Australian Government
Geoscience Australia

ASTRA
The Australian Strategic Air Traffic Management Group

Australian Government
Civil Aviation Safety Authority

airservices australia

SouthPAN

# Guidelines for Aerodrome and Aircraft Operators for SouthPAN-Enabled APV Implementation

The following document provides a set of generic guidelines for Aerodrome Operators and Aircraft Operators within Australia to facilitate the operational implementation of SBAS-enabled Approaches with Vertical guidance (APV) operations. It has been prepared by the Satellite Based Augmentation System (SBAS) Sub Group of the Australian Strategic Air Traffic Management Group, ASTRA.

The document is modelled on Guidelines for ANSP/Aerodromes and Aircraft Operators for LPV implementation published by the European Satellite Services Provider S.A.S. (ESSP SAS) under its EGNOS Service Provision Contract with the European Global Navigation Satellite Systems Agency (GSA).

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For questions and further information

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# 1 Executive Summary

## 1.1 Purpose and Scope of Document

Australia and New Zealand governments are jointly implementing a Satellite-Based Augmentation System (SBAS), known as the Southern Positioning Augmentation System (SouthPAN). It will provide four services:

i. L1 SBAS[1] aviation-certified Safety-of-Life Service;

ii. L1 SBAS Open Service;

iii. Dual Frequency Multi-Constellation (DFMC) SBAS Open Service; and

iv. Precise Point Positioning (PPP) service.

Currently, only the L1 SBAS Safety-of-Life (SOL) Service is intended for aviation use. In the future, it is expected that emerging international standards and products will enable derivative aviation applications of the DFMC Open Service.

The L1 SBAS SOL Service is being developed to comply with Standards and Recommended Practices (SARPs) of the International Civil Aviation Organisation (ICAO). The L1 SBAS SOL Service will add to the global set of SBAS, which include:

- United States of America: Wide Area Augmentation System (WAAS);
- Europe: European Geostationary Navigation Overlay Service (EGNOS);
- Japan: Multi-functional Satellite Augmentation System (MSAS);
- India: GPS Aided GEO Augmented Navigation (GAGAN);
- Russia: System for Differential Corrections and Monitoring (SDCM);
- China: BeiDou Satellite Based Augmentation System (BDSBAS);
- Korea: Korea Augmentation Satellite System (KASS); and
- Africa: Augmented Navigation for Africa (ANGA).

The L1 SBAS SOL Service can support all phases of flight, including enroute, terminal, non-precision, and precision approach. L1 SBAS is required for certain flight procedures, including Lateral Navigation/Vertical Navigation (LNAV/VNAV) (for aircraft without Baro-VNAV avionics), Localiser Performance (LP), and Localiser Performance with Vertical guidance (LPV).

This document provides advice and guidance for aerodrome and aircraft operators in implementing SBAS-based procedures using the SouthPAN L1 SBAS SOL Service.

The material presented in this document is informative and only to be applied in conformance with provisions of the Civil Aviation Safety Regulations and associated Manual of Standards.

In all cases, the requirements of the operator's approved Operations Manual, Safety Management System, and Aircraft Flight Manual, as and where applicable, shall be satisfied.

[1] The L-band is between 1 and 2 GHz, and L1 frequency is 1,575.42MHz

# 2 Air Navigation in Australia and SouthPAN

## 2.1 What is the Southern Positioning Augmentation Network?

The Southern Positioning Augmentation Network (SouthPAN) is Australia and New Zealand's ICAO-compliant augmentation of the United States of America's Global Positioning System (GPS), and is provided by the Australian Commonwealth Government through Geoscience Australia (GA), and the New Zealand Government through Toitū Te Whenua Land Information New Zealand (LINZ). It broadcasts, on the GPS L1 frequency, integrity messages in real-time, providing information on the health of the GPS constellation. In addition, correction data improves the accuracy of the current GPS services from about ten metres to two metres in the horizontal dimension and to four metres in the vertical dimension. The SouthPAN Service Volume includes all continental Australia south of latitude 20°S and New Zealand and has the system-inherent capability to be extended to other regions, such as the neighbouring countries, and more generally regions within the coverage of two satellites being used to transmit the SouthPAN signal.

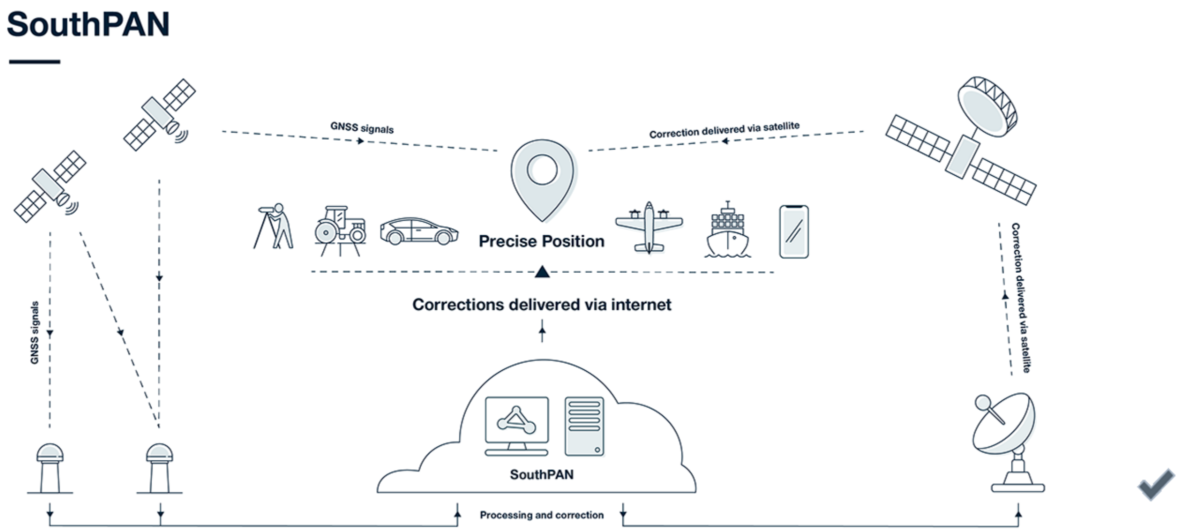


Figure 1 Southern Positioning Augmentation Network Elements

## 2.2 Why the Southern Positioning Augmentation Network is Being Deployed

Global Navigation Satellite System (GNSS) satellites are located in Medium Earth Orbits and orbit the Earth roughly once every twelve hours, arranged so that a GNSS receiver can always see four and usually between eight and thirteen satellites. A GNSS receiver can measure the time it takes for each satellite's signal to reach it, which contains information about where each satellite should be at any point in time. This enables the receiver to calculate the distance to each satellite, and therefore its own position relative to the satellites and the Earth.

The principal sources of error to this position arise as radio signals from the GNSS satellites are delayed as they pass through the Earth's atmosphere; from the satellites' atomic clocks that can drift away from perfectly correct time; and from position uncertainties of the satellites themselves.

For aviation, the greatest problem posed by these errors is that the three-dimensional position of an aircraft (altitude, along-track, cross-track) cannot be assured to the level required to conduct higher performance Instrument Flight Procedures. In Australia, GPS can be safely used to conduct enroute, terminal, and non-precision approach operations to LNAV-minima (RNP APCH), but vertical guidance and lower minima require either highly accurate Baro-VNAV avionics or a terrestrial navigation aid like an Instrument Landing System (ILS).

SBAS technology works by using a network of accurately surveyed reference stations to estimate the errors on GNSS satellite signals and provide corrections to aircraft using two or three dedicated SBAS satellites in Geostationary Earth Orbit (GEO). The GEO satellites are permanently located above the service area, and can also be used by non-aviation users to improve their own accuracy.

A Ground Based Augmentation System (GBAS) works in a similar fashion to SBAS, however GBAS corrections are only useable at a single airport. SBAS corrections are valid across an entire region and unlike GBAS, it is not necessary for an SBAS reference station to be located at an aerodrome to support approach operations.

Prior to the implementation of SouthPAN, GNSS-based Instrument Flight Procedures in Australia have provided lateral guidance only—for instance, RNP APCH. Approach procedures with vertical guidance have been available for some time to aircraft with Barometric Vertical Navigation (Baro-VNAV) equipment, but there is limited Baro-VNAV avionics available for about 85% of Australia’s IFR fleet. In addition, Baro-VNAV-derived approach minima can be limited by the non-converging lateral path and local temperature and pressure conditions.

## 2.3 SBAS as an Aviation Augmentation

The SouthPAN L1 SBAS SOL Service consists of signals for timing and positioning intended for most transport applications in different domains. The SoL service is based on integrity data provided through the SouthPAN satellite signal. The main objective of the SouthPAN SOL service is to gain the safety benefits of GNSS-enabled Approaches with Vertical Guidance (APV) for the entire Australian IFR aircraft fleet, leveraging Localiser Performance with Vertical Guidance (LPV) minima where feasible, and LNAV/VNAV in other locations.

To provide the SOL Service, the SouthPAN system has been designed so that its Signal in Space (SiS) is compliant to the ICAO SARPs Annex 10 Aeronautical Telecommunications Vol I to be used in all phases of flight from en-route, terminal, and approach operations (RNP APCH procedures down to LPV as low as 200 ft).

## 2.4 Service Description

The SouthPAN system is divided into four functional segments:

1) **Ground Segment**: This is composed of reference stations and data facilities located across Australia, New Zealand, Antarctica, and other countries, interconnected using a network. The Ground Segment comprises:

   - **GNSS Reference Stations** (GRS): Around 35 GNSS Reference Stations receive GNSS signals, so that their observed range can be compared with the expected range based on their known, accurately surveyed position. The GRS then sends this information to the Corrections Processing Facility;

- **Uplink Centres (UPC)**: These two facilities receive the data from the GRSs, process the data to calculate corrections and integrity information, generate the navigation data, generate the navigation signals, and uplink the signals to the SouthPAN Space Segment. The UPCs are the 'brains' of SouthPAN, with one of each located in Australia and New Zealand.

2) **SouthPAN Support Segment:** In addition to the Ground Segment, the system has support facilities on the ground, which perform operations and maintenance activities to keep SouthPAN operational, and conduct performance assessments to ensure safety requirements continue to be met through its life cycle.
3) **SouthPAN Space Segment:** This segment is composed of two satellites in Geostationary Earth Orbit (GEO), transmitting the navigation Signal-In-Space (SiS) available for use by aviation and non-aviation users: Inmarsat-4 F2 will be replaced by Inmarsat-8 F1, and a yet-to-be acquired second GEO satellite.
4) **User Segment**: The User Segment comprises SBAS-enabled GNSS receivers, which are tailored for various applications and user types. The User Segment includes aircraft avionics compliant with (E)TSO-C145/-C146, or equivalent.

## 2.5 Service Partners

The Australian and New Zealand Governments, through Geoscience Australia and Toitū Te Whenua Land Information New Zealand respectively, are jointly providing Southern Positioning Augmentation Network.

The Australian Government completed a review in 2011 for the cost of establishing SBAS in Australia, to cover aviation operations at smaller aerodromes, and found it was not economically justified.

The New Zealand Government also conducted a study in 2014, and found the benefits to NZ aviation alone did not out-weigh the cost of developing and operating a SBAS.

In 2019, a joint Australia-New Zealand benefit study was completed, and the benefits of SBAS were found to be significant to both economies. The Economic Benefits Report is available at:

https://frontiersi.com.au/wp-content/uploads/2018/08/SBAS-Economic-Benefits-Report.pdf

Australia and New Zealand have thus agreed to partner together to deploy SouthPAN. A formal announcement was made at the Australia-New Zealand Leaders' Meeting on 28 February 2020 to commit to jointly implement SouthPAN across Australia and New Zealand.

The new project follows eighteen (18) months of successful trials which tested twenty seven (27) projects across a range of industries, and estimated the economic value of the technology. SouthPAN will be delivered under the joint science research and innovation treaty Australia New Zealand Science, Research, and Innovation Cooperation Agreement (ANZRICA).

## 2.6 Services

SouthPAN offers high-performance navigation and positioning services to all users of satellite radio navigation. The services available are:

- L1 SBAS Safety-of-Life (SOL) Service;
- L1 SBAS Open Service
- Dual Frequency Multi Constellation SBAS Open Service (augmenting GPS and Galileo); and
- Precise Point Positioning (PPP) Via SouthPAN Open Service.

There are currently no plans to provide a DFMC SBAS Safety-of-Life Service.

More information on SouthPAN and its services are available on www.ga.gov.au/southpan.

### 2.6.1 L1 SBAS Safety-of-Life Service

For safety-critical SBAS-enabled applications in aviation, the Safety-of-Life (SOL) Service must be used; for example, to support instrument approaches with vertical guidance. The service provides an alert within a specified time if the navigation system performance degrades.

### 2.6.2 L1 SBAS Open Service

The L1 SBAS Open Service is provided using the same L1 SBAS navigation signal. However, the navigation data may be used differently by non-aviation users where safety-of-life is not at risk—for example, in agriculture and surveying sectors. Through the use of GNSS receivers that do not meet all the requirements of an aviation receiver, users can achieve better performance compared to L1 SBAS SOL Service users.

