AC 21-36(1)  JANUARY 2013

GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) EQUIPMENT: AIRWORTHINESS GUIDELINES

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1. REFERENCES

- Parts 21, 23, 25, 26, 27, 29 and 91U of CASR 1998
- CAO 20.18 Appendix XI- Approved GNSS equipment for ADS-B
- CAO 20.91 Instructions and directions for performance-based navigation
- CASA AC 21-37 “Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Sensors”
- CASA AC 21-38 “Aircraft Electrical Load Analysis and Power Source Capacity”
- CASA AC 21-99 “Aircraft Wiring and Bonding”
- CASA AC 91U-2 RNAV 10 (RNP 10)
- CASA AC 91U-3 RNP 4
- CASA AC 91U-II-B-2 RNAV 5
- CASA AC 91U-II-B-3 RNAV 1 and RNAV 2
- CASA AC 91U-II-C-2 RNP 2
- CASA AC 91U-II-C-3 RNP 1
- CASA AC 91U-II-C-5 RNP APCH
- CASA 356/12 Instructions – use of Global Navigation Satellite System (GNSS)

Advisory Circulars (ACs) are intended to provide advice and guidance to illustrate a means, but not necessarily the only means, of complying with the Regulations, or to explain certain regulatory requirements by providing informative, interpretative and explanatory material.

Where an AC is referred to in a ‘Note’ below the regulation, the AC remains as guidance material.

ACs should always be read in conjunction with the referenced regulations.

This AC has been approved for release by the Executive Manager, Standards Division.

Draft only: January 2013
REFERENCES (CONTINUED)

- FAA AC 23.1311-1C “Installation of Electronic Displays in Part 23 Airplanes”
- RTCA, Inc. document, DO-229(D), "Minimum Operational Performance Standards For Global Positioning System/Wide Area Augmentation System Airborne Equipment"
- RTCA, Inc. document, DO-253C, "Minimum Operational Performance Standards For GPS Local Area Augmentation System Airborne Equipment"
- RTCA, Inc. document, DO-316, "Minimum Operational Performance Standards for Global Positioning System/Aircraft-based Augmentation System Airborne Equipment"

2. PURPOSE

2.1 This Advisory Circular (AC) provides guidance material for authorised persons under Subpart 21.M of the CASR 1998 for the design, development and subsequent airworthiness approval of Global Navigation Satellite System (GNSS) equipment installations into aircraft registered in Australia. This AC is designed to expand on installation requirements of GNSS equipment in conjunction with FAA AC 20-138C. This equipment may be either:

- GNSS stand-alone equipment that provides deviations (steering commands) for en-route, terminal or approach operations (including Category I Precision Approaches); or
- GNSS sensors integrated into a multi-sensor navigation or flight management system.

2.2 The GNSS equipment may be used in some or all of the following situations:

- Navigation under the Visual Flight Rules (VFR):
  - Visual Navigation; and
  - Night VFR Area Navigation;

- Navigation under the Instrument Flight Rules (IFR):
  - Dead Reckoning (DR) Substitute;
  - Performance-Based Navigation:
    - RNAV 10 (authorised as RNP 10);
    - RNAV 5;
    - RNAV 1 and RNAV 2;
    - RNP 4;
    - RNP 2;
    - RNP 1;
    - RNP 0.3; and
    - RNP APCH (LNAV, LNAV/VNAV, LP and LPV);
  - Supplemental Performance-Based Navigation specifications:
    - APV Baro-VNAV;
– Radius to Fix path terminators (RF Legs);
– Fixed Radius Transitions;
– Oceanic area navigation outside RNP 10 and RNP 4 designated airspace;
– North Atlantic Minimum Navigation Performance Specification; and
– GNSS Landing System (GLS).

3. STATUS OF THIS ADVISORY CIRCULAR

3.1 This is the second AC to be written on this subject and replaces AC 21-36(0) issued in April 2005. It has been amended to provide updated information since the previous version.

4. ACRONYMS

ABAS Aircraft Based Augmentation System
AC Advisory Circular
ADS-B Automatic Dependent Surveillance Broadcasting
AFM Aircraft Flight Manual
AI Attitude Indicator
AIP GEN Aeronautical Information Package General
ALT Altitude
APR Approach
AR All Revisions
CAAP Civil Aviation Advisory Publication
CAO Civil Aviation Order
CASA Civil Aviation Safety Authority
CDI Course Deviation Indicator
dBm Decibels milli-Watt
DO Document (RTCA)
DR Dead Reckoning
EASA European Aviation Safety Agency
EFIS Electronic Flight Instrument System
EMI Electromagnetic Interference
ETSO European Technical Standard Order
FAA Federal Aviation Administration
FAF Final Approach Fix
FAR Federal Aviation Regulation
FDE Fault Detection and Exclusion
AC 21-36(1): Global navigation satellite system (GNSS) equipment: airworthiness guidelines

FMS  Flight Management System
FOV  Field of View
FTE  Flight Technical Error
GBAS  Ground Based Augmentation System
GLS  Global Positioning Landing System
GPWS  Ground Proximity Warning System
HAE  Height Above Ellipsoid
HDOP  Horizontal Dilution of Precision
HFOM  Horizontal Figure of Merit
HSI  Horizontal Situation Indicator
Hz  Hertz
IAS  Indicated Airspeed
IFR  Instrument Flight Rules
ILS  Instrument Landing System
INTEG  Integrity
LAAS  Local Area Augmentation System
LAME  Licenced Aircraft Maintenance Engineer
LIC  Licence
LNAV  Lateral Navigation
LODA  Letter of Deviation Authority (FAA)
LOI  Loss of Integrity
MOPS  Minimum Operational Performance Standards
MSG  Message
NAC  Navigation Accuracy Category
NAV  Navigation
NM  Nautical Mile
NPA  Non Precision Approach
NSE  Navigation System Error
OBS  Omni Bearing Selector
PBN  Performance-Based Navigation
PNT  Position, Navigation and Timing
PVT  Position Velocity Time
RAIM  Receiver autonomous integrity monitoring
RFI  Radio Frequency Interference
5. DEFINITIONS

**Aircraft-Based Augmentation System (ABAS)** – An augmentation system that augments and/or integrates the information obtained from the other GNSS elements with information available on board the aircraft.

**Ground-Based Augmentation System (GBAS)** – An augmentation system in which the user receives augmentation information directly from a ground-based transmitter.

**Satellite-Based Augmentation System (SBAS)** – A wide coverage augmentation system in which the user receives augmentation information from a satellite-based transmitter. SBAS augments core satellite constellation by providing ranging, integrity and correction information via geostationary satellites. SBAS is designed for international interoperability among SBAS systems.

**Local Area Augmentation System (LAAS)** – is the GBAS provided by the Federal Aviation Administration (FAA) of the United States of America (USA).
Wide Area Augmentation System (WAAS) – is the SBAS provided by the FAA and is limited to continental USA only.

