



**Australian Government**  

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**Civil Aviation Safety Authority**

# **ADVISORY CIRCULAR**

## **AC 91.U-04**

### **Airworthiness requirements for performance based navigation**

Advisory Circulars 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.

**Advisory Circulars should always be read in conjunction with the relevant regulations.**

## Audience

This Advisory Circular (AC) applies to:

- operators applying for navigation authorisations under Civil Aviation Order (CAO) 20.91, under the provisions of Part 91U of the *Civil Aviation Safety Regulations 1998 (CASR)*
- personnel preparing all, or part of, the documentation packages supporting applications for the navigation authorisations identified above
- design and maintenance engineering personnel, as this AC contains information pertinent to installation.

## Purpose

This AC provides information and guidance on an acceptable means of compliance with the airworthiness requirements to conduct performance based navigation (PBN) operations, within Australia, under:

- required navigation performance (RNP) 1
- RNP 2
- area navigation (RNAV) 1
- RNAV 2
- RNP 4
- RNAV 5
- RNP 10

Additional authorisations may be required for:

- RNP authorisation required (AR)
- RNP approach (APCH)
- RNP 0.3.

These operations are consistent with the navigation specifications as described in International Civil Aviation Organization (ICAO) Performance-based Navigation Manual - Edition 4 (Doc 9613 - PBN Manual) and include RNAV and RNP navigation specifications.

Unless specified otherwise, all subregulations, regulations, divisions, subparts and parts referenced in this AC are references to the *Civil Aviation Safety Regulations 1998 (CASR 1998)*.

## For further information

For further information on this AC, contact the Civil Aviation Safety Authority (CASA) office closest to you. (Telephone: 131 757).

## Status

Version	Date	Details
1.0	Feb 2015	Initial release of this AC

## Contents

<b>1</b>	<b>Reference material</b>	<b>4</b>
1.1	Acronyms	4
1.2	References	5
<b>2</b>	<b>Background</b>	<b>6</b>
<b>3</b>	<b>Airworthiness compliance</b>	<b>7</b>
3.1	Introduction	7
3.2	Equipment standards	7
3.3	Equipment installation	8
3.4	Continuing airworthiness	8
<b>Appendix A</b>	<b>GNSS equipment capability for PBN applications</b>	<b>12</b>

# 1 Reference material

## 1.1 Acronyms

The acronyms and abbreviations used in this AC are listed in the table below.

<b>Acronym</b>	<b>Description</b>
14 CFR	Title 14 Code of Federal Regulations (previously Federal Aviation Regulation of the USA)
AC	Advisory Circular
AFM	Aircraft Flight Manual
AFMS	Aircraft Flight Manual Supplement
CAAP	Civil Aviation Advisory Publication
CAO	Civil Aviation Order
CAR 1988	<i>Civil Aviation Regulations 1988</i>
CASA	Civil Aviation Safety Authority
CASR 1998	<i>Civil Aviation Safety Regulations 1998</i>
CS	Certification Specification (of EASA)
EASA	European Aviation Safety Agency
ETSO	European Technical Standard Order
FAA	Federal Aviation Administration (of the USA)
FMS	Flight Management System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
ICAO	International Civil Aviation Organization
ICA	Instructions for Continued Airworthiness
IFR	Instrument Flight Rules
MEL	Minimum Equipment List
MMEL	Master Minimum Equipment List
OEM	Original Equipment Manufacturer
PBN	Performance-based Navigation
RNAV	Area Navigation
RNP	Required Navigation Performance
TSO	Technical Standard Order

## 1.2 References

### Regulations

Regulations are available on the ComLaw website <http://www.comlaw.gov.au/Home>

Document	Title
Part 21 of CASR 1998	Certification and airworthiness requirements for an aircraft and parts
Part 42 of CASR 1998	Continuing Airworthiness requirements for aircraft and aeronautical products
Subpart 91.U MOS	Instructions and directions for performance-based navigation
CAO 20.18	Aircraft Equipment - basic operational requirements
CAO 20.91	Instructions and directions for performance-based navigation

