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Toitū Te Whenua
Land Information
New Zealand

SouthPAN

Service Definition Document for Open Services

Project: Southern Positioning Augmentation Network

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Disclaimer

To the maximum extent permitted by law, each End User's access to and/or use of the Southern Positioning Augmentation Network (**SouthPAN**) including, without limitation, each End User's access to and/or use of the SouthPAN Open Service, Safety-of-Life Service or Aeronautical Radio Navigation Service (collectively, the **End-User Services**) or any associated data or services:

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The End-User Services have the performance targets defined in sections 6, 7, and 8 of this document.

For the purposes of this disclaimer:

- the **Commonwealth of Australia** includes its servants, agents, officers, representatives and instrumentalities (however described), and
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Limitations

There are a number of limitations that may affect SouthPAN or any of the End-User Services. This section lists some of those limitations, but is not an exhaustive statement of all limitations. End-Users should consult this SouthPAN Service Definition Document for Open Services and independently consider the suitability of SouthPAN or any of the End-User Services for any particular purpose.

Atmospheric (ionospheric) activity north of 20°S will cause issues with maintaining lock on Global Navigation Satellite System (**GNSS**) Space Vehicles (**SV**) (due to scintillation) and/or introducing large localised gradients (due to plasma bubbles). The former is an issue for most End-Users Services; the latter for single-frequency and Safety-of-Life Services.

Service coverage will be further limited by other factors including, without limitation, the following:

- location of SouthPAN Geostationary Payloads (**SGP**s);
- Effective Isotropic Radiated Power (**EIRP**) of SGPs;
- SGP satellite elevation mask set by user equipment;
- user environment (noise, sky-view);
- ability of the SouthPAN System to detect GNSS SVs:
    - SV satellite elevation mask set by the SouthPAN System;
    - Number of GNSS Reference Site (**GRS**) necessary to track a particular satellite;
    - Location of GRS; and
    - GRS local environment (noise, sky-view);
- electromagnetic activity in the ionosphere;
- number of healthy GNSS SVs; and
- geometry of healthy GNSS SVs.

Licence

Revision History

Revision Date	Rev.	Summary of Changes	Record ID
14 September 2022	01	Initial revision	AU: D2022-51289 NZ: A5013157
05 December 2022	02	Updating of timelines and figure 2	AU: D2022-70648 NZ: A5013157

Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Document identification

Project title	Southern Positioning Augmentation Network
GA Location	HPE Content Manager
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LINZ Location	LINZone Objective
LINZ Record ID	A5013157

1.2 Document overview

Section	Section Heading	Section Description
2	Reference documents	A list of documents referenced in the SDD-OS
3	Executive Summary	An executive summary of SDD-OS.
4	SouthPAN overview	A summary of the SouthPAN system architecture, the deployment strategy leading to its Full Operating Capability, and the organisational framework supporting its deployment and operations.
5	Specification of navigation signals	The Radio Frequency characteristics of the navigation signals, the characteristics of the spread spectrum code scheme, and the navigation message structures and data content.
6	L1 SBAS Open Service (OS-L1)	The performance of OS-L1 service offered to users.
7	DFMC SBAS Open Service (OS-DFMC)	The performance of OS-DFMC service offered to users.
8	PVS Open Service (OS-PVS)	The performance of OS-PVS service offered to users.
9	GRE Observables (OS-GOBS)	The performance of the OS-GOBS service offered to users.
10	SouthPAN End User receivers	Discussion of implementation on End User devices.

1.3 Document maintenance

This document is subject to change and will undergo review no later than one year after publication.

1.4 Purpose

GNSS equipment manufacturers, applications developers, and End-Users should use this document to implement the early Open Services from SouthPAN on their devices.

1.5 Terminology, acronyms and abbreviations

1.5.1 Definitions

In this document, unless the contrary intention appears:

Commonwealth of Australia includes its servants, agents, officers, representatives and instrumentalities (however described).

End-User means any person who accesses or uses any of the End-User Services, or any person who accesses or uses goods or services that rely on the use of, or access to, the End-User Services. For the avoidance of doubt, an End-User includes any person who accesses or uses any of the End-User Services for the purposes of making goods or services available to one or more other persons.

End-User Services means any one or more of the Open Service, Safety-of-Life Service and the Aeronautical Radio Navigation Service.

Open Service means a SouthPAN service accessed or used by End-Users not engaged in operations where safety-of-life is at risk.

Safety-of-Life Service means the SouthPAN service accessed or used by End-Users engaged in operations where safety-of-life is at risk.

SouthPAN means the Southern Positioning Augmentation Network.

Sovereign in Right of New Zealand includes its servants, agents, officers, representatives and instrumentalities (however described).

Aeronautical Radio Navigation Service means a radionavigation service intended for the benefit and for the safe operation of aircraft.

AUSCORS means the GNSS Continuously Operating Reference Station (CORS) Network operated by Geoscience Australia

PositioNZ means the GNSS Continuously Operating Reference Station (CORS) Network operated by Toitū Te Whenua Land Information New Zealand