Fault Detection and Exclusion (FDE) – is a receiver processing scheme that autonomously provides integrity monitoring for the position solution, using redundant range measurements. The FDE consist of two distinct parts: fault detection and fault exclusion. The fault detection part detects the presence of an unacceptably large position error for a given mode of flight. Upon the detection, fault exclusion follows and excludes the source of the unacceptably large position error, thereby allowing navigation to return to normal performance without an interruption in service.

Global Positioning System (GPS) – The U.S. Global Positioning System (GPS) Standard Positioning Service (SPS) consists of space-based positioning, navigation, and timing (PNT) signals delivered free of direct user fees for peaceful civil, commercial, and scientific uses worldwide.

Globalnaya Navigatsionnaya Sputnikovaya Sistema (GLONASS) – is a Russian satellite based radio navigation system, which provides a positioning service anywhere in the world.

Galileo – The European Union satellite-based radio navigation system currently under development, which will provide a positioning service anywhere in the world.

Global Navigation Satellite System (GNSS) – The GNSS is a generic term for satellite-based navigation, including GPS, SBAS, GBAS, GLONASS, and any other satellite navigation system.

PVT – Position/Velocity/Time.

SA – Selective Availability is a requirement for the receiver to properly account for satellite range error if it is reflected in the User Range Accuracy index (commonly referred to as being “Selective Availability aware”)

6. BACKGROUND

6.1 Since the initial approval of GNSS in Australia (1993) as an en-route supplemental means of navigation, ongoing developments to receiver design, and improved accuracy guarantee together with the gathering of an extensive knowledge base has increased the applicability and acceptance of GNSS navigation. This includes the development and deployment of augmentation systems that enhance the accuracy and availability of GNSS navigation data.

6.2 As the FAA released AC 20-138C on 8 May 2012, the CASA AC 21-36(1) includes major changes to reflect:

- TSO-C129a cancellation;
- updated guidance related to FAA TSO-C115c;
- AC 20-C138C (Chapters 18 to 22) addresses equipment installed performance for various operations;
- clarifying information for the ground proximity warning system/terrain awareness and warning system (GPWS/TAWS) glideslope alerting function; and
- additional testing procedures for GNSS that support automatic dependent surveillance - broadcast (ADS-B).
6.3 Applicability

6.3.1 This AC is applicable to all Australian registered aircraft being modified for GNSS based navigation equipment or sensors. It provides guidance on the design, installation and testing of GNSS equipment or systems.

6.3.2 This AC does not include information on the aircraft installation requirements for RNP AR operations or Baro-VNAV since these items are beyond the scope of this document.

6.4 Related Australian Reading Materials

- Aeronautical Information Package (AIP) - General (GEN);
- CAO 20.91- Instructions and directions for performance-based navigation;
- CAO 20.18 - Aircraft equipment – basic operational requirements; and

6.5 Approved Equipment

6.5.1 The GNSS equipment fitted to an aircraft must be capable of the intended operations. The Australian AIP provides detail concerning the minimum equipment fit requirements necessary for the proposed operation. Appendix 1 of this AC contains a list of approved equipment.

6.6 TSO-C129a - Cancelled

6.6.1 TSO-C129a has been cancelled, but this does not affect existing equipment. Equipment produced under FAA TSO-C129(AR) is still eligible for installation in accordance with the guidance in this AC.

6.6.2 TSO-C129(AR) Class A equipment is a sensor/navigation computer combination. The provision of pressure altitude data from an approved source (i.e. barometric aiding) is a mandatory requirement for approval of the installation of TSO-129a A1 or A2 based GNSS equipment intended for IFR area navigation operations as detailed in CAO 20.91.

6.6.3 There are no re-use or replacement possibilities for antennas certified under TSO-C129/C129a.
Notes:

1. Intended to provide data to an integrated navigation system which provides enhanced guidance to an autopilot/flight director to reduce flight technical error and limited to CASR Part 121 aircraft.

2. Requirement for the integrated navigation system to provide a level of GNSS integrity equivalent to RAIM

6.7 Effective Noise Density

6.7.1 Equipment not meeting the effective noise density e.g. TSO-C129(AR) may experience performance degradation as more GNSS satellites are launched. Equipment intended for use beyond 2020 in applications such as ADS-B should be qualified using the effective noise density. Equipment should be qualified using the effective noise density shown below in Table 2.

<table>
<thead>
<tr>
<th>Receiver Function</th>
<th>Effective Noise Density (dBm/Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Acquisition (GPS Only)*</td>
<td>-172.2</td>
</tr>
<tr>
<td>GPS Tracking and Re-acquisition</td>
<td>-171.9</td>
</tr>
<tr>
<td>SBAS Tracking and Re-acquisition</td>
<td>-172.8</td>
</tr>
</tbody>
</table>

Table 2: Effective Noise Density
6.8 TSO-C145(AR)/TSO-C146(AR)

6.8.1 TSO-C145c defines an acceptable standard for Airborne Navigation Sensors using GPS augmentation by WAAS. TSO-C146c defines an acceptable standard for Stand-Alone Airborne Navigation Equipment using GPS augmentation by WAAS. There are no equipment performance limitation for GPS/SBAS equipped aircraft to have other positioning and navigation systems on-board TSO-C146(AR). There are no plans to withdraw authorisations for TSO-C145a/C146a or TSO-C145b/C146b equipment.

6.8.2 GPS/SBAS TSO-C146(AR) Class Gamma equipment is considered the direct replacement for a Class A sensor/navigation computer combination certified to TSO-C129(AR). Additionally, TSO-C145(AR) equipment can also replace TSO-C129(AR) Class B & C equipment.

6.8.3 Applicants will have to establish sensor/antenna compatibility when replacing TSO-C129(AR) sensors with TSO-C145(AR) sensors.

6.8.4 These items of equipment meet the functional Class Gamma or Class Delta of FAA TSO-C145/145c see Table 3: TSO-C145(AR) and TSO-C146(AR) - Equipment classes.

<table>
<thead>
<tr>
<th>Class</th>
<th>Functional</th>
<th>Operational</th>
<th>Domestic Enroute</th>
<th>Oceanic Enroute</th>
<th>Terminal</th>
<th>Departure</th>
<th>NPA</th>
<th>LNAV/NAV</th>
<th>Precision approach (APV/14GUS)</th>
<th>ILS</th>
<th>Integrated sensor</th>
<th>Stand-alone</th>
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</thead>
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<tr>
<td>Beta 1</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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</tr>
</tbody>
</table>

Table 3: TSO-C145(AR) and TSO-C146(AR) - Equipment classes

6.9 TSO-C161a/C162a(AR)

6.9.1 TSO-C161a defines an acceptable standard for GPS/GBAS that provides precision approach capability and PVT information. TSO-C162a defines an acceptable standard for GPS/GBAS equipment designed to receive VHF data broadcast.

