PROGRAMME OF THE EUROPEAN UNION

EGNOS Open Service (OS)

Service Definition Document (SDD)

Issue 3.0

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Only minimum expected performance characteristics are included in the commitment even though the users can usually experience a better performance. These characteristics are expressed in statistical values under given assumptions.

The minimum level of performance of the EGNOS OS is obtained under the condition that compliance is ensured with:

- The main GPS SPS SIS characteristics and performance defined in the GPS ICD [RD-4], in SBAS MOPS appendix B [RD-2] and in GPS SPS Performance Standard [RD-3];
- The receiver characteristics as described in chapters 4 and 6 and;
- Use of EGNOS OS Service within the conditions and limitations of use set forth in the EGNOS OS SDD.

The commitment regarding the expected performance as well as any other commitment in this document shall be without prejudice to the disclaimer of liability below.

User responsibilities

The user retains his responsibility to exercise a level of care appropriate with respect to the uses to which he puts the EGNOS OS, taking into account the considerations outlined above.

Before any use of the EGNOS OS, all users should study this document in order to understand how they can use the service, as well as, to familiarise themselves with the performance level and other aspects of the service they can rely on.

In case of doubt, the users and other parties should contact the EGNOS helpdesk (see section 3.4.2 for contact details).

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[1] According to regulation EU 2017/373

DOCUMENT CHANGE RECORD

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• Section 3.1.2.3: Including the active GEO information at present, updating the number of RIMS and updating the picture of the RIMS location.
• Section 6.2: Including the improvements derived from the past EGNOS system releases
• Including Appendix A Satellite navigation concept(EGNOS OS performances from ESR2.3.1) and Appendix B Ionospheric activity and impact on gnss (Satellite Navigation Concept)</td><td>2</td><td>0</td><td>18/03/2013</td></tr>
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• EGNOS Service Provision scheme updated after the declaration of the EGNOS Safety of Life assisted service for Maritime Users (ESMAS).
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1 EXECUTIVE SUMMARY

The European Geostationary Navigation Overlay Service (EGNOS) provides an augmentation service to the Global Positioning System (GPS) Standard Positioning Service (SPS). Today, EGNOS augments GPS using the L1 (1575.42 MHz) Coarse/Acquisition (C/A) civilian signal function by providing correction data and integrity information for improving positioning, navigation, and timing services over Europe. EGNOS will augment both GPS and Galileo in the future, using L1 and L5 (1176.45 MHz) frequencies.

The purpose of this "EGNOS OS Service Definition Document" (EGNOS OS SDD) is to provide information on the EGNOS Open Service (EGNOS OS).

The document describes the EGNOS system architecture and Signal-In-Space (SIS) characteristics, the OS service performance achieved, and provides information on the established technical and organisational framework, at European level, for the provision of this service. It is intended to be of use for receiver manufacturers, equipment integrators, GNSS application developers and final users of the EGNOS OS.

This document does not address EGNOS SoL Service for Aviation, nor EGNOS Safety of Life assisted service for Maritime users nor EDAS performance.

- Information about the EGNOS SoL Service for Aviation is available in a separate document called the “EGNOS SoL Service for Aviation Service Definition Document”[RD-5],
- Information about the EGNOS SoL assisted service for maritime users is available in the document “EGNOS Safety of Life assisted service for Maritime users (ESMAS) – Service Definition Document”[RD-9].
- Information regarding EDAS can be found in another separate document called the “EGNOS Data Access Service (EDAS) – Service Definition Document”[RD-6].

This document will be updated in the future as required in order to reflect any changes and improvements to the EGNOS OS Service.

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2 INTRODUCTION

2.1 Purpose and scope of the document

The EGNOS Service Definition Document – Open Service (EGNOS SDD OS) presents the characteristics of the service offered to users by the EGNOS Open Service (EGNOS OS) highlighting the positioning and timing performance currently available to suitably equipped users using both the GPS SPS broadcast signal and the EGNOS OS augmentation signals.

This document is intended to all potential users of EGNOS OS: road applications service providers and end users, precision agriculture community, telecommunication and computer operators, maritime users, or any user community interested in obtaining better positioning accuracy in those applications where safety is not critical (i.e. a failure in EGNOS OS performance do not imply any direct or indirect personal damage).

The EGNOS OS SDD comprises 7 main sections and 5 appendixes:

- Section 1 is an Executive Summary of the document.
- Section 2 ("Introduction") defines the scope of the document and the relevant reference documentation. In addition, this section clarifies the terms and conditions of EGNOS OS use, including liability and its intended lifetime.
- Section 3 ("Description of the EGNOS System and EGNOS OS Provision") gives a brief overview of the EGNOS system, as well as its technical and organisational framework for EGNOS OS service provision.
- Section 4 ("EGNOS SIS") introduces the EGNOS Signal In Space characteristics and performance in the range domain.
- Section 5 ("EGNOS Receivers") summarizes the main functionalities that should be fulfilled by any GNSS receiver to use EGNOS OS.
- Section 6 ("EGNOS OS Performance") describes the positioning Service offered to users by the EGNOS OS and the minimum performance in the positioning domain.
- Section 7 ("EGNOS Time Information Performance") deals with the EGNOS Time Service, giving its expected performance.
- Appendix A Satellite navigation concept contains fundamental information of the satellite navigation (GNSS) as complementary concepts for the rest of the document.
- Appendix B Ionospheric activity and impact on gnss assesses the impact of the ionospheric activity on GNSS and in particular on SBAS systems.
- Appendix C EGNOS OS observed performance reports on the EGNOS performance achieved during the period mid November 2023 – April 2024 at 32 EGNOS reference station locations.
- Appendix D Definitions provides the list of definitions used in the document.
- Appendix E List of acronyms provides the list of acronyms used in the document.

2.2 EGNOS OS Lifetime

The EGNOS Services are intended to be provided for a minimum period of 20 years, as from its first declaration date, with 6 years advance notice in case of significant changes in the Services provided.

2.3 The use of EGNOS OS

The EGNOS OS is intended to deliver a wide range of benefits to European citizens in the multimodal domains.

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Shown below are some examples of applications of EGNOS OS in different areas:

- In agriculture, EGNOS OS enables the high-precision spraying of fertilisers and pesticides, reducing the amount of chemicals needed for achieving optimal yield and productivity. It can also support other innovative applications.
- EGNOS OS is used in combination with geodetic techniques to improve methods in the area of property boundary mapping, land parcel identification and geo-traceability.
- In road transport, EGNOS OS allows for the development of new applications such as "pay-per-use" insurance or automatic road tolling, reducing the need for more costly alternative infrastructure. It can also be used to improve fleet tracking solutions in any road or maritime application domain.
- In rail, EGNOS OS can be used for non-safety critical applications such as passenger information systems or asset management.
- In maritime domain, the EGNOS OS could be used for non SOLAS navigation, recreation and leisure applications.
- EGNOS OS improves the precision of all personal navigation applications, giving rise to a myriad of new possibilities, such as, emergency localisation, friend finding or geo-localised advertising.

EGNOS OS also broadcasts a reliable time standard with unprecedented accuracy to be used by computer and telecommunication networks.

2.4 Reference Documents

RD	Document Title
[RD-1]	ICAO Standards and Recommended Practices (SARPS) Annex 10 Volume I (Radio Navigation Aids) 8th edition of July 2023 (which incorporated all amendments up to and including No 93)
[RD-2]	RTCA MOPS DO 229 (Revisions C, D Change 1, E or F)
[RD-3]	GPS Standard Positioning Service Performance Standard – April 2020 5th Edition
[RD-4]	IS GPS 200 Revision N – NAVSTAR GPS Space Segment / Navigation User Interface – 22nd Aug 2022
[RD-5]	EGNOS SoL Service for Aviation Service Definition Document (SoL SDD) https://egnos.gsc-europa.eu/documents/egnos-safety-life-service-sdd
[RD-6]	EGNOS Data Access Service Service Definition Document (EDAS SDD) https://egnos.gsc-europa.eu/documents/egnos-data-access-service-sdd
[RD-7]	REGULATION (EU) 2021/696 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 28 April 2021 establishing the Union Space Programme and the European Union Agency for the Space Programme and repealing Regulations (EU) No 912/2010, (EU) No 1285/2013 and (EU) No 377/2014 and Decision No 541/2014/EU
[RD-8]	EC/ESA/CNES User Guide for EGNOS Application Developers Ed. 2.0 – 15th December 2011
[RD-9]	EGNOS Safety of Life assisted service for Maritime users Service Definition Document (ESMAS SDD) https://egnos.gsc-europa.eu/documents/egnos-safety-life-assisted-service-maritime-users-esmas
[RD-10]	IMO resolution A.1046 (27) Date: 30 November 2011 https://wwwcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/Documents/A%20-%20Assembly/1046(27).pdf
[RD-11]	COMMISSION IMPLEMENTING REGULATION (EU) 2017/373 of 1 March 2017 laying down common requirements for providers of air traffic management/air navigation services and other air traffic management network functions and their oversight, repealing Regulation (EC) No 482/2008, Implementing Regulations (EU) No 1034/2011, (EU) No 1035/2011 and (EU) 2016/1377 and amending Regulation (EU) No 677/2011.

Table 1: Reference documents

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3 DESCRIPTION OF THE EGNOS SYSTEM AND EGNOS OS SERVICE PROVISION ENVIRONMENT

3.1 EGNOS: the European SBAS

Satellite navigation systems are designed to provide a positioning and timing service over vast geographical areas (typically continental or global coverage) with high accuracy performance. However, a number of events (either internal to the system elements or external, due to environmental conditions) may lead to positioning errors that are in excess of the typically observed navigation errors. For a large variety of users, such errors will not be noticed or may have a limited effect on the intended application. However, for a number of user communities, they may directly impact the safety of operations. Therefore, there is an absolute need to correct such errors, or to warn the user in due time when such errors occur and cannot be corrected. For this reason, augmentation systems have been designed to improve the performance of existing global constellations.

EGNOS is a Satellite Based Augmentation System (SBAS). SBAS systems are designed to augment the navigation system constellations by broadcasting additional signals from geostationary (GEO) satellites. The basic scheme is to use a set of monitoring stations (at very well-known positions) to receive the navigation signals from core GNSS constellations that will be processed in order to obtain some estimations of these errors that are also applicable to the users (e.g. ionospheric errors and satellite position/clock errors). Once these estimations have been computed, they are transmitted in the form of "differential corrections" by means of a GEO satellite. Today, EGNOS augments GPS signals and will augment Galileo signal in the future.

Along with these correction messages which increase accuracy, some integrity data for the satellites that are in view of this network of monitoring stations and for the Ionospheric Grid Points visible from the service area are also broadcast, increasing the confidence that a user can have in the satellite navigation positioning solution.

The reader is invited to read Appendix A for background information about the Satellite Navigation Concept.

EGNOS is part of a developing multi-modal inter-regional SBAS service, able to support a wide spectrum of applications in many different user communities, such as maritime, aviation, rail, road, agriculture.

Similar SBAS systems, designed according to the same standard (i.e. SARPs [RD-1]), have already been commissioned by the US (Wide Area Augmentation System – WAAS), Japan (MTSAT Satellite based Augmentation System – MSAS), India (GPS Aided GEO Augmented Navigation – GAGAN) and Republic of Korea (Korea Augmentation Satellite System – KASS). Analogous systems are under commissioning or deployment in other regions of the world (e.g. System of Differential Correction and Monitoring – SDCM - in Russia, BeiDou SBAS – BDSBAS - in China, Southern Positioning Augmentation Network - SouthPAN - in Australia and New Zealand, and African Satellite Augmentation System – ANGA in Africa and Indian Ocean).

EGNOS provides services to European Union Member States (EU-MS), to EGNOS Programme participating States (Switzerland, Norway, Iceland) and to other countries with an agreement with the EU on the provision of EGNOS services. The worldwide existing and planned SBAS systems are shown in Figure 1.

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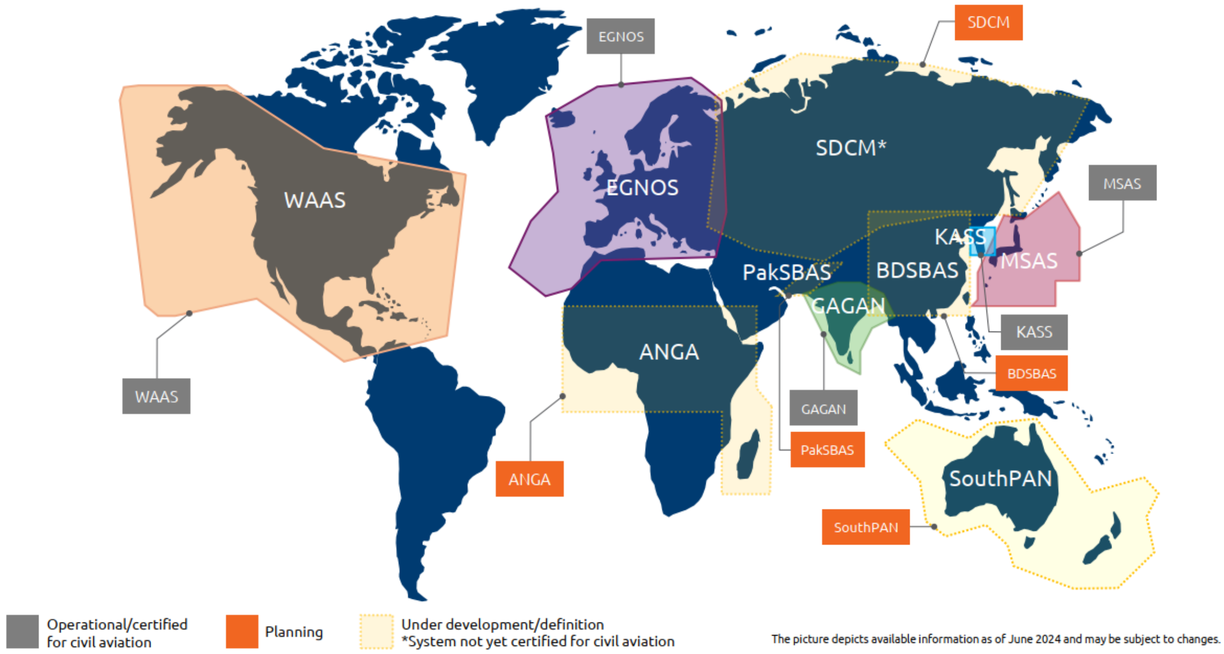

Figure 1: Existing and planned SBAS systems with indicative service areas[2]

3.2 EGNOS Services

EGNOS provides corrections and integrity information to GPS signals over a broad area centred over Europe and it is fully interoperable with other existing SBAS systems.