### 2.6.3 DFMC SBAS Open Service

The Dual Frequency, Multi-Constellation (DFMC) SBAS Open Service is provided by SouthPAN for the benefit of non-aviation industries, such as agriculture and resource sectors. The dual frequency component removes the adverse impact of active ionosphere where availability of an L1 SBAS service would be low. The multi-constellation component provides improved availability and robustness against single GNSS constellation service degradation.

ICAO Annex 10 Volume I Amendment 93 (published in November 2023) includes the aviation standards and recommended practices for DFMC SBAS; however, the standards for aircraft avionics are not yet available. Consequently, there are currently no plans to provide a DFMC SBAS SOL Service from SouthPAN, and any potential future government decision will be based on the benefits driven by equipage rates across the domestic fleet (and international aircraft that operate into Australia).

### 2.6.4 Precise Point Positioning Via SouthPAN Open Service

The Precise Point Positioning (PPP) Via SouthPAN (PVS) Open Service allows users to achieve horizontal accuracies of as little as 10 cm after 'convergence', a period of time used to refine observations in consumer-grade equipment to a level only previously achievable with survey-grade equipment.

The user records direct observable like the carrier phase, where not only the timing of the message is encoded, but also whether the wave of that signal is going "up" or "down" at a given moment.

PPP can provide near real-time corrections that currently require post-processing. Determining a position to this accuracy typically involves a convergence time in the tens of minutes.

The PVS Open Service is not used by aircraft avionics. It is expected that "off-the-shelf" GNSS equipment for ground use by land surveyors, agriculture, mining, and maritime applications will utilise PPP.

## 2.7 Comparison with Other SBAS Services

Other SBAS services are either currently available or being developed. These services include:

a) **Wide Area Augmentation System (WAAS)**

Commissioned in July 2003 (http://gps.faa.gov)

Serves North America, with benefits that extend into Central and South America and over the Atlantic and Pacific Oceans. Using WAAS, aircraft can access over 3,400 runway ends with minimums as low as 200 feet. A WAAS Localizer Performance with Vertical guidance (LPV) line of minimum on an RNAV (GPS) approach provides a similar level of service to the Category I Instrument Landing System (ILS). There are nearly four times as many WAAS-enabled LPVs than there are ILS glide slopes in the U.S. National Airspace System; as of 18 September 2023, there were 4,127 LPV and 734 LP approach procedures enabled by WAAS in the United States.

b) **European Geostationary Navigation Overlay Service (EGNOS)**

Commissioned for aviation use in March 2011 (https://egnos-user-support.essp-sas.eu/)

Serves Europe and surrounding countries with specific agreements with the European Union. It consists of three core services:

- Open Service: free and open to the public, the Open Service is used by mass-market receivers and common user applications;
- EGNOS Data Access Service (EDAS): offered on a controlled access basis (i.e. via the internet and mobile phones) for customers requiring enhanced performance for professional use; and
- Safety of Life Service (SoL): for safety-critical transport applications, including civil aviation, which require enhanced and guaranteed performance and an integrity warning system.

Its use in other domains such as surveying, agriculture or maritime is increasing. As of 18 September 2023, EGNOS supports over 923 flight procedures at 495 aerodromes and helipads in Europe.

c) **Multi-Functional Transport Satellite (MTSAT) Satellite Based Augmentation System (MSAS)** [RD-1]

The Japan Civil Aviation Bureau decided implementation of its own SBAS in 1993, aiming at commissioning in 2000. Operation started from September 2007.

Serves Japan and surrounding area.

Provides RNAV (enroute to RNP 0.3) in Fukuoka FIR, and horizontal guidance only due to ionospheric activities. Japan has plans to introduce LPV flight procedures.

d) **GPS Aided Geostationary Earth Orbit (GEO) Augmented Navigation (GAGAN)** [RD-2]

Commissioned in December 2013 (http://gagan.aai.aero/gagan/)

The GAGAN system provides non-precision approach (NPA) service accurate to within the radius of 1/10th of a nautical mile (Required Navigation Performance or RNP-0.1) over the Indian FIR as well as precision approach service of APV-1.0 (Approach with Vertical guidance) over the Indian landmass on nominal days.

e) **System of Differential Correction and Monitoring (SDCM)**

Currently under development, SDCM is an SBAS that provides augmentation of GPS and GLONASS satellite signals. SDCM uses transponders on the Luch Multifunctional Space Relay System geostationary communication satellites to transmit correction and integrity data. The SDCM Space Segment will be composed of 3+1 GEO satellites.

f) **BeiDou Satellite Based Augmentation System (BDSBAS)**

BeiDou-3 (BDS-3) has entered service on 31 July 2020. BDS-3 provides the major functions of navigation and positioning, as well as data communications. It can provide seven types of services including positioning, navigation and timing, global short message communication, regional short message communication, internationals search and rescue, satellite-based augmentation, ground-based augmentation, and precise point positioning.

The global positioning accuracy is better than 10m, the velocity measurement accuracy is better than 0.2m/s, timing accuracy is better than20 nanoseconds, service availability is better than 99%, while the performance in the Asia/Pacific region is better.

The BDS-3 satellite constellation includes BDSBAS, a SBAS function. It is intended to serve China and the surrounding areas.

g) **Korean Augmentation Satellite System (KASS)**

Currently under development by South Korea and the Thales Group, KASS is planned for aviation use in 2023. A contract for the development of KASS has been made by the Korea Aerospace Research Institute (KARI).

KASS intends to operate via a relay provided by an existing geostationary satellite to serve the southern Korean peninsula, within the Incheon Flight Information Region (FIR).

h) **Augmented Navigation for Africa (ANGA)**

Currently under development in African nations that are members of the Agency for the Safety of Air Navigation in Africa (ASECNA), ANGA will provide a L1 SBAS SOL Service from 2025, and potentially DFMC SBAS from 2030.

## 2.8 Performance Based Navigation Procedures Based On GNSS

Performance-based navigation (PBN) is the internationally recognised regulatory framework for implementing area navigation, with an emphasis on GNSS as the enabling technology.

PBN includes the definition of navigation specifications in terms of the **accuracy**, **integrity**, **continuity,** and **availability** required for various types of operations. It uses on-board equipment such as global navigation satellite systems (GNSS) receivers, stand-alone navigators, and integrated navigation systems.

PBN is absolute navigation — the aircraft determines its current latitude and longitude, and where it is in relation to the intended flight path. As long as the aircraft has a means of determining its current position, it can operate anywhere within coverage of the relevant GNSS system.

PBN equipment became mandatory for all Australian IFR aircraft in 2016, whilst in New Zealand, aspects of PBN have been progressively introduced since 2009.

SBAS is a GNSS technology that fits within the ICAO PBN regulatory framework.

## 2.9 Ground Based Augmentation System

Ground Based Augmentation System (GBAS) is an ICAO standardised approach aid that supports Category I Precision Approach in its initial format and in its enhanced version it will be able to support Category III approach and landing operations.

GBAS is a local area augmentation service at an aerodrome. A satellite receiving array consisting of typically four receivers observes the signal from the core constellation and generates integrity and correction information that is transmitted to aircraft conducting approaches on a VHF radio link. Information defining the approach procedure for a Final Approach Segment data block is also transmitted to the aircraft.

GBASs supporting Category I approaches are installed at Sydney and Melbourne Airports servicing all runway ends.

The integration of SBAS information by GBAS will provide for increased availability and support approaches below the Category I minima.

GBAS services will continue to be provided once SBAS is available and provides the potential for achieving Category II and III minima.

## 2.10 Conventional Navigation Aids

Conventional ground-based radio navigation aids used in Australia comprise Non Directional Beacons (NDB), VHF Omnidirectional Radio Range (VOR), Distance Measuring Equipment (DME) and Instrument Landing System (ILS). ILS is the only conventional navigation aid in use which provides vertical guidance derived from its glide path signal; and lateral guidance, using its localiser signal component.

Conventional navigation aids operate independently of satellite systems and provide an alternative capability if GNSS signals are disrupted.

ILS installations, with electronic vertical guidance, allow aircraft to conduct three dimensional instrument approaches, which enhances safety by reducing Controlled Flight Into Terrain (CFIT) events. Deployment and maintenance costs limit ILS implementation. ILS is the only technology used in Australia to support Category II and III approaches.

ILS and VOR and to a lesser extent DME and NDB are common avionics in the Australian and international aircraft fleet.

## 2.11 Safety Case

The Australia and New Zealand SBAS service will be provided by the Governments of Australia and New Zealand through Geoscience Australia and Land Information of New Zealand respectively.

Airservices Australia and Airways New Zealand will include the SBAS into their respective Aeronautical Radionavigation Service Provider Part 171 certificates.

Safety cases providing the necessary safety arguments will be provided to the Civil Aviation Safety Authority of Australia (CASA) and Civil Aviation Authority of New Zealand (CAANZ) to support the service inclusions into the respective certificates.

## 2.12 Business Case

The consulting firm Booz Allen Hamilton was engaged by the Australian Government in 1997, 2002, and 2009 to review the viability of SBAS for Australia. Additionally, a review of SBAS was conducted by the Department of Infrastructure and Transport in 2011. These reviews were directed solely to the aviation industry and found that the business case for government investment in SBAS was unjustified.

In 2015, Castalia was commissioned by the New Zealand Government to undertake an economic analysis of the impact of SBAS to the New Zealand aviation sector. This study also concluded that an SBAS investment to benefit aviation alone was not justified. It did however note that if the benefits to other sectors of the New Zealand economy were included then the outcome would likely be different.

In late 2016, Geoscience Australia was provided $12 million in funding, along with an additional $2 million from New Zealand, to undertake a two-year SBAS test-bed which would explore applications of L1 GPS SBAS, Dual-Frequency Multi-Constellation SBAS, and Precise

Point Positioning delivered over SBAS channels. A key change of focus of advocacy for SBAS was to emphasise applications of SBAS across Australia's most important industry sectors in addition to aviation.

Geoscience Australia, in collaboration with LINZ, initiated the SBAS test-bed program across Australia and New Zealand. The program was managed by FrontierSI (formerly the Cooperative Research Centre for Spatial Information) who worked with Ernst and Young and an industry consortium to demonstrate the use of the technology. Ultimately the test-bed program concluded that the economic benefits to Australian and New Zealand industries from SBAS would be greater than $7.6 billion over 30 years. These benefits coming from productivity gains through new technologies that automate tasks, reduce risk, and improve safety in a range of operating practices. For example:

- SBAS will improve the accuracy of collision avoidance systems in mining haul trucks, enabling them to operate with greater speed and efficiency, which will generate around $577 million in fuel and labour savings over 30 years;
- Enhanced geo-fencing, or virtual fencing, technology will prevent around 1770 serious injuries in the construction sector;
- Farmers will save around $820 million over 30 years in feed and fertiliser due to improved pasture practices using SBAS-enabled virtual fencing; and
- SBAS will reduce flight delays and diversions and will enable larger aircraft and medivac flights to get to remote areas.

## 2.13 Flight planning and flight notifications

The availability and health of the SouthPAN service is required to be provided to the users of equipped with SBAS avionics ((E)TSO-C145/-C146).

The proposed notification concept will cover SouthPAN Notice To Airmen (NOTAMs) and GPS Receiver Autonomous Integrity Monitoring (RAIM) Prediction Service.

For SouthPAN, there will be two types of NOTAMs:

- SouthPAN NOT AVBL; and
- SouthPAN IS NOT AVBL FOR [Line of Minima].

For GPS RAIM:

- When SouthPAN is not available, the GPS RAIM Prediction Service must be utilised for IFR operations. The forecasts provided in the GPS RAIM Prediction Service will include the same information as those available before the implementation of SouthPAN. This supports the requirement under CASR Part 91 MOS 14.06 [RD-3] for obtaining a prediction of "GNSS integrity availability" and revising the flight plan/planning an alternate if it wasn't available.

ICAO Annex 10 [RD-4], Aeronautical Telecommunications SARPs specifies the need for a NOTAM service:

6.2.6 "Before publishing procedures based on SBAS signals, a State is expected to provide a status monitoring and NOTAM system".

and it goes further:

"[…] a mathematical service
volume model is to be used."

And for timeliness, ICAO specifies:

9.3 "For scheduled events, notification should be given to the NOTAM authority at least 72 hours prior to the event. For unscheduled events, notification to the NOTAM authority should be given within 15 minutes. Notification should be given for events of 15 minutes, or longer, duration."

Accordingly, information as to the availability and health of the SouthPAN service will be provided to aviation users. The NOTAM service will assume that aviation users are equipped with avionics compliant to (E)TSO-C145a/-C146a or later revisions.

NOTAM information for WAAS is given in Appendix 1 and 2.

### 2.13.1 SBAS and RAIM

SouthPAN is compatible with avionics certified to (E)TSO-C145a/-C146a or later. When SouthPAN is operating normally, GNSS satellite health messages are continuously passed to (E)TSO-C145/-C146 equipment, so that the avionics know which of the core GPS satellites can be trusted and which should be ignored. When SouthPAN is available, GPS RAIM forecasts are not required for (E)TSO-C145/-C146 avionics.