1.5.2 Acronyms

BPSK means Binary Phase Shift Keying

CORS means Continuously Operating Reference Station

CPF means Correction Processing Facilities

DFMC means dual frequency multi constellation

DFREI means Dual Frequency Range Error Indicator

EASA means European Union Aviation Safety Agency

ECEF means Earth Centred Earth Fixed

EUROCAE means the European Organisation for Civil Aviation Equipment

EUSPA means the European Union Agency for the Space Programme

FAA means Federal Aviation Administration

FEC means Forward Error Correction

GA means Geoscience Australia

GCC means Ground Control Centres

GEO means Geostationary Earth Orbit

GRE means GNSS Reference Equipment

GRS means GNSS Reference Stations

GNSS means Global Navigation Satellite System

HPE means Horizontal Position Error

IOC means Initial Operating Capability

IODG means Issue of Data GEO

IODN means Issue of Data Navigation

ITRF means International Terrestrial Reference Frame

LINZ means Toitū Te Whenua Land Information New Zealand

PNT means Position, Navigation, and Timing

PPP means Precise Point Positioning

PRN means pseudorandom noise

PVS means PPP Via SouthPAN

RAIM means Receiver Autonomous Integrity Monitoring

RHCP means Right Hand Circularly Polarised

RTCA means Radio Technical Commission for Aeronautics

SBAS means satellite-based augmentation system

SIS means Signals-In-Space

SOL means Safety-of-Life

SWAN means SouthPAN Wide Area Network

UDREI means User Defined Range Error Indicator

UTC means Universal Time Coordinated

VPE means Vertical Position error

WGS84 means World Geodetic System 1984

2 Reference documents

Ref.	Code	Title	Publisher
[1]	DO-229F	Minimum Operational Performance Standards for Global Positioning System/Satellite-Based Augmentation System Airborne Equipment, Revision F	RTCA
[2]	ED-259	Minimum Operational Performance Standards for Galileo –Global Positioning System –Satellite-Based Augmentation System Airborne Equipment	EUROCAE
[3]	IS-GPS-200N	NAVSTAR GPS Space Segment/Navigation User Interface Specification, Revision N	US Space Force
[4]	IS-GPS-705J	NAVSTAR GPS Space Segment/User Segment L5 Interface Specification, Revision J	US Space Force
[5]	OS-SIS-ICD_v2.0	European GNSS (Galileo) Open Service Signal-In-Space Interface Control Document, Issue 2.0	EUSPA

3 Executive summary

The Southern Positioning Augmentation Network (**SouthPAN**) provides augmentation services for United States Global Positioning System (**GPS**) and European Union Galileo Global Navigation Satellite System (**GNSS**) constellations. SouthPAN can be used to improve the position, navigation, and timing for a broad range of users in Australia and New Zealand.

This version of the SouthPAN Service Definition Document for Open Services is intended for use by GNSS equipment manufacturers, applications developers, and End-Users. It contains a description of the SouthPAN system architecture, Radio Frequency characteristics of the navigation signals, structure and contents of the navigation messages, and indicative performance requirements for the Open Services.

This document will be updated in the future as the Open Services are improved and new functionality is introduced.

4 SouthPAN overview

SouthPAN is a satellite-based augmentation system (**SBAS**) broadcasting Signals-In-Space (**SIS**) and providing services via the internet, jointly made available to End-Users free-of-charge by the Commonwealth of Australia as represented by Geoscience Australia (**GA**) and the Sovereign in Right of New Zealand as represented by Toitū Te Whenua Land Information New Zealand (**LINZ**).

SouthPAN is intended to provide improved Position, Navigation, and Timing (**PNT**) capabilities to End-Users in Australia and New Zealand. These capabilities will be made available to End-Users through their GNSS-enabled devices and dedicated internet services. End-Users may not necessarily be aware that the performance of their GNSS devices has been affected by SouthPAN.

Early services will be provided to non-Safety-of-Life users as the infrastructure for the Safety-of-Life Service is deployed and certified.

SouthPAN will provide the Open Services via navigation Signals-In-Space and the internet, as described in Table 1.

Table 1: Relationship between services and navigation signals

Open Service	Description	Signal-In-Space
L1 SBAS	L1 SBAS Open Service (OS-L1), providing augmentation of the GPS L1 C/A signal.	L1 navigation signal
DFMC SBAS	Dual Frequency Multi-Constellation (DFMC) SBAS Open Service (OS-DFMC), providing augmentation of the GPS L1 C/A, GPS L5, Galileo E1, and Galileo E5a signals.	L5 navigation signal
PPP via SouthPAN	Precise Point Positioning (PPP) via SouthPAN Open Service (OS-PVS), providing augmentation of the GPS L1 C/A, GPS L5, Galileo E1, and Galileo E5a signals. The PPP technique allows End-Users to achieve more accurate position compared to OS-DFMC.	L5 navigation signal

See section 5 for further details of the different Open Services.

Figure 1 shows the service areas of the SouthPAN Open Services.

- OS-L1 covers mainland Australia and New Zealand; and
- OS-DFMC and OS-PVS cover both country’s Exclusive Economic Zones.

