SBAS/EGNOS INTRODUCTION

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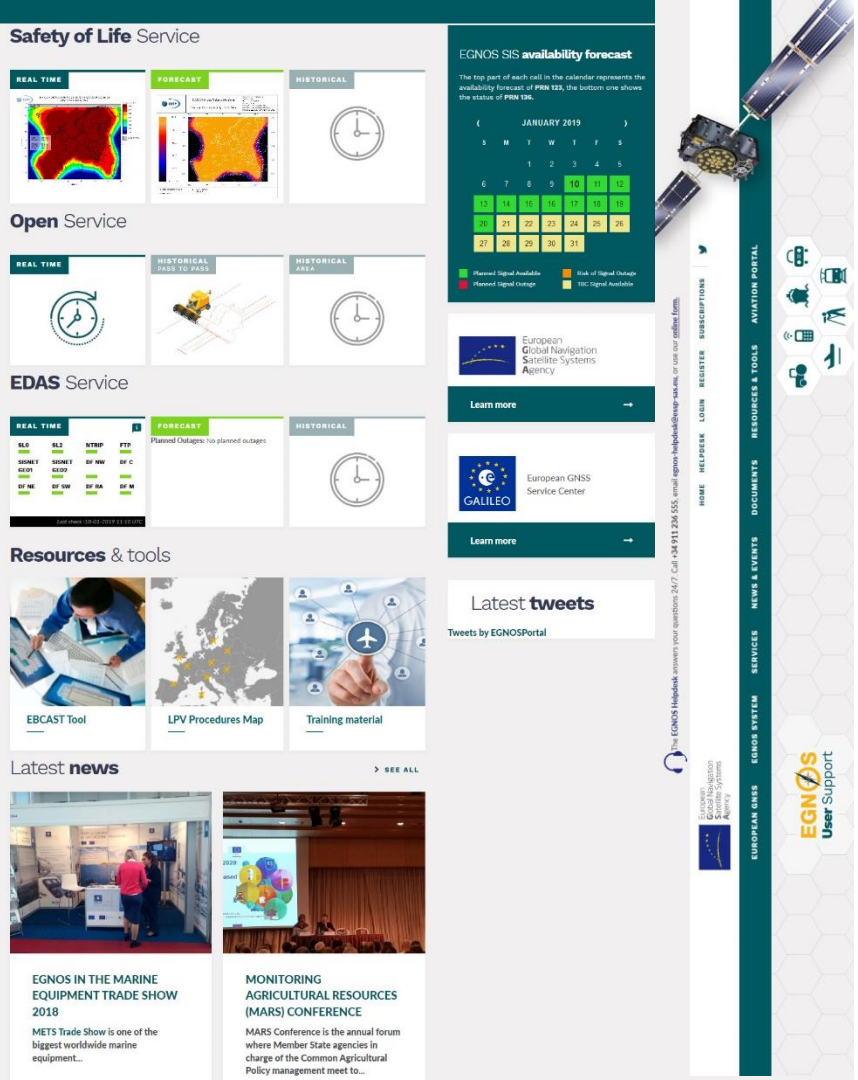
Gabriella Povero | Navigation Technologies

GNSS Training

AIT, Bangkok | 14-18 January 2019



OUTLINE

- INTRODUCTION TO AUGMENTATION SYSTEMS
- EGNOS AND ITS SERVICES
- EGNOS ARCHITECTURE
- EGNOS PERFORMANCE

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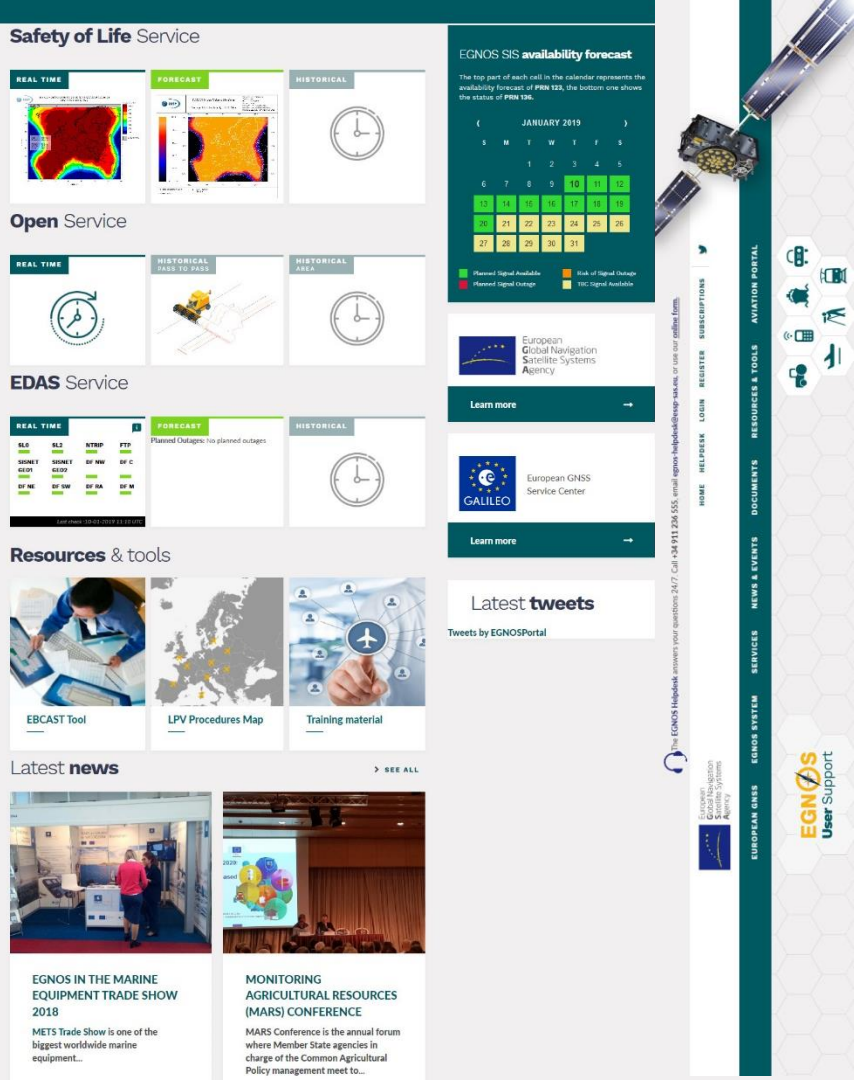

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WHAT'S UP IN THE SKY?