6.10 TSO-C196(AR)

6.10.1 TSO-C196a defines an acceptable standard for GPS equipment without ground-based or space-based augmentation. The TSO has been updated to revision “a” for harmonisation with TSO-C129a’s cancellation. TSO-C196(AR) has equipment performance limitations that requires other positioning and navigation systems appropriate to the operations on-board the aircraft. TSO-C196a equipment is intended as a direct replacement for Class B & C sensors certified to TSO-C129(AR). The basis for this TSO is Class Beta 1 without SBAS requirements.
6.10.2 Improvements with TSO-C196 are:
- Selective Availability aware;
- Fault detection and exclusion; and
- Ensure no degradation due to other satellite systems.

6.10.3 It is acceptable for TSO-C145b/c sensors to simply disable GPS/SBAS tracking loops to qualify as a TSO-C196a. TSO-C129a was cancelled effective 21 November 2011 as TSO-C129a did not provide sufficient performance for all operational applications. Airborne navigation equipment previously approved under all revisions of TSO-C129(AR) may still be installed under the provisions of their original approval.

6.10.4 TSO-C196 encompasses many of the technical performance improvements in TSO-C145(AR) equipment but does not include SBAS technical requirements and operational advantages.

6.10.5 TSO-C196 equipment still requires other navigation equipment to be available unless operating in oceanic and remote areas, provided the operator obtains a Fault Detection and Exclusion (FDE) prediction program. These limitations must be documented in the installation/instruction manual.

6.10.6 Applicants will have to establish sensor/antenna compatibility when replacing TSO-C129(AR) sensors with TSO-C196 sensors. See FAA AC 20-138C 5-5.4 for antenna compatibility.

6.11 TSO-C115(AR)

6.11.1 TSO-C115c defines an acceptable standard for Flight Management System (FMS) using Multi-Sensor inputs. It is not acceptable to use systems certified to TSO-C115 revisions for GNSS sensor integration, unless they are revision “b” or later.

6.11.2 There are no plans to withdraw TSO-C115b or earlier versions. For more information on TSO-C115(AR) see FAA AC 20-138(AR).

6.12 Design, Development and Approval of Modifications

6.12.1 FAA AC 20-138C is endorsed by CASA as appropriate guidance material for the design, development and approval of modifications intended for Australian registered aircraft involving the installation of GNSS equipment. Copies of this AC may be obtained from the FAA website at http://rgl.faa.gov/.
6.12.2 References to the FAA procedures, documentation and regulatory requirements contained in FAA AC 20-138C are not applicable to Australian registered aircraft. All modifications to Australian registered aircraft must comply with Australian regulations.

6.12.3 Related CASA guidance material AC 21-38 – Aircraft Electrical Load Analysis and Power Source Capacity and AC 21-99 – Aircraft Wiring and Bonding provide additional guidance material for consideration during design and installation.

6.13 Human Factors Considerations

6.13.1 Concerns have been expressed that there is insufficient and sometimes conflicting guidance material with respect to the human factors issues of GNSS receiver installations. This section is intended to provide guidance, in practical terms, in identifying acceptable locations for IFR installations of GNSS receivers installed without remote annunciators, the associated course deviation indicators (CDI) and when required, the remote Annunciators and/or indicators that are to be installed. The goal is to ensure an efficient and concise instrument scan. The principles explained below, whilst primarily aimed at installations into normal category aircraft, may be applied to other aircraft.

6.13.2 FAA AC 20-138C Section 11-8 General Human Factors Considerations, has further information on human factors considerations.

6.14 General design considerations

6.14.1 In planning an IFR GNSS installation in an existing aircraft there are a number of inter-related design considerations, all of which are dependent on the existing instrument panel of the aircraft in question. The PBN requirements are in addition to the other airworthiness installation requirements. The PBN requirements are detailed in the relevant CASA advisory circulars that are listed in the References section of this AC.

6.15 Deviations from the Basic T Configuration

6.15.1 Deviations from the basic T-configuration (14 CFR 23.1321) have been approved for individual instrument arrangements if the droop angle (angle below the 14 CFR 23.1321(d) position) is 15° or less, or if the elevated angle is 10° or less see Figure 1: Horizontal Reference Line. These angles are measured from a horizontal reference line that passes through the centre of the attitude reference data with lines passing through the centre of the airspeed and altitude data.
6.16 Pilot Field of View

6.16.1 The pilot should be able to use all the required instruments with “minimum head and eye movement. Primary optimum FOV is based on the vertical and horizontal visual fields from the design eye reference point that can be accommodated with eye rotation only.

6.16.2 With the normal line-of-sight established at 15° below the horizontal plane, the values for the vertical and horizontal (relative to normal line-of-sight forward of the aircraft) are ±15°, as shown in Figure 2 - Optimum Field of View. This area is normally reserved for primary flight information and high priority alerts.

6.17 Course Deviation Indicator

6.17.1 Installation of a GNSS receiver certified for IFR operations requires that the GNSS be connected to a remote CDI or Horizontal Situation Indicator (HSI), either conventional or electronic. This CDI/HSI is to be part of the pilot’s primary instrument scan during approach and other IFR operations, and thus should be located to ensure an efficient and concise scan.

6.17.2 FAA AC 20-138C Section 11-8 General Human Factors Considerations b. (1) Display Visibility, requires that: each display element (including the CDI) be located clearly visible to the pilot. The CDI connected to a GNSS receiver to be within the pilot’s primary field of view.
6.17.3 By assuming a typical minimum eye-to-instrument panel distance of 600 mm, the 15° field of view figure equates to a circle with a radius of approximately 160 mm. This would mean that the CDI would need to be within approximately a 160 mm radius of the centre of the Attitude Indicator (AI) on most aircraft. The only means to achieve this on most conventional instrument panels would be to use an HSI. However, it is presumed that the intention of FAA AC 20-138C was not to mandate a HSI in every GNSS equipped aircraft as experience has shown that a CDI external to the basic "T" may be acceptable.

6.17.4 Depending on the layout of other instruments and indicators that are to be included in the scan, including the GNSS receiver that is normally installed in the centre radio stack, an external CDI is usually best located at the top of the instrument panel as close as possible to the altimeter. Based on experience however, the locations identified in Figure 3 for an external CDI may be considered acceptable. See Figure 3: Acceptable locations for Remote CDI.

![Figure 3: Acceptable locations for Remote CDI](image)

6.17.5 The acceptable locations identified in Figure 3 are considered appropriate for aircraft that do not have a HSI. Aircraft that use a HSI to show track deviation for a VOR/ILS should also show GNSS track deviation on the same HSI, for the primary GNSS receiver. CDI for a secondary GNSS receiver, or a back-up indicator for the primary GNSS receiver, do not need to meet the constraints described in this section.

6.17.6 The CDI is to be visible and unobstructed from the pilot’s view with the pilot’s hands on the control column, regardless of the pilot’s sitting position. If movement of the upper torso from a normal seated position is required to see the CDI, its location is not acceptable.

**Note:** As some manufacturers do not recommend that their receivers be installed without remote CDIs, the designer should consider this fact and justify any deviation.