EGNOS provides three services:

- **Safety of Life (SoL) Service**, that provides the most stringent level of signal-in-space performance to all Safety of Life user communities, in particular for the aviation sector through the EGNOS Safety of Life for Aviation, and for the maritime sector through the EGNOS Safety of Life assisted service for MAritime userS (ESMAS);
- **Open Service (OS)**, freely available to any user;
- **EGNOS Data Access Service (EDAS)** for users who require access to specific GNSS data streams for the provision of added-value services, professional applications, commercial products, R&D, etc.

SoL for Aviation, ESMAS and OS services are transmitted by GEO SIS whereas EDAS is provided by internet access.

All of these EGNOS services are available and granted throughout their respective service areas.

3.2.1 Safety of Life Service (SoL) for Aviation

The main objective of the EGNOS SoL Service for Aviation is to support civil aviation operations down to Localiser Performance with Vertical Guidance (LPV) minima. At this stage, a detailed performance characterisation has been conducted only against the requirements expressed by civil aviation but the EGNOS SoL Service for Aviation might also be used in a wide range of other application domains (e.g.

[2] Represented SBAS according to the SBAS service provider identifiers defined in the ICAO SARPS [RD-1].

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maritime, rail, road…) in the future. In order to provide the SoL Service for Aviation, the EGNOS system has been designed so that the EGNOS Signal-In-Space (SIS) is compliant to the ICAO SARPs for SBAS [RD-1].

Two EGNOS SoL Service for Aviation levels (NPA and APV-I) were declared with the first issue of the EGNOS SoL Service for Aviation SDD v1.0 in March 2011 and an additional one (LPV-200) was declared with the EGNOS SoL Service for Aviation SDD v3.0 in September 2015 enabling the following SBAS-based operations in compliance with requirements as defined by ICAO in Annex 10[RD-1]:

- Non-Precision Approach operations and other flight operations supporting PBN navigation specifications other than RNP APCH, not only for approaches but also for other phases of flight.
- Approach operations with Vertical Guidance supporting RNP APCH PBN navigation specification down to LPV minima as low as 250 ft.
- Category I precision approach with a Vertical Alert Limit (VAL) equal to 35m and supporting RNP APCH PBN navigation specification down to LPV minima as low as 200 ft.

The EGNOS SoL Service for Aviation has been available since March 2nd, 2011, and the corresponding SDD is [RD-5], which defines a model for an aviation receiver bounding the local errors for an aircraft in flight. The receiver, based on this model, uses the EGNOS data to compute a high confidence bound on the residual error in the navigation solution (user level integrity) and compares it to a pre-established tolerance to determine whether the service can be used operationally or not within a limited geographical area, called the service area. This high confidence bound together with the capacity to warn the user within a specific time (time to alert) is what has been defined as SBAS integrity (i.e., a measure of the trust that can be placed in the correctness of the information supplied by SBAS, including its ability to provide timely and valid warnings to the user (alerts)).

3.2.1.1 EGNOS Safety of Life (SoL) assisted service for Maritime userS (ESMAS)

In an operational environment a vessel travels close to various obstacles for the GNSS signals: buildings, port infrastructure, other vessels or even bridges, that create multipath, interference or blockages of satellite signals. As such, the SBAS integrity model mentioned above is not valid for maritime applications. Current PVT user solutions usually rely on GNSS complemented by a variety of sensors and/or sensor fusion techniques to offer accuracy and a certain level of confidence in the position for safety purposes.

The ESMAS offers a service tailored to maritime users to enable marine navigation in harbour entrances, harbour approaches and coastal waters of the European Union Member States and EGNOS contributing countries (Iceland, Norway, and Switzerland) in line with IMO Resolution A.1046 .

This service targets a large variety of users. It provides certain performance that the corrections being broadcast shall or shall not be used and up to which extent. Therefore, it increases the confidence that a user can have in the satellite SIS information. The receiver manufacturer will be responsible to combine this information with other sensor(s) to compute the navigation position and the associated confidence levels.

The ESMAS has been available since March 13th, 2024, and the corresponding SDD is [RD-9].

3.2.2 Open Service (OS)

The main objective of the EGNOS OS is to improve the achievable positioning accuracy by correcting several error sources affecting the GPS signals. The corrections transmitted by EGNOS contribute to mitigate the ranging error sources related to satellite clocks, satellite position and ionospheric effects. The other error sources (tropospheric effects, multipath and user receiver contributions) are local effects that cannot be corrected by a wide area augmentation system. Finally, EGNOS can also detect distortions affecting the signals transmitted by GPS and prevent users from tracking unhealthy or misleading signals.

The EGNOS OS is accessible in Europe to any user equipped with an appropriate GPS/SBAS compatible receiver for which no specific receiver certification is required.

The EGNOS OS has been available since October 1st, 2009, being this document the applicable SDD.

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3.2.3 EGNOS Data Access Service (EDAS)

EDAS is the EGNOS terrestrial data service which offers ground-based access to EGNOS data in real time and also in a historical FTP archive to authorised users (e.g. added-value application providers). EDAS is the single point of access for the data collected and generated by the EGNOS ground infrastructure (RIMS and NLES mainly) distributed over Europe and North Africa. EDAS users and/or application Providers will be able to connect to EDAS, and directly exploit the EGNOS products or offer added-value services[3] based on EDAS data.

The EDAS service is available since July 26th, 2012, and the corresponding SDD is [RD-6].

3.3 EGNOS Architecture

To provide its services to users equipped with appropriate receivers, the EGNOS system comprises three main segments: the Space Segment, the Ground Segment and the User Segment. EGNOS functional architecture is shown in Figure 2.

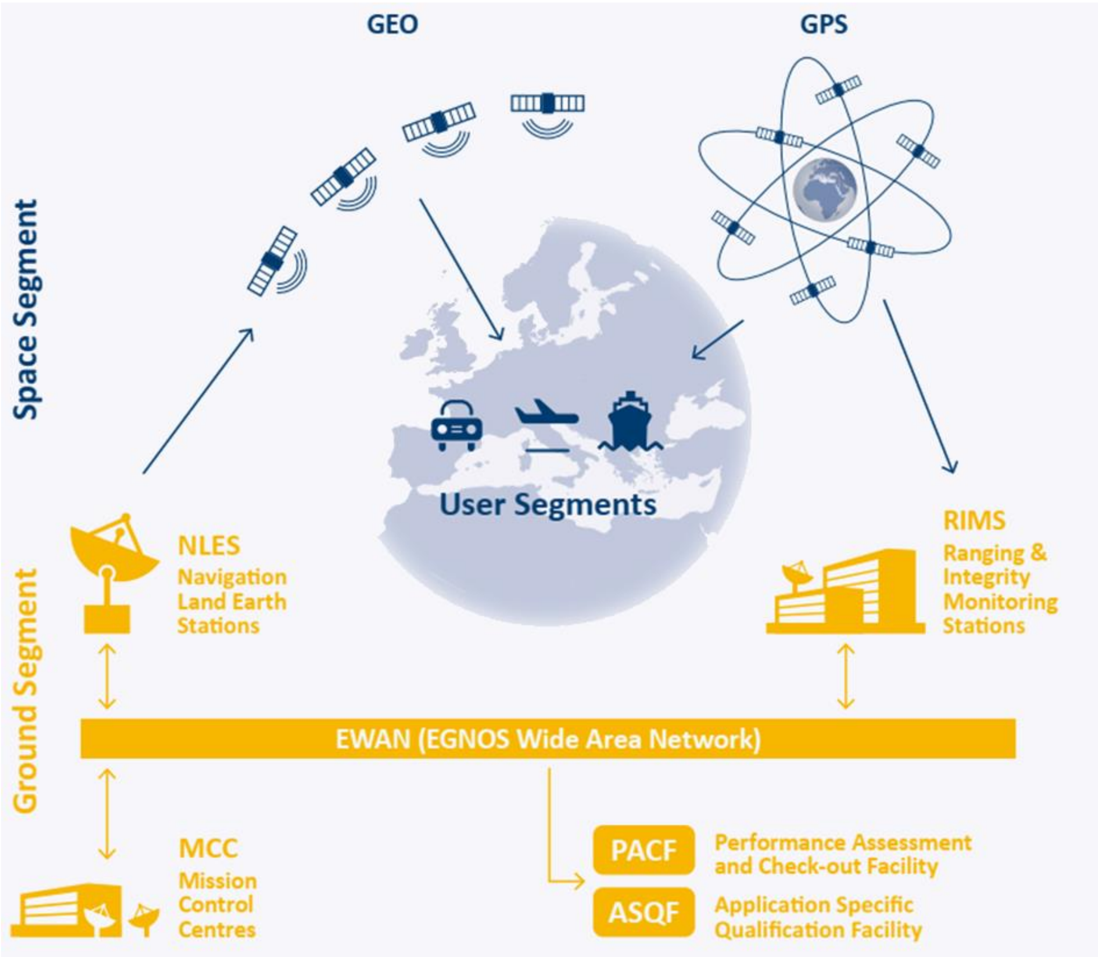

Figure 2: EGNOS architecture

[3] Examples of potential applications that could be provided are: EGNOS pseudolites; provision of EGNOS services through RDS, DAB, Internet; accurate ionospheric delay/TEC maps; provision of performance data (e.g. XPL availability maps, GIVE maps, etc.); provision of EGNOS message files.

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3.3.1 EGNOS Space Segment

The EGNOS Space Segment comprises at least 3 geostationary (GEO) satellites broadcasting corrections and integrity information for GPS satellites in the L1 frequency band (1575.42 MHz). The configuration of the GEOs in operation does not change frequently but possible updates are nevertheless reported to users by the EGNOS Service Provider. At the date of publication, the 3 GEOs used by EGNOS are the following ones.

GEO Name	PRN Number	Orbital Slot
ASTRA-5B	PRN 123	**23.5 E**
ASTRA SES-5	PRN 136	**5 E**
EUTELSAT 5 West B[4]	PRN 121	**5 W**

Table 2: GEOs used by EGNOS

This space segment configuration provides a high level of redundancy over the whole service area in case of a geostationary satellite link failure. The EGNOS operations are handled in such a way that, at any point in time, at least two of the GEOs broadcast an operational signal and the other one broadcasts a test signal. This secures a switching capability in case of interruption and ensures a high level of continuity of service.

The detailed configuration of operational and test satellites is reported in the EGNOS User Support webpage[5].

The EGNOS space segment is constantly replenished over time in order to maintain the required level of redundancy. The exact orbital location of future satellites may vary, though this will not impact the service offered to users. Similarly, different PRN code numbers may be assigned to future GEOs.

It is important to remark that these changes in the EGNOS GEO space segment are performed in a seamless manner without any interruption from an EGNOS user point of view and without compromising at any moment the EGNOS performances. For this purpose, and whenever there could be any relevant information complementing the SDD, an EGNOS Service Notice is published[6] and distributed.

3.3.2 EGNOS Ground Segment

The EGNOS Ground Segment comprises a network of Ranging Integrity Monitoring Stations (RIMS), two Mission Control Centres (MCC), two Navigation Land Earth Stations (NLES) per GEO, and the EGNOS Wide Area Network (EWAN) which provides the communication network for all the components of the ground segment.

Two additional facilities are also deployed as part of the ground segment to support system operations and service provision, namely the Performance Assessment and Checkout Facility (PACF) and the Application Specific Qualification Facility (ASQF), which are operated by the EGNOS Service Provider.

[4] At the time of the publication of this document, EUTELSAT 5 West B is used for testing purposes and broadcasts Message Type 0 indicating it cannot be used for SoL applications by the certified receivers. This satellite will not be used in EGNOS OP until its qualification is completed.

[5] https://egnos.gsc-europa.eu/

[6] https://egnos.gsc-europa.eu/documents/field_gc_document_type/service-notices-87

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3.3.2.1 Ranging Integrity Monitoring Stations (RIMS)

The main function of the RIMS is to collect measurements from GPS satellites and to transmit these raw data every second to the Central Processing Facilities (CPF) of each MCC. The current RIMS network comprises 38 RIMS sites located over a wide geographical area described in Figure 3.