### Advisory material

CASA's Advisory Circulars are available at <http://www.casa.gov.au/AC>

CASA's Civil Aviation Advisory Publications are available at <http://www.casa.gov.au/CAAP>

Document	Title
Civil Aviation Advisory Publication (CAAP) 37-1( )	Minimum Equipment List (MEL)
AC 21-36( )	Global Navigation Satellite System (GNSS) Equipment: Airworthiness Guidelines
AC 21-38( )	Aircraft Electrical Load Analysis and Power Source Capacity
AC 21-46( )	Airworthiness Approval of Avionics Equipment
AC 21-99( )	Aircraft Wiring and Bonding
AC 91.U-II-1	Navigation Authorisations
Federal Aviation Administration (FAA) AC 20-138D	Airworthiness Approval of Positioning and Navigation Systems
Doc 9613	ICAO Performance-based Navigation (PBN) Manual - Edition 4

## 2 Background

PBN is navigation that uses global navigation satellite systems (GNSS) and computerised on-board systems to conduct operations. These systems are implemented using RNAV and RNP navigation specifications, depending on the requirements of the airspace in which the aircraft is operating.

The difference between RNAV and RNP is that on-board performance monitoring and alerting is required for RNP, but not for RNAV.

CAO 20.18 (Aircraft equipment – basic operational requirements) mandates the installation of GNSS into all instrument flight rules (IFR) aircraft from 4 February 2016. On 4 February 2016, the Back-up Navigation Network comes into existence. This will result in approximately 200 terrestrial navigation aids being withdrawn from service soon after this date; therefore, from 4 February 2016, Australia will effectively be GNSS PBN airspace.

The operational requirements for PBN are primarily in CAO 20.91 - Instructions and directions for performance-based navigation.

The GNSS equipment performance standards that will determine the PBN capability of the aircraft requirements deemed appropriate by CASA for PBN operations are shown in Table 1 in Appendix A.

Whilst the equipment fitted to the aircraft may be suitable for a particular operation, specific equipment configurations and/or additional approvals may be required (e.g. oceanic approval).

## 3 Airworthiness compliance

### 3.1 Introduction

- 3.1.1 The PBN concept requires that the aircraft meets certain airworthiness certification standards (including the necessary navigation system performance) to be eligible for a particular operation.
- 3.1.2 When aircraft are modified to install new systems, design and certification engineers need to be aware of the requirements for each of the navigation specifications, particularly the system performance, functional and installation requirements.
- 3.1.3 The airworthiness element consists of ensuring that:
- the aircraft meets the eligibility requirements for the functions and performance requirements as defined in navigation specifications; and
  - the aircraft also complies the installation requirements for the relevant airworthiness standards (e.g. US 14 CFR / European Aviation Safety Agency [EASA] Certification Specification [CS] Part 25).
- 3.1.4 Installation of GNSS equipment is to meet the criteria in AC 21-36 ( ), in which FAA AC 20-138D is endorsed by CASA as appropriate guidance material for design, development and approval of modifications intended for Australian registered aircraft involving the installation of GNSS equipment. Alternate methods would need to be justified and demonstrate equivalence to the published guidance. All modifications to Australian registered aircraft must comply with Australian regulations.
- Note:** References to FAA procedures, documentation and regulatory requirements contained in FAA AC 20-138D are not applicable to Australian registered aircraft
- 3.1.5 For the continued airworthiness operational approval, the operator is expected to be able to demonstrate that the navigation system will be maintained to ensure compliance with type design. There are few specific continued airworthiness requirements regarding navigation system installations, other than:
- database and configuration management
  - systems modifications
  - software revisions.

### 3.2 Equipment standards

- 3.2.1 The GNSS equipment performance standards deemed appropriate by CASA for PBN operations are shown in Table 1 in Appendix A; however, the original equipment manufacturer (OEM) may limit the type of aircraft their equipment can be fitted to (e.g. some OEM limit installation of their equipment to aircraft below 5,700 kg). Equipment holding approvals listed in Table 1, but fitted contrary to the OEM recommendations, are not acceptable.
- 3.2.2 A number of airframe manufacturers do not use Technical Standard Order (TSO) equipment, but certify the aircraft as a complete system. These items would not have a marking indicating approval against one of the listed standards. In some cases, the



capability of the GNSS component may not be detailed in the Aircraft Flight Manual (AFM) and, therefore, would require confirmation from the OEM or further research.