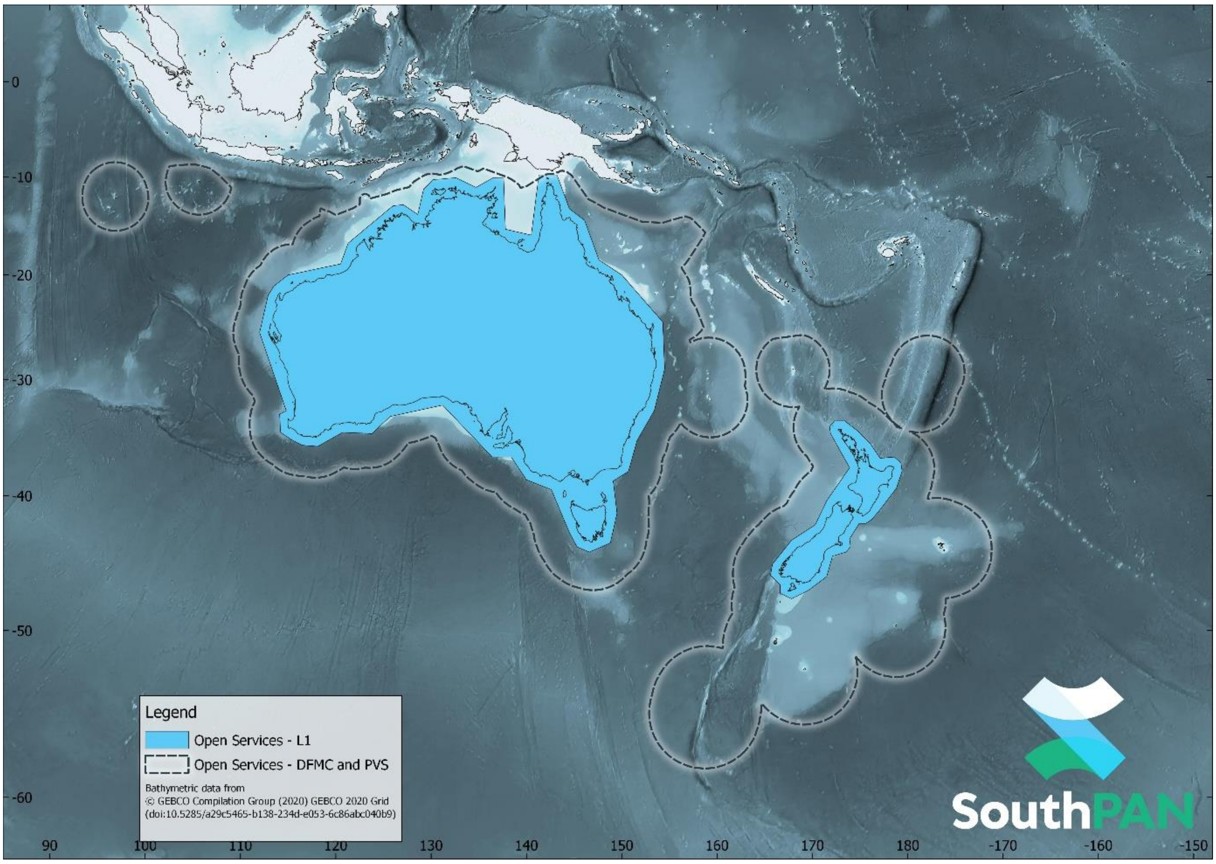

Figure 1: SouthPAN early Open Services Coverage

4.1 System architecture

SouthPAN uses a network of ground stations receiving GNSS signals. These are delivered to a computation centre, which generates corrections to reduce ordinary errors for GNSS (including satellite orbit, clock drift, and ionospheric propagation delay). SouthPAN estimates residual errors that cannot be rectified and will independently monitors GNSS satellites to alert users of any faults.

The error corrections, residuals, and satellite health information are packaged in formats standardised in ICAO, RTCA, and EUROCAE documents. These are broadcast Geostationary Earth Orbit (GEO) satellites and are available online. Users cannot use SouthPAN GEO signals for ranging.

Figure 2 shows the end-to-end system architecture. The segments forming the SouthPAN system are grouped together.

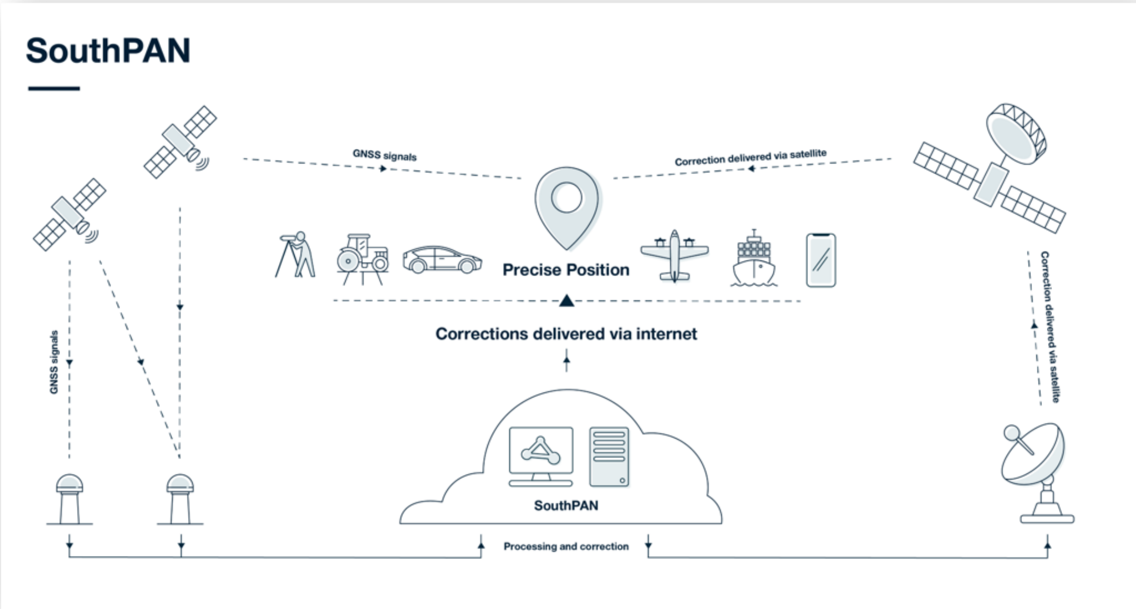

Figure 2: SouthPAN System Architecture

4.1.1 Ground facilities

SouthPAN ground facilities consist of a network of GNSS Reference Stations (**GRS**), Ground Control Centres (**GCC**) and Correction Processing Facilities (**CPF**). These are connected by the SouthPAN Wide Area Network (**SWAN**).

The SouthPAN GRS network will primarily comprise sites in Australia and New Zealand, with additional stations in Antarctica and foreign territories. The ground stations monitor navigation signals from the GPS and Galileo navigation satellite systems.

After data delivered to the CPFs undergoes rigorous quality control checks, it is sent to the processing algorithms. These estimate the errors resulting from inaccuracies in the satellite orbits, satellite clocks, and signal bias models. The CPFs also assess the effect of the ionosphere on satellite signals.

These error estimates, together with an estimation of the residual error, are transmitted to the users using the SouthPAN satellite, and are available on the internet.

Users can then use this information, with their measurements to obtain a position solution that has greater accuracy.

4.1.2 Space facilities

SouthPAN has a satellite uplink facility and a satellite in geostationary orbit (**GEO**).

The satellite uplink facility receives the SouthPAN data streams from the CPF, generates the navigation signals, and sends the signals to the SouthPAN GEO satellite. The SouthPAN GEO acts as a "bent pipe"—translating the uplinked navigation signal to the L1 and L5 frequencies, then re-broadcasting without alteration.