Figure 3: EGNOS RIMS sites

3.3.2.2 Central Processing Facility (CPF)

The Central Processing Facility (CPF) is a module of the MCC that uses the data received from the network of RIMS stations to:

1. Elaborate clock corrections for each GPS satellite in view of the network of RIMS stations. These corrections are valid throughout the geostationary broadcast area (i.e. wherever the EGNOS signal is received).

2. Elaborate ephemeris corrections to improve the accuracy of spacecraft orbital positions. In principle, these corrections are also valid throughout the geostationary broadcast area. However, due to the geographical distribution of the EGNOS ground monitoring network, the accuracy of these corrections will degrade when moving away from the core of the EGNOS service area.
3. Elaborate a model for ionospheric errors over the EGNOS service area in order to compensate for ionospheric perturbations to the navigation signals.

These three sets of corrections are then broadcast to users to improve positioning accuracy.

In addition, the CPF estimates the residual errors that can be expected by the users once they have applied the set of corrections broadcast by EGNOS. These residual errors are characterised by two parameters:

- User Differential Range Error (UDRE): this is an estimate of the residual range error after the application of clock and ephemeris error correction for a given GPS satellite.
- Grid Ionospheric Vertical Error (GIVE): this is an estimate of the vertical residual error after application of the ionospheric corrections for a given geographical grid point.

These two parameters can be used to determine an aggregate error bounded by the horizontal and vertical position errors. Such information is of special interest for Safety of Life users but may also be beneficial to other communities needing to know the uncertainty in the position determined by the user receiver.

Finally, the CPF includes a large number of monitoring functions designed to detect any anomaly in GPS and in the EGNOS system itself and is able to warn users within a very short timeframe (less than Time To Alert (TTA)) in case of an error exceeding a certain threshold.

3.3.2.3 Navigation Land Earth Stations (NLES)

The messages elaborated by the CPF are transmitted to the NLESs. The NLESs (two for each GEO for redundancy purposes) transmit the EGNOS message received by the CPF to the GEO satellites for broadcast to users and to ensure the synchronisation with the GPS signal.

The NLES are grouped by pairs, pointing to a Geostationary satellite. For each GEO, one NLES is active (broadcasts) and the other in Back-up mode.

The main functions of the NLES include:

- the selection of the CPF that broadcasts the SBAS message,
- the modulation of the message provided by the CPF,
- the synchronization of the uplink signal with GPS time,
- the transmission of the data to the GEO satellites,
- monitoring that the received signal from the GEO satellites is the one transmitted and within certain power levels.

3.3.2.4 Central Control Facility (CCF)

The EGNOS system is controlled through a Central Control Facility (CCF) located in each of the Mission Control Centres. These facilities are manned on a 24/7 basis in order to ensure permanent service monitoring and control.

3.3.3 EGNOS User Segment

The user segment consists of the user equipment that processes the received signals from the GNSS satellites (EGNOS and GPS) and uses them to derive and apply position, time, and integrity information. The equipment ranges from smartphones and handheld receivers, to sophisticated, specialized receivers used for high-end safety critical applications.

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3.4 EGNOS Organisational Framework

3.4.1 Bodies involved in the EGNOS Programme and Service Delivery

The European Union (EU) is the owner of the EGNOS system.

As per the Space Regulation [RD-7];

- The European Commission has the overall responsibility for the implementation of the EGNOS Programme, including for security and determines the priorities and long-term evolutions.
- The European Union Agency for the Space Programme (EUSPA) is in charge of the EGNOS exploitation and - according to the Financial Framework Partnership Agreement between the European Commission representing the European Union, EUSPA and ESA- acts as System Prime for the System in Operations for EGNOS, i.e. is responsible for maintenance changes and mid-term improvement of the System in operations.
- ESA is in charge of the System evolution and - according to the Financial Framework Partnership Agreement between the European Commission representing the European Union, EUSPA and ESA- acts as Design Authority, i.e. holds the technical responsibility of the system baseline, design integrity and consistency including for the System in Operations.

The ESSP is the current EGNOS Services Provider within Europe, certified according to the Single European Sky (SES) regulation as Air Navigation Service Provider (ANSP). ESSP provides the EGNOS OS, EDAS and SoL Service for Aviation compliant with ICAO (International Civil Aviation Organization) Standards and Recommended Practices throughout the European Civil Aviation Conference (ECAC) region. ESSP as EGNOS service provider also generates EGNOS Notice To Airmen (NOTAM) proposals to the appropriate Aeronautical Information Service providers within Europe that should validate and distribute the final Official EGNOS NOTAM.

3.4.2 How to get information on EGNOS and EGNOS applications or contact the service provider

Detailed information about the EGNOS programme, EGNOS system status, and EGNOS services performance can be found by accessing the sources listed in Table 3.

Topic	Description and Web/contact details
EGNOS Programme	EC institutional information about the EGNOS Programme https://defence-industry-space.ec.europa.eu/eu-space/egnos-satellite-navigation_en
What is EGNOS?	General information related to EGNOS Programme. https://www.euspa.europa.eu/eu-space-programme/egnos
EGNOS User Support and Helpdesk	EGNOS user support website is the main source of information for EGNOS OS and EGNOS SoL aviation users: EGNOS OS and EGNOS SoL Service for Aviation status and performance, system description, historical and real time services performance, forecasts, EGNOS OS and EGNOS SoL Service for Aviation applicable documentation, FAQs, etc. The helpdesk is accessible on-line through the website and also by e-mail and by phone. It is the direct point of contact for any question related with the EGNOS OS and EGNOS SoL Service for Aviation, including performance and applications. https://egnos.gsc-europa.eu/ **helpdesk@egnos.gsc-europa.eu** **Helpdesk line: +34 911 236 555**

EGNOS Safety of Life assisted service for maritime users and EDAS User Support Website and Helpdesk	ESMAS User support Website is the main source of information for ESMAS and EDAS status and performance, system description, historical and real time services performance, forecasts, applicable documentation, FAQs, etc. The helpdesk is accessible on-line through the website and also by e-mail and by phone. It is the direct point of contact for any question related with the EDAS and ESMAS service, including performance and applications. https://edas-maritime.gsc-europa.eu/ helpdesk@edas-maritime.gsc-europa.eu Helpdesk line: +34 911 236 555
EGNOS Service Provider activity	ESSP official reporting of the service provider activities, news, etc. http://www.essp-sas.eu
EGNOS certified receivers	EASA mailbox for any question related to service difficulties or malfunctions of EGNOS certified receivers egnos@easa.europa.eu
EGNOS Working Agreements (EWA)	Formalization between ESSP and a specific organization for introducing EGNOS procedures. EGNOS-working-agreement@essp-sas.eu
EGNOS app	Direct point of contact for any question related with the EGNOS system, its performance, and applications. https://itunes.apple.com/app/egnos/egnosApp https://play.google.com/store/apps/egnosApp

Table 3: Where to find information about EGNOS

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4 EGNOS SIS

4.1 EGNOS SIS Interface Characteristics

The EGNOS Signal In Space format is compliant with the ICAO SARPs for SBAS [RD-1]. This section provides an overview of the EGNOS SIS interface characteristics, related to carrier and modulation radio frequency (section 4.1.1) and structure, protocol, and content of the EGNOS message (section 4.1.2).

4.1.1 EGNOS SIS RF Characteristics

The EGNOS GEO satellites transmit right-hand circularly polarised (RHCP) signals in the L band at 1575.42 MHz (L1)[7]. The broadcast signal is a combination of a 1023-bit PRN navigation code of the GPS family and a 250 bits per second navigation data message carrying the corrections and integrity data elaborated by the EGNOS ground segment.

The EGNOS SIS RF characteristics are compliant with the corresponding values defined in the ICAO SARPs [RD-1].

4.1.2 EGNOS SIS Message Characteristics

The EGNOS SIS Navigation Data is composed of a number of different Message Types (MT) as defined in the SBAS standard. Table 4 describes the MTs that are used by EGNOS and their purpose.

The format and detailed information on the content of the listed MTs and their use at SBAS receiver level are given in the ICAO SARPs [RD-1][8] and RTCA SBAS MOPS [RD-2].

Message Type	Contents	Purpose
0	Don't Use (SBAS test mode)	Discard any ranging, corrections, and integrity data from that PRN signal. Used also during system testing.
1	PRN Mask	Indicates the slots for GPS and EGNOS GEO satellites provided data[9]
2-5	Fast corrections	Range corrections and accuracy
6	Integrity information	Accuracy-bounding information for all satellites in one message
7	Fast correction degradation factor	Information about the degradation of the fast term corrections
9[10]	GEO ranging function parameters	EGNOS GEO satellites orbit information (ephemeris)

[7] An EGNOS L1 message is currently broadcast as well by the EGNOS GEOs through the civil frequency L5 (1176.45 MHz). This signal does not have any impact for Safety of Life users, who are limited to the use of the L1 frequency as defined in RTCA SBAS MOPS [RD-2]. This represents a deviation with respect to the ICAO SARPS [RD-1], in which it is required that each frequency is used to broadcast its specific message. It is expected that future versions of EGNOS will solve this non-compliance [RD-1].

[8] Note that ESSP, as EGNOS Service Provider, continuously monitors that SBAS messages broadcast by all SBAS visible from the EGNOS Service Area are compliant with the format specifications defined in the ICAO SARPs for SBAS [RD-1].

[9] EGNOS provides corrections for all operational/healthy GPS satellites included in this PRN mask. The introduction of Block III satellites is done under specific Competent Authority review following the process in accordance with [RD-11].

[10] MT9 is broadcast with some information about the orbital position of the broadcasting EGNOS GEO satellite. At this stage, the EGNOS system does not support the Ranging function which is described in the ICAO SARPs as an option. This is indicated by a special bit coding of the Health and Status parameter broadcast in MT17. In particular, GEO satellite position broadcast in

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10	Degradation parameters	Information about the correction degradation upon message loss
12	SBAS network Time/UTC offset parameters	Parameters for synchronisation of EGNOS Network time with UTC
17	GEO satellite almanacs	EGNOS GEO satellites Almanacs[11]
18	Ionospheric grid point masks	Indicates for which geographical point ionospheric correction data is provided
24	Mixed fast/long-term satellite error corrections	Fast-term error corrections for up to six satellites and long-term satellite error correction for one satellite in one message.
25	Long-term satellite error corrections	Corrections for satellite ephemeris and clock errors for up to two satellites
26	Ionospheric delay corrections	Vertical delays/accuracy bounds at given geographical points
27	EGNOS service message	Defines the geographic region of the service
63	Null message	Filler message if no other message is available

Table 4: EGNOS SIS transmitted MTs

WARNING

Under some circumstances, which would necessitate the ceasing of use of the EGNOS service for Safety of Life applications, EGNOS will broadcast Message Type 0 to indicate that the system is under test. The contents of MT0 will be similar to the MT2 contents (i.e. fast corrections) and could be processed by a non-SoL receiver like a regular MT2. This kind of message is usually named MT0/2. When Message Type 0/2 is broadcast, OS users may consider continuing using the system. However, in such case, the service may be degraded due to the on-going testing and the minimum performance levels described in the OS SDD do not apply.

Since April 2003, the Message Type 0/2 is implemented under the MOPS DO 229 specifications. It consists of broadcasting a message type 2, providing fast corrections and ranging data, on the frame reserved to the message type 0. It still indicates that the system is on test mode, but it also optimizes the use of the SIS data capacity.

When an EGNOS operational signal (without MT0) is available from one of the EGNOS GEOs, it is recommended to preferentially use such a signal over possible other signals under test from other GEOs.

4.2 EGNOS Time and Geodetic Reference Frames

Strictly speaking, the time and position information that are derived by an SBAS receiver that applies the EGNOS corrections are not referenced to the GPS Time and the WGS84 reference systems as defined in the GPS Interface Specification. Specifically, the position coordinates and time information are referenced to separate reference systems established by the EGNOS system, namely the EGNOS Network Time (ENT) timescale and the EGNOS Terrestrial Reference Frame (ETRF). However, these specific EGNOS reference

both MT9 and MT17 are set to fixed position (x, y, z), and GEO position rate of change in MT9 & MT17, as well as GEO acceleration and aGf0 & aGf1 parameters in MT9, are permanently set to zero.

[11] Regarding MT17 GEO satellite almanacs, there is a deviation to the specifications in the ICAO SARPS [RD-1], which requires that a SBAS service provider use MT17 to broadcast the almanac of all the GEOs of the same system. Currently, the MT17 broadcast by the EGNOS operational GEOs only include the operational GEOs almanacs, while the MT17 broadcast by the test GEO only includes the test GEO almanac.

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systems are maintained closely aligned to their GPS counterparts and, for the vast majority of users, the differences between these two time/terrestrial reference frames are negligible.

4.2.1 EGNOS Terrestrial Reference Frame – ETRF

EGNOS was initially designed to fulfil the requirements of the aviation user community as specified in the ICAO SARPS [RD-1]. [RD-1] establishes the GPS Terrestrial Reference Frame, WGS84, as the terrestrial reference to be adopted by the civil aviation community.

The EGNOS Terrestrial Reference Frame (ETRF) is an independent realisation of the International Terrestrial Reference System (ITRS[12]) which is a geocentric system of coordinates tied to the surface of the Earth and in which the unit distance is consistent with the International System of Units (SI[13]) definition of the metre. The ITRS is maintained by the International Earth Rotation and Reference Systems Service (IERS[14]) and is the standard terrestrial reference system used in geodesy and Earth research. Realizations of ITRS are produced by the IERS under the name International Terrestrial Reference Frames (ITRF). Several realizations of the ITRS exist, being ITRF2014 the last one.