- 3.2.3 Paragraphs 9D.3 (e), 9D.5 (e) and 9D.8 (e) to CAO 20.18 enable CASA to approve a multi-sensor navigation system that includes GNSS and inertial integration as providing an alternate means of compliance to the requirements of paragraph 9D.9. Aircraft to which these paragraphs are applicable should have the aircraft navigation capability specified in the AFM.

### **3.3 Equipment installation**

- 3.3.1 Post manufacture modifications to install GNSS equipment that conform to the guidelines detailed in CASA AC 21-36( ) or, the now superseded, CAAP 35-1 are acceptable to CASA for PBN operations. The AC also provides guidance on the installation of GNSS equipment to enable efficient operation in single and multi-crew situations. An important aspect of the installation is the electrical load analysis (ELA) conducted to confirm that the aircraft's electrical system was capable of supplying the required power post modification. Refer to CASA AC 21-38( ) for further information.

### **3.4 Continuing airworthiness**

- 3.4.1 To obtain a navigation authorisation, the operator needs to demonstrate that the aircraft:
- meets the airworthiness requirements for each authorisation
  - will be maintained compliant with the airworthiness requirements
  - will conform to its type design.
- 3.4.2 Engineering personnel should be provided with training (where required) to ensure that they are familiar with PBN airworthiness requirements.

#### **3.4.3 Aircraft maintenance program**

- 3.4.3.1 When design engineers approve aircraft installations, they are responsible for ensuring that the modification package includes detailed instructions for continued airworthiness (ICA) in accordance with Part 42. A key element in operating an aircraft is for it to be maintained so that it remains compliant with its type design.
- 3.4.3.2 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 needs to be included in the ICA.
- 3.4.3.3 Each aircraft is required to have a maintenance program for the navigation authorisations. The systems associated with navigation authorisations require maintenance to maintain them compliant with requirements (e.g. an aircraft's altimetry systems and an associated reduced vertical separation minimum [RVSM] approval).

3.4.3.4 The following instructions should be included in the ICA:

- removal and installation of system components
- system configuration
- system testing and troubleshooting procedures
- any periodic checks and inspections.

3.4.3.5 14 CFR / EASA CS Part 2X.1529 require manufacturers and aircraft modifiers / installers to provide the operator with ICA.

#### **3.4.4 Aircraft configuration management**

3.4.4.1 Each operator is responsible for the control of the configuration of their aircraft in service. This means that no changes may be made to the aircraft unless it has been approved by the aircraft manufacturer or by a CASA authorised person.

#### **3.4.5 Software configuration management**

3.4.5.1 Software is categorised as an aircraft part and, therefore, needs to be managed in the same way as any other aircraft part. The configuration of the aircraft software requires management so that it remains current and compliant. The software is managed in accordance with approved equipment manufacturer's instructions.

3.4.5.2 Installed software on multiple installations is to be kept at the same amendment status. Cross-checking of installed software versions between duplicate systems needs to be carried out.

3.4.5.3 Software configuration limitation prescribed by an aircraft or equipment manufacturer is to be observed by operators.

#### **3.4.6 Navigation database**

3.4.6.1 Paragraph 13 to CAO 20.91 specifies the requirements for navigation databases. Navigation databases are to be obtained from suppliers holding a regulatory Letter of Acceptance Type 1 or Type 2 and maintained current for the present aeronautical information regulation and control (AIRAC) cycle, except as provided in paragraphs 13.10, 13.11 and 13.12 to CAO 20.91.

#### **3.4.7 Minimum equipment list**

3.4.7.1 Aircraft are operated with a minimum equipment list (MEL) to enable the aircraft to be flown with acceptable deficiencies. The safety basis of the MEL is that the aircraft is operated using redundant systems and alternate procedures to achieve an equivalent level of safety.