SouthPAN may also be unavailable. An aircraft might fly outside the service volume, or a technical issue might cause SouthPAN to fail for a short period of time.

When SouthPAN is not available, pilots must use the GPS RAIM Prediction Service to complete flight planning for all IFR flights.

In addition to SBAS capability, (E)TSO-C145/-C146 avionics have RAIM Fault Detection and Exclusion (FDE) capability, which not only detects an error, but then excludes the faulty satellite from further position calculations. With one satellite failure, the avionics will continue to operate in Fault Detection (FD) mode. If a second GNSS satellite fails, then the avionics will flag the loss of integrity and the pilot must use an alternate means of navigation. For example, a VOR.

Avionics certified to (E)TSO-C129a cannot process SBAS navigation signals and IFR operations must always be supported with a GPS RAIM Prediction. (E)TSO-C129a avionics have RAIM Fault Detection (FD), which checks whether an error exists in the GNSS signals being received. If an error is found, the system will produce a GPS RAIM failure annunciation or alert. When that happens, the avionics may not be used for approach operations.

The current GPS RAIM Prediction Service has three sections:

- (E)TSO-C129a Fault Detection Prediction

  When RAIM FD is forecast not to be available for (E)TSO-C129a avionics, it must be assumed that a RNP APCH will not be possible. During those times, pilots must plan on using another type of approach, such as ILS, VOR or NDB, or reschedule the flight, to avoid the outage period.

- (E)TSO-C145/-C146 Fault Detection Only Prediction

  When GPS RAIM FD is forecast as not available for (E)TSO-C145/-C146 avionics, it must be assumed that a RNP APCH will not be possible. During those times, pilots should plan on using another type of approach, such as ILS, VOR or NDB, or reschedule the flight to avoid the outage period.

- (E)TSO-C145/-C146 Fault Detection and Exclusion Prediction

  When RAIM FDE is forecast not to be available for (E)TSO-C145/-C146 avionics, but RAIM FD is available, an aircraft must be capable of diverting to its alternate aerodrome or schedule its arrival to conduct the approach outside the period of RAIM FDE unavailability. If, on arrival, a RAIM error is not announced by the avionics, the approach may be conducted. However, if a satellite failure occurs during the period of RAIM FDE unavailability, a RAIM failure will be announced, and it will be necessary for the aircraft to divert or hold until RAIM is restored.

When SouthPAN is available, RAIM predictions will be provided by the SouthPAN GNSS RAIM Prediction Service (GRPS). Under consideration with CASA is the need for the provision of FDE.

### 2.13.2 Southern Positioning Augmentation Network NOTAMs

Airservices Australia generate NOTAMs when SouthPAN services are unavailable at a specific aerodrome or over a wider area.

The predictions will utilise a service volume model (SVM) that considers current and anticipated GNSS constellation status and geometry along with the availability of SouthPAN GEO satellites, and compute estimates of the availability of service where GNSS-based approach procedures are published.

The predictions will run twice daily to ensure the most up-to-date information is used, and will compute the expected availability of LPV, SouthPAN-based LNAV/VNAV, and LNAV instrument flight procedures for a period of eighteen hours for all aerodromes in its database.

The prediction will be re-run in response to an unscheduled change in the GNSS constellations. This typically implies a satellite failure.

SouthPAN NOT AVBL would include scheduled events that remove the entire SouthPAN service.

SouthPAN NOT BE AVBL FOR [Line of Minima] would be for:

- LP
- LNAV/VNAV
- LPV

# 3 Aviation Applications

## 3.1 Enroute and terminal

SBAS improves the accuracy, availability, and integrity of GNSS navigation in the enroute and terminal phases of flight. As noted in section 2.13.1, the provision of integrity by SouthPAN obviates the need for GNSS RAIM checks.

SBAS-enabled enroute navigation provides added flexibility for direct routing, which improve airspace capacity and relieves congestion, while reducing fuel use and pollution.

## 3.2 Approach

### 3.2.1 LNAV

LNAV refers to lateral two-dimension (2D) guidance for a GNSS non-precision approach. A RNP APCH to LNAV minima provides continuous guidance for an IFR pilot to fly the correct horizontal path, but it does not provide guidance for the vertical path. The pilot must ensure that the aircraft is at the correct altitude at each fix, adding workload at a critical phase of the flight. The aircraft must not descend below the minimum descent altitude (MDA) unless the pilot has visual contact with the runway environment and satisfies the prescribed visibility.

Some GNSS receivers (including Garmin, Avidyne and Bendix King by Honeywell) are capable of displaying an advisory vertical profile for use on LNAV GNSS approaches. This is generally known as LNAV+V. There are safety-critical differences between LNAV+V and LNAV/VNAV or LPV instrument approaches.

- LNAV+V is a feature implemented by avionics manufacturers, solely for advisory purposes. From an instrument flight procedure design perspective, they are identical to LNAV-only procedures. Procedure designers have no knowledge of its existence; no assurance is given, by anyone, that vertical guidance provided by LNAV+V will protect an aircraft from collision with terrain.
- LNAV+V procedures are not specifically coded into the aircraft's navigation database; the vertical advisory guidance is generated by the GNSS receiver itself and based only on the information used for the 2D LNAV Line of Minima. It is critical that pilots respect and observe all step-down fixes throughout the approach, and not descend below the LNAV MDA unless visual.
- LNAV/VNAV and LPV lines of minima shown on approach charts must not be used when conducting LNAV+V operations.

### 3.2.2 LNAV/VNAV

Approaches with vertical guidance (3D approaches) offer a smooth and stabilised descent. They improve situational awareness and reduce workload.

In Australia, two technologies are available to support the use of LNAV/VNAV Lines of Minima[2]:

- Baro-VNAV, which requires avionics including an air data computer — typically a certified flight management system (FMS) or other suitably certified area navigation system capable of computing barometric VNAV paths and showing relevant vertical deviations (within a range of plus or minus 75 feet) on the cockpit instrument navigation displays.
  - Baro-VNAV relies on highly accurate aircraft digital altimetry, taking into account the aerodrome local QNH and which is subject to temperature limitations.
  - The use of Baro-VNAV is restricted to runways with a validated published RNAV (GNSS) or RNP instrument approach procedure with LNAV/VNAV minima.
  - Baro-VNAV equipment is not capable of, and must not be used to fly to, LPV or LP approach minima.
- The SouthPAN SBAS implementation requires avionics, either stand-alone or within a multi-sensor flight management system, certified to €TSO C145/146, which is capable of processing SBAS signals to generate GNSS corrections of sufficient accuracy and integrity to support vertical guidance.
  - The use of LNAV/VNAV minima with SBAS-enabled avionics is not constrained by temperature limitations printed on approach charts.

For both SBAS and Baro-VNAV equipment, the pilot must specifically select the LNAV/VNAV approach from the navigation system database by name[3]. The navigation database will typically include an indicator of the lowest available approach minima that the navigation system can support. For example the availability of LPV minima may be presented on the navigator as *RNAV 30 GPS LPV*, while LNAV/VNAV minima as *RNAV 30 GPS L/VNAV* for an approach with chart title RNAV-Z (GNSS) or RNP RWY 30.

However, at many locations, LNAV/VNAV landing minimums, which comprise a decision altitude (DA) and visibility requirement, are lower than those for a runway aligned LNAV approach at the same location.

Because Baro-VNAV equipment availability preceded SouthPAN, LNAV/VNAV lines of minima have been provided for some time on many Australian RNAV(GNSS) or RNP approach procedure charts.

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[2] LNAV/VNAV lines of minima are developed specifically for Baro-VNAV, but can be utilised also by SBAS equipped aircraft, since that SBAS accuracy and integrity levels exceeds requirements associated with LNAV/VNAV lines of minima.

[3] A single RNAV (GNSS) or RNP approach may have multiple lines of minima, including LNAV, LNAV/VNAV, LP and/or LPV. The presentation of available minima may differ between navigation systems when selecting an approach. In all cases, pilots must confirm that the navigation system annunciations match the minima being used.

### 3.2.3 LP

Localizer Performance (LP) approaches are 2D approaches designed as a dedicated line of minima on non-precision RNAV(GNSS) or RNP approaches with SBAS-augmented lateral guidance. Similar to Localizer-only procedures (e.g. Cairns LOC RWY 33), they are used in locations where terrain or obstructions do not allow publication of vertically-guided LPV procedures, but provide improved minima over LNAV procedures.

Both LP and LNAV lines of minima are Minimum Descent Altitudes (MDA) rather than DAs. It is possible to have LP and LNAV lines of minima published on the same approach chart. An LP is published if it provides lower minima than the LNAV.

The improved minima is achieved because the lateral guidance is angular, with needle sensitivity increasing as the aircraft gets closer to the missed approach point.

### 3.2.4 LPV

Localizer Performance with Vertical Guidance (LPV) approaches are designed to provide a line of minima that takes advantage of the refined accuracy of SBAS lateral and vertical guidance similar to ILS. Like an ILS, a LPV has continuous vertical guidance and is flown to a Decision Height (DH). The design of an LPV approach incorporates angular guidance with increasing sensitivity as an aircraft gets closer to the runway, or point in space (PinS) for procedures designed for helicopters.

Indicator sensitivities provided by Course Deviation Indicator (CDI) or Horizontal Situation Indicator (HSI) equipment are very similar to those of the ILS at similar distances, which aid pilots in transferring their ILS flying skills to LPV approaches.

The important point is the guidance is angular, with needle sensitivity increasing as the aircraft gets closer to the missed approach point.

### 3.2.5 CAT I, II and III

The term “category” or “CAT” is used to denote different classes of minima for 3D instrument approaches.

- Category I designates a 3D approach with a decision height down to and including 200 ft.
- Category II designates a 3D approach with a decision height down to and including 100 ft.
- Category III designates a 3D approach with a decision height down to and including 0 ft

Whilst LPV approaches with minima equivalent to Category I are possible in Australia, the configuration of the runway environment, including pavement dimensions, markings and lighting, will frequently require higher minima.

## 3.3 Point-in-Space (PinS)

The Point-in-Space (PinS) is an approach procedure designed for helicopters only and includes both a visual and an instrument segment. It is aligned with a reference point located to permit subsequent flight manoeuvring or approach and landing using visual manoeuvring in adequate visual conditions to see and avoid obstacles. There are also PinS departure procedures.

SBAS-augmented GNSS can be used to achieve LPV-equivalent minima, subject to other requirements for approval.

# 4 Instrument Flight Procedures

## 4.1 Design Standards and Designer Requirements

Australia complies with ICAO Standards and Recommended Practices (SARPS) for the design and validation of instrument flight procedures.

Instrument Flight Procedure Designers are certified in accordance with CASR Part 173 requirements.

### 4.1.1 SBAS Instrument Flight Procedures

The design criteria for SBAS NPA, APV and precision approach Category I procedures are described in ICAO Doc 8168 – PANS-OPS [RD-5]. Australian instrument flight procedures must also be designed and validated in compliance with CASR and Manual of Standards (MOS) Part 173. Ground and flight validation requirements are described in ICAO Doc 9906 *Quality Assurance Manual for Flight Procedure Design*.

SBAS LNAV/VNAV, LP, LPV and CAT I instrument approaches will be designed with a nominal glide path angle (GPA) of 3°, unless terrain or obstacle constraints require a steeper angle. The maximum GPA shall be 3.5°.

The approaches shall be aligned will the runway centreline, unless terrain or airport siting issues require an offset alignment. The offset angle from the runway centreline shall not exceed 5°. SBAS instrument approaches cannot utilise offset alignment as a noise abatement measure.

The SBAS APV or CAT I segment includes the final approach and initial and intermediate phases of the missed approach. RNP APCH LNAV obstacle clearance standards are applied to the initial and intermediate approach segments, with angular LPV transitions commencing 2 NM prior to the FAF.

Procedure design criteria for a PinS approach and the detailed design requirements for a visual segment are established in ICAO Procedures for Air Navigation Services — Aircraft Operations, (PANS-OPS, Doc 8168).

### 4.1.2 SBAS Instrument Flight Procedure Designer

The Instrument Flight Procedure Designer for SBAS LPV procedures shall be certified to CASR Part 173 – Instrument Flight Procedure Design.

CASR Part 173 prescribes the requirements for the certification of designers of instrument approach and departure procedures, including:

- the qualifications and training required for persons engaged in instrument flight procedure design;
- the procedures to be used by organisations in the conduct of design work; and
- provisions for on-going maintenance of procedures.

Individuals employed by certified designers must meet these minimum qualification and experience standards.

General validation requirements are contained in MOS 173.