In order to define the ETRF, the ITRF2000 coordinates and velocities of the RIMS antennas are estimated using space geodesy techniques based on GPS data. Precise GPS ephemeris and clock corrections produced by the International GNSS Service (IGS[15]) are used to filter the GPS data collected over several days at each RIMS site and to derive the antenna coordinates and velocities with geodetic quality. This process is repeated periodically (at least once per year) in order to mitigate the degradation of the ETRF accuracy caused by the relative drift between the two reference frames.

The ETRF is periodically aligned to the ITRF2000 in order to maintain the difference between the positions respectively computed in both frames below a few centimetres. The same can be said about the WGS84 (WGS84 (G1150) aligned to ITRF2000). Conversion of ETRF data into WGS84 (G1150) is obtained by applying the offset that exists at a certain epoch between the ETRF and the ITRF2000 to the ITRF2000 to WGS84 (G1150) frame. Note that currently these last two reference frames are almost equivalent (offsets minor than 2cm).

This means that, for the vast majority of applications, it can be considered that the positions computed by an EGNOS receiver are referenced to WGS84 and can be used with maps or geographical databases in WGS84.

4.2.2 EGNOS Network Time: ENT – GPS Time Consistency

The time reference used by EGNOS to perform the synchronisation of the RIMS clocks is the EGNOS Network Time (ENT). The ENT timescale is an atomic timescale that relies on a group of atomic clocks deployed at the EGNOS RIMS sites. The EGNOS CPFs compute the ENT in real time, using a mathematical model which processes timing data collected from a subset of the RIMS clocks.

[12] Detailed information on ITRS (concepts, realisation, materialization ...) can be found on the official website: https://itrf.ign.fr/en/

[13] Information on the International System of Units (SI) can be obtained from https://www.bipm.org/en/

[14] Information on IERS can be obtained from http://www.iers.org/

[15] Information on IGS can be obtained from http://www.igs.org/

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The ENT is continuously steered towards GPS Time (GPST) by the EGNOS Ground Control Segment and the relative consistency between the two timescales is maintained at the level of tens of nanoseconds as observed in Figure 4:

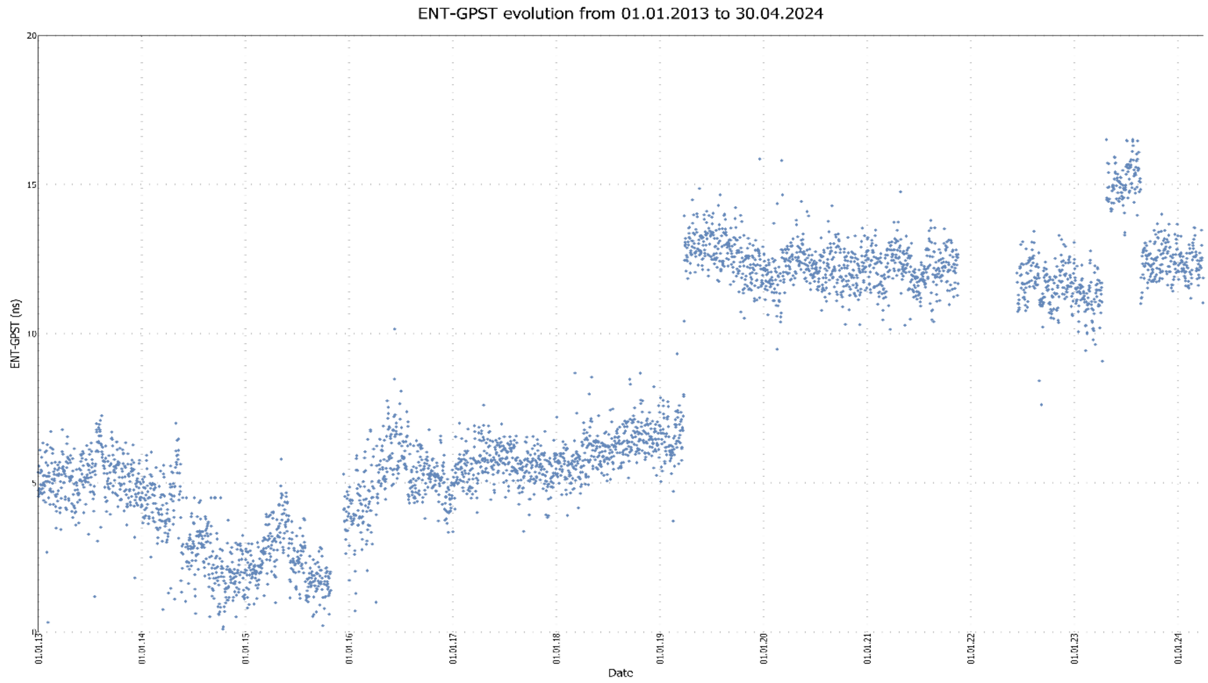

Figure 4: ENT GPS time offset evolution (Period 01/01/20213 – 30/04/2024)

All satellite clock corrections computed by the EGNOS Ground Segment and transmitted to the EGNOS users are referenced to the ENT timescale. Moreover, the offset between ENT and UTC is broadcast in the EGNOS navigation message. Applying EGNOS corrections on GPS measurements, a precise time and navigation solution referenced to ENT is obtained. Therefore, the assessment of the time difference between ENT and UTC is a key issue for time users as described in section 7.2.

Despite the high level of consistency between the ENT and GPST timescales, EGNOS users are advised not to combine uncorrected GPS measurements (i.e. those referenced to GPST) and GPS measurements which have been corrected using EGNOS parameters (i.e. those referenced to ENT), when computing a navigation solution. Indeed, this approach might noticeably degrade the accuracy of the solution (by up to 10 to 20 metres). EGNOS users who want to combine GPS measurements referenced to different timescales should account for an additional unknown corresponding to the time offset between the two time references in the receiver navigation models.

4.3 EGNOS SIS Performance in the Range Domain

This section focuses on the EGNOS SIS accuracy performance in the range domain. Accuracy in the range domain is defined as the statistical difference between the range measurement made by the user and theoretical distance between the true satellite position and the true user position. The EGNOS system has been qualified using conservative models that take into account the detailed behaviour of the EGNOS system under a number of operating conditions.

The accuracy performance at range level is characterised by two parameters, representing respectively the performance of the time and orbit determination process, and the ionospheric modelling process:

- The Satellite Residual Error for the Worst User Location (SREW) in the relevant service area, representing the residual range error due to the ephemeris and clock errors once EGNOS corrections are applied.
- The Grid Ionospheric Vertical Delay (GIVD) which represents the residual range error due to ionospheric delay after applying the EGNOS ionospheric correction at each of the grid points predefined in the MOPS [RD-2]. The ionospheric vertical delay relevant for a given user/satellite pair is the delay at the geographical point where the satellite signal crosses the ionospheric layer. This is called the User Ionospheric Vertical Delay (UIVD) and it is computed by interpolation of GIVDs of the neighbouring grid points.

Table 5 provides the comparison of the pseudorange error budget when using the EGNOS OS and GPS stand-alone to correct for clock, ephemeris, and ionospheric errors.

Error sources (1σ)	GPS - Error Size (m)	EGNOS - Error Size (m)
GPS SREW	4.0 (see note 1)	2.3
Ionosphere (UIVD error)	2.0 to 5.0 (see note 2)	0.5
Troposphere (vertical)	*0.1*	*0.1*
GPS Receiver noise	*0.5*	*0.5*
GPS Multipath (45° elevation)	*0.2*	*0.2*
GPS UERE 5 ° elevation	7.4 to 15.6	4.2 (after EGNOS corrections)
GPS UERE 90 ° elevation	4.5 to 6.4	2.4 (after EGNOS corrections)

Table 5: Typical EGNOS and GPS stand-alone SIS UERE

Note 1: As of GPS Standard Positioning Service Performance Standard [RD-3].

Note 2: This is the typical range of ionospheric residual errors after application of the baseline Klobuchar model broadcast by GPS for mid-latitude regions.

The shaded parameters in the EGNOS columns are provided for information only and give an idea of the overall range accuracy performance that can be expected when using the EGNOS OS in a clear sky[16] environment with high-end receiver equipment properly accounting for tropospheric effects. Only the SREW and User Ionospheric Vertical Delay (UIVD) parameters do not depend on the type and brand of receiver.

Please note that the values in the GPS column are provided for information only and that the actual applicable UERE budget can be found in GPS SPS PS [RD-3]. *In case where there are discrepancies between Table 5 and* [RD-3], *the latter shall prevail.*

As stated above, the EGNOS SREW and UIVD values in Table 5 relate to the "Worst User Location" (WUL) inside the service area and are calculated with conservative models. EGNOS SIS Users will usually experience better performance.

Statistical data on the actually achieved range availability of EGNOS SIS are given in Appendix A Satellite navigation concept.

[16] *Clear sky* makes reference to the situation where no obstacles are causing obstructions or reflections in the GPS/EGNOS signals. In this scenario, all the satellites above the horizon (or above 5° elevation) are visible and can be used in positioning computation.

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5 EGNOS RECEIVERS

Since the SBAS standards have been initially derived to meet the stringent navigation performance requirements applicable to civil aviation approach and landing operations, the reference SBAS receiver standards have also been developed by the civil aviation community. These standards are called SBAS Minimum Operational Performance Standards (MOPS) and are published by the Radio Technical Commission for Aeronautics (RTCA) under the reference DO-229 [RD-2]. This receiver standard has been designed by and for the aviation community and therefore supports both horizontal and vertical navigation and implements a large number of features aimed at ensuring the integrity of the derived position.

A number of these specific message processing techniques are not required for non – Safety of Life applications and may even result in degraded performance over what could be reached if implementing a tailored processing of EGNOS signals for OS. However, at this stage, no unique standard exists describing the use of EGNOS messages for OS users and therefore, different types of implementation have been selected by receiver manufacturers.

Typically, an SBAS receiver designed to support the OS is expected to:

- Track GPS satellites, process GPS L1 signals and navigation data:
    - Acquire pseudo-range measurements based on C/A code.
    - It is recommended applying a smoothing filter and monitoring the quality of the pseudo-range measurements to obtain better accuracy performance.
- Track SBAS satellites (PRNs from 120 to 158) and process SBAS L1 signal:
    - Decode and apply the PRN satellite mask broadcast through message type 1.
    - Decode and apply satellite clock corrections (broadcast through message types 2 – 5 and 24 and corresponding to satellites selected by message type 1).
    - Decode and apply satellite ephemeris corrections (broadcast though message types 24 – 25) corresponding to satellites selected by message type 1.
    - Decode and apply ionospheric corrections (broadcast through message type 26 for ionospheric grid points selected by message type 18).
    - Apply tropospheric error corrections following a tropospheric model.
- Optionally, an OS receiver may use:
    - Decode almanac data from SBAS satellites (broadcast through message type 17) for tracking purposes.
    - Apply the content of message type 12, if used for offset to UTC determination.

For the purpose of assessing the EGNOS OS performance as reported in section 6, the following assumptions have been made for the OS user equipment processing:

The system performance shall be met with any receiver that implements the MOPS DO-229 navigation weighted solution and message processing (equivalent to Class 3 GPS/WAAS receiver requirements) but which does not take into consideration the protection level criteria to declare that a solution is available.

Note that in the monitoring of satellites/Ionospheric Grid Points, an EGNOS OS receiver is assumed to take into account the UDRE/GIVE indicator status as a MOPS receiver Class 3 (i.e. those satellites or IGPs which are either “Not Monitored” or are labelled as “Don't Use” will be discarded).

Many GNSS receivers currently available on the market are able to receive and process EGNOS signals and can be used to support numerous non – Safety of Life applications. A non-exhaustive list of EGNOS compatible receivers available on the market with general information on their suitability for a set of identified applications can be found in the EC/ESA/CNES publication “Use Guide for EGNOS Application Developers” [RD-8] with the latest information available on the EGNOS Portal website (see section 3.4.2).

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6 EGNOS OS SERVICE PERFORMANCE

6.1 EGNOS OS Service Description and Characteristics

The EGNOS OS was the first EGNOS Service declared operational on the 1st October 2009. It is intended for general purpose applications and consists of signals for augmenting GPS, freely accessible without any direct charge.

The EGNOS OS is available to any users equipped with a SBAS enabled receiver. The minimum performance reported in this section is the performance that can be experienced when using receiving equipment compliant with RTCA MOPS DO229 Class 3 specifications as described in section 5. It also assumes GPS characteristics/performance as mentioned in section 2.1 and a clear sky environment with no obstacle masking satellite visibility greater than 5° above the local horizontal plane.

The OS will also be available to users having receivers not fully compliant to the MOPS, but which are able to process the following Message Types transmitted by EGNOS: 1, 2-5, 18, 24, 25, 26 (optionally 9, 12, 17). However, in this case, the observed performance may deviate (positively or negatively depending on the implementation chosen by the receiver manufacturer) from that reported in this section.

The “minimum” performance figures shown in this section take into account a number of abnormal system states or non-typical environmental conditions that can statistically be expected to occur during the lifetime of the system.