Early Open Services will use a single satellite payload in GEO located at 143.5°E, transmitting data on the L1 (1,575.42 MHz) and L5 (1,176.45 MHz) frequencies with the PRN 122 identity. Additional satellites will be added to provide another navigation frequency of 1,207.14 MHz. When complete, SouthPAN will use two satellites in GEO. The PRN codes and orbital positions of these additional satellites are still to be finalised.

Early Open Services will use a single, dedicated, uplink facility to transmit the data stream to the geostationary satellite. Additional uplink facilities will be deployed to provide redundancy and support new satellites.

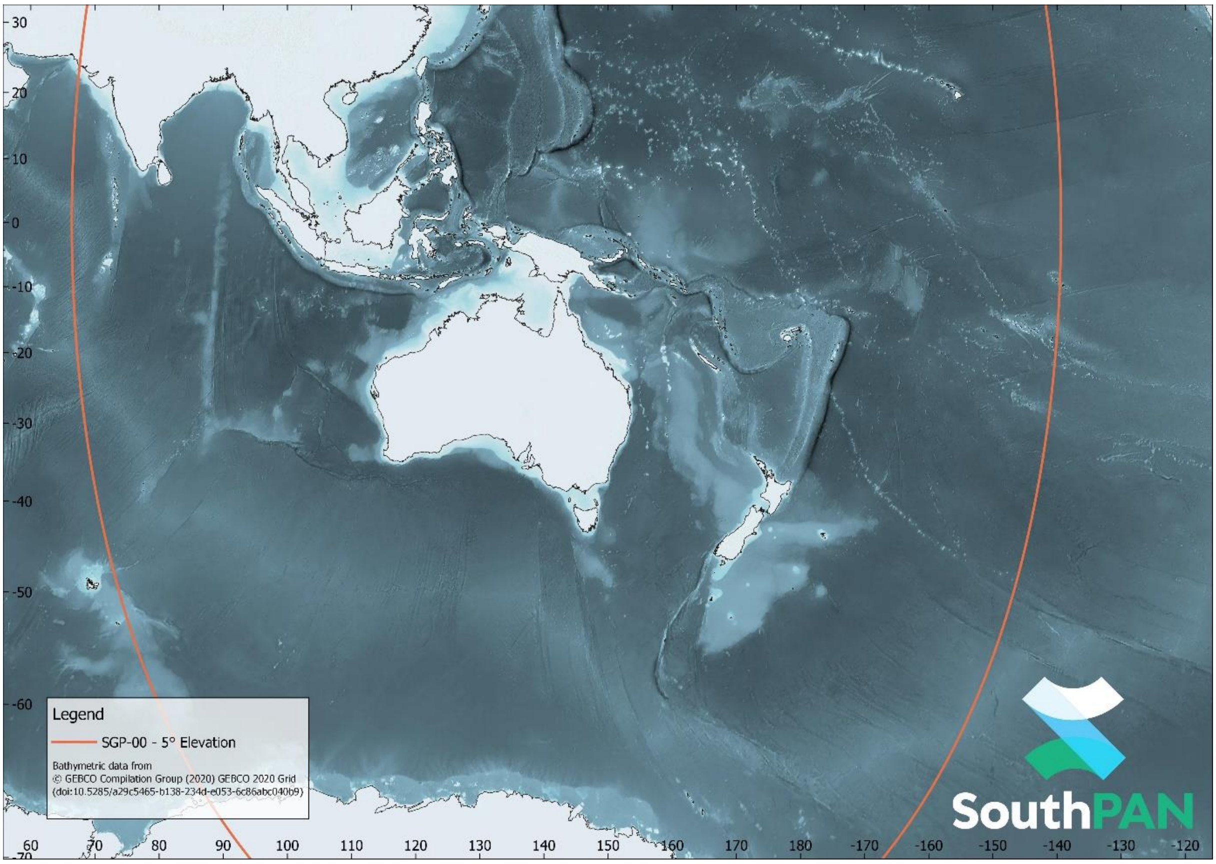

Figure 3: Satellite Coverage for SouthPAN early services

4.2 Deployment strategy

The SouthPAN early Open Services will use similar infrastructure to the SBAS Test-bed Demonstrator Trial system. This operated between 2017 and 2020.

The Open Service is available for non-Safety-of-Life (SOL) users while the infrastructure for the SOL service is deployed and certified. The key deployment milestones are described in Table 2.

Table 2: Key deployment milestones

Milestone	Description	Comment
Initial Operating Capability-95	Commencement of early services using existing infrastructure. Open Services only.	Q3 2022
Initial Operating Capability-99.5	Additional infrastructure will be integrated into the SouthPAN system, improving accuracy and availability. Open Services only.	Early 2024 (indicative)

Milestone	Description	Comment
Initial Operating Capability-99.9	Additional infrastructure will be integrated into the SouthPAN system, improving accuracy and availability. Open Services only.	Late 2026 (indicative)
Introduction of new navigation signal	A new satellite will include functionality for a new navigation signal, which will be used for the PVS service. Open Services only.	Late 2027 (indicative)
Initial Operating Capability-99.9 with Safety-of-Life services	Following a safety assessment, SouthPAN services will be certified for use in Safety-of-Life applications. Open Services and Safety-of-Life Services.	Early2028 (indicative)
Full Operating Capability	The final satellite will be integrated into the SouthPAN system, providing the maximum level of service availability. Open Services and Safety-of-Life Services.	Late 2028 (indicative)

Planned infrastructure developments include:

- Dedicated GRS for SouthPAN in New Zealand and Australia will be deployed. Each GRS will consist of redundant GNSS receivers that will be connected to the CPFs through a dedicated, redundant communication network (SWAN). Initially, SouthPAN will use data from the AUSCORS[1] and PositioNZ[2] GNSS Continuously Operating Reference Station (**CORS**) networks.
- Dedicated uplink and monitoring facilities in Australia and New Zealand.
- Two new satellites in GEO with enhanced features, most notably an additional navigation signal at 1,207.14 MHz, will be added to the system. The PVS Open Service will migrate from L5 to this third navigation signal. Users will be advised of changes to PRN codes and dates for activating the new service.
- A new data format to support the PPP via SouthPAN (**PVS**) service on the new navigation signal, improved accuracy and reduced convergence times.

