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Toitū Te Whenua
Land Information
New Zealand

SouthPAN Service Definition Document for Data Access Services

Project: Southern Positioning Augmentation Network

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SouthPAN

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:

- is on an 'as-is' and 'as available' basis with all faults, and the Commonwealth of Australia and the Sovereign in Right of New Zealand each disclaim all warranties, guarantees or representations of any kind, and
- is entirely at each End User's own risk, and the Commonwealth of Australia and the Sovereign in Right of New Zealand each disclaim any liability to any End User or anyone else for any liability whatsoever (including, without limitation, any liability for negligence).

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Where an End-User accesses or uses any of the End-User Services for the purposes of making goods or services available to one or more other persons, that End-User assumes, to the maximum extent permitted by law, any and all liability to those persons in connection with or arising out of those End-User Services and will be taken to have made those persons aware of this disclaimer.

The End-User Services have the performance targets defined in sections 11, 12, and 13 of this document.

For the purposes of this disclaimer:

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

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 Service Definition Document for Data Access 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:

- 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
9 November 2023	01	Initial revision	AU: D2023-53486 NZ: A5563666

Approvals

	Signature
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1.1 Document identification

Project title	Southern Positioning Augmentation Network
GA Location	HPE Content Manager
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LINZ Record ID	A5563666

1.2 Document overview

Section	Section Heading	Section Description
2	Reference Documents	A list of documents referenced in the SDD-DAS
3	Executive Summary	An executive summary of SDD-DAS.
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	Connection Details	A synopsis of the key steps involved in configuring SouthPAN DAS connection
6	DAS Registration	A brief outline of the SouthPAN DAS registration process
7	DS2DC Client	An overview of DS2DC Client architecture
8	DS2DC Protocol	Comprehensive analysis of the DS2DC communication protocol: Message structure, categorization, and authentication sequence
9	SouthPAN DAS Message	In depth study of SouthPAN DAS message structure
10	SDAS Messages	Detailed analysis of SouthPAN SBAS service message types, parameters, and their significance in the scope of SBAS services
11	L1 SBAS Open Service (OS-L1-DAS)	A closer look at signal augmentation, coverage, reference frame, and performance metrics in L1 SBAS Open Service within SouthPAN
12	DFMC Open Service (OS-DFMC-DAS)	An extensive analysis of the SouthPAN DFMC SBAS service, with attention to its covered region, reference basis, and performance predictions.
13	PVS Open Service (OS-PVS-DAS)	Introduction to SouthPAN PVS augmented signalling and open service
14	GRE Observables (OS-GOBS)	This section is currently under development and will be updated with additional information in upcoming revisions of this document

Section	Section Heading	Section Description
15	SouthPAN End User receivers	This section provides detailed insights into SouthPAN's certification status for safety-critical applications, emphasizing the strict adherence to DO-229F and associated standards for device compliance.
Appendix A	SINCA Description	A quick overview of the SINCA compression and decompression techniques in the context of SouthPAN DAS messages.

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 SouthPAN DAS from SouthPAN on their devices.

1.5 Terminology, acronyms, and abbreviations

1.5.1 Definitions

In this document, unless the contrary intention appears:

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

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

Early Open Service means an Open Services provided before Final Operating Capability has been achieved (see Table 3).

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.

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

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).

1.5.2 Acronyms

BPSK means Binary Phase Shift Keying

CORS means Continuously Operating Reference Station

CPF means Correction Processing Facilities

DAS means Data Access Service

DC means Data Client

DFMC means Dual Frequency Multi Constellation

DFREI means Dual Frequency Range Error Indicator

DS means Data Server

DS2DC means Data Server to Data Client

EASA means European Union Aviation Safety Agency

ECEF means Earth Centred Earth Fixed

EU means End User

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

SINCA means SISNeT Compression Algorithm

SIS means Signals-In-Space

SISNeT means Signal in Space through the Internet

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]	DO-401	Minimum Operational Performance Standards for Galileo –Global Positioning System –Satellite-Based Augmentation System Airborne Equipment	RTCA
[4]	IS-GPS-200N	NAVSTAR GPS Space Segment/Navigation User Interface Specification, Revision N	US Space Force
[5]	IS-GPS-705J	NAVSTAR GPS Space Segment/User Segment L5 Interface Specification, Revision J	US Space Force
[6]	OS-SIS-ICD_v2.0	European GNSS (Galileo) Open Service Signal-In-Space Interface Control Document, Issue 2.0	EUSPA
[7]	SBAS-STN-0001	Service Definition Document for Open Services	GA LINZ
[8]	E-RD-SYS-E31-010	SISNeT User Interface Document	European Space Agency

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 Data Access Services (**DAS**) is intended for use by GNSS equipment manufacturers, applications developers, and End-Users. It contains a description of the SouthPAN system architecture, structure and contents of the navigation messages, and indicative performance requirements for DAS.

This document will be updated in the future as DAS is improved, and new functionality is introduced.

4 SouthPAN overview

SouthPAN is a satellite-based augmentation system (**SBAS**) broadcasting Signals-In-Space (**SIS**) and providing Data Access Services (**DAS**), 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 Open 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	Data Access Service
L1 SBAS	L1 SBAS Open Service (OS-L1), providing augmentation of the GPS L1 C/A signal.	L1 navigation data
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.	DFMC navigation data
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.	PVS navigation data

See section 10 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.

4.1 Service Architecture

Table 2 depicts the relationship between SouthPAN's individual End-User services and groupings of services. These terms are used throughout the SDDs and in other SouthPAN documentation.

