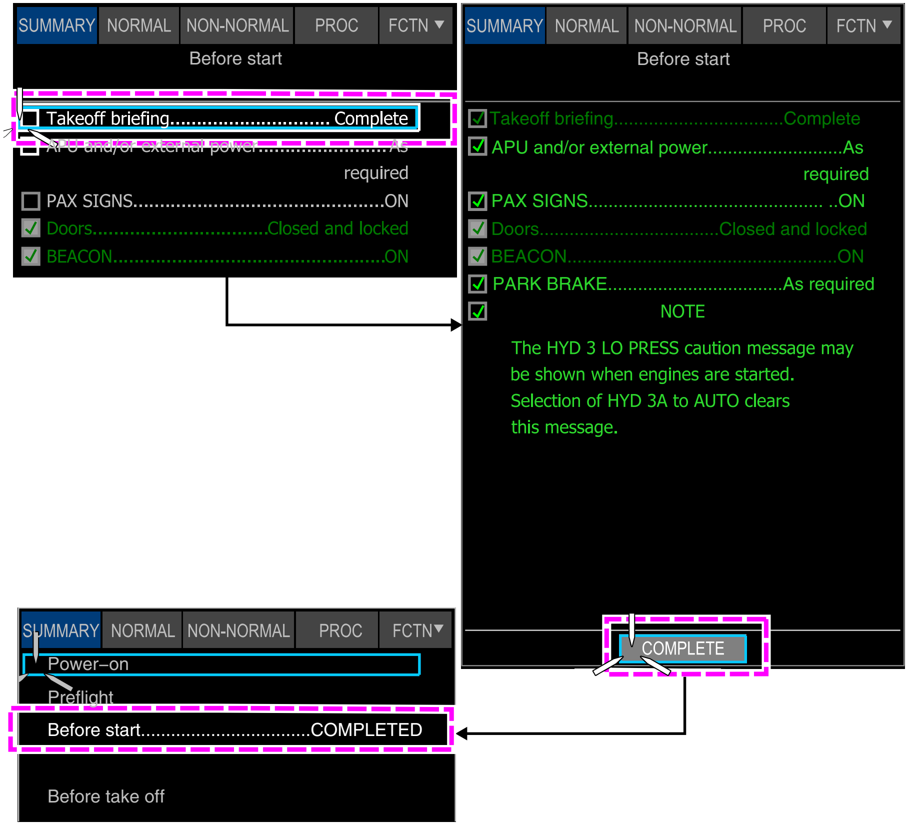
The cursor and the focus indicator can be manually moved to skip an open item, but will have to be done to complete the checklist. Refer to Figure 21–02–14.



Skipped Item
Figure 21–02–14

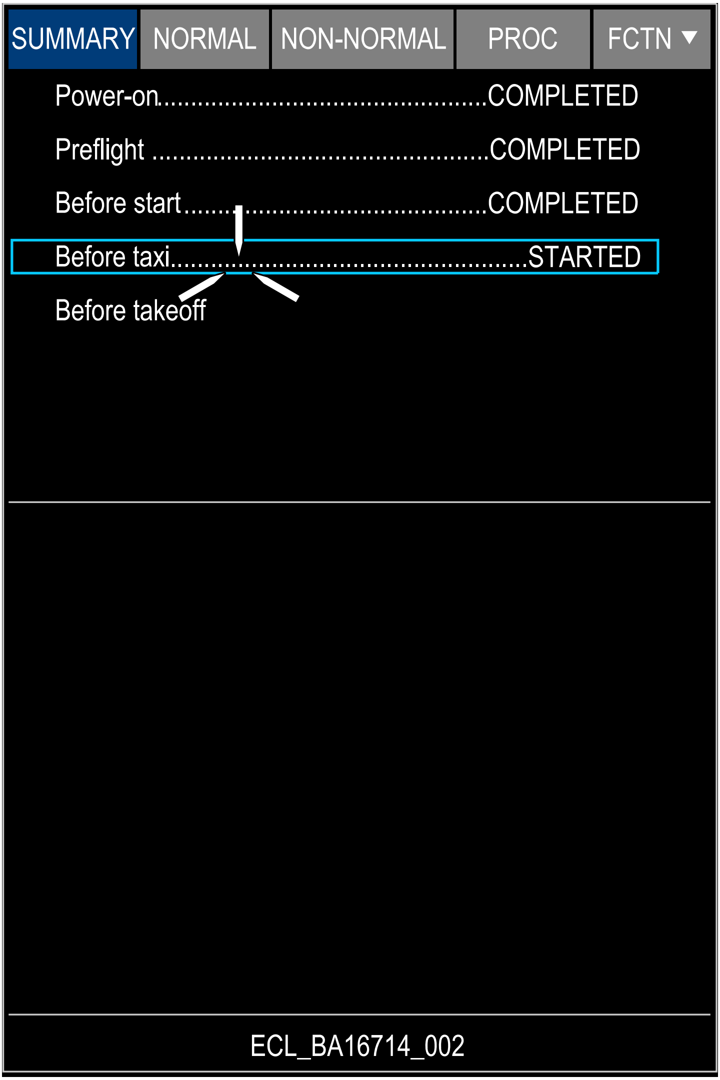
When the first open item (non-sensed) is selected, the status STARTED is displayed at the bottom of the page.

When all the items from the checklist are selected, the status STARTED change for COMPLETED and the cursor moves on it. Then the COMPLETE soft switch is selected and the SUMMARY page is displayed with the status of the checklist. The position of the cursor and the focus indicator is displayed on the next checklist that is not COMPLETED. Refer to Figure 21–02–15.



Checklist Operation
Figure 21–02–15

If the SUMMARY soft tile switch is selected before the checklist is completed, the checklist status displays STARTED. Selecting the checklist again opens the checklist with the cursor and focus indicator positioned over the first open item. Refer to Figure 21–02–16.

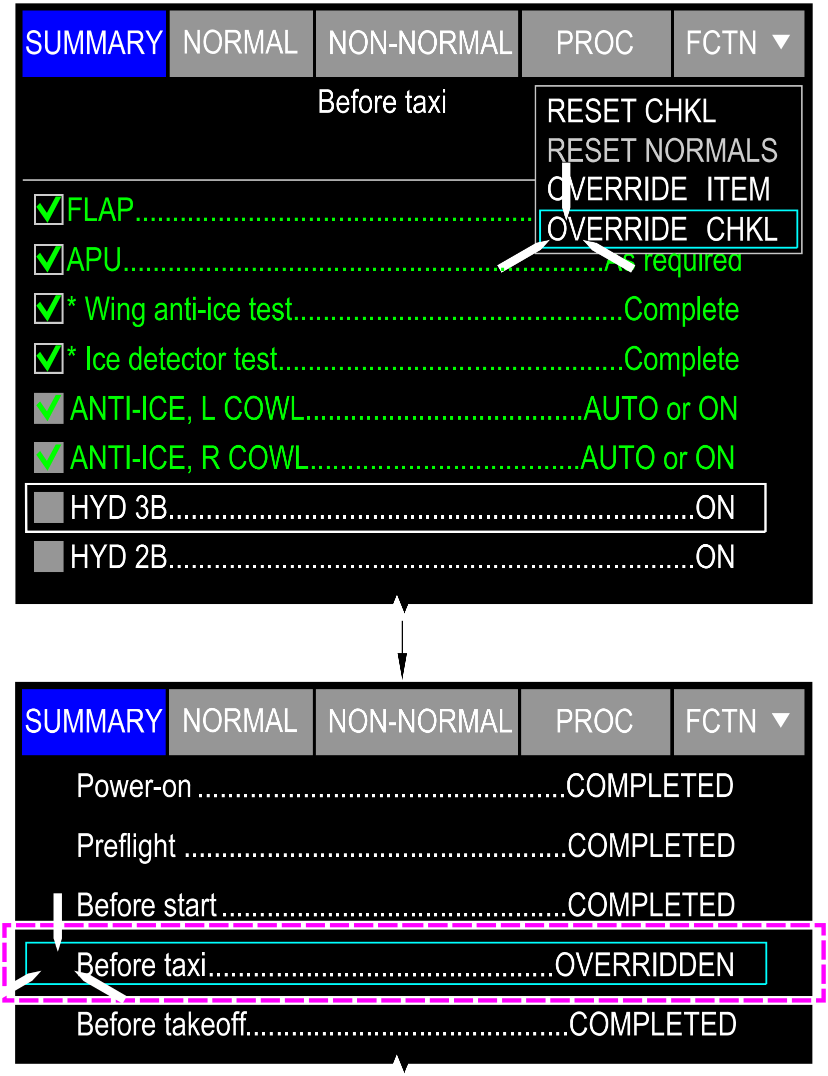


STARTED Checklist
Figure 21–02–16

A. Checklist override

If needed, any started (not completed) displayed checklist can be overridden by selecting OVERRIDE CHKL in the FCTN drop-down menu.

When the checklist is overridden, all the checklist items display in gray. OVERRIDDEN displays at the end of the checklist in the SUMMARY page (refer to Figure 21–02–17) and in the NORMAL, NON-NORMAL, or PROC page.



Checklist override
Figure 21–02–17

B. Checklist follow-on

A checklist follow-on is displayed when another checklist or procedure is required at the completion of a non-normal checklist or procedure. The follow-on checklist or procedure will be displayed on the SUMMARY page, when the non-normal checklist is completed. Refer to Figure 21–02–18

Checklist Follow–on
Figure 21–02–18

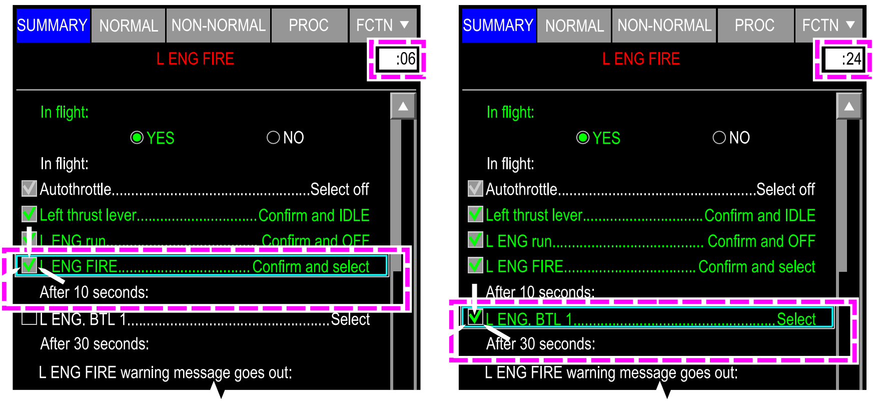
C. Checklist timer

When a checklist item that has a time restriction is selected, a timer with the restriction time is automatically displayed below the FCTN tile. The timer countdown starts when the checklist item is the next item. The timer is removed when another checklist item is selected.

The ECL can only run one checklist timer at a time. If a second timed action item is started in the same checklist, it overrides the first timer (refer to Figure 21–02–19).

NOTE

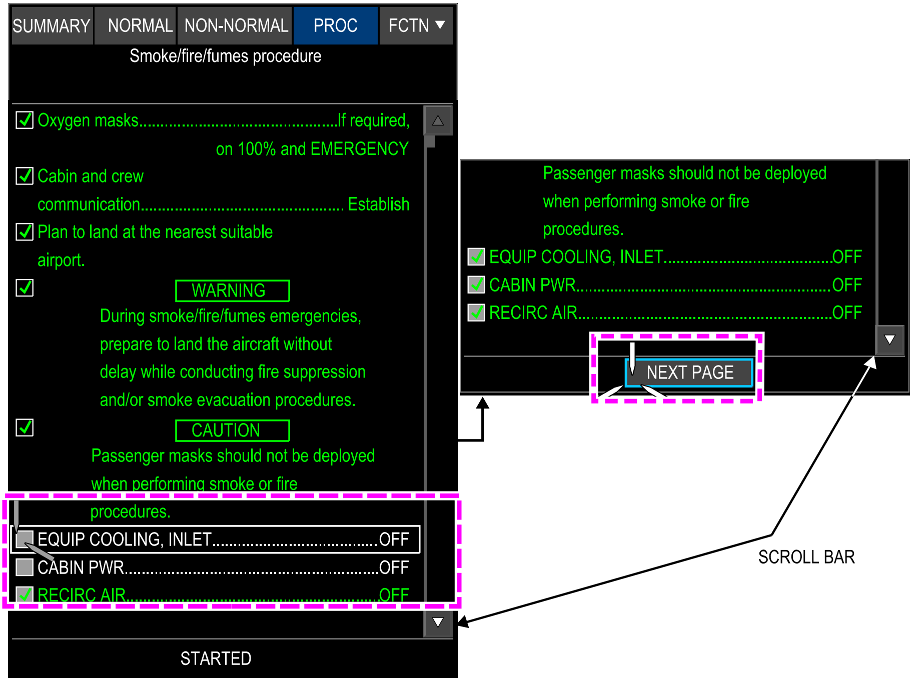
The timer is advisory only. It does not prevent the flight crew from executing any part of the checklist.



Checklist timer
Figure 21–02–19

D. Page scrolling

A scroll bar is displayed on the right side of the page when all the items or procedures cannot be displayed on one page. The scroll down is automatic when all the items or procedures of the page are selected. When all the items or procedures of one page are selected, the NEXT PAGE soft tile switch is displayed and can be selected to have access to the next page. Refer to Figure 21–02–20.



Manual Page Scrolling
Figure 21–02–20

E. ECL failure

The ECL is able to detect the database-related errors that follow:

- Mismatch between Data Module Cabinets (DMCs),
- Corrupted ECL database, or
- ECL format not compliant.

When the database-related errors are detected, the ECL is not available and all the ECL page content is removed. Additionally, the CHECKLIST NOT AVAILABLE message is displayed on the selected Multifunction Window (MFW). Refer to Figure 21–02–21.

NOTE

When a database error has been detected, the ECL will send a message to the Onboard Maintenance System (OMS).

The AFM and the QRH can be used to complete the applicable checklist.

ECL failure
Figure 21–02–21

EICAS MESSAGES

There are no EICAS messages associated to the ECL.

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CHAPTER 22 – FLIGHT MANAGEMENT SYSTEM

GENERAL

FMS – DESCRIPTION

FMS – OPERATION

List of figures

GENERAL

FMS – DESCRIPTION

FMS – OPERATION

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FMS - OVERVIEW

There are two Flight Management Systems (FMS) installed in the aircraft.

The primary FMS functions are to:

- Compute aircraft position and velocity,
- Store flight plans (manually entered or loaded through datalink),
- Calculate takeoff and landing data, performance, and V-speeds,
- Make weight and balance calculations,
- Monitor Required Navigation Performance (RNP),
- Execute LNAV/VNAV and LPV approaches,
- Integrate autothrottle operation into the vertical profile,
- Automatically tune navigation radios,
- Apply altitude temperature correction for departures, arrivals, and approaches,
- Plan step climbs and descents, and
- Calculate Receiver Autonomous Integrity Monitoring (RAIM) approaches outside Satellite Based Augmentation System (SBAS) coverage.

The FMS sends steering guidance to the flight director for:

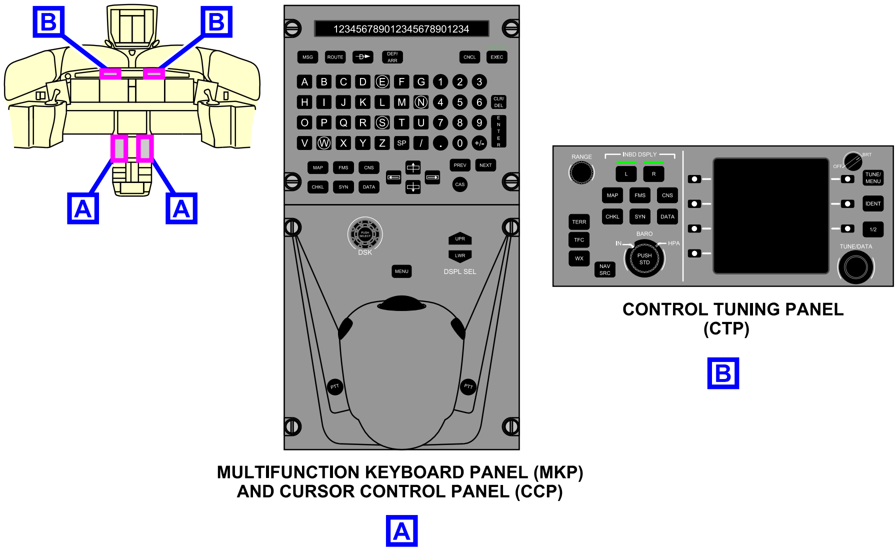
- Multisensor RNAV operations,
- RNP 0.3 for approach,
- Automatic FMS to LOC capture,
- Holding patterns,
- Lateral and vertical direct to navigation,
- Parallel offset,
- Navigation to nearest airports,
- Pilot-defined waypoints and routes, and
- Alternate airport and alternate direct routing.

Each FMS individually computes and monitors position solutions and issues a warning if there is a conflict.

The FMS controls are the quick access keys on the panels that follow (refer to Figure 22–01–1):

- Control Tuning Panel (CTP),
- Multifunction keyboard Panel (MKP), and
- Cursor Control Panel (CCP).

The FMS information is displayed on the Multifunction Windows (MFWs).



FMS controls
Figure 22–01–1

FMS – INSTALLATION AND COMPONENTS

The FMS that supplies information to the side coupled to the flight director is the master FMS. All flight plan entries are routed to the master FMS for processing. The flight plan is updated in the master FMS, then routed to the other FMS (slave). Refer to Figure 22–02–1.

The three FMS operating modes are:

- Single mode – Active when only one FMS is operational (e.g. MEL dispatch).
- Synchronized mode – Active when the master and slave FMS computers communicate with each other (cross talk).
- Split mode – Active when a fault prevents communication between the master and slave FMS computers.

Flight Director	Master	Slave
Coupled Left	FMS 1	FMS 2
Coupled Right	FMS 2	FMS 1

FMS Master/Slave operation
Figure 22–02–1

FMS QUICK ACCESS KEYS

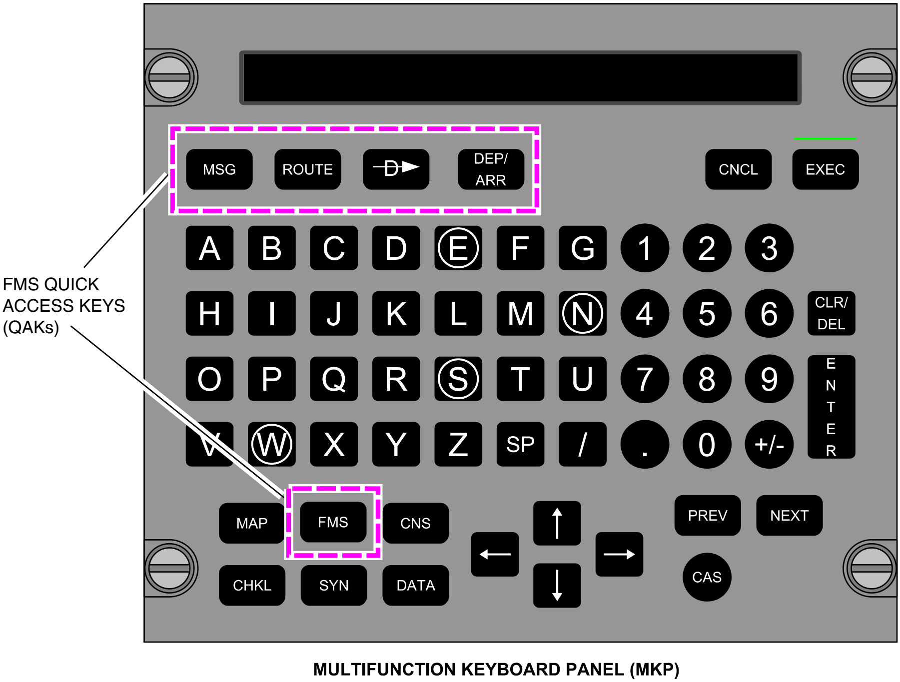
The FMS has five quick access keys on the Multifunction Keyboard Panel (MKP) (refer to Figure 22–02–2):

MSG – Shows the MESSAGES - FMS dialog box,

ROUTE – Shows the ROUTE soft switch,

Direct To (symbol) – Shows the direct to dialog box, DEP/ARR – Shows the DEPARTURES or ARRIVALS dialog box, and

FMS – Shows an FMS page.



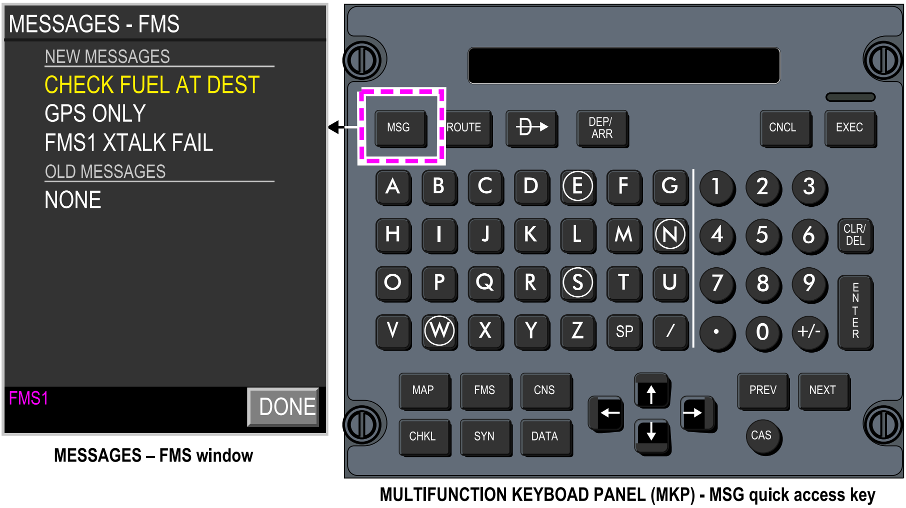
FMS – MKP – Quick access keys
Figure 22–02–2

A. MSG quick access key

The MSG quick access key on the MKP shows the MESSAGES - FMS dialog box on the onside MFW of DU 5. Refer to Figure 22–02–3.

New messages are displayed below NEW MESSAGES. Caution messages are displayed in amber and advisory messages are displayed in white. After the messages have been viewed, they are displayed below OLD MESSAGES when the dialog box is re-opened.

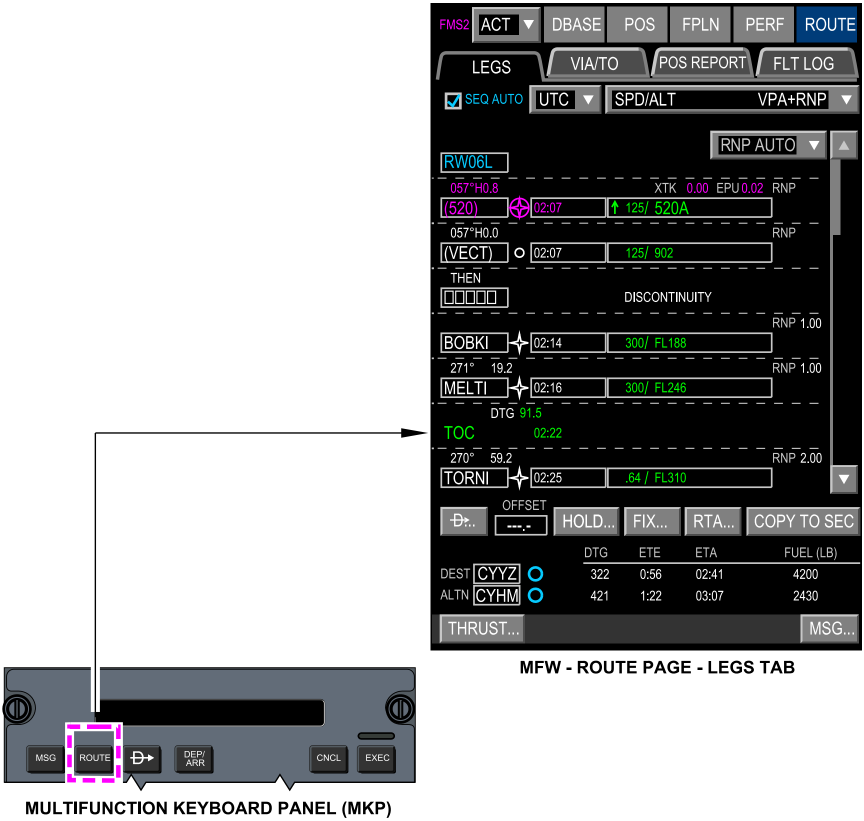
The dialog box closes when the DONE switch is selected.



FMS – MKP – MSG quick access key
Figure 22–02–3

B. ROUTE quick access key

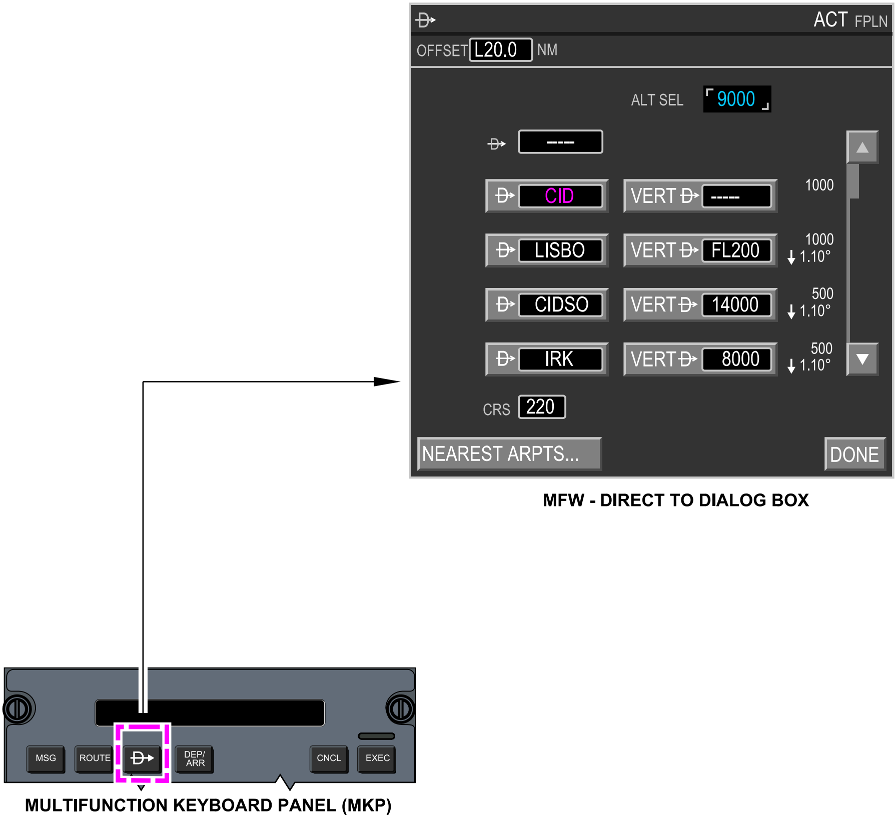
The ROUTE quick access key on the MKP shows the FMS page with the ROUTE soft switch and the LEGS tab selected. Refer to Figure 22–02–4.



FMS – MKP – ROUTE quick access key
Figure 22–02–4

C. Direct to (symbol) quick access key

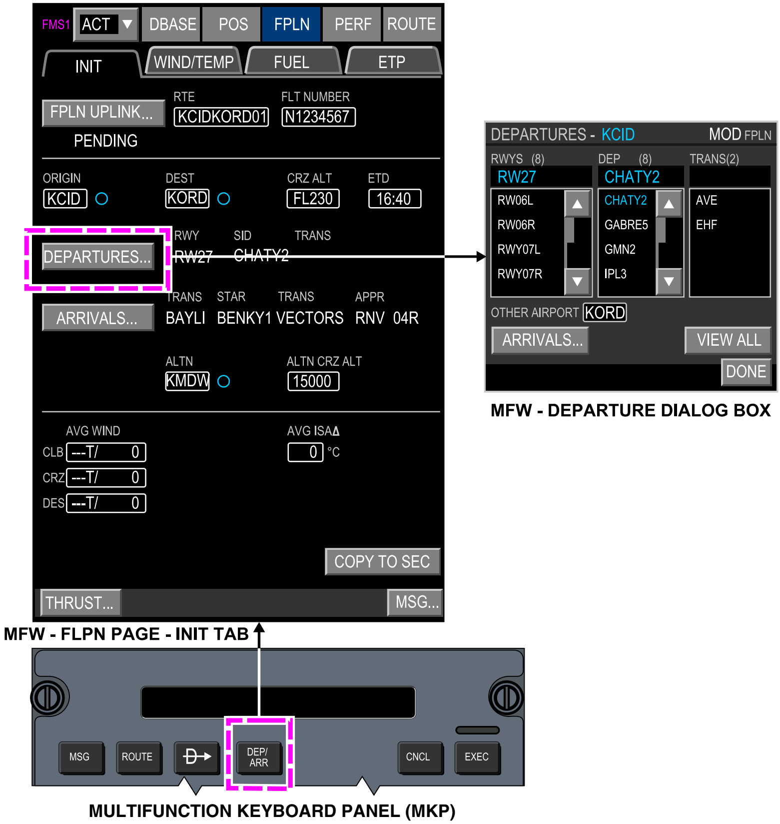
The Direct to (symbol) quick access key on the MKP shows the direct to dialog box (refer to Figure 22–02–5). If the FMS or MAP page is not already displayed, the LEG tab under the ROUTE soft switch is displayed. The direct to dialog box closes when the direct to quick access key is pushed again.



FMS – MKP – Direct to (symbol) quick access key
Figure 22–02–5

D. DEP/ARR quick access key

The DEP/ARR quick access key on the MKP shows the INIT tab under the FPLN soft switch, and opens the DEPARTURES or ARRIVALS dialog box. Refer to Figure 22–02–6.



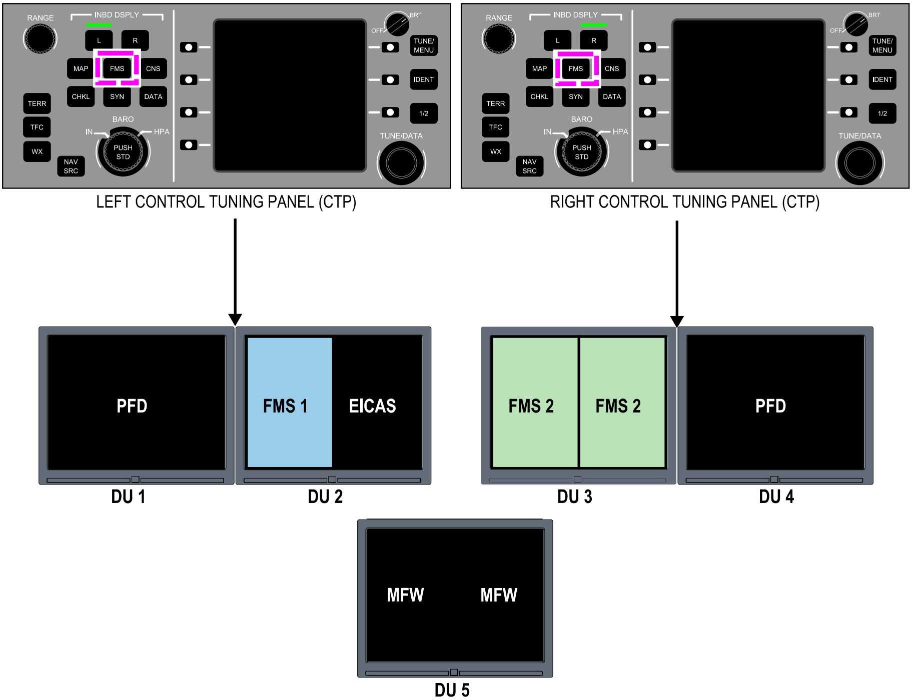
FMS – MKP – DEP/ARR quick access key
Figure 22–02–6

The origin airport DEPARTURES dialog box opens when the aircraft is on the ground, or when airborne within 50 nm of the origin airport. The ARRIVALS dialog box of the flight plan destination airport opens when the aircraft is airborne and the distance from the origin airport is greater than 50 nm.

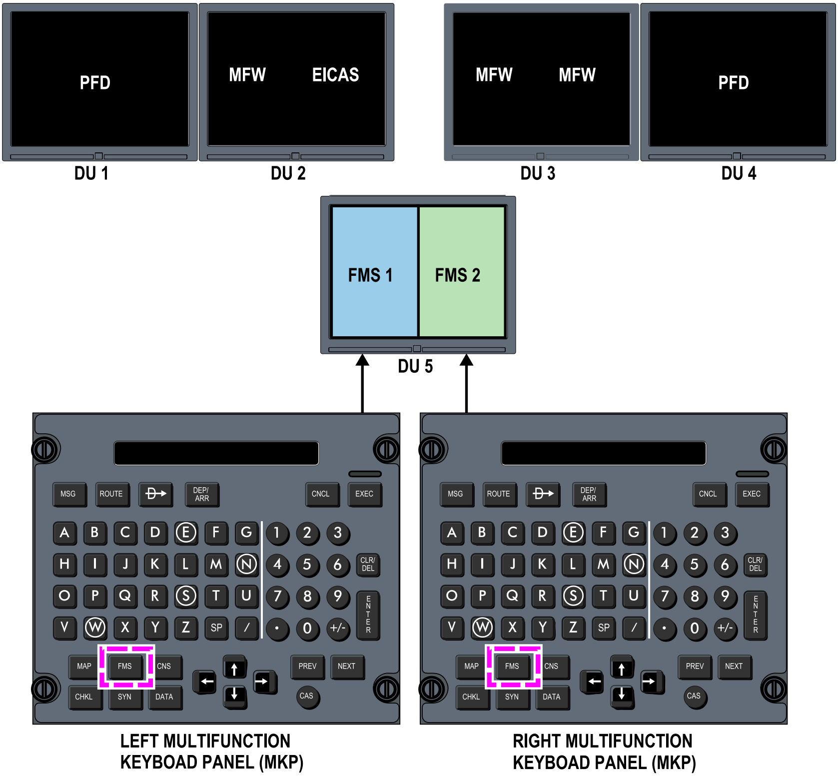
E. FMS Quick Access Key (QAK) – Display

The FMS pages are displayed on the Multifunction Windows (MFWs) when the Flight Management System (FMS) QAK is selected on the Control Tuning Panels (CTPs) (refer to Figure 22–02–7) or Multifunction Keyboard Panels (MKPs) (refer to Figure 22–02–8).

- When the FMS QAK on the left CTP is pushed, the FMS 1 page is displayed on DU 2,
- When the FMS QAK on the right CTP is pushed, the FMS 2 page is displayed on DU 3,
- When the FMS QAK on the left MKP is pushed, the FMS 1 page is displayed on DU 5 on the left MFW, and
- When the FMS QAK on the right MKP is pushed, the FMS 2 page is displayed on DU 5 on the right MFW.



FMS page display – CTP – FMS Quick Access Key (QAK)
Figure 22–02–7



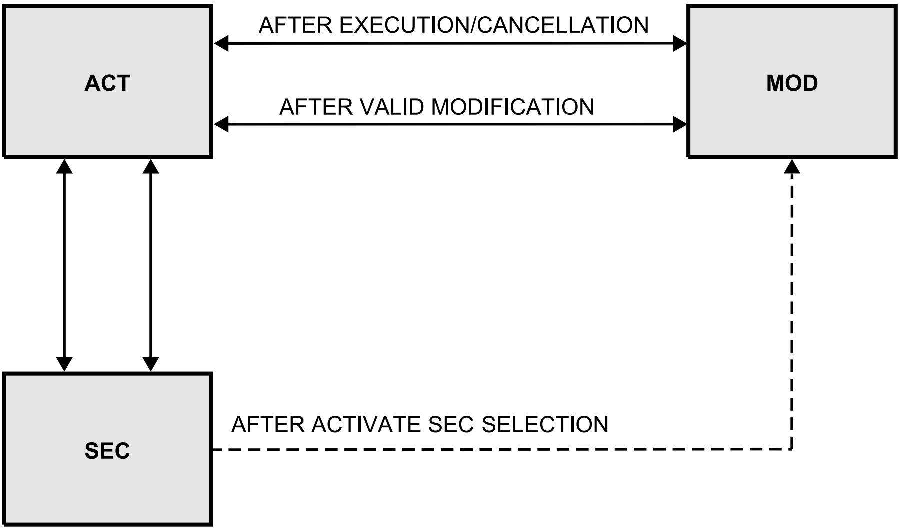
FMS page display – MKP – FMS Quick Access Key (QAK)
Figure 22–02–8

On power-up, the FMS default display is the DBASE soft switch. The FMS quick access key selections display the default, or the last opened page if the FMS has been previously accessed.