GNSS

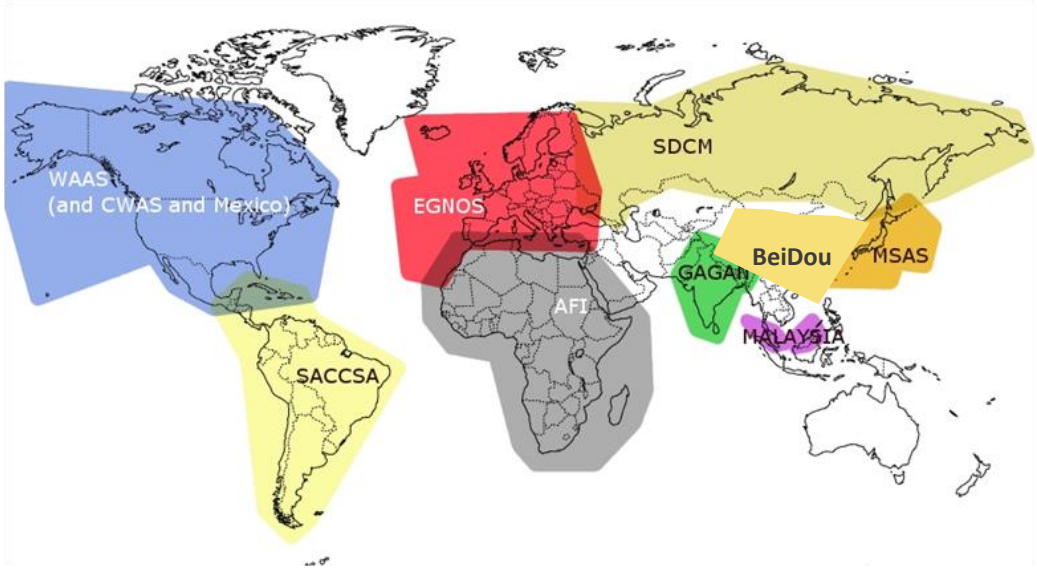
RNSS

Quasi-Zenith Satellite System (QZSS)

IRNSS-NAVIC

SBAS

SATELLITE BASED AUGMENTATION SYSTEMS



Used to improve the performance of global navigation satellite systems (GNSS)

USA	WAAS - Wide Area Augmentation System
European Union	EGNOS - European Geostationary Navigation Overlay Service
Japan	MSAS - Multifunctional Satellite Augmentation System
India	GAGAN - GPS Aided Geo Augmentation Navigation
Russia	SDCM - System of Differential Correction and Monitoring
China	BeiDou Wide Area Differential service
Korea	KASS - Korea Augmentation Satellite System
Latin America	SACCSA - Solución de Aumentación para Caribe, Centro y Sudamérica
Africa	AFI (Africa-Indian Ocean)
Thailand, Malaysia	

AUGMENTATION: PURPOSES

An augmentation system has the general objective of **improving the use of GNSS**, through the provision of additional information (differential corrections or measurements).

- Systems that keep the focus on **accuracy**.

  They are intended for:
  - LBS in general including leisure
  - Mapping
  - Cadastral
  - Surveying

- Systems for **Safety of Life** applications with focus on **integrity**:
  - Air navigation
  - Water navigation
  - Transports in general

- Systems for other services with **legal or liability** implications:
  - Road Tolling
  - Exclusive Economic Zone control

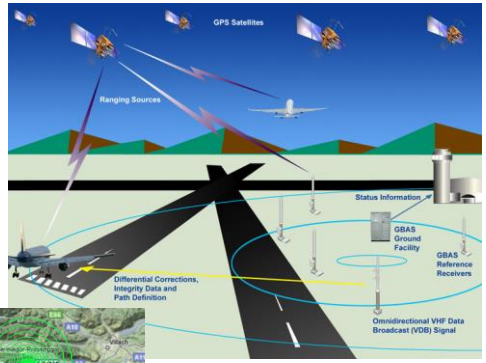
SBASs are standardized at ICAO level to ensure interoperability

SAFETY AND ACCURACY

- **Safety** is guaranteed through the satisfaction of requirements provided by internationals bodies as International Civil Aviation Organization (ICAO) and International Maritime Organization (IMO).
  - Such requirements take also into account accuracy but the human life protection is the main driver.
  - **Integrity**:
    - Timely alarms in case of GNSS signal failure
    - Information to users to compute the level of trust (confidence bounds) of the received GNSS signals
- In non-SoL systems **accuracy** is the focus. Different levels of performance can be achieved to satisfy different needs including economic aspects.

COVERAGE

- A different categorization can be done on the basis of the system coverage:
  - Local area (LAAS or GBAS)
    - Range corrections
    - Common SVs view
  - Wide Area (SBAS)
    - Separate corrections for each error
    - Large network of reference stations needed



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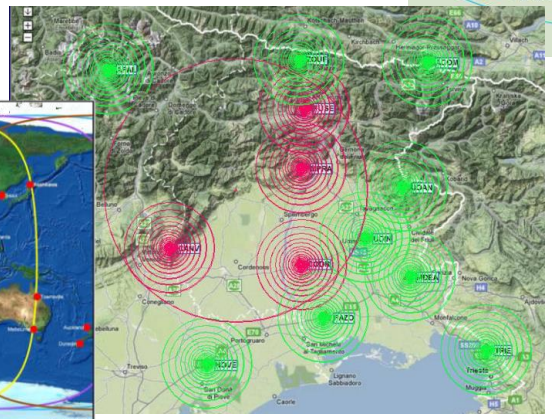
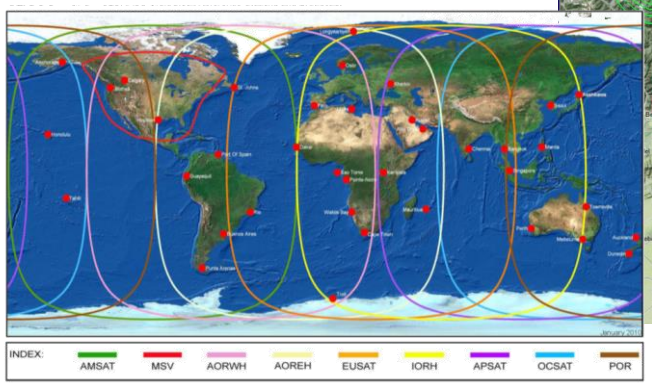




ERRORS

Errors affecting GNSS performance depend on several factors:

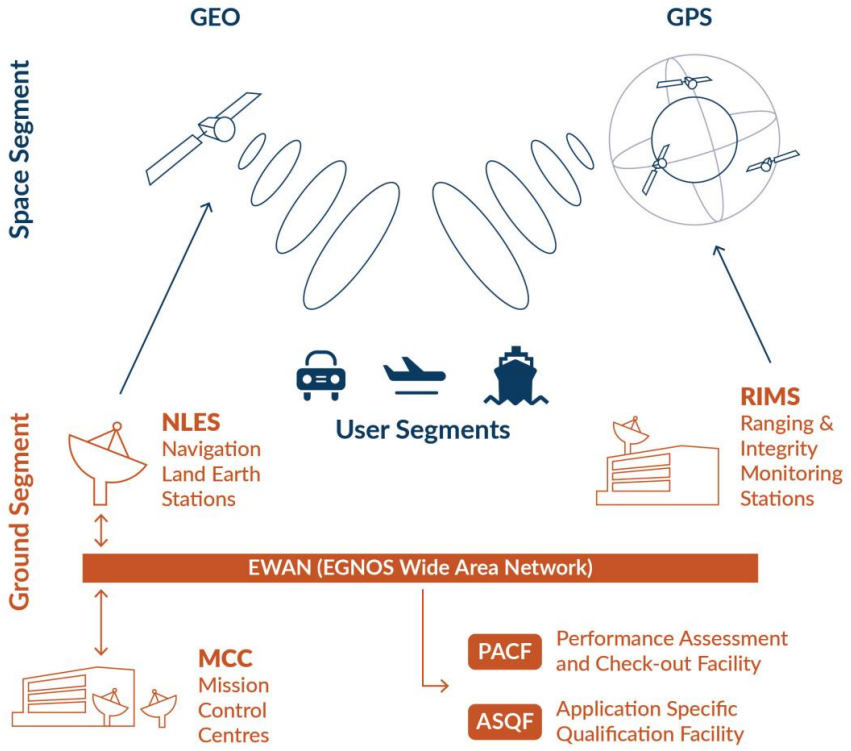
- At **system (space-control)** level:
  - **Clock errors**
  - **Ephemeris errors**
  - [Selective Availability (S/A)]
- During the path from satellite to receiver (**propagation**):
  - **Ionosphere effects**
  - **Troposphere effects**
- At **receiver** level:
  - Receiver noise
  - Multipaths, interfering signals, etc.

- Error sources can be divided in two main groups:
  - errors with **strong spatial** correlation
  - errors with **weak spatial** correlation

  Spatial correlation refers to the variation of the error magnitude with respect to the change of the receiver position.
- Different GNSS receivers will experience the effect of the same error source depending on:
  - the error spatial correlation
  - the distance among the receivers
- Two receivers with a certain degree of proximity will be affected by **common errors** and by **errors with a strong spatial correlation** that can be mitigated.

SBAS STRUCTURE

- **Space Segment**
  - geostationary satellites
- **Ground Segment**
  - Control and Monitoring Centres
  - Network of Monitoring Stations
  - Stations to upload messages
- **User Segment**
  - All receivers enabled to elaborate the SBAS signal to improve performance
  - Applications based on provided services
- **Services** enabled by broadcast **signals**



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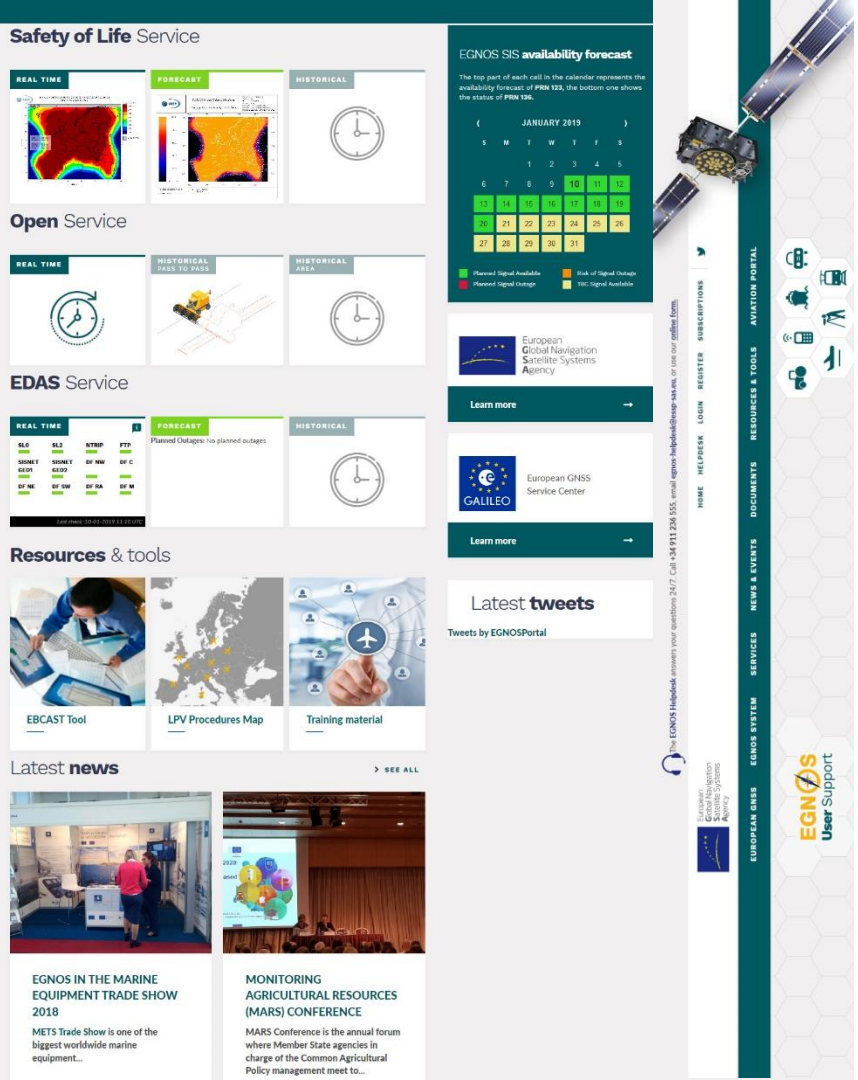

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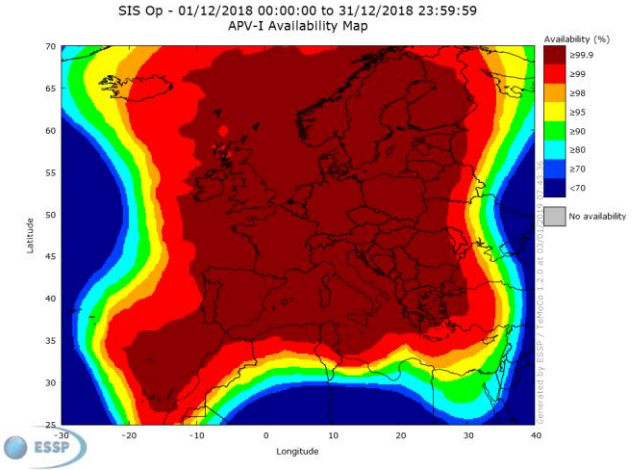
EGNOS