### 4.1.3 Ground and Flight Validation

ICAO Doc 9906 [RD-6] sets out the requirements for flight procedure validation, which may be summarised as follows:

- The full validation process includes ground validation and flight validation.
- Ground validation must always be undertaken. It encompasses a systematic review of the steps and calculations involved in the procedure design as well as the impact of the procedure on flight operations. It must be performed by persons trained in flight procedure design and with appropriate knowledge of flight validation issues.
    - Ground validation consists of an independent IFP design review and pre-flight validation.
- Flight validation consists of flight simulator evaluation and evaluation flown in an aircraft. The IFP validation process must be carried out as part of the initial IFP design as well as for any amendment to an existing IFP.
- If the State can verify—through ground validation—the accuracy and completeness of all obstacle and navigation data considered in the procedure design, and any other factors normally considered in the flight validation, then the flight validation requirement may be dispensed with.
- Flight validation is required under the following conditions:
    - the flyability of a procedure cannot be determined by other means;
    - the procedure requires mitigation for deviations from design criteria;
    - the accuracy and/or integrity of obstacle and terrain data cannot be determined by other means;
    - new procedures differ significantly from existing procedures; and
    - for helicopter PinS procedures.

## 4.2 Channel Numbers

Each SBAS supported approach procedure has a unique channel number that is assigned by ICAO.

Each State has a designated responsible person for coordinating and requesting a channel number through ICAO's online process for assigning the unique channel numbers.

## 4.3 Instrument Approach Procedure Chart

Each of the Approach Categories in Section 3.2 has an approach minimum, also known as a Line of Minima.

For SBAS LPV approaches, there will be a line of minima titled LPV, and depending upon the approach and aerodrome runway. The lowest available Decision Altitude (DA) will be based on a Height above Threshold (HAT) of 200 or 250 feet.

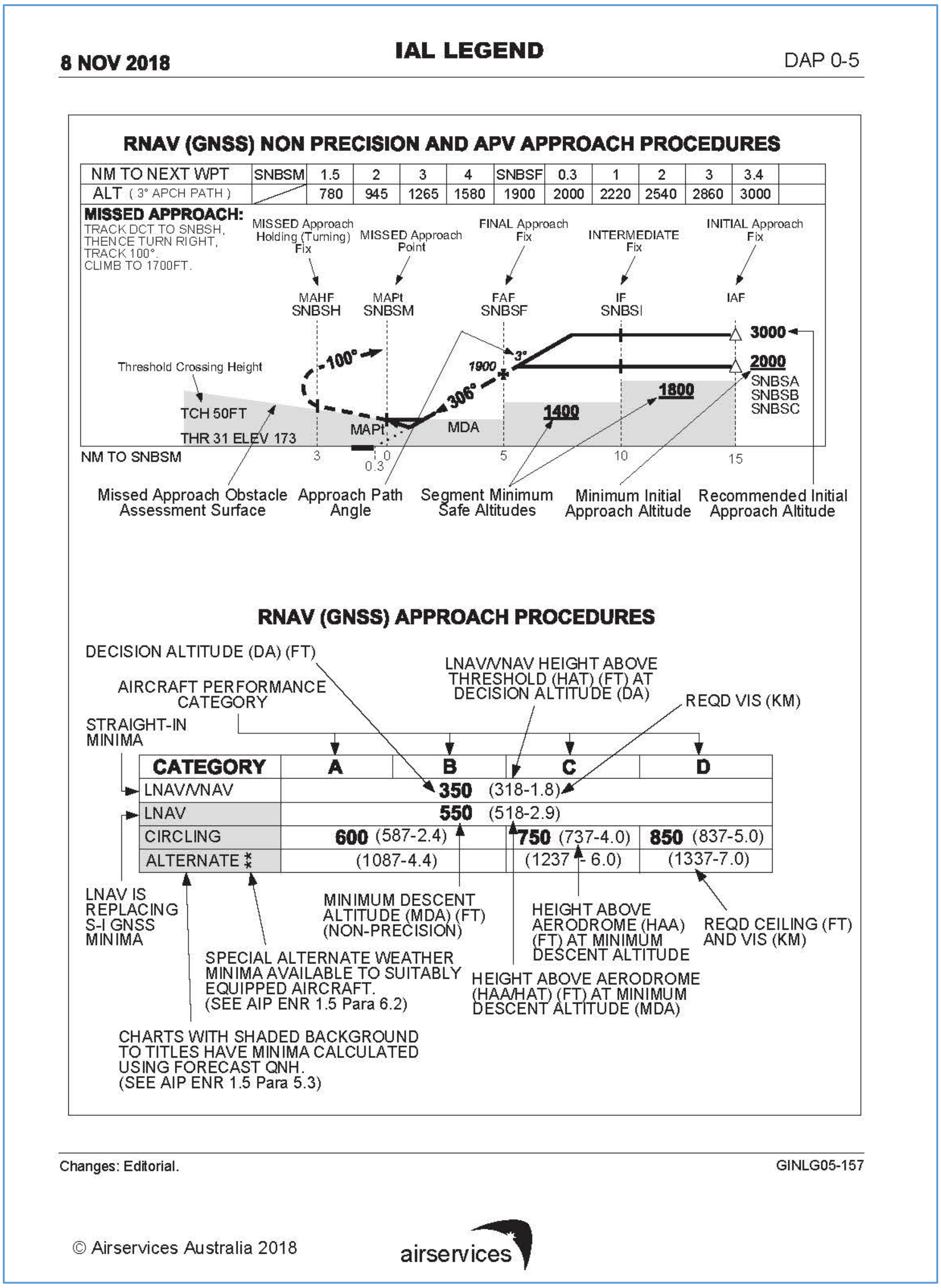


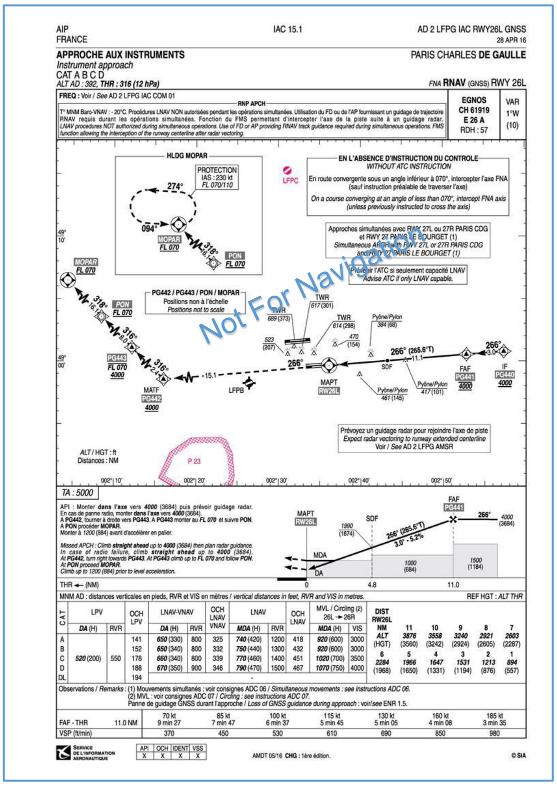

Figure 2 Example of Approach Chart

For an LPV-200 Line of Minima, the 3D RNP Approach has a Decision Height (DH) of 200 feet, and so is equivalent to a CAT I approach. The difference in designation is that a CAT I approach typically provided by an Instrument Landing System (ILS) can be used to provide guidance below the DH provided the pilot has acquired visual reference to the landing runway. For an LPV-200 approach, the SBAS-enabled vertical guidance may only be used to the DH; beyond the DH the pilot must visually navigate the aircraft.

Accordingly, it is not permissible to couple an aircraft's autopilot to SBAS-enabled LPV guidance, below the DH for CAT I, when flying an LPV-200 approach.

The terminology where LPV Line of Minima are 250 feet or higher differ slightly, since this is considered an APV, not CAT I precision approach. However, the same operating logic applies, and pilots must not continue an LPV autopilot-coupled approach below the APV Line of Minima.

LPV Approach Charts for an EGNOS RWY 26L at Paris Charles De Gaulle Airport, and WAAS RWY 22 at Minneapolis/St Paul Airport, are given below as examples:



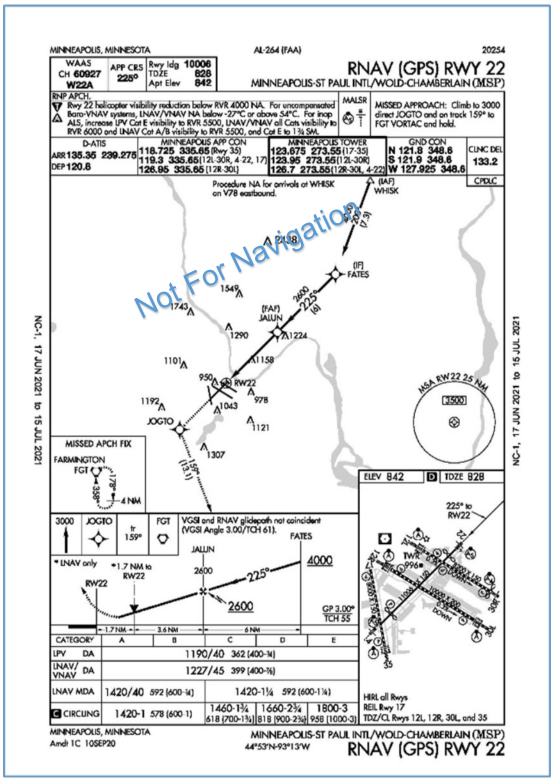




Figure 3 Examples of EGNOS and WAAS Approach Charts

# 5 Air Traffic Control

The instrument approach supported by SouthPAN is a line-of-minima shown on RNP or RNAV(GNSS) approach charts.

Pilots will file a Flight Plan that includes LPV capability in Item 10: Equipment and Capabilities as

B LPV (APV with SBAS)

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| | | |
|---|---|---|
| | M | for military |
| | X | if other than any of the defined categories above |

**Item 9 – Number of Aircraft**

| | |
|---|---|
| Enter | Number of aircraft where there are more than one, otherwise leave blank. |

**Type**

| | |
|---|---|
| Enter | Aircraft type. Where more than one aircraft type is included in a formation, enter the type of the lowest performance aircraft. Additional details regarding the formation must be inserted at Item 18. |
| Requirements | Use the two to four letter ICAO approved aircraft type abbreviation.<br>For aircraft type abbreviations not approved by ICAO, enter ZZZZ and specify the type of aircraft in Item 18 preceded by TYP/. |

**Wake Turbulence Category**

| | | |
|---|---|---|
| Circle | H | for aircraft 136,000KG MTOW or more |
| | M | for aircraft between 7,000 and 136,000KG MTOW |
| | L | for aircraft 7,000KG MTOW or less. |

**Item 10 – Equipment and Capabilities**

Circle to indicate the presence of serviceable equipment that the pilot is qualified to use and where applicable, has authorisations from the State of Registry:

| | |
|---|---|
| N | no COM/NAV/Approach Aid equipment for the route to be flown or the equipment is unserviceable. |
| S | standard COM/NAV/Approach Aid equipment of VHF/ILS/VOR. |
| A | GBAS Landing System |
| B | LPV (APV with SBAS) |
| C | LORAN C |
| D | DME |
| E1 | FMC WPR ACARS |
| E2 | D-FIS ACARS |

Figure 4 AIP Australia ENR 1.10

The phraseology to be used by the appropriate Approach Controller will be as per AIP Australia GEN 3.4, para 6.14 Approach and Area Control Services.

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6.14 **Approach and Area Control Services**

| ***Circumstances*** | ***Phraseologies***<br>* Denotes pilot transmission |
|---|---|
| 1. Departures Instructions | a. TRACK (*three digits*) DEGREES [MAGNETIC] TO (*or* FROM) (*significant point*) [UNTIL (*time*) (*or* REACHING) (*fix or significant point or level*)] |
| 2. Approach Instructions | •a. CLEARED DME (*or* GNSS) ARRIVAL [SECTOR (*identifying letter of the sector*)]<br>b.* REQUEST [STRAIGHT-IN] (*chart title*) APPROACH<br>c. CLEARED [STRAIGHT-IN] (*chart title*) APPROACH [FOLLOWED BY CIRCLING TO RUNWAY (*number*)] |
| RNAV (GNSS) (or RNP APCH) approach via an IAWP or IF | d.* REQUEST (*chart title*) APPROACH VIA (*last two letters of the IAWP or IF designator*)<br>•e. RECLEARED DIRECT *(last two letters of the IAWP or IF designator)* CLEARED (*chart title*) APPROACH<br>f. COMMENCE APPROACH AT (*time*) |
| RNAV (RNP) (or RNP AR APCH) approach where an aircraft has been subject to vectoring or random tracking and is subsequently re-cleared direct to the IAF. | g. RECLEARED DIRECT (*IAF/ Latest Intercept Point designator*) *followed as necessary by:*<br>(i)TRACK VIA (*chart title*) MAINTAIN (*or* DESCEND TO) (*level*)<br>(ii) WHEN ESTABLISHED, CLEARED (*chart title)* APPROACH |

Figure 5 AIP Australia GEN 3.4

Clearance for RNAV or RNP approach authorises descent to the applicable approach minima, subject to satisfying crew qualifications, aircraft equipment and operational requirements.

# 6 Aerodromes

The major operational benefit of SBAS for the aviation industry is the capability to provide Approach Procedures with Vertical guidance (APV).