Table 2: SouthPAN service architecture

SouthPAN Services			
Open Services			Safety-of-Life Services
L1 SBAS SIS	DFMC SBAS SIS	PVS SIS	L1 SBAS SIS
L1 SBAS DAS	DFMC SBAS DAS	PVS DAS	

SouthPAN services are defined in a series of Service Definition Documents (SDD):

- SBAS-STN-0001: SDD for Open Services SBAS-STN-0001 [7]—defines the SouthPAN Open Services L1 SBAS, DFMC SBAS, and PVS provided via the L1 and L5 navigation SIS transmitted by geostationary satellite.
- SBAS-STN-0002: SDD for Data Access Services—defines the SouthPAN Open Services L1 SBAS, DFMC SBAS, and PVS provided via the internet (this document).
- SBAS-STN-0003: SDD for Safety-of-Life Services—defines the SouthPAN L1 SBAS Safety-of-Life Service provided via the L1 navigation SIS transmitted by geostationary satellite(s) (future document).

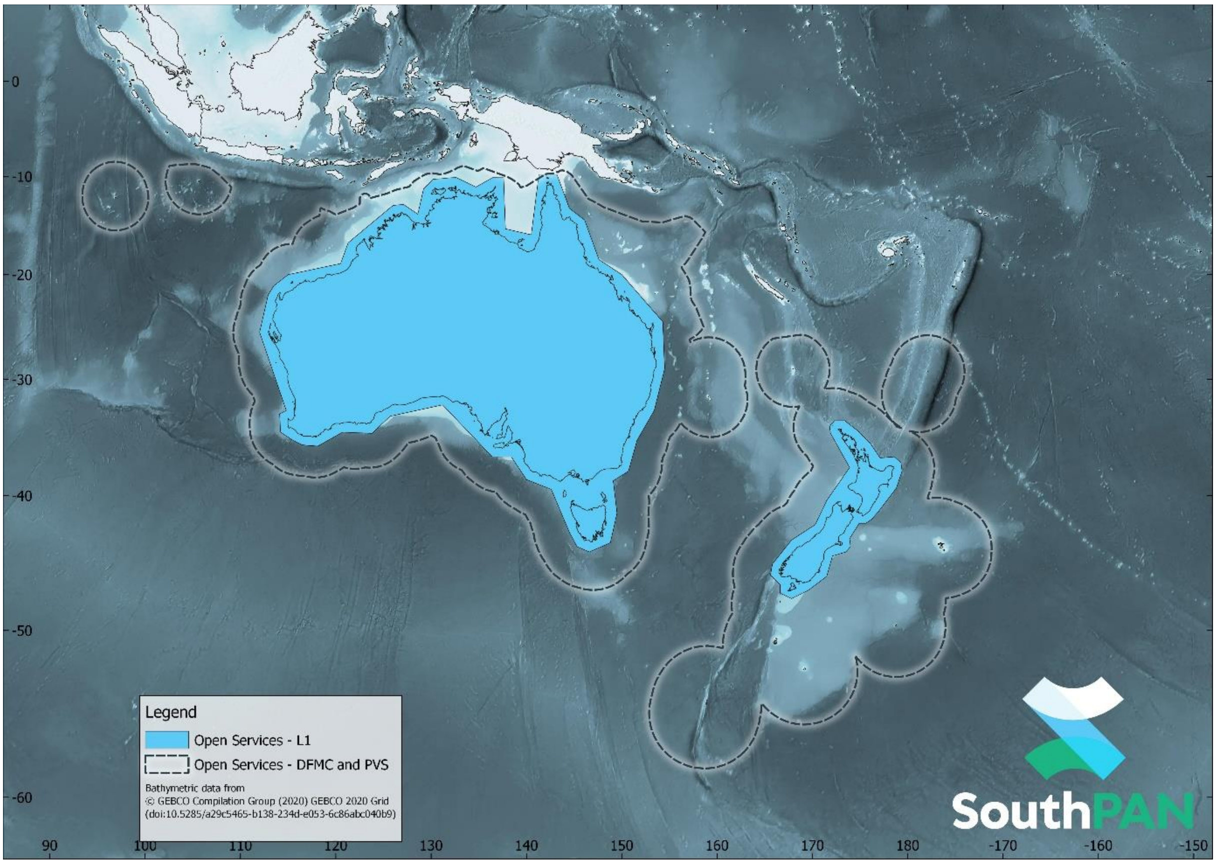

Figure 1: SouthPAN Early Open Services Coverage

4.2 System architecture

SouthPAN uses a network of ground stations receiving GNSS signals. These are delivered to a computation centre, which generates corrections to reduce errors for GNSS (including satellite orbit, satellite clock offset, and ionospheric propagation delay). SouthPAN estimates residual errors that cannot be rectified and will independently monitor 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 via Geostationary Earth Orbit (GEO) satellites and are available online. Users cannot use the SouthPAN GEO signals for ranging.

Figure 2 shows the end-to-end system architecture.