- EGNOS - **European Geostationary Navigation Overlay Service** - is Europe regional SBAS
- EGNOS was promoted by the European Tripartite Group formed by Eurocontrol, the European Commission and the European Space Agency.
- It was initially designed for **aviation** to enable aircrafts to use GPS for all phases of flight, from *en route* down to *precision approaches* to any airport within its coverage area.
- EGNOS provides safety of life navigation services also to **maritime** and **land-based** users Its main features are the provision of:
  - Wide Area Differential corrections
  - Integrity information



- Currently it augments **GPS L1 C/A** signal
- Galileo augmentation planned in future system versions

EGNOS

- EGNOS is operational since **2009**
- EGNOS meets stringent **International Civil Aviation Organisation** (ICAO) requirements for all phases of flight
- It is compliant with relevant ICAO **Standards And Recommended Practices for SBAS** (SARPS) and **Minimum Operational Performance Standard** (MOPS)
- EGNOS is **fully interoperable** with all other SBAS worldwide
- EGNOS is managed by:

European GNSS Agency (GSA): exploitation phase, overall operational programme management

European Satellite Service Provider (ESSP): is the EGNOS Services Provider within Europe, certified according to the Single European Sky (SES) regulation as an Air Navigation Service Provider (ANSP) (under GSA contract).

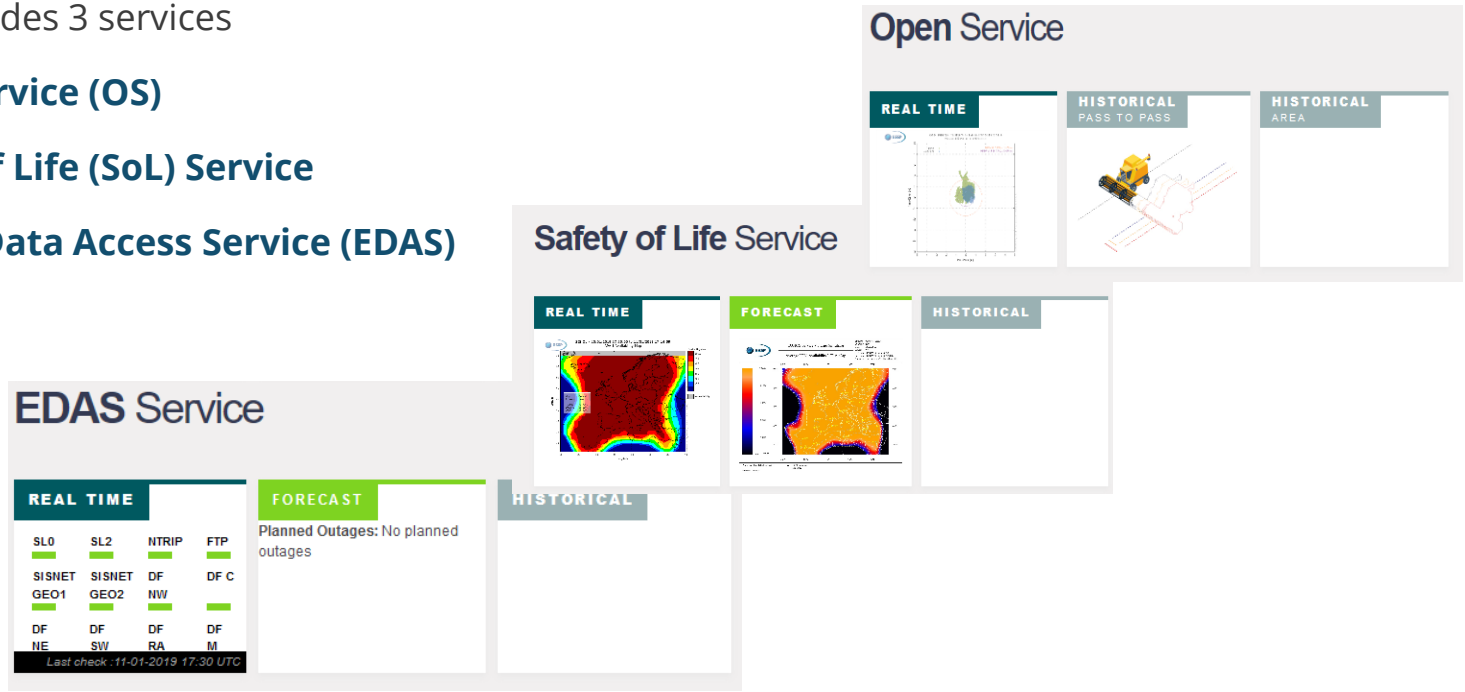
European Commission (EC): owner of the EGNOS system.

European Space Agency (ESA): led EGNOS technical development; mandated by EC as agent for design and procurement for system evolutions.

EGNOS SERVICES

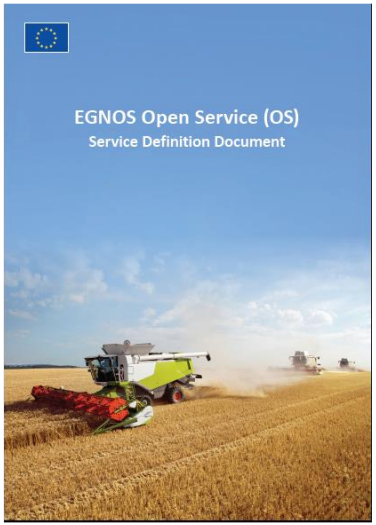
EGNOS provides 3 services

- **Open Service (OS)**
- **Safety of Life (SoL) Service**
- **EGNOS Data Access Service (EDAS)**



EGNOS OS

- **EGNOS Open Service:** available since 1st October 2009
- OS is **freely accessible** with a GPS/SBAS compatible receiver within the EGNOS OS area without any specific authorisation requirements.
- EGNOS OS can only be used for **non-safety critical purposes**.
- The EGNOS OS service improves positioning accuracy by correcting error sources affecting GNSS signals.
- The corrections transmitted by EGNOS help mitigate ranging error sources related to **satellite clocks**, **satellite position** and **ionospheric effects**.
- EGNOS can also detect distortions affecting the signals transmitted by GNSS, preventing users from tracking **unhealthy or misleading** signals that could lead to inaccurate positioning.