Because the vast majority of small aircraft (generally, Beechcraft King Air and smaller types) do not have Baro-VNAV equipment, SBAS is the only means by which these aircraft can acquire APV capability at aerodromes that do not have ground ILS or GBAS infrastructure.

In addition to the fitment of SBAS-capable avionics, suitable approach procedures must be designed with specific APV minima. Instrument Flight Procedure designers may utilise:

- LNAV/VNAV procedure criteria, of which a significant number have existed for some time;
- LPV procedure criteria, which can have lower approach minima (ceiling and visibility) compared to LNAV/VNAV due to more precise converging angular horizontal and vertical guidance; and
- LP procedure design criteria, at locations where terrain considerations preclude the use of LPV.

Significant safety gains from APV will be rapidly obtained by SBAS-equipped aircraft that are not Baro-VNAV equipped through the use of existing approach procedures to LNAV/VNAV minima. This does not involve significant change to these procedures.

Unlike GBAS, it is not necessary for a SBAS reference station to be located at an aerodrome to support approach operations – SBAS does not require any infrastructure on the aerodrome.

Similarly, it is not necessary for aerodromes to be equipped with barometric pressure and temperature sensor broadcasting equipment to support SouthPAN-enabled LNAV/VNAV, LPV, or LP approaches. Where an aerodrome barometric pressure setting is not available, or a forecast barometric pressure setting is used, pilots must apply standard compensating increases to the procedure’s approach minima.

## 6.1 Regulated Aerodromes

Civil Aviation Safety Regulations 1998 Part 139 and the Part 139 Manual of Standards provide the rules for aerodromes.

Aerodromes will be either 'regulated' (certified) or 'unregulated'. Aerodromes must be regulated in order to support instrument flight procedures based on SouthPAN augmentation.

### 6.1.1 Aerodrome Facilities

All aerodrome facilities must comply with the applicable standards for each facility, as published in CASA Part 139 (Aerodromes) Manual of Standards.

The change of a runway status from non-instrument to instrument and instrument non-precision to precision approach are deemed to represent facility upgrades.

For example, changing a non-instrument Code 3 runway to a non-precision instrument runway is defined as an “upgrade” and will result in the required runway strip width being increased from 90 m wide to 280 m wide, which will change the origin of the OLS Transitional Surfaces. The inner edge width of the approach surface will also increase from 90 m to 280 m wide.

## 6.2 Non-precision and Precision Runway

Runway categorisation is outlined in CASA MOS Part 139. An instrument runway means one of the following types of runways nominated for the use of aircraft using instrument approach procedures:

- Non-precision approach runway. A runway served by visual aids and non-visual aid(s) intended for landing operations following an instrument approach operation Type A and a visibility not less than 1 000 m.
- Precision approach runway, category I. A runway served by visual aids and non-visual aid(s) intended for landing operations following an instrument approach operation Type B with a decision height (DH) not lower than 60 m (200 ft) and either a visibility not less than 800 m or a runway visual range not less than 550 m.

As a consequence, LPV-200 operations:

- With DH ≥ 250 ft (Type A instrument approach operation) may be promulgated at both category I precision approach runway-ends and non-precision approach runways.
- With DH < 250 ft (Type B instrument approach operation) must only be promulgated at category I precision approach runway-ends.

## 6.3 Survey Requirements

An aerodrome operator must protect the aerodrome’s obstacle limitation surfaces to the limits specified in the Manual of Standards Part 139 (Aerodromes) version 1.15 if the standards that existed prior to 13 August 2020 have been grandfathered under the provisions contained in Chapter 2 of the Part 139 (Aerodromes) Manual of Standards. If the grandfathering provisions are not available, the Obstacle Limitation Surface must comply with Table 7.15 (1) contained in Chapter 7 or the Part 139 (Aerodromes) Manual of Standards.

## 6.4 Runway Dimension

Requirements for Runway Strips are unchanged by the existence of SBAS enabled procedures. Refer to the MOS Part 139, Section 6.

## 6.5 Airfield Lighting

Airfield Lighting and Markings shall meet the requirements of Part 139 Manual of Standards Aerodromes.

# 7 Aircraft Operators

In order to establish that an aircraft is equipped with a GNSS meeting RNP APCH requirements, relevant documentation, specific to the aircraft, must be examined.

The starting point for most non-airline aircraft is the Aircraft Flight Manual (AFM), which will include statements of compliance for relevant navigation standards. Often, this information is provided in an AFM Supplement.

CASA Part 91 Manual of Standards Chapter 26 sets out the basic requirements for an aircraft to be eligible for IFR operations including RNP APCH.

Many Australian IFR aircraft were previously equipped with SBAS-compatible avionics in order to satisfy requirements for Automatic Dependent Surveillance Broadcast (ADS-B) surveillance transmissions.

Individual approvals by CASA are not required where an aircraft's documentation satisfies the deeming provisions, or where a CAR 21J/M organisation or person has issued an approval.

Aircraft owners should note that requirements for fitment and crew qualifications are dependent on the relevant CASR part governing the operation.

## 7.1 Aircraft Equipment

In accordance with CASA Part 91 Manual of Standards Chapter 26 or other relevant requirements, all Australian registered aircraft operating under the IFR are required to be equipped with GNSS navigation equipment capable of operating to the applicable PBN Navigation Specification.

IFR aircraft in Australia must be equipped with a GNSS navigation system which satisfies, or is equivalent to (E)TSO-C129( ), (E)TSO-C145( ), (E)TSO-C146( ) or (E)TSO-C196a.

Equipment requirements for air transport and larger aircraft are specified in CASR Part 121 (Australian Air Transport Operations – Larger Aeroplanes) Manual of Standards 2020 [RD-8]

### 7.1.1 Stand-Alone Navigation Equipment

Avionics certified to (E)TSO-C146 (or equivalent) are capable of utilising SouthPAN SBAS-derived augmentation, although individual aircraft installations may have manufacturer and configuration dependencies.

Equipment compliant with (E)TSO-C146 are stand-alone navigation systems, where the system's navigation functions do not depend on interconnection with other aircraft equipment.

These avionics revert to Receiver Autonomous Integrity Monitoring (RAIM) when SBAS is not available.

GNSS stand-alone navigation systems known to comply with TSO-C146a or later include:

- Avidyne IFD 540/440
- Bendix King by Honeywell KSN 765 and KSN 770
- Garmin GPS/GNS 400/500W series
- Garmin GTN and GTN Xi series

- Garmin GPS 175 and GNX 375.

Note that this list is not intended to be all inclusive and does not imply that the product supports SouthPAN, which may vary by manufacturer and model.

### 7.1.2 Multi-Sensor Flight Management System (FMS)

Avionics certified to (E)TSO-C145 (or equivalent) are capable of utilising SouthPAN SBAS-derived augmentation, although individual aircraft installations may have manufacturer and configuration dependencies.

Equipment compliant with TSO-C145 generally forms part of a multi-sensor Flight Management System (FMS).

Compliant multimode receivers include:

- Collins Aerospace Multimode Receiver (GLU-2100)[4]
- Honeywell Integrated Multi-Mode Receiver (iMMR) [Appendix 3]

### 7.1.3 Equipment Standards

Avionics intended for use with SouthPAN (and other SBAS) must comply with FAA/EASA (E)TSO-C145a, or (E)TSO-C146a, or later versions.

- TSO-C145c defines an acceptable standard for Airborne Navigation Sensors using GPS augmentation using the FAA WAAS.
- TSO-C146c defines an acceptable standard for Stand-Alone Airborne Navigation Equipment using GPS augmentation using the FAA WAAS.

There are no plans to withdraw authorisations for TSO-C145a/C146a or TSO-C145b/C146b equipment.

AIP GEN 1.5 sets out the required navigation aids to be carried on IFR flights, or night VFR flights, in Australian airspace.

## 7.2 Airworthiness Considerations

CASA AC 21-36 *Global Navigation Satellite Systems (GNSS) Equipment: Airworthiness Guidelines* [RD-23] provides advice in relation to airworthiness considerations for GNSS equipment installations in Australian aircraft.

Rules applicable to navigation databases are set out in CASR Part 91 Manual of Standards [RD-7], Section 14.07. Refer to Section 1.07 for definitions applicable to database providers and Letters of Approval.

[4] https://rgl.faa.gov/Regulatory_and_Guidance_Library/rgTSO.nsf/0/B37A7ED9B284803C862582B3005B62F9?OpenDocument

## 7.3 Database Requirements

Navigation data used to fly RNAV (GNSS) or RNP procedures, including procedures SBAS-enabled lines of minima, must satisfy the requirements of ICAO Annex 15. [RD-16]

Aircraft operators are required to ensure the quality, accuracy and integrity of the data loaded into their avionics.

## 7.4 Pilot Qualifications, Competency and Recency Requirements

Pilots must only use RNAV or RNP procedures, including SBAS-enabled procedures, if they are qualified to do so.

Pilots should be familiar with the following items prior to conducting LPV approaches, many of which are common with PBN RNP APCH:

1. The meaning and proper use of aircraft equipment/navigation suffixes.
2. Procedure characteristics as determined from chart depiction and textual description.
3. Use of navigation system including procedure selection and ILS look-alike principle:
   a) Methods to select approaches (i.e., procedure name menus or channel number) and confirming correct approach ID/reference path identifier (RPI).
   b) No manual change of waypoints included in the approach.
   c) Flying the procedure.
5. Distinction between ILS flight guidance cues and LPV guidance cues.
6. Required navigation equipment for approach operations using SouthPAN or any operational restrictions/limitations, as outlined in the Airplane Flight Manual, Rotorcraft Flight Manual, Approved Flight Manual Supplements, Operations Specification, or Letter of Authorisation.
7. Levels of automation, mode annunciations, changes alerts, interactions reversions, and degradations.
8. Functional integration with other aircraft systems.
9. Set-up and interpretation of electronic displays and symbols.
10. Use of LNAV mode(s).
11. Use of VNAV mode(s).
12. Understanding the performance requirement and the fail-down capabilities of the system.
13. ATC procedures/phraseology.
14. Functionality of vector to final mode.
15. Flight crew contingency procedures for a loss of GPS and/or SouthPAN capability to emphasize maintaining separation from terrain, obstacles and other aircraft.
16. Impact of aircraft integrations that incorporate both (SouthPAN) LPV/LP capability and Baro-VNAV capability.
17. Alternate airport requirements and selection of an alternate airport.

## 7.5 Pilot Training

As is the case for other forms of PBN RNP APCH, pilots who wish to make use of LPVs need to have the necessary training, authorisations, and materials.

A training program that provides both theoretical and practical training is necessary. The degree of detail and extent of training required for an Australian pilot to utilise SouthPAN is dependent on the pilot's existing qualifications, recency, and prior experience with 3D approaches.

Flight operations conducted under an Air Operator's Certificate (AOC) are also subject to the requirements associated with the relevant approvals.

Where a pilot has no prior experience with PBN RNP APCH operations, the training requirements would typically cover the following:

- PBN concept;
- Navigation specifications;
- Use of PBN;
- PBN Operations; and
- Requirements of Specific RNAV and RNP specifications.

Training programs typically utilise a simulator, training device, or line training in an aircraft, to gain proficiency in RNAV (GNSS) and other RNP approaches.

Operators should develop a program and make sure pilots are trained in the following areas before being allowed to conduct RNP APCH operations to LPV minima:

1. **Operational Source Documents:** Ensure that the operator and pilots know of and reference the appropriate source documents for the operation, including:
    a) Instrument Flying Handbook;
    b) Instrument Procedures Handbook;
    c) Aeronautical Information Publication (AIP); and
    d) ICAO DOC 9613 PBN Manual. [RD-12]
2. **Pilot Training:** Ensure the crew has proper training regarding:
    a. Whether FMS avionics used with SouthPAN are capable of supporting all lines of minima; and
    b. The use of avionics to comply with LPV approaches in accordance with the manufacturer operations manual.
3. **Development of Contingency Procedures:** Ensure that operators and pilots understand and comply with regulatory requirements applicable to avionics that make use of SouthPAN capabilities.

# 8 Helicopter Operations

## 8.1 Point-In-Space (PinS)

[RD-9]

The Point-in-Space approach is based on GNSS or SBAS and is an approach procedure designed for helicopters only that includes both a visual and an instrument segment. Therefore, it can be published with LNAV and/or LPV minima.

- Obstacle clearance is provided for all IFR segments of the procedure including the missed approach segment.
- During an approach to land, the instrument segment ends at the PinS Missed Approach Point (MAPt). From there, flight continues with a visual segment.
- In an approach procedure, the visual segment (VS) is the segment of a helicopter PinS approach between a point (MAPt) and the heliport or the landing location.

