Galileo Masterclass Brazil 2022
External 5
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EGNOS overview

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