These types of characterisation are considered to provide valuable and complementary insights into EGNOS service performance for receiver manufacturers, for GNSS application developers and for end users of the EGNOS OS.

The performance reported in this document is the one that can be obtained with the version of EGNOS currently in operation. It is the objective that future versions will deliver, as a minimum, an equivalent level of performance. The SDD will be updated whenever necessary.

6.2 EGNOS OS Service Performance Requirements

6.2.1 Positioning Accuracy

The EGNOS OS minimum accuracy is specified in Table 6. Statistical values of the measured OS accuracy over Europe are provided in Appendix A Satellite navigation concept.

Accuracy	Definition	Value
Horizontal	Corresponds to a 95% confidence bound of the 2-dimensional position error[17] in the horizontal local plane for the Worst User Location	3 m
Vertical	Corresponds to a 95% confidence bound of the 1-dimensional unsigned position error in the local vertical axis for the Worst User Location	4 m

Table 6: OS Horizontal and Vertical Accuracy

[17] As for the case of range errors, the horizontal and vertical positioning accuracies correspond to a composition of residual errors from different sources (EGNOS ground and space segments, local environment, and user segment). The assumptions taken on residual error sources beyond the control of EGNOS (e.g. tropospheric effects, receiver noise and multipath) are similar to the ones described in section 4.3.

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6.2.2 Positioning Accuracy Compliance Area

The EGNOS OS compliance area has been defined as the minimum area where at least 99% of the time:

- the user is able to calculate its position and
- the accuracy performance is described in section 6.2.1.

This area is given in red in Figure 5. It has been elaborated on the basis of the results of several months of observation of EGNOS performance. The map represents the minimum level of performance which can be expected under the same conditions to those under which it has been computed. These conditions, which refer to both the internal status of the system (number of RIMS used, number of GEOs, etc.) and the external conditions (GPS constellation status, environmental conditions, etc.), are representative enough of nominal Open Service performance. Users can usually experience better performance as reported in Appendix A Satellite navigation concept.

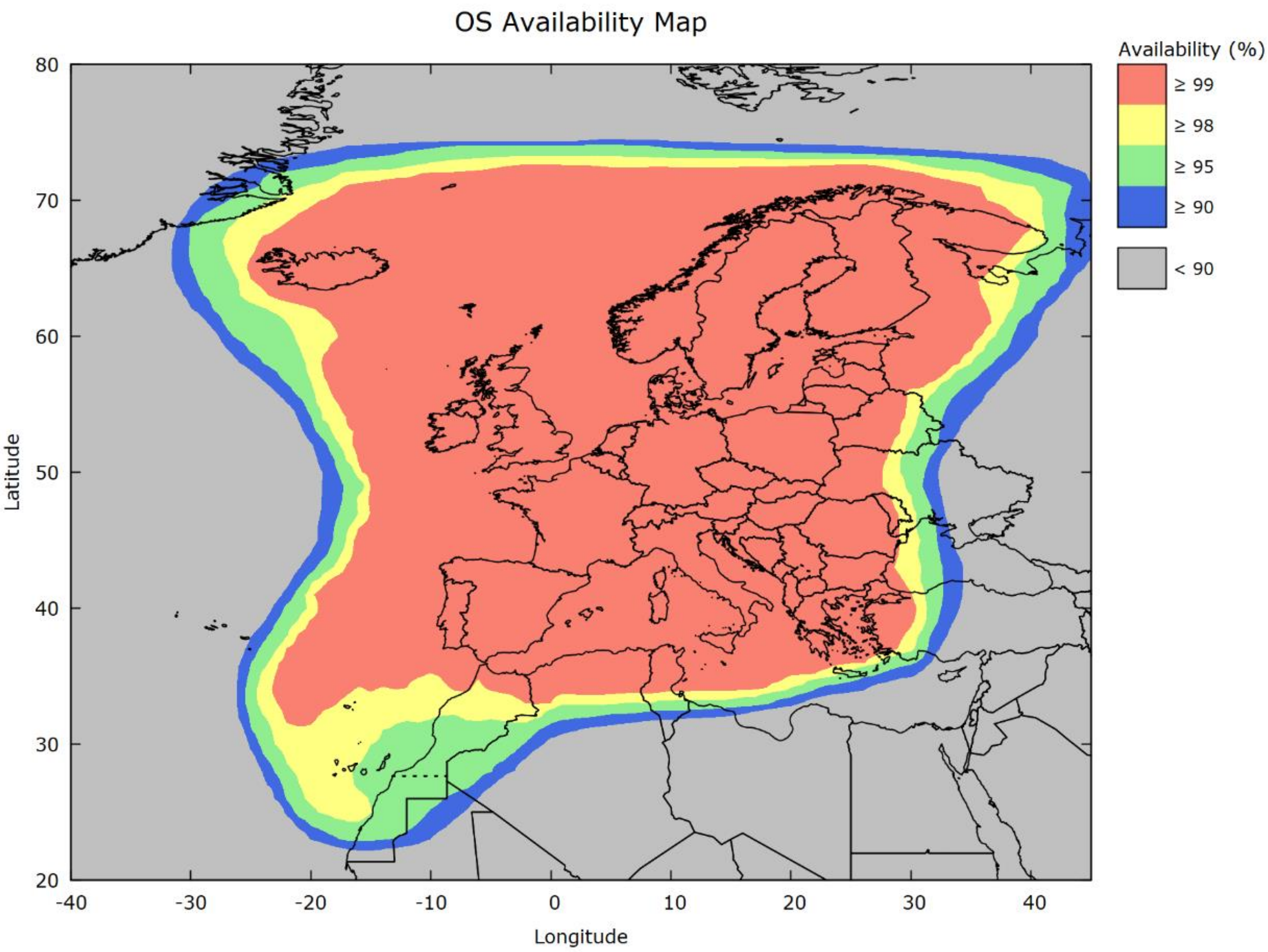

Figure 5: EGNOS OS compliance area (in red)

Use of the EGNOS OS is possible beyond the red area defined in Figure 5,

- however, the service performance will gradually degrade as the user moves away from the nominal compliance area as shown in Figure 5 for a given accuracy performance, the service will become progressively less available as the user gets further from the compliance area (for example, 98% of the time in the yellow area). Alternatively, in order to maintain a given service availability performance (for example, 99% of the time), the user will have to accept statistically higher positioning errors than the ones described in section 6.2.1.

6.3 EGNOS OS Limitations

The EGNOS OS has been designed to improve the accuracy of the navigation solution over that available from a GPS – only receiver. In the vast majority of cases, the EGNOS OS will be available and will provide performance in line with or beyond the minimum performance levels described in the previous sections of this document. However, in a limited number of situations, users may experience non-nominal navigation performance levels. The most common causes for such abnormal behaviour are listed below in Table 7.

Root Cause	Most Likely Symptoms
Broadcasting Delays As explained in section 3.3, one of the functions of EGNOS is to elaborate a model of the ionosphere and to broadcast this model to users so that they can correct the related errors. When using the SBAS standard, the reception of all the parameters that are necessary to build such a model may take up to 5 minutes to be received, depending on the receiver. Therefore, the full positioning accuracy may not be reached as soon as the receiver is turned on.	**EGNOS OS Service Not immediately available** The receiver does not immediately use EGNOS to compute a navigation solution and, therefore, the position accuracy improvement is not available until a few minutes after the receiver is turned on.
GPS or EGNOS Signal Attenuation The receiver power level of GPS and EGNOS signals is extremely low. Using satellite navigation under heavy foliage or in an in-door environment will weaken further the signals up to a point where the receiver will either lose lock of such signals or have a very degraded performance.	**Degraded Position Accuracy** The position solution may demonstrate instability with higher error dispersion than usual. It may also be affected by sudden jumps when satellites are lost due to excessive attenuation. The performance of the receiver in such a difficult environment may be improved with a high-quality receiver and antenna design.
EGNOS Signal Blockage The EGNOS signals are broadcast by two geostationary satellites. This ensures some level of redundancy in case a satellite link is lost due to shadowing by a close obstacle (e.g. local orography or buildings). In addition, when moving North to high latitudes, the geostationary satellites are seen lower on the user's horizon and therefore are more susceptible to masking. At any latitude, it may happen that, in an urban environment, the EGNOS signals are not visible for some time.	**Degraded Position Accuracy After Some Time** The effect of losing the EGNOS signal (on both GEOs) on the receiver will be equivalent to reverting to a GPS-only receiver. The navigation solution will still be available but will demonstrate a degraded accuracy since no clock ephemeris or ionospheric corrections will be available to the user receivers. However, such degradation will not be instantaneous since the SBAS standard has been designed to cope with temporary signal blockages. The exact time the receiver can continue to provide good accuracy in case of the loss of signal depends on the receiver design.

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Local Multipath In urban environments, the GPS and EGNOS signals will be prone to reflections on nearby objects (building, vehicles…). This may cause significant errors which cannot be corrected by the EGNOS system due to their local nature.	**Degraded Position Accuracy** The navigation solution will tend to meander around the true position and may demonstrate deviations of a few tens of metres. This effect will have a greater impact on static users or in those users moving at slow speed. High-quality receiver and antenna design is able to attenuate the effect of multipath in some specific conditions.
Local Interference GPS and EGNOS use a frequency band that is protected by the International Telecommunication Union (ITU). However, it is possible that in some specific locations, spurious transmissions from services operating in adjacent or more remote frequency bands could cause harmful interference to the satellite navigation systems. Such events can be intentional (jamming, spoofing) or unintentional and they are usually localised for ground users. In most cases, national agencies are in charge of detecting and enforcing the lawful use of spectrum within their national boundaries.	**Degraded Position Accuracy or Complete Loss of Service** Depending on the level of interference, the effect on the user receiver may be a degradation of the position accuracy (unusual noise level affecting the positioning) or a total loss of the navigation service in case the interfering signals preclude the tracking of navigation signals, even if certified receivers are expected to be designed and tested in order to be capable of operating satisfactorily in typical interference conditions (refer to [RD-2] Appendix C EGNOS OS observed performance). The detection, mitigation, and control of potential spurious transmissions from services operating in frequency bands that could cause harmful interference and effects to the satellite navigation systems (degrading the nominal performances) is under the responsibility of local authorities.
Ionospheric Scintillation Under some circumstances due to solar activity and in some specific regions in the world (especially for boreal and subtropical latitudes), ionospheric disturbances (called scintillation) will affect the GPS and EGNOS navigation signals and may cause the complete loss of these signals for a short period of time.	**Degraded Position Accuracy** The position solution may be affected when satellite tracking is lost due to scintillation. If the number of tracked satellites drops seriously, a 3-dimensional position may not be available. Eventually, the navigation service may be completely lost in case less than 3 satellites are still tracked by the user receiver. In cases when only the EGNOS signal is lost, the impact will be similar to the one described for “EGNOS signal blockage” above.
Receiver Design and Configuration Refer to WARNING in section 4.1.2	**Variable** Depending on the nature of the receiver implementation and configuration, the impact on the positioning may vary within different accuracy levels[18].

[18] User should take into account that manufacturers are able to choose the most convenient way to apply EGNOS corrections, as far as any of these methods comply with MOPS (see [RD-2]). Thus, the receiver design will also affect the final performance of the user.

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Degraded GPS Core Constellation The GPS constellation is under continuous replenishment and evolution. On rare occasions, it may happen that the basic GPS constellation (as described in the GPS SPS PS [RD-3] becomes temporarily depleted and that it does not meet the GPS SPS PS commitment.	**Degraded EGNOS OS Service performance** In such a case, the EGNOS OS performance can be degraded. The performance experienced by the receiver may be worse than the minimum performance indicated in section 6.2.1.

Table 7: EGNOS OS limitations

7 EGNOS TIME INFORMATION PERFORMANCE

In addition to positioning and navigation, EGNOS also offers timing service which is about the provision of a precise and stable atomic time reference which allows EGNOS users to have a highly accurate common time reference, for:

- Synchronization: using EGNOS Network Time (ENT) as an absolute atomic time reference to synchronize GNSS receivers in different locations.
- Timing: accurately measuring time against a standard and global time reference such as UTC.

The EGNOS Network Time (ENT) is not a recognised metrological timescale standard. In order to effectively support timing applications, the EGNOS system transmits specific corrections that allow the tracing of ENT to the physical realisation of the UTC by Observatoire de Paris, UTC (OP).

7.1 Coordinated Universal Time (UTC) Timescale and UTC (k)

Coordinated Universal Time (UTC), maintained by the Bureau International des Poids et Mesures (BIPM), is the time scale that forms the basis for the coordinated dissemination of standard frequencies and time signals.

UTC is computed by the BIPM by processing clock data collected over a global network of atomic clocks operated by national metrology institutes and observatories. Each of these national institutes generates locally a physical realisation of the UTC which is commonly called UTC (k).

Unlike ENT and GPST, which are realised as continuous timescales consistent with the SI definition of the second, UTC includes regular one-second magnitude discontinuities. These “leap seconds” are introduced artificially in UTC in order to keep its time of day aligned to mean solar time, which is based on the Earth’s rotation period.

Ideally, EGNOS should provide traceability in real time to UTC as computed by BIPM. This is however not possible due to constraints which are difficult to overcome, such as the fact that the UTC time scale is available only 6 weeks afterwards (UTC is disseminated monthly through the BIPM publication “Circular T” with a latency of 6 weeks).