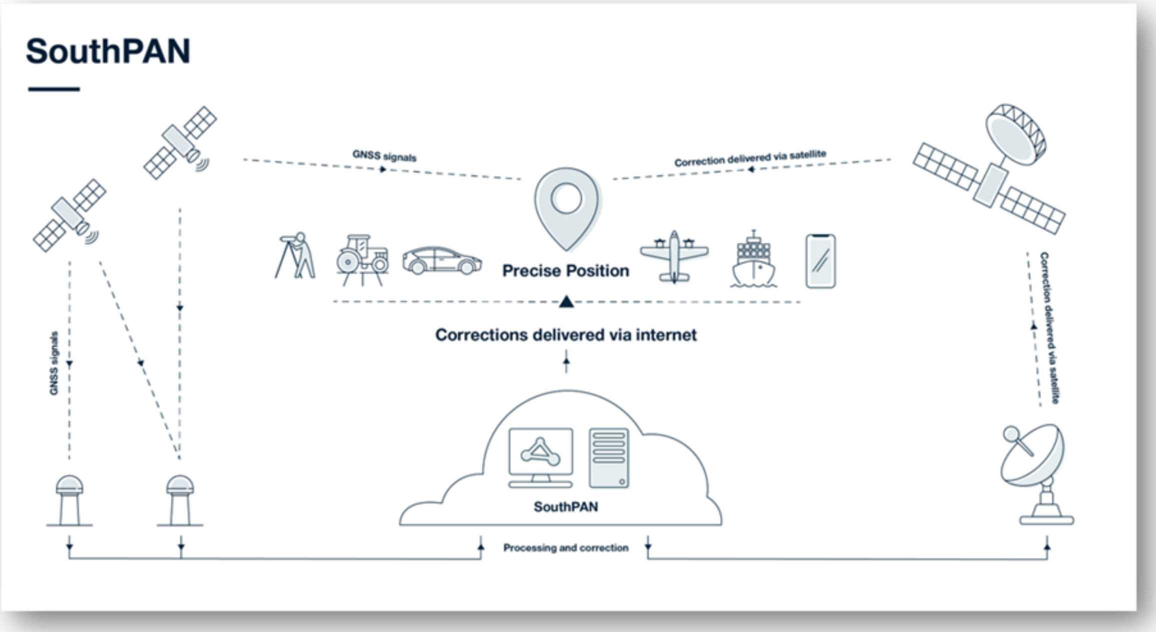

Figure 2: SouthPAN System Architecture

4.2.1 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 the data delivered to the CPFs has undergone rigorous quality control checks, it is sent to the processing algorithms. These algorithms 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 via the SouthPAN satellite and are also available on the internet.

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

4.2.2 Space facilities

SouthPAN has a satellite uplink facility and satellites 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 a new L5b (1207.14MHz) navigation signal in addition to the current L1 and L5 signals. 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 satellite in GEO. Additional uplink facilities will be deployed to provide redundancy and support new satellites.

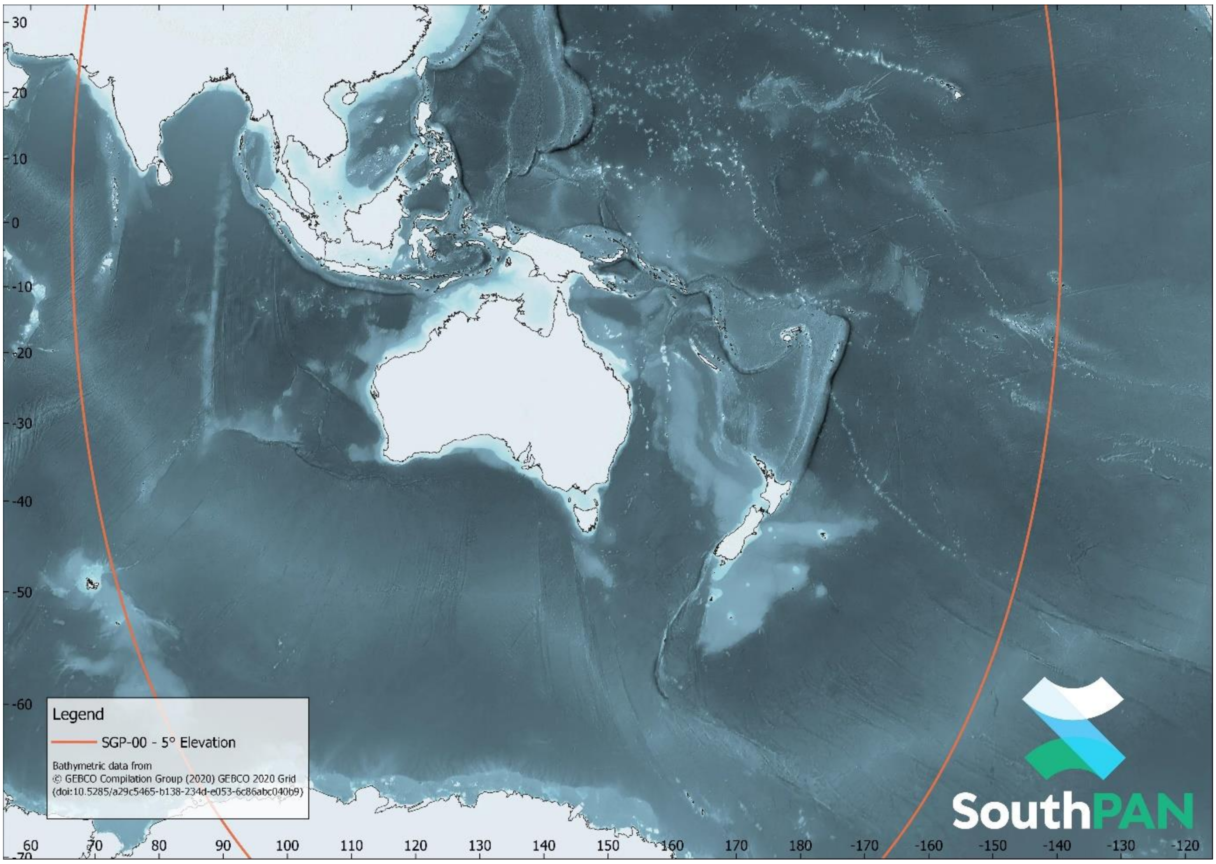

Figure 3: Satellite Coverage for SouthPAN Early Open Services

4.2.3 Data Access Facilities

SouthPAN has server infrastructure to provide Data Access Services via the internet. SouthPAN data is transferred from the CPF to these servers for dissemination to users. These are hosted on high availability cloud infrastructure and provide access using the methods described in the Service Definition Document for Data Access Services (this document).

4.3 Deployment strategy

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 3.

Table 3: Key deployment milestones

Milestone	Description	Comment
Initial Operating Capability-95	Commencement of Early Open 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 (
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 L5b	A new satellite will include functionality for a new navigation signal L5b, 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 L5b on 1,207.14 MHz, will be added to the system. The PVS Open Service will migrate

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

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.

This SDD will be regularly updated throughout the deployment period.