6.18 Remote Annunciators

6.18.1 In the early days of GNSS IFR approvals, it was generally accepted that certain remote annunciators were required for an IFR approach approval.
6.18.2 Foremost amongst these was a requirement that when it was possible to display navigation information from more than one source on the same CDI/HSI, the navigation source driving that CDI/HSI was to be annunciated.

**Note:** See FAA AC 20-138C 13.3a. Navigation Source Selection

6.18.3 Remote annunciators were also common for MSG, WPT, GNSS Approach ARM/ACT and OBS/LEG, though the requirement for these annunciators was somewhat open to interpretation. FAA AC 20-138C Section 11-8 General Human Factors Considerations – b. Display Visibility, clearly required navigation source annunciation, but there is also a requirement for failure annunciation to be located within the pilot’s primary field of view.

6.18.4 In the early development of GNSS in Australia the design of an installation that featured automatic override of the GNSS navigation source by ILS data was not recommended. This was due in part to the possible differences between the published ILS and GNSS approaches. As the deactivation of this feature could only be done at the hardware level and involved wiring changes it was considered prudent to have the installation designed with this consideration in mind.

6.18.5 However some examples of modern equipment have this feature available as an internal function and which may be capable of being set by the aircrew. An example is that with the introduction of these integrated GNSS/VOR/ILS systems (e.g., Garmin GNS-430), an external switch is no longer required for a GNSS and VOR/ILS to share a common CDI/HSI as the switching and annunciations are handled internally. In approving the initial installation of the Garmin GNS-430, the FAA found that many approvals of the GNS-430 could be completed without any remote annunciators.

**Note:** Installation Memo from Garmin, dated 25 January 1999, and letter from FAA Small Airplane Directorate, also dated 25 January 1999 provide further information. These are included in Appendix B of Garmin GNS-430 Installation Manual at Rev H and later.

6.18.6 This guidance is still applicable, however the design may incorporate the automatic override feature providing sufficient indication is provided to the pilot, together with appropriate procedures in the AFM Supplement, to ensure an unambiguous notification of the source of the displayed navigation data. This would be especially important for autopilot/flight director coupled systems.

6.18.7 RTCA, Inc. document, DO-208, titled "Minimum Operational Performance Standards For Airborne Supplemental Navigation Equipment using Global Positioning System (GPS)" is the internationally accepted industry standard for GNSS receivers from which the GNSS TSO 129 and 129a are derived. TSO-129a has been cancelled, but this does not affect equipment with existing TSOA/LODA approvals.

6.18.8 RTCA, Inc. document, DO-229, titled "Minimum Operational Performance Standards For Global Positioning System/Wide Area Augmentation System Airborne Equipment", now at Rev C (DO-229, is the internationally accepted industry standard for GNSS receivers from which the various GNSS TSO-C145 and 146 are derived).

RTCA DO-229 originally stated:

"The horizontal deviation display, displays used for failure annunciation, manoeuvre anticipation, and automatic mode switching shall be located within the pilot's primary field of view (i.e., within 15 degrees of the pilot's primary line of sight), as shall any indication requiring immediate aircrew action."

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RTCA DO-229 was revised in 1998 and introduced the concept of a "normal field of view", making it clear that many annunciations previously required in the pilot’s primary field of view did not have to be so prominent.

6.19 Location of Loss of Integrity Monitoring & Other annunciations

6.19.1 Displays used for waypoint sequencing, start of a turn, turn anticipation, active waypoint, distance to active waypoint, desired track and actual track (track angle error), and automatic mode switching should be located within the pilot’s primary field of view, or, on a readily accessible display page.

6.19.2 Displays used for loss of integrity monitoring, TO/FROM indication, approach mode annunciation should be located within the pilots primary field of view.

6.19.3 Traditionally, 14 CFR Part 23 airplanes with “classic” analog instrumentation in the “basic T” arrangement have included the centre radio stack within the allowable field of view to satisfy this guidance.

6.19.4 In essence, those annunciations not normally provided on the CDI/HSI, could, per FAA AC 20-138C, be provided anywhere between the airspeed indicator on the left, and the centre radio stack on the right.

“The primary field of view definition should be broad enough to include the centre radio stack on FAR Part 23 airplanes with “classic”, analog basic ‘T’”

6.19.5 Operational experience has shown that systems with the system annunciators on the front panel and installed in the radio stack are often not observed by pilots and consideration should be given to optimising the location of these annunciators. Bright cockpit light conditions, particularly with direct sunlight, aggravate the condition. It is therefore strongly recommended that system annunciators are located in the primary field of view for each required pilot.

6.20 Definition of Centre Radio Stack

6.20.1 FAA AC 20-138C is focused on smaller normal category aircraft, and that fact presumably influenced the development of the definition of "optimum field of view". CASA accepts that many installations may be done without remote annunciators, per FAA AC 20-138C, but the term "centre radio stack" needs to be constrained.

6.20.2 In fact, in the majority of smaller single engine aircraft, the radio stack is displaced to the right of centre; in some cases it is so far to the right that it is directly in front of the right seat pilot/passenger (e.g. older Beech Bonanzas and Barons). Some of these cannot be considered "centre radio stacks". Further, on larger aircraft, the distance from the attitude indicator to the "centre radio stack" may be much more than what was envisioned when this wording was developed.

6.20.3 On most single engine normal category aircraft, the distance from the attitude indicator (AI) to the centre of the instrument panel is 250 mm – 350 mm. Since it is really the proximity of the radio stack to the attitude indicator that is of concern, CASA will accept that any radio stack that is centred within 350 mm of the centreline of the AI qualifies as a "centre radio stack", per FAA AC 20-138C, regardless of whether the radio stack is in the centre of the instrument panel or not. Considering newer radios are a standard 6.25” (~160 mm) wide, this means that if the AI centreline is within 280 mm of the closest edge of the radio stack, that radio stack qualifies as a "centre radio stack".
6.20.4 As an example, on most later model Cessna C-172s (refer Figure 4: Typical Cessna 172 Instrument Panel), the centre radio stack is displaced about 75 mm to the right of centre, but the distance from the AI to the edge of the radio stack is ~240 mm. This would qualify as a "centre radio stack". See Figure 4: Typical Cessna 172 Instrument Panel.

![Figure 4: Typical Cessna 172 Instrument Panel](image)

6.21 Installations without remote annunciators

6.21.1 For GNSS receivers installed in the centre radio stack, as constrained above, CASA will accept the installations without remote annunciators, in accordance with FAA AC 20-138C, provided certain conditions are met. The GNSS receiver is to provide all required annunciations on the front of the receiver and is to be intended for installation without remote annunciators. The entire GNSS receiver and display is to be visible and unobstructed from the pilot’s view, regardless of the pilot’s sitting position.

6.21.2 If movement of the upper torso, from a normal seated position, is required to see all or part of the receiver or display, its location is not acceptable. To facilitate an effective scan, the GNSS receiver should also be located at roughly the same height as the CDI/HSI that it is driving. If the CDI/HSI is level with the directional gyro, the receiver should not be more than 25 mm below the CDI/HSI as shown in Figure 5.
6.21.3 If the CDI/HSI is below the directional gyro, the receiver should not be below the CDI/HSI, as shown in Figure 6. The centre of the receiver should also be within 75 mm vertically of the centre of the CDI/HSI that it is driving.