Each of the early Open Services will be improved over the deployment period. During this Initial Operating Capability (**IOC**) phase, Open Service performance attributes such as accuracy and availability are expected to improve as additional infrastructure is established.

We will update this Service Definition Document for Open Services throughout the deployment period.

4.3 Organisational framework

4.3.1 Roles & Responsibilities

The SouthPAN Program is a joint undertaking between Australian and New Zealand Governments. The operational organisations responsible are GA and LINZ.

[1] https://gnss.ga.gov.au/stream
[2] https://www.linz.govt.nz/data/geodetic-services/positionz

4.3.2 Further information and support

Organisation	Webpage	Email
Geoscience Australia	www.ga.gov.au/southpan	clientservices@ga.gov.au
Toitū Te Whenua Land Information New Zealand	www.linz.govt.nz/southpan	southpan@linz.govt.nz

5 Specification of navigation signals

5.1 L1 SBAS signal

This section describes the L1 SBAS navigation signal.

5.1.1 Radio Frequency characteristics

The carrier frequency is centred around 1,575.42 MHz with at least 95% of the broadcast power contained within a 4 MHz bandwidth. Users within the Coverage Area will receive the RF signal at the antenna port of a 3 dBi linearly polarised antenna at a strength of between -161 dBW and -153 dBW. The L1 signal will be Right Hand Circularly Polarised (**RHCP**) in accordance with the ITU Radio Regulations for RHCP, Article 1, Number 154.

5.1.2 Modulation

The L1 SBAS navigation messages are modulated on the L1 signal in accordance with DO-229F [1].

The 250 bits per second of the L1 SBAS navigation message is convolutionally coded using a rate 1/2 Forward Error Correction (FEC) code. The transmitted sequence will be the Modulo-2 addition of the L1 SBAS navigation message at a rate of 500 symbols per second and the 1,023-bit pseudorandom noise (PRN) spreading code at a rate of 1.023 mega-chips per second, which is then BPSK-modulated onto the carrier.

The PRN code for the SouthPAN L1 SBAS navigation signal is 122, which has a G2 chip delay of 52 and an initial G2 setting of 0267 (octal), with the first ten chips being 1510 (octal).

5.1.3 List of Message Types

SouthPAN will transmit the L1 SBAS navigation messages defined in Table 3 below. An abridged description is provided, along with notes and special conditions that SouthPAN users may require to achieve maximum performance. The complete message definition is in DO-229F [1].

Table 3: SouthPAN L1 SBAS Message Types

Message Type	Contents	Purpose	Notes
0	Do Not Use for Safety Applications	Indicates the SBAS is in test mode	During SouthPAN early services, the L1 SBAS navigation signal must not be used for Safety-of-Life applications. Hence, SouthPAN will make use of the MT0/2 strategy as described in DO-229F [1] section A.4.4.1. SouthPAN will not broadcast MT2 and instead include MT2 data in MT0 messages. This indicates to SOL users (for instance, aircraft) that SouthPAN cannot be used for SOL applications (for example, to land at an airport).
1	PRN Mask Assignments	List of GPS satellites to be augmented	GEO PRN 122 is included in the MT1 mask.
2-5	Fast Corrections	Range corrections and accuracy	During SouthPAN early services, the MT2 message is broadcast using the MT0/2 approach (see MT0 entry in this table). The transmission of MT0/2 achieves the same outcome as transmitting “Do Not Use” or “Not Monitored” in the UDREI, and explicitly protects the continuity of navigation for RAIM users that receive the L1 SBAS signal. SouthPAN may broadcast UDREI with “Do Not Use” values but will minimise their use to meet performance requirements.
6	Integrity Information	Accuracy-bounding information for all satellites in one message	The transmission of MT0/2 achieves the same outcome as the “Do Not Use” UDREI approach, and explicitly protects the continuity of navigation for RAIM users that receive the L1 SBAS signal. SouthPAN may broadcast UDREI with “Do Not Use” values but will minimise their use to meet performance requirements.
7	Fast Corrections Degradation Factor	Information about the degradation of the fast corrections	
10	Degradation Factor	Information about the correction degradation upon message loss	

Message Type	Contents	Purpose	Notes
25	Long Term Satellite Error Corrections	Corrections for satellite ephemeris and clock errors for up to four satellites	The Long Term Correction messages will usually use the “Velocity Code=0” approach, allowing the inclusion of corrections for four satellites in each MT25 message. Depending on the number of satellites monitored and the convergence status of the system, some of the correction slots might be left empty by referring to “zero” in the PRN Mask Number field.
24	Mixed fast Corrections/ Long Term Satellite error Corrections	Fast-term error corrections for up to six satellites and long-term satellite error corrections for up to two satellites in one message	SouthPAN may be configured to use MT4 with less than seven active satellites, rather than broadcasting MT24. If the “Velocity Code=0” approach is used (as defined for MT25) the long-term corrections for two satellites will be included in each MT24.
18	Ionospheric Grid point Mask	Indicates for which geographical point ionospheric correction data is provided	
26	Ionospheric Delay Corrections	Vertical delays/accuracy bounds at given geographical points	
9	GEO Navigation	SouthPAN GEO satellites orbit information (ephemeris)	SouthPAN will not support GEO ranging. MT9 will be populated as follows: • XG and YG are populated with the coordinates of the reference position of the GEO. ZG parameter is set to zero. • URA is set to 15. • Velocity parameters XG, YG and ZG rate-of-change are set to zero. • Acceleration Parameters XG, YG and ZG acceleration are set to zero. • Clock parameters AGF0 and AGF1 are set to zero. • GEO Satellite is always set to Not Monitored by the SBAS augmentation at messages MT2-5, and MT6.