F. Flight Plan Status CNCL and EXEC switches

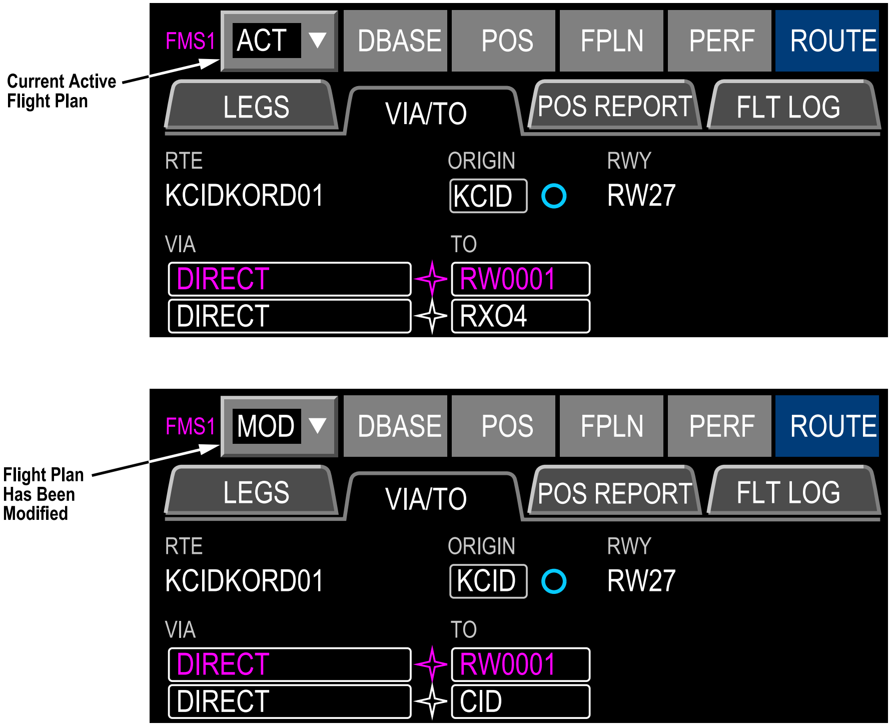
The soft switch bar contains a drop-down menu to display the Active (ACT) or Secondary (SEC) flight plan information.

When an active flight plan is modified, the ACT indication is replaced by MOD. When the modification is completed, it must be executed or canceled. Soft switches are used to either Cancel (CNCL) or Execute (EXEC) the modified flight plan. Alternatively, the CNCL or EXEC quick access keys on the MKP can be used. Refer to Figure 22–02–9.



ACT/SEC flight plans
Figure 22–02–9

The COPY TO SEC soft switch copies the active flight plan to the secondary flight plan. When the secondary flight plan displays, the ACTIVATE SEC copies the secondary flight plan into a Modified (MOD) flight plan (refer to Figure 22–02–10). Selecting the EXEC soft switch executes the Modified flight plan (MOD), making it the Active (ACT) flight plan. The former Active flight plan is transferred into the Secondary flight plan (ACT and SEC flight plans swap).



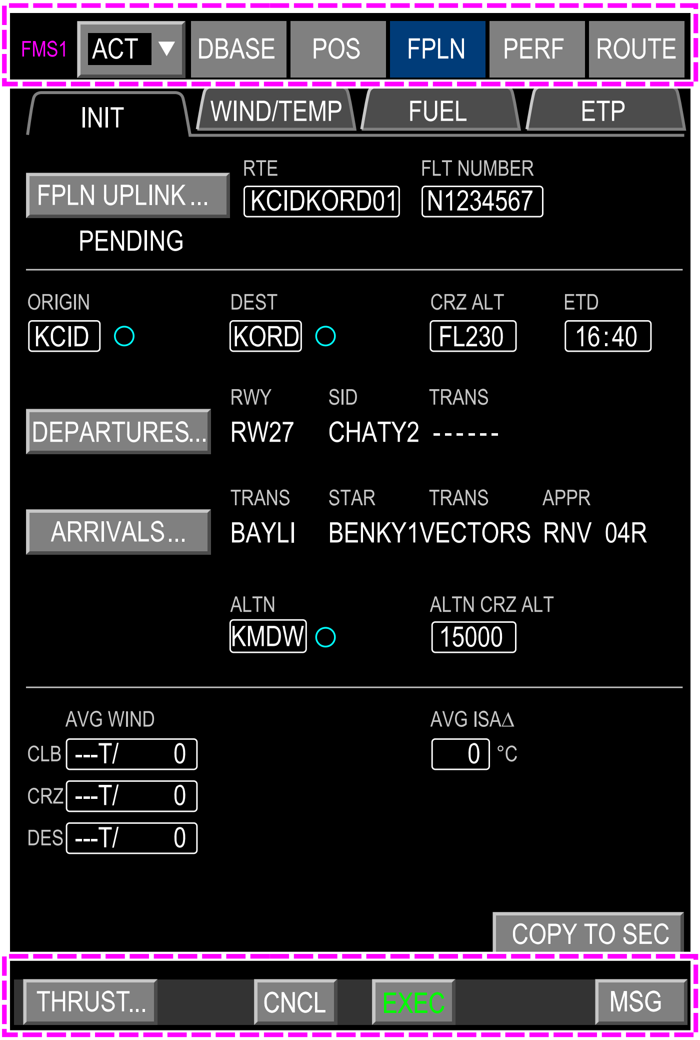
Modification to flight plan
Figure 22–02–10

FMS PAGE – DESCRIPTION

A. Overview

FMS data is divided into five groups. Each group of data is displayed when the applicable soft switch is selected at the top of the FMS page (refer to Figure 22–02–11). The groups are:

- DBASE (Database),
- POS (Position),
- FPLN (Flight Plan),
- PERF (Performance), and
- ROUTE (Route).



FPLN page – INIT tab
Figure 22–02–11

The FMS pages, tabs, and related dialogue boxes are structured as follows:

FMS page	Related tabs	Related dialogue box
DBASE (Database)	STATUS	PRINT
	SEARCH	• DEF PILOT WPT • PILOT WPTS
	DEFAULTS	None
POS (Position)	FMS	SAT DESELECT
	IRS	None
	GNSS	GNSS INFORMATION
	VOR/DME	NAVAID INHIBIT
FPLN (Flight plan)	INIT	• FPLN UPLINK • DEPARTURES • ARRIVALS
	WIND/TEMP	None
	FUEL	None
	ETP	• CALC ETP • NEAREST ARPTS
PERF (Perform-ance)	DEP (Departure)	• NADP
	CLB (Climb)	None
	CRZ (Cruise)	• CSC • FUEL CALCULATOR
	DES (Descent)	None
	ARR	• ARRIVALS • ARRIVAL DATA

FMS page	Related tabs	Related dialogue box
		• TEMP COMP
ACT (Active) ROUTE	LEGS	• D • HOLD • FIX • COPY TO SEC
	VIA/TO	COPY TO SEC
	POS REPORT (Position report)	None
	FLT LOG (Flight log)	None
SEC (Second) ROUTE	SEC LEGS	• D • HOLD • FIX • ACTIVATE SEC
	SEC VIA/TO	COPY TO SEC
	POS REPORT (Position report)	None
	FLT LOG (Flight log)	None

The FMS source (FMS 1 or FMS 2) is displayed in magenta at the top left of the page. To the right of the FMS source is a drop-down menu that is used to select either the ACT (Active) or SEC (Secondary) flight plan. The soft switches are ordered in a logical sequence for entering flight plan data.

The bottom of the FMS page includes soft switches used to:

- Open dialog boxes for engine thrust settings or to access FMS messages, and

- Cancel or execute modifications made to the flight plan data in the FMS.

B. Flight plan tile drop-down menu

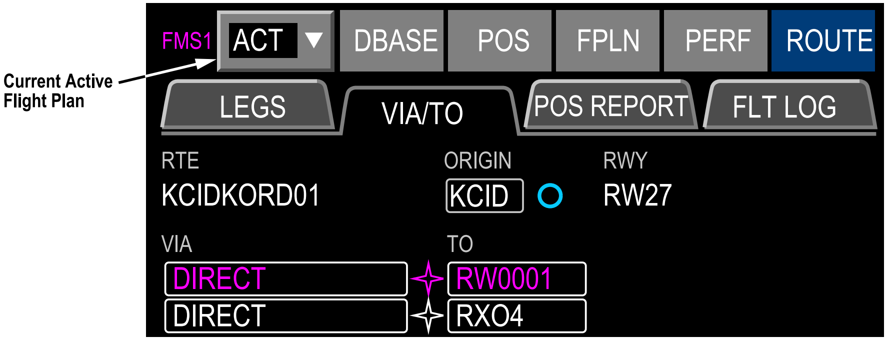
The flight plan drop-down menu is used to select either the active or secondary flight plan. It displays one of three conditions.

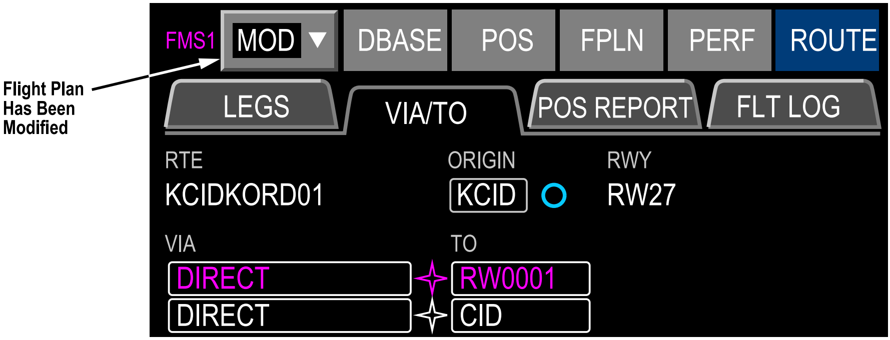
ACT indicates that the FMS is displaying the Active flight plan. Refer to Figure 22–02–12.

MOD indicates that the flight plan has been Modified, and the changes must be executed or canceled using the MKP EXEC or CNCL switches. The EXEC or CNCL soft switches may also be used. These soft switches display:

- On the bottom menu bar of the FMS page, and
- Below the aircraft symbol if the MAP is displayed in a multifunction window,

Canceled modifications leave the active flight plan unchanged.

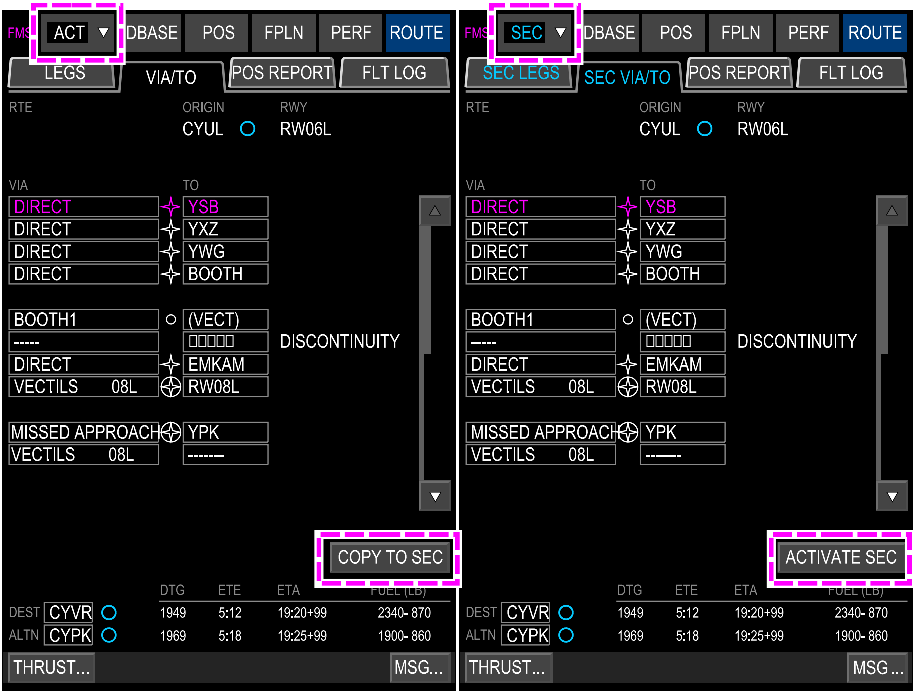




Modification to flight plan
Figure 22–02–12

SEC indicates that the FMS is displaying data for the secondary flight plan. Refer to Figure 22–02–13.

A Secondary (SEC) flight plan may be created at any time by selecting SEC from the drop-down list. It is also possible to copy the Active (ACT) flight plan to the SEC flight plan by selecting the copy to secondary (COPY TO SEC) soft switch. Tabs related to the secondary flight plan display with a cyan title preceded by SEC (i.e. SEC LEGS, SEC VIA/TO). The ACTIVATE SEC soft switch replaces the COPY TO SEC soft switch when the secondary flight plan displays. Activating the secondary flight plan makes it the new ACT plan.



Secondary flight plan display
Figure 22–02–13

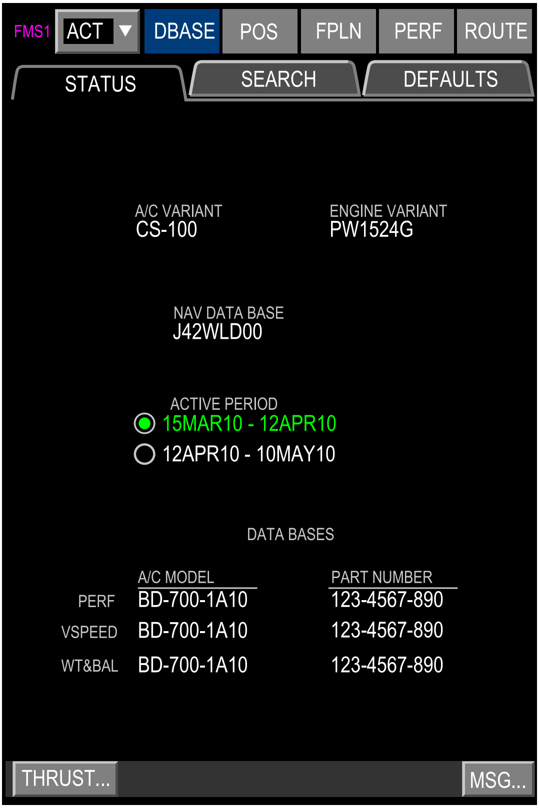
C. FMS – (Data base) page

The DBASE (database) page displays database information on navigation, performance, V-speeds, weight and balance, and aircraft information.

Databases can only be configured on the ground. Current database information displays in green. When the database is out of date or there is a wrong configuration, the database information displays in amber.

There are three tabs that display under the DBASE page (refer to Figure 22–02–14):

- STATUS
- SEARCH
- DEFAULTS



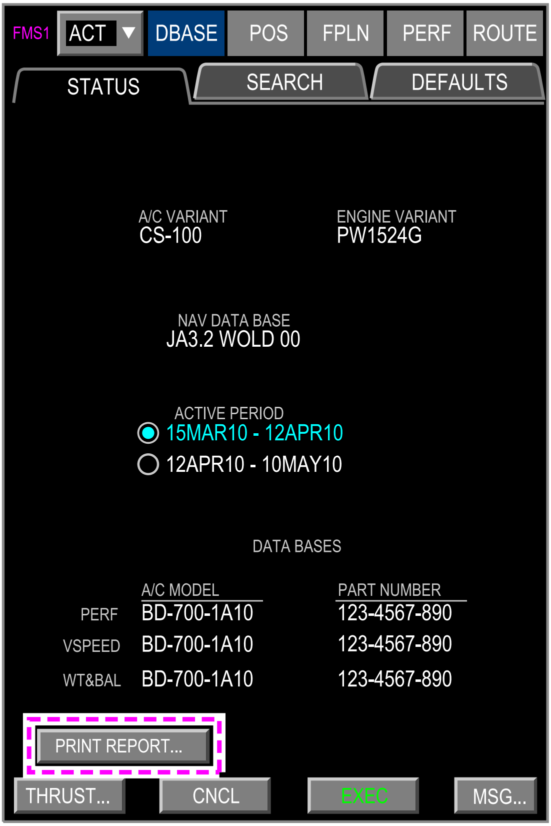
DBASE page – STATUS tab
Figure 22–02–14

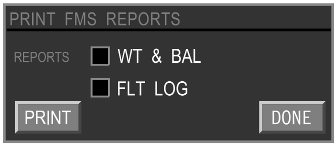
(1) STATUS Tab

The STATUS tab displays the data that follow (refer to Figure 22–02–15):

- The aircraft variant,
- The engine variant,
- The current and alternate navigation databases with their associated region,

- The current databases for performance, V-speeds, and the weight and balance displayed at the bottom of the page.





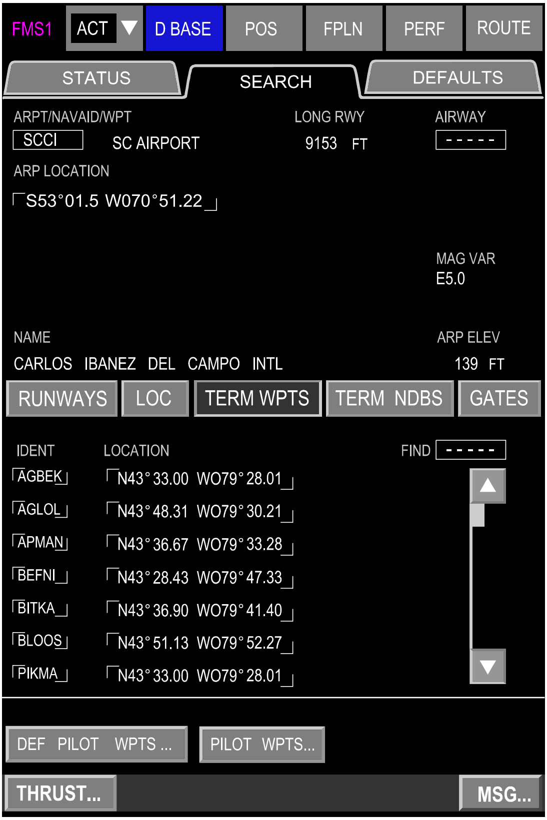
DBASE page – STATUS tab – FIX FMS report
Figure 22–02–15

The ACTIVE PERIOD navigation database can only be selected when the aircraft is on the ground. The current database displays in green. An out of date database displays in amber.

Database selection is inhibited in flight (selection is grayed out).

(2) SEARCH Tab

The upper half of the SEARCH tab includes two data entry boxes. The left data entry box is for airport, navaid, and waypoint searches (refer to Figure 22–02–16). The right data entry box is for airway data searches.



DBASE page – ARPT (airport) entry
Figure 22–02–16

AIRPORT/NAVAID/WAYPOINT SEARCH

Entering an airport identifier in the ARPT/NAVAID/WPT data entry box displays the data that follow:

- The name of the airport,
- The Airport Reference Point (ARP),
- The longest runway length,
- The magnetic variation,

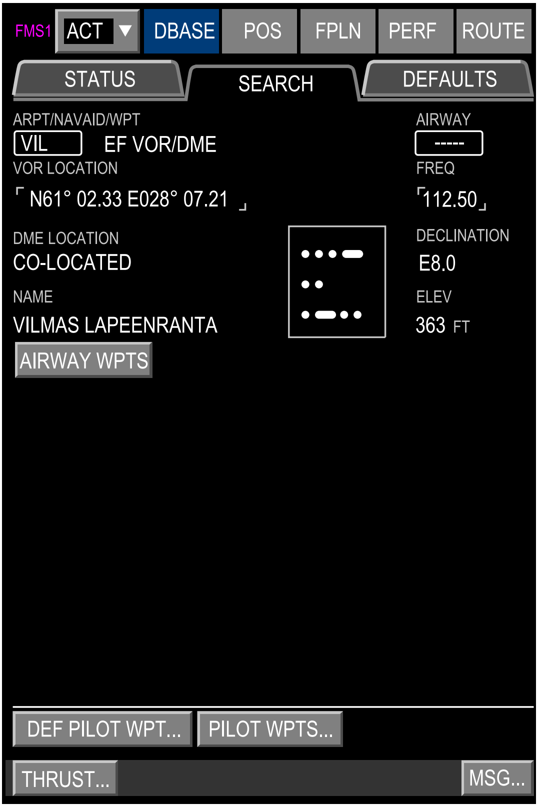
- The airport elevation, and
- The soft tile switches specific to that airport.

Soft tile switches relating to specific airports are:

- RUNWAYS: Available runways and associated information
- LOC: Available localizers and associated information
- TERM WPTS: Available terminal waypoints and associated information
- TERM NDBS: Available terminal NDBs and associated information
- GATES: Available gates and associated information

Entering a navaid into the APRT/NAVAID/WPT data entry box displays the data that follow (refer to Figure 22–02–17):

- The name of the navaid,
- The location,
- The frequency,
- The declination,
- The elevation,
- The type of navaid,
- The Morse code identifier, and
- The DME location.



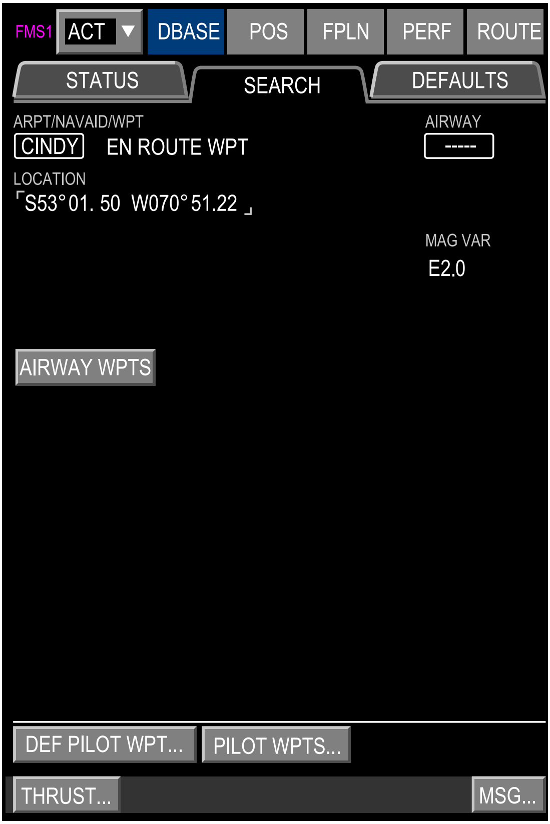
DBASE page – SEARCH tab – NAVAID entry
Figure 22–02–17

The AIRWAY WPTS soft switch permits access to airways associated with the entered navaid.

Entering a waypoint into the ARPT/NAVAID/WPT data entry box displays the data that follow (refer to Figure 22–02–18):

- The location,
- The type of waypoint,
- The variation, and

- A soft tile switch to access airways associated with the waypoint.



DBASE page – SEARCH tab – Waypoint entry
Figure 22–02–18

Entering an airway designator into the AIRWAY data entry box displays the number of waypoints on that airway, the airway end waypoints, and a list of all waypoints on that airway. Refer to Figure 22–02–19.

DBASE page SEARCH tab – AIRWAY
Figure 22–02–19

Two soft tile switches at the bottom of the SEARCH tab access the pilot defined waypoints dialog boxes.

The DEF PILOT WPTS soft tile switch opens a dialog box to create waypoints (refer to Figure 22–02–20). The PILOT WPTS soft tile switch opens a dialog box to review or delete created waypoints.

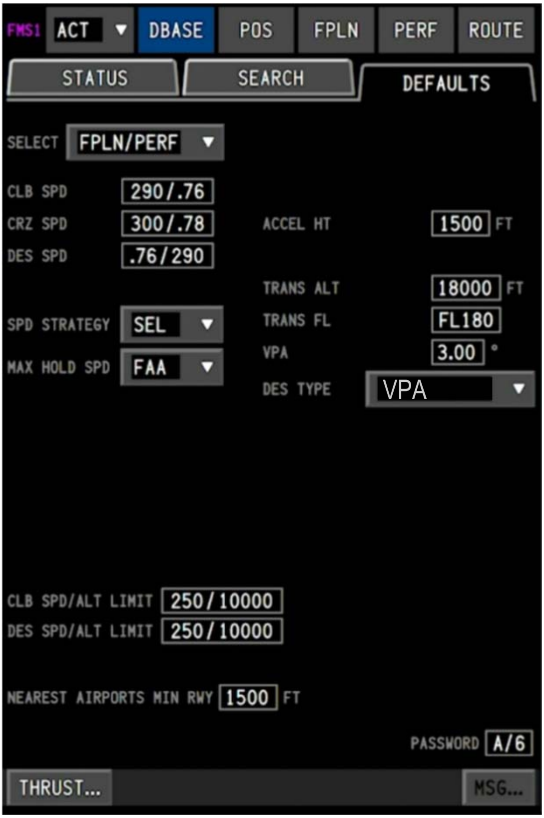
DBASE page SEARCH tab – Pilot–defined waypoints
Figure 22–02–20

(3) DEFAULTS Tab

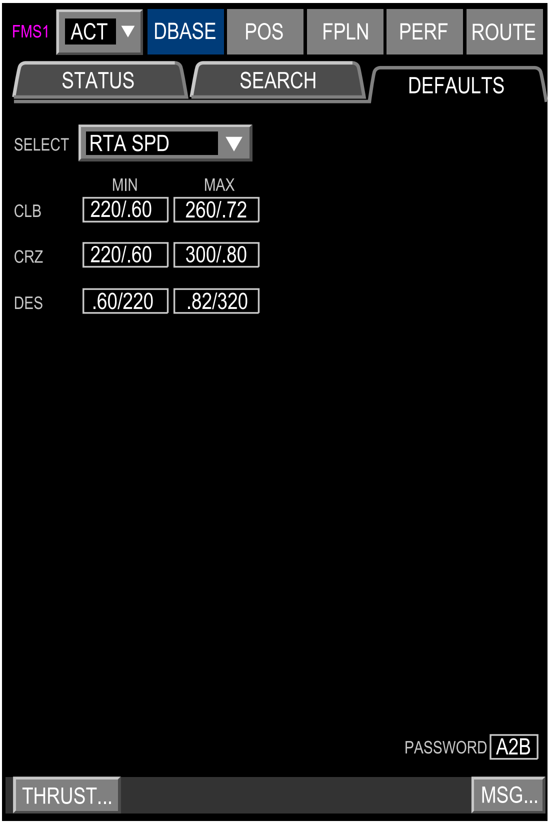
The DEFAULTS tab displays FMS default data. Data is accessed from the SELECT drop-down list. The selections are:

- FPLN/PERF as shown in Figure 22–02–21,
- RTA SPD as shown in Figure 22–02–22, and
- FUEL MGMT as shown in Figure 22–02–23.

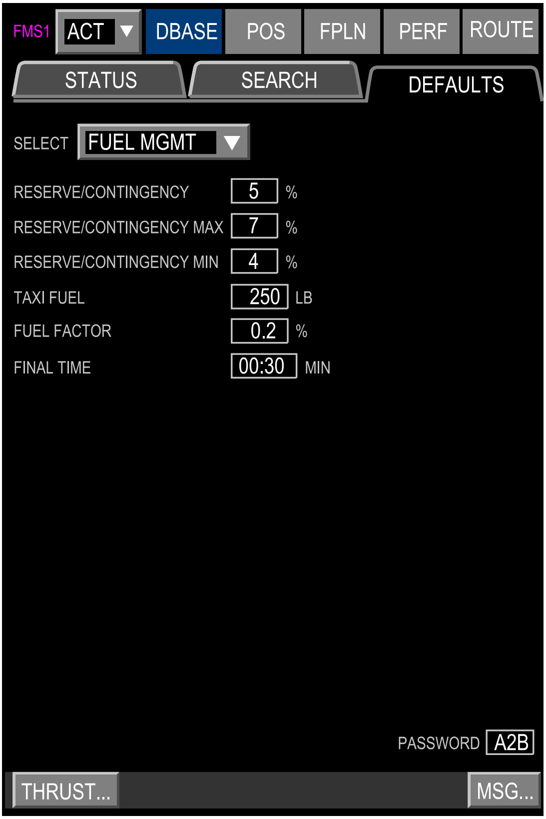
Modifications to the default data requires the entry of a password.



DBASE page – DEFAULTS Tab – FPLN PERF
Figure 22–02–21



DBASE page – DEFAULTS Tab – RTA SPD
Figure 22–02–22



DBASE page – DEFAULTS Tab – FUEL MGMT
Figure 22–02–23

D. FMS – POS (Position) page

The POS (position) tile has four tabs:

- FMS
- IRS
- GNSS
- VOR/DME

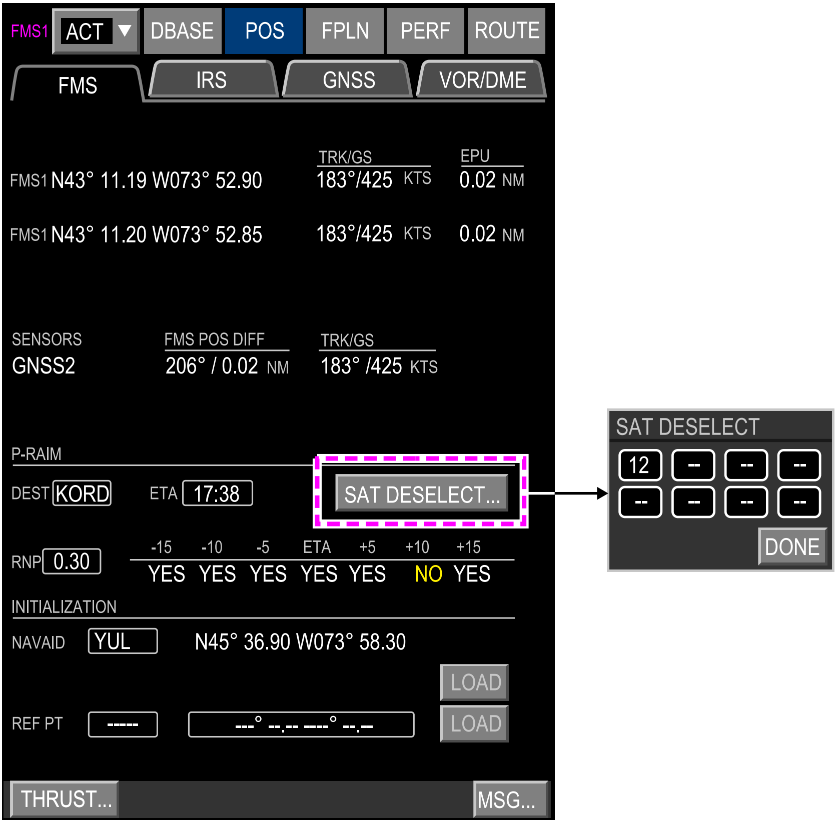
(1) FMS Tab

The FMS tab displays aircraft position data. Certain FMS abnormal parameters display on this page. RAIM capability and sensor status display in the center of the page. Refer to Figure 22–02–24.

POS page – FMS tab
Figure 22–02–24

The LOAD soft tile switch is used to initialize the IRS position (airport, gate, reference point). Once the reference position is entered, selecting LOAD starts the IRS alignment process.

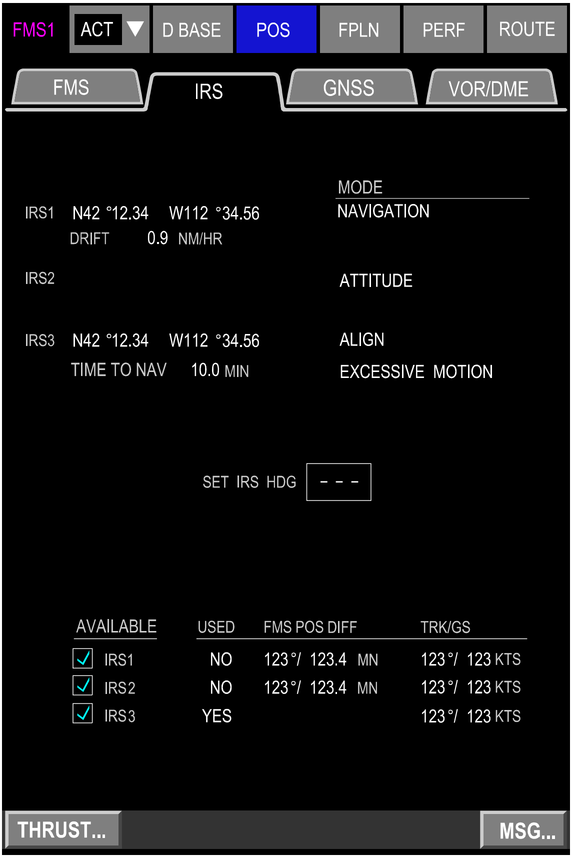
A satellite deselect soft tile switch opens a dialog box to inhibit the use of specific satellites. Refer to Figure 22–02–25.



POS page – FMS Tab – SAT DESELECT
Figure 22–02–25

(2) IRS Tab

The IRS tab displays IRS position data and functional MODE (refer to Figure 22–02–26). TIME TO NAV displays when in ALIGN mode. If an IRS is being used for position and attitude computation, YES displays under the USED column at the bottom of the page.



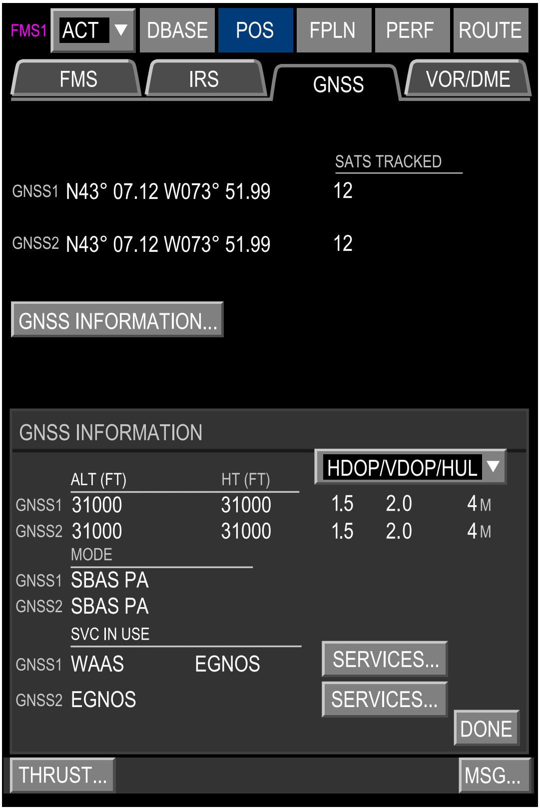
POS page – IRS tab
Figure 22–02–26

(3) GNSS Tab

The GNSS tab displays (refer to Figure 22–02–27):

- The GNSS positions,
- The GNSS/FMS comparisons, and
- The various satellite information.

The GNSS INFORMATION soft tile switch displays satellite services being used.

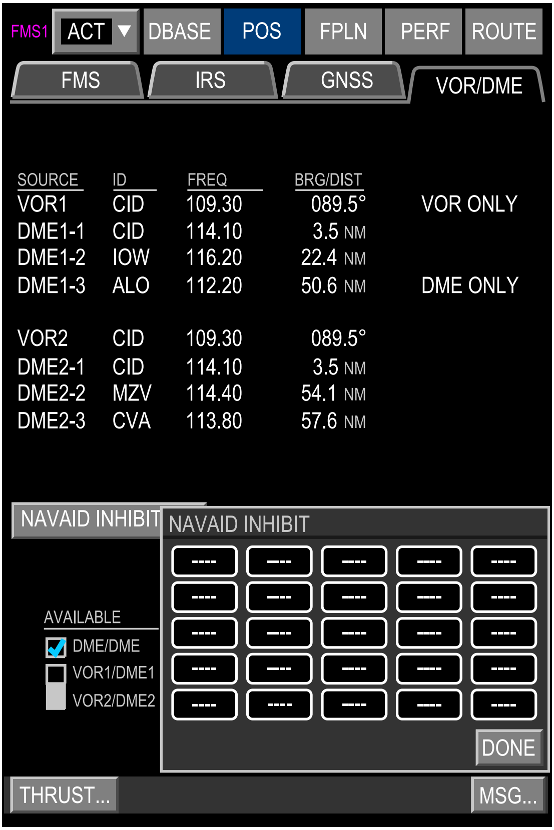


POS page – GNSS tab – GNSS INFORMATION dialog box
Figure 22–02–27

(4) VOR/DME Tab

The VOR/DME tab displays the VORs and DMEs in use by the FMS. Columns display the data that follow (refer to Figure 22–02–28):

- The identifications,
- The frequencies, and
- The relative bearings and distances.



POS page – VOR/DME tab
Figure 22–02–28

Navaids are inhibited by selecting the NAVAID INHIBIT soft tile switch. The DME/DME or VOR/DME availability can be modified, but the default is set to use both.