**Visual Segment (VS)**

1) The PinS approach procedure includes either a ***"proceed visually"*** instruction of a "***proceed VFR"*** instruction from the MAPt to the heliport or landing location.
2) **Proceed VFR:** developed for heliport or landing locations that do not meet the standards for a heliport. The PinS instrument approach delivers the helicopter to a MAPt. Prior to or at the MAPt, the pilot shall decide to proceed VFR or to execute a missed approach, based on visibility.
    - Pilot determines whether visibility is met based on the published minimum visibility or the visibility required by State regulations (whichever is higher)
    - There is no protection after the MAPt if MA is not initiated. The pilot is responsible to see and avoid obstacles

    **Proceed visually**: developed for a heliport or a landing location. The PinS instrument approach segment delivers the helicopter to a MAPt. Prior to or at the MAPt, the pilot shall decide to proceed visually to the heliport or landing location or to execute a missed approach

    - A **Direct VS** or a **Manoeuvring VS** connects the MAPt to the heliport or landing location
    - The minimum visibility is based on the distance from the MAPt to the heliport or landing location
    - IFR obstacle clearance areas are not applied to the visual segment. However the visual segment is protected, by operational limitations in the case of "manoeuvring" VS

[RD-10]

The Point-in-Space (PinS) concept is a flight operation based on GNSS and designed for helicopters only. It relies on the possibility for the pilot to conduct flight under Instrument Meteorological Conditions (IMC) to/from a Point-in-Space (PinS) and not directly to/from the heliport. Those procedures enable to implement IFR procedures on non-instrument

FATO (Final Approach and Take-Off) located on aerodromes or isolated heliports as well as landing locations.

Two kinds of PinS operations are possible: PinS departure operations and PinS approach operations and the scope of this document is the PinS approach operations.

PinS approach operations can be summarized as follows:

- The pilot conducts flight under Instrument Flight Rules (IFR) from the Initial Approach Fix (IAF) to a Point-in-Space (PinS), which is considered as a missed approach point (MAPt). This part of the operation is the **instrument flight phase**.
- Then,
  - if appropriate visual references are obtained, the pilot proceeds using visual references from the PinS to the FATO. This part of the operation is the **visual flight phase**;
  - if appropriate visual references are not obtained, the pilot performs an instrument missed approach procedure. This operation is part the **instrument flight phase**.

PinS departure operations can be summarized as follows:

- The pilot proceeds using visual references from the FATO to a Point in Space called the IDF (Initial Departure Fix). This part of the operation is the **visual flight phase** which could be:
  - a “proceed visually” procedure; or
  - a “proceed VFR” procedure.
- The **instrument flight phase** starts once the pilot has passed the IDF at or above a certain altitude (MCA: Minimum Crossing Altitude).

PinS departure procedures are designed in accordance with ICAO Doc 8168 Volume II

Two types of visual flight phase are possible for the PinS approach:

- PinS “*proceed visually*” approach; and
- PinS “*proceed VFR*” approach

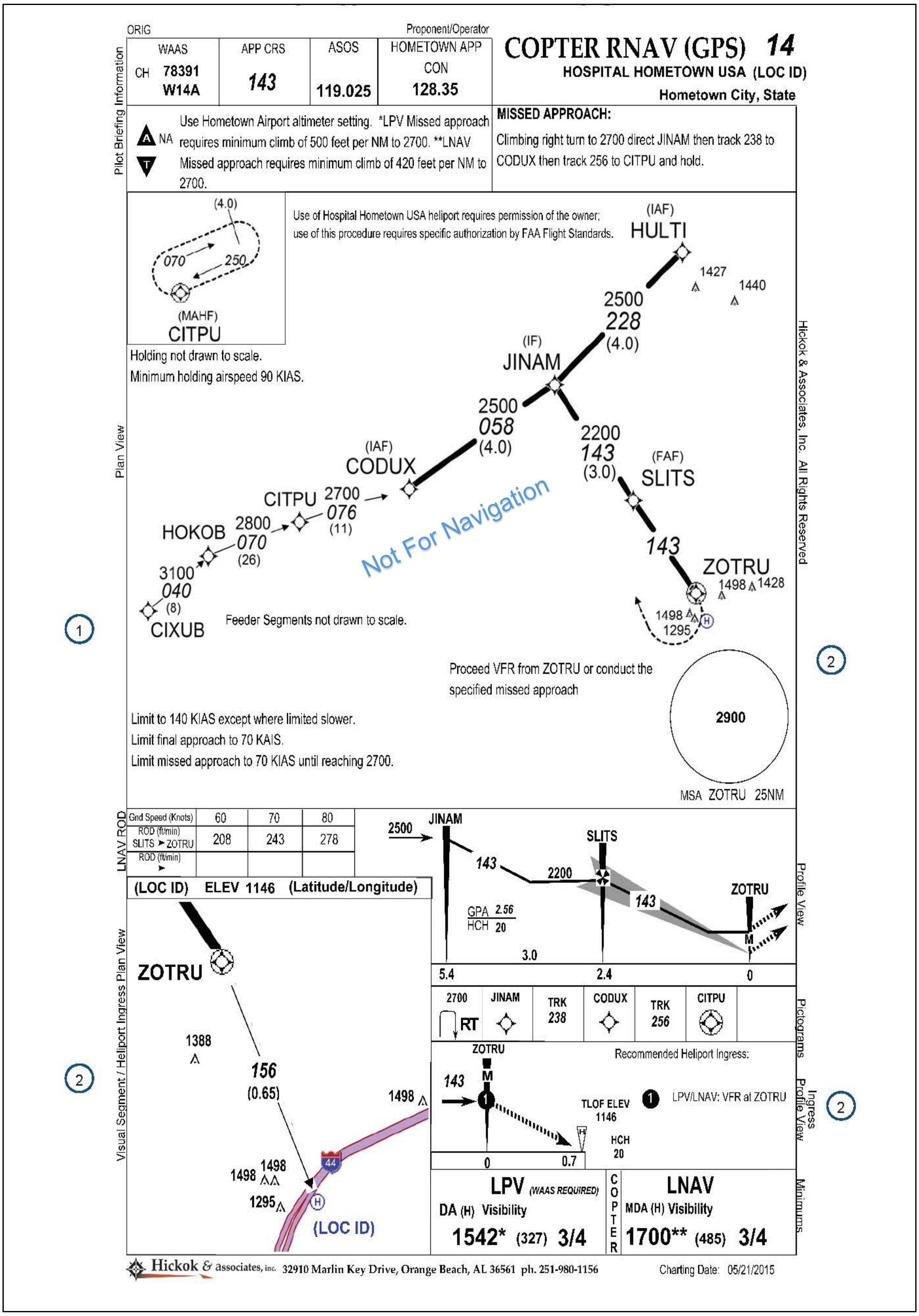


Figure 6 Example Approach Chart with LPV (Hickok & Associates Inc)

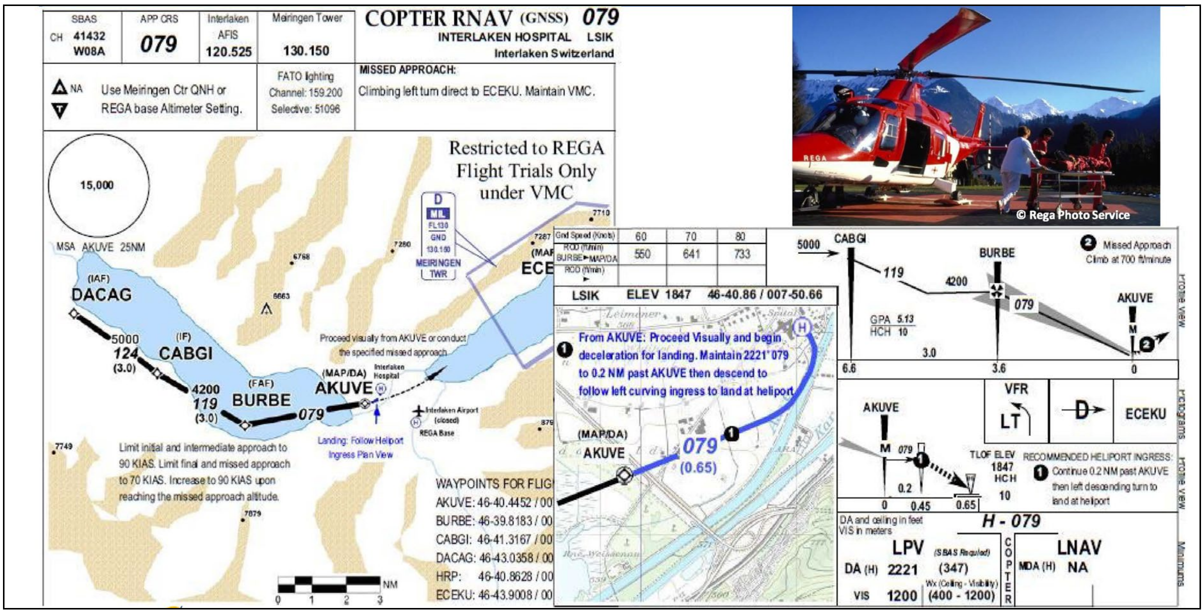


Figure 7 PBN Point in Space (PinS) Approach – EGNOS Training [RD-11]

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# List of Acronyms

Table 1 List of Acronyms

| | |
|---|---|
| AC | Advisory Circular |
| ADS-B | Automatic Dependent Surveillance Broadcast |
| AFM | Aircraft Flight Manual |
| AIP | Aeronautical Information Publication |
| ANGA | Augmented Navigation for Africa |
| AOC | Air Operator's Certificate |
| APV | Approach with Vertical guidance |
| ASTRA | Australian Strategic Air Traffic Management Group |
| ATC | Air Traffic Control |
| ATS | Air Traffic Services |
| Baro-VNAV | Barometric vertical navigation |
| BDSBAS | BeiDou Satellite Based Augmentation System |
| CAANZ | Civil Aviation Authority of New Zealand |
| CAO | Civil Aviation Order |
| CAR | Civil Aviation Regulations 1988 |
| CASA | Civil Aviation Safety Authority |
| CASR | Civil Aviation Safety Regulations 1998 |
| CDI | Course Deviation Indicator |
| CFIT | Controlled Flight Into Terrain |
| CPF | Central Processing Facility |
| DA | Decision Altitude |
| DFMC | Dual Frequency Multi-Constellation |

| | |
|---|---|
| DH | Decision Height |
| DME | Distance Measuring Equipment |
| EDAS | EGNOS Data Access Service |
| EGNOS | European Geostationary Navigation Overlay System |
| ESSP | European Satellite Services Provider |
| FAF | Final Approach Fix |
| FAS DB | Final Approach Segment Data Block |
| FATO | Final Approach and Take-Off |
| FD | Fault Detection |
| FDE | Fault Detection and Exclusion |
| FIR | Flight Information Region |
| FMS | Flight Management System |
| GA | Geoscience Australia |
| GAGAN | GPS Aided Geostationary Earth Orbit Augmented Navigation |
| GBAS | Ground Based Augmentation System |
| GEO | Geostationary Earth Orbit |
| GLONASS | Global Orbiting Navigation Satellite System |
| GNSS | Global Navigations Satellite System |
| GPA | Glide Path Angle |
| GPS | Global Positioning System |
| GRS | GNSS Reference Station |
| GSA | European Global Navigation Satellite Systems Agency |
| HAT | Height Above Threshold |
| HSI | Horizontal Situation Indicator |
| IAF | Initial Approach Fix |

| | |
|---|---|
| ICAO | International Civil Aviation Organisation |
| IDF | Initial Departure Fix |
| IFR | Instrument Flight Rules |
| ILS | Instrument Landing System |
| IMC | Instrument Meteorological Conditions |
| KARI | Korean Aerospace Research Institute |
| KASS | Korean Augmentation Satellite System |
| L1 | GPS L1 Band: 1575.42 MHz with a bandwidth of 15.345 MHz |
| LINZ | Land Information New Zealand |
| LNAV | Lateral navigation |
| LNAV/VNAV | Lateral navigation with vertical navigation |
| LP | Localiser Performance |
| LPV | Localiser Performance with Vertical guidance |
| MAPt | Missed Approach Point |
| MCA | Minimum Crossing Altitude |
| MCS | Master Control Station |
| MDA | Minimum Descent Altitude |
| MOS | Manual of Standards |
| MRS | Monitoring and Ranging Station |
| MSAS | MTSAT Satellite Based Augmentation System |
| MTSAT | Multi-Functional Transport Satellite |
| NDB | Non Directional Beacon |
| NLES | Navigation Land Earth Station |
| NOTAM | Notice to Airmen |
| NPA | Non-Precision Approach |

| | |
|---|---|
| OAS | Obstacle Assessment Surface |
| OCA/H | Obstacle Clearance Altitude/Height |
| OS | Open Service |
| PANS-OPS | Procedures for Air Navigation Services – Aircraft Operations |
| PBN | Performance Based Navigation |
| PinS | Point-in-Space |
| PPP | Precise Point Positioning |
| PRN | Pseudorandom Noise Number |
| QZSS | Quasi-zenith satellite system |
| RAIM | Receiver Autonomous Integrity Monitoring |
| RNP | Required Navigation Performance |
| RNP APCH | RNP Approach |
| RPI | Reference Path Indicator |
| SARPs | Standards and Recommended Practices (of ICAO) |
| SAS | Société par Actions Simplifiée or simplified joint-stock company in English, similar to a limited company |
| SBAS | Satellite Based Augmentation System |
| SDCM | System of Differential Correction and Monitoring |
| SID | Standard Instrument Departure |
| SiS | Signal in Space |
| SoL | Safety of Life |
| SouthPAN | Southern Positioning Augmentation Network |
| STAR | Standard Instrument Arrival |
| SVM | Service Volume Model |
| TSO | Technical Standard Order |
| VAL | Vertical Alert Limit |

| | |
|---|---|
| VNAV | Vertical navigation |
| VOR | VHF Omnidirectional Radio Range |
| VPL | Vertical Protection Level |
| VS | Visual Segment |
| WAAS | Wide Area Augmentation System |