6.21.4 The above guidance applies to the primary GNSS receiver and the primary CDI/HSI. For aircraft in which two GNSS receivers are installed, it is recommended that the receivers be installed at approximately the same height as the CDIs that they are driving, though it may not be possible to meet the 75 mm constraint. Generally, the primary receiver, which would normally drive the HSI, should be mounted above the secondary receiver.
6.22 Installations with Remote Annunciators

6.22.1 Even when the constraints of section Installations without remote annunciators are met, remote annunciators can significantly improve a pilot’s scan and reduce workload. For that reason, an applicant may choose to install remote annunciators in the pilot’s primary field of view. In such a case, the guidelines below are recommended.

6.22.2 If GNSS receivers are installed in a location other than the instrument panel (e.g. in the centre pedestal) then these installations are required to have remote annunciators.

6.22.3 For installations containing more than one approach navigation source, the navigation source (for example ILS, GPS/GBAS etc.) selected for the approach must be positively indicated in the primary field of view. Consideration should be given to the overall aircraft-level annunciation philosophy.

Note: Aircraft requiring two pilots must have this annunciation at each pilot station.

6.22.4 The approach type (GLS) must be clearly annunciated to the flight crew prior to and throughout the entire approach in the primary field of view.

6.23 Requirements for Installations with Remote Annunciators

6.23.1 In other installations, it may not be possible to meet the above dimensional constraints for locating the receiver. In such situations, remote annunciators and/or indicators will be required for an IFR approval. The installed location of the GNSS receiver is still required to meet 14 CFR 23.1321, 25.1321, 27.1321 or 29.1321 regardless of whether remote annunciators are used. "Head movement" as used in 14 CFR Part 23.1321, is interpreted, in the context of an IFR GNSS receiver approval, to mean movement of the head without movement of the upper torso. If the installed location of the receiver requires a pilot to reposition his/her upper torso, from the normal piloting position, in order to read part of the display, or adjust a control, that location is not acceptable for installation of an IFR GNSS receiver.

6.23.2 The following guidance is provided as FAA AC 20-138C does not address what remote annunciators/indicators are required when the receiver cannot be located to preclude the need for such remote annunciators. Remote annunciators are defined as annunciators external to the GNSS receiver and they may be:

- grouped on an annunciator control unit (e.g. MD-41);
- individual annunciators;
- integral to the CDI/HIS; or

6.24 Nav Source Annunciator

6.24.1 Annunciation of the navigation source on or next to the affected CDI/HSI has long been considered a requirement as the consequences of the pilot not knowing the navigation source could be hazardous. Thus an annunciation of the navigation source is to be included in the pilot’s primary field of view, or immediately adjacent to the CDI/HSI that the GNSS is driving, if remote annunciators are required. This annunciator is typically "NAV/GNSS", "VLOC/GNSS" or "VOR/GNSS", and is typically green, cyan and/or white in colour.
6.25 **Message Annunciator**

6.25.1 All newer GNSS receivers provide an array of messages for the pilot’s information. If the constraints of section 6.22 Installations without remote annunciators of this AC cannot be met, a remote "message" annunciator is required to draw the pilot’s attention to the existence of such a message. This annunciator is typically "MSG" or "GNSS MSG", and is typically amber in colour. This message annunciator should be located in the pilot’s primary field of view.

6.26 **Waypoint Annunciator & Distance-to-Go Indicator**

6.26.1 All GNSS navigation is predicated on flying to waypoints, and pilots will regularly scan the distance-to-go indication to assist themselves with their situational awareness. If the distance-to-go indication is not within the pilot’s normal scan, the head movement required to observe the distance-to-go indication can significantly disrupt an instrument scan. Furthermore, on some displays, there can be a lot of information presented on a small display, and distance to next waypoint may not be prominent on a cluttered display.

6.26.2 It is recommended that if the constraints of section 6.22 Installations without remote annunciators of this AC cannot be met, a distance-to-go indicator should be provided within the pilot’s primary field of view. Even if the constraints of section 6.22 Installations without remote annunciators of this AC can be met, it is recommended that consideration be given to providing distance-to-go indication within the pilot’s primary field of view.

6.26.3 Often it may not be possible or practical to provide such a distance-to-go indicator within the pilot’s primary field of view. While a waypoint annunciator does not provide the same information, nor will it obviate completely the need to scan the GNSS receiver, it may reduce the frequency with which the receiver must be scanned, and will alert the pilot upon waypoint arrival. Even if distance-to-go is within the pilot’s primary field of view, a waypoint annunciator provides a prominent and timely reminder of waypoint arrival. Thus, when the constraints of section 6.22 Installations without remote annunciators of this AC cannot be met, as a minimum, a waypoint annunciator should be placed within the pilot’s primary field of view. This annunciator is typically "WPT" or "GNSS WPT", and is typically amber in colour.

6.27 **Integrity or Receiver Autonomous Integrity Monitor (RAIM) Annunciators**

6.27.1 GNSS receivers must be capable of annunciating when they should not be used for navigation, either because of some failure or because of poor satellite coverage. In some cases, the NAV flag will appear on the CDI/HSI, and course guidance will be removed, but in other situations, the indication may be subtler. A dedicated annunciator to indicate that the pilot should not rely on GNSS navigation would provide the pilot with unambiguous information. Such annunciator is typically "INTEG", "GNSS INTEG", "RAIM" or "LOI" (Loss of Integrity) and is typically amber in colour. If this annunciation is available on the receiver and also causes the message annunciator to illuminate, inclusion of a dedicated remote annunciator is optional. The integrity or RAIM annunciator should be located in the pilot’s primary field of view.
6.28  Approach/Terminal, or Approach Arm/Activate Annunciators

6.28.1 GNSS receivers must annunciate when they are in Terminal or Approach mode. A dedicated annunciator to indicate the mode of operation would provide the pilot with unambiguous information. Such an annunciator typically consists of two segments, either one or no segments being illuminated at any given time. The segments are typically either "TERM/APR", or "GNSS APR: ARM/ACT", and are typically green in colour. During normal approach operations, the mode of operation will change from Terminal to Approach at 2 Nm back from the Final Approach Fix (FAF), and will then change back to Terminal mode when the missed approach is selected. The only time that the mode of operation might change unexpectedly would be following some other event (e.g. hardware failure, loss of satellite coverage), but such an event would be annunciated by a message light or other indication. Thus, if annunciation of mode of operation is available on the receiver, inclusion of a dedicated annunciator is optional.

6.29  Other Annunciators

6.29.1 The use of other remote annunciators, such as to indicate OBS/LEG, MAN/AUTO waypoint sequencing, Parallel Track, etc., are optional if these annunciations are readily available on the receiver.