E. FMS – FLPN (Flight Plan) page

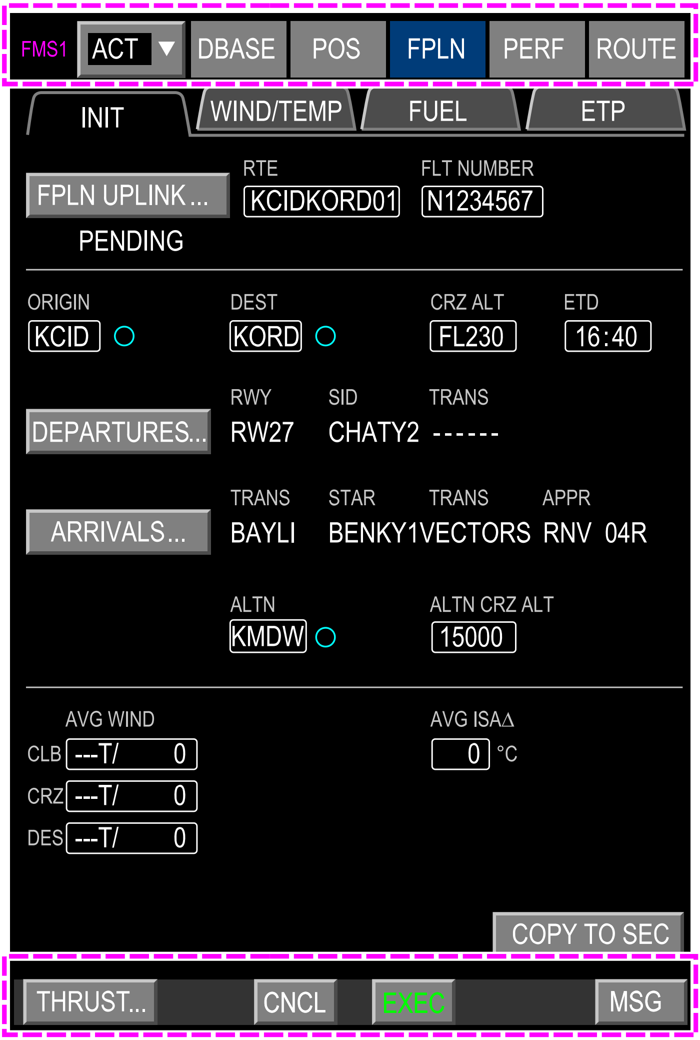
The FPLN (Flight Plan) page has four tabs:

- INIT (Initialization)
- WIND/TEMP
- FUEL
- ETP (Equal Time Points)

(1) INIT Tab

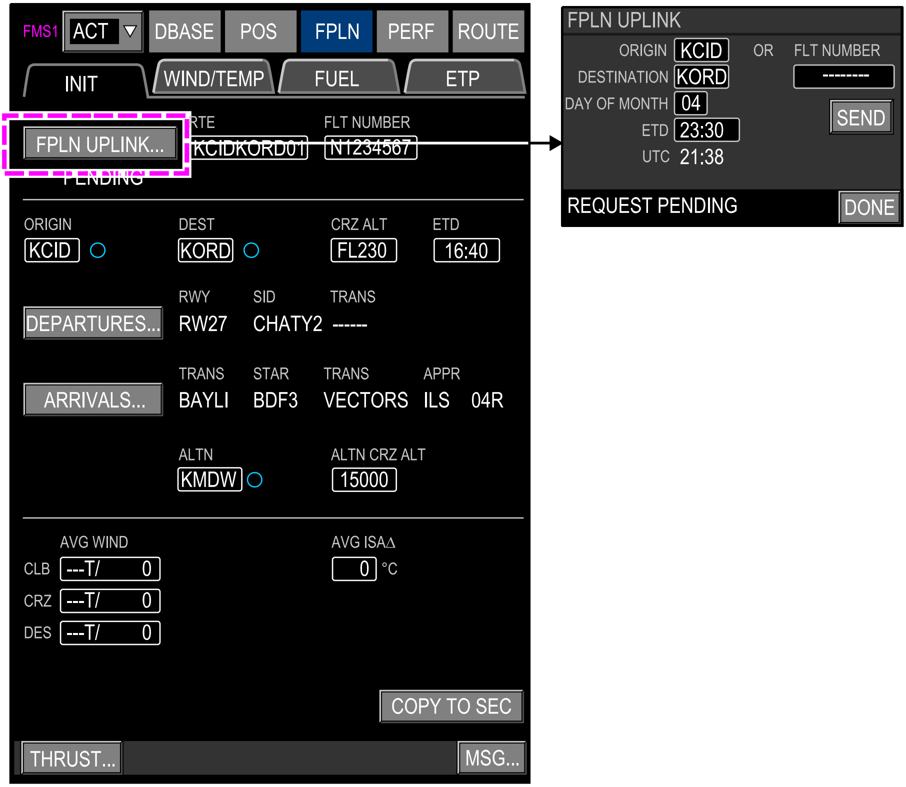
The INIT tab is used to initialize flight plans in the FMS. Three soft tile switches are used for data entry (refer to Figure 22–02–29):

- FPLN UPLINK,
- DEPARTURES, and
- ARRIVALS.



FPLN page – INIT tab
Figure 22–02–29

FMS flight plan data can be uploaded using the FPLN UPLINK soft tile switch (refer to Figure 22–02–30). Route information is entered in the data entry boxes of the dialog box.

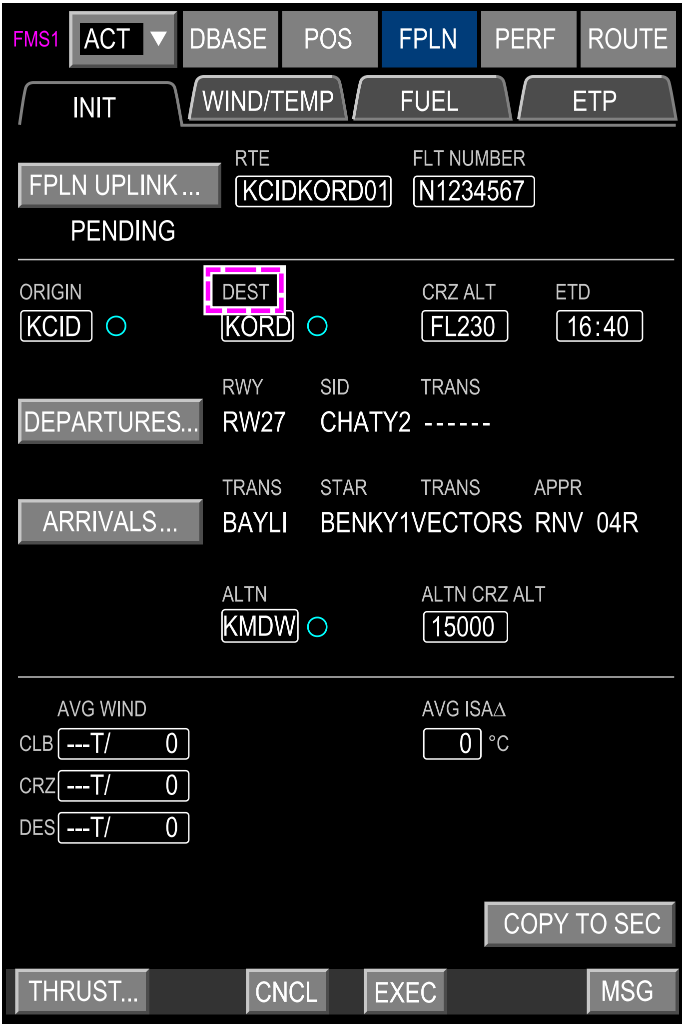


FPLN page – INIT tab – FPLN UPLINK dialog box
Figure 22–02–30

Selecting SEND in the dialog box uploads the requested flight plan. A status message displays below the FPLN UPLINK soft tile switch. Flight plans may be manually entered on the INIT tab if the uplink feature is not active.

The DEST (Destination) data entry box on the FPLN−INIT page shows the defined destination airport in the flight plan, which is required to define the arrival and approach procedures in support of the Lateral and Vertical Navigation functions and also to enable the time and fuel performance predictions for the arrival phase. Refer to Figure 22−02−31.

If the DEST airport is changed during an active flight, then any arrival and approach procedure loaded in the flight plan will be deleted and the ARRIVAL performance data will be cleared.



FPLN page – DEST
Figure 22–02–31

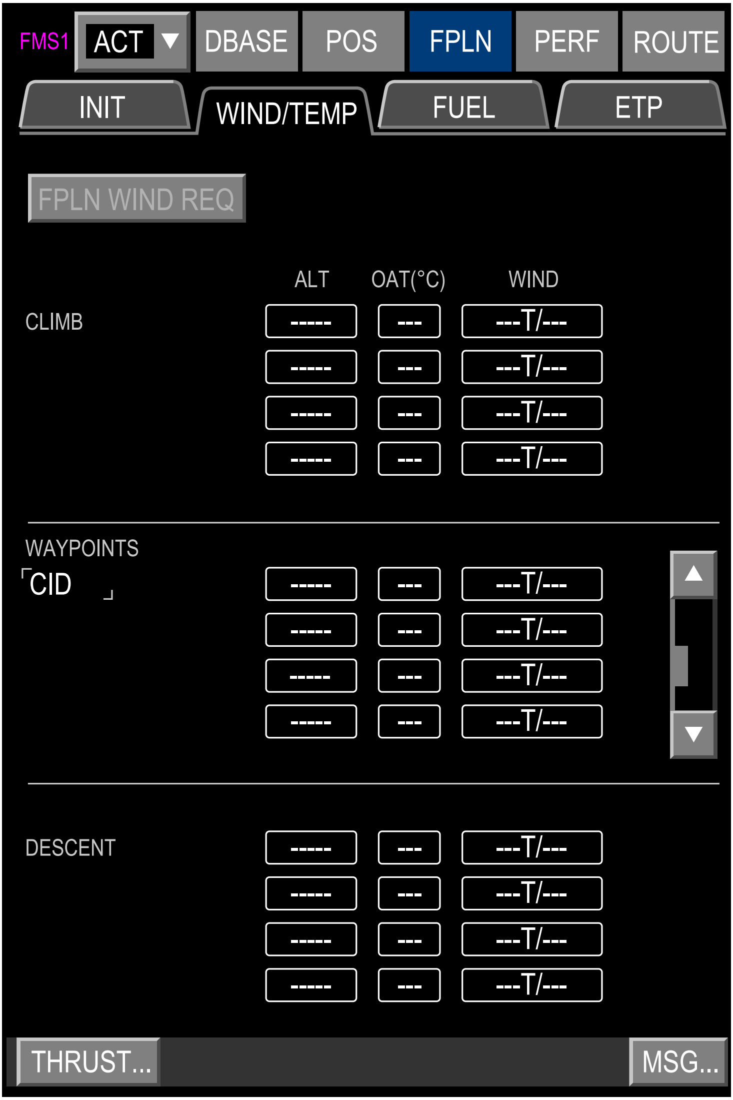
DEPARTURE and ARRIVAL dialog boxes display when the corresponding soft tile switch is selected. Refer to Figure 22–02–32.

FPLN page – INIT tab – DEPARTURES and ARRIVALS dialog boxes
Figure 22–02–32

Transitions displayed are based on the flight plan route. The VIEW ALL soft tile switch in each dialog box displays all arrival or departure transitions for the selected airport in a separate dialog box.

(2) WIND/TEMP Tab

The WIND/TEMP tab is used to enter wind and temperature information (refer to Figure 22–02–33). The entered data improves FMS performance prediction accuracy. Selecting the FPLN WIND REQ automates data entry if the function is active.



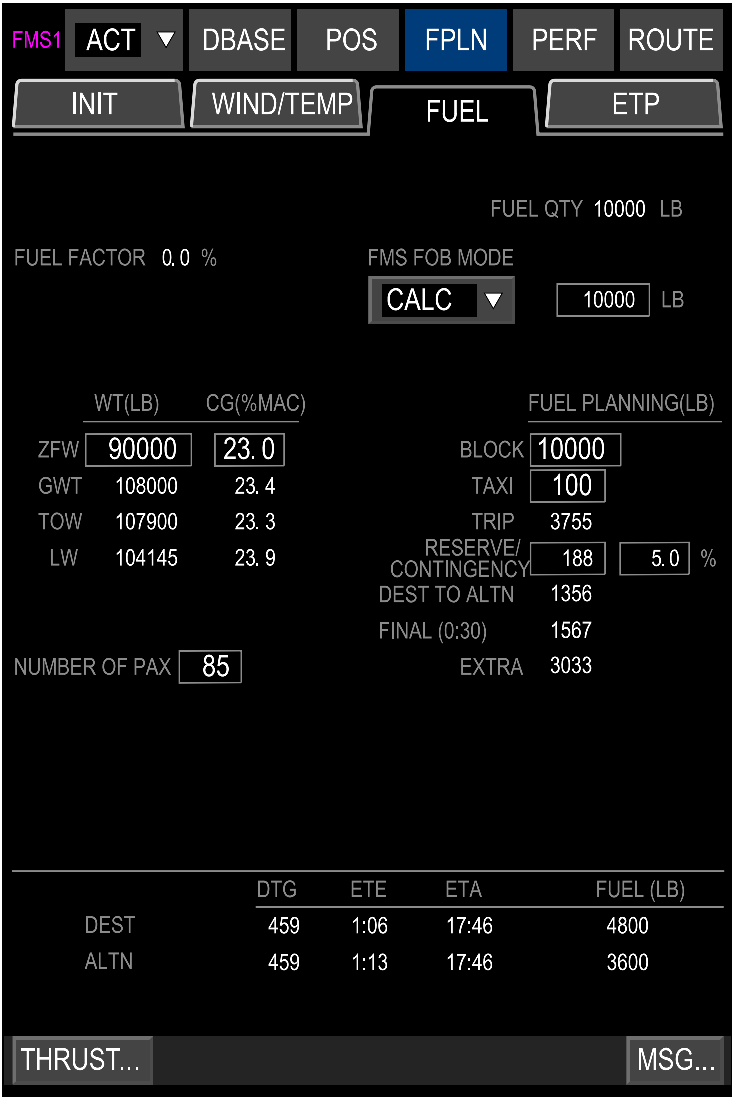
FPLN page – WIND/TEMP tab
Figure 22–02–33

All flight plan waypoints are listed. ALT displays in feet AGL, unless preceded by F or FL, which denote flight levels.

(3) FUEL Tab

The FUEL tab is used to enter fuel data. The FMS calculates enroute and arrival fuel parameters.

Selecting the FUEL LOAD REQ soft tile switch activates an uplink request for fuel load. Refer to Figure 22–02–34.



FPLN page – FUEL tab
Figure 22–02–34

The FMS FOB MODE drop-down list has two selections:

- CALC determines the remaining fuel quantity, based on the initial fuel quantity and calculated fuel used, as measured by the engine fuel flow sensors.
- SENSED determines the remaining fuel quantity based on fuel tank quantity sensors.

CALC is the default selection. Failure of a fuel flow sensor requires the selection of SENSED.

The RESERVE/CONTINGENCY fuel can be entered as a quantity or a percentage. The FINAL fuel reflects the time for holding that is entered on the DBASE DEFAULTS tab FUEL MGMT drop-down list.

BLOCK fuel is entered in the BLOCK data entry box. The FMS calculates and displays enroute and destination fuel quantities in the data fields below. During preflight planning, pilots can manipulate the BLOCK data to determine minimum flight plan fuel requirements. At the bottom of the page, data displays for the destination and alternate airports. Distance and time to go, as well as fuel required for both is constantly updated during the flight.

An amber FUEL REQD message displays in the TRIP, DEST TO ALTN, FINAL, or EXTRA data fields when flight plan fuel requirements are not met. An amber MSG soft tile switch also displays in the menu bar at the bottom of the page. The FMS MSG will be either CHECK FUEL AT DEST or CHECK FUEL AT ALTN.

At a high level, the FMS is constantly running an algorithm that blends current (measured) data with predicted data pulled from the PERF database of the FMS. Over the next 400 nm, the FMS begins with 100% measured data at present position (current altitude, groundspeed, fuel flow, etc.) and transitions to 100% predicted data at 400 nm in front of the aircraft (same parameters). Beyond 400 nm, the data will be 100% predicted data, and as with any predicted data, can be modified by wind input to the FMS. The measured data at present position already takes into account the current winds as that factors in the groundspeed.

Fuel insufficient for final is shown in Figure 22–02–35.

Fuel insufficient for final and alternate below reserve value is shown in Figure 22–02–36.

Fuel insufficient for final and alternate is shown on Figure 22–02–37.

FUEL INSUFFICIENT FOR FINAL

FPLN page – FUEL tab – Fuel sufficient for destination and ALTN but fuel required for FINAL
Figure 22–02–35

FUEL INSUFFICIENT FOR FINAL AND ALTERNATE BELOW RESERVE VALUE

FPLN page – FUEL tab – Fuel sufficient for destination and ALTN but fuel required for FINAL and CHECK FUEL AT messages displayed (ALTN below reserve limit)
Figure 22–02–36

FUEL INSUFFICIENT FOR FINAL AND ALTERNATE

FPLN page – FUEL tab – Fuel sufficient for destination but fuel required for FINAL and ALTN
Figure 22–02–37

(4) ETP Tab

The Equal Time Point (ETP) tab allows selection of the Nearest Airports function. Selecting the NEAREST ARPTS... soft tile switch opens a dialog box to display the closest suitable airports that meet or exceed the MIN RWY LENGTH with their associated information. Refer to Figure 22–02–38.

For each airport, the dialog box shows the bearing and distance to the airport (BRG/DIST), the Time To Go (TTG), the fuel remaining at the destination and information on the longest runway at the airport.

FPLN page – ETP tab
Figure 22–02–38

F. FMS – PERF (performance) page

The PERF (Performance) page has five tabs:

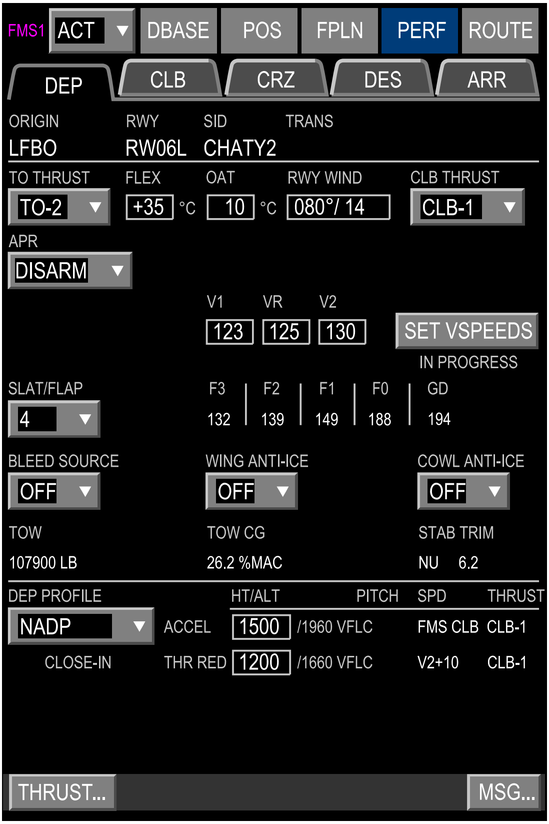
- DEP: Departure performance settings,
- CLB: Climb performance settings,
- CRZ: Cruise performance settings and fuel calculator,
- DES: Descent performance settings, and
- ARR: Arrival performance settings.

(1) DEP Tab

The Departure (DEP) tab page (refer to Figure 22–02–39) is divided into three sections:

- The top section displays the origin, runway, SID, and transition for the SID. A TO THRUST drop down list opens a takeoff performance dialog box.
- The middle section is a performance data entry section for departure. The data entry boxes have obvious entry requirements. Selecting SET VSPEEDS displays the V–speeds on the PFD. If the FMS is inoperative, the speeds may be entered using the AVIO tab on the AVIONIC synoptic page. Selecting VSPEEDS REQ uploads V–speeds and is an operator option. The BLEED source drop–down lists display APU, ENG, and OFF options to be selected by the flight crew. The WING ANTI–ICE and COWL ANTI–ICE drop–down lists display ON, and OFF options to be selected by the flight crew. The APR ARM check box defaults to checked whenever a derated takeoff is selected (TO–1, TO–2, or TO–3). The check box is grayed if TO (no derate) is selected.

- The bottom section of the DEP tab is the departure profile, which can be used for noise abatement departure procedures (NADP). It displays the NADP soft switch and the procedure being used, as well as the associated altitudes for thrust and speed adjustments. The DEP PROFILE function has three possible selections:
  - STANDARD – In this departure profile, the acceleration defaults to 1500 ft AAE. The thrust reduction occurs when the slats/flaps are retracted. This is the default selection at aircraft power-up or when a new flight plan is entered.
  - NADP CLOSE-IN – In this departure profile, the thrust reduction altitude (THR RED) is lower than the acceleration altitude (ACCEL). The difference between the ACCEL and THR RED altitudes must be 300 ft or more, otherwise an amber INVALID ENTRY message will be displayed.
  - NADP — DISTANT – In this departure profile, the acceleration altitude (ACCEL) is lower than the thrust reduction altitude (THR RED). The difference between the ACCEL and THR RED altitudes must be 300 ft or more, otherwise an amber INVALID ENTRY message will be displayed.



PERF page – DEP tab
Figure 22–02–39

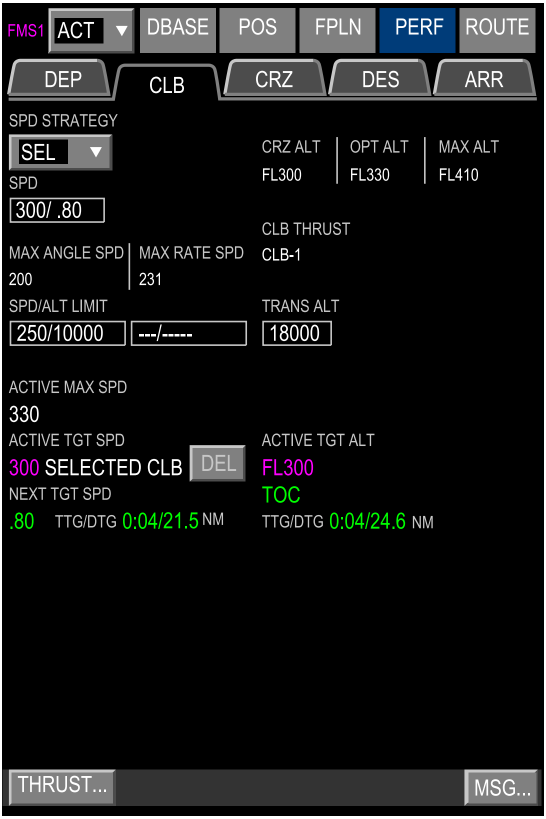
NOTE

When TO THRUST is selected or a FLEX value in entered, an amber THRUST MODE REQ FAIL message will be displayed if the active thrust mode reported by the FADEC does not change to match the selected mode.

(2) CLB Tab

The Climb (CLB) tab page (refer to Figure 22–02–40) displays:

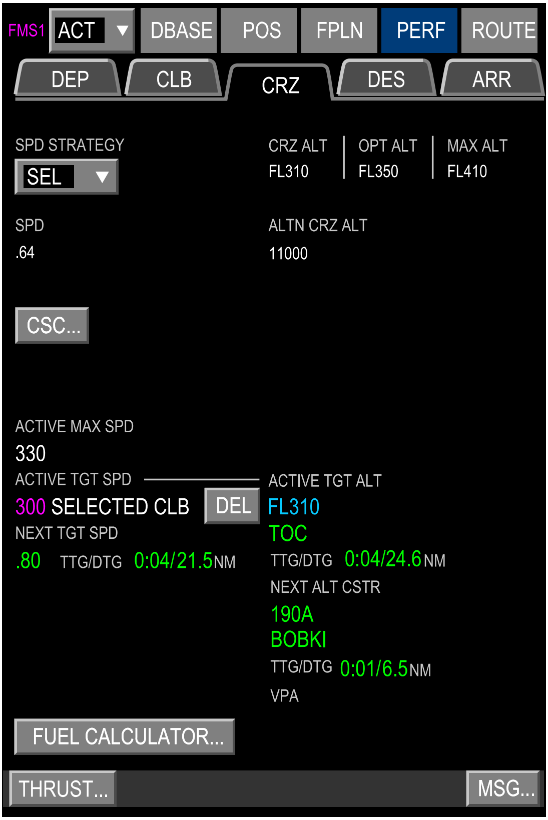
- A drop-down list for SPD STRATEGY that includes ECON or SEL (Selected),
- The data input boxes for Speed and Altitude Limit (SPD/ALT LIMIT) and transition altitude (TRANS ALT),
- The cruise, optimum, and maximum altitudes are displayed along with current speed strategy, maximum angle, and maximum rate speeds with the current thrust selection, and
- The active flight phase and the next targets are displayed on the bottom half of the page.



PERF page – CLB tab
Figure 22–02–40

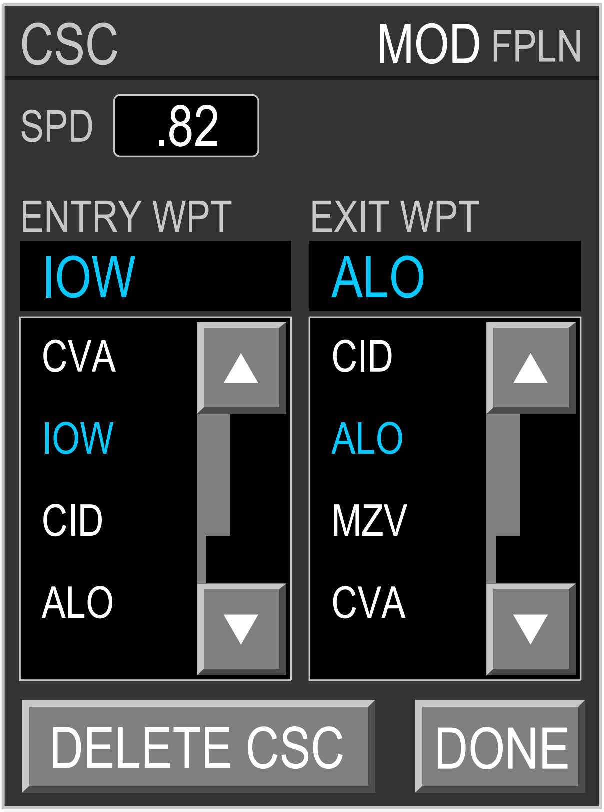
(3) CRZ Tab

The Cruise (CRZ) tab page (refer to Figure 22–02–41) displays the cruise, optimum, maximum, and alternate altitude with the speed strategy (SELECTED). FMS assigned ACTIVE TGT SPD and ACTIVE TGT ALT display in magenta. NEXT TGT SPD defines the top of climb and the subsequent flight phases, including, the next target, top of descent, and the descent profile information.



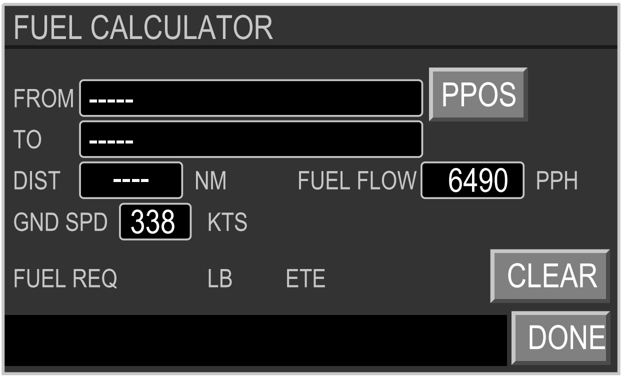
PERF page – CRZ tab
Figure 22–02–41

Two soft switches display the Constant Speed Cruise segment (CSC), and a FUEL CALCULATOR.... The CSC... soft switch opens a dialog box that allows data entry for entry and exit points and the speed to be flown in between these points. This data can also be entered on the LEGS tab of the ROUTE page. Refer to Figure 22–02–42.



PERF page – CRZ tab – CSC dialog box
Figure 22–02–42

Selecting the FUEL CALCULATOR... soft switch at the bottom of the CRZ page displays a dialog box that is used to calculate and view fuel requirements, from present or entered position to a specified destination. Calculations are based on current fuel flow by default, but the value may be overridden. Current ground speed displays by default, but also may be overridden. FUEL REQ indicates the required fuel between the entered FROM and TO waypoints. Refer to Figure 22–02–43.

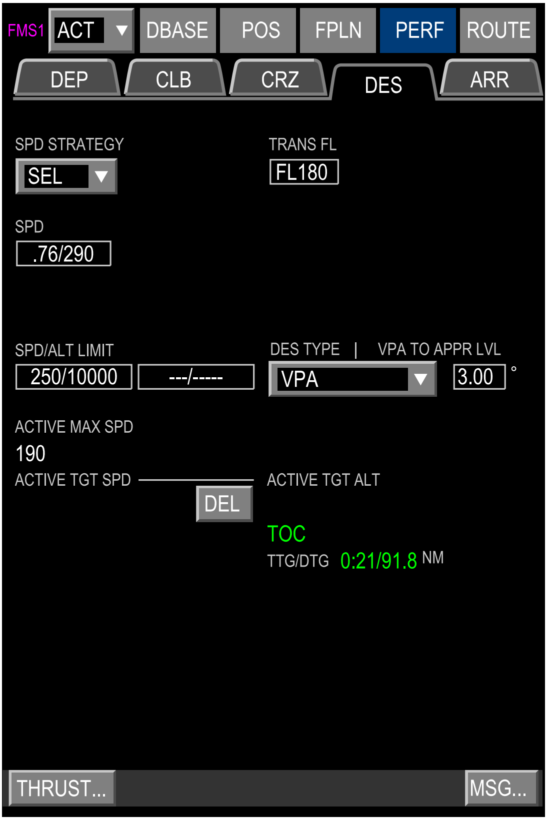


PERF page – CRZ tab – FUEL CALCULATOR dialog box
Figure 22–02–43

(4) DES Tab

The Descent (DES) tab page (refer to Figure 22–02–44) displays active phase of flight information and speed strategy. The data entry boxes are for speed/altitude limit and the transition altitude.

The DES TYPE drop-down list allows selection for VPA (Vertical Path Angle) descent. If VPA is selected, a data entry box displays for desired angle.



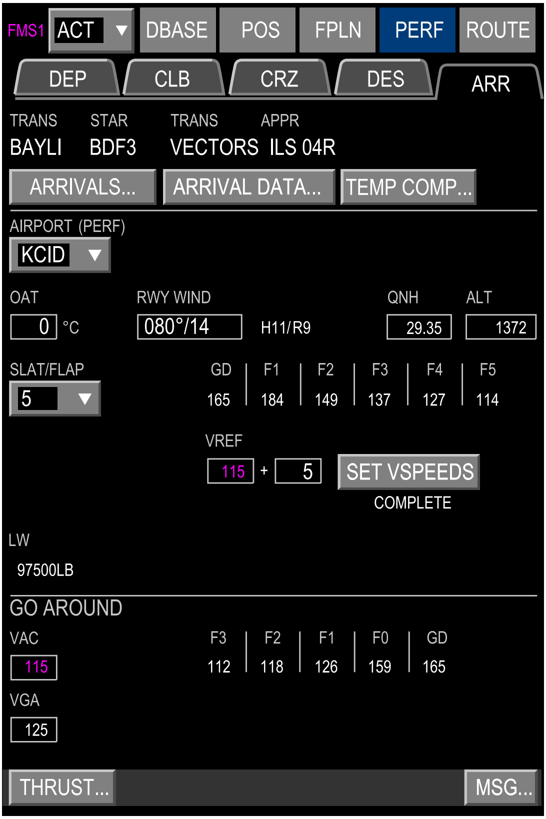
PERF page – DES tab
Figure 22–02–44

(5) ARR Tab

The arrival (ARR) tab page (refer to Figure 22–02–45) displays three sections:

- The top portion of the ARR tab has soft switches that display dialog boxes for the Arrivals for the airport (ARRIVALS...), Arrival Data for the approach selected (ARRIVAL DATA...), and for Temperature Compensation (TEMP COMP...).

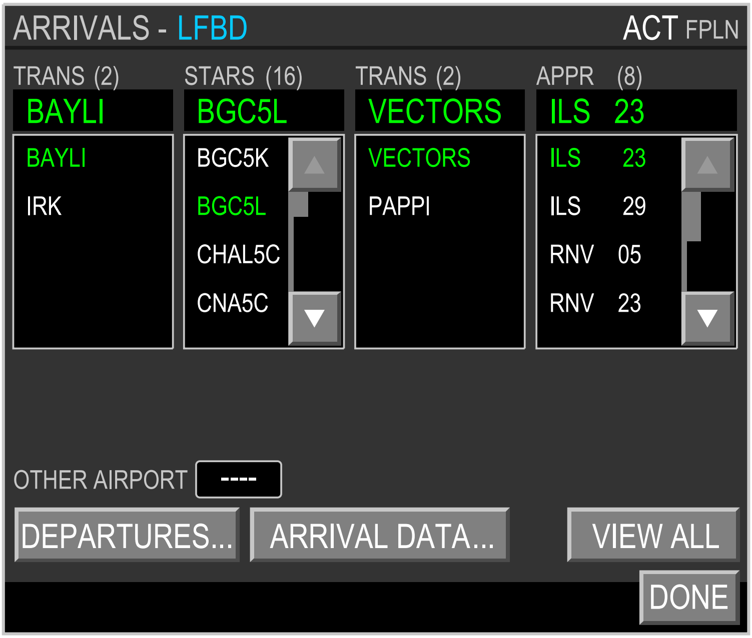
- The middle section of the ARR tab displays airport performance data for the airport in the drop-down list and data entry boxes for landing parameters and conditions.
- The bottom section displays the go-around flap schedule, the go-around target speed (VGA), and the single engine go-around speed (VAC). The landing performance soft tile switch displays a dialog box for computing landing airfield performance requirements.



PERF page – ARR tab
Figure 22–02–45

The ARRIVALS... soft switch presents the scrolling display/selections that follow (refer to Figure 22–02–46):

- The arrival transition,
- The arrival,
- The approach transition, and
- The approach.



PERF page – ARR tab – ARRIVALS dialog box
Figure 22–02–46

Additional soft switches permit direct access to other dialog boxes. Any selection opens the associated arrival information dialog box where changes can be made, if required.

The OTHER AIRPORT field is available to view airport-related information that is not part of the flight plan.

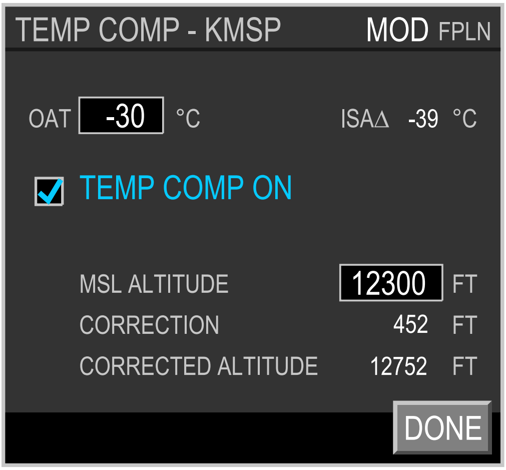
The Runway Extension (RWY EXT) field is available only when a Visual (VIS) approach is selected in the APPR field. Once the RWY EXT field is active, the crew may enter a distance from the threshold to which the runway centerline may extend.

The ARRIVAL DATA... soft tile switch opens approach information for the selected approach. Refer to Figure 22–02–47.

PERF page – ARR tab – ARRIVAL DATA dialog boxes
Figure 22–02–47

The Temperature Compensation (TEMP COMP...) soft tile switch opens the TEMP COMP dialog box (refer to Figure 22–02–48) that is used to correct procedure altitudes for cold weather. Only database altitudes below the transition level are corrected. Selecting TEMP COMP ON displays a copyright symbol beside the temperature corrected altitudes on the LEGS page.

The pre-selector can only be set to the nearest 100 feet. The flight crew may have to adjust the altitude pre-selector for the missed approach altitude to the nearest higher altitude when temperature-compensated altitude values are used.