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# Reference Documents

Table 2 Reference Documents

| | |
|---|---|
| [RD-1] | MSAS Development presentation to GBAS/SBAS International Workshop, Seoul, 3-5 June 2019 – Susumu Daito, Electronic Navigation Research Institute |
| [RD-2] | GAGAN (GPS Aided Geo Augmented Navigation) – Airports Authority of India |
| [RD-3] | Part 91 (General Operating and Flight Rules) Manual of Standards |
| [RD-4] | ICAO Annex 10 – Aeronautical Telecommunications |
| [RD-5] | ICAO Doc 8168 – Procedures for Air Navigation Services Aircraft Operations PANSOPS |
| [RD-6] | ICAO Doc 9906 – Quality Assurance Manual for Flight Procedure Design |
| [RD-7] | CASR Part 91 Manual of Standards, Chapter 26 |
| [RD-8] | CASR Part 121 (Australian Air Transport Operations – Larger Aeroplanes) Manual of Standards 2020 |
| [RD-9] | EGNOS – Flight Crew Basic Theoretical Training<br>for RNP APCH Down to LPV Minima |
| [RD-10] | Helicopter Point in Space Operations in controlled and Uncontrolled airspace - Generic Safety Case |
| [RD-11] | Flight Crew Basic Theoretical Training for RNP APCH Down to LPV Minima Issue 1.2 – October 2017 |
| [RD-12] | ICAO Doc 9613 – Performance Based Navigation (PBN) Manual |
| [RD-13] | ICAO Annex 4 – Aeronautical Charts |
| [RD-14] | ICAO Annex 6 – Operation of Aircraft |
| [RD-15] | ICAO Annex 14 - Aerodromes |
| [RD-16] | ICAO Annex 15 – Aeronautical Information Services |
| [RD-17] | RTCA DO-229D Minimum Operational Performance Standards for Global |

| | |
|---|---|
| | Positioning System/Wide Area Augmentation System Airborne Equipment |
| [RD-18] | EGNOS – How To Become Compliant With European Requirements For RNP APCH Operations To LPV Minima |
| [RD-19] | Aeronautical Information Manual – Official Guide to Basic Information and ATC Procedures: US Department of Transportation, August 15, 2019 |
| [RD-20] | AIP Australia, 27 Feb 2020 |
| [RD-21] | Transport Canada Aeronautical Information Manual (TC AIM) – TP 14371 |
| [RD-22] | GNSS NOTAM – AI Operations-9 27-28 November 2013, Aline Troadec, RNAV Approach Specialist , Eurocontrol |
| [RD-23] | CASA AC 21-36 Global Navigation Satellite Systems (GNSS) Equipment: Airworthiness Guidelines |

# Appendix 1 Extract from FAA – Aeronautical Information Manual

[RD-19]

Extract from Federal Aviation Administration - Aeronautical Information Manual

August 15, 2019

Pgs 1−1−30 …

**c. General Requirements**

**1.** WAAS avionics must be certified in accordance with Technical Standard Order (TSO) TSO−C145a, Airborne Navigation Sensors Using the (GPS) Augmented by the Wide Area Augmentation System (WAAS); or TSO−C146a, Stand−Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS), and installed in accordance with Advisory Circular (AC) 20−130A, Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors, or AC 20−138A, Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for Use as a VFR and IFR Navigation System.

**2.** GPS/WAAS operation must be conducted in accordance with the FAA−approved aircraft flight manual (AFM) and flight manual supplements. Flight manual supplements will state the level of approach procedure that the receiver supports. IFR approved WAAS receivers support all GPS only operations as long as lateral capability at the appropriate level is functional. WAAS monitors both GPS and WAAS satellites and provides integrity.

**3.** GPS/WAAS equipment is inherently capable of supporting oceanic and remote operations if the operator obtains a fault detection and exclusion (FDE) prediction program.

**4.** Air carrier and commercial operators must meet the appropriate provisions of their approved operations specifications.

**5.** Prior to GPS/WAAS IFR operation, the pilot must review appropriate Notices to Airmen (NOTAMs) and aeronautical information. This information is available on request from a Flight Service Station. The FAA will provide NOTAMs to advise pilots of the status of the WAAS and level of service available.

**(a)** The term MAY NOT BE AVBL is used in conjunction with WAAS NOTAMs and indicates that due to ionospheric conditions, lateral guidance may still be available when vertical guidance is unavailable. Under certain conditions, both lateral and vertical guidance may be unavailable. This NOTAM language is an advisory to pilots indicating the expected level of WAAS service (LNAV/VNAV, LPV, LP) may not be available.

EXAMPLE−

!FDC FDC NAV WAAS VNAV/LPV/LP MINIMA MAY NOT BE AVBL 1306111330-1306141930EST

or

!FDC FDC NAV WAAS VNAV/LPV MINIMA NOT AVBL, WAAS LP MINIMA MAY NOT BE AVBL 1306021200-1306031200EST

WAAS MAY NOT BE AVBL NOTAMs are predictive in nature and published for flight planning purposes. Upon commencing an approach at locations NOTAMed WAAS MAY NOT BE AVBL, if the WAAS avionics indicate LNAV/VNAV or LPV service is available, then vertical guidance may be used to complete the approach using the displayed level of service. Should an outage occur during the approach, reversion to LNAV minima or an alternate instrument approach procedure may be required. When GPS testing NOTAMS are published and testing is actually occurring, Air Traffic Control will advise pilots requesting or cleared for a GPS or RNAV (GPS) approach that GPS may not be available and request intentions. If pilots have reported GPS anomalies, Air Traffic Control will request the pilot's intentions and/or clear the pilot for an alternate approach, if available and operational.

(b) WAAS area-wide NOTAMs are originated when WAAS assets are out of service and impact the service area. Area−wide WAAS NOT AVAILABLE (AVBL) NOTAMs indicate loss or malfunction of the WAAS system. In flight, Air Traffic Control will advise pilots requesting a GPS or RNAV (GPS) approach of WAAS NOT AVBL NOTAMs if not contained in the ATIS broadcast.

EXAMPLE−

For unscheduled loss of signal or service, an example NOTAM is: !FDC FDC NAV WAAS NOT AVBL 1311160600− 1311191200EST.

For scheduled loss of signal or service, an example NOTAM is: !FDC FDC NAV WAAS NOT AVBL 1312041015- 1312082000EST.

(c) Site−specific WAAS MAY NOT BE AVBL NOTAMs indicate an expected level of service; for example, LNAV/VNAV, LP, or LPV may not be available. Pilots must request site−specific WAAS NOTAMs during flight planning. In flight, Air Traffic Control will not advise pilots of WAAS MAY NOT BE AVBL NOTAMs.

NOTE −

Though currently unavailable, the FAA is updating its prediction tool software to provide this site-service in the future.

(d) Most of North America has redundant coverage by two or more geostationary satellites. One exception is the northern slope of Alaska. If there is a problem with the satellite providing coverage to this area, a NOTAM similar to the following example will be issued:

EXAMPLE −

!FDC 4/3406 (PAZA A0173/14) ZAN NAV WAAS SIGNAL MAY NOT BE AVBL NORTH OF LINE FROM 7000N150000W TO 6400N16400W. RMK WAAS USERS SHOULD CONFIRM RAIM AVAILABILITY FOR IFR OPERATIONS IN THIS AREA. T-ROUTES IN THIS SECTOR NOT AVBL. ANY REQUIRED ALTERNATE AIRPORT IN THIS AREA MUST HAVE AN APPROVED INSTRUMENT APPROACH PROCEDURE OTHER THAN GPS THAT IS ANTICIPATED TO BE OPERATIONAL AND AVAILABLE AT THE ESTIMATED TIME OF ARRIVAL AND WHICH THE AIRCRAFT IS EQUIPPED TO FLY. 1406030812-1406050812EST.

6. When GPS−testing NOTAMS are published and testing is actually occurring, Air Traffic Control will advise pilots requesting or cleared for a GPS or RNAV (GPS) approach that GPS may not be available and request intentions. If pilots have reported GPS anomalies, Air Traffic Control will request the pilot's intentions and/or clear the pilot for an alternate approach, if available and operational.

EXAMPLE− Here is an example of a GPS testing NOTAM: !GPS 06/001 ZAB NAV GPS (INCLUDING WAAS, GBAS, AND ADS-B) MAY NOT BE AVAILABLE WITHIN A 468NM

RADIUS CENTERED AT 330702N1062540W (TCS 093044) FL400-UNL DECREASING IN AREA WITH A DECREASE IN ALTITUDE DEFINED AS: 425NM RADIUS AT FL250, 360NM RADIUS AT 10000FT, 354NM RADIUS AT 4000FT AGL, 327NM RADIUS AT 50FT AGL. 1406070300-1406071200.

7. When the approach chart is annotated with the symbol, site−specific WAAS MAY NOT BE AVBL NOTAMs or Air Traffic advisories are not provided for outages in WAAS LNAV/VNAV and LPV vertical service. Vertical outages may occur daily at these locations due to being close to the edge of WAAS system coverage. Use LNAV or circling minima for flight planning at these locations, whether as a destination or alternate. For flight operations at these locations, when the WAAS avionics indicate that LNAV/VNAV or LPV service is available, then the vertical guidance may be used to complete the approach using the displayed level of service. Should an outage occur during the procedure, reversion to LNAV minima may be required.

NOTE −

Area−wide WAAS NOT AVBL NOTAMs apply to all airports in the WAAS NOT AVBL area designated in the NOTAM, including approaches at airports where an approach chart is annotated with the W symbol.

8. GPS/WAAS was developed to be used within GEO coverage over North America without the need for other radio navigation equipment appropriate to the route of flight to be flown. Outside the WAAS coverage or in the event of a WAAS failure, GPS/WAAS equipment reverts to GPS−only operation and satisfies the requirements for basic GPS equipment. (See paragraph 1−1−17 for these requirements).

9. Unlike TSO−C129 avionics, which were certified as a supplement to other means of navigation, WAAS avionics are evaluated without reliance on other navigation systems. As such, installation of WAAS avionics does not require the aircraft to have other equipment appropriate to the route to be flown. (See paragraph 1−1−17d for more information on equipment requirements.)

(a) Pilots with WAAS receivers may flight plan to use any instrument approach procedure authorized for use with their WAAS avionics as the planned approach at a required alternate, with the following restrictions. When using WAAS at an alternate airport, flight planning must be based on flying the RNAV (GPS) LNAV or circling minima line, or minima on a GPS approach procedure, or conventional approach procedure with “or GPS” in the title. Code of Federal Regulation (CFR) Part 91 non−precision weather requirements must be used for planning. Upon arrival at an alternate, when the WAAS navigation system indicates that LNAV/ VNAV or LPV service is available, then vertical guidance may be used to complete the approach using the displayed level of service. The FAA has begun removing the A **NA** (Alternate Minimums Not Authorized) symbol from select RNAV (GPS) and GPS approach procedures so they may be used by approach approved WAAS receivers at alternate airports. Some approach procedures will still require the A **NA** for other reasons, such as no weather reporting, so it cannot be removed from all procedures. Since every procedure must be individually evaluated, removal of the A **NA** from RNAV (GPS) and GPS procedures will take some time.

NOTE −

Properly trained and approved, as required, TSO-C145() and TSO-C146() equipped users (WAAS users) with and using approved baro-VNAV equipment may plan for LNAV/VNAV DA at an alternate airport. Specifically authorized WAAS users with and using approved baro-VNAV equipment may also plan for RNP 0.3 DA at the alternate airport as long as the pilot has verified RNP availability through an approved prediction program.

d. Flying Procedures with WAAS

1. WAAS receivers support all basic GPS approach functions and provide additional capabilities. One of the major improvements is the ability to generate glide path guidance, independent of ground equipment or barometric aiding. This eliminates several problems such as hot and cold temperature effects, incorrect altimeter setting, or lack of a local altimeter source. It also allows approach procedures to be built without the cost of installing ground stations at each airport or runway. Some approach certified receivers may only generate a glide path with performance similar to Baro−VNAV and are only approved to fly the LNAV/VNAV line of minima on the RNAV (GPS) approach charts. Receivers with additional capability (including faster update rates and smaller integrity limits) are approved to fly the LPV line of minima. The lateral integrity changes dramatically from the 0.3 NM (556 meter) limit for GPS, LNAV, and LNAV/VNAV approach mode, to 40 meters for LPV. It also provides vertical integrity monitoring, which bounds the vertical error to 50 meters for LNAV/VNAV and LPVs with minima of 250' or above, and bounds the vertical error to 35 meters for LPVs with minima below 250'.