4.4 Organisational framework

4.4.1 Roles & Responsibilities

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

4.4.2 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 Connection Details

To encourage uptake and interoperability, SouthPAN DAS has been developed to be compliant with the SISNeT protocol provided by the EGNOS Data Access Service (EDAS). For consistency, the nomenclature of components has been maintained (such as DS2DC and SINCA).

This section offers essential details for configuring the connection settings required for SouthPAN DAS messages.

Hostname/Static IP Addresses:

sisnet.data.gnss.ga.gov.au

13.239.151.7 / 54.153.169.141 / 3.104.99.86

User/Password:

Provided upon registration – see Section 6.

Service Connection Details:

Each of the services will be provided on two ports to maximise service availability. End-Users may choose to use one or both of the ports to access the services depending on their own availability requirements. Navigation solutions may vary marginally between each port, and should End-Users need to change from one port to the other then some discontinuity in position and time may be apparent.

Service	Protocol	Format	Ports	Notes
OS-L1-DAS	DS2DC/SISNeT	RTCA DO-229D	61001, 62001	See Section 10
OS-DFMC-DAS	DS2DC/SISNeT	EUROCAE ED-259/ DO-401	61005, 62005	See Section 10
OS-PVS-DAS	DS2DC/SISNeT	EUROCAE ED-259/ DO-401 (MT32)	61005, 62005	See Section 10
OS-GOBS	Ntrip v2.0	RTCM 3.2	TBD	Future service – coming from 2025

6 DAS Registration

SouthPAN DAS access is available upon registration. To request a DAS account, users must send an email request to the SouthPAN DAS provider at gnss@ga.gov.au with their preferred username, and the DAS provider will provide the corresponding password to the user.

7 DS2DC Client

Figure 4 illustrates the architecture of the DS2DC client. In this diagram, boxes denote various functional components, while ellipses represent different pieces of information. The blue ellipses specifically signify the output data generated by the DS2DC client.

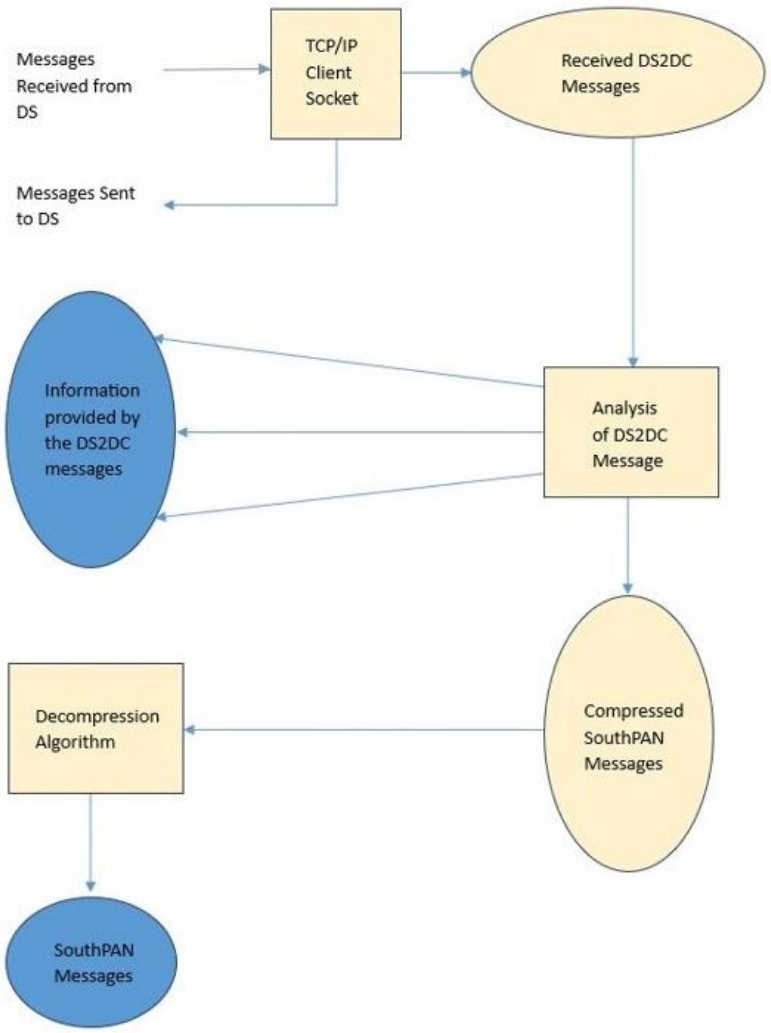

Figure 4: DS2DC Client Architecture

The architecture of the DS2DC client comprises the following functional blocks:

- TCP/IP Client Socket (TCS): This component is responsible for establishing a TCP/IP connection with the Data Server (DS). It utilizes a pre-defined IP address and port to facilitate the exchange of text messages with the DS. It handles both sending messages to the DS and receiving responses from the DS.
- Analysis of DS2DC Messages (ADM): This block plays a crucial role in analysing the content of messages received from the DS. Its primary function is to extract and convert the information contained in these messages into a user-friendly and readily processable format.
- Decompression Algorithm (DA): The DS employs a compression algorithm named SINCA to compress SouthPAN DAS messages before transmitting them to users. A detailed explanation of the SINCA algorithm is presented in Appendix A.

These functional blocks collectively constitute the core of the DS2DC client's architecture, facilitating the user's ability to establish connections and receive up to date SouthPAN DAS messages.

8 DS2DC Protocol

8.1 Fundamentals of the SouthPAN DS2DC protocol

The information in this section is based on [RD7]. The communication protocol utilized between the Data Server (DS) and the Data Client (DC) is referred to as DS2DC. The DS2DC protocol operates with text strings, which are transmitted directly via the TCP/IP protocol by activating a socket connection between the DC and DS. These text strings are commonly referred to as "DS2DC messages." Each DS2DC message consists of text fields separated by commas. Each field contains specific information within the message. The first field is an uppercase text label that serves to identify the purpose of the DS2DC message, called the "Message Name." Figure 5 provides an illustration of the general structure of a DS2DC message.