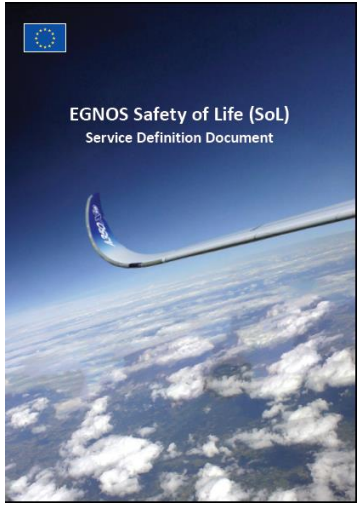


OS minimum accuracy

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

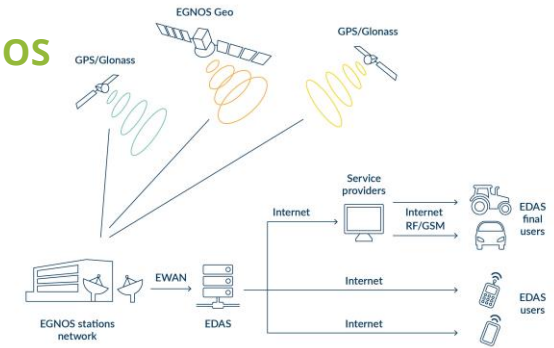
EGNOS SOL SERVICE

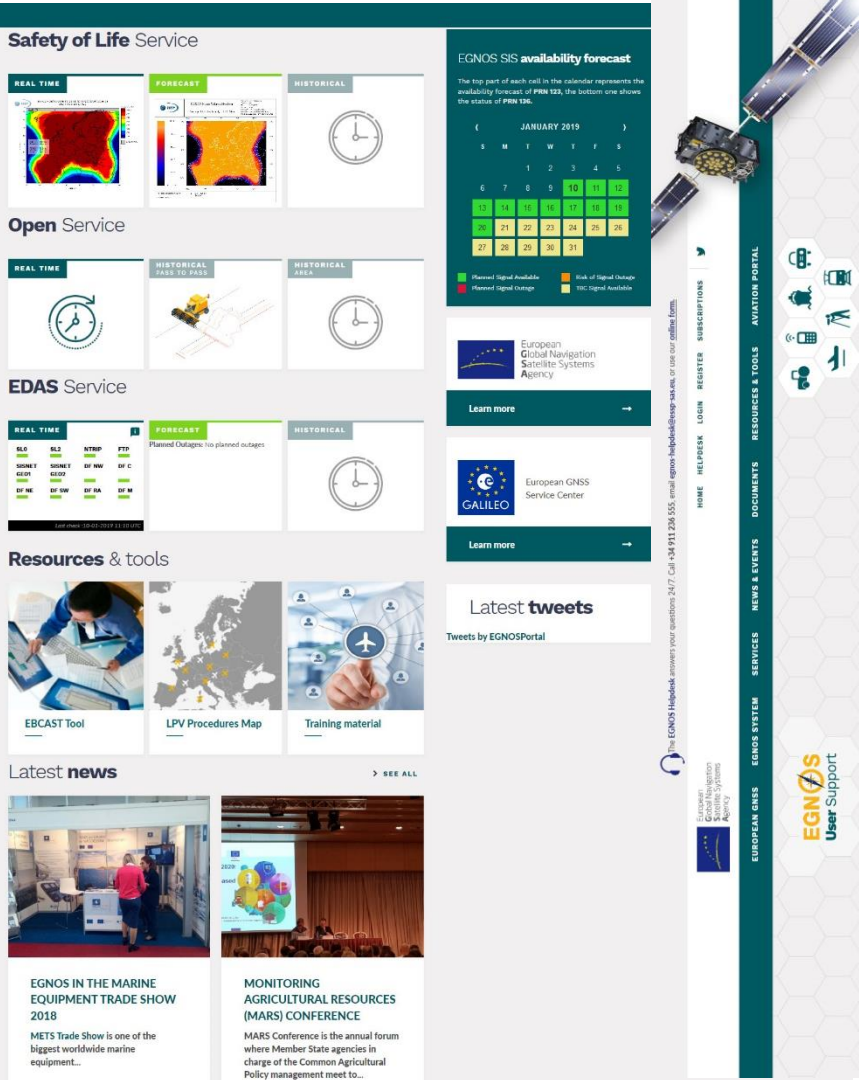
- **EGNOS SoL Service** is available since 2nd March 2011
- It provides the **most stringent level of signal-in-space** (SIS) performance for all SoL users
- It supports **civil aviation operations** down to LPV (Localiser Performance with Vertical Guidance) minima (performance characterisation conducted).
- SoL may be used in **maritime, railways and road** domains whenever citizens' life can be endangered by performance of the navigation system below specified accuracy or by no alert notice given within a specified time interval.
- SoL SIS was designed to comply with ICAO SARPS.
- Sol SIS provides **integrity information**, it is **open** and **freely accessible**.
- Sol SIS:
  - augmentation signal to GPS SPS for positioning
  - additional timing signal



EGNOS EDAS

- The **EGNOS Data Access Service (EDAS)** offers ground-based access to EGNOS data through the **Internet** on a controlled access basis.
- EDAS is the access point to **data collected and generated by the EGNOS ground infrastructure** distributed over Europe and North Africa.
- EDAS provides **the same data that is broadcast** by the EGNOS satellites (EGNOS Message) in near real-time.
- EDAS delivers EGNOS data to users who **cannot always view the EGNOS satellites** (such as those in urban canyons).
- EDAS primarily provides the following **types of data**:
  - raw GPS, GLONASS and EGNOS geostationary satellite observations
  - navigation data collected by the entire network of EGNOS stations;
  - EGNOS augmentation messages, as normally received by users via the EGNOS geostationary satellites.





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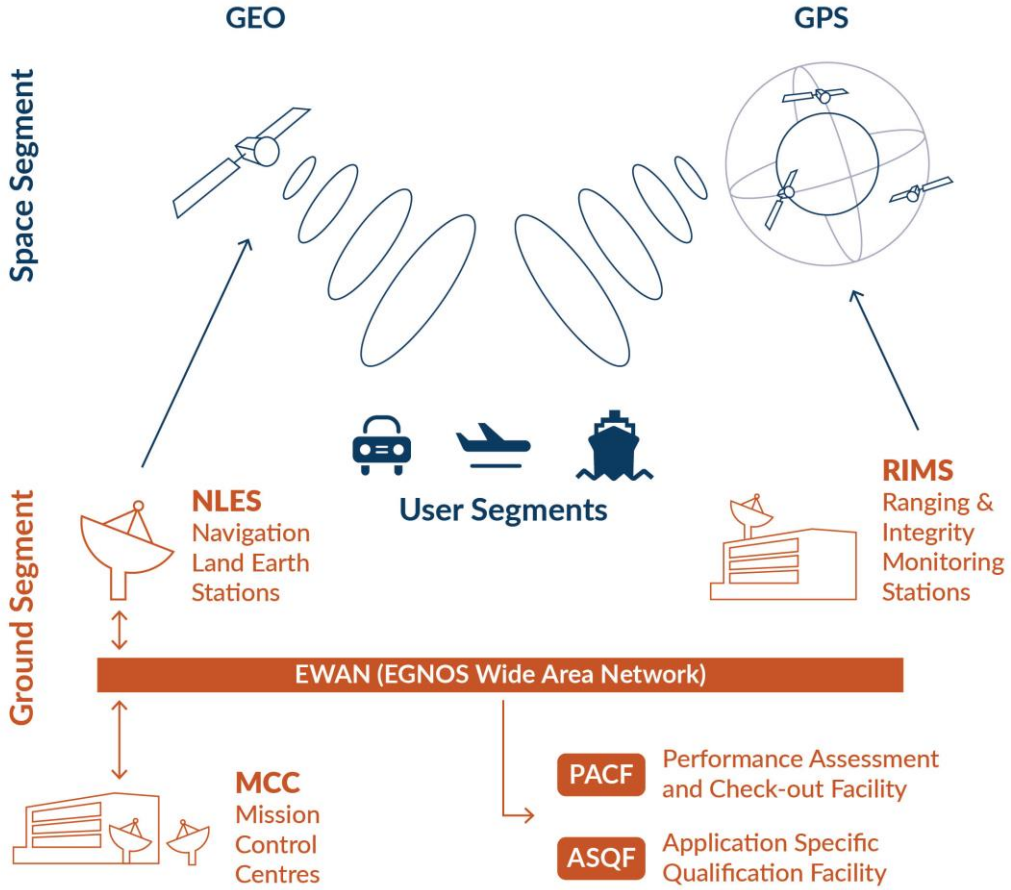
SYSTEM ARCHITECTURE