2. When an approach procedure is selected and active, the receiver will notify the pilot of the most accurate level of service supported by the combination of the WAAS signal, the receiver, and the selected approach, using the naming conventions on the minima lines of the selected approach procedure. For example, if an approach is published with LPV minima and the receiver is only certified for LNAV/VNAV, the equipment would indicate "LNAV/VNAV available," even though the WAAS signal would support LPV. If flying an existing LNAV/VNAV procedure with no LPV minima, the receiver will notify the pilot "LNAV/VNAV available," even if the receiver is certified for LPV and the signal supports LPV. If the signal does not support vertical guidance on procedures with LPV and/or LNAV/VNAV minima, the receiver annunciation will read "LNAV available." On lateral only procedures with LP and LNAV minima the receiver will indicate "LP available" or "LNAV available" based on the level of lateral service available. Once the level of service notification has been given, the receiver will operate in this mode for the duration of the approach procedure, unless that level of service becomes unavailable. The receiver cannot change back to a more accurate level of service until the next time an approach is activated.

NOTE −

*Receivers do not "fail down" to lower levels of service once the approach has been activated. If only the vertical off flag appears, the pilot may elect to use the LNAV minima if the rules under which the flight is operating allow changing the type of approach being flown after commencing the procedure. If the lateral integrity limit is exceeded on an LP approach, a missed approach will be necessary since there is no way to reset the lateral alarm limit while the approach is active.*

3. Another additional feature of WAAS receivers is the ability to exclude a bad GPS signal and continue operating normally. This is normally accomplished by the WAAS correction information. Outside WAAS coverage or when WAAS is not available, it is accomplished through a receiver algorithm called FDE. In most cases this operation will be invisible to the pilot since the receiver will continue to operate with other available satellites after excluding the "bad" signal. This capability increases the reliability of navigation.

4. Both lateral and vertical scaling for the LNAV/VNAV and LPV approach procedures are different than the linear scaling of basic GPS. When the complete published procedure is flown, ±1 NM linear scaling is provided until two (2) NM prior to the FAF, where the sensitivity

increases to be similar to the angular scaling of an ILS. There are two differences in the WAAS scaling and ILS: 1) on long final approach segments, the initial scaling will be ±0.3 NM to achieve equivalent performance to GPS (and better than ILS, which is less sensitive far from the runway); 2) close to the runway threshold, the scaling changes to linear instead of continuing to become more sensitive. The width of the final approach course is tailored so that the total width is usually 700 feet at the runway threshold. Since the origin point of the lateral splay for the angular portion of the final is not fixed due to antenna placement like localizer, the splay angle can remain fixed, making a consistent width of final for aircraft being vectored onto the final approach course on different length runways. When the complete published procedure is not flown, and instead the aircraft needs to capture the extended final approach course similar to ILS, the vector to final (VTF) mode is used. Under VTF, the scaling is linear at ±1 NM until the point where the ILS angular splay reaches a width of ±1 NM regardless of the distance from the FAWP.

5. The WAAS scaling is also different than GPS TSO−C129() in the initial portion of the missed approach. Two differences occur here. First, the scaling abruptly changes from the approach scaling to the missed approach scaling, at approximately the departure end of the runway or when the pilot selects missed approach guidance rather than ramping as GPS does. Second, when the first leg of the missed approach is a Track to Fix (TF) leg aligned within 3 degrees of the inbound course, the receiver will change to 0.3 NM linear sensitivity until the turn initiation point for the first waypoint in the missed approach procedure, at which time it will abruptly change to terminal (±1 NM) sensitivity. This allows the elimination of close in obstacles in the early part of the missed approach that may otherwise cause the DA to be raised.

6. There are two ways to select the final approach segment of an instrument approach. Most receivers use menus where the pilot selects the airport, the runway, the specific approach procedure and finally the IAF, there is also a channel number selection method. The pilot enters a unique 5−digit number provided on the approach chart, and the receiver recalls the matching final approach segment from the aircraft database. A list of information including the available IAFs is displayed and the pilot selects the appropriate IAF. The pilot should confirm that the correct final approach segment was loaded by cross checking the Approach ID, which is also provided on the approach chart.

7. The Along−Track Distance (ATD) during the final approach segment of an LNAV procedure (with a minimum descent altitude) will be to the MAWP. On LNAV/VNAV and LPV approaches to a decision altitude, there is no missed approach waypoint so the along−track distance is displayed to a point normally located at the runway threshold. In most cases, the MAWP for the LNAV approach is located on the runway threshold at the centerline, so these distances will be the same. This distance will always vary slightly from any ILS DME that may be present since the ILS DME is located further down the runway. Initiation of the missed approach on the LNAV/ VNAV and LPV approaches is still based on reaching the decision altitude without any of the items listed in 14 CFR Section 91.175 being visible, and must not be delayed while waiting for the ATD to reach zero. The WAAS receiver, unlike a GPS receiver, will automatically sequence past the MAWP if the missed approach procedure has been designed for RNAV. The pilot may also select missed approach prior to the MAWP; however, navigation will continue to the MAWP prior to waypoint sequencing taking place.

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# Appendix 2 GPS and WAAS NOTAMs

**GPS and WAAS NOTAMS**:

There are numerous sources and services for providing aeronautical information and NOTAMs to pilots. The two primary sources that will be discussed are the United States Flight Service Station (FSS) and PilotWeb which is found on the internet. Both sources are provided by the FAA. The FSS services are provided through an FAA contract with Lockheed Martin Corporation except for the State of Alaska which are provided by FAA employees. The FSS only provide GPS NOTAMs on request by the pilot. These NOTAMs consist of satellite outages and area outages contained in the Air Route Traffic Control Center (ARTCC) NOTAMs. The FSS no longer provides receiver autonomous integrity monitoring (RAIM) outage information, but instead refers the pilot to the AC 90-100A GPS RAIM Prediction website at www.raimprediction.net/ac90-100/.

The PilotWeb Site provides access to current NOTAM information from the United States NOTAM System. GPS and WAAS NOTAMs require an understanding of the website and how to locate the required information. Satellite outages are displayed by entering KGPS or KNMH in the location block of the NOTAM Retrieval section on the home page of PilotWeb. GPS and WAAS area outages, system outages, and interference NOTAMs are located on the ARTCC Notices, TFRs and Special Notices Page. The specific ARTCC has to be checked for the area you are interested in to get the information. After you select the ARTCC selecting View GPS NOTAMs will show you only those NOTAMs that have GPS as a keyword. This may miss some WAAS NOTAMs that do not have the GPS keyword such as a WAAS system outage that would be listed as an FDC NOTAM. Airport specific FDC NOTAMs can be found by entering the airport identifier in the location block of the NOTAM Retrieval section. If you are required to check RAIM due to a WAAS outage, the primary RAIM source is located at www.raimprediction.net/ac90-100/.

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# Appendix 3 Honeywell IMMR FAA TSO

TSO for Honeywell Integrated Multi-Mode Receiver (IMMR) Model IMMR 10.1

U.S. Department of Transportation

**Federal Aviation Administration**

**Transport Airplane Directorate**
**Los Angeles Aircraft Certification Office**

3960 Paramount Boulevard
Lakewood, California 90712-4137

March 21, 2017

In reply refer to: 130L-17-64

Honeywell International, Inc.
Attn: Ms. Fay Trowbridge, TSO Administrator
15001 NE 36th St.
Redmond, WA 98052

Dear Ms. Trowbridge:

Honeywell International Inc.
Technical Standard Order Authorization
Honeywell Integrated Multi-Mode Receiver (IMMR) Model IMMR 10.1
TSO-C34e, TSO-C35d (INCOMP), TSO-C36e, TSO-C40c, TSO-C145d,
TSO-146d, TSO-C161a, TSO-C162a

This is in reply to your letter 17FAA008 dated January 30, 2017 requesting TSO authorization for the Integrated Multi-Mode Receiver (IMMR). We accept your statement certifying that your article meets the requirements of TSO-C34e, TSO-C35d CL A (INCOMP), TSO-C36e CL B, TSO-C40c, TSO-C145d CL 2, TSO-146d CL 4, TSO-C161a CL C, TSO-C162a and that you meet the requirements of Title 14, Code of Federal Regulations part 21 subpart O. Effective this date, we authorize you to identify the IMMR as defined in the table below with the marking requirements defined in 14 CFR 45.15(b) and in the above listed TSOs.

| IMMR Model No. | Description | Part Number |
|---|---|---|
| IMMR 10.1 | IMMR | 69002600-[ ] |

This authorization currently applies to the following versions as defined within the submitted data:

| IMMR Model No. | IMMR Part No. | Hardware Part Number | Software | |
|---|---|---|---|---|
| | | | Desc | Part Number |
| IMMR 10.1 | 69002600-0101 | 69002513-020 | Application Software | SWM69003225-502 |
| | | | Base OPC Software * | SWM69003224-001 |

*The OPC Software is a Parameter Data Item (PDI) as defined by DO-178C and may be updated to support specific aircraft configurations/installations. Part Number shown is the Base OPC configuration which provides for full functionality of the IMMR.

*Purpose - Aviation Safety Professionalism - Technical Excellence Pride - Highest Quality*

This authorization is granted in conjunction with deviations as detailed in Honeywell letter 17FAA008 which have been approved as follows:

- AIR 130-16-130-DM190, 31-Aug-16, Response to Honeywell's Deviation Request to TSO-C40c for their IMMR 10.1 Integrated Multi-Mode Receiver, Part Number 69002600-[ ]
- FAA Memorandum dated 09-Sep-16, Response to Honeywell's Deviation Request to TSO-C161a for their IMMR 10.1 Integrated Multi-Mode Receiver, Part Number 69002600-[ ]
- FAA Memorandum dated 24-Aug-16, Response to Technical Standard Orders TSO-C36 (DO-195 Centering Accuracy Testing in the Presence of Interfering Signals) for the IMMR 10.1 Integrated Multi-Mode Receiver, Part Number 69002600-[ ]
- 130L-16-156, 29-Jul-16, Request for Approval to deviate from the requirements of TSO–C34e, TSO - C35d, TSO-C36e, TSO-C40c, TSO-C145d, TSO-C146d, TSO-C161a and TSO–C162a environmental qualification standards for the IMMR 10.1 Integrated Multi-Mode Receiver, Part Number 69002600-[ ] in accordance with 14 CFR 21.618
- 130L-16-118, 19-Jul-2016, Request for Approval to deviate from the requirements of TSO–C34e, TSO - C35d, TSO-C36e, TSO-C40c, TSO-C145d, TSO-C146d, TSO-C161a and TSO–C162a software development standards for the IMMR 10.1 Integrated Multi-Mode Receiver, Part Number 69002600-[ ] in accordance with 14 CFR 21.618

Note: No Non-TSO function identified.

We consider your quality system, as defined in your quality control manual, Rev G, dated October 16, 2016, satisfactory for production of this article, at your manufacturing facility located at 21111 N 19$^{th}$ Avenue Phoenix, AZ 85027.

The conditions and tests required for TSOs approval of this article are minimum performance standards. It is the responsibility of those installing this article either on or within a specific type or class aircraft to determine that the aircraft installation conditions are within the TSOs standards. TSO articles must have separate approval for installation in an aircraft. The article may be installed only if performed under 14 CFR part 43 or the applicable airworthiness requirements.

This TSO authorization, issued under 14 CFR 21.611, is effective until surrendered, withdrawn or otherwise terminated under the provisions of 14 CFR 21.613. With notice, we may withdraw this TSO authorization if articles are not in compliance with the applicable TSO performance standards per 14 CFR 21.2.

You must obtain FAA approval prior to making any changes to the location of your manufacturing facilities pursuant to 14 CFR 21.609(b).

Without further FAA approval, we don't allow manufacturers to mark articles after they change their company's name, address, or ownership. You must notify the ACO and MIDO of name, address, or proposed ownership changes.

Per 14 CFR 21.614, a holder of a TSOA may not transfer it. If you wish to transfer it, you must request a transfer from the FAA.

Send to the office below any design change(s) for this TSO article as outlined in 14 CFR 21.619(a). You should notify us of minor design changes within six months. Also, as recipient of this authorization, we require you to report any failure, malfunction, or defect relating to articles produced under this authorization in accordance with the provisions of 14 CFR 21.3. The report should be communicated initially by telephone to the Manager, Technical and Administrative Support Staff, ANM-103L, (562) 627-5300, within 24 hours after it has been determined the failure has occurred and followed up with a written notice. Federal Aviation Administration Form 8010-4 (Malfunction or Defect Report) or other appropriate format is acceptable in transmitting the required details.

Please note that technical data the FAA retains may be subject to Freedom of Information Act (FOIA) requests. This office will notify you of any request(s) pertaining to your data and give you the opportunity to protect the data from public disclosure.

If you have any questions regarding this authorization, please contact Mr. Daniel Bui, by telephone at (562) 627-5339; by e-mail at daniel.bui@faa.gov; or by fax at (562) 627-5210.

Sincerely,

Steve Bogucki
Manager, Technical and Administrative Support Staff

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