Message Name	,	Field 1	,	Field 2	,	…	,	Field N-1	,	Field N		<LF> or <CR><LF>

Figure 5: General Structure of a DS2DC message

Note that every message in the DS2DC protocol must conclude with one of the following:

- A line feed (LF) character
- A carriage-return character followed by a line feed character (CRLF)

Depending on their direction, DS2DC messages can be categorized into two main groups:

- Messages from End User (EU) to the DS: These messages, in line with SISNeT terminology, are referred to as R-Messages or RMs. They often serve to request specific services from the DS and are commonly known as "DS2DC messages." The names of these messages always commence with an alphabetic character.

- Messages from the DS to the End User (EU): As per SISNeT terminology, these messages are called S-Messages or SMs. These messages typically start with an asterisk (*) character, followed by the message name being responded to. For instance, if an RM is named 'MSG,' the corresponding SM would be '*MSG.'

The classification of DS2DC messages is depicted in Figure 6 for reference.

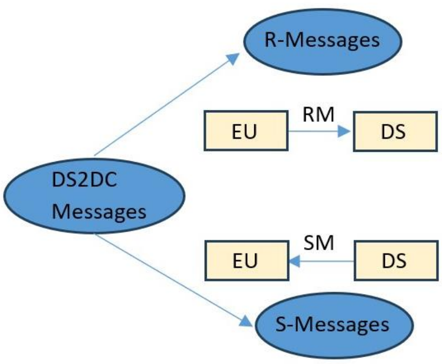

Figure 6: Types of DS2DC messages

8.2 Available DS2DC Messages in SouthPAN

The list below explains the purposes of certain DS2DC messages in SouthPAN.

- R – Messages:
  - AUTH: This R-Message (RM), in the format provided below, enables the implementation of an essential authentication process. This process is a prerequisite for any interaction with the DS. For further information on this process, see Section 8.3.
  - START: This RM enables the user to continuously receive SouthPAN DAS messages from the data server until a STOP message is sent.
  - STOP: This RM is utilized when the user intends to cease receiving SouthPAN DAS messages following the transmission of the START message.
- S – Messages:
  - *AUTH: A positive response to an authentication message (AUTH), signifying that the DC Client is granted permission to engage with the DS.
  - *START: This response corresponds to the START message and is consistently followed by the reception of SouthPAN DAS messages.
  - *STOP: This response indicates that the continuous reception of SouthPAN DAS messages has been halted in response to the STOP message.
  - *ERR: In cases where the user is not authorized, an error message will be transmitted resulting in access being denied.

8.3 The Authentication Process

Once a connection to the Data Server is established, the client socket must engage in an authentication dialogue with the DS within a 10-second timeframe to gain authorization for service access. As described in Section 8.2, the authentication protocol relies on the utilization of the "AUTH" R-Message and its associated "*AUTH" S-Message. The comprehensive sequence of actions is as follows:

- The DS2DC Client initiates a connection with the DS.
- Subsequently, the DS2DC Client dispatches an AUTH message in the specified format, which contains private credentials corresponding to a valid account, namely, a username and password.

  Format:

AUTH	,	User	,	Password

  Fields:

Field	Comments
AUTH	The message name
User	Username corresponding to valid SISNeT account
Password	The corresponding password

- If the authentication data matches a valid account, the Data Server will respond with an *AUTH message in the format provided, granting access to the DS. Subsequently, the DC client can initiate its regular interaction with the DS using the START RM.

Format:

*AUTH

Fields:

Field	Comments
*AUTH	The message name

9 SouthPAN DAS Message

The End-User will receive the most recent SouthPAN DAS messages by using the 'START' R-message. The response to the START message is the *START S-message, and this response is consistently followed by the reception of SouthPAN DAS messages in the provided format until a 'STOP' R-message is transmitted.

Format:

*MSG	,	GPS Week	,	GPS Time	,	SINCA Compressed SouthPAN Message

Fields:

Field	Comments
*MSG	The message identity
GPS Week	The GPS week corresponding to the SouthPAN message
GPS Time	The GPS time corresponding to the SouthPAN message
SouthPAN Message	The SouthPAN message in SINCA format (see Section Appendix A)

In order to enhance communication speed, the Data Server employs the SISNeT Compression Algorithm (SINCA). Users are required to apply a decompression technique to retrieve the original SouthPAN DAS messages. For comprehensive details regarding the SINCA compression and decompression process, please refer to Section Appendix A.

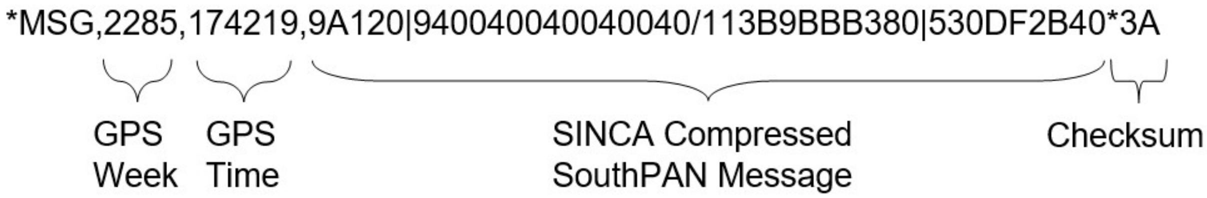

Figure 7: General Structure of SouthPAN message

10 DAS Messages

10.1 OS-L1-DAS Messages

10.1.1 List of Message Types

SouthPAN will transmit the L1 SBAS navigation messages defined in Table 4 below. An abridged description is provided, along with notes and special conditions that End-Users may require to achieve maximum performance. The complete message definition is in RTCA DO-229F [1].

Table 4: SouthPAN L1 SBAS Message Types

Message Type	Contents	Purpose	Notes
0	During development contains MT2 data	Don't use for safety of life applications	During SouthPAN Early Open 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	Identity of GNSS satellites to be augmented	GEO PRN 122 is included in the MT1 mask.
2-5	Fast Corrections	Range corrections and accuracy	During SouthPAN Early Open 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.

Message Type	Contents	Purpose	Notes
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	
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	

Message Type	Contents	Purpose	Notes
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.
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). • Health and Status word indicates that the Service Provider is SouthPAN (‘8’) (Bits 4-7 set to 1000) • X_G and Y_G are populated with the coordinates of the reference position of the GEO. Z_G parameter is set to zero. • Velocity parameters X_G, Y_G and Z_G 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.

10.2 OS-DFMC-DAS Messages

10.2.1 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] and DO-401 [3].

Table 5: 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 Open 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>
</table>

Message Type	Contents	Purpose	Notes
32	Satellite clock-ephemeris error corrections and covariance matrix	Error estimates for slow varying GNSS satellite ephemeris and clock errors	SouthPAN will not use MT32 to broadcast information for the SouthPAN geostationary satellites.
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 SGP-01 satellite. • the parameter (in MT40) is populated with oe 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 SGP-00 satellite. • t_a 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] and DO-401 [3]. 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.

10.2.2 Time-out table

SouthPAN Early Open 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] and DO-401 [3].

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.

10.2.3 Ephemeris Navigation Database

ED-259 [2] and DO-401 [3] state 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.

10.2.4 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.

End-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.

10.3 OS-PVS-DAS Messages

10.3.1 PVS corrections within the DFMC SBAS navigation messages

MT32 DFMC SBAS corrections fields are a vehicle for the transmission of the PVS corrections. The resolution of the MT32 corrections allow for the accuracies described in Table 6: OS-PVS MT32 resolutions.

Table 6: 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	0.00012207 m/s	DFMC SBAS & PVS
Time of applicability, t_D	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 DFMC SBAS and PVS users.
- Even Value - Mod (t_D/16, 2) == 0: The correction is applicable only to DFMC SBAS users.

The MT32 corrections use the same equations that ED-259 [2] and DO-401 [3] define 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.

10.3.2 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.

11 L1 SBAS Open Service (OS-L1-DAS)

11.1.1 L1 SBAS Open Service Augmented Signal

The SouthPAN L1 SBAS service augments the GPS L1 C/A signal defined by IS-GPS-200N [4] in accordance with RTCA DO-229F [1].

11.1.2 L1 SBAS Open Service Coverage

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

11.1.3 L1 SBAS Open Service Reference Frame

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

11.1.4 L1 SBAS Network Open Service (OS-L1-DAS)

OS-L1-DAS is the L1 SBAS Open Service delivered via SouthPAN DAS. This is not for a Safety-of-Life Service.

It has the following indicative performance expectation.

Table 7: OS-L1-DAS Performance Expectations

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

11.1.5 L1 SBAS Observed Performance

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

12 DFMC Open Service (OS-DFMC-DAS)

12.1.1 DFMC SBAS Augmented Signal

The SouthPAN DFMC SBAS service augments the following GNSS signals using an ionosphere-free combination in accordance with ED-259 [2] and DO-401 [3]:

- GPS L1 C/A signal defined by IS-GPS-200 [4];
- GPS L5 signal defined by IS-GPS-705 [5]; and
- Galileo E1 and E5a signals defined by OS-SIS-ICD [6].

12.1.2 DFMC SBAS Open Service Coverage

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

12.1.3 DFMC Open Service Reference Frame

OS-DFMC corrections are provided relative to WGS84 in accordance with ED-259 [2] and DO-401 [3].

12.1.4 DFMC SBAS Network Open Service (OS-DFMC-DAS)

OS-DFMC-DAS is the DFMC SBAS Open Service delivered via SouthPAN DAS. This is not a Safety-of-Life Service.

It has the following indicative performance expectation.

Table 8: OS-DFMC-DAS Performance Expectations

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

12.1.5 DFMC SBAS Observed Performance

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

13 PVS Open Service (OS-PVS-DAS)

13.1.1 PVS Augmented Signal

When using ED-259 [2] or DO-401 [3] 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] and DO-401 [3].
- For GAL, the signal augmented is the F/NAV navigation for the E1/E5A ionosphere-free combination as described in ED-259 [2] and DO-401 [3].

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.

13.1.2 PVS Open Service Coverage

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

13.1.3 PVS Open Service Reference Frame

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

13.1.4 PVS Network Open Service (OS-PVS-DAS)

OS-PVS-DAS is the PVS Open Service delivered via SouthPAN DAS. This is not a Safety-of-Life Service.

It has the following indicative performance expectations:

Table 9: OS-PVS-DAS Performance Expectations

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

13.1.5 PVS Observed Performance

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

14 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.

15 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 10 then it should meet the requirements for using SouthPAN Data Access Services and be able to achieve the performance described in Section 11.

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

Safety-of-Life End-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 End-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).

Appendix A SINCA Description

A.1 SINCA Compression Algorithm

The SISNeT Compression Algorithm (SINCA) is a straightforward technique employed by the DS to enhance communication speed during the crucial task of transmitting SouthPAN DAS messages. By utilizing the SINCA algorithm, the message length is reduced. You can find a visual representation of the SINCA compression algorithm in Figure 8.

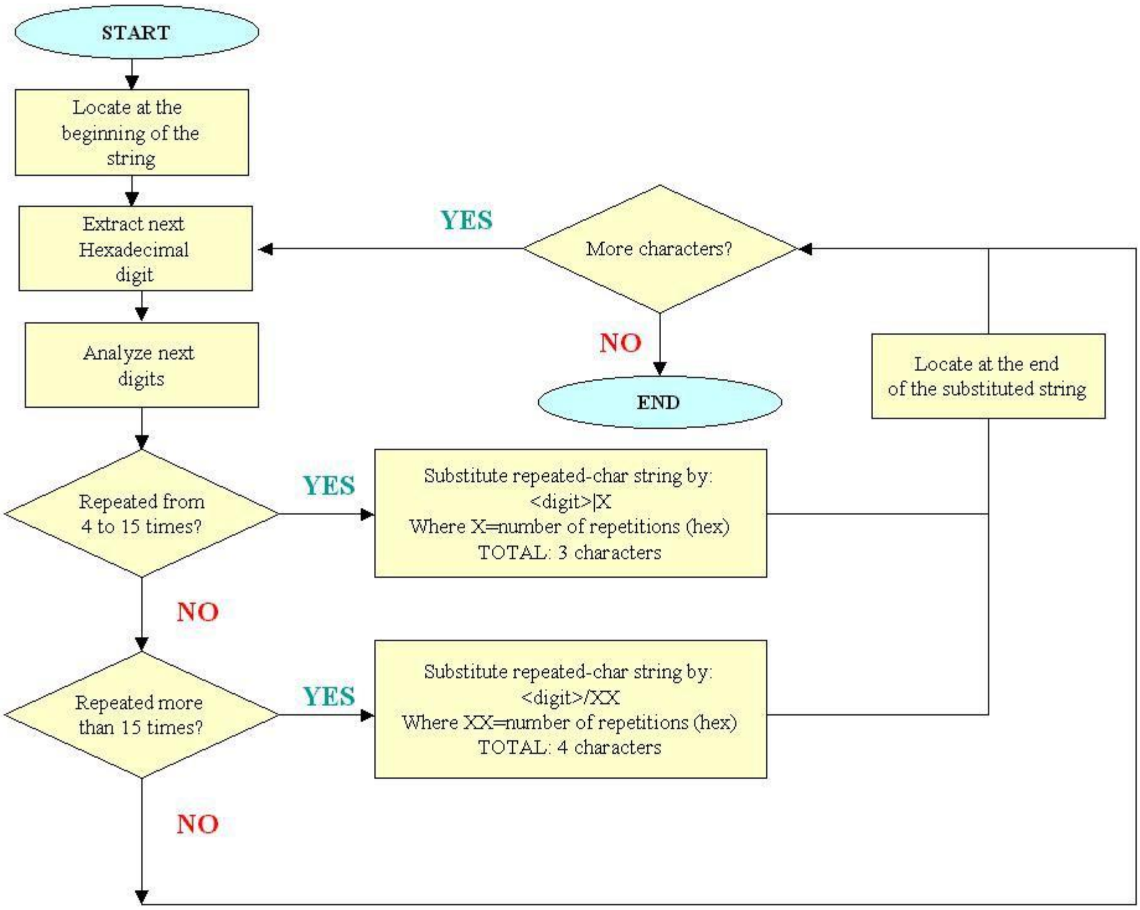

Figure 8: SINCA Compression Algorithm

The SINCA compression process involves evaluating each digit within the hexadecimal string. If a digit is repeated between 4 and 15 times, all the repetitions are replaced with the format:

<repeated_digit>|X

Where 'X' represents a hexadecimal digit indicating the number of repetitions. For example, if the substring is found to be:

AAAAAAAAAAAA

It is compressed to:

A|C

Since 'A' is repeated 12 times. Only one digit is used to represent the number of repetitions, allowing a maximum of 15 repetitions. A minimum of 4 repetitions is set as a threshold since the compressed string always consists of three characters. Without this threshold, no compression would be achieved.

If a digit is repeated more than 15 times, the compression method remains the same, but the number of repetitions is indicated using two digits, and a '/' separator is employed:

<repeated_digit>/XX

The reason for using a different separator is to facilitate the decompression process. The '|' character indicates to read only the next character, while the '/' character signifies reading the next two characters.

As depicted in Figure 9, SINCA compression can significantly reduce the length of a SouthPAN message, decreasing it from 68 characters to only 46 characters or even less. This represents a compression rate of 67.6% compared to the original size.

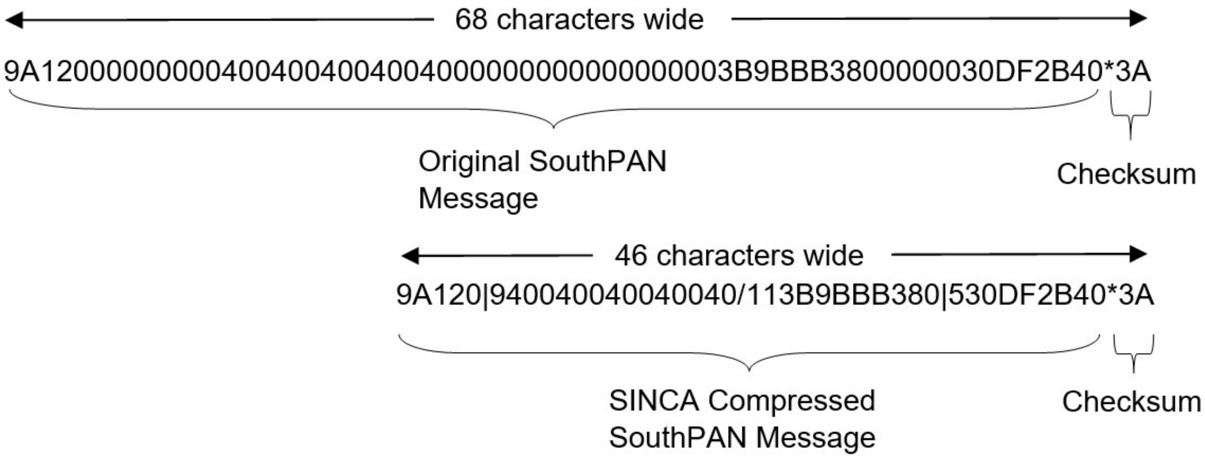

Figure 9: Example of SINCA Compression

A.2 SINCA Decompression Algorithm

Figure 10 provides an illustration of how to implement the decompression algorithm. The process involves assessing each character within the compressed string. When an 'X|Y' string is encountered, it is replaced with 'XX...X', where 'X' is repeated Y times (with Y being a hexadecimal digit). When a 'X/YY' string is encountered, it is replaced with 'XX...X', where 'X' is repeated YY times (with YY being a two-digit hexadecimal number). The algorithm continues until it reaches the end of the compressed string.

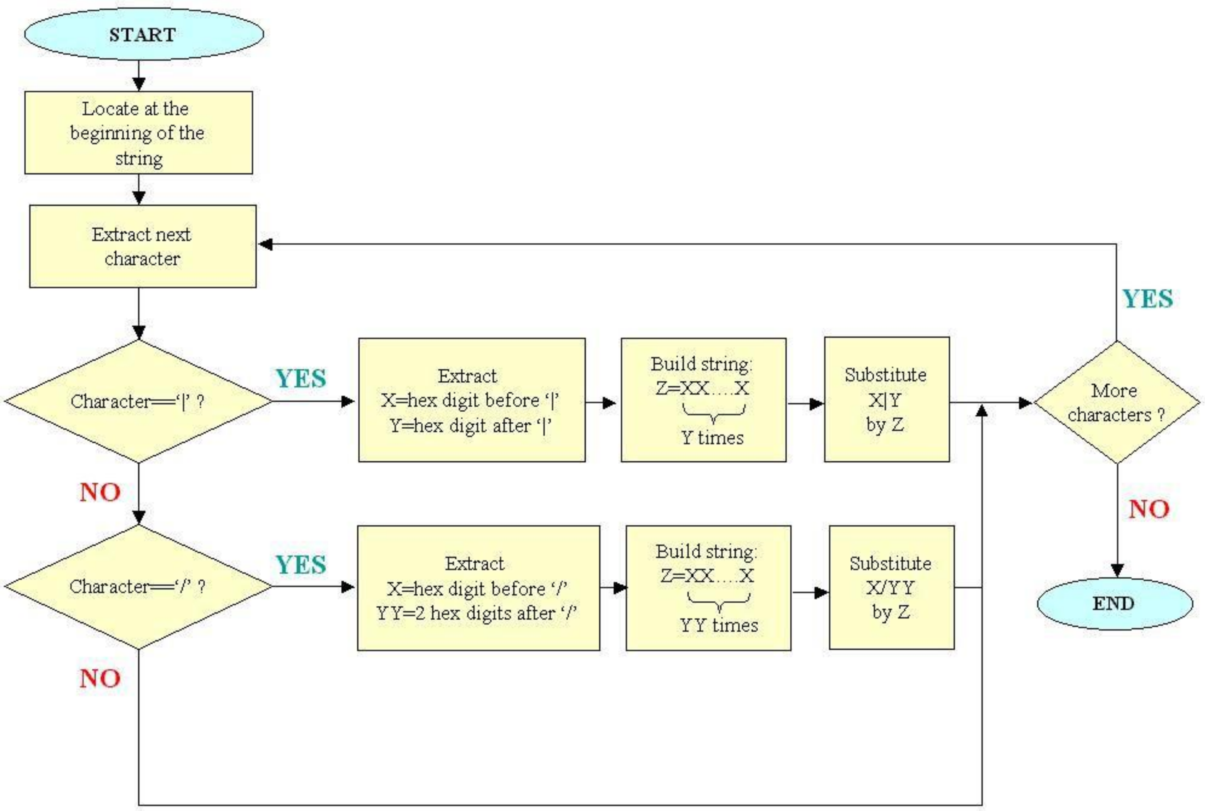

Figure 10: SINCA Decompression Algorithm

Figure 11 shows an example of SINCA decompression. The original string was 46 characters in width. However, after decompression, the resulting string extends to 68 characters, making it 1.48 times longer than the compressed version.

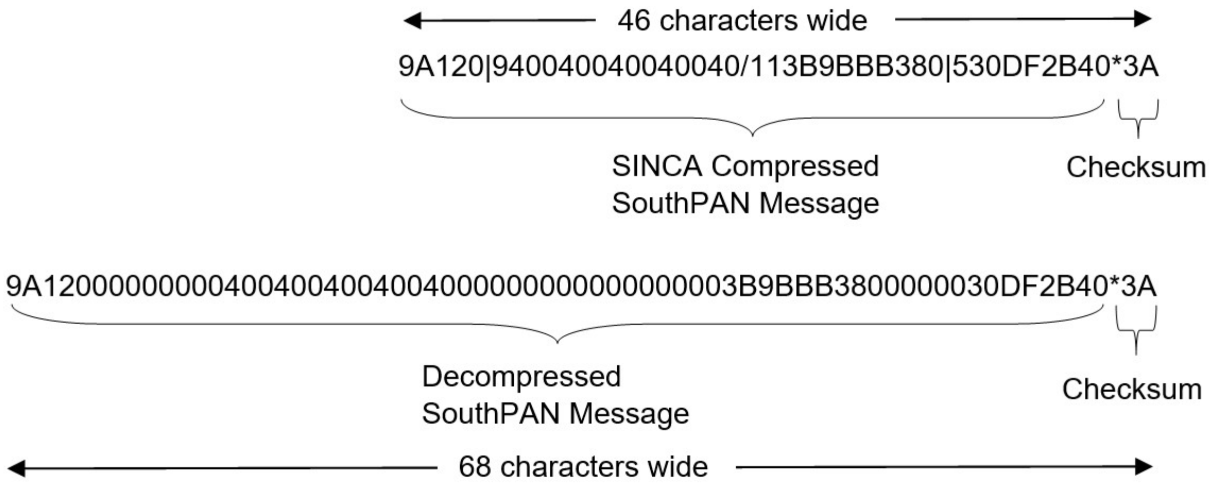

Figure 11: Example of SINCA Decompression

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