PERF page – ARR tab – TEMP COMP dialog box
Figure 22–02–48

The middle section of the ARR tab page displays the data that follows (refer to Figure 22–02–49):

- The approach type,
- The landing data,

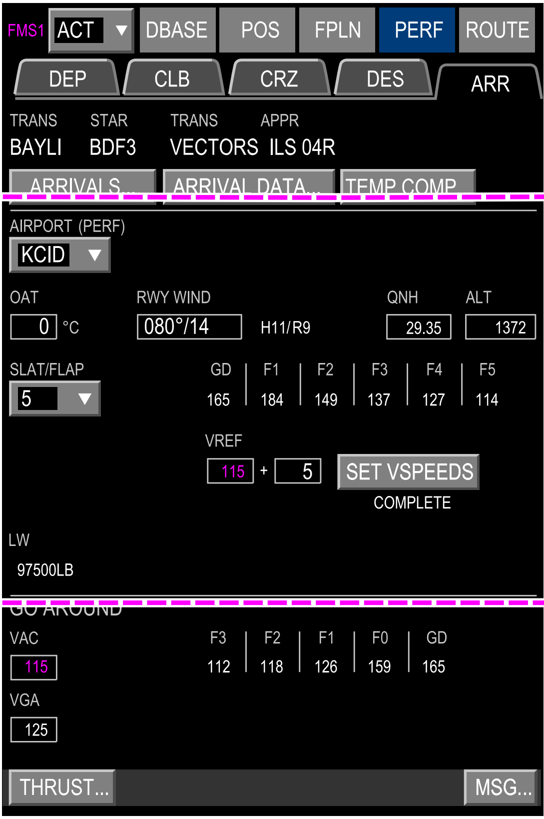
- The performance information, and
- The data entry boxes.

The AIRPORT (PERF) drop-down list defaults to the arrival airport. The alternate airport may be selected from the drop-down list. VREF, GO AROUND, and flap speeds are automatically calculated for the selected airport.

Runway temperature, wind, and altimeter setting have data entry boxes. Entering the wind speed and direction in the RWY WIND box automatically displays the headwind (H) and crosswind (L or R) components in the area directly to the right of the box.

If gusty wind conditions exist at the arrival airport, ½ of the gust wind speed, up to a maximum of 10 knots, can be entered in the box located next to VREF. Selecting the SET VSPEEDS soft switch displays the corrected VREF, GO AROUND, and flap speeds on the PFD.

Landing flap setting is selected from the SLAT/FLAP drop-down list.



PERF page – ARR tab – Middle section
Figure 22–02–49

G. FMS – ROUTE page

The ROUTE tile has four tabs:

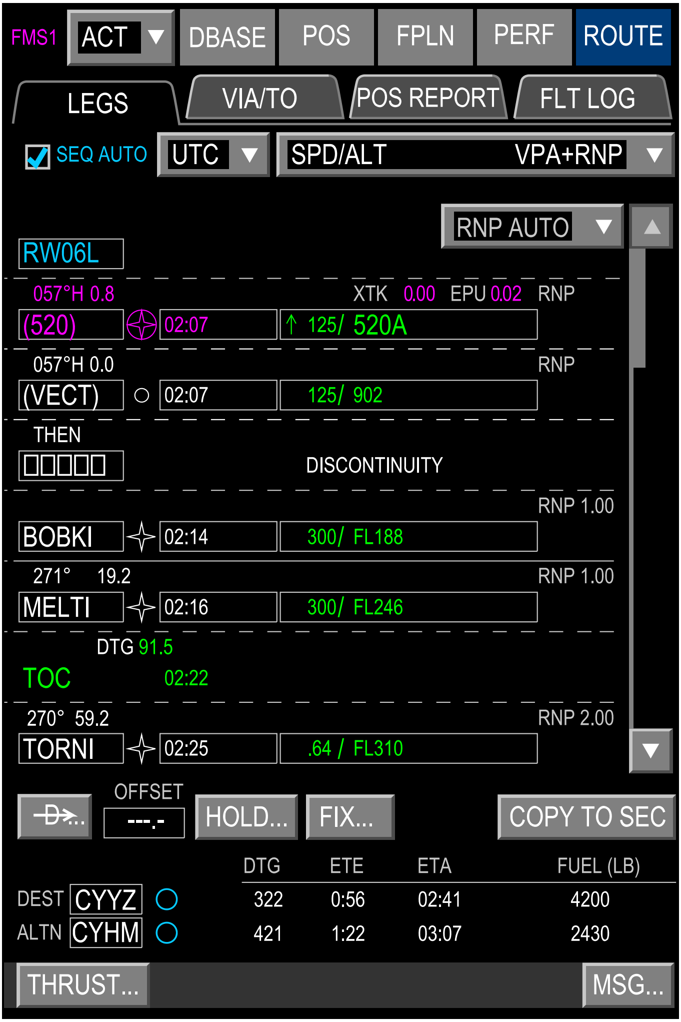
- LEGS
- VIA/TO
- POS REPORT
- FLT LOG

(1) LEGS Tab

The LEGS tab displays the active flight plan broken down into sequenced waypoints, with two drop-down lists for route display options along the top of the legs and four soft tile switches for flight plan changes along the bottom of the display. Refer to Figure 22–02–50.

At the bottom of the LEGS tab there is a flight plan summary for the destination and alternate.

Display options in the first drop-down list are FUEL and UTC. Fuel displays the estimated FOB and deviation from the original planned fuel. UTC displays the estimated time over each waypoint in Coordinated Universal Time.



ROUTE page – LEGS tab
Figure 22–02–50

The second drop-down list has three selections (refer to Figure 22–02–51):

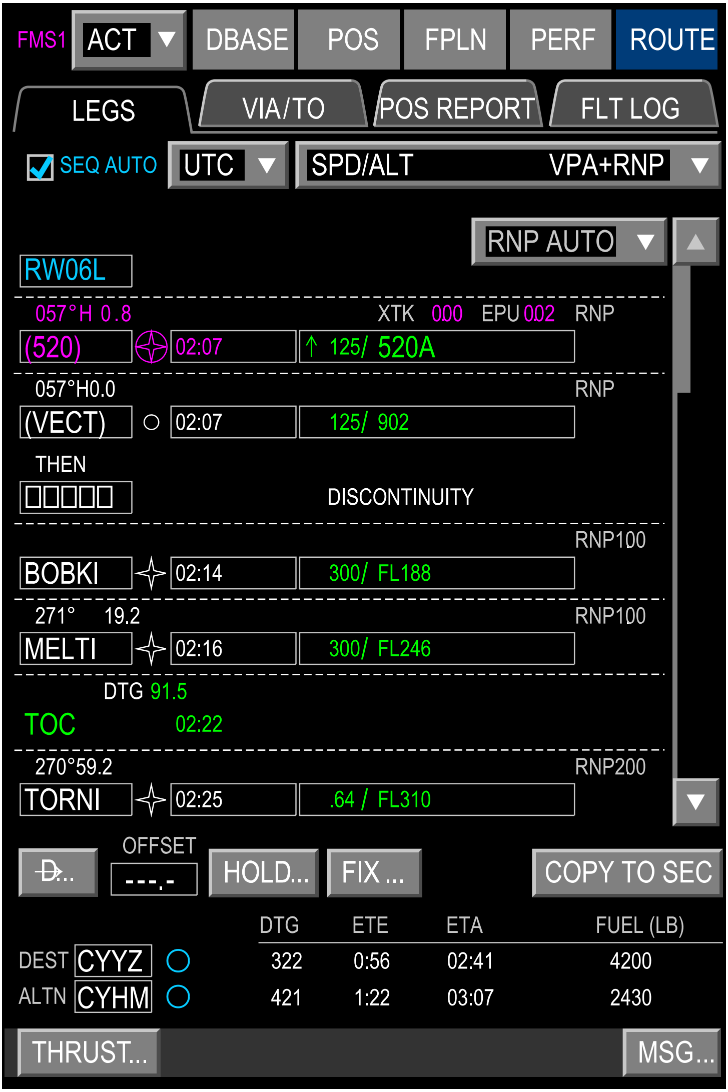
- SPD/ALT VPA + RNP
- SPD/ALT VP
- AOAT WIND TAS/GS

The SPD/ALT VPA+RNP selection displays the projected speed and altitude over a waypoint, and the required navigation performance and vertical path angle.

The SPD/ALT VPA selection only displays during the descent and arrival portions of the flight.

ROUTE Page – Legs Tab – SPD/ALT VPA+RNP selection
Figure 22–02–51

The OAT WIND TAS/GS selection displays the estimated outside air temperature, wind data, projected true airspeed and ground speed over each "to" waypoint as calculated by the FMS with IRS and ADS inputs. Refer to Figure 22–02–52.



ROUTE page – LEGS tab – OAT WIND TAS/GS Selection
Figure 22–02–52

There are four soft tile switches along the bottom of the ROUTE page LEGS tab

- COPY TO SEC
- FIX...
- HOLD...
- Direct to symbol (D with an arrow through it)

The COPY TO SEC soft key copies the active flight plan into the secondary flight plan.

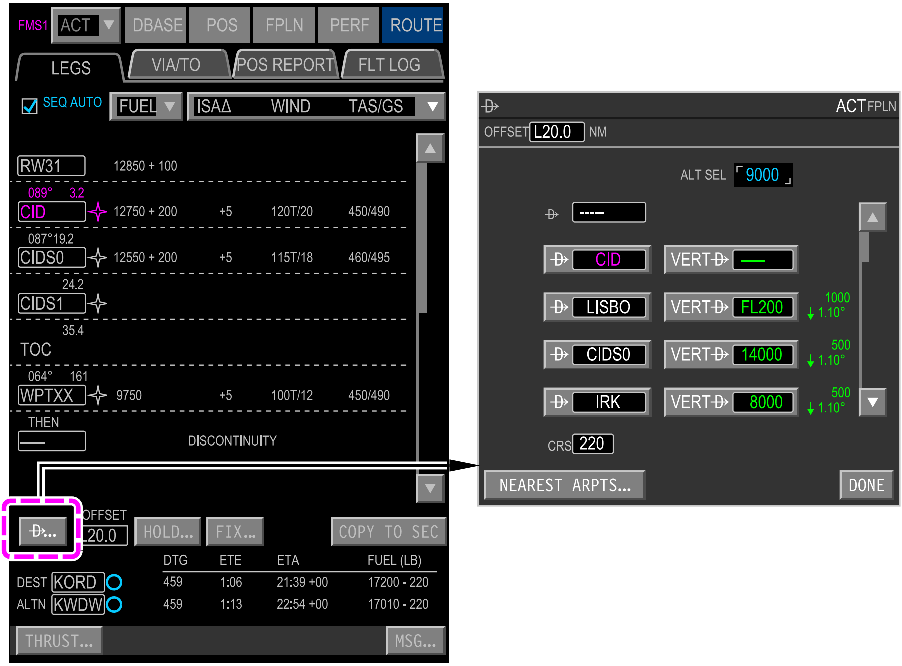
The FIX soft key opens a dialog box for the creation of the following types of fixes:

- Abeam
- Radial crossing
- Distance crossing
- Time offset
- Along track ETA
- Latitude or longitude crossing

Selecting the HOLD soft tile switch opens a dialog box for inserting, or modifying a holding pattern.

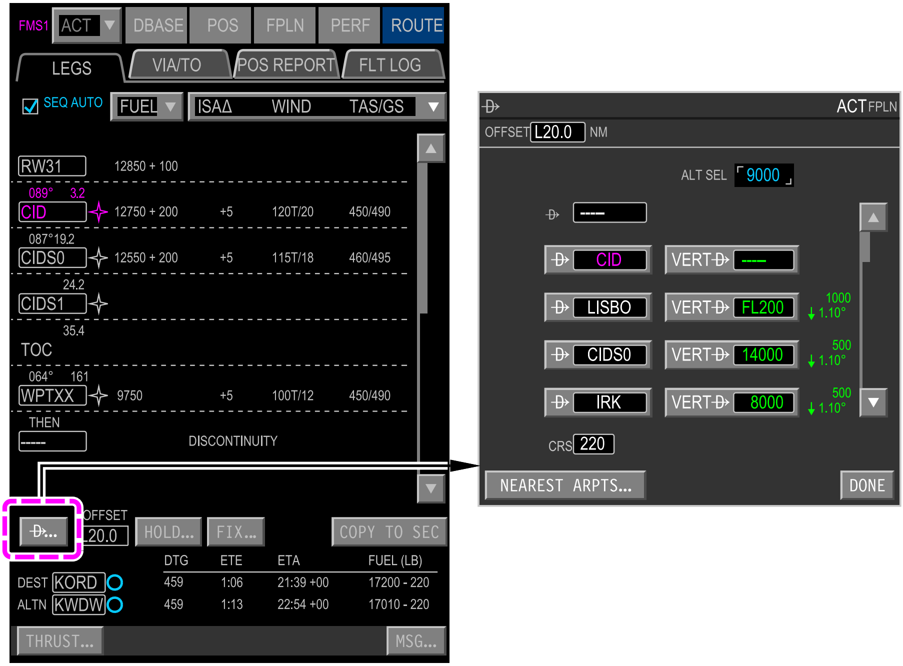
Selecting the Direct to soft tile switch opens a dialog box for entering (refer to Figure 22–02–53):

- A direct route to a waypoint
- An OFFSET parallel track
- A VERTICAL flight path constraints



Direct to selecting offest route modification
Figure 22–02–53

In the direct to dialog box, any flight plan waypoint may be selected by scrolling through the list (refer to Figure 22–02–54). Alternatively, a waypoint identifier may be entered in the Direct to data entry box above the TO waypoint. The course (CRS) data entry box displays the direct course to the selected waypoint. It may be overridden to establish an intercept course.



Direct to selecting offest route modification
Figure 22–02–54

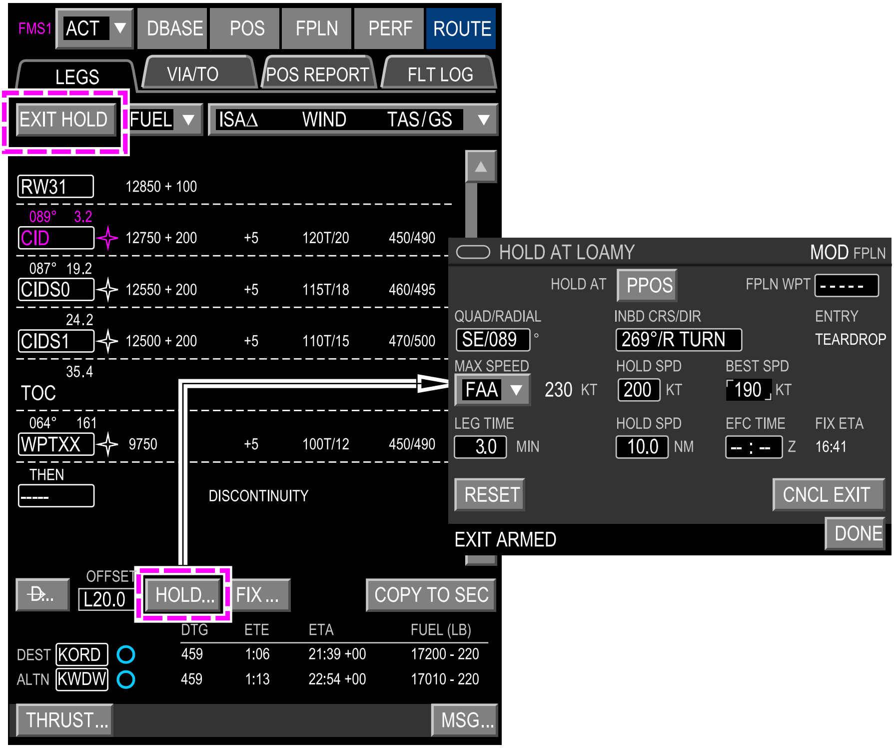
Selecting OFFSET allows the creation of a parallel track that is offset laterally (L or R) by a defined distance from the flight plan route. Clearing the data field cancels the offset.

Entering an altitude in the data entry box beside the VERT D symbol displays vertical speed, flight path angle and flight phase, such as climb or cruise.

After pressing the Direct to symbol, a modified (MOD) flight plan is created (refer to Figure 22–02–55). The dialog box is closed by selecting DONE. Selecting the CNCL button at the bottom of the FMS page, or on the map, or on the MKP cancels pending flight plan modifications. Pending modifications to the flight plan are made using the EXEC soft tile switch either at the bottom of the FMS page, or on the map, or on the MKP. This changes the MOD flight plan to the Active (ACT) flight plan.

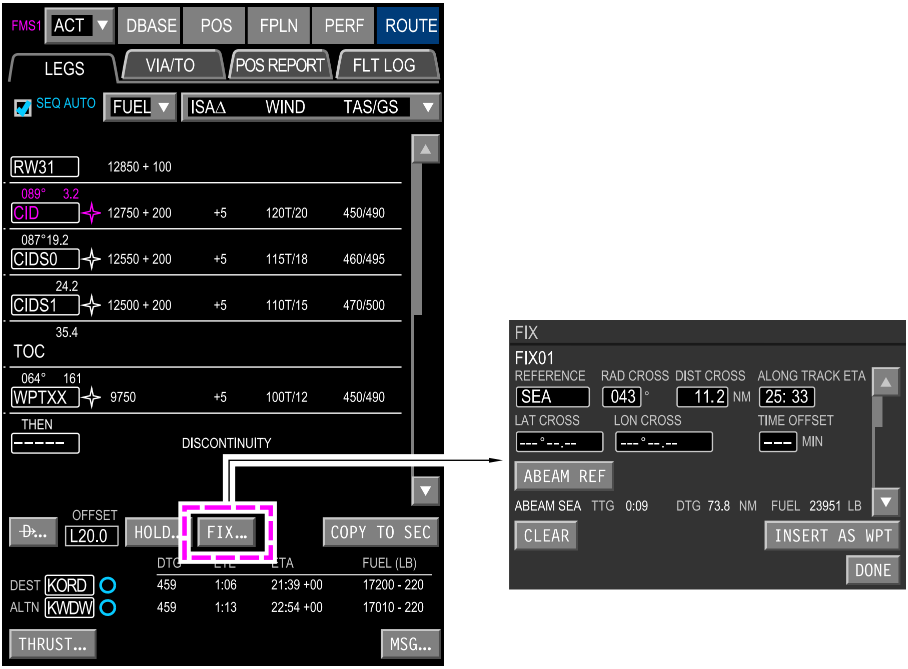
ROUTE Page – Legs Tab – Direct to offset route modifies flight plan
Figure 22–02–55

Selecting the HOLD... soft tile switch displays the HOLD dialog box (refer to Figure 22–02–56). A hold can be inserted at the Present Position by using the PPOS soft tile switch or entering the identifier in the FLPN WPT data box. Modifications to the hold are made by changing the displayed data. An EXIT HOLD soft tile switch displays at the top of the LEGS tab when flying a holding pattern. When EXIT ARMED displays in the dialog box, the FMS navigates to the hold fix and then exits the hold.



ROUTE Page – Legs Tab – HOLD dialog box
Figure 22–02–56

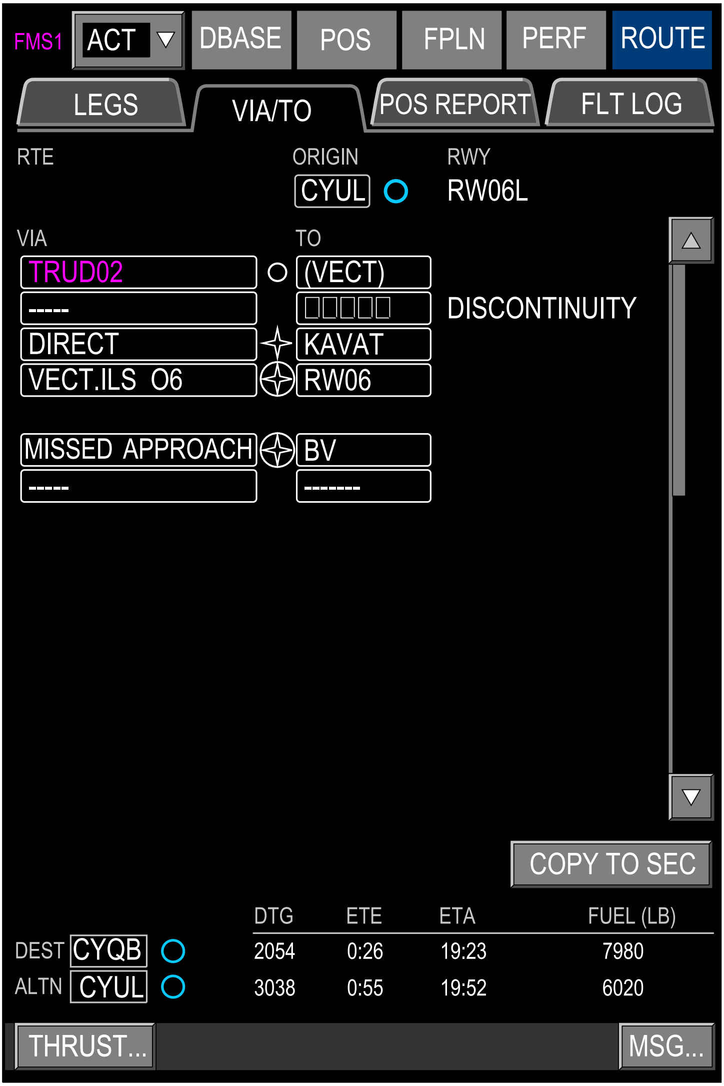
The FIX soft tile switch displays a box that allows the creation of up to 10 fixes (refer to Figure 22–02–57). The INSERT AS WPT soft tile switch allows the fix to be inserted into the flight plan.



ROUTE Page – Legs Tab – FIX dialog box
Figure 22–02–57

(2) VIA/TO Tab

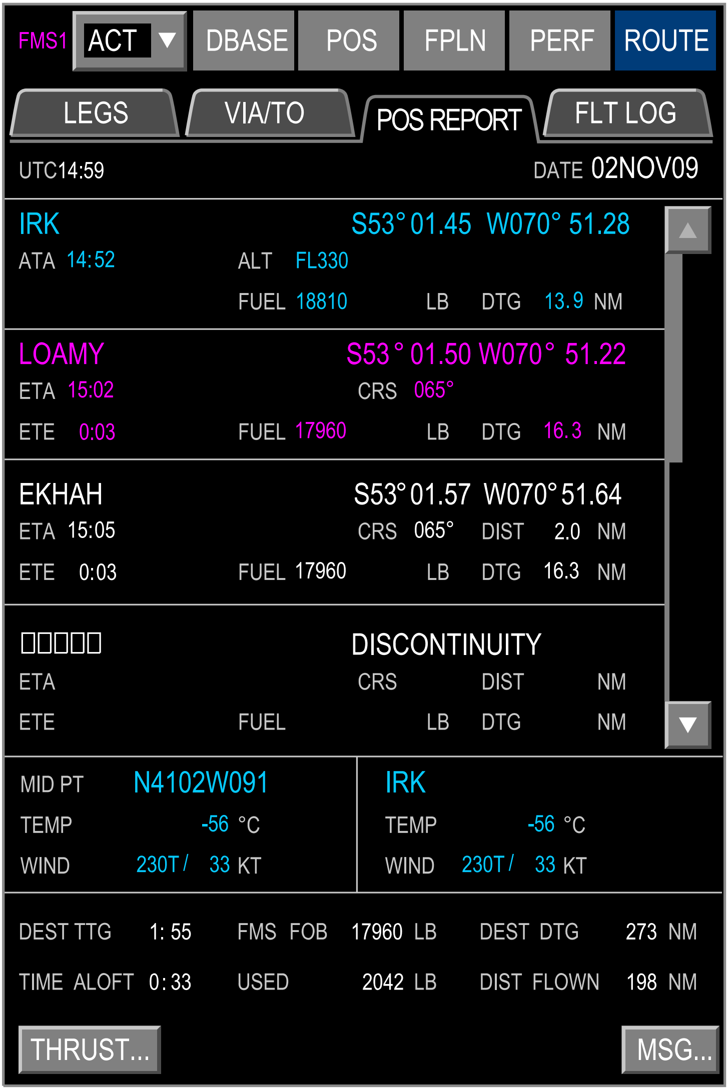
Selecting the VIA/TO tab of the ROUTE page displays the RTE, ORIGIN, and RWY, with two columns (refer to Figure 22–02–58). The first column displays the route legs and the second column displays the waypoint, SID, STAR, and approach. DEST and ALTN data boxes display at the bottom.



ROUTE page – VIA/TO tab
Figure 22–02–58

(3) POS REPORT Tab

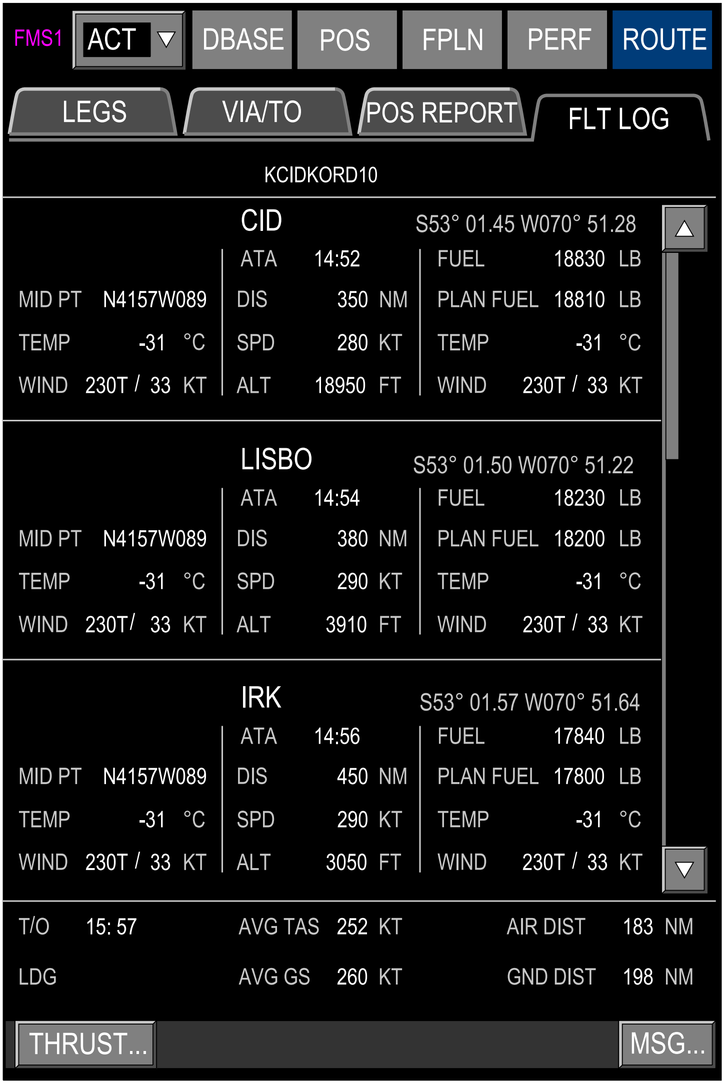
The POS REPORT tab displays the last overflown waypoint, and the next three waypoints in the flight plan (refer to Figure 22–02–59). Each waypoint displays ETA, time and distance to go, and forecast fuel overhead. Temperature and wind display for the overflown waypoint, and the midpoint of the previous leg.



ROUTE page – POS REPORT tab
Figure 22–02–59

(4) FLT LOG Tab

The FLT LOG tab displays summary information for each waypoint (refer to Figure 22–02–60). The takeoff and landing times display at the bottom of the page along with average speeds and remaining distances.



ROUTE page – FLT LOG tab
Figure 22–02–60

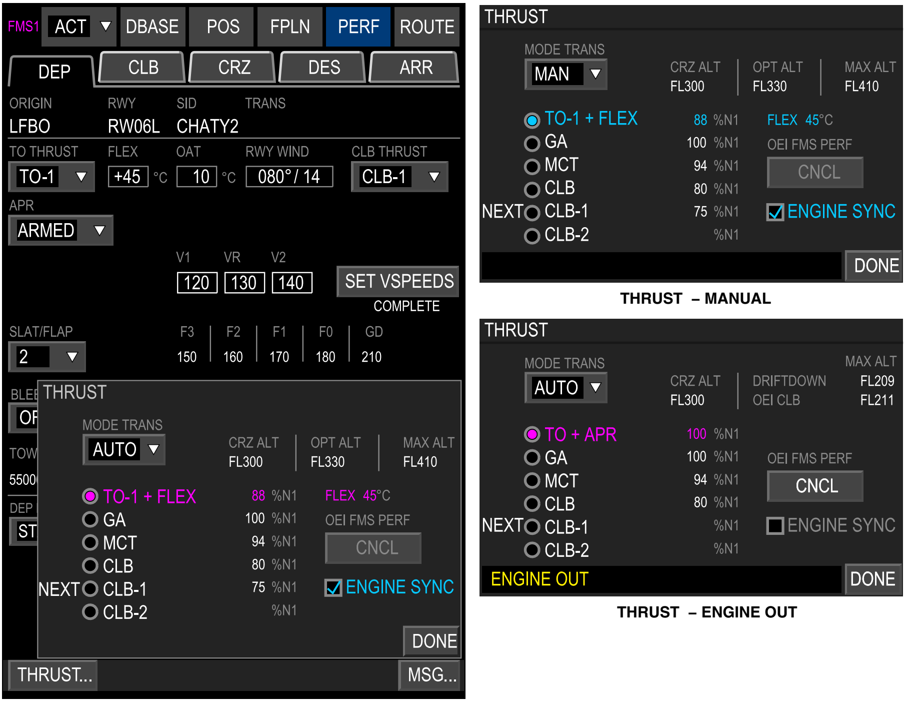
H. FMS – THRUST soft switch

Selecting the THRUST soft switch on the menu bar at the bottom of the page opens a dialog box with three available selections from a drop-down list (refer to Figure 22–02–61):

- AUTO: Thrust transitions automatically when required.
- MAN: Thrust mode has to be manually selected from the drop-down list.
- AUTO ENGINE OUT: This box displays if there is an engine failure.

In case of engine failure, the associated PERF data is automatically selected with a flag to indicate ENG OUT. Text displays in magenta for automatic mode and cyan for manual mode.

NEXT displays beside the next thrust mode to be used. Reference N1 value is beside each thrust mode.



PERF page – DEP tab – Thrust dialog box
Figure 22–02–61

I. FMS – MSG soft switch

The MSG soft tile switch on the menu bar at the bottom of the page is identical in function to the MSG QAK, which displays FMS messages in a dialog box. New white messages are alerts and new amber messages are cautions (refer to Figure 22–02–62). Previously read messages are listed under OLD MESSAGES. Selecting the MSG soft tile switch opens the message dialog box. When an active message has been viewed, DONE soft tile switch is selected, the dialog box closes, and the MSG tile turns black.

DBASE page – STATUS tab – Messagedialog box
Figure 22–02–62

J. FMS – Vertical situation display

The Vertical Situation Display (VSD) gives a graphical picture of the vertical flight path and the vertical situation relative to terrain and runway, which enhance situational awareness. It also gives a side view of the vertical profile and is framed by altitude and distance references. Refer to Figure 22–02–63.

When selected, the VSD displays the vertical path along the aircraft route or track, from left to right, regardless of changes in direction on the flight plan.

The VSD is displayed in the lower third of any MFW when MAP is selected and occupies one half of a DU (single partition). When a DU is displayed on the MAP view on both DU partitions, the VSD is displayed on the left side partition only.

NOTE

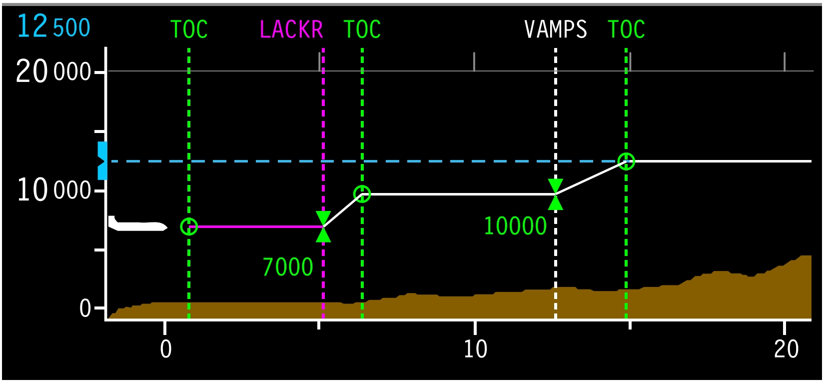
The VSD must not be used as a terrain avoidance or navigation tool. It is intended to be used to enhance vertical situational awareness only.

Vertical Situation Display (VSD)
Figure 22–02–63

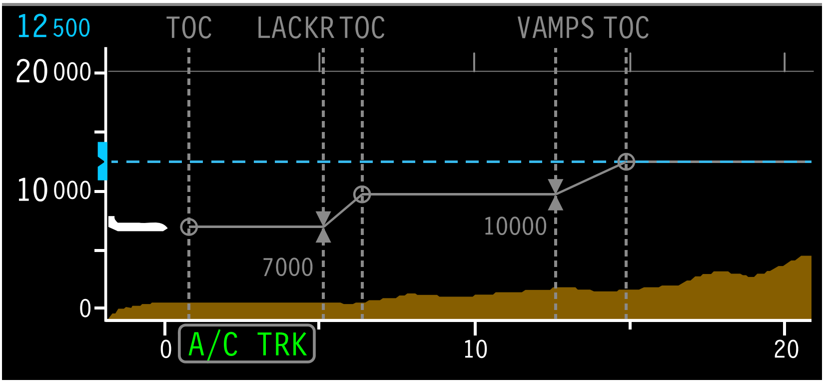
(1) VSD formats

The VSD can display either the flight plan vertical path or the Aircraft Track (A/C TRK). The vertical profile usually displays the flight plan format but will revert automatically to A/C TRK when the aircraft deviates from the lateral flight plan by more than the RNP value, or the FMS is not providing vertical guidance. The VSD window can be overlaid with lateral and vertical waypoints, altitude targets, altitude constraints, and TAWS data.

Terrain on the VSD can be displayed in one of two formats: flight plan vertical path format or Aircraft Track (A/C TRK) format (refer to Figure 22–02–64).



VIEW IN VERTICAL PATH FORMAT



VIEW IN AIRCRAFT TRACK FORMAT

VSD formats
Figure 22–02–64

(2) Amber altitude constraints

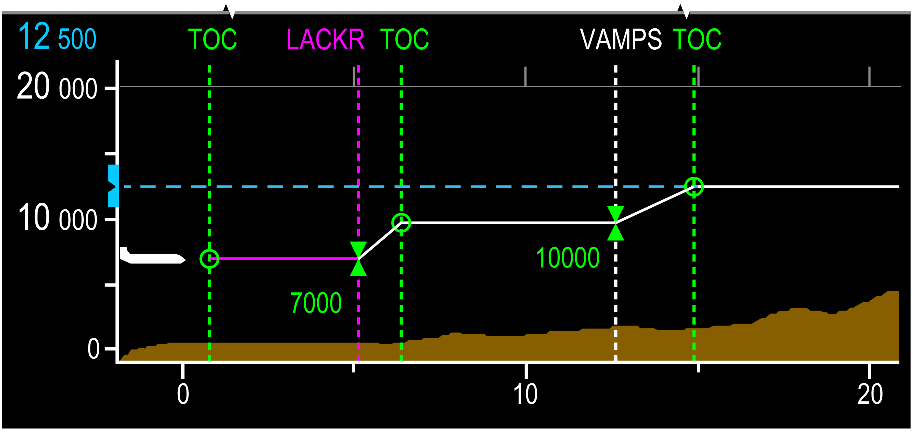
If the aircraft is unable to meet the required altitude constraints specified in the flight plan legs, the VSD will display the constraint altitude in amber. An UNABLE FPLN ALT message will also be displayed on the PFD.

If the amber constraint is displayed in the climb phase of flight, an amber triangle will also be displayed.

(3) Vertical path format

The vertical path format is automatically displayed when the aircraft flies along the flight plan route and the navigation source is FMS or LOC. In this case, the flight plan vertical profile is displayed in magenta (from aircraft position to the first waypoint in the flight plan) and in white (subsequent waypoints). The waypoint and altitude constraints on the VSD coincide with those of the ROUTE – LEGS page in value and color. Refer to Figure 22–02–65.

The displayed terrain shows the terrain ahead of the aircraft along the flight plan route when the aircraft position is within the required Required Navigation Performance (RNP) value.



VSD – Flight plan vertical profile (green)
Figure 22–02–65

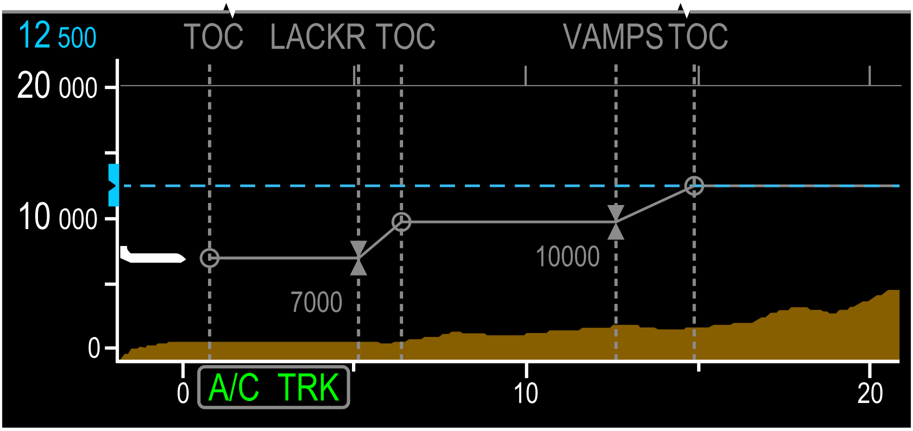
(4) A/C TRK path format

The aircraft track format is automatically displayed when the aircraft is not tracking the flight plan route (refer to Figure 22–02–66). In this case, the flight plan vertical profile is displayed in grey (de-emphasized). The waypoint and altitude constraints coincide with the ROUTE – LEGS page, but the color is removed.