6.30  Installations in Electronic Flight Instrument Systems Equipped Aircraft

Installations of panel-mounted GNSS receivers in aircraft equipped with EFIS require special consideration. Generally, remote annunciations should be provided on the EFIS display, whenever possible. It is assumed that the navigation source and GNSS distance-to-go will always be available on the EFIS display, but some older or simpler EFIS may not allow for annunciation of GNSS messages and other alerts. In such a situation, it is strongly recommended that, as a minimum, a GNSS message annunciator be provided in the pilot’s primary field of view, even if the constraints of section Installations without remote annunciators are met. If the constraints of section Installations without remote annunciators are not met, then the required remote annunciators noted in section...
6.30.1 Installations with Remote Annunciators are to be in the pilot’s primary field of view.

6.31 Multi-Function Displays

6.31.1 Installations that utilize generic multi-function displays that receive and display input from a variety of sources (e.g. combined RMI/TCAS/GPS Track/GPS Moving Map etc.) need to be evaluated to confirm the priority of display of the various inputs. This is to ensure that necessary flight information is not removed during critical phases of flight.

6.32 Autopilot Interfaces

6.32.1 When a GNSS system is interfaced to an autopilot to provide a navigation steering capability, the aircraft steering function must meet airworthiness criteria. The steering function must allow the aircraft to intercept and capture a flight plan leg, maintain a flight plan leg within the TSE limits for the designated performance requirement, transition between flight plan legs using fly-by and fly-over transitions without undue delay or S turning.

6.32.2 To obtain adequate autopilot response, it is not acceptable to change the CDI scaling from the default full scale values (5 NM (TSO-C129 systems) or 2 NM (TSO-C146 systems) en route, 1 NM terminal and 0.3 NM for approach.

6.32.3 Some navigation systems provide a capability to limit bank angle. This capability should not be used since there is a potential for bank angle limits to cause the aircraft to not comply with the navigation accuracy requirements.

6.33 Installations in Aircraft Operated by Two Crew

6.33.1 For aircraft approved for single pilot operations in the Type Certificate, there is no requirement to provide any indicators or annunciators on the co-pilot’s side. However, an operator may choose to provide GNSS navigation information on the co-pilot’s side, either as back-up information, or to allow the pilot in the co-pilot’s seat to perform all flying and navigating duties. If GNSS guidance is provided to a CDI/HSI on the co-pilot’s side, it is strongly recommended that the required annunciators noted above be installed for the co-pilot, if the constraints of section: 0 Installations without remote annunciators, cannot be met. Otherwise, a flight manual limitation may be added, requiring that GNSS approaches be flown by the pilot in the pilot’s seat.

6.33.2 When an aircraft is required to be operated by two pilots by the Type Certificate additional installation requirements apply so that either pilot can operate the system, monitor the systems and provide cross-checking. When a single system is installed, the control / display for the system must be located where it can be viewed and operated with minimal head movement for either pilot. The displays required to be within the pilot’s primary field of view must be replicated for both pilots.

6.33.3 Dual independent systems are an acceptable means of meeting the above requirement but either pilot should be able to select either system to their primary instrument displays. In dual installations, the primary (No. 1 systems) should be connected to an electrical power source that is unlikely to fail or be shed in the event of an electrical power generations system failure.

6.34 Alternative Installations

6.34.1 When situations arise that are beyond the scope of the installations discussed in this AC, guidance should be obtained from your local CASA Office on the acceptability of the installation.
6.35 Performance-Based Navigation

6.35.1 Performance-Based Navigation (PBN) is being implemented globally; in Australia PBN will be predicated on GNSS. CAO 20.91 contains the details for all PBN navigation specifications except for RNAV 10 (RNP 10) and RNP 4, which are in Subpart 91.U of CASR 1998.

6.36 ADS-B

6.36.1 Position and other flight parameters derived from GNSS are critical to the effective operation of ADS-B. AC 21-45(1) provides details parameters necessary or compliance with ADS-B regulations published in Paragraph 9B of CAO 20.18. Refer to FAA AC 20-138C for information on functional testing. Error! Reference source not found.
6.37 Aircraft Flight Manual Supplements (AFM Supp)

6.37.1 The approved Aircraft Flight Manual Supplement provides the operational capability information and restrictions for the pilot to confirm what operations the aircraft is approved for. Except for stand-alone GNSS equipment fitted only as a supplemental aid for VFR navigation, an appropriate AFM Supp containing the limitations and referencing the GNSS manufacturer’s operating procedures applicable to the equipment as installed, should be submitted to CASA or an Authorised Person for approval.

6.37.2 Some imported STCs contain approvals for features or procedures that are available or relevant only within the approving country’s airspace. There is no requirement for the approved AFM Supp to be amended to remove these features.

6.37.3 If the installed GNSS equipment does not have an appropriate TSO authorisation or equivalent, a limitation placard stating the restrictions detailed in the Australian AIP is to be installed in clear view of, and easily readable, by the pilot.

6.38 Layout

6.38.1 The layout for an AFM Supp (see Appendix 5 of FAA AC 20-138C) should follow the format of the approved flight manual and include the following:

Section 1 General
This section should contain an appropriate statement to describe the equipment capability and the type/s of procedures available e.g. IFR RNAV, Oceanic RNAV etc.

Note: Full technical details of the system installed in the aircraft, including reference to the Part 21.M approval documentation controlling the incorporation, are contained in the aircraft log book.

Section 2 Limitations
Any airworthiness or operational limitations on the use of the system resulting from the design or equipment capability.

The limitations section should include:
- part number of equipment and revision date
- software version details
- if equipment TSO-C129(AR) or TSO-C196(AR) is installed, then supply details on other operational, approved navigation equipment installed appropriate to the operation
- TSO-C number and revisions used

The limitations section should also list each of the navigation specifications the aircraft meets and the document used to determine compliance. There must also be a statement that these approvals do not constitute an operational approval to conduct those operations.

If the equipment does not have the capability to carry out Radius to Fix legs, there must be a statement in the Limitations section that states the equipment cannot be used for procedures that include RF legs.
Section 3 Emergency/Abnormal Procedures

(a) Emergency Procedures: detail of changes to published aircraft emergency procedures introduced with the installation of the new equipment

(b) Abnormal Procedures: details of procedures to be followed in the event that GNSS derived information is identified as invalid or is no longer available. Procedures detailed in the manufacturer’s handbook would be sufficient.

Section 4 Normal Procedures

This section contains either operating procedures in terms of manufacturer’s instructions or reference to the manufacturer’s operating manual, which would then be required to be available to the aircrew at all times whilst in flight.

Details are to be provided explaining all the functions and indications provided by the system annunciators, system switches, pilot’s display, flight director/autopilot coupled operation and any other procedure necessary for the efficient and effective operation of the installed equipment.

Section 5 Performance

Any change in performance to the basic Airplane Flight Manual.

Section 6 Weight and Balance

Revised weight and balance data if applicable from the basic Airplane Flight Manual.

Section 7 System Description

Provide a brief description of the system, its operation, installation and other relevant elements required for description.