Instead of that, EGNOS provides access to the local UTC realisation at Observatoire de Paris, UTC (OP). A physical link between UTC (OP) and the EGNOS system has been established so that the ENT – UTC (OP) time offset can be monitored and predicted by the EGNOS system.

Figure 6 shows the evolution of the UTC – UTC (OP) offset from January 2013 to April 2024.

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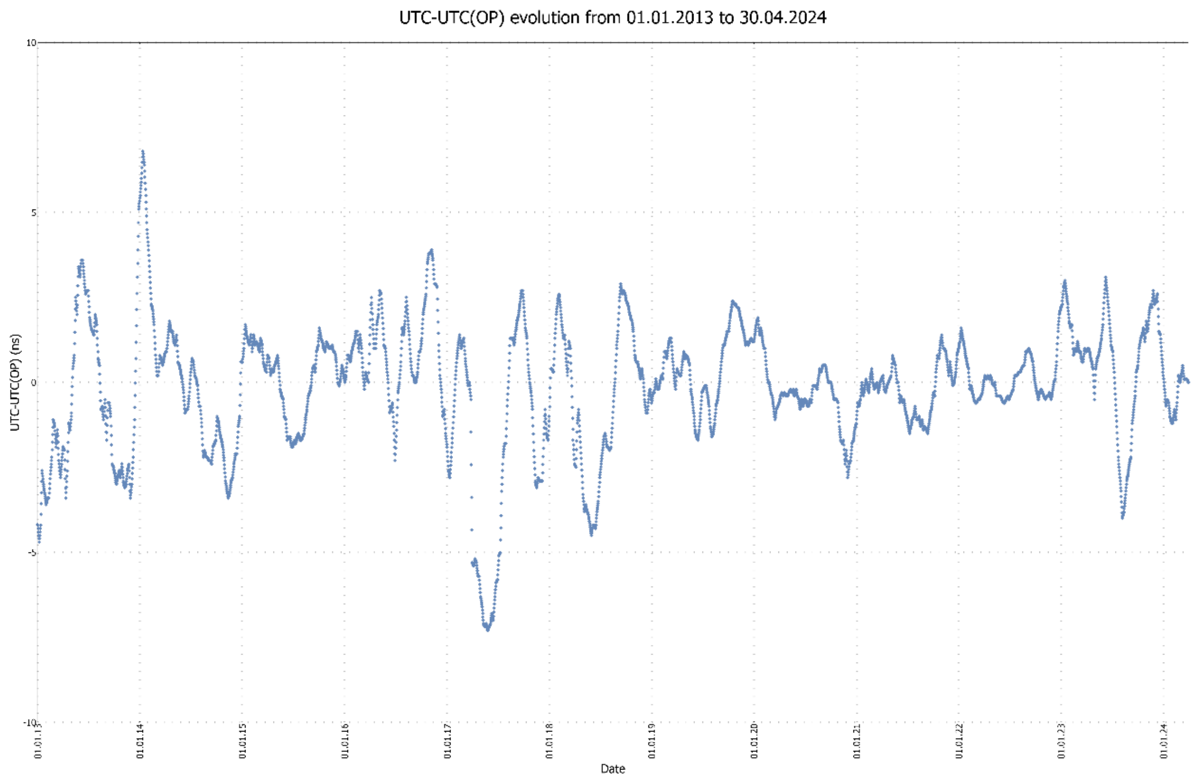

Figure 6: Circular T UTC-UTC(OP) long-term evolution (Period 01/01/2013 – 30/04/2024)

7.2 UTC (OP) Dissemination via EGNOS SIS

ENT is disseminated through the SBAS corrections embedded in the EGNOS Signal In Space. The accuracy of the local realization of ENT computed by an EGNOS receiver depends on the user ranging accuracy (affected by the errors described in Appendix A Satellite navigation concept).

In order to access the EGNOS time service at a given instant, the EGNOS timing receiver first has to estimate the local ENT time by applying the EGNOS corrections to the GPS measurements. It is assumed that EGNOS timing users will use static receivers whose precise coordinates are known with an uncertainty of a few centimetres. In this case, the uncertainty of the local ENT time estimate can be modelled as:

$$\sigma(ENT_{local}) = \frac{UERE_{EGNOS}}{c\sqrt{N}} [sec]$$

where

c is the speed of light

N is the number of measurements

Mobile EGNOS users can also have access to a local ENT realisation since it is estimated within the receiver navigation processing. However, in this case the accuracy of the ENT estimate is degraded with respect to the static case since it is amplified by the Time DOP [19].

$$\sigma(ENT_{local}) = \frac{UERE_{EGNOS}}{c}.TDOP\ [sec]$$

In order to relate the local realisation of ENT to UTC (OP), the EGNOS receiver has to decode the EGNOS message 12 (MT12) which provides the time offset between the two timescales and apply it to the ENT estimate. The difference between ENT and UTC (OP) is modelled in MT12 as an integer number of leap seconds plus a linear offset model (including the following parameters: bias, drift, and time of applicability).

The accuracy of the offset between ENT and the UTC (OP) recovered using the message type 12 parameters is specified as 20 nanoseconds (3σ).

[19] Time DOP (TDOP) is a factor due to satellite geometry and characterises how the range errors translate into time determination errors at user receiver level. More information about DOP-related terms can be found in Appendix A Satellite navigation concept.

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APPENDIX A SATELLITE NAVIGATION CONCEPT

Satellite Navigation (GNSS) is a technique whereby mobile and static users can determine their position based on the measurement of the distance (range) between a number of orbiting satellites and the user receiver. Each satellite of the constellation broadcasts periodic signals that can be used by the user equipment to precisely determine the propagation time between the satellite signal transmission and the satellite signal reception by the receiver. This propagation time can easily be converted into a distance since, at a first approximation, the signals travel in space at a constant speed (the speed of light). Each satellite also continuously broadcasts all information (so-called ephemeris) necessary to determine the exact position of the satellite at any point in time.

Knowing the spacecraft position and the distance from that particular satellite, the user position is known to be somewhere on the surface of an imaginary sphere with a radius equal to that distance. If the position of and distance to a second satellite is known, the user/aircraft must be located somewhere on the circumference of the circle of where the two spheres intersect. With a third and fourth satellite, the location of the user can be inferred[20].

A GNSS receiver processes the individual satellite range measurements and combines them to compute an estimate of the user position (latitude, longitude, altitude, and user clock bias) in a given geographical coordinate reference frame.

The estimation of the satellite-to-user range is based on the measurement of the propagation time of the signal. A number of error sources affect the accuracy of these measurements:

- Satellite clocks: any error in the synchronisation of the different satellite clocks will have a direct effect on the range measurement accuracy. These errors are similar for all users able to view a given satellite.
- Signal distortions: any failure affecting the shape of the broadcast signal may have an impact on the propagation time determination in the user receiver.
- Satellite position errors: if the spacecraft orbits are not properly determined by the system's ground segment, the user will not be able to precisely establish the spacecraft location at any given point in time. This will introduce an error when computing the user position. The size of the error affecting the range measurements depends on the user's location.
- Ionospheric effects: The Ionosphere is an ionised layer of the atmosphere located a few hundred kilometres above the surface of the Earth. When transiting through the ionosphere, the satellite navigation signals are perturbed, resulting in range measurement errors. The size of the error will depend on the level of solar activity (peaks in the solar activity occur on approximately an 11-year cycle) and on the satellite elevation above the horizon. For a low elevation satellite (5° above the horizon), the error affecting the measurement is about 3 times larger than the error affecting a satellite seen at the zenith.
- Tropospheric effects: The troposphere is the lower part of the atmosphere where most weather phenomena take place. The signal propagation in this region will be affected by specific atmospheric conditions (e.g. temperature, humidity…) and will result in range measurement errors. The size of the error will also depend on the satellite elevation above the horizon. For a low elevation satellite

[20] Based on this principle (called triangulation), the location of a receiver could theoretically be determined using the distances from only 3 points (satellites). However, in reality, the determination of a location requires in addition an estimate of the "unknown" receiver clock bias. This necessitates an additional (4th) range measurement.

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(5° above the horizon), the error affecting the measurement is about 10 times larger than the error affecting a satellite seen at the zenith.

- Reflections: When propagating towards the user receiver, navigation signals are prone to reflections from the ground or nearby objects (buildings, vehicles…). These reflected signals combine with the direct signals and introduce a bias in the range measurements made by the user receiver, denoted as multipath error.
- Thermal noise, Interference and User receiver design: the navigation signals have an extremely low power level when they reach the user receiver. The range measurements made by the receiver will therefore be affected by ambient noise and interfering signals, and among other sources of disturbances, the accuracy of such measurements will also depend on the quality of the user receiver design.

When trying to characterise the overall range measurement errors, all error sources described above are aggregated and a unique parameter is used called the User Equivalent Range Error (UERE). The UERE is an estimate of the uncertainty affecting the range measurements for a given satellite.

When computing its position, the user receiver combines the range measurements from the different satellites in view. Through this process, the individual errors affecting each range measurement are combined which results in an aggregate error in the position domain. The statistical relationship between the average range domain error and the position error is given by a factor that depends on the satellite geometry; this factor is named DOP (Dilution Of Precision).

One of the GNSS constellations is named Global Positioning System (GPS). The GPS is a space-based radio-navigation system owned by the United States Government (USG) and operated by the United States Air Force (USAF). GPS provides positioning and timing services to military and civilian users on a continuous worldwide basis. Two GPS services are provided: the Precise Positioning Service (PPS), available primarily to the armed forces of the United States and its allies, and the Standard Positioning Service (SPS) open to civil users (further information can be found on https://www.gps.gov/technical). The GPS Signal In Space characteristics are defined in the GPS ICD [RD-4].

The GPS SPS performance characteristics are defined in the GPS SPS Performance Standards (GPS SPS PS) [RD-3].

Other satellite navigation constellations are being deployed that are currently not augmented by EGNOS. In particular, the European Galileo constellation is meant to be augmented by subsequent versions of EGNOS.

The GPS architecture

In order to provide its services, the GPS system comprises three segments: the Control, Space, and User Segment. The Space and Control segments are briefly described below.

The Space Segment comprises a satellite constellation. The GPS baseline constellation comprises 24 slots in 6 orbital planes with four slots in each plane. The baseline satellites occupy these slots. Any surplus GPS satellites that exist in orbit occupy other locations in the orbital planes. The nominal semi-major axis of the orbital plane is 26,559.7 Km. The signals broadcast by the GPS satellites are in the L-band carriers: L1 (1575.42 MHz) and L2 (1227.6 MHz). Each Satellite broadcasts a pseudo-random noise (PRN) ranging signal on the L1 carrier.

The Operational Control System (OCS) includes four major subsystems: a Master Control Station, a backup Master Control Station, a network of four Ground Antennas, and a network of globally distributed Monitoring Stations. The Master Control Station is located at Schriver Air Force Base, Colorado, and is operated on a continuous basis (i.e. 24h, 7 days a week, all year); it is the central control node for the GPS satellite constellation and is responsible for all aspects of the constellation command and control.

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APPENDIX B IONOSPHERIC ACTIVITY AND IMPACT ON GNSS

Appendix B.1 Ionosphere and GNSS

Ionosphere is one of the main error sources in Global Navigation Satellite Systems (GNSS) error budget. The ionosphere is a highly variable and complex region of the upper atmosphere ionized by solar radiations and therefore containing ions and free electrons. The negatively charged free electrons and ions affect the propagation of radio signals and in particular, the electromagnetic satellite signals. Its dispersive nature makes the ionospheric refractive index different from unity. The structure of the ionosphere is continually varying in response to changes in the intensities of solar radiations: as solar radiation increases, the electron density in the ionosphere also increases. The ionosphere structure is also affected and disturbed by changes in the magnetic field of the Earth resulting from its interaction with the solar wind and by infrequent high-energy particles ejected into space during powerful solar eruptions such as coronal mass ejections and solar flares.

The ionospheric effects on satellite signals must be properly accounted for in the GNSS positioning process in order to obtain reliable and accurate position solutions. A large number of models and methods for estimating the ionospheric signal delay have been developed. The most widely used model is probably the Klobuchar model. Coefficients for the Klobuchar model are determined by the GPS control segment and distributed with the GPS navigation message to GPS receivers where the coefficients are inserted into the model equation and used by receivers for estimation of the signal delay caused by the ionosphere.

In the case of SBAS systems, the SBAS receivers inside the corresponding service area use the SBAS ionospheric corrections, which are derived from real-time ionospheric delay measurements. The SBAS ground system obtains these measurements from a network of reference stations and uses them to estimate the vertical delays and associated integrity bounds at the ionospheric grid points (IGPs), of a standardized ionospheric grid located 350 km above the surface of the Earth [RD-1]. The user equipment uses the SBAS grid information to compute a vertical delay and vertical integrity bound for each line of sight to a satellite; then applies a standardized “obliquity factor” to account for the angle at which the line of sight pierces the ionospheric grid.

Appendix B.2 Impact of the ionospheric activity on GNSS

The GNSS signal delay as direct effect of ionosphere is always present and varies in size; however, it is generally well modelled and can be estimated to an extent that makes GNSS/SBAS usable. During periods with increased ionospheric activity or geomagnetic storms (caused by sudden eruptions of the Sun), GNSS/SBAS users can experience residual ionospheric effects owing to a high ionosphere variability impossible to be effectively modelled and corrected, which can reduce navigation performance at user level. The increase in the residual ionospheric effects implies a higher error over-bounding (this is, higher protection level) and in case this higher over-bounding exceeds the maximum value for the intended operation (this is, alert limit) the service availability for such operation is impacted.