3.4.7.2 Operator MELs, based on the content of the relevant Master MEL (MMEL), are tailored to the operation and aircraft configuration. An operator MEL may be more stringent than the MMEL; however, any entry that is less stringent must be supported by a safety analysis to show that the alternate provision is acceptable and that safety is not degraded, and needs to be approved.

- 3.4.7.3 Paragraph 9D to CAO 20.18 provides details for the mandatory GNSS equipment requirements for IFR flight. Apart from being a primary navigation sensor, GNSS may interface to multiple systems in modern aircraft. The principal interfaces for GNSS are to automatic dependent surveillance – broadcast (ADS-B) and terrain awareness and warning system (TAWS), but there may be others (depending on specific aircraft configurations). Consideration is to be given to the flight crew human factors when considering failures and effects of those failures on the aircraft, its system and flight crew.
- 3.4.7.4 Operator MELs need to identify the systems that GNSS interfaces to so that in the event of GNSS being inoperative, the full impact of the failure can be readily determined. The cross-reference needs to be in the GNSS and affected systems parts of the MEL. The operator's MEL needs to identify any unserviceability that affects the conduct of any PBN operation. In the operator MEL, each of these entries must have:
- a clear statement of the number of systems installed in the aircraft
  - the number that must be operative
  - the conditions applicable, considering the operator's operating environment.
- 3.4.7.5 In many cases, the numbers of equipment items will depend on the intended operation and the route being flown, each operating case must be explicitly stated. Reference to a guide or similar document for the numbers of equipment required for an operation is acceptable for consistency and to reduce repetition.
- 3.4.7.6 MMELs consideration of the source of electrical power for systems are essential for the continued safe flight and landing of the aircraft. For this reason, it is now common for the remarks associated with equipment to require any systems connected to high priority busses (i.e. essential or battery busses) to be operative.
- 3.4.7.7 When developing MELs, operators should be cognisant of the need to preserve the electrical power to essential systems for as long as practicable in the event of an electrical power system failure.<sup>1</sup>

### **3.4.8 AFM and Flight Manual Supplements**

- 3.4.8.1 The AFM should provide details of the equipment fitted to the aircraft and the overall capability of the systems fitted. In general, the AFM statements are not an operational authorisation, but provide the proof that the aircraft is capable of certain operations by providing the appropriate RNAV/RNP system operating and abnormal procedures applicable to the equipment installed; including (where applicable) reference to required modes and systems configuration necessary to support a PBN capability.
- 3.4.8.2 When aircraft have new navigation systems installed, the Aircraft Flight Manual Supplement (AFMS) should state the capability of the aircraft in a similar manner to that stated above. The AFMS should identify each PBN specification for which the aircraft has an airworthiness approval.

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<sup>1</sup> CAAP 37-1( ) provides further information and guidance on developing and seeking approval of MEL from CASA.

- 3.4.9 In the Normal Operation section of the AFMS, the operating instructions should include the interfaces of the navigation system to the aircraft systems. There is no requirement to replicate the navigation system manufacturer's operating instructions provided that:
- the operating instructions (pilot's Guide) is clearly identified with the document number and required revision status
  - the requirement that the document must be carried in the aircraft and be accessible by the crew.

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## **Appendix A**

# **GNSS equipment capability for PBN applications**

## A.1 GNSS/FMS equipment capability for PBN operations

A.1.1 At present time, the following TSO GNSS and flight management system (FMS) equipment are acceptable for PBN operations.

- FAA TSO-C129/C129a or EASA European Technical Standard Order (ETSO) - C129a (Cancelled) - Airborne Supplemental Navigation Equipment using the Global Positioning system (GPS). TSO-C129a is cancelled, but this does not affect equipment with an existing TSO Approval (TSOA)/Letter of Design Approval (LODA).
- FAA TSO-C145 (AR) or EASA ETSO-C145 (AR) - Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS).
- 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-C196 (AR) or ETSO-C196 (AR) - Airborne Navigation Sensors for Global Positioning Systems using Aircraft Based Augmentation System (ABAS).
- FAA TSO-C115 (AR) - FMS using multi-sensor inputs.