6.38.2 Evaluation of Installed Equipment

A suggested post installation evaluation sheet is attached at Appendix 2 of this AC and a checklist is attached at Appendix 3 of this AC. The procedure is designed for follow-on installations carried out in accordance with an approved data set (note: this could be a Subpart 21.M of CASR 1998 approval or STC etc.).

6.38.3 Variations to the approved data set necessitated by a different aircraft configuration will need to be evaluated for impact and may require additional approval. This could call for additional items to be included in the test procedure to evaluate the differences.

6.38.4 First of Type or First of Model GNSS installation may also require a more comprehensive testing procedure to evaluate the GNSS/Aircraft interface.

6.39 Continued Airworthiness

6.39.1 To obtain a navigation authorisation, the aircraft operator must demonstrate that the aircraft meets the airworthiness requirements for each authorisation sought, and that the aircraft will be maintained compliant with the airworthiness requirements and conforming to its type design. For GNSS installations, the following aspects must be addressed:

- The electrical load must be analysed in accordance with AC 21-38 and meet all regulatory requirements and aircraft manufacturer limits. The ELA is particularly important for older aircraft that were originally equipped with air-driven instruments that have subsequently been replaced with electronic display systems.
- System installation configuration. Most GNSS systems have an extensive configuration capability to enable interfacing to a broad range of aircraft systems. This installation configuration forms part of the type design of the aircraft and must be included in the instructions for continued airworthiness. For easy reference, it is acceptable to include a copy of the configuration table as an Appendix in the Aircraft Flight Manual Supplement.

- Software configuration management. The configuration of the aircraft software must be managed so that it remains current and compliant. The software must be managed in accordance with approved equipment manufacturer’s instructions. Installed software on multiple installations should be kept at the same amendment status. Cross-checking of installed software versions between duplicate systems needs to be carried out.

- Navigation databases. Navigation authorisations require the navigation database in GNSS systems to be maintained current is the aircraft is operated under the IFR. Navigation databases must be obtained from suppliers that hold a regulatory Letter of Approval.
APPENDIX 1

APPROVED GNSS EQUIPMENT

At the present time there are five Technical Standard Orders (TSO) that are accepted by CASA for airborne GNSS equipment:

- FAA TSO-C129/C129a or EASA ETSO-C129a (Cancelled) Airborne Supplemental Navigation Equipment using the Global Positioning system (GPS). TSO-C129a has been cancelled, but this does not affect equipment with an existing TSOA/LODA.
- FAA TSO-C146(AR) or EASA ETSO-C146(AR) Stand-alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS).
- FAA TSO-C161(AR) or ETSO-C161a Ground Based Augmentation System Positioning and Navigation Equipment (incorporating TSO C162(AR) or ETSO-C162(AR) Ground Based Augmentation System Very High Frequency Data Broadcast Equipment).
- FAA TSO-C196(AR) or ETSO-C196(AR) Airborne Navigation Sensors for Global Positioning Systems using Aircraft Based Augmentation Systems.

Further detailed information on the minimum performance specifications for individual types of equipment can be found in the relevant FAA TSO on FAA website or EASA website for certification standards on ETSO.

Equipment that does not have a FAA TSO or equivalent approval may be considered for acceptance by CASA provided sufficient data is provided to enable evaluation against the equivalent TSO.
# APPENDIX 2

## POST INSTALLATION EVALUATION SHEET

<table>
<thead>
<tr>
<th>AIRCRAFT TYPE:</th>
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<tbody>
<tr>
<td>Model:</td>
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<tr>
<td>Registration VH:</td>
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<tr>
<td>GNSS Equipment type:</td>
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<td>Model Part number:</td>
<td>Serial number:</td>
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<td>TSO-C number:</td>
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<td>RNP operations:</td>
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</table>

### 1.0 Introduction:

1.1 This document is a suggested ground/flight evaluation procedure designed to confirm the functions and serviceability of the GNSS equipment installed in the aircraft in accordance with approved.

1.2 An appropriately rated LAME/check pilot is to initial the entry identifying the outcome of the evaluation of each item and, when completed, finalise and certify the checklist in the certification box at the bottom of the document.

1.3 Types of operation that equipment will be used for should be stated under RNP operations.

1.3 Approved data package used in this installation: __________________________

### CHECK PILOT SIGN (Flight test only):

LIC. NO: _______________________________________________________

CERTIFICATION: The GNSS installation has been found to COMPLY/NOT COMPLY with the functionality requirements of CASA AC 21-36(1).

LAME SIGN: ___________________________________________________

LIC. NO: _______________________________________________________

CERT. OF APPROVAL: ___________________________________________

DATE:..............................................
APPENDIX 3

INSTALLATION CHECKS

PART A – Installation Evaluation: Ground Check

<table>
<thead>
<tr>
<th>Test Instructions</th>
<th>Pass</th>
<th>Fail</th>
<th>N/A</th>
</tr>
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<tbody>
<tr>
<td>Verify that the installation of the equipment is in accordance with the approved</td>
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<td>drawings and related data, consistent with the type of approval sought (VFR/IFR)</td>
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<td>and meets the aircraft requirements for the applicable navigation specifications for</td>
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<td>which a navigation authorisation will be sought.</td>
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<td>System documentation should support maintenance of FTE (95% of flying time) during</td>
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<td>straight and curved path segments, for each phase of flight and each autopilot and</td>
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<td>or FD mode.</td>
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<td>Provide an electrical load analysis to verify that the total electrical load</td>
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<tr>
<td>requirements are within the capabilities of the aircraft's electrical generating</td>
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<tr>
<td>system in conjunction with guidance in AC 21-38(0).</td>
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<tr>
<td>Evaluate the GNSS installation from the pilot’s normal seating position, in</td>
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<td>accordance with the guidelines detailed in CASA AC 21-36 General design</td>
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<td>considerations, for:</td>
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<tr>
<td>• acceptable location of equipment controls, switches, etc;</td>
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<tr>
<td>• acceptable location of related annunciators, indicators, displays;</td>
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<td>Note: If movement of the upper torso, from a normal seated position, is required to</td>
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<td>see all or part of the receiver or display, its location is not acceptable.</td>
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<td>• correct placarding and identification of all relevant components (if required);</td>
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<td>• correct switch functions and dimmer operation; and</td>
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<td>• applicable circuit breakers (labels and accessibility).</td>
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<tr>
<td>Verify the visibility and operation of the controls, displays, and annunciators</td>
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<td>relating to the GNSS installation under day and night conditions are consistent with</td>
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<td>the guidelines detailed in CASA AC 21-36</td>
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<tr>
<td>Verify that the night lighting associated with the GNSS equipment is consistent</td>
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<td>with other cockpit lighting with no distracting cockpit glare or reflections</td>
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<td>evident.</td>
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<tr>
<td>All controls are to be illuminated for identification and ease of use.</td>
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<tr>
<td>Test Instructions</td>
<td>Pass</td>
<td>Fail</td>
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<tr>
<td>Verify that all switching and transfer functions affecting the GNSS equipment installation are assessed. This includes but not limited to:</td>
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<td>- electrical bus switching,</td>
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<td>- equipment selector switches, and</td>
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<td>- remote switches including navigation source selector switches.</td>
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<td>Ensure that the expected aircraft system response during switching to all alternate navigation sources is accomplished as expected, and the switching itself does not induce any inaccurate guidance indications.</td>
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<tr>
<td>Verify that the correct software version is displayed on the relevant data page.</td>
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<tr>
<td>Record software version(s): __________________________________________________________________________</td>
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<td>Record software version date(s): __________________________________________________________________________</td>
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<tr>
<td>2.7 With GNSS derived data displayed on each relevant display, verify proper display of deviations, To/From flags, bearing to waypoint, desired track and distance to waypoint.</td>
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<td>2.8 Verify the various failure modes and associated annunciations, such as:</td>
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<td>- loss of electrical power;</td>
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<td>- loss of signal reception;</td>
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<td>- GNSS equipment failure;</td>
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<td>- FMS equipment failure</td>
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<tr>
<td>- Display equipment failures or other display anomalies</td>
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<tr>
<td>- autopilot/flight director response to flags, etc by simulating the appropriate fault condition; and</td>
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<td>- loss of barometric-aiding input.</td>
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<tr>
<td>2.9 Confirm the lack of Radio Frequency Interference (RFI) from VHF radio transmissions by tuning each VHF transmitter to the frequencies listed below and transmitting for a period of 35 seconds while observing the signal status of each satellite being received.</td>
<td></td>
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<tr>
<td>Note: Degradation of individually received satellite signals below a point where navigation is no longer possible is not acceptable.</td>
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<tr>
<td>2.10 121.150 MHz</td>
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<tr>
<td>121.175 MHz</td>
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<td></td>
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<tr>
<td>121.185 MHz (8.33 kHz channel spacing)</td>
<td></td>
<td></td>
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<tr>
<td>121.190 MHz (8.33 kHz channel spacing)</td>
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<tr>
<td>121.200 MHz</td>
<td></td>
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<tr>
<td>130.285 MHz (8.33 kHz channel spacing)</td>
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<tr>
<td>131.250 MHz</td>
<td></td>
<td></td>
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<tr>
<td>131.275 MHz</td>
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</tbody>
</table>
### Test Instructions