The current solar cycle#25 started in December 2019. The solar cycle is the periodic change in the Sun's activity (including changes in the levels of solar radiation and ejection of solar material) and appearance (visible in changes in the number of sunspots, flares, and other visible manifestations) with a typical duration of eleven years. The number of sunspots (SSN) is one of the main parameters to monitor the ionosphere behaviour (Figure 7). In solar cycle#24 a first maximum of number of sunspots was reached in 2012 and a

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second relative maximum, higher than the first one, was reached in 2014. The activity continued afterwards with a decreasing trend, and with cycle#25 once again rising up.

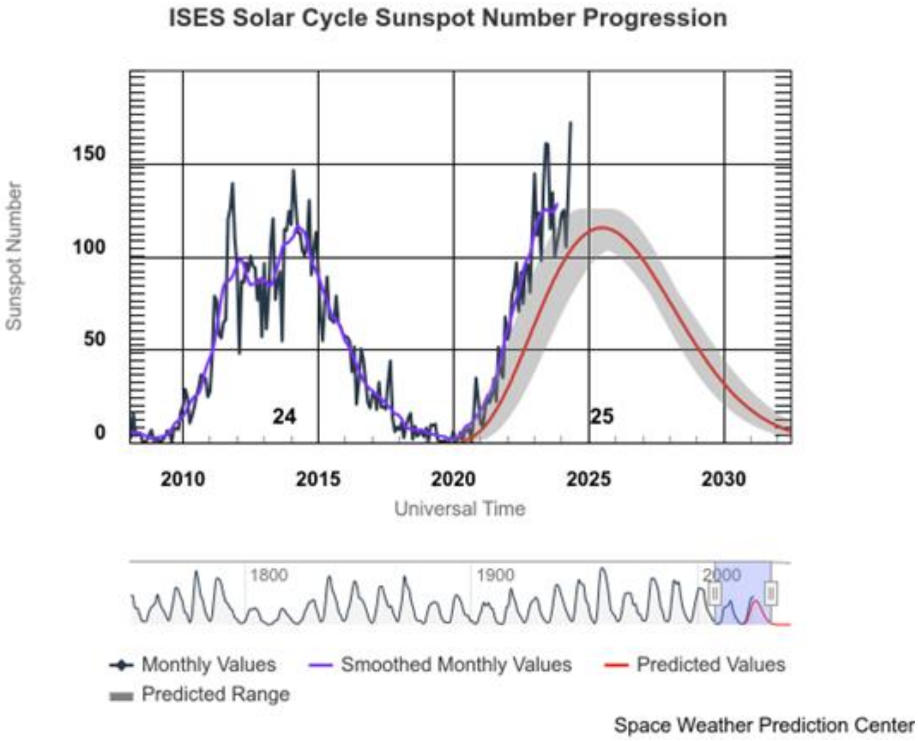

Figure 7: SSN progression from NOAA/SWPC

The dependence of SBAS system performance on the ionosphere variations is especially noticeable during the period when the solar activity increases. SBAS systems estimate ionospheric delays assuming a bidimensional behaviour of the ionosphere (no height), which is valid in a nominal situation, but which is not accurate in case of high solar activity or geomagnetic storms when the ionosphere presents high spatial gradients and behaves as a 3-dimensional body (whose properties change with the height). This is considered as an intrinsic limitation of single frequency SBAS systems.

This link between EGNOS performance and solar activity is particularly clear in the case of performance degradations observed in the South of Europe. Performance degradation is also observed in the North during periods with high geomagnetic activity.

It must be noted that in the coming years, during the rap up of the current solar cycle 25, this SBAS performance's behaviour is expected to be observed again. That increase is linked to the solar cycle#25, which is being more active than initial predictions.

Additionally, it should be highlighted that the ionospheric events in case of impact on GNSS/SBAS-based operations cannot be currently notified to users in advance. Even if the possibility of predicting that kind of phenomenon, using space weather forecasts, to potentially alert users is still under investigation, the high impact for the SBAS users shows the clear need of understanding the mechanisms involved in this process.

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Appendix B.3 Improvement and robustness achieved by EGNOS

EGNOS Programme is advancing towards a deeper understanding of the effects of ionosphere at user performance level to improve the EGNOS system behaviour towards ionospheric disturbances, make it more robust and provide a better service to the EGNOS users. The increase of the robustness of EGNOS to the solar activity has been an objective of the EGNOS program with the aim of improving service performance. During the last years, this improvement in the service performance has been observed, showing since November 2023 a quite significant increase in the robustness against these kind of degradations. It must be noted that the impact of the Solar Cycle will be removed with the introduction of EGNOS V3 in the coming years for dual frequency users.

ESSP, as the EGNOS Service Provider, is continuously analysing the impact which could be faced by the different EGNOS users' communities. Whenever there is any relevant information (complementary to the different SDDs) related to this matter that could be of interest for the users, an EGNOS Service Notice is published (https://egnos.gsc-europa.eu/documents/field_gc_document_type/87) and distributed.

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APPENDIX C EGNOS OS OBSERVED PERFORMANCE

This appendix to the EGNOS OS SDD provides the actual EGNOS OS accuracy performance that has been measured at 32 EGNOS RIMS sites (the ones inside the EGNOS OS positioning compliance area – see section 6.2.2) in the period mid November 2023 – April 2024.

Appendix C.1 Position Accuracy

The position accuracy is monitored using the EGNOS RIMS receivers. Figure 8 gives the HNSE (95%) and VNSE (95%) values measured during around 6 months (mid November 2023 – April 2024) at 32 RIMS sites. The colour scheme for accuracy values varies from green (lower position accuracy) to blue (higher position accuracy).

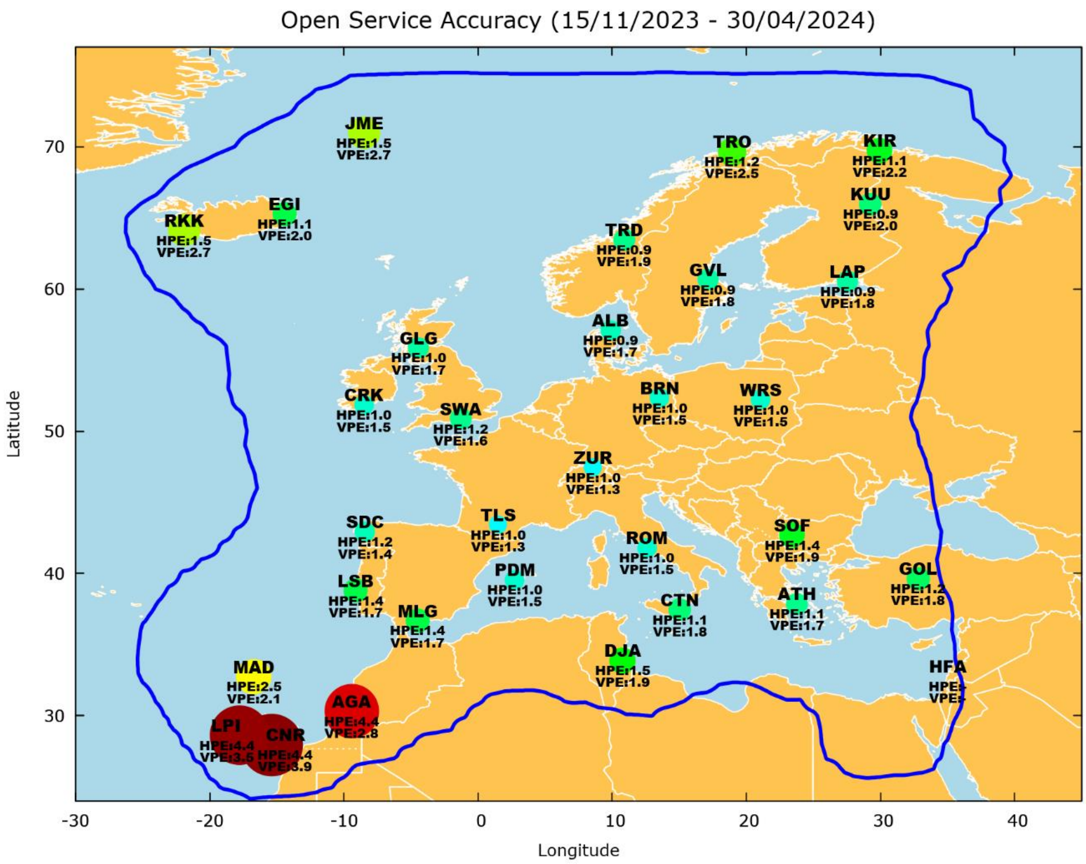

Figure 8: EGNOS Open Service accuracy (95%)

The next figures show the histogram and cumulative distribution function of HNSE (Horizontal Navigation System Error) and VNSE (Vertical Navigation System Error), which are computed at the previous stations for each second.

Further updated information on EGNOS OS observed performance can be found/requested via the EGNOS Service Provider website (see section 3.4.2).

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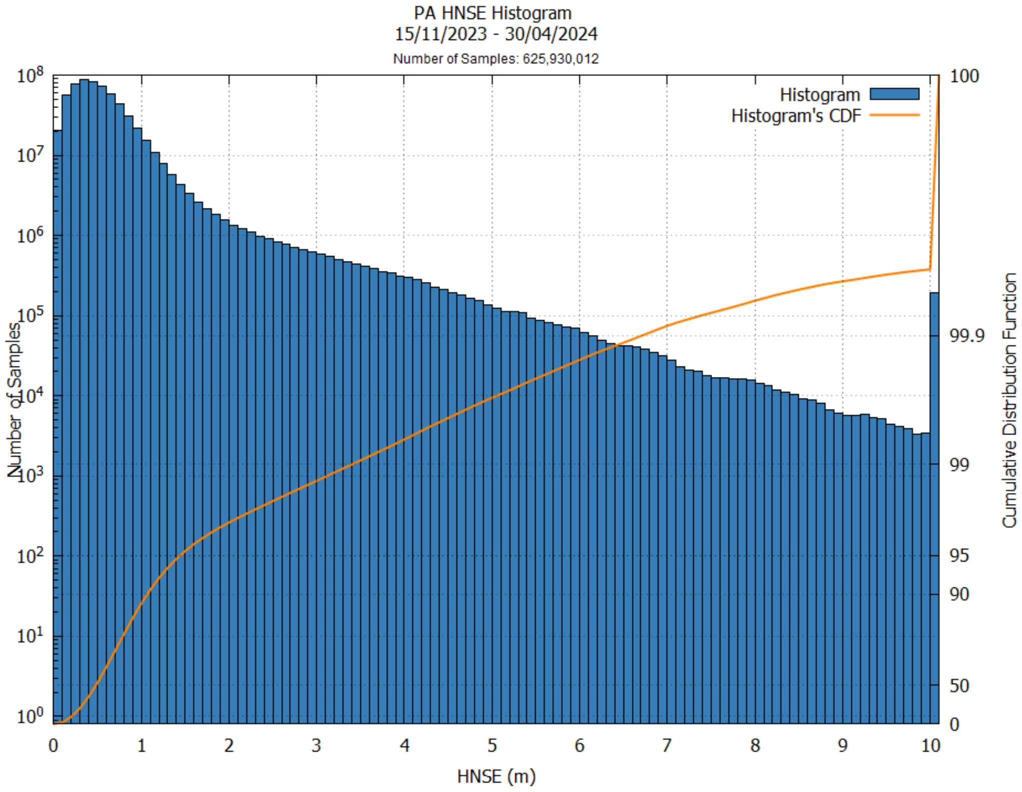

Figure 9: EGNOS Open Service HNSE Histogram and Cumulative Distribution

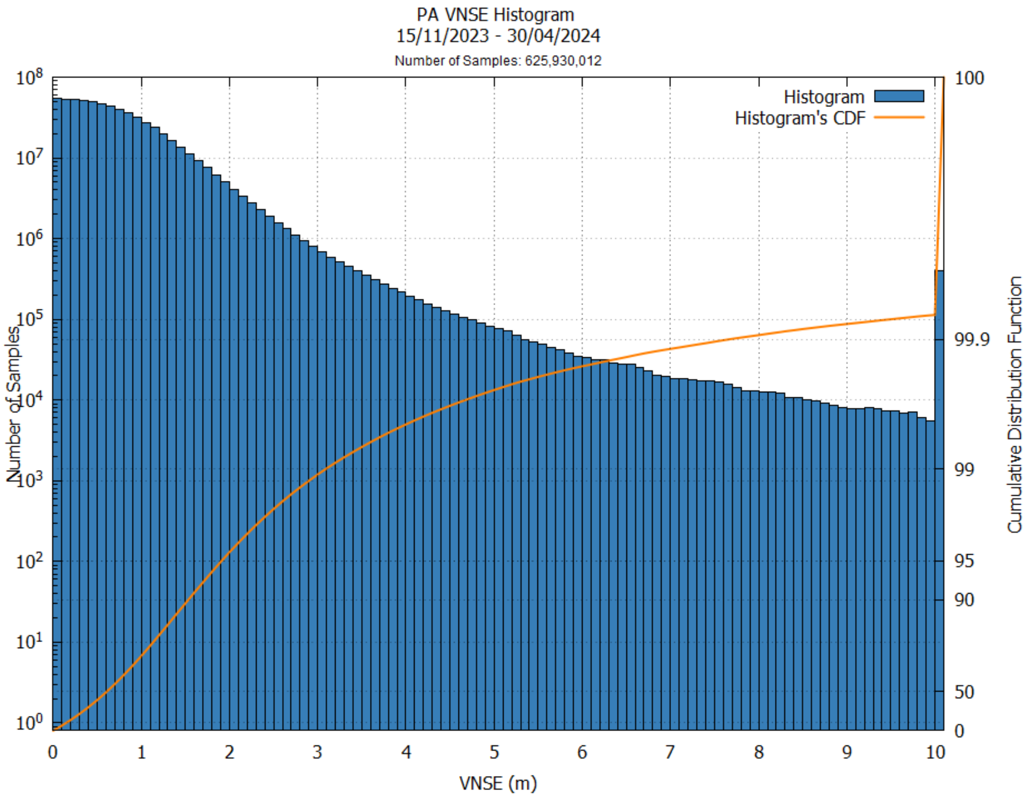

Figure 10: EGNOS Open Service VNSE Histogram and Cumulative Distribution

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Appendix C.2 Open Service Availability

Figure 11 presents the Open Service Availability measured in the monitoring stations during the last 6 months (mid November 2023 – April 2024). EGNOS OS Availability is defined in the present document as the percentage of time when the instantaneous HNSE is lower than 3 meters and the instantaneous VNSE is lower than 4 meters over the total number of samples with valid PA navigation solution.