**Note:** When using the TSO C129/129a Class B or Class C, TSO C145 (AR) or TSO C196 (AR) GNSS sensors, a separate navigation system is required to provide the navigation function. Table 1 identifies acceptable navigation systems standards for the navigation specification listed.

A.1.2 Refer to Table 1 for list of GNSS equipment and their capability for RNAV/RNP operations. Note that only PBN operations under RNP 1, RNP 2, RNAV 1, RNAV 2, RNP 4, RNAV 5 and RNP 10 have been considered for this equipment.

A.1.3 The GNSS equipment required for PBN operations is influenced by a number of factors which may vary between individual routes. As a contingency, an alternate means of navigation is to be available at dispatch; the loss of a sensor during flight does not necessarily preclude continuation or commencement of a PBN procedure.

A.1.4 Table 1 provides guidance and it must be noted that the equipment installed is to satisfy the airworthiness requirements as outlined in this AC and relevant regulatory requirements.

**Table 1 - Approved GNSS equipment for PBN applications**

	RNAV 10 (RNP 10) Oceanic and remote navigation	RNAV 5 En-route and terminal <sup>1</sup> navigation	RNAV 2 En-route and terminal <sup>1</sup> navigation	RNAV 1 En-route and terminal <sup>1</sup> navigation	RNP 4 Oceanic and remote navigation	RNP 2 Oceanic and remote, en-route and terminal <sup>1</sup> navigation	RNP 1 En-route and terminal <sup>1</sup> navigation	RNP APCH Non Precision Approach
<b>TSO C129</b>	Acceptable <sup>3</sup>	Acceptable <sup>3</sup>	Class A1 or Class B <sup>2</sup> or C <sup>2</sup>	Class A1 or Class B <sup>2</sup> or C <sup>2</sup>	Acceptable <sup>3</sup>	Class A1 or Class B <sup>2</sup> or C <sup>2</sup>	Class A1 or Class B <sup>2</sup> or C <sup>2</sup>	Class A1, B1 <sup>2</sup> , B3 <sup>2</sup> , C1 <sup>2</sup> and C3 <sup>2</sup>
<b>E/TSO C129a</b>	Acceptable <sup>3</sup>	Acceptable <sup>3</sup>	Class A1 or Class B <sup>2</sup> or C <sup>2</sup>	Class A1 or Class B <sup>2</sup> or C <sup>2</sup>	Acceptable <sup>3</sup>	Class A1 or Class B <sup>2</sup> or C <sup>2</sup>	Class A1 or Class B <sup>2</sup> or C <sup>2</sup>	Class A1, B1, B3, C1 and C3
<b>E/TSO C145(AR)</b>	Acceptable <sup>3</sup>	Acceptable <sup>3</sup>	Acceptable <sup>2</sup>	Acceptable <sup>2</sup>	Acceptable <sup>3</sup>	Class 1 <sup>2</sup> , 2 <sup>2</sup> or 3 <sup>2</sup>	Class 1 <sup>2</sup> , 2 <sup>2</sup> or 3 <sup>2</sup>	LNAV – Classes 1, 2, 3 LNAV/VNAV – Classes 2, 3 LP/LPV Class 3
<b>E/TSO C146(AR)</b>	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Class Gamma and Operational Class 1, 2 or 3	Class Gamma and Operational Class 1, 2 or 3	Class Gamma: LNAV Classes 1, 2, 3 LNAV/VNAV Classes 2, 3 LP/LPV Class 3
<b>E/TSO C196(AR)</b>	Acceptable <sup>3</sup>	Acceptable <sup>3</sup>	Acceptable <sup>2</sup>	Acceptable <sup>2</sup>	Acceptable <sup>3</sup>	Acceptable <sup>2</sup>	Acceptable <sup>2</sup>	LNAV

**Note 1:** ‘Terminal’ navigation terminology is included to enable operators with equipment classified in that manner to identify its capability.

**Note 2:** Also requires a E/TSO-C115b FMS installed IAW with FAA AC 20-138D

**Note 3:** Also requires a navigation system meeting the requirements of FAA AC 20-130A or AC-138B (or later version).