The displayed terrain relates to the aircraft current track, ahead of the aircraft. The profile is referenced to the aircraft track when any one of the conditions that follow occurs:

- Active FD mode is not FMS or LOC,
- GNSS fail,
- RNP is exceeded,
- Difference between current and desired track is more than 90 degrees,
- Flight plan discontinuity is active,
- Flight plan sequence inhibit is active,
- Flight plan offset is selected, or
- There is no valid flight plan.

When in the A/C TRK path format, the A/C TRK label is displayed in green below the distance scale.



VSD – Flight plan vertical profile (not following profile)
Figure 22–02–66

(5) VSD symbology

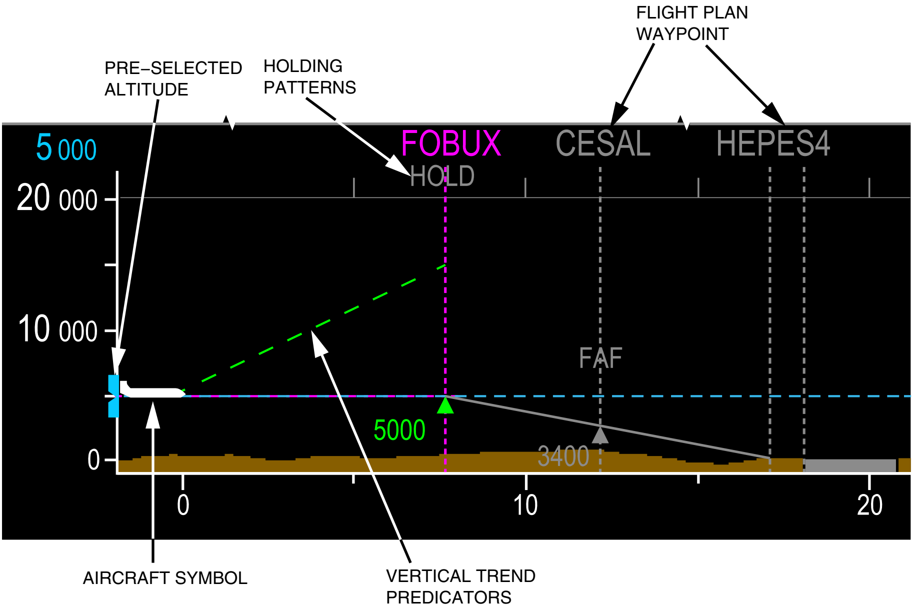
The VSD includes the graphic symbology that follows (refer to Figure 22–02–67):

- Aircraft symbol (white when normal and magenta when invalid),
- Flight plan waypoint is displayed as a vertical drop line,
- Holding patterns,
- Approach,
- Runway,
- Preselected altitude (cyan bug), and
- TAWS.
- Vertical trend predictors:
  - Displayed as a green dashed line that extends from the nose of the aircraft symbol to the 1/4 range line.

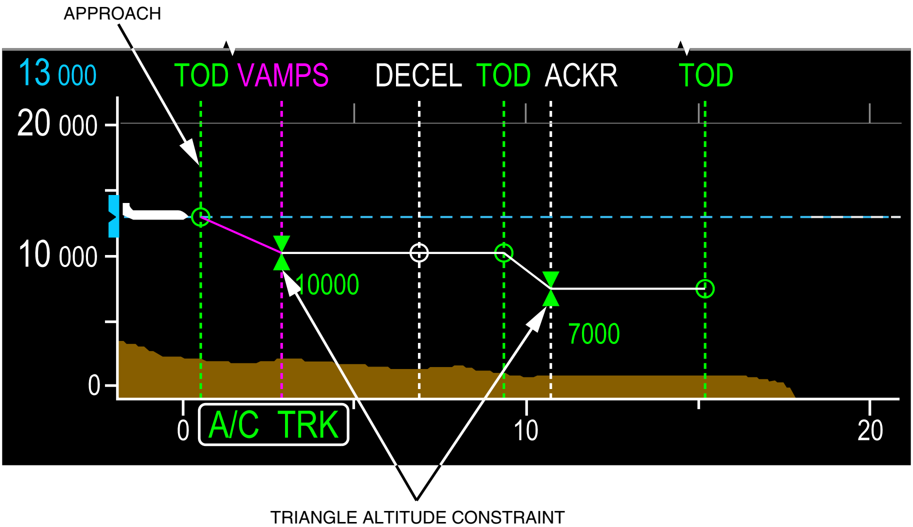
  - It is based on current vertical speed and does not show if the vertical speed is less than 150 ft/min.

- Altitude constraint triangle displays (refer to Figure 22–02–68):
  - Upright for at or above altitude constraints.
  - Inverted for at or below altitude constraints.
  - Both upright and inverted for at altitude constraint.
  - Green triangle for able to meet altitude constraint.
  - Amber triangle for unable to meet altitude constraint (for climb paths only) (refer to Figure 22–02–69).
  - Grey triangle for de-emphasized A/C TRK.

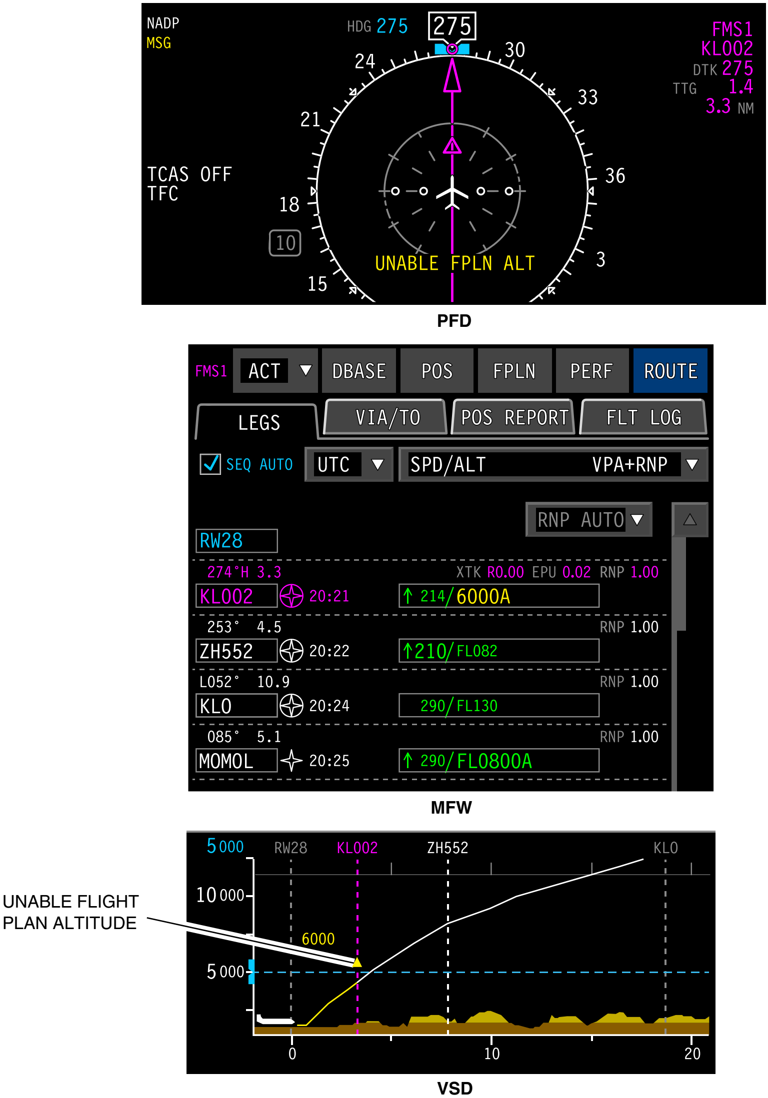
When a hold is programed and the aircraft is at the fix entering the hold, the VSD reverts to A/C TRK format and stays in A/C TRK until the aircraft fully exits the hold (departing the fix).



VSD – Symbology (part 1)
Figure 22–02–67



VSD – Symbology (part 2)
Figure 22–02–68



VSD symbology – Amber altitude constraint
Figure 22–02–69

(6) VSD range

The altitude tape displays baro-corrected altitude in a fixed format (0 to 40000 ft) when the selected range is 80 nm or greater.

At less than 80 nm, the VSD range varies with the selected map range (refer to Figure 22–02–70) and is referenced to the flight plan route or to the aircraft track.

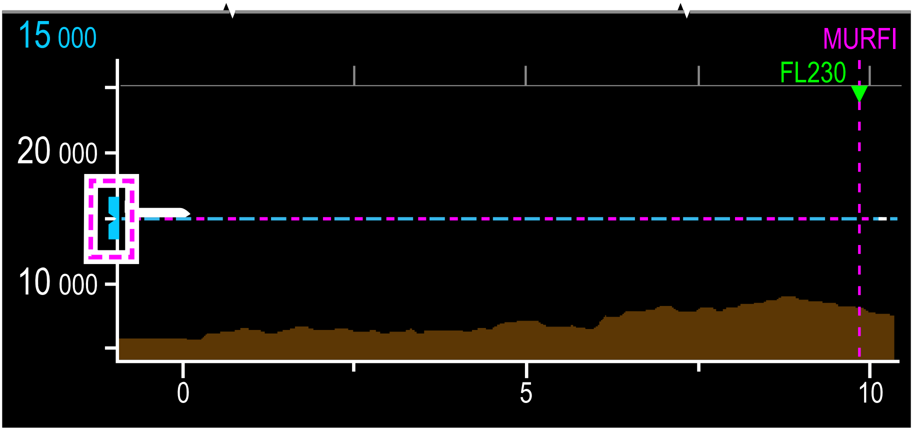
A difference may exist between map range and VSD range. The MAP range may be selected as low as 1000 feet. The minimum range of the VSD is 10 nm.

VSD MAP RANGE (NM)	VSD ALTITUDE (FT)	ALTITUDE INCREMENT (FT)
10	5000	1250
20	10000	2500
40	20000	5000
80 and greater	40000	10000

VSD full range
Figure 22–02–70

(7) Altitude selection

Preselected altitude is displayed as a digital readout with a corresponding bug and dashed altitude line adjacent to the altitude scale (refer to Figure 22–02–71). The bug stays visible at the upper or lower limit of the altitude tape if the preselected value is off-scale.



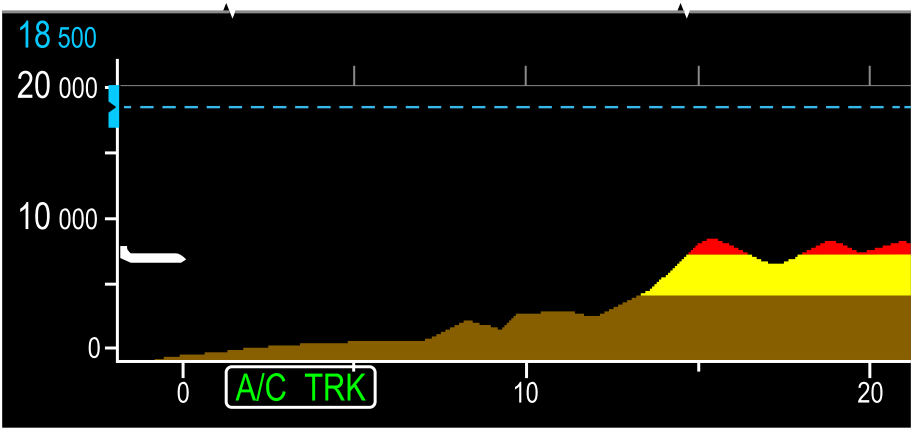
VSD – Preselected altitude
Figure 22–02–71

(8) VSD terrain overlay

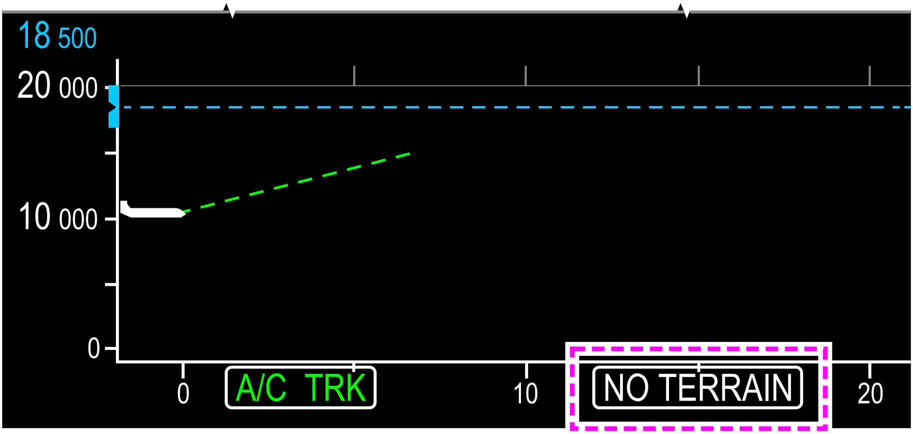
The Terrain Awareness Warning System (TAWS) supplies a terrain overlay on the VSD (refer to Figure 22–02–72). This terrain overlay uses the same colors and elevation rules as the lateral maps on the MFW. The NO TERRAIN message is displayed on the VSD if the FMS and TAWS lateral references disagree (refer to Figure 22–02–73).

NOTE

The VSD must not be used as a terrain avoidance or navigation tool. It is intended to be used to enhance vertical situational awareness only.



VSD terrain overlay – With terrain
Figure 22–02–72

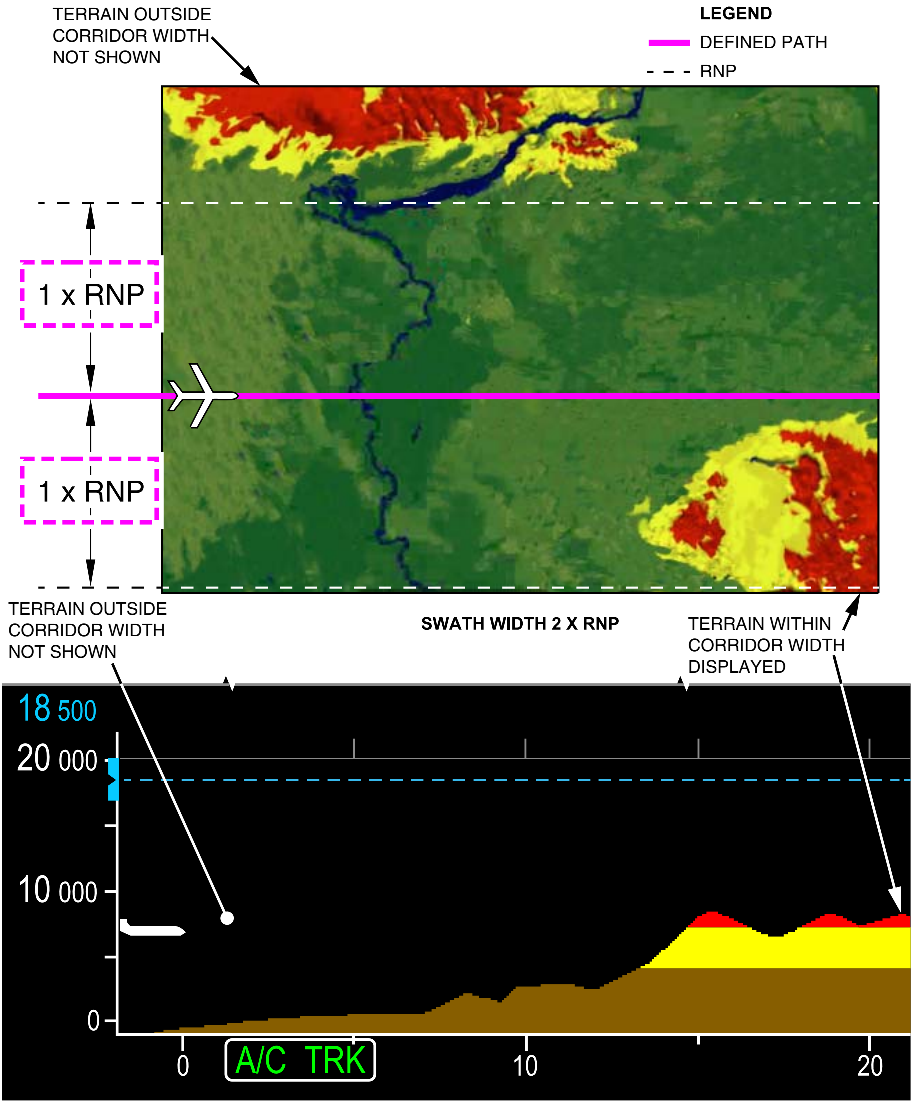


VSD terrain overlay – NO TERRAIN
Figure 22–02–73

(9) VSD corridor width

The width of the terrain corridor shown on the VSD is two times the RNP value (1 x RNP on either side of the centerline). The terrain profile displays the highest elevations within the width of the corridor. Refer to Figure 22–02–74.

When the RNP value is not available from the FMS, the corridor width is derived from the TAWS internal RNP logic. TAWS computes RNP logic based on phase of flight.



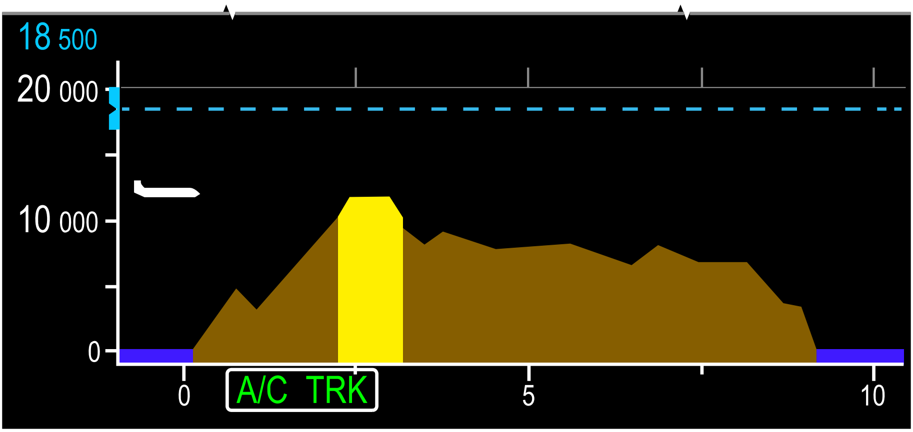
VSD – Corridor width
Figure 22–02–74

(10) Alerted terrain on VSD

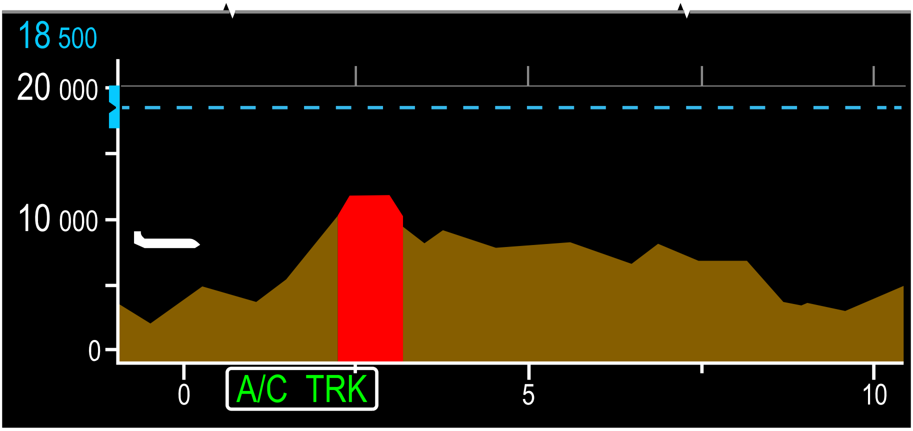
On the VSD, alerted terrain is displayed with the same color convention used on lateral maps. However, unlike lateral maps, alerted terrain on the VSD does not flash.

Alerted terrain is associated with a TAWS caution (refer to Figure 22–02–75) or warning (refer to Figure 22–02–76).

When a TAWS alert is active, the area of terrain on the VSD associated with the alert is solid and shaded with the TAWS alert color. Water is treated like terrain for purposes of relative terrain color and intensity. The vertical path format changes automatically to A/C TRK format until the TAWS alert is resolved.



VSD – Terrain alert caution
Figure 22–02–75

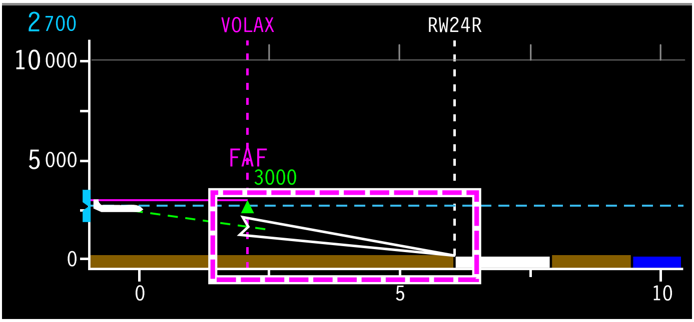


VSD – Terrain alert warning
Figure 22–02–76

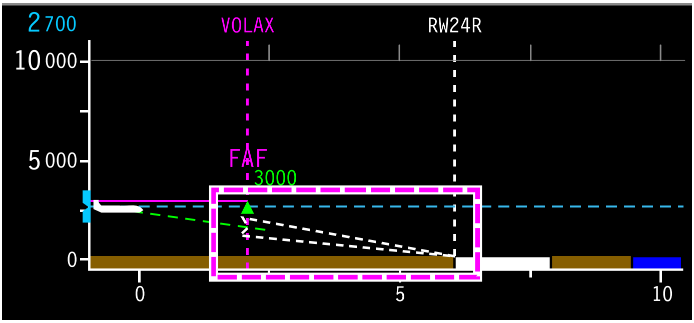
(11) VSD destination runway

A side view of the runway is displayed when defined in the flight plan. When flying an ILS or an approach with vertical guidance (RNAV/LPV), the VSD displays a white feather symbol that represents the glideslope or glidepath. During an ILS approach, the feather is displayed as a solid white line, while during an LPV approach, it is displayed as a white dashed line.

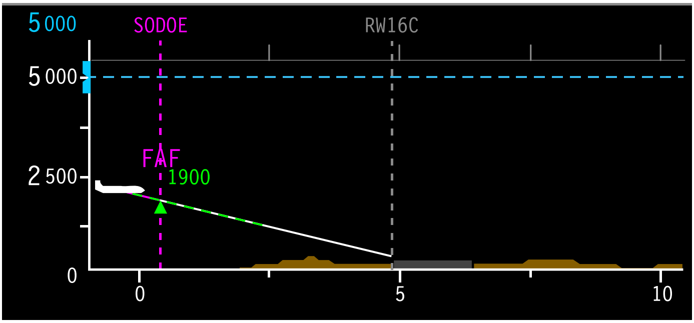
During non-precision approaches, a flight path line is displayed along the descent path to the runway.



ILS FEATHER



LPV FEATHER



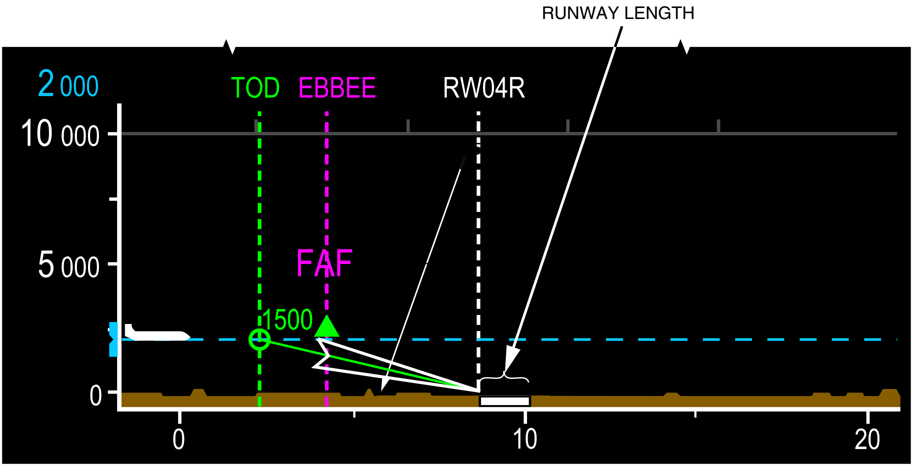
NON–PRECISION APPROACH

VSD destination runway
Figure 22–02–77

(12) VSD proportional runway length

The length of the runway on the VSD is proportional to the selected range (refer to Figure 22–02–78). As the range changes the runway increases or reduces in size, in conformity with the range. At higher ranges, a minimum runway size is displayed.

Runways are scaled to the selected range.

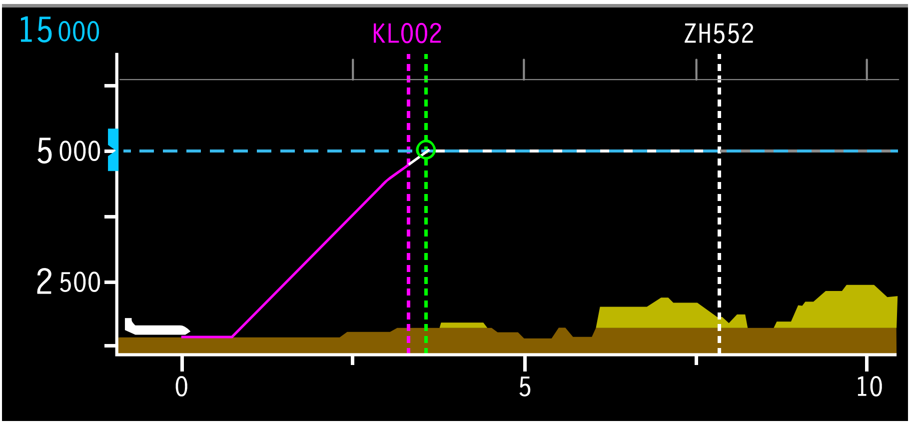


VSD – Proportional runway lengths
Figure 22–02–78

(13) VSD phase of flight

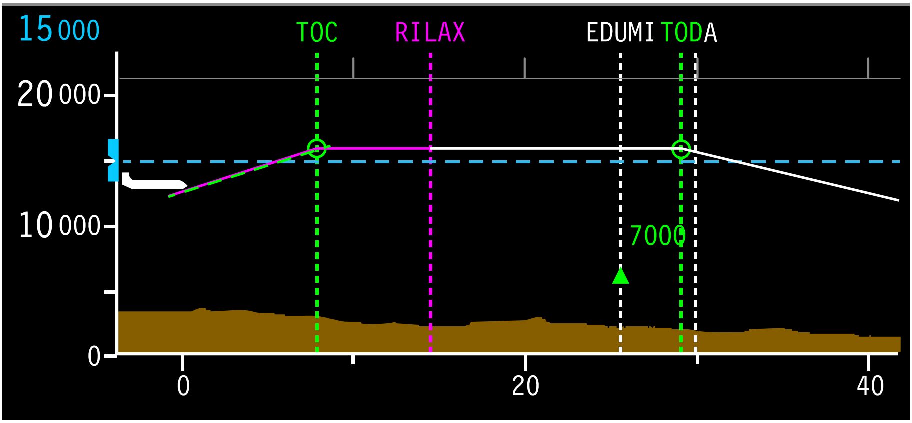
The VSD supplies advisory vertical and lateral information for all phases of flight:

- Takeoff – Displays vertical flight path to climb waypoint (refer to Figure 22–02–79).
- Climb – Displays altitude constraints and top of climb (refer to Figure 22–02–80).
- Cruise – Displays en route waypoints preselected altitude and holds (refer to Figure 22–02–80).
- Descent – Displays top of descent, deceleration point, and altitude constraints (refer to Figure 22–02–81).
- Approach – Displays approach path, selected runway identifier, and missed approach path (refer to Figure 22–02–82).



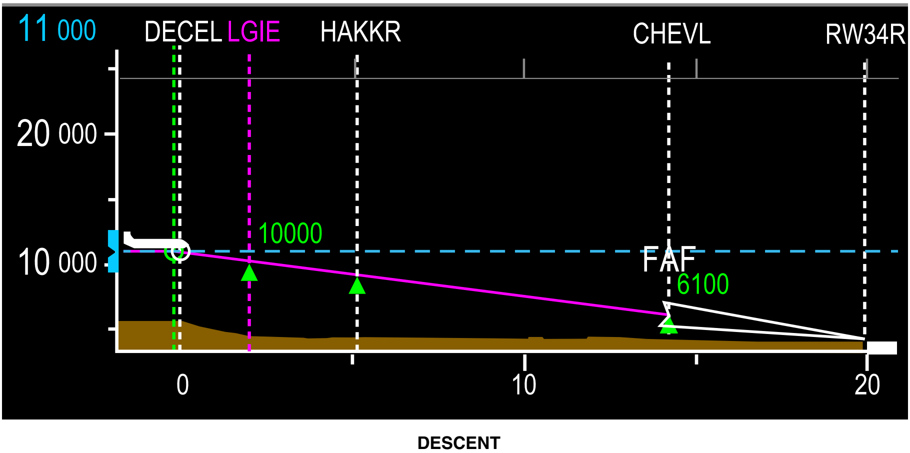
TAKEOFF

VSD Phase of Flight – Takeoff
Figure 22–02–79

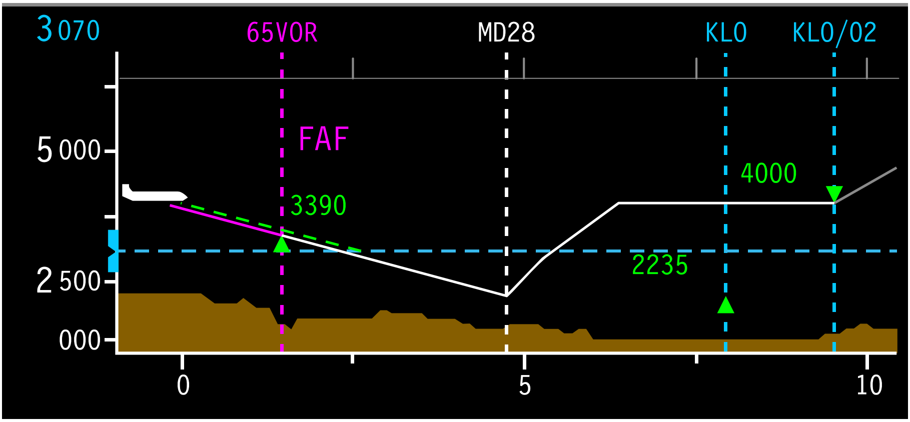


CLIMB AND CRUISE

VSD Phase of Flight – Climb and cruise
Figure 22–02–80



VSD Phase of Flight – Descent
Figure 22–02–81



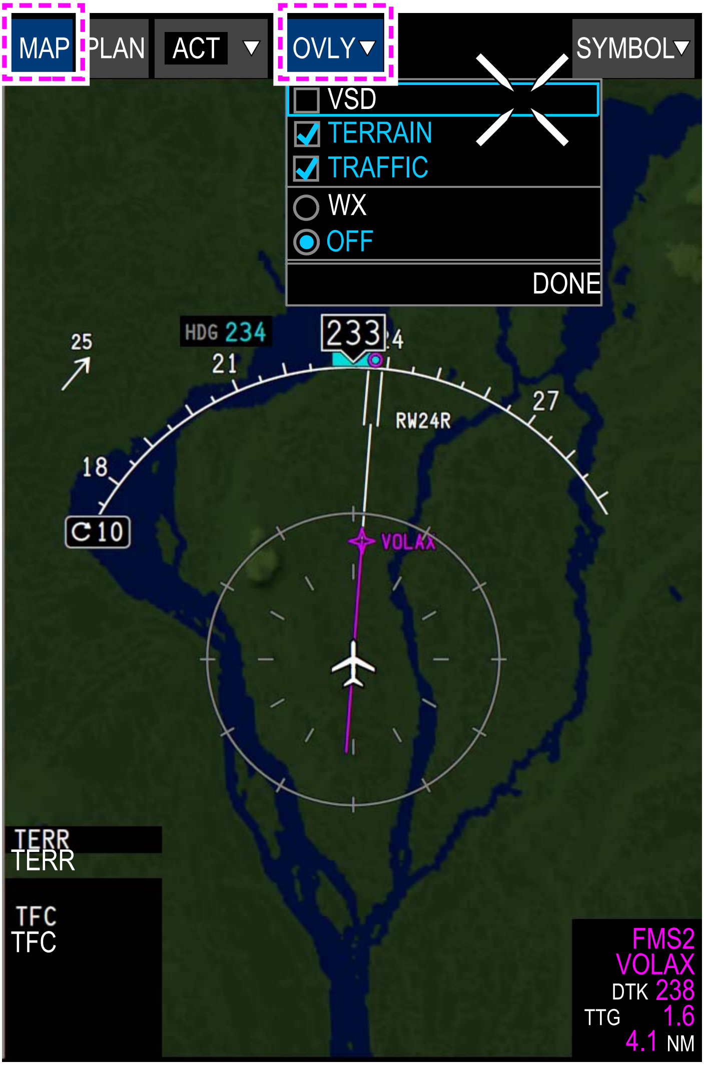
VSD Phase of Flight – Approach
Figure 22–02–82

(14) VSD Controls

VSD controls are accessed when the MAP Quick Access Key (QAK) is selected on either Control Tuning Panel (CTP) or the MAP QAK on either Multifunction Keyboard Panel (MKP) is pushed.

The MAP QAK is also accessed when the MENU switch on the Cursor Control Panel (CCP) is pushed.

When VSD is selected on the OVLY drop-down menu of the MAP page, the VSD is displayed (refer to Figure 22–02–83).



VSD controls
Figure 22–02–83

(15) VSD invalid

The VSD overlay is only available in MAP mode. When PLAN is selected, the VSD information is removed and a magenta aircraft symbol is displayed (refer to Figure 22–02–84).

When the map range is selected below 1 NM, the selection is not valid.

VSD invalid
Figure 22–02–84

FMS – GRAPHICAL FLIGHT PLANNING

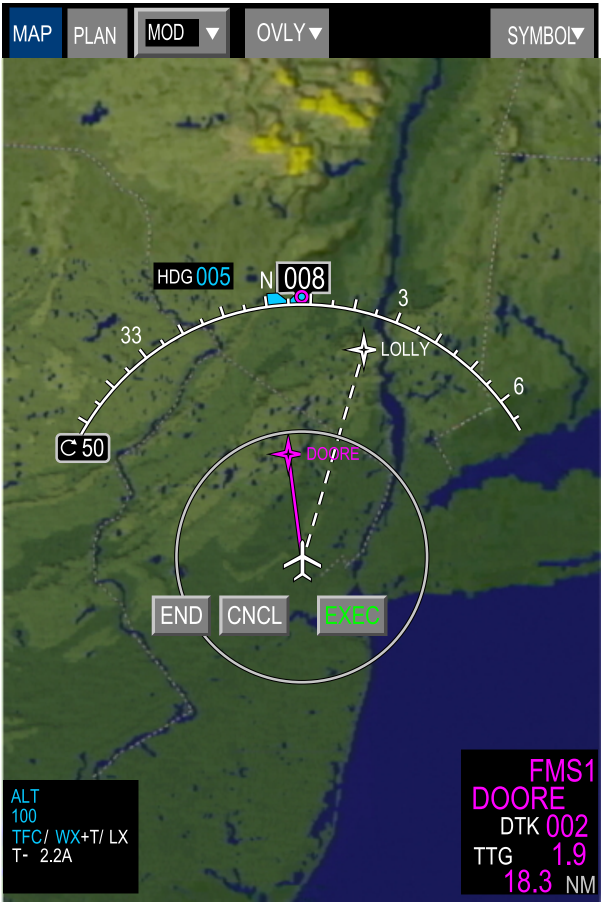
FMS flight plans can be modified graphically on the MAP display. Selecting a smart object or symbol on the MAP causes a pop-up menu to display, allowing interactive modifications directly on the MAP display.

The Present Position (PPOS) menu can only be accessed by selecting the aircraft symbol. The navaid/waypoint menu is accessible by selecting a navaid/waypoint MAP symbol. Navigation information displays in the MAP menu in three categories, separated by a gray line within the menus that follow (refer to Figure 22–02–85):

- Flight plan modifications (e.g. direct to, OFFSET, REROUTE, ...).
- Entry/modification of route parameters (e.g. AIRWAYS, FIX, HOLD, ...), and
- Support functions (e.g. CENTER MAP, INFO, NAV AID TUNING...).