<table>
<thead>
<tr>
<th>Test Instructions</th>
<th>Pass</th>
<th>Fail</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>131.290 MHz (8.33 kHz channel spacing)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>131.300 MHz</td>
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<tr>
<td>For installations on rotorcraft, confirm that the rotorblades do not degrade the received GNSS signals sufficiently to affect the GNSS receiver functions.</td>
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</tbody>
</table>

*Note: This may require a ground run to confirm*

2.11 Confirm correct function of the GNSS equipment by comparing the displayed position with the actual position when the aircraft is located at a known surveyed location.

*Note: The accuracy of GNSS equipment is not a function of the installation, and need not be evaluated for each installation. The accuracy of the equipment has been demonstrated under the evaluation of the sensor, typically as part of the TSO Authorisation.*

2.12 Verify that a warning associated with loss of navigation is accompanied by a visible indication within the pilot’s primary field of view as defined in CASA AC 21-36

2.13 Verify the navigation data presented corresponds to that displayed on the flight instruments by reviewing the appropriate GNSS equipment data pages.

2.15 For TSO-C129 or 129a or TSO-C196a certified equipment:
- De-select satellites and confirm appropriate annunciation.
- Verify all appropriate warning flags appear on the flight instruments.
- Reselect satellites.
- Verify the warning and flag conditions clear.

*Note: Shielding of the antenna may be required in order to block the GNSS signals and then observe the displays.*

2.16 Fail the GNSS receiver by opening the appropriate system circuit breaker.

Verify the flight instrument NAV flags come into view.

2.17 Fail the air data inputs (if fitted) by opening the appropriate system circuit breakers.

Monitor the relevant GNSS status pages and verify that True Air Speed (TAS), Indicated Air Speed (IAS), and Altitude (ALT) fields (as applicable) are cleared.

Enter the data manually.

Verify proper manual data entry is achieved.

2.18 Verify no objectionable Electromagnetic Interference (EMI) or RFI exists between the GNSS equipment and the other aircraft systems and vice versa by the conduct of a tailored test sequence.

A copy of the test program, including the list of installed equipment tested, should be attached to this evaluation sheet.

2.19 Verify that operation of the GNSS and the description of the system are accurately presented in the Aircraft Flight Manual supplement.

2.20 Verify that the RAIM Prediction System (RPS), where separate from the receiver,
2.21 Verify that any equipment fitted to the aircraft that utilises data derived from the new installation functions correctly (eg. FMS, ADS-B etc).

*Note: A list of all affected equipment should be provided.*

### PART B - Flight Check

<table>
<thead>
<tr>
<th>Test Instructions</th>
<th>Pass</th>
<th>Fail</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1 Verify continuity of navigation data during normal aircraft manoeuvring for the navigation modes to be validated:</td>
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<tr>
<td>- bank angles of up to 30°, and</td>
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<td>- pitch angles associated with approaches, missed approaches and departures</td>
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<tr>
<td>3.2 Evaluate the steering response of the autopilot/flight director when coupled to the GNSS equipment.</td>
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<tr>
<td>Verify that leg changes do not result in unacceptable over or undershoot conditions.</td>
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<tr>
<td>3.3 Verify the overall operation of the GNSS equipment to include at least the following:</td>
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<tr>
<td>- hold at a designated waypoint;</td>
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<tr>
<td>- intercept and track to or from a waypoint on a selected course,</td>
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<td>- turn anticipation;</td>
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<tr>
<td>- waypoint sequencing;</td>
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<tr>
<td>- selection of an approach;</td>
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<td></td>
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<tr>
<td>- Direct To function</td>
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<tr>
<td>- general presentation of navigational data (depiction of the &quot;TO&quot; waypoint, distance to waypoint, estimated time of arrival, estimated time en route, ground speed, etc.); and</td>
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<tr>
<td>- confirm that the Flight Technical Error is less than 1 nm during the enroute and approach transition operating modes and, if enabled, 0.25 nm for non-precision approach mode.</td>
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<tr>
<td><em>Note: This test may not be necessary if the FTE has been previously established for the aircraft. One acceptable way of assessing FTE is to monitor the measured cross-track deviation using the navigation display provided.</em></td>
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<tr>
<td>3.4 Verify that manual approach selection or manual amendment of the approach overrides any automatic selection.</td>
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<tr>
<td>3.5 Verify that, once an approach has been selected, appropriate feedback to the pilot (e.g. display of approach name (including runway), airport and reference path identifier) is given to indicate the approach has been correctly selected.</td>
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<tr>
<td>3.6 If enabled, select and fly an appropriate Non-Precision Approach to confirm the operation of the Receiver Autonomous Integrity Monitor prediction function and correct sequencing of modes.</td>
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</tbody>
</table>