Message Type	Contents	Purpose	Notes
17	GEO Almanac	SouthPAN GEO satellites Almanacs	SouthPAN will not support GEO ranging. MT17 will be populated as follows: • Health and Status word indicates the Ranging function is “Off” (Bit 0 set to 1). • The following information will be set: • Health and Status word indicates that the Service Provider is SouthPAN (‘8’) (Bits 4-7 set to 1000) • XG and YG are populated with the coordinates of the reference position of the GEO. ZG parameter is set to zero. • Velocity parameters XG, YG and ZG rate-of-change are set to zero.
27	SBAS Service	Defines the geographic region of the service	SouthPAN will use MT27 to define the geographic service area during early Open Services. In the future, MT28 will be used and MT27 will not be used.
62	Internal Test Message		MT62 will be broadcast approximately every 700 to 1000 seconds for internal testing purposes only. It will not carry information for use by SouthPAN users.
63	Null Message	Placeholder message if no other message is available	MT63 may be a placeholder message if no other message is scheduled. It will not carry information for use by SouthPAN users.
12	SBAS Network Time/UTC Parameters	Parameters for synchronisation of SouthPAN Network time with UTC	All MT12 fields are set to zero. SouthPAN is not connected to a reference time laboratory, and this message does not indicate the UTC/SouthPAN Network Time scale offset.

5.2 L5 SBAS Signal

This section describes the L5 SBAS navigation signal. As per Table 1, the SouthPAN L5 SBAS signal provides both the DFMC and PVS services. As per Table 2, the PVS service will be transitioned to a new navigation signal in the future.

5.2.1 Radio Frequency Characteristics

The carrier frequency is centred around 1,176.45 MHz with at least 95% of the broadcast power contained within a 20 MHz bandwidth. Users within the Coverage Area will receive the RF signal at the antenna port of a 3 dBi linearly polarised antenna at a strength of between -158.25 dBW and -152.5 dBW. The L5 signal will be Right Hand Circularly Polarised (RHCP) in accordance with the ITU Radio Regulations for RHCP, Article 1, Number 154.

5.2.2 Modulation

The DFMC SBAS message is modulated on the in-phase component of the L5 signal in accordance with ED-259 [2].

The 250 bits per second of the DFMC SBAS navigation message is convolutionally coded using a rate 1/2 Forward Error Correction (FEC) code. This 500 symbol per second sequence is then spread using Manchester (bi-binary) coding, with a “0” symbol encoded as a “01” bit sequence and a “1” symbol encoded as a “10” bit sequence. The transmitted sequence will be the Modulo-2 addition of the Manchester coded L5 SBAS navigation message at a rate of 1,000 bits per second and the 10,230-bit pseudorandom noise (PRN) spreading code, which is then BPSK-modulated onto the carrier to produce 10.230 mega-chips per second.

The PRN code for the SouthPAN L5 SBAS navigation signal is 122, with an XB code advance of 3023 chips and an initial XB code state of 10305 (octal).

5.2.3 List of Message Types

SouthPAN will transmit the L5 SBAS navigation messages below. (An abridged description is provided, along with notes and special conditions that SouthPAN users may require to achieve maximum performance. The complete message definition is contained in ED-259 [2])

Table 4: SouthPAN L5 SBAS Message Types

<table>
<tr><th>Message Type</th><th>Contents</th><th>Purpose</th><th>Notes</th></tr>
<tr><td>0</td><td>Do Not Use for Safety Applications</td><td></td><td>Following a similar approach to the MT0/2 strategy used for the L1 SBAS early service, the L5 DFMC MT0 message will be used to transmit the integrity information from messages MT34, 35 or 36.</td></tr>
<tr><td>31</td><td>PRN Mask Assignments</td><td>List of satellites to be augmented</td><td>GEO PRN 122 is included in the MT31 mask.</td></tr>
<tr><td>34, 35, 36</td><td>Integrity information (DFREI and DFRECI)</td><td>Accuracy-bounding information for all satellites in one message</td><td>The Message Type ID on the integrity messages for the SouthPAN early DFMC service is always set to “0”, meaning that the integrity information is broadcast within the “Do Not Use for Safety Applications” message. This is a similar approach to the one used in DO-229F [1] for MT0/2 messages in the L1 SBAS Open Service.
Spare bits of the message, in positions 222 & 223, will be used as an identifier signifying the type of integrity data contained within the nominal MT0 as follows:
<table><tr><th>Bits 222 & 223</th><th>Integrity Message ID</th></tr><tr><td>01 (int =1)</td><td>MT34</td></tr><tr><td>10 (int =2)</td><td>MT35</td></tr><tr><td>11 (int =3)</td><td>MT36</td></tr></table></td></tr>
<tr><td>32</td><td>Satellite clock-ephemeris error corrections and covariance matrix</td><td>Error estimates for slow varying GNSS satellite ephemeris and clock errors</td><td>SouthPAN will not use MT32 to broadcast information for the SouthPAN geostationary satellites.</td></tr>
</table>