Graphical planning menu selections
Figure 22–02–85

Graphical Flight Planning (GFP) treats displayed map symbols as smart (navigation) objects, enabling them to be selected and made part of the current route. The three soft switches are used to terminate (END), Cancel (CNCL) or confirm (EXEC) route changes. Refer to Figure 22–02–86.

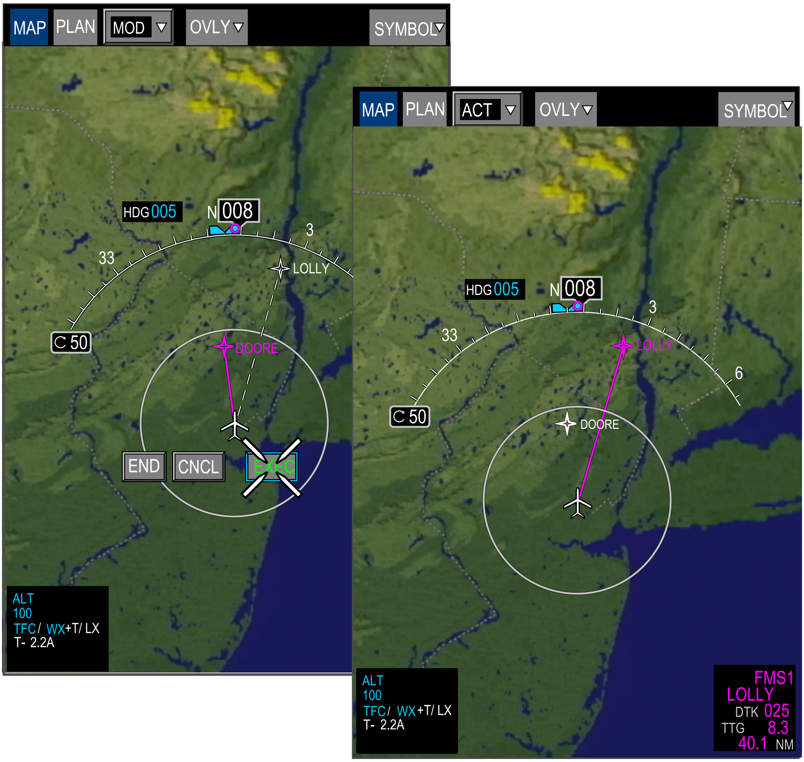


Graphical reroute function
Figure 22–02–86

Modifying a route to fly direct to a different waypoint from present position with the GFP tool is a simple process. Selecting the waypoint displays a menu, selecting the Direct/OFFSET menu item converts waypoints and symbols into smart objects.

Moving the cursor over the desired smart object and selecting it with the CCP select switch creates a new route. A white dotted track line displays the new route (refer to Figure 22–02–87). Selecting the EXEC soft switch modifies the routing. The dotted white track line turns magenta and the MOD tile changes to ACT, confirming the route modification.

The GFP can use any symbol that is linked to the FMS database for route changes.



Graphical flight plan modification
Figure 22–02–87

FMS – MESSAGE

FMS operational and status messages display on one or more locations on the HSI portion of the PFD and on the MFW MAP display. FMS message displays provide flight deck situational awareness on changes to FMS navigation performance, upcoming changes to FMS/AP mode, and flight plan annunciations.

For a complete listing of FMS messages, refer to the most recent version of the Rockwell-Collins operators guide for the Bombardier CSeries flight management system.

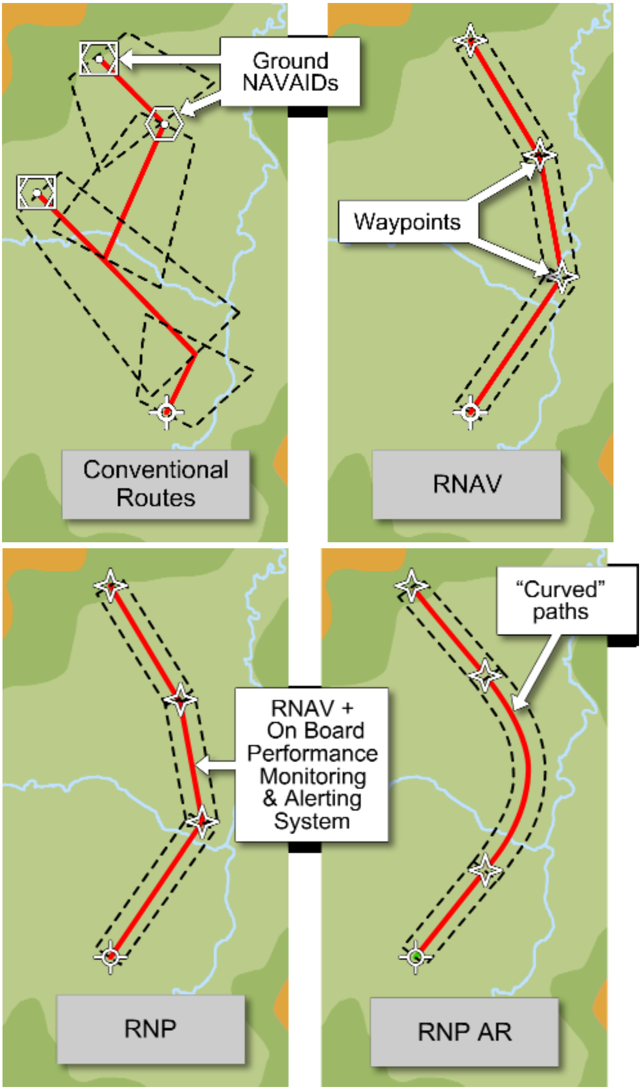
REQUIRED NAVIGATION PERFORMANCE (RNP) IN AN AREA NAVIGATION (RNAV)

A. Conventional Navigation to Performance-Based Navigation (PBN)

For decades, to fly from departure to arrival, the aviation industry used conventional navigation systems such as VOR/DME and NDB for continental flights, and Inertial Navigation Systems (INS) for oceanic flights and flights over remote areas.

Due to the constant traffic growth, and the requirements for an increase in airspace capacity and flight efficiency, these conventional navigation systems have reached their limits. This is because, due to their limited range, a large quantity of NAVAIDs is necessary to cover a large area.

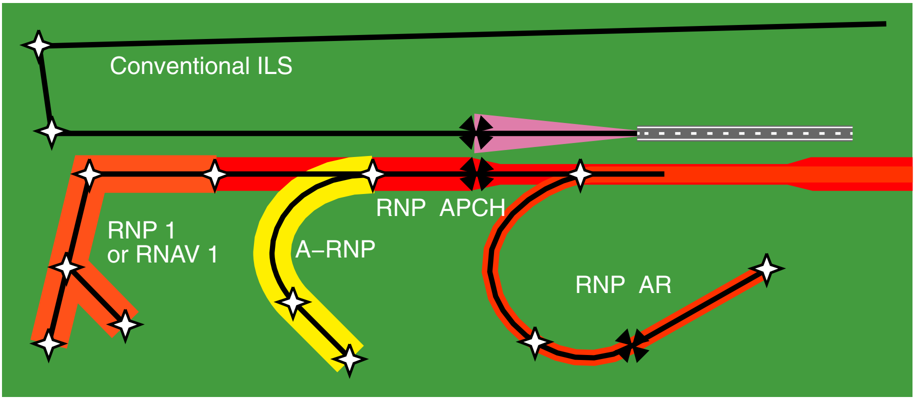
The maintenance of these NAVAIDs generates high costs and the limited flexibility of the NAVAIDs offers limited flight efficiency (e.g. non-direct routes, non-curved approaches). Refer to Figure 22–03–1.



Conventional navigation to Performance–Based Navigation (PBN)
Figure 22–03–1

The new method of navigation, also referred to as Area Navigation (RNAV), started with the introduction of the Flight Management System (FMS) and the Inertial Reference System (IRS).

More recently, introduction of Required Navigation Performance (RNP) has revolutionized the instrument approach, allowing the aircraft to be flown along a precise flight path with great accuracy. Refer to Figure 22–03–2.



ILS vs RNAV/RNP/RNP APCH/RNP AR approaches
Figure 22–03–2

The main difference between RNAV and RNP is the requirement to monitor the navigation performance, and to alert the flight crew of any non-conformance to the navigation performance criteria during the approach.

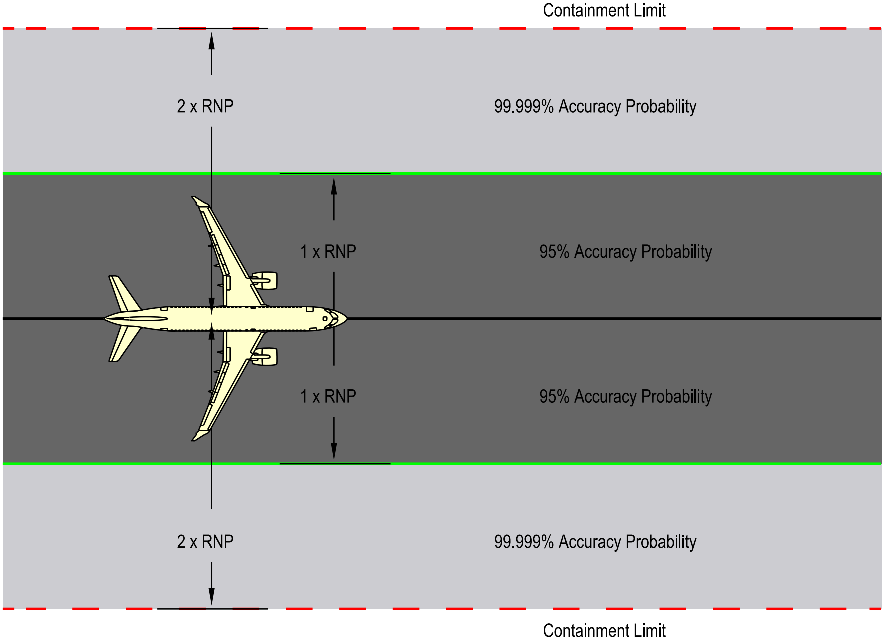
The requirement that includes On-Board Performance Monitoring and Alerting (OBPMA) is referred to as an RNP specification. When an aircraft does not have an OBPMA that monitors the navigation, the navigation system is then referred to as a RNAV system.

The aircraft is equipped with OBPMA (alert message and XTK check) navigation performance. The FMS sets the RNP value according to phase of flight and uses a lower RNP value, if required, according to the procedure flown. The flight crew operates both RNAV and RNP procedures in the same way.

B. Required Navigation Performance (RNP)

Required Navigation Performance (RNP) is RNAV capability plus the accuracy requirement of the navigation system to meet a specified value.

RNP-capable aircraft require that a specific level of accuracy be achieved 95% of the time, and twice this value 99.999% of the time. Twice the RNP is called the containment limit. Refer to Figure 22–03–3.



Required navigation performance
Figure 22–03–3

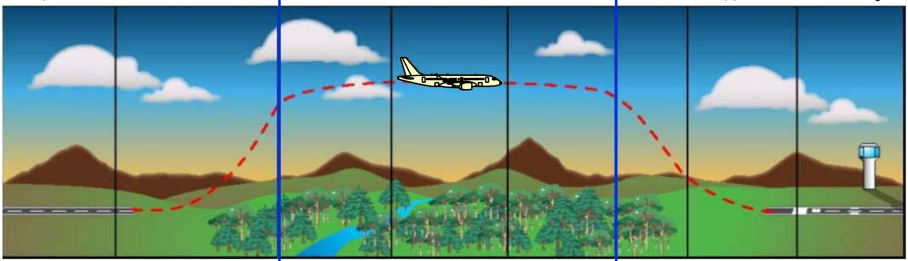
The aircraft is RNP-capable and incorporates associated onboard performance-monitoring, and alerting features, to notify the pilot when the RNP for a particular phase, or segment of a flight, is not being met.

C. RNP and RNAV terms

RNP and RNAV terms	
Term	**Definition**
RNAV	Area navigation
RNAV airspace	Airspace where the aircraft navigation system must provide the accuracy specified in the governing document. ex: RNAV 1 and RNAV 2 / FAA AC 90-100A
RNP	Required Navigation Performance RNP is a lateral limit, or boundary, expressed in nautical miles, in which the on-board navigation system must be capable of staying within, and which is displayed to the pilot in the primary field of view.
RNP airspace	Airspace where the navigation system must meet the continuity, integrity, monitoring and accuracy criteria of the governing document. The system must also provide crew alerting when the specified accuracy to clearances is not met.
RNP AR	Required Navigation Performance – Authorization Required Airspace where specific authorization is required in addition to the technical performance capabilities of the navigation system.

D. RNP and RNAV accuracy levels

The table shows RNP levels required for each airspace segment. Operation in RNP designated airspace permits reduced aircraft separation allowing increased air traffic. Refer to Figure 22–03–4.



	FLIGHT PHASE	NAVIGATION SPECIFICATION	REQUIRED ACCURACY	ENABLING SYSTEM
ENROUTE	Oceanic/ Remote	RNAV 10 RNP 4	±10 nm (95%) ± 4 nm (95%)	GNSS/INS GNSS
	Continental	RNAV 5 RNAV 2 RNAV 1	± 5 nm (95%) ± 2 nm (95%) ± 1 nm (95%)	VOR/DME/ GNSS/INS
TERMINAL	Arrival/ Departure	RNAV 2 RNAV 1 RNP 1	± 2 nm (95%) ± 1 nm (95%) ± 1 nm (95%)	DME/GNSS DME/GNSS GNSS
	Approach/ Landing	RNP APCH	Down to 0.3 nm in final approach phase (95%)	GNSS
		RNP AR APCH	Down to 0.3 nm in final approach phase (95%)	GNSS

RNP and RNAV accuracy levels
Figure 22–03–4

E. RNP performance values

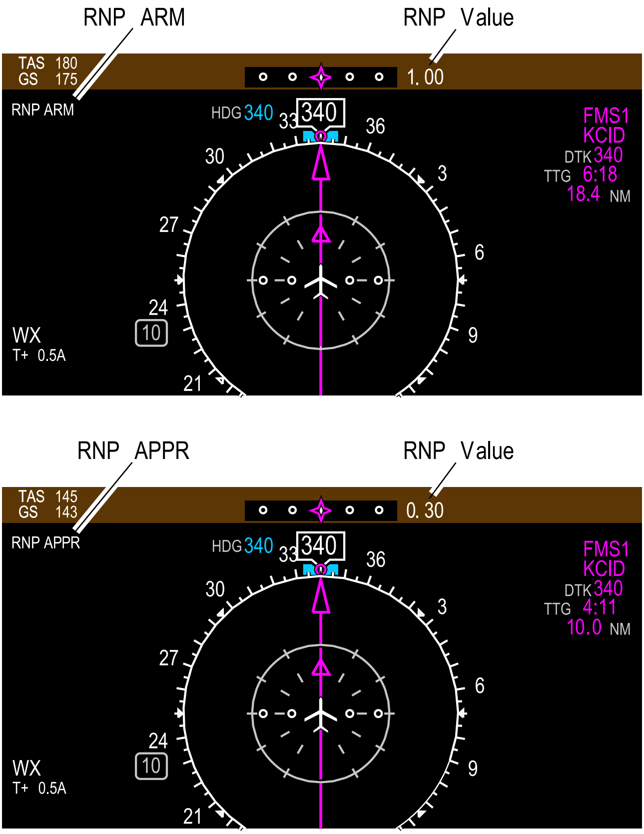
The FMS automatically sets the RNP to the following values:

- 1.00 nm at power-up
- 0.30 nm during an FMS non-precision approach
- 1.00 nm during a SID or STAR
- 1.00 nm upon entry into the terminal area

- 2.00 nm for enroute, or upon exit from the terminal area

(1) RNP

Figure 22–03–5 shows the RNP performance values.



RNP performance values
Figure 22–03–5

The RNP ARM message appears within 31 nm of the airport reference point or STAR. The RNP value changes to 1.00.

The RNP APPR message replaces RNP ARM when between the Final Approach Course Fix (FACF) and the Final Approach Fix (FAF). The RNP value changes to 0.30.

NOTE

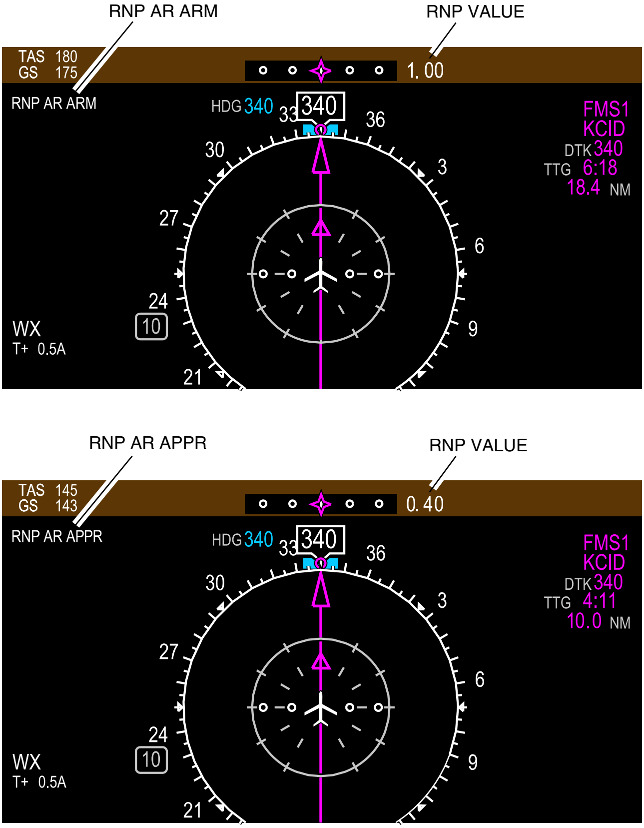
The FACF is defined as a fix, on the final approach course, located before the glidepath intercept point, or FAF.

The RNP value flashes when the aircraft enters airspace where RNP is decreased.

During RNP operations, the pilot must verify that the RNP scale annunciation is appropriate for the RNP leg.

(2) RNP AR

Figure 22–03–6 shows the RNP AR performance values.



RNP AR performance values
Figure 22–03–6

The RNP AR ARM message appears within 31 nm of the initial approach fix. The RNP value is 1.00.

The RNP AR APPR message replaces RNP AR ARM at the start of the initial approach segment, when RNP AR approach mode is active. The RNP value is set to 0.3 by default unless a different value is set in the navigation database.

The RNP value flashes when the aircraft enters airspace where RNP is decreased.

During RNP AR operations, the pilot must verify that the RNP scale annunciation is appropriate for the RNP leg.

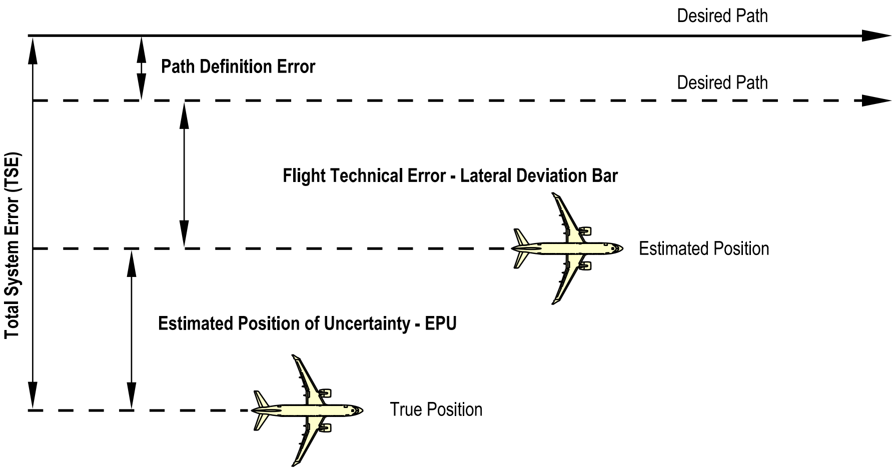
F. RNP and total system error

Navigation accuracy required for RNP is affected by several errors, grouped together as Total System Error (TSE).

TSE includes:

- Estimated Position of Uncertainty (EPU)
- Flight Technical Error (FTE)
- Path Definition Error (PDE)

Figure 22–03–7 shows the RNP and total system accuracy.



RNP and total system accuracy
Figure 22–03–7

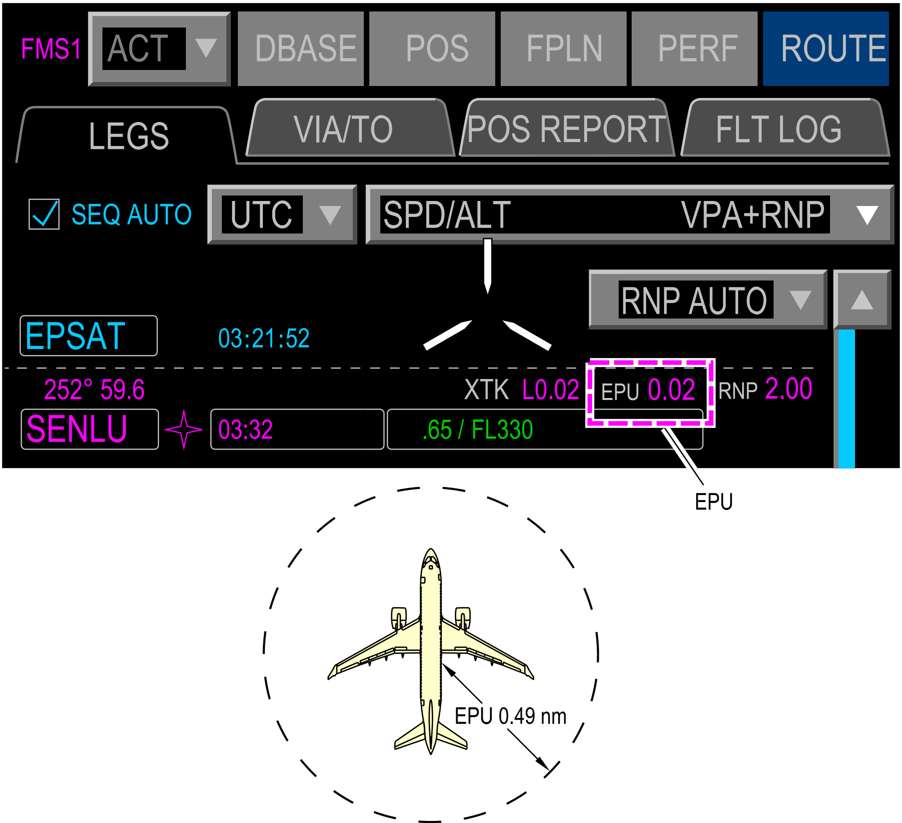
EPU refers to the error attributable to the navigation system and is only monitored by the flight crew.

FTE is directly affected by the flight technique as it is the measure of pilot ability to maintain the aircraft on the desired track.

PDE refers to any FMS database error. The error is not under pilot control and is generally regarded as minimal.

G. Estimate Position of Uncertainty (EPU)

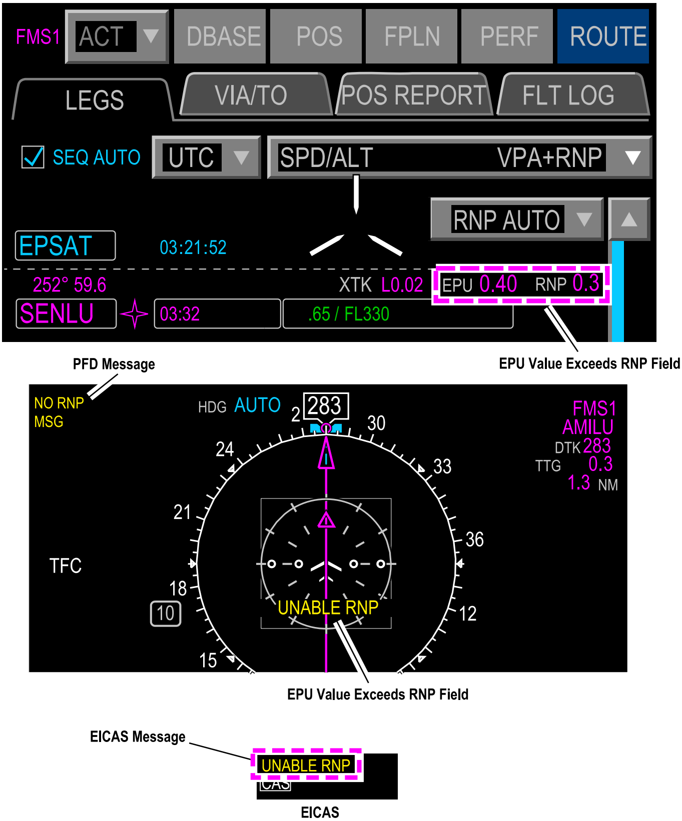
The Estimated Position of Uncertainty (EPU) is an error calculation done by the FMS, based on sensors available for position updates. This is shown in the LEGS tab on the ROUTE tile. Refer to Figure 22–03–8.



Estimated Position of Uncertainty (EPU)
Figure 22–03–8

The potential error is represented by the circle, while the EPU is the radius of the circle, in nautical miles. The true position of the aircraft is somewhere within the circle. The more accurate the sensor, the smaller the circle.

If the EPU value exceeds the value shown in the RNP field of the LEGS tab, an NO RNP message is displayed on the PFD, and UNABLE RNP is shown on the FMS message line. An EICAS message is also posted. Refer to Figure 22–03–9.

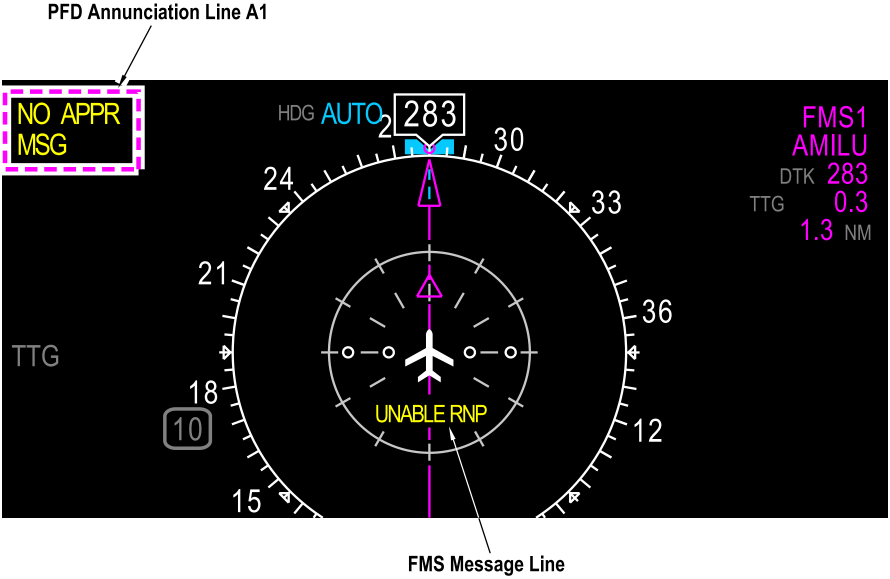


EPU messages
Figure 22–03–9

H. Missed approach considerations

Depending on the type of failure or signal degradation, associated messages are displayed.

Selection of a non-SBAS or a non-GNSS approach may be necessary if any of the amber messages that follow, which indicate excessive EPU, are annunciated. Refer to Figure 22–03–10.

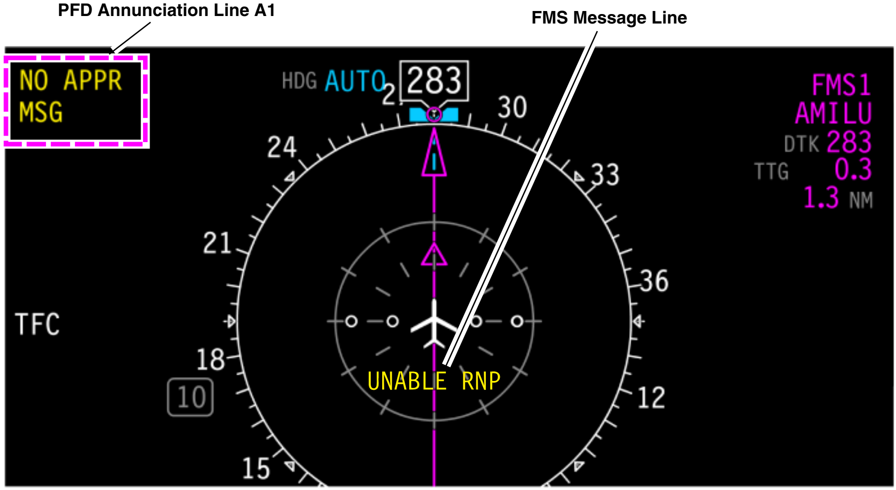


ANNUNCIATIONS ASSOCIATED WITH RNP APPROCHES IN THE TERMINAL AREA	
PFD Annunciation Line A1	
NO APPR	No approach available inside 31 NM limit.
FMS Message Line	
GNSS REVERTED	Single GNSS failed.
UNABLE RNP	Any of these messages can be displayed with the NO APPR annunciation on the PFD depending upon the type of failure. Consult the RC FMS operators guide for further details.
GNSS NOT AVAILABLE	
APPR NOT AVAILABLE	

Missed approach considerations
Figure 22–03–10

I. RNP AR missed approach considerations

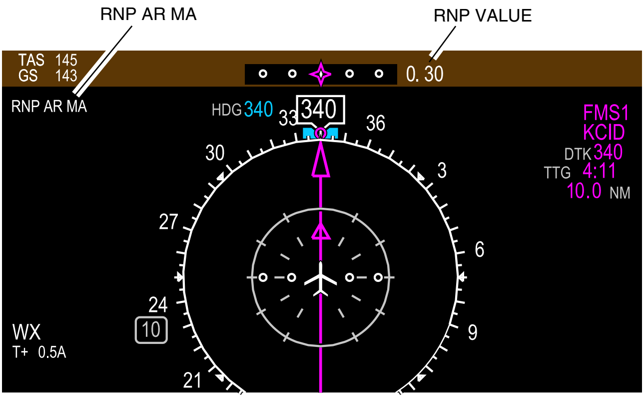
During RNP AR operation, certain types of failure or signal degradation will cause associated messages to appear (refer to Figure 22–03–11). If a NO APPR message is displayed on the PFD, a missed approach must be done.



ANNUNCIATIONS ASSOCIATED WITH RNP APPROACHES IN THE TERMINAL AREA	
PFD Annunciation Line A1	
NO APPR	No approach available inside 31 NM limit.
FMS Message Line	
GNSS REVERTED	Single GNSS failed.
UNABLE RNP	Any of these messages can be displayed with the NO APPR annunciation on the PFD depending upon the type of failure. Consult the RC FMS operators guide for further details.
GNSS NOT AVAILABLE	
APPR NOT AVAILABLE	

RNP AR missed approach considerations
Figure 22–03–11

The RNP AR MA message appears when the RNP AR missed approach waypoint is crossed during a go-around (when the MAP is sequenced) (refer to Figure 22–03–12).



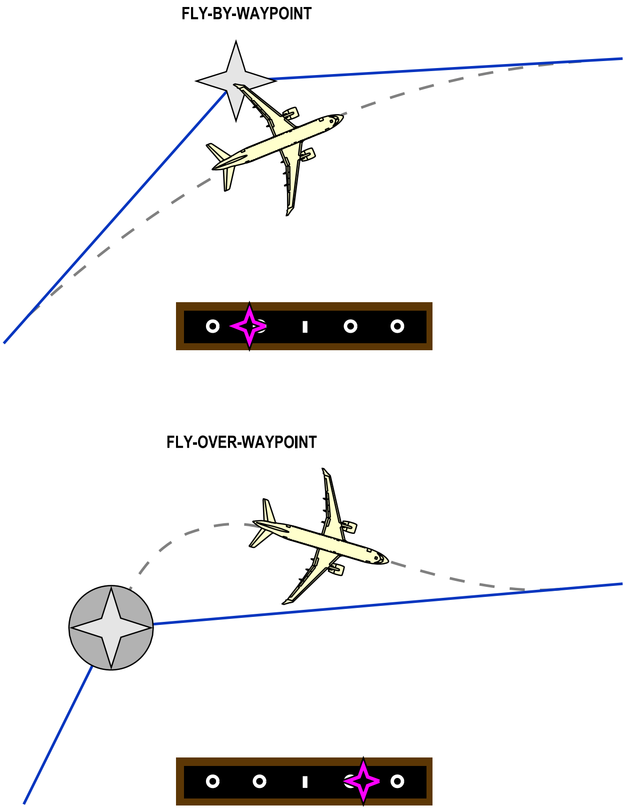
RNP AR missed approach
Figure 22–03–12

J. Flight technical errors

Flight Technical Errors (FTEs) occur when the FMS or pilot deviates from the centerline of the FMS route segment.

Some FTEs are unavoidable due to the waypoint-to-waypoint route design including (refer to Figure 22–03–13):

- Fly-by waypoints
- Fly-over waypoints

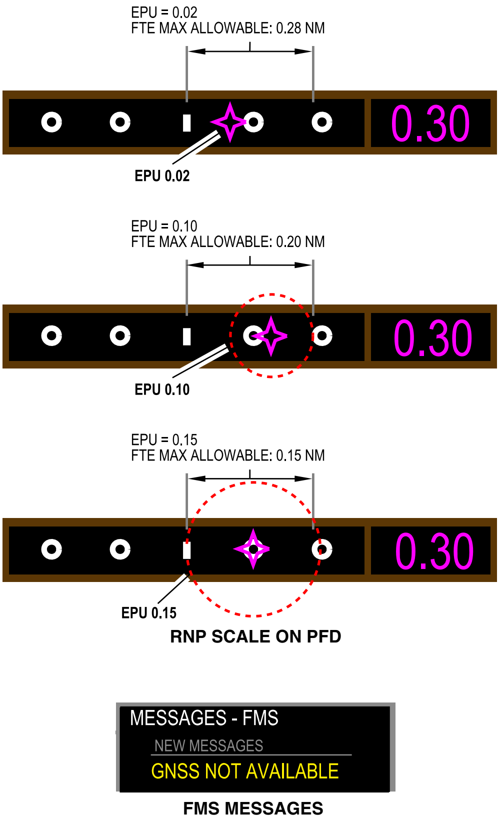


Flight technical errors
Figure 22–03–13

K. EPU considerations

EPU has a direct effect on the amount of FTE allowed. RNP minus EPU is the allowable FTE.

The greater the EPU, the less margin available for FTE. EPU displays as a dotted red circle as shown in Figure 22–03–14.



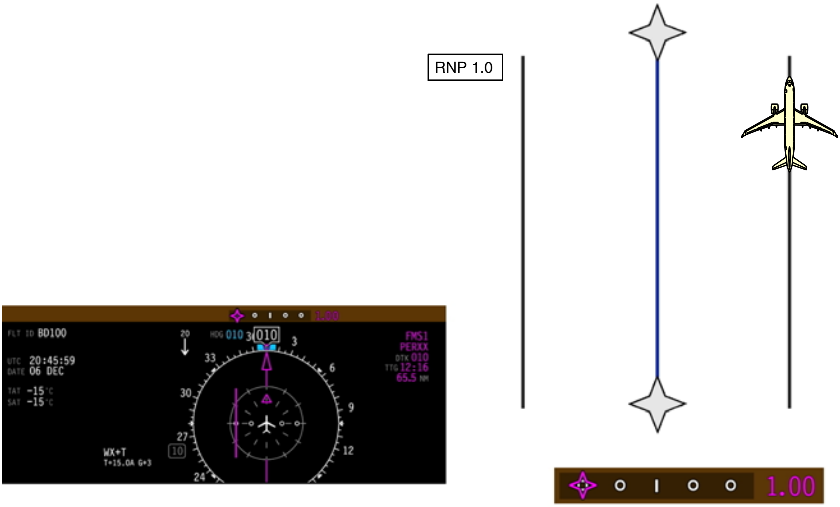
EPU considerations
Figure 22–03–14

The EPU value should be monitored for a deteriorating EPU in all critical phases of flight.

Related messages are displayed in the MESSAGES – FMS box.

L. RNP deviations

The RNP deviation scale is displayed on the PFD and indicates the Flight Technical Error (FTE). The scale includes a center mark with two dots on either side. Refer to Figure 22–03–15.



