

B777 Alerting Issues – Loss/degradation of GPS

1. Initiating Condition: Poor GPS satellite availability or geometry leading to decreased GPS signal integrity

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated	
Visual Alerts	EICAS caution message "NAV UNABLE RNP"	ANP>RNP (includes RAIM monitoring)	Meaning of text can be unclear			When ANP<RNP	
	FMS CDU scratchpad message "VERIFY POSITION" (only if large error introduced)	The difference between the FMC position and the updating sensor (GPS) is greater than 12NM for 5 seconds.	Meaning of alert can be unclear	Text messages on FMS scratchpad can be inadequately salient. Also, once cleared by pilot action, they may not be re-displayed		When ANP<RNP	
	RAIM forecast message from dispatch during preflight planning or update inflight via ACARS	Inadequate satellite availability/ geometry as detected by RAIM forecast analysis performed by dispatch (inflight update can be generated by dispatch or requested by pilots)			May not be provided before flight if RNP approach not anticipated		
	PFD Navigation Performance Scales/ANP Bars flash first 10 seconds of exceedence, turn amber if exceeded 10 seconds (if installed)	ANP>RNP					When ANP<RNP
	RNP/ANP alphanumeric under airplane symbol turns amber (if installed)	ANP>RNP					When ANP<RNP
	Amber TERR POS annunciation on Nav Display and EICAS advisory message "TERR POS"	ANP>RNP		Relationship of these indications to GPS position/updating is not transparent			When ANP<RNP

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1. Initiating Condition: Poor GPS satellite availability or geometry leading to decreased GPS signal integrity – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
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Aural Alerts	Beeper associated with EICAS caution message "NAV UNABLE RNP"	ANP>RNP				When ANP<RNP
Tactile Alerts	None					
Visual Cues	ANP value (labeled "ACTUAL") greater than RNP value on CDU POS REF page 2		Meaning of text can be unclear			
	Navigation source annunciation on Nav Display (and FMS CDU POS REF page 2) changes from "GPS" to backup source (e.g., LOC-DME, ADIRU, etc.)	ANP>RNP		Not highly salient		
Aural Cues	None					
Tactile/ Somatic Cues	None					

Expected Pilot Response(s)

- Perform NAV UNABLE RNP procedure.
- Return to ground-based navigation, if any, as directed by the NNP.
- During RNP approach, execute missed approach (also directed by the NNP but timely response is required so pilots may not be able to wait for checklist).

How does pilot know condition is resolved/recovered?

- Lookup of FMS CDU page displaying ANP/ RNP; inspection of ANP/RNP values.
- Removal of multiple alerts driven by ANP>RNP.

Issues with regard to multiple concurrent non-normal conditions

- Loss of terrain clearance warning.
- False terrain clearance warning.
- Loss of separation from air traffic (ADS or NextGen navigation/surveillance).

B777 Alerting Issues – Loss/degradation of GPS

2. Initiating Condition: Intentional spoofing (intentional introduction of false position into the GPS receiver) leading to false position input from GPS to the FMS

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	FMS CDU scratchpad message "VERIFY POSITION" (only if large error introduced)	The difference between the FMC position and the updating sensor (GPS) is greater than 12NM for 5 seconds.	Meaning of alert can be unclear	Text messages and alerts on FMS scratchpad can be inadequately salient. Also, once cleared they may not be re-displayed. Alerting and cueing depends on continued operation of multi-mode navigation, with at least inertial position inputs. The alerting threshold for "VERIFY POSITION" likely far exceeds RNP values for all but Oceanic procedural separation, so these alerts may be of limited safety value in current RNP or future Next Gen operations.		When position difference has been reduced to within limits or the inaccurate position source has been manually deselected from the FMS solution
	EICAS advisory message "FMC Message"	Driven by FMS CDU "VERIFY POSITION" message, using its threshold				EICAS message is removed when the text message is cleared from the FMS CDU scratchpad
	MSG amber annunciation on FMS CDU	Driven by FMS CDU "VERIFY POSITION" message, using its threshold				
Aural Alerts	None					
Tactile Alerts	None					

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2. Initiating Condition: Intentional spoofing (intentional introduction of false position into the GPS receiver) leading to false position input from GPS to the FMS – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Cues	PFD Navigation Performance Scales/ANP Bars flash first 10 seconds of exceedence, turn amber if exceeded 10 seconds (if installed)	Only presented in subset of conditions in which calculated ANP>RNP				When ANP<RNP
	RNP/ANP alphanumeric under airplane symbol turns amber (if installed)	Only presented in subset of conditions in which calculated ANP>RNP				
	ANP value greater than RNP value on CDU POS REF page	Only presented in subset of conditions in which calculated ANP>RNP	Meaning of text can be unclear.			When ANP<RNP
	Possible visible map shift, if the system makes a position change or correction while a pilot is looking at the navigation display		Map shift, if it occurs, may not be noticed, or if noticed the caused will be unclear and it will not be evident whether the shift was to a more or less accurate position. In the absence of map shift and FMS text alerts there will be no alerting or cueing to false position.			
Aural Cues	None					
Tactile/Somatic Cues	None					

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2. Initiating Condition: Intentional spoofing (intentional introduction of false position into the GPS receiver) leading to false position input from GPS to the FMS – Cont.

Expected Pilot Response(s)

- Verify position using alternative means (e.g. radar, DME).
- Identify false information.
- Eliminate source of false information from the position solution.

Possible sources of confusion with regard to pilot response(s)

- Without effortful investigation it may not be clear to the pilot which navigation sources is/are providing the false position; also, because of the normally high accuracy of GPS pilots tend to believe its information and downplay the other sources. This is particularly the case because the FMS are programmed to heavily weight the GPS position in calculating the mixed-source FMS position solution (using GPS as the primary source) because of the normal great accuracy of GPS. As a result, the FMS position may drift or shift into a false position that may appear, to the pilots, to be a malfunction of the IRS or Radio position sources.

How does pilot know condition is resolved/recovered?

- Verifying position after reverting to alternative navigation.

Issues with regard to multiple concurrent non-normal conditions

- Loss of terrain clearance warning.
- False terrain clearance warning.
- Loss of separation from air traffic (ADS or NextGen navigation/surveillance).