SPACE SEGMENT

- EGNOS data transmission primarily relies on three telecommunication **geostationary satellites** centred over Europe:
  - PRN 120 **Test Mode**
    Inmarsat-3F2 AOR-E
    (Atlantic Ocean Region East)
    stationed at 15.5° W.
  - PRN 123 **Safety of Life Mode**
    Astra 5B
    stationed at 31.5° E.
  - PRN 136 **Safety of Life Mode**
    Astra SES-5
    stationed at 5.0°E.

- High level of redundancy over the whole service area in the event of a failure in the geostationary satellite link.
- Any time, EGNOS operations ensure at least two GEOs broadcast an operational signal.

- Real time information about status:
  https://egnos-user-support.essp-sas.eu/new_egnos_ops/egnos_system_realtime

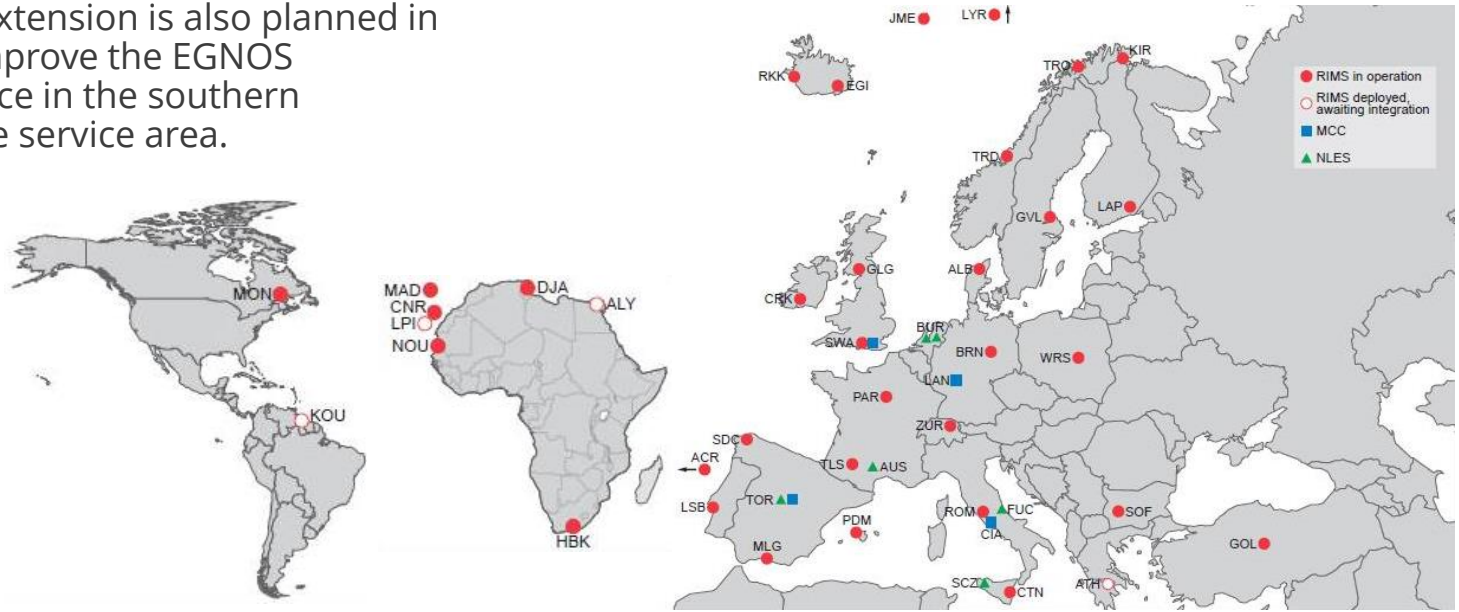
EGNOS GROUND SEGMENT

The EGNOS Ground Segment consists of:

- 40 **Ranging Integrity Monitoring Stations** (RIMS) (extensions foreseen)
- 2 **Mission Control Centres** (MCC): these receive the information from the RIMS and generate correction messages to improve satellite signal accuracy and information messages on the status of the satellites (integrity). The MCC act as the EGNOS system's 'brain'.
- 6 **Navigation Land Earth Stations** (NLES) (2 for each GEO)
- The **EGNOS Wide Area Network** (EWAN) which provides the communication network for all the components of the ground segment.
- 2 additional facilities are also deployed as part of the ground segment to support system operations and service provision:
  - the **Performance Assessment and Checkout Facility** (PACF) - performance analysis, troubleshooting, and operational procedures as well upgrading specifications and validations and providing maintenance support.
  - the **Application Specific Qualification Facility** (ASQF) - provides civil aviation and aeronautical certification authorities with the tools to qualify, validate and certify the different EGNOS applications.

RIMS

- The main function of the **40 RIMS** is to collect measurements from GNSS satellites and to transmit these raw data (GPS L1 and L2 + GEO/GLO L1) every second to the **Central Processing Facilities** (CPF) of each MCC.
- Additional RIMS in La Palma, (Spain), Athens (Greece) and Alexandria (Egypt) have been deployed.
- A further extension is also planned in order to improve the EGNOS performance in the southern parts of the service area.