RNP deviations
Figure 22–03–15

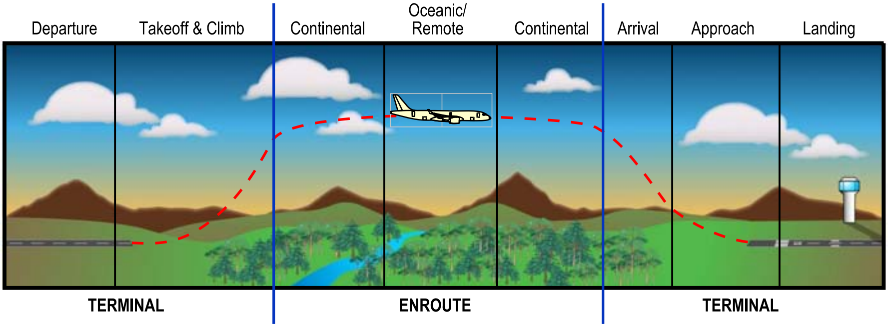
The lateral deviation indicator on the HSI displays lateral deviation. Deflection of the lateral deviation indicator represents the FTE. Full scale deflection of the lateral deviation indicator on either side of the center mark represents the FTE equivalent to the maximum RNP value for that segment of flight.

M. RNP 4.0 operation

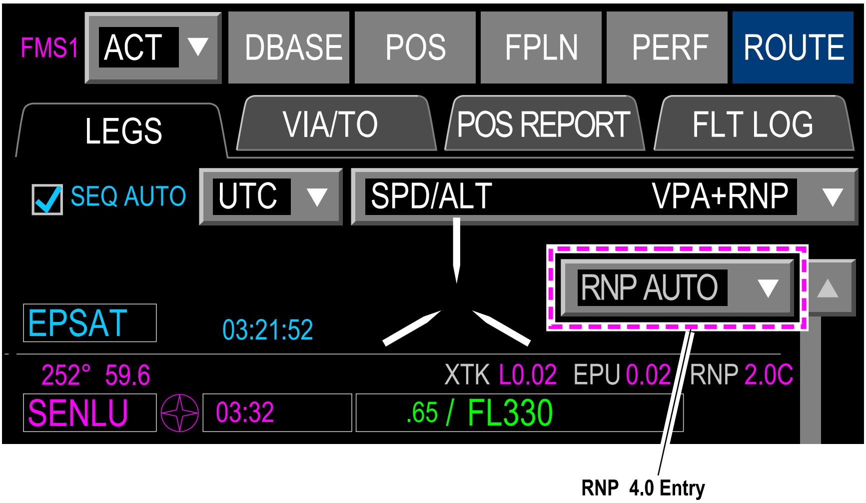
Manual RNP entry is only permitted in remote or oceanic, RNP 4.0 airspace. Normally this setting should be RNP AUTO.

RNP 4.0 may be selected in oceanic or remote airspace on the LEGS tab in the ROUTE tile (refer to Figure 22–03–16).

The RNP 4.0 option is not available when in terminal area or on approach.



	FLIGHT PHASE	NAVIGATION SPECIFICATION	REQUIRED ACCURACY	ENABLING SYSTEM
ENROUTE	Oceanic/ Remote	RNAV 10 RNP 4	±10 nm (95%) ± 4 nm (95%)	GNSS/INS GNSS
	Continental	RNAV 5 RNAV 2 RNAV 1	± 5 nm (95%) ± 2 nm (95%) ± 1 nm (95%)	VOR/DME/ GNSS/INS



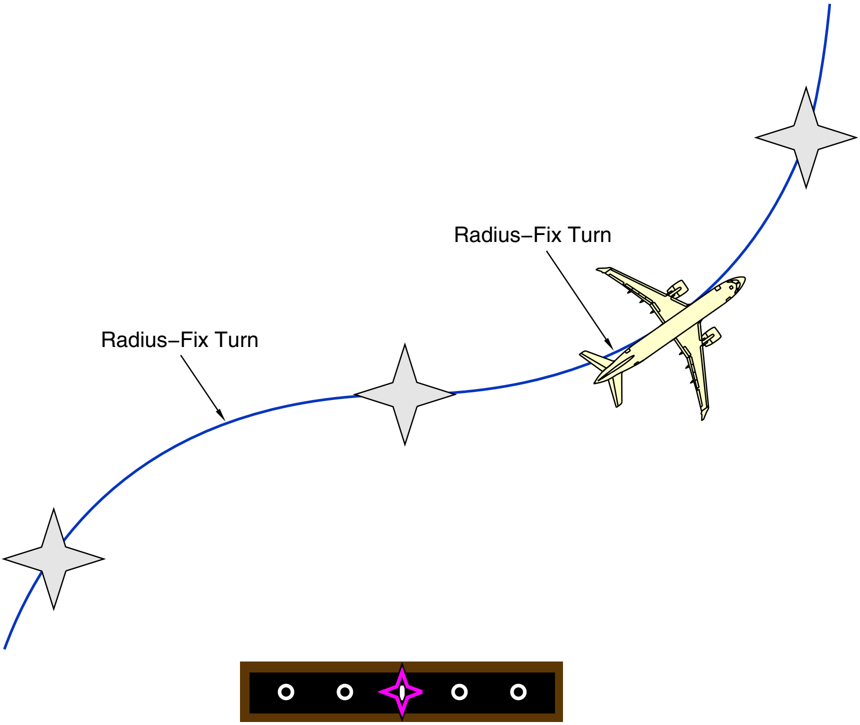
RNP 4.0 operations
Figure 22–03–16

N. Radius-to-Fix (RF) legs

Radius-to-Fix (RF) legs are a constant radius path around a defined turn that terminates at a fix. Encoded into the navigation database, RF legs allow the aircraft to avoid critical areas of terrain or conflicting airspace.

RF legs improve the use of airspace and procedures to/from runways that are otherwise limited to traditional linear flight paths, or not previously served by an IFR procedure.

This improves accuracy by maintaining precise, positive course guidance along the curved track, resulting in little or no RNP deviation. Refer to Figure 22–03–17.



Radius–to–fix legs
Figure 22–03–17

RF legs can only be performed when half–bank is not selected. Half–bank is automatically de-selected during the approach when FMS is the active navigation source.

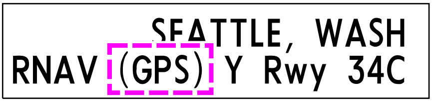
O. Types of RNP approaches

(1) GNSS approaches

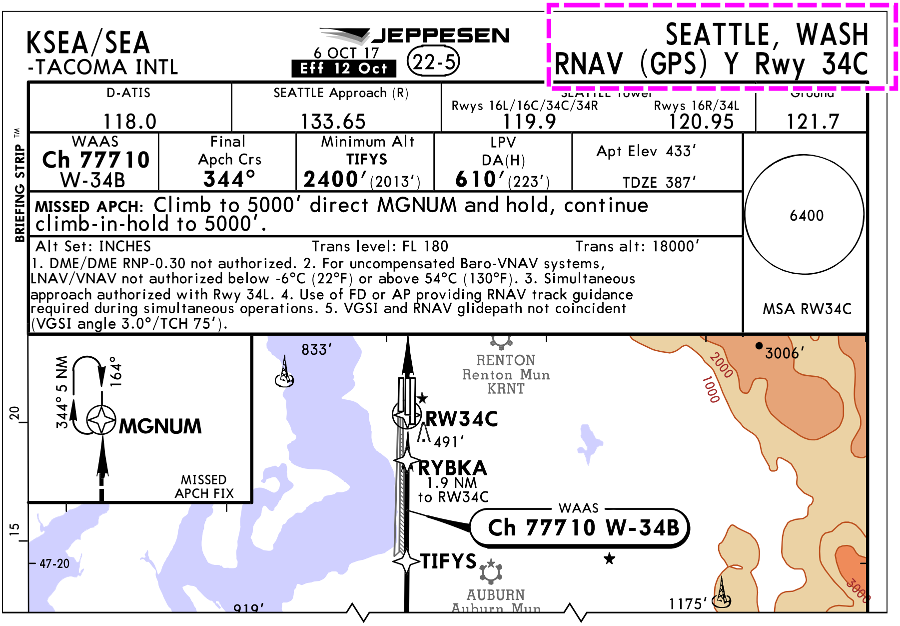
Types of approaches on Instrument Approach Procedures (IAPs) identify the system requirements and required flight crew training.

Approaches that contain (GPS) or (GNSS) in their title can be made using installed equipment without a Letter Of Authorization (LOA) from the regulatory authorities (refer to Figure 22–03–18).

Example chart: KSEA RNAV (GPS) Rwy 34C



GPS / GNSS APPROACHES



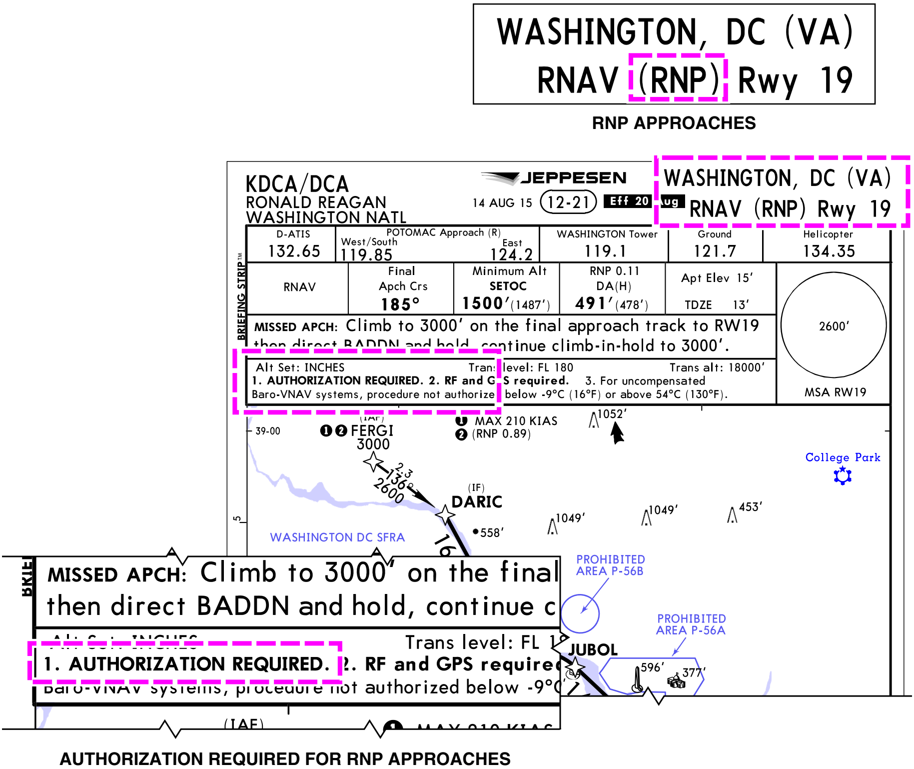
GNSS instrument approach procedure identification
Figure 22–03–18

(2) RNP AR approaches

RNP AR approaches contain (RNP) in the title of the Instrument Approach Procedures (IAPs) and clearly identify that authorization is required (refer to Figure 22–03–19).

Operators must receive a Letter Of Authorization (LOA) from their local authority, as well as implementation of approved crew training.

Example chart: KDCA RNAV (RNP) Rwy 19

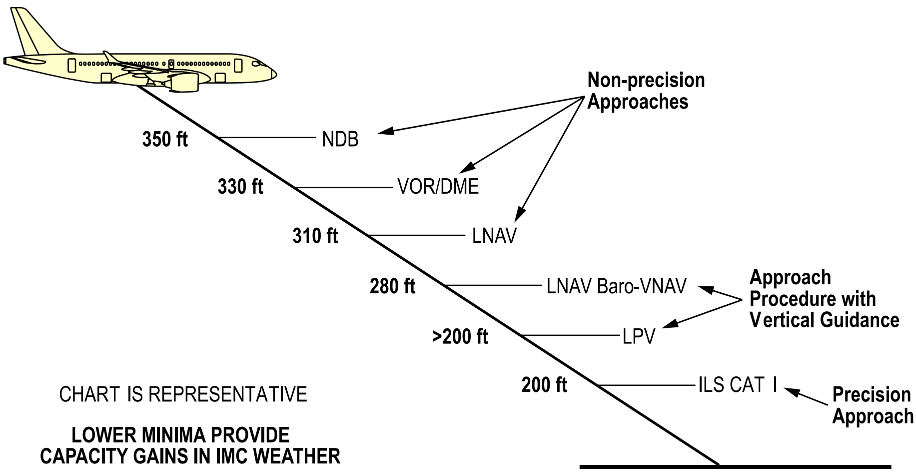


RNP AR instrument approach procedure identification
Figure 22–03–19

APPROACH PROCEDURE WITH VERTICAL GUIDANCE (APV)

Approach Procedure with Vertical Guidance (APV) is a new approach category. There are now three categories (refer to Figure 22–03–20):

- Precision Approach (PA),
- Non-Precision Approach (NPA), and
- APV.



Approach procedure with vertical guidance
Figure 22–03–20

APV includes the two types of approach that follow:

- Localizer Performance with Vertical guidance (LPV)

  The LPV requires a GNSS receiver with a Satellite Based Augmentation System (SBAS) and offers the lowest minimums. The lateral performance is equivalent to a localizer, having angular guidance with increasing sensitivity as the aircraft gets closer to the runway. Vertical guidance is derived from the SBAS GNSS receiver before the Final Approach Fix (FAF) to the runway.

- LNAV approach with BARO-VNAV

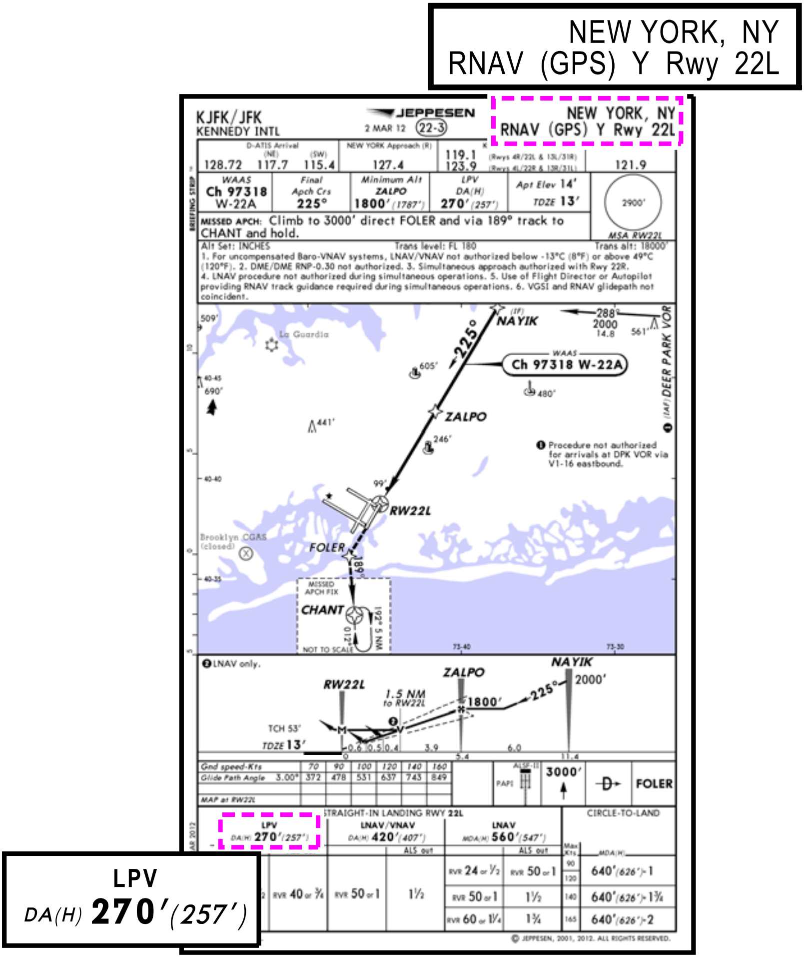
  LNAV approach with BARO-VNAV requires a GNSS receiver but not SBAS coverage. This is an approved approach with vertical guidance using barometric altitude inputs from the air data computer before and after the FAF to the runway. Lateral guidance remains linear down to the runway. Minimums are generally higher than with LPV.

LPV and LNAV approach with BARO-VNAV require a navigation system capable of operations using RNP.

LOCALIZER PERFORMANCE WITH VERTICAL GUIDANCE (LPV)

The Localizer Performance with Vertical guidance (LPV) approach is similar to an ILS approach, and allow a descent to 200 to 250 ft Decision Altitude (DA).

The FMS constructs a final approach segment using inputs from GNSS with Satellite Based Augmentation System (SBAS). Refer to Figure 22–03–21.

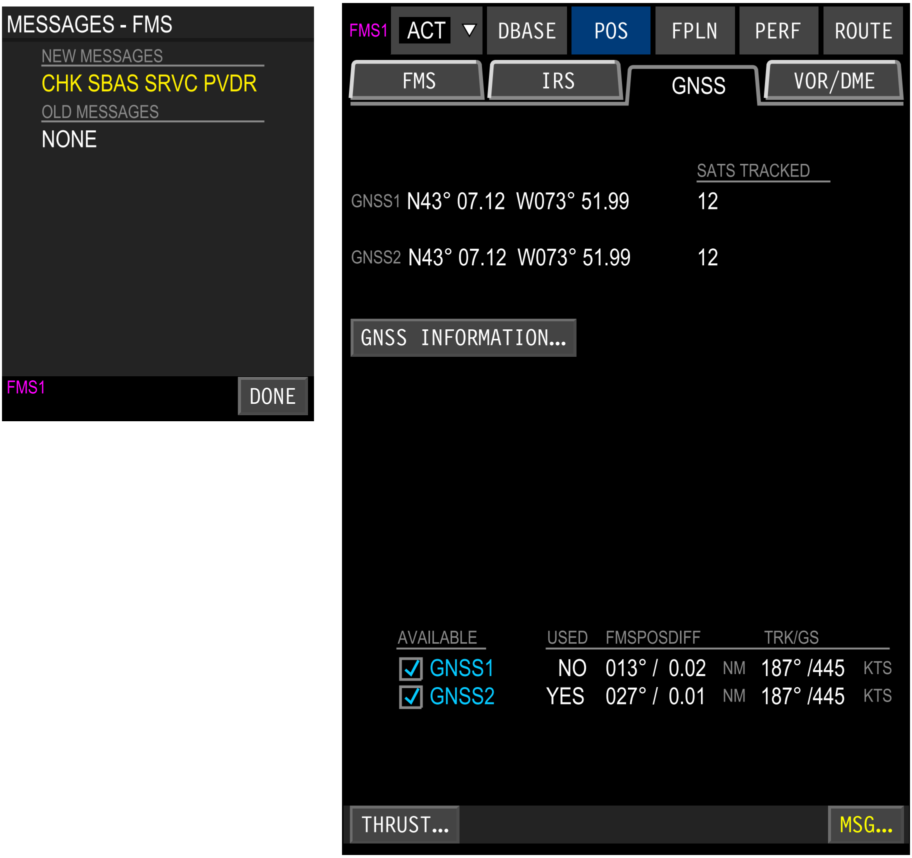


Localizer performance with vertical guidance
Figure 22–03–21

A. SBAS service providers

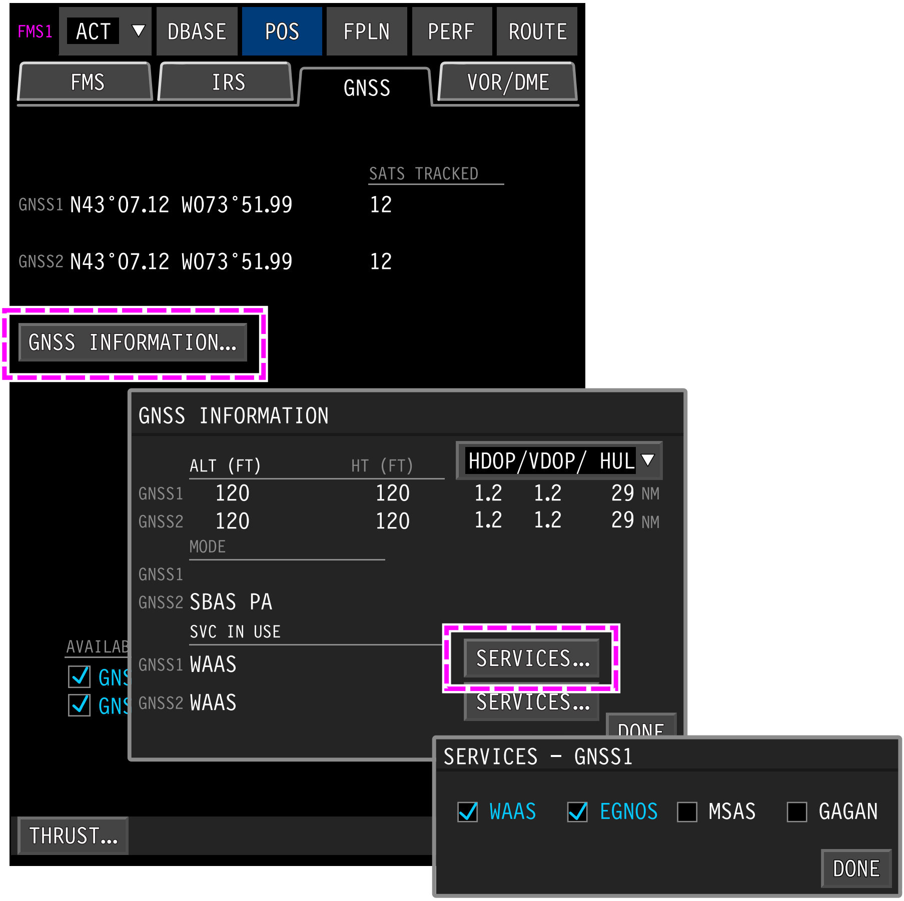
The required SBAS service provider must be enabled to support the LPV approach.

If the SBAS service provider is not selected, or is not available to support terminal or approach operations, an amber CHK SBAS SRVC PVDR message displays on the MESSAGE FMS window, and the FMS reverts to basic GNSS for lateral navigation. Refer to Figure 22–03–22.



SBAS service providers – MSG
Figure 22–03–22

SBAS service providers can be enabled or disabled by selecting the GNSS INFORMATION soft key from the GNSS tab of the FMS POS page, and then selecting SERVICES. Refer to Figure 22–03–23.



SBAS service providers – GNSS INFORMATION
Figure 22–03–23

On the SERVICES-GNSS 1 or 2 window, the selected SBAS service providers display cyan with a check and the deselected ones display white with no check. The selections can be modified using the cursor and are retained during shutdown.

Each service provider covers a specific region.

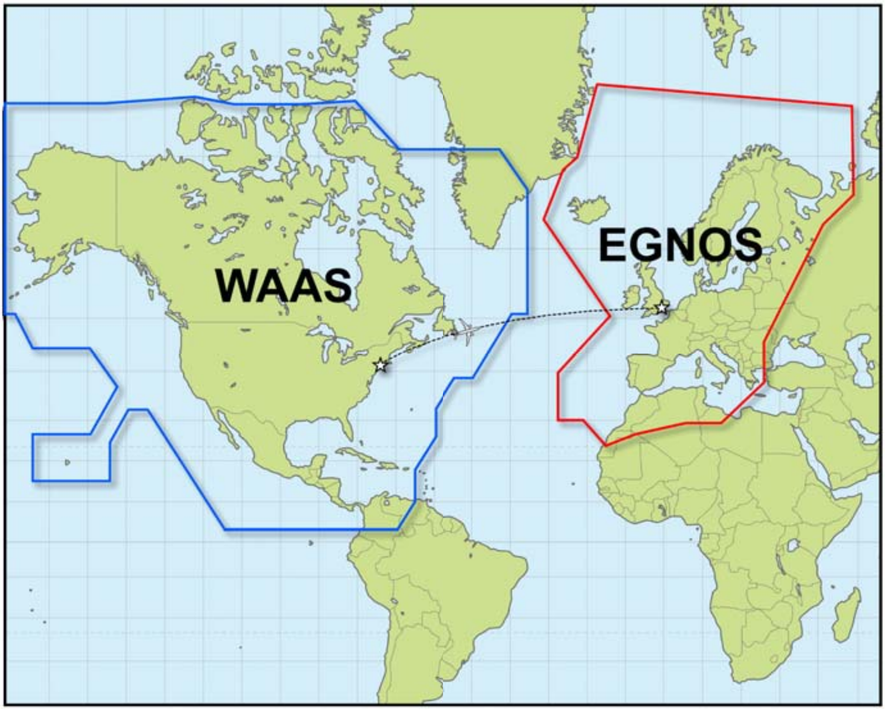
B. SBAS coverage areas

The FMS is designed to operate with all available SBAS systems.

If the flight is planned across more than one SBAS coverage area, both SBAS systems should be enabled.

When both SBAS systems are enabled, during transition from one SBAS coverage area to another, the FMS automatically sequences to the next enabled system.

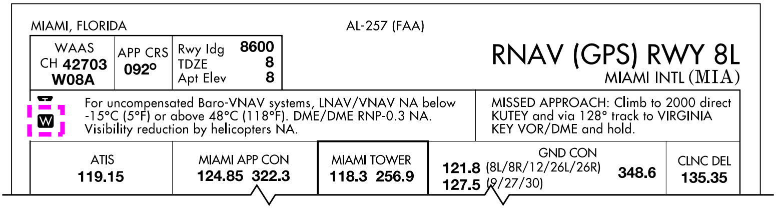
The SBAS coverage areas are shown on Figure 22–03–24.

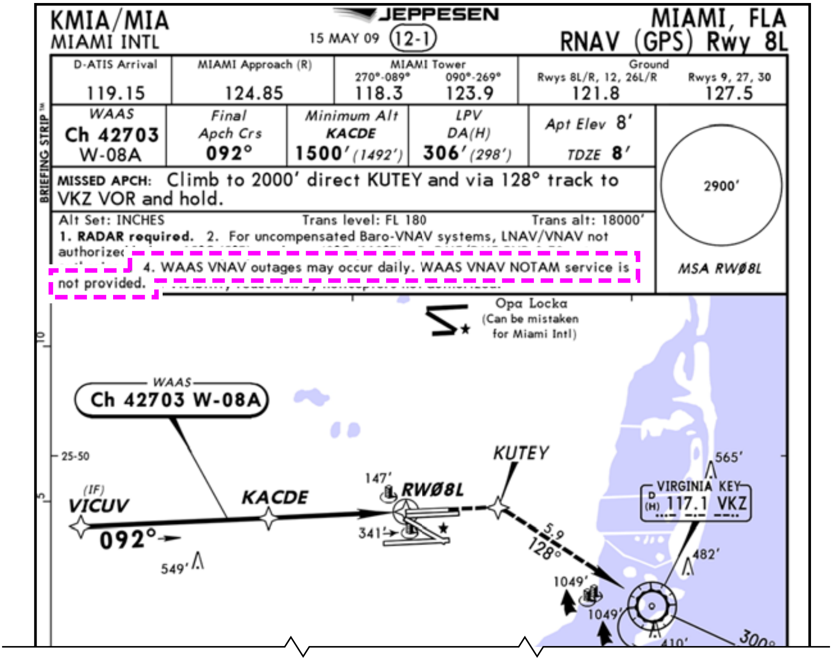


SBAS coverage areas
Figure 22–03–24

C. Potential Wide Area Augmentation System (WAAS) outage

If Wide Area Augmentation System (WAAS) coverage has been determined to be uncertain at the destination, it will be indicated on the approach chart. A NOTAM will not be provided. Refer to Figure 22–03–25.





4. WAAS VNAV outages may occur daily. WAAS VNAV NOTAM service is not provided.

Potential WAAS outages
Figure 22–03–25

FAA charts present a white W on a black background shown on the briefing strip.

Jeppesen charts will state if a potential WAAS outage exists in the NOTES section.

During approach whenever WAAS coverage is noted to be unreliable, aircrew should be prepared to select an alternate approach.

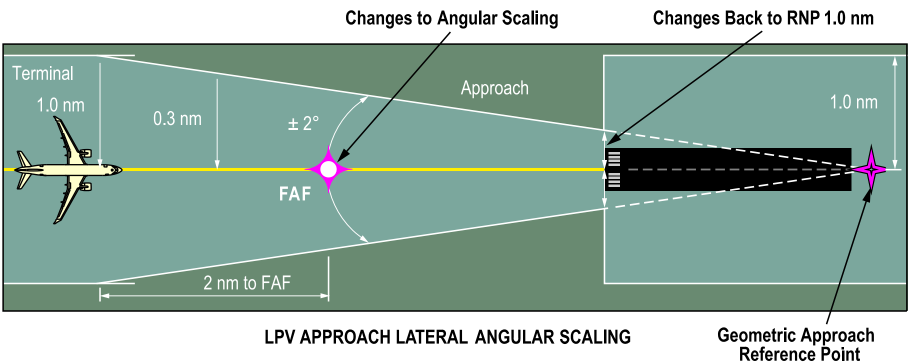
D. LPV lateral scale transitions

The angular lateral scaling for an LPV approach maintains a 2° horizontal course from the FAF, to the geometric approach reference point, located at the far end of the runway, similar to the localizer antenna position.

The geometric approach reference point is the point where the 2° angle starts for the approach.

The lateral scale changes back from angular 2° to linear 1 nm at the runway threshold.

Figure 22–03–26 shows the LPV lateral scale transitions.



LPV lateral scale transitions
Figure 22–03–26

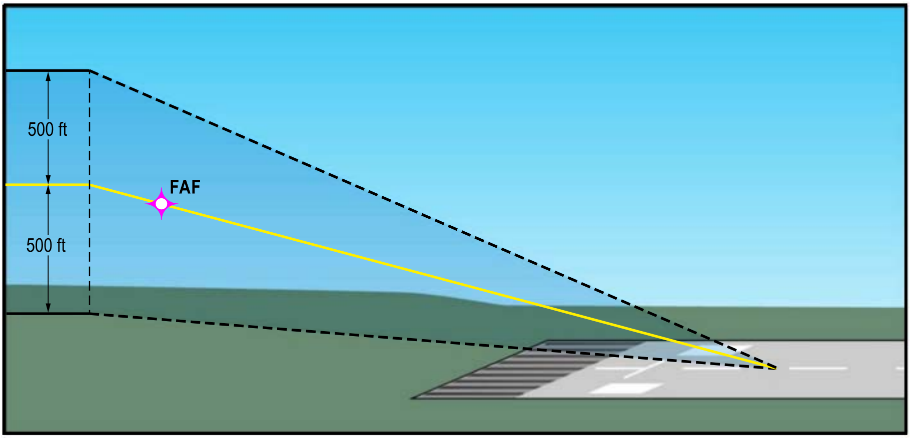
E. LPV vertical scale transitions

In a LPV approach, the vertical path is angular, like a glideslope on an ILS.

Prior to the FAF, the vertical scaling is linear, and maintains ±500 ft for a full scale deflection of the vertical scale.

Shortly before reaching the FAF, the vertical scaling transitions to an angular scaling on a 3° glideslope down to the threshold crossing height.

Figure 22–03–27 shows the LPV vertical scale transitions.



LPV vertical scale transitions
Figure 22–03–27

F. LPV approach and temperature compensation

LPV approaches use a barometrically-corrected altitude input from the air data computer for the initial portion of the approach.

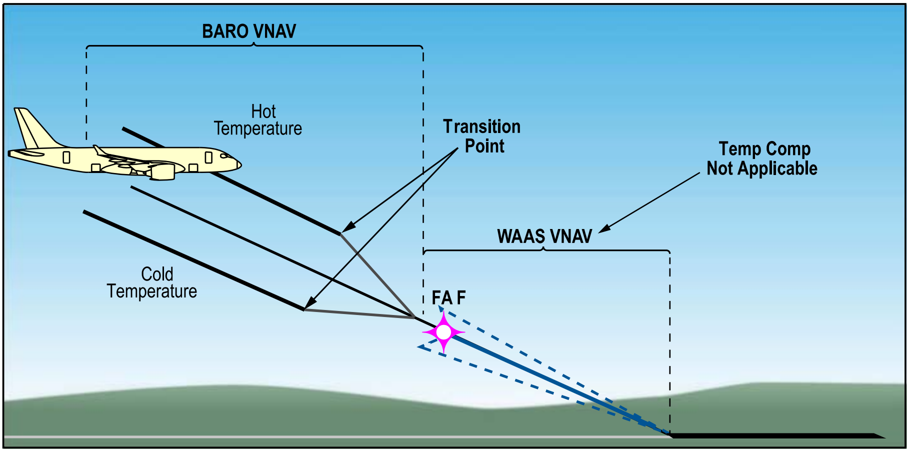
From the FAF to the MAP, vertical guidance is based on vertical position information obtained from the GNSS. Unlike the baro-VNAV portion, the GNSS-based portion is not affected by temperature.

Without temperature compensation, if OAT is significantly colder than ISA, the aircraft will need to reduce vertical rate to reach the FAF (refer to Figure 22–03–28). But, if temperature is significantly warmer than ISA, the aircraft will need to increase vertical rate to reach the FAF.

Temperature compensation can be used to ensure a smooth glidepath transition. The aircraft is capable of cold temperature compensation.

NOTE

Minimums are affected by temperature.

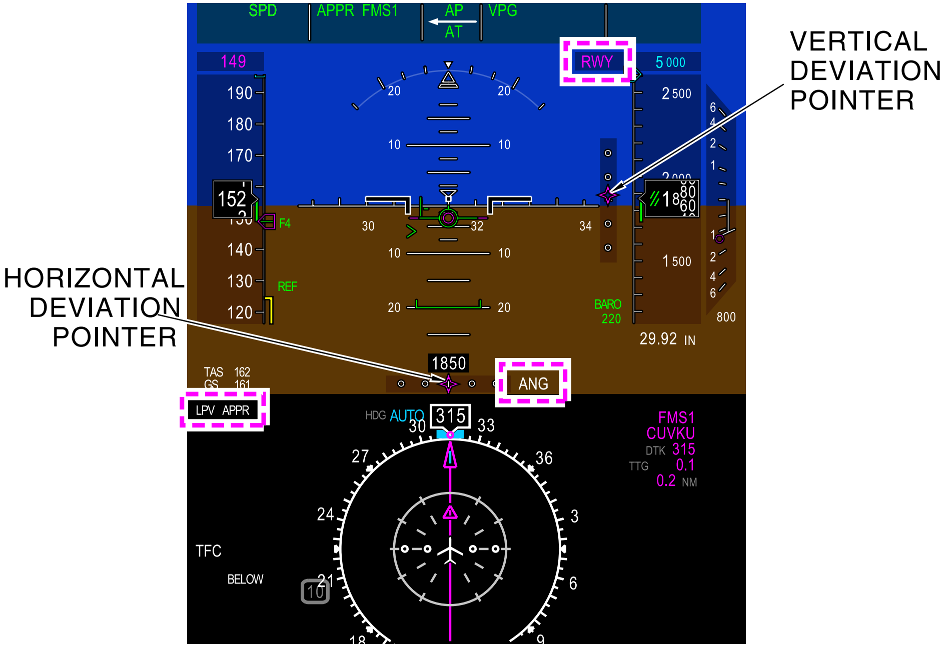


Effect of temperature on LPV approaches
Figure 22–03–28

G. LPV indications

When the aircraft enters the terminal area, LPV ARM displays in the top left corner of the HSI. The lateral and vertical deviation pointers display on their respective deviation scale.

After the Final Approach Course Fix (FACF) and prior to FAF, the FMS activates the approach and LPV APPR displays (refer to Figure 22–03–29). The lateral and vertical deviation scaling changes to angular, increasing the sensitivity as the aircraft approaches the runway.