Message Type	Contents	Purpose	Notes
39, 40	SBAS satellites ephemeris and covariance matrix	Error estimates for slow varying SBAS satellite ephemeris and clock errors	Geo-ranging capability is not supported by SouthPAN. Only the message header and Keplerian parameters are populated with non-dummy values, as follows: • Satellite slot Delta (in MT39) is filled with PRN122 delta GEO slot according to MT31. • IODG (in MT39). • Service Provider ID (in MT39) is set to 8. • Keplerian parameters (in MT39 and MT40) are filled with orbital parameters for INMARSAT 4-F1 satellite. • t_e parameter (in MT40) is populated with toe corresponding to the message transmission. • DFREI (in MT40) is always set to 15, meaning “Not for use in SBAS mode”. All the other fields (clock and covariance parameters) in message 40 are set to dummy zero. The accuracy of the Keplerian parameters is expected to be coarse (in the order of tens of kilometres) but enough to allow an approximate computation of the signal Doppler. SouthPAN GEO Satellites are always set to Not Monitored.
37	Degradation parameters and DFREI scale table	Information about the correction degradation upon message loss	The time reference identifier is always set to 0 to indicate GPS.
47	Almanacs of SBAS satellites	SBAS GEO satellites almanacs	Only SBAS I almanac section is populated with non-dummy values: • Satellite slot Delta (in MT47) is filled with PRN122 delta GEO slot according to MT31. • SBAS Provider ID (in MT47) is set to 8. • Ownership Indicator (in MT47) is set to one. • Keplerian parameters (in MT47) are populated with orbital parameters for INMARSAT 4-F1 satellite. • ta parameter (in MT47) is populated with the second in day corresponding to the time message transmission. • All the fields in the messages 47 in SBAS II section are set to dummy zero.

Message Type	Contents	Purpose	Notes
42	SBAS Network Time/UTC	Parameters for synchronisation of SBAS Network time with UTC	This message is declared as RESERVED in ED-259 [2]. Field UTC Standard identifier is set to 7, indicating that UTC is not provided. All the other parameters into the Common parameter's sections are set to dummy zero. GPS and Galileo offset (relative to SBAS Network Time) are set to zero. A Time Service is not provided. The objective of this message is to provide a time synchronization system. However, its information is not needed for the SBAS DFMC service or the application of the corrections information. Users are to ignore this MT in processing.
62	Internal SBAS L5 test message		This message is broadcast approximately every 700-1000 seconds for internal testing purposes. It does not carry information to be acquired or used by the DFMC SBAS users.
63	SBAS L5 null message	Filler message if no other message is available	This message will be used as a placeholder if no other message is available for broadcast. It does not carry information to be acquired or used by the L5 SBAS users. SouthPAN early DFMC Services may broadcast MT63 messages with the contents bits set to values different from zero as part of the system broadcast initialisation sequence.

5.2.4 Time-out table

SouthPAN early services use a dynamic scheduling algorithm to optimise the DFMC SBAS message sequence for efficient usage of the available bandwidth. Maximum Update Intervals are implemented as per ED-259 [2].

The effective update rate is increased for the MT31 message and MT32 messages to improve time to first fix and support high accuracy position solutions by refreshing the information more frequently than the Maximum Update Interval. Additionally:

- MT62 has a Maximum Update Interval of 1000 seconds.
- MT42 has a Maximum Update Interval of 240 seconds.

5.2.5 Ephemeris Navigation Database

ED-259 [2] states that the receiver shall use a navigation database with the last three broadcast navigation messages for GPS and the last four broadcast navigation messages for Galileo.

We recommended receiver manufacturers extend the length of their navigation database. This will improve the robustness of the calculated solutions.

5.2.6 User Smoothing Time

The performance of the SouthPAN DFMC SBAS Open Service is based on the presumption that the user will implement an ionosphere-free code-carrier smoothing filter with a characteristic time of 600 seconds.

Users may choose a different characteristic time due to their operational environment (for example, 100 seconds to cope with regular satellite loss-of-lock) however this may impact positioning performance.

5.3 PVS through L5 SBAS Signal

SouthPAN will specify signal and data formats to support the provision of PPP corrections (OS-PVS) on a third navigation signal. Until this third navigation signal is available, the PVS Open Service will be transmitted on the L5 navigation signal.

5.3.1 PVS corrections within the DFMC SBAS navigation messages

MT32 DFMC SBAS corrections fields are a vehicle for the broadcast of the PVS corrections. The resolution of the MT32 corrections allow for the accuracies described in Table 5: OS-PVS MT32 resolutions.

Table 5: OS-PVS MT32 resolutions

Parameter	Bit Length	Resolution	Max Error	Use
Satellite Slot Number	8	1	n/a	DFMC SBAS & PVS
IODN	10	1	n/a	DFMC SBAS & PVS
δx (ECEF)	11	0.0625 m	0.03125 m	DFMC SBAS & PVS
δy (ECEF)	11	0.0625 m	0.03125 m	DFMC SBAS & PVS
δz (ECEF)	11	0.0625 m	0.03125 m	DFMC SBAS & PVS
δB	12	0.03125 m	0.015625 m/s	DFMC SBAS & PVS
δx rate-of-change (ECEF)	8	0.00048828 m/s	0.00024414 m/s	DFMC SBAS & PVS
δy rate-of-change (ECEF)	8	0.00048828 m/s	0.00024414 m/s	DFMC SBAS & PVS
δz rate-of-change (ECEF)	8	0.00048828 m/s	0.00024414 m/s	DFMC SBAS & PVS
δB rate-of-change	9	0.00024414 m/s	0.0012207 m/s	DFMC SBAS & PVS
Time of applicability, tD	13	16 secs	n/a	DFMC SBAS & PVS

The MT32 time of applicability field indicates whether the corrections are used for DFMC SBAS-only or DFMC SBAS and PVS. By message format, the Time of Applicability is always a multiplier of 16. The parity of $t_D/16$ indicates the MT32 correction usability:

- Odd Value - Mod ($t_D/16$, 2) == 1: The correction is applicable to both SBAS and PVS users.
- Even Value - Mod ($t_D/16$, 2) == 0: The correction is applicable only to SBAS users.

The MT32 corrections use the same equations that ED-259 [2] defines for DFMC SBAS.

The End User is not required to decode the MT31 to use the OS-PVS, as the MT32 message already includes the PRN number itself at the Satellite Slot Number.

5.3.2 Applicability of Corrections

The performance of the SouthPAN PVS Open Service is based on the presumption that the applicability time of the corrections is 100 seconds since the time of reception of the relevant MT32.

The applicability time must be measured since the time of reception of the SBAS message and not since the time of applicability field t_D.