RIMS SITES

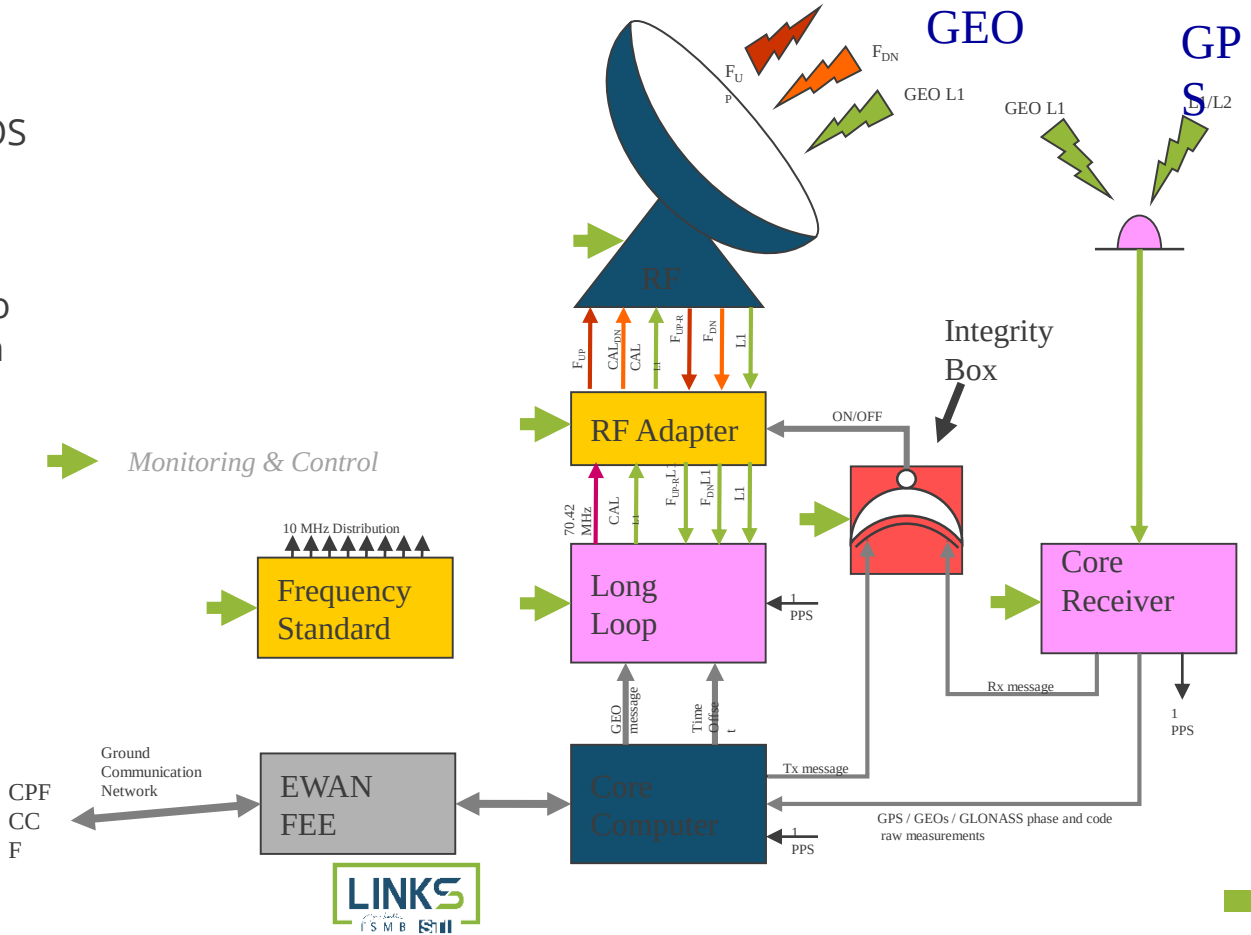
- Each RIMS site is surveyed w.r.t.:
  - Electromagnetic Interference
  - Multipath environment

Reykjavik

Trondheim

NLES BLOCK DIAGRAM

2 Navigation Land Earth Services per GEO satellite: the NLES transmit the EGNOS message received from the Central Procesing Facility to the GEO satellites for broadcasting to users and to ensure synchronisation with the GPS signal.



USER SEGMENT - EGNOS ADOPTION

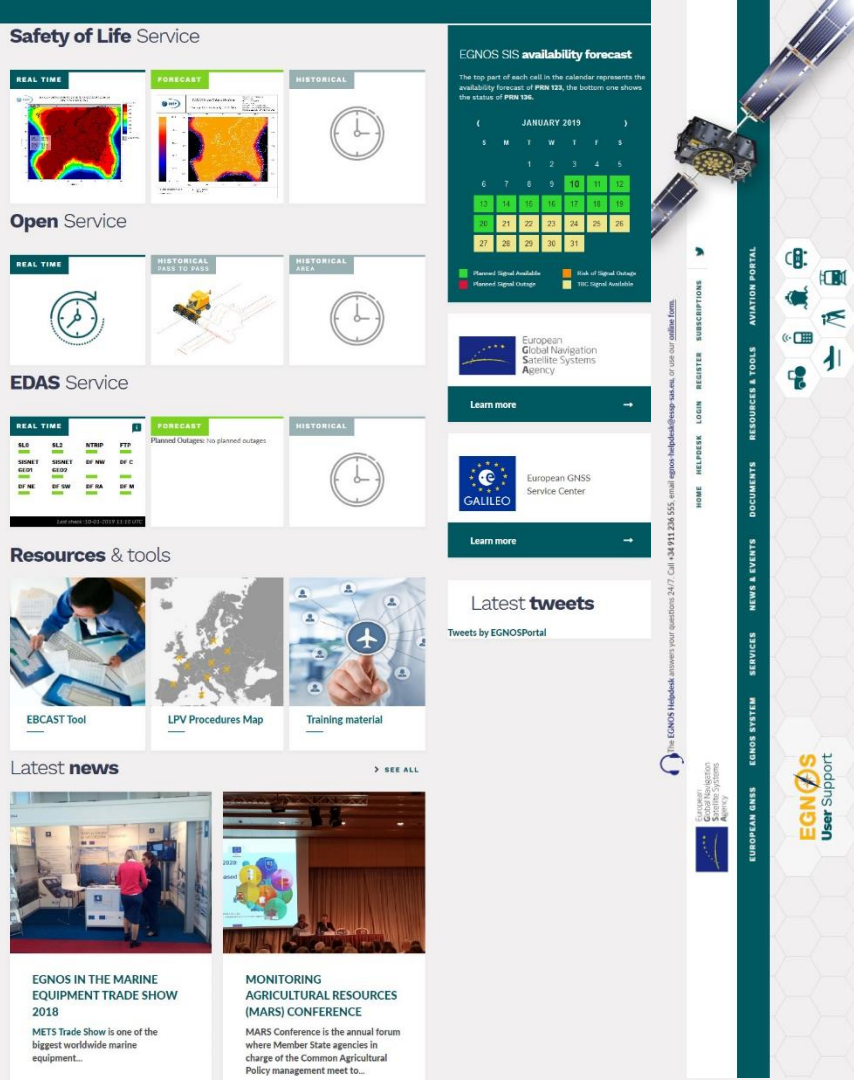
- 301 airports with EGNOS landing procedures
- 557 EGNOS approaches