LPV indications
Figure 22–03–29

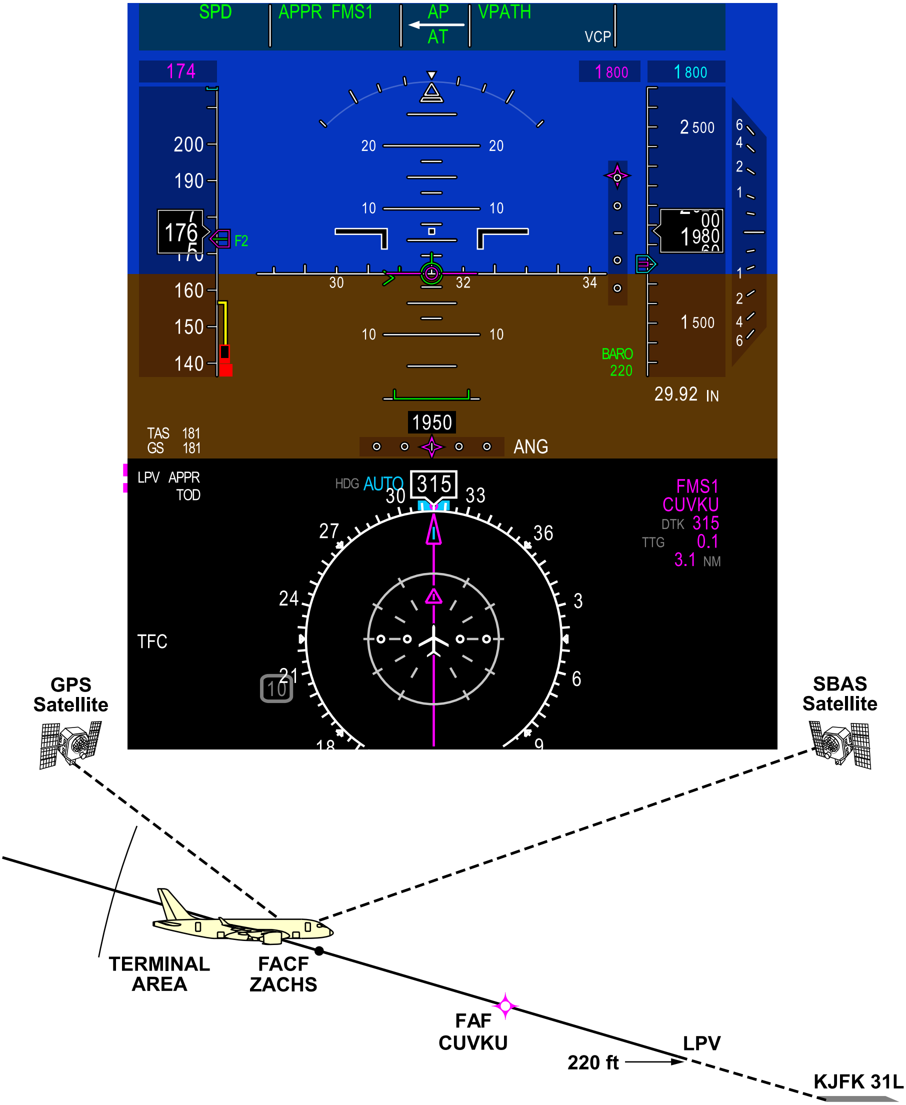
When the vertical deviation pointer starts to move down approaching the FAF, the FMS target altitude changes from the FAF crossing altitude to RWY.

H. LPV approach

Upon entering the terminal area during an LPV approach, the FMS monitors LPV approach accuracy, and sets the LPV horizontal and vertical alert levels. LPV ARM displays on the top left corner of the HSI. Refer to Figure 22–03–30.

Prior to the FAF, the FMS activates the approach. LPV ARM changes to LPV APPR.

On the FMA, VGP is captured as the aircraft approaches the FAF, providing a vertical guidance to the runway, based on the GNSS position with SBAS correction.

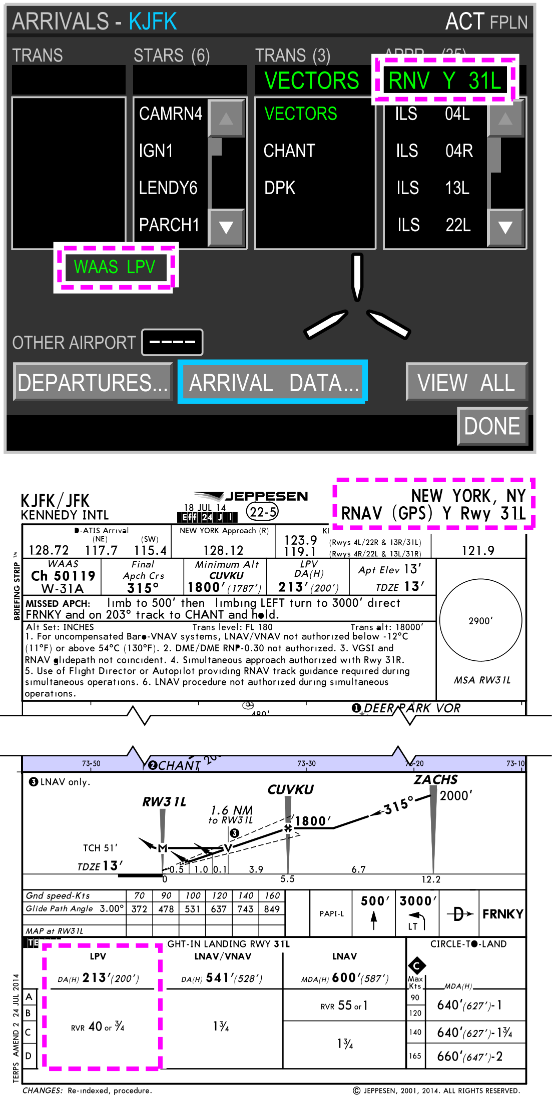


LPV approach
Figure 22–03–30

I. LPV approach identification

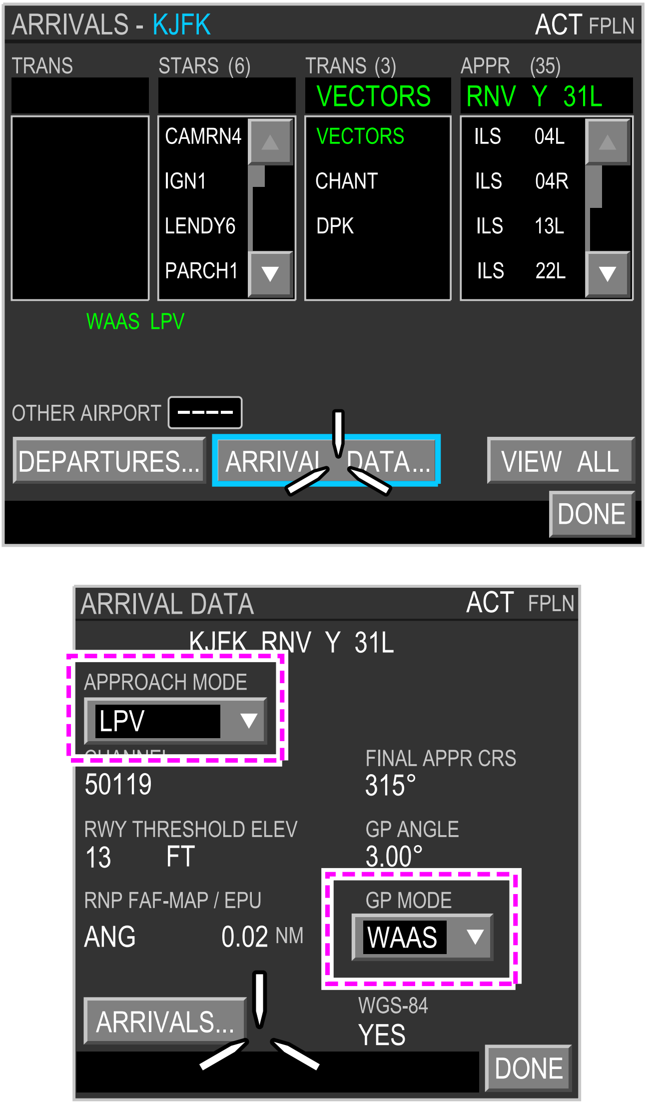
LPV approaches are identified on the ARRIVALS window as RNV with the runway number and may include a suffix letter, such as Y, or Z (refer to Figure 22–03–31). The LPV approach chart is identified as RNAV (GPS) in the United States and RNAV (GNSS) elsewhere.

The default GNSS approach is the highest charted service. In this example, it is LPV. A green WAAS LPV message displays on the ARRIVAL window once the approach is selected.



LPV approach identification
Figure 22–03–31

On the ARRIVAL DATA window, LPV displays in white under APPROACH MODE, and WAAS displays in white under GP MODE. Refer to Figure 22–03–32.

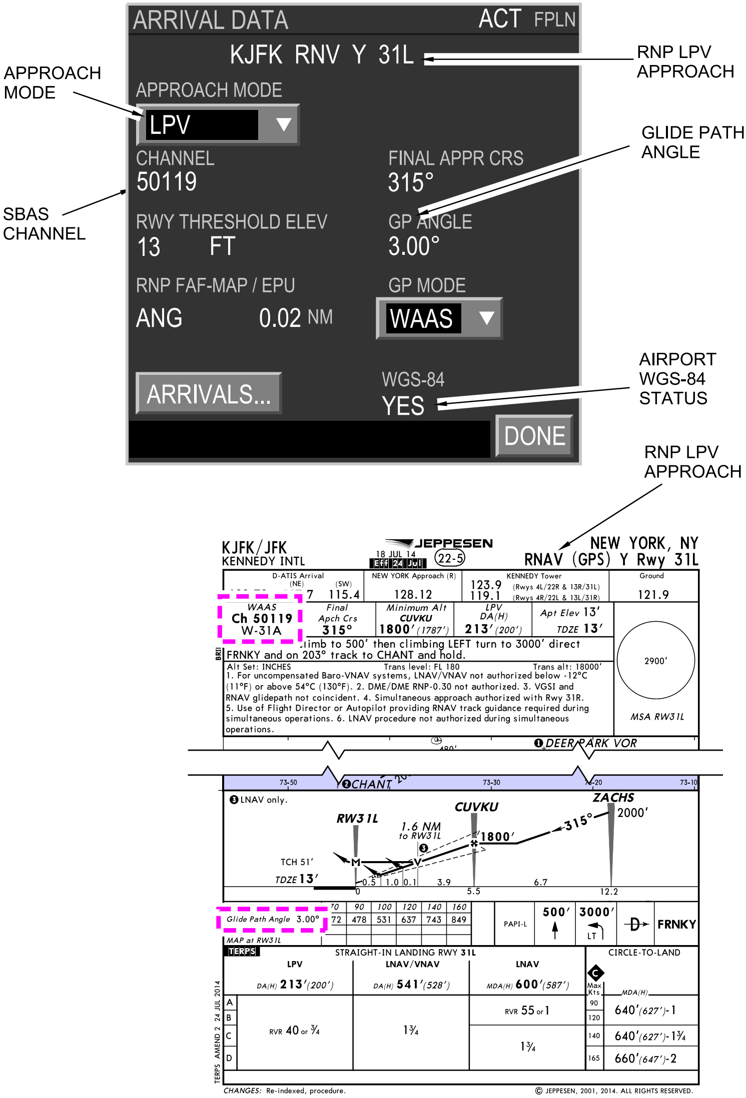


LPV approach identification – ARRIVAL DATA
Figure 22–03–32

J. LPV data confirmation

The LPV approach data can be confirmed on the ARRIVAL DATA window by comparing the following with the LPV approach chart (refer to Figure 22–03–33):

- The approach and VNAV guidance selected
- The approach mode
- The glide path angle
- The SBAS channel
- The airport WGS-84 status

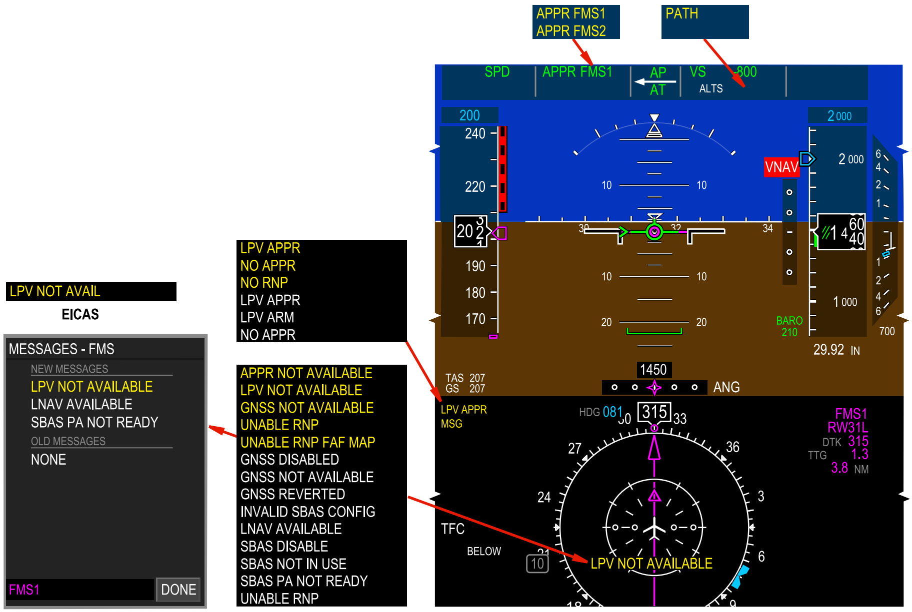


LPV data confirmation
Figure 22–03–33

K. LPV failure indications

FMS position monitoring is automatically set for each phase of flight. Any exceedance of navigation performance sets appropriate flags and messages on the PFD and MESSAGES FMS window (refer to Figure 22–03–34). There is an EICAS message for LPV failure.

A LPV approach can continue after a single failure of a GNSS receiver or loss of SBAS, if this occurs inside the Initial Approach Fix (IAF).



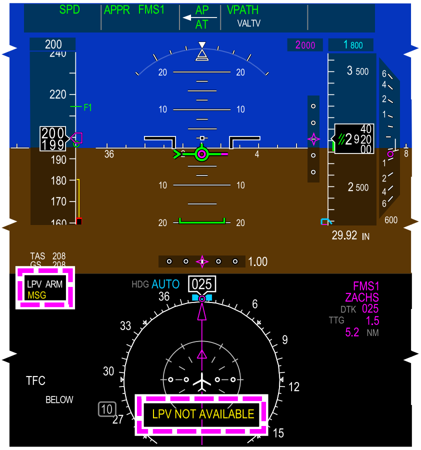
LPV failure indications
Figure 22–03–34

(1) Single GNSS failure in LPV ARM mode

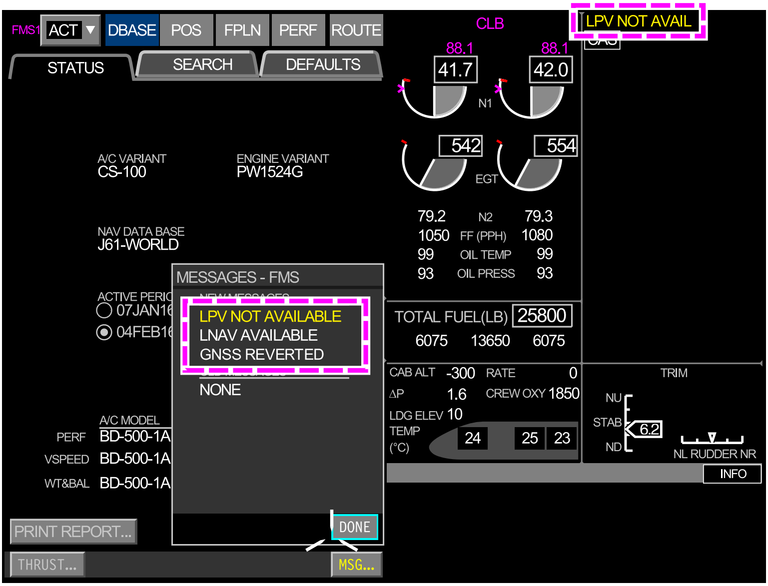
If a single GNSS receiver fails when the approach is armed but not active, the messages that follow are displayed on the failed side only (refer to Figure 22–03–35):

- On the lower PFD:
  - MSG in amber
  - LPV NOT AVAILABLE in amber on the HSI
- On the MAP page:
  - LPV NOT AVAILABLE amber message
- LPV NOT AVAIL caution message on EICAS
- On the MESSAGES – FMS window:
  - LPV NOT AVAILABLE in amber
  - LNAV AVAILABLE in white
  - GNSS REVERTED in white

The opposite side remains functional with normal indications using the remaining GNSS.



PFD



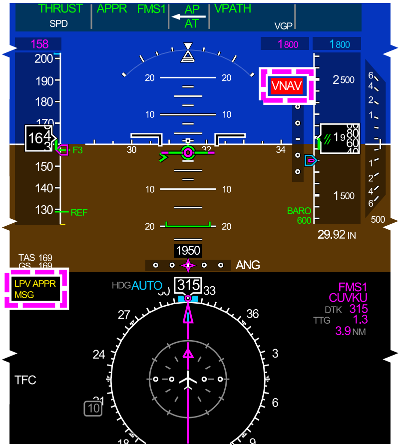
MFW

Single GNSS failure in LPV ARM mode (Part 1)
Figure 22–03–35

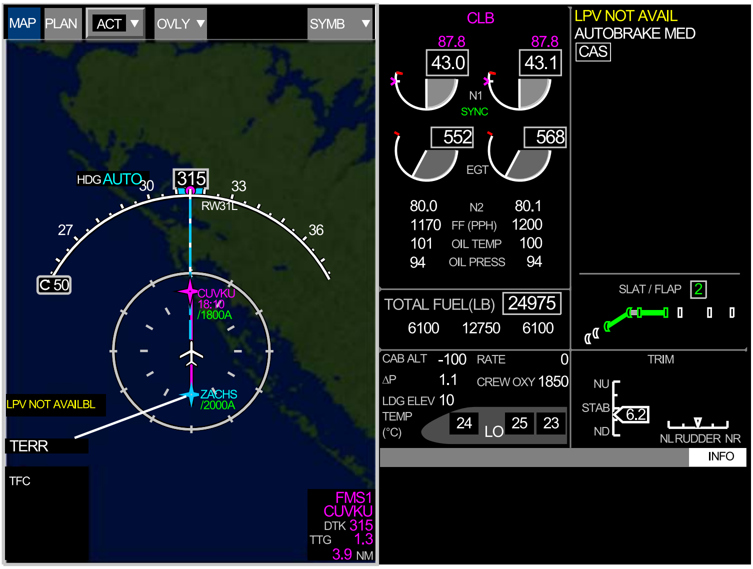
If a single GNSS receiver is still failed when the approach becomes active, these additional messages are displayed on the failed side PFD (refer to Figure 22–03–36):

- An amber LPV APPR
- A red VNAV flag above the vertical scale

The failed side no longer has vertical guidance but the opposite side remains functional with vertical guidance indication.



PFD



MFW

Single GNSS failure in LPV ARM mode (Part 2)
Figure 22–03–36

(3) Single GNSS failure with LPV APPR active

If the approach is already active when the GNSS receiver fails, a white MSG and a GNSS REVERTED message display on the failed side PFD (refer to Figure 22–03–37). The GNSS REVERTED message also displays on the MESSAGES-FMS window.

Failure indications after LPV APPR active
Figure 22–03–37

There are no messages, failures, or flags displayed on the functioning side. Vertical guidance is available on both sides.

NOTE

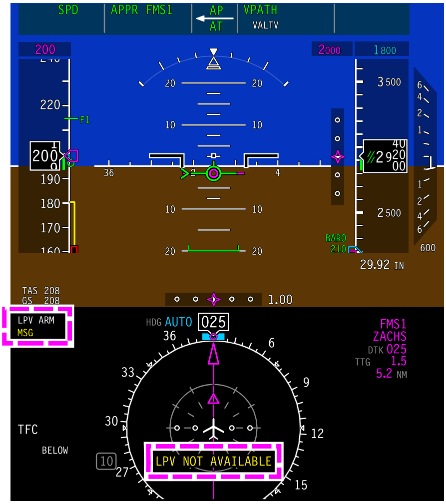
For a complete list of FMS messages, refer to the CS100-300 ProLine Fusion Flight Management System (FMS) Operators Guide.

(4) Single SBAS failure during LPV approach

If a single SBAS receiver fails when the LPV approach is armed, the messages that follow are displayed (refer to Figure 22–03–38):

- LPV NOT AVAIL caution message on the EICAS
- Amber MSG on the failed side PFD
- Amber LPV NOT AVAILABLE on the HSI and MAP page of the failed side
- Amber LPV NOT AVAIL on the MESSAGES - FMS window

The vertical guidance is available on both PFDs.



PFD FAILED SIDE

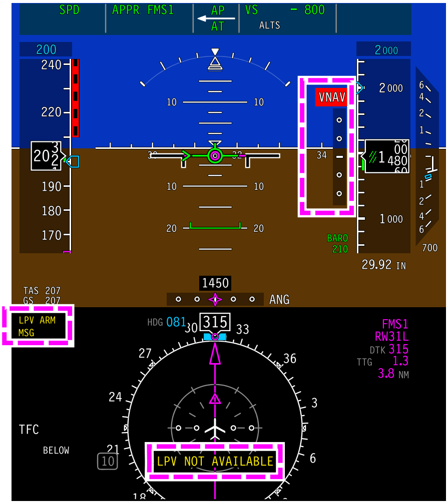
MFW FAILED SIDE

Single SBAS failure indications during LPV approach (Part 1)
Figure 22–03–38

If a single SBAS receiver fails or is still failed when the LPV approach is active, on the failed side only (refer to Figure 22–03–39):

- An amber LPV APPR displays on PFD
- The vertical guidance is lost and a VNAV flag displays
- Amber LPV NOT AVAIL on the HSI and MAP page of the failed side

On the functioning side, a white LPV APPR displays and no flags or messages are displayed.



PFD FAILED SIDE

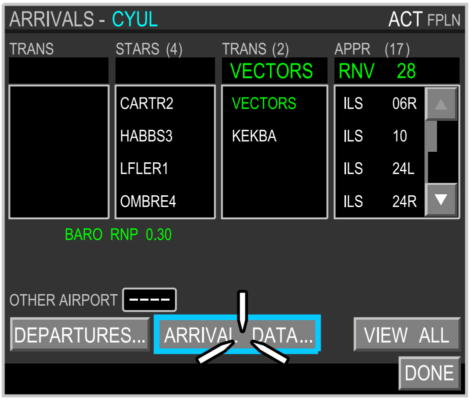
MFW FAILED SIDE

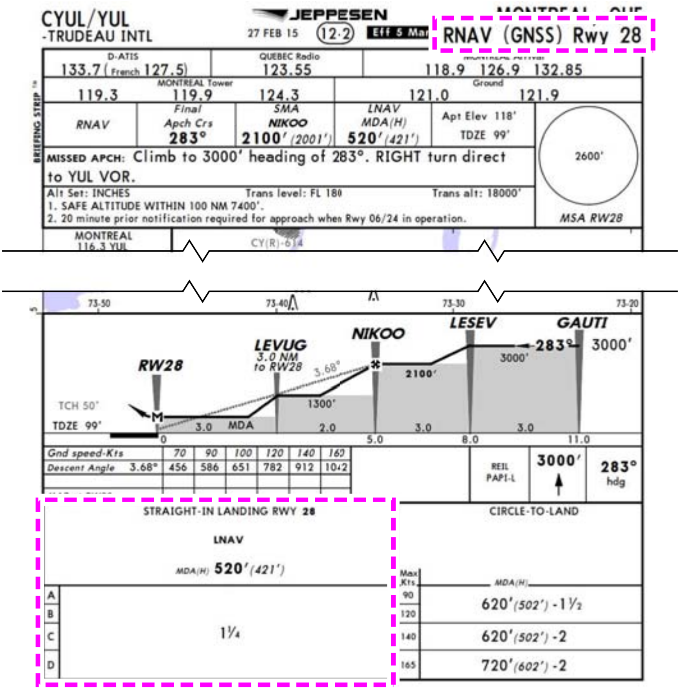
Single SBAS failure indications during LPV approach (Part 2)
Figure 22–03–39

LATERAL NAVIGATION (LNAV) AND VERTICAL NAVIGATION (VNAV)

A. LNAV approach identification

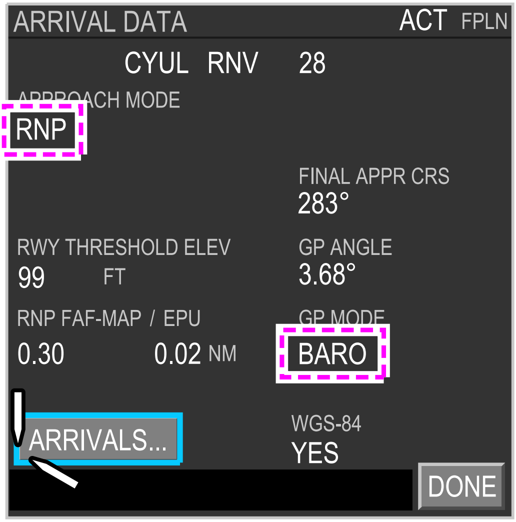
In this example, the highest charted service on this Montreal (YUL) instrument approach chart is LNAV and is identified as RNAV (GNSS) (refer to Figure 22–03–40). BARO RNP 0.3 displays on the ARRIVAL window.

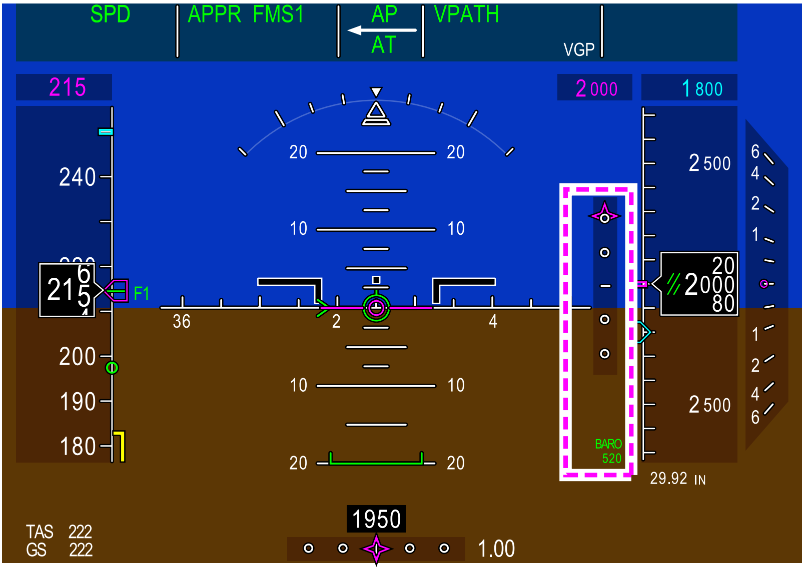




LNAV approach identification Example (continued)
Figure 22–03–40

On the ARRIVAL DATA window, RNP displays in white under APPROACH MODE, and BARO displays in white under GP MODE (refer to Figure 22–03–41). Vertical guidance based on barometric altitude is shown on the glidepath indicator and is available down to the runway. MDA minimums must be respected.

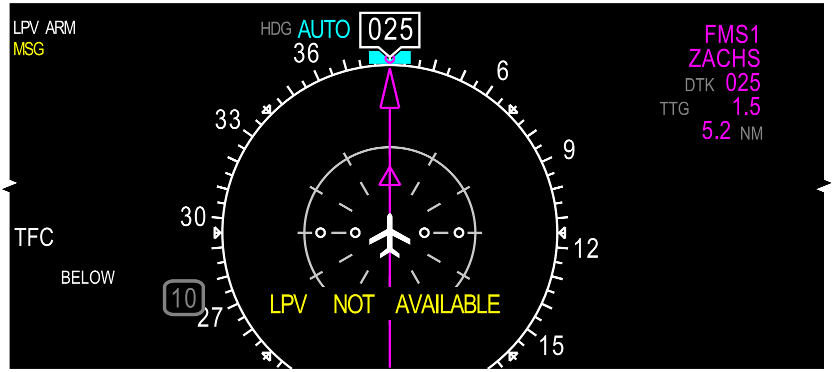


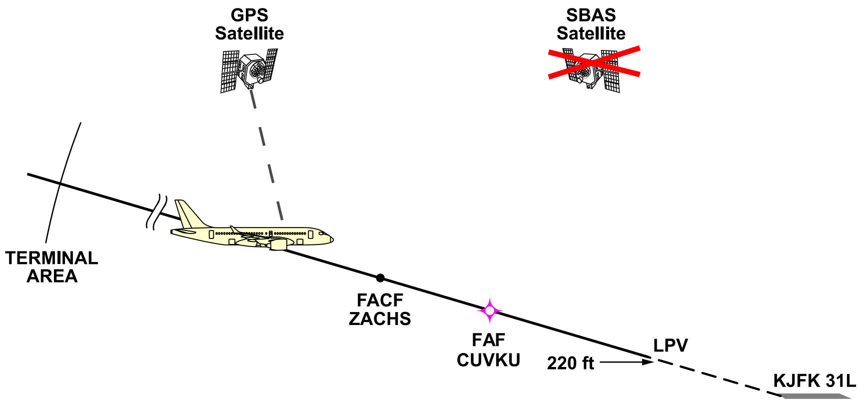


LNAV approach identification Example (continued)
Figure 22–03–41

B. LNAV/VNAV alternative approach

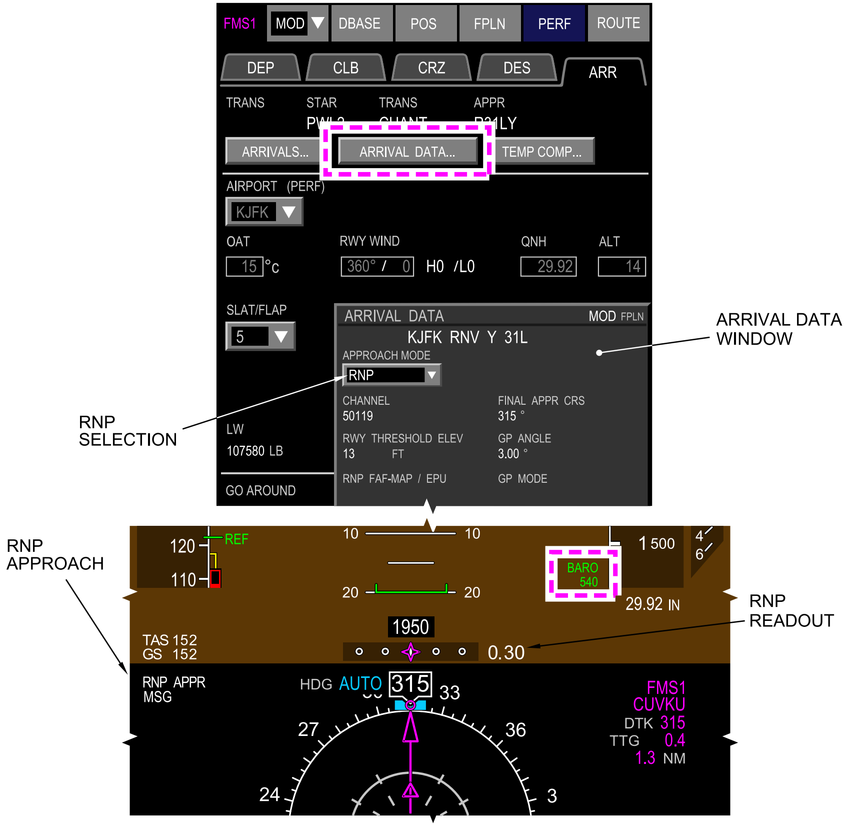
If the SBAS correction signal is lost, a LPV approach is not possible as indicated by an amber LPV NOT AVAILABLE message on the HSI (refer to Figure 22–03–42). A GNSS approach mode with higher minimums, or a go-around must be selected.





LNAV/VNAV alternative approach
Figure 22–03–42

If time permits, the approach mode may be changed to a LNAV/VNAV approach with barometric guidance by selecting RNP as the approach mode on the ARRIVAL DATA window (refer to Figure 22–03–43). The decision altitude needs to be adjusted to the LNAV/VNAV minimums.



LNAV/VNAV alternative approach – Continued
Figure 22–03–43

An RNP readout of 0.30 replaces ANG and RNP APPR is displayed on the PFD. Horizontal and vertical guidance are now linear.

C. LNAV – Lateral only alternative approach

If LNAV AVAILABLE is displayed on the MESSAGES window and time or conditions do not permit any approach changes, the approach may be continued as a LNAV approach.

A vertical mode (VS or FPA) has to be set, and the approach minimum needs to be adjusted to the LNAV approach minimum.

Alternatively, a go-around may be performed.

During an approach, the indications that follow are displayed on the PFD (refer to Figure 22–03–44):

- An amber LPV APPR message
- A VNAV flag and vertical deviation scale without deviation pointer

LNAV – Lateral only alternative approach
Figure 22–03–44

D. Definition of L/V approach

L/V approach is an LNAV/VNAV approach that uses SBAS with the Wide Area Augmentation System (WAAS) information for vertical guidance instead of using barometric VNAV references.

Both lateral and vertical deflection scales are angular like ILS and can be flown to the published LNAV/VNAV minima.

MISSED APPROACH PROCEDURES (MAP) INN RADIUS–TO–FIX (RF) LEGS

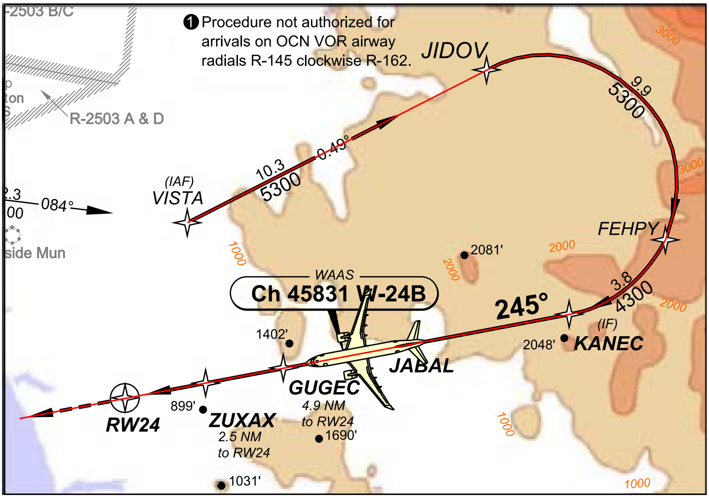
Performing a missed approach while in a RF leg requires special consideration due to proximity to terrain or traffic.

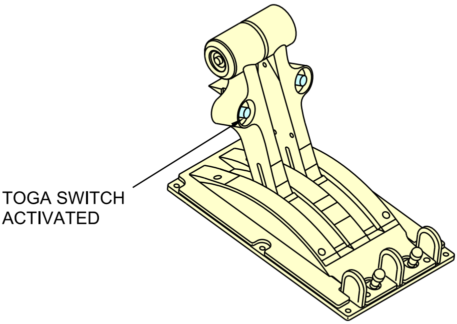
Upon initiating a go-around, the AFCS lateral mode changes from APPR FMS(x) to FMS(x), and the vertical mode from VGP to VNAV Go-Around (VGA).

The AFCS remains in VGA mode until another vertical mode is selected, or the first altitude constraint is captured.

Maintain the published lateral path to the MAP. Use TAWS display to assist with terrain avoidance. Verify FMS remains as navigation source, verify FMS(x) is active mode on FMA. Monitor vertical mode to capture the altitude constraint. Engage the autopilot if not already engaged.

If above missed approach altitude, maintain current altitude by selecting ALT on FCP. Continue the lateral path as shown on the approach chart (refer to Figure 22–03–45). Contact ATC for clearance altitude.





Missed approach procedures in RF legs
Figure 22–03–45

FMS - EICAS MESSAGES

A. Warning messages

None

B. Caution messages

Message	Description	Inhibit
APPROACH NOT AVAIL	Shows when a Global Navigation Satellite System (GNSS) approach is selected, the aircraft is in the arrival terminal area, the FMS navigation mode is not GNSS base or the SBAS service provider is not available (for an LPV only approach), or the GNSS accuracy is less than required for the approach.	TO
FMS 1 FAIL	Flight Management System (FMS) 1 has detected a failure.	TO, LDG
FMS 2 FAIL	FMS 2 has detected a failure.	TO, LDG
FMS FUEL	Shows when FMS messages CHECK FUEL AT ALTN or CHECK FUEL AT DEST or CHECK FUEL PLAN or CHECK BLOCK FUEL is posted.	TO, LDG
FMS OEI PERF ACTIVE	One Engine Inoperative (OEI) performance data active and can be canceled on the THRUST window.	TO, LDG
FMS PERF DEP CONFIG	Mismatch between sensed aircraft configuration state (bleeds, ANTI-ICE switches, SLAT/FLAP lever position) and FMS entered configuration.	TO, LDG
FMS PERF DEP VSPEEDS	FMS Gross Speed check has found Vspeeds values not entered between minimum/maximum operational allowed values.	TO, LDG

Message	Description	Inhibit
FMS POSITION	Shows when one of the FMS messages that follow is shown: INITIALIZE POSITION or RE-ENTER SET POS or RESET INITIAL POS.	TO, LDG
GNSS NOT AVAIL	Shows when the FMS is not using GNSS position data as part of its calculations to determine position. Shows if either of the conditions that follow is true: • All GNSS sensors are not available and at least one sensor is enabled, or • At least one sensor is disabled and one sensor is enabled and no enabled sensor is available.	TO, LDG
LPV NOT AVAIL	Shows when a GNSS LPV approach is selected, the aircraft is in the arrival terminal area, and the FMS navigation mode is not GNSS based, or the SBAS service provider is not available, or the GNSS accuracy is less than required for the approach.	TO
UNABLE RNP	Shows when loss of integrity condition exists. The aircraft may not be able to maintain the required RNP accuracy when this message shows.	TO

C. Advisory messages

None

D. Status messages

None