The update interval of the MT32 corrections in the DFMC SBAS sequence is increased to improve the high accuracy corrections validity.

5.4 Network Delivery

This section will be updated with details of this delivery channel in future versions of this document.

6 L1 SBAS Open Service (OS-L1)

6.1.1 L1 SBAS Open Service Augmented Signal

The SouthPAN L1 SBAS service augments the GPS L1 C/A signal defined by IS-GPS-200N [3] in accordance with DO-229F [1].

6.1.2 L1 SBAS Open Service Coverage

OS-L1 coverage is shown in Figure 1: SouthPAN early Open Services Coverage.

6.1.3 L1 SBAS Open Service Reference Frame

OS-L1 corrections are provided relative to WGS84 in accordance with DO-229F [1].

6.1.4 L1 SBAS Signal in Space Open Service (OS-L1-SIS)

OS-L1-SIS is the L1 SBAS Open Service delivered via the Signal-In-Space, which is not certified for Safety-Of-Life.

It has the following indicative performance requirements:

Table 6: OS-L1-SIS Performance Requirements

Performance Measure	Target
Horizontal Position Error (HPE) (95%)	≤ 3 metres
Vertical Position Error (VPE) (95%)	≤ 4 metres
Service Availability	≥ 0.95

6.1.5 L1 SBAS Network Open Service (OS-L1-INT)

This section will be updated with details of the OS-L1-INT service in future versions of this document.

6.1.6 L1 SBAS Observed Performance

This section will be updated with observed performance information in future versions of this document.

7 DFMC Open Service (OS-DFMC)

7.1.1 DFMC SBAS Augmented Signal

The SouthPAN DFMC SBAS L5 service augments the following GNSS signals using an ionosphere-free combination in accordance with ED-259 [2]:

- GPS L1 C/A signal defined by IS-GPS-200 [3];
- GPS L5 signal defined by IS-GPS-705 [4]; and
- Galileo E1 and E5a signals defined by OS-SIS-ICD [5].

7.1.2 DFMC SBAS Open Service Coverage

OS-DFMC coverage is shown in Figure 1: SouthPAN early Open Services Coverage

7.1.3 DFMC Open Service Reference Frame

OS-DFMC corrections are provided relative to WGS84 in accordance with ED-259 [2].

7.1.4 DFMC SBAS Signal in Space Open Service (OS-DFMC-SIS)

OS-DFMC-SIS is the DFMC SBAS Open Service delivered via the Signal-In-Space, which is not certified for Safety-Of-Life.

It has the following indicative performance requirements:

Table 7: OS-DFMC-SIS Performance Requirements

Performance Measure	Target
Horizontal Position Error (HPE) (95%)	≤ 1.5 metres
Vertical Position Error (VPE) (95%)	≤ 2.5 metres
Service Availability	≥ 0.95

7.1.5 DFMC SBAS Network Open Service (OS-DFMC-INT)

This section will be updated with details of the OS-DFMC-INT service in future versions of this document.

7.1.6 DFMC SBAS Observed Performance

This section will be updated with observed performance information in future versions of this document.

8 PVS Open Service (OS-PVS)

8.1.1 PVS Augmented Signal

When using ED-259 [2] to provide high accuracy corrections, the following DFMC SBAS conventions must be the followed:

- For GPS, the signal augmented is the L1 LNAV navigation for the L1/L5 ionosphere-free combination as described in ED-259 [2].
- For GAL, the signal augmented is the F/NAV navigation for the E1/E5A ionosphere-free combination as described in ED-259 [2].

The GPS modernisation program continue to launch and commission L5-capable satellites into the constellations and is not complete at the time of writing. End Users may experience degradation of the DFMC SBAS and PVS Open Services performances as non-L5-capable GPS satellites are in-view. The regularity of this degradation will decrease as L5-capable GPS Block-III and Block-IIIF launches proceed.

8.1.2 PVS Open Service Coverage

OS-PVS coverage is shown in Figure 1: SouthPAN early Open Services Coverage.

8.1.3 PVS Open Service Reference Frame

OS-PVS corrections are provided relative to ITRF2014 at the current epoch.

8.1.4 PVS Signal in Space Open Service (OS-PVS-SIS)

OS-PVS-SIS is the PVS Open Service delivered via the Signal-In-Space, which is not certified for Safety-Of-Life.

It has the following indicative performance requirements:

Table 8: OS-PVS-SIS Performance Requirements

Performance Measure	Target
Horizontal Position Error (HPE) (95%)	≤ 0.375 metres
Vertical Position Error (VPE) (95%)	≤ 0.525 metres
Convergence Time	≤ 80 minutes
Service Availability	≥ 0.95

8.1.5 PVS Network Open Service (OS-PVS-INT)

This section will be updated with details of the OS-PVS-INT service in future versions of this document.

8.1.6 PVS Observed Performance

This section will be updated with observed performance information in future versions of this document.

9 GRE Observables (OS-GOBS)

GNSS Observations will be provided from the GNSS Reference Equipment once this is deployed. This section will be updated with information in future versions of this document.

10 SouthPAN End User receivers

SouthPAN is not currently certified for Safety-of-Life applications.

If your device conforms to DO-229F [1]—including processing functionality of the message types described in Section 5, Specification of navigation signals—then it should meet the requirements for using SouthPAN Open Service Signal-In-Space and be able to achieve the performance described in section 6.

The minimum requirement for using SouthPAN's L1 Open Service is by implementing the DO-229F [1] navigation weighted solution and message processing.

Safety-of-Life user receivers may receive the SouthPAN L1 SBAS signal on PRN 122 but will ignore the SBAS messages due to the existence of Message Type 0 (MT0). Safety-of-Life user receivers are those that are certified to Federal Aviation Administration (FAA) Technical Standing Order TSO-C145 or -C146, and their equivalents published by the European Union Aviation Safety Agency (EASA) ((E)TSO-C145/-C146).