- ~60% EU tolled roads take advantage of Galileo/EGNOS
- First cars in the market with eCall using Galileo/EGNOS (Volvo and Honda)
- Main car makers are testing Galileo in view of the first highly autonomous cars

- IMO recognised Galileo for merchant shipping
- 10% Galileo OS penetration in receiver models
- 80% EGNOS OS penetration in receivers models

- Around 80% of tractors in Europe using GNSS are equipped with EGNOS
- 55% of all new 'GNSS tractors' in the EU are Galileo enabled

- Over 50% of surveying and mapping receivers are Galileo-capable
- Around 80% of mapping and GIS receivers are EGNOS compatible
- The main PPP providers support Galileo corrections (Fugro, Veripos, NovAtel and Trimble)



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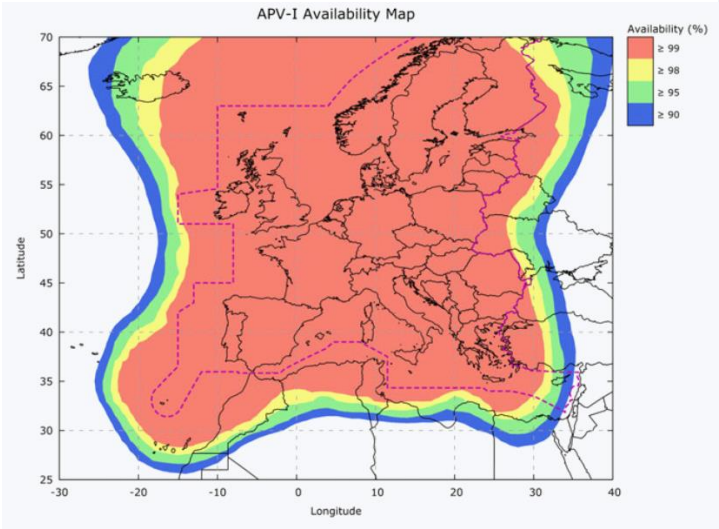
EGNOS PERFORMANCE

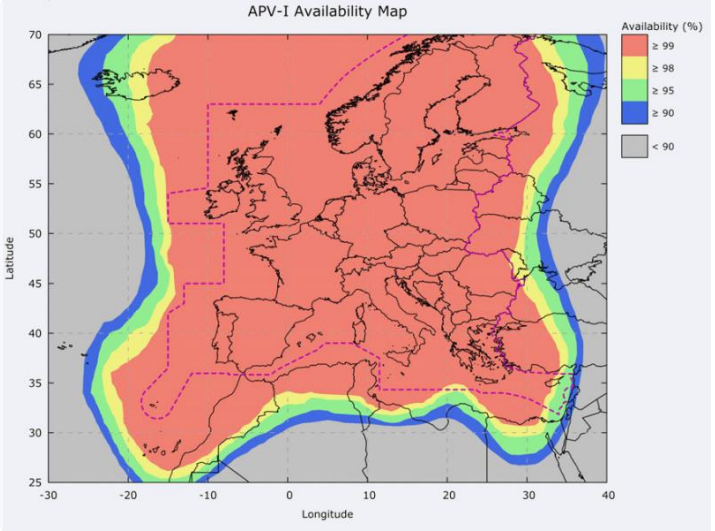
Publication

Issue 3.2

- SoL APV-1 SDD Availability

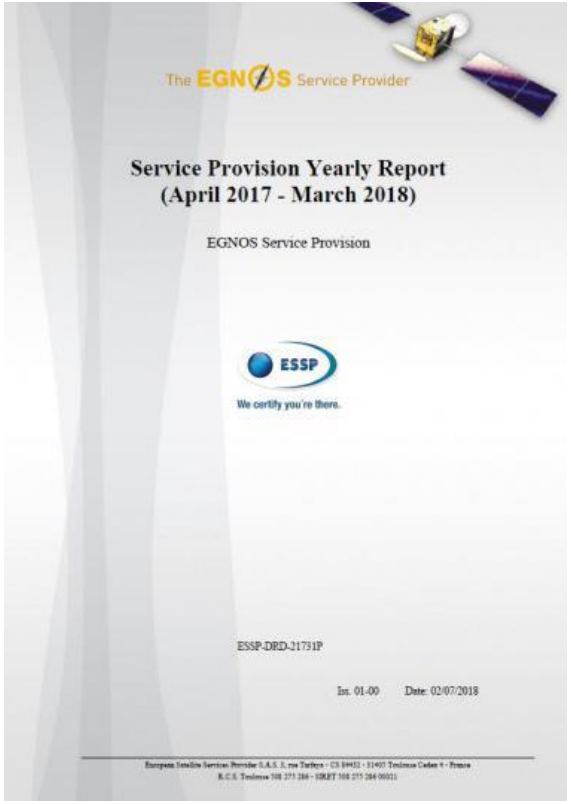


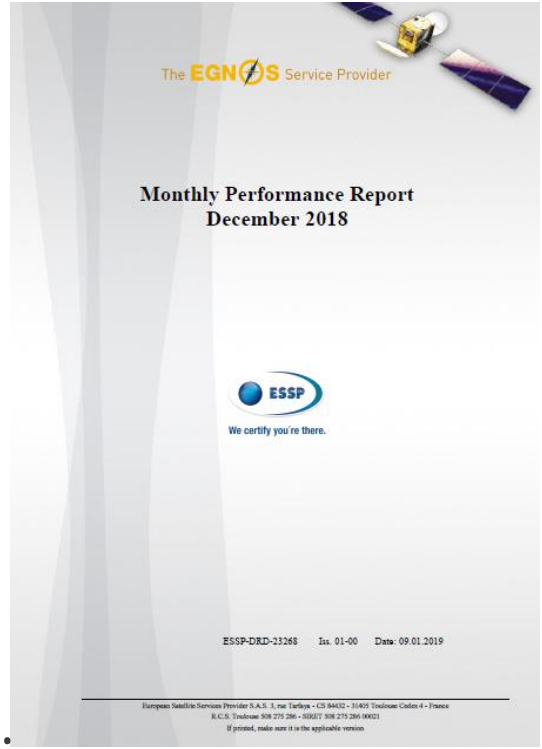
Current SDD



New SDD

EGNOS PERFORMANCE





EGNOS Portal:
www.egnos-portal.gsa.europa.eu

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