The blue line of this figure indicates the OS Compliance Area, as was previously explained in section 6.2.2). The size of each icon represents the degree of compliance between the real performance measured and the reference value (99%).

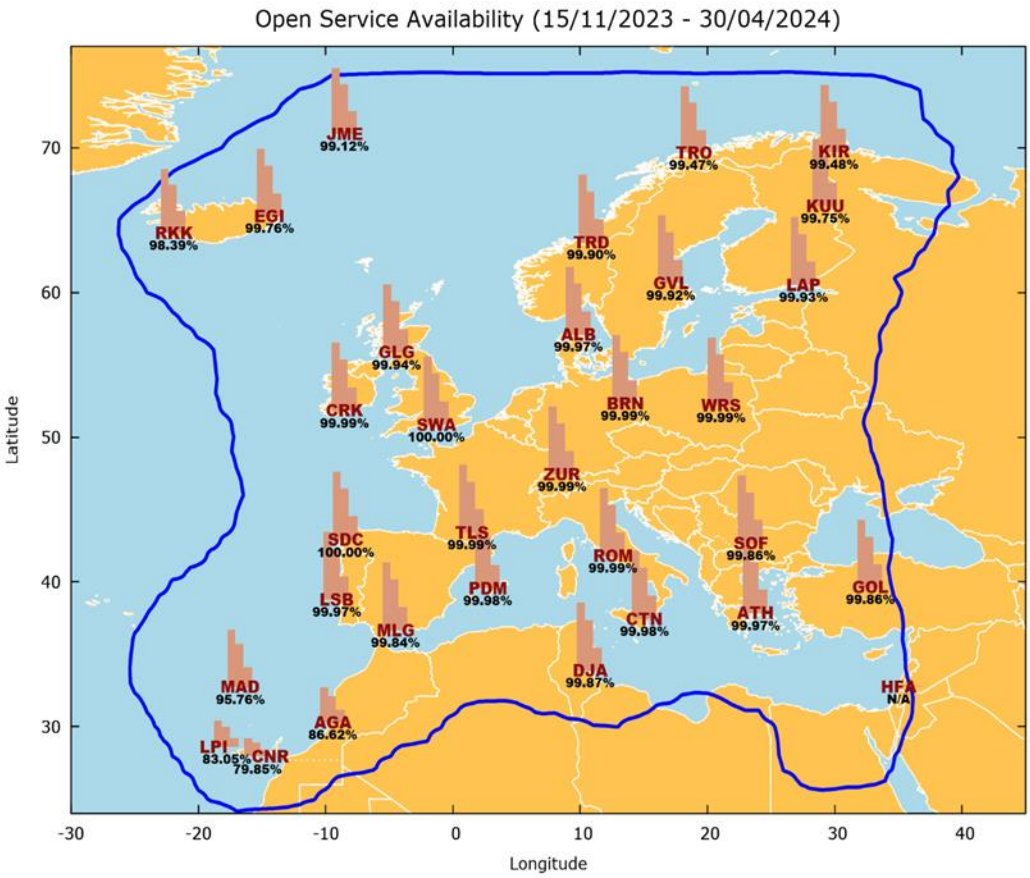
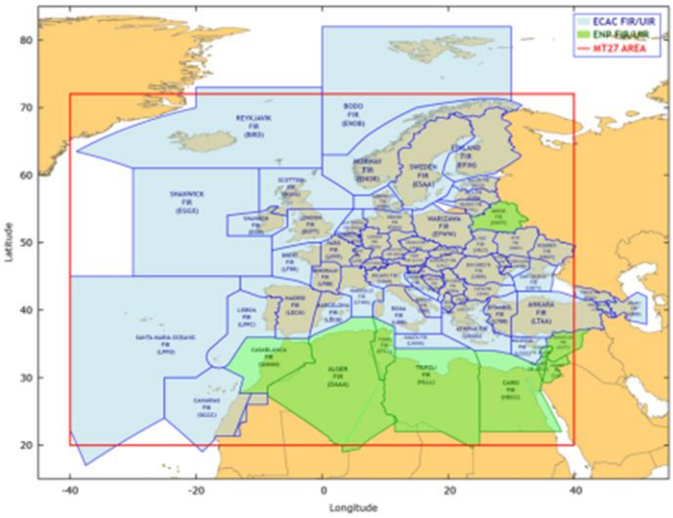


Figure 11: EGNOS Open Service availability at reference stations

APPENDIX D DEFINITIONS

Terms	Definition
Accuracy	The position error is the difference between the estimated position and the actual position. The EGNOS OS minimum accuracy is specified in Table 6 Statistical values of the measured OS accuracy over Europe. For an estimated position at a specific location, the probability that the position error is within the EGNOS OS minimum accuracy requirements should be at least 95%.
Availability	EGNOS OS Availability is defined as the percentage of time when the instantaneous HNSE (Horizontal Navigation System Error) is lower than 3 meters and the instantaneous VNSE (Vertical Navigation System Error) is lower than 4 meters.
ECAC	Consists of the envelope of all FIRs of ECAC96 member States (including Canary Islands FIR) and the oceanic control areas of Reykjavik, Swanwick and Santa Maria. The ECAC landmass comprises the landmass region of ECAC member states, including ECAC islands (e.g. Canary Islands). EGNOS service coverage is limited in the North by 70 degrees latitude (70° N), in the South by 20 degrees latitude (20° N), in the East by 40 degrees longitude (40° E), and in the West by 40 degrees longitude (40° W).  **Figure 12: ECAC 96 FIRs**
EGNOS OS Compliance Area	Minimum area where at least 99% of the time any user is able to calculate its position with an accuracy compliant with the requirements detailed in section 6.2.1: Instantaneous HNSE (Horizontal Navigation System Error) lower than 3 meters and the instantaneous VNSE (Vertical Navigation System Error) lower than 4 meters.
EGNOS Service Area	Geographic region defined in the EGNOS Service Message MT27 which comprises latitudes from 20° to 70° and longitudes from -40° to 40°. As part of the EGNOS Service Area, the concept of EGNOS OS Compliance Area is defined by the OS availability map.

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End/ Final OS user	Every member of EGNOS OS user community interested in obtaining better positioning accuracy in those applications where safety is not critical (i.e. where a failure in availability, integrity, continuity and/or accuracy of the EGNOS SIS could not cause any kind of direct or indirect personal damage, including bodily injuries or death).

Table 8: Definitions

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APPENDIX E LIST OF ACRONYMS

The following table provides the definition of the acronyms used in this document.

ACRONYM	DEFINITION		
ANSP	Air Navigation Service Provider	**IS**	Interface Specification
AOR	Atlantic Ocean Region	**ITRF**	International Terrestrial Reference Frame
ASQF	Application Specific Qualification Facility	**ITU**	International Telecommunications Union
BIPM	Bureau International des Poids et Mesures	**LPV**	Localizer Performance with Vertical guidance
C/A	Coarse/Acquisition	**MCC**	Mission Control Centre
CCF	Central Processing Facility	**MDA/H**	Minimum Descent Altitude / Height
CNES	Centre National d'Études Spatiales	**MI**	Misleading Information
CPF	Air Navigation Service Provider	**MLIT**	Ministry of Land, Infrastructure, Transport and Tourism (Japan)
DAB	Digital Audio Broadcast	**MOPS**	Minimum Operational Performance Standards
dBi	deciBel isotropic	**MSAS**	MTSAT Satellite-based Augmentation System
dBW	deciBel Watt	**MT**	Message Type
DFS	Deutsche Flugsicherung	**MTSAT**	Multi-Function Transport Satellite
DGAC	Direction Générale de l´Aviation Civile	**NATS**	National Air Traffic Service
DOP	Dilution Of Precision	**NAV-EP**	Navegaçao Aerea de Portugal
DSNA	Direction des Services de la Navigation Aérienne	**NLES**	Navigation Land Earth Station
EASA	European Aviation Safety Agency	**NSE**	Navigation System Error
EC	European Commission	**OCS**	Operational Control System
ECAC	European Civil Aviation Conference	**OS**	Open Service
EDAS	EGNOS Data Access Service	**PACF**	Performance and Check-out Facility
EGNOS	European Geostationary Navigation Overlay Service	**PDOP**	Position Dilution Of Precision
ENAV	Ente Nazionale Di Assistenza Al Volo	**PL**	Protection Level
ENT	EGNOS Network Time	**PNT**	Precise Navigation and Timing
ESA **ESR**	European Space Agency EGNOS System Release	**PPS**	Precise Positioning Service
ESSP	European Satellite Services Provider	**PRN**	Pseudo-Random Number
ETRF	EGNOS Terrestrial Reference Frame	**PS**	Performance Standard
EU	European Union	**PVT**	Position Velocity and Timing
EUSPA	EGNOS Terrestrial Reference Frame	**RAIM**	Receiver Autonomous Integrity Monitoring
ESMAS	EGNOS Safety of Life assisted service for MAritime userS	**RD**	Reference document

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EWAN	EGNOS Wide Area Network	**RF**	Radio Frequency
FAA	Federal Aviation Administration	**RHCP**	Right Hand Circularly Polarised
FDE	Fault Detection and Exclusion	**RIMS**	Range and Integrity Monitoring Station
FIR	Flight Information Region	**RTCA**	Radio Technical Commission for Aeronautics
ESA	European Space Agency	**RTCM**	Real Time Correction Message
ESMAS	EGNOS Safety of Life assisted service for MAritime userS	**SARPs**	Standards and Recommended Practices
ESR	EGNOS System Release	**SAS**	Société par Actions Simplifiée
ESSP	European Satellite Services Provider	**SBAS**	Satellite-Based Augmentation System
ESP	EGNOS Service Provider	**SDCM**	System of Differential Correction and Monitoring
ETRF	EGNOS Terrestrial Reference Frame	**SDD**	Service Definition Document
ETSO	European Technical Standard Orders	**SES**	Single European Sky
EU	European Union	**SI**	International System of Units
EUSPA	European Union Agency for the Space Programme	**SIS**	Signal-In-Space
EWA	EGNOS Working Agreement	**SoL**	Safety of Life
EWAN	EGNOS Wide Area Network	**SOLAS**	Safety Of Life At Sea
FAA	Federal Aviation Administration	**SPS**	Standard Positioning Service
FAQ	Frequently Aked Questions	**SPU**	Service Provision Unit
FDE	Fault Detection and Exclusion	**SREW**	Satellite Residual Error for the Worst user location
FIR	Flight Information Region	**SW**	Software
FTP	File Transfer Protocol	**TDOP**	Time Dilution Of Precision
GAGAN	GPS Aided GEO Augmented Navigation	**TEC**	Total Electron Content
GEO	Geostationary Satellite	**TF**	Technical File
GIVD	Grid Ionospheric Vertical Delay	**TN**	Technical Note
GIVE	Grid Ionospheric Vertical Error	**TTA**	Time-To-Alert
GLONASS	Global Navigation Satellite System	**TWAN**	Transport Wide Area Network
GNSS	Global Navigation Satellite System	**UDRE**	User Differential Range Error
GPS	Global Positioning System	**UERE**	User Equivalent Range Error
GPST	GPS Time	**UIVD**	User Ionospheric Vertical Delay
HDOP	Horizontal Dilution of Precision	**US**	United States
HMI	Hazardously Misleading Information	**UTC**	Coordinated Universal Time
HPE	Horizontal Position Error	**UTC (OP)**	Coordinated Universal Time (Observatoire de Paris)
ICAO	International Civil Aviation Organization	**VDOP**	Vertical Dilution of Precision
ICD	Interface Control Document	**VNSE**	Vertical Navigation System Error
IERS	International Earth Rotation and Reference Systems Service	**VPE**	Vertical Position Error
IGP	Ionospheric Grid Point	**WAAS**	Wide Area Augmentation System
IGS	International GNSS Service	**WGS84**	World Geodetic System 84 (GPS Terrestrial Reference Frame)

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IMO	International Maritime Organization	**WUL**	Worst User Location

Table 9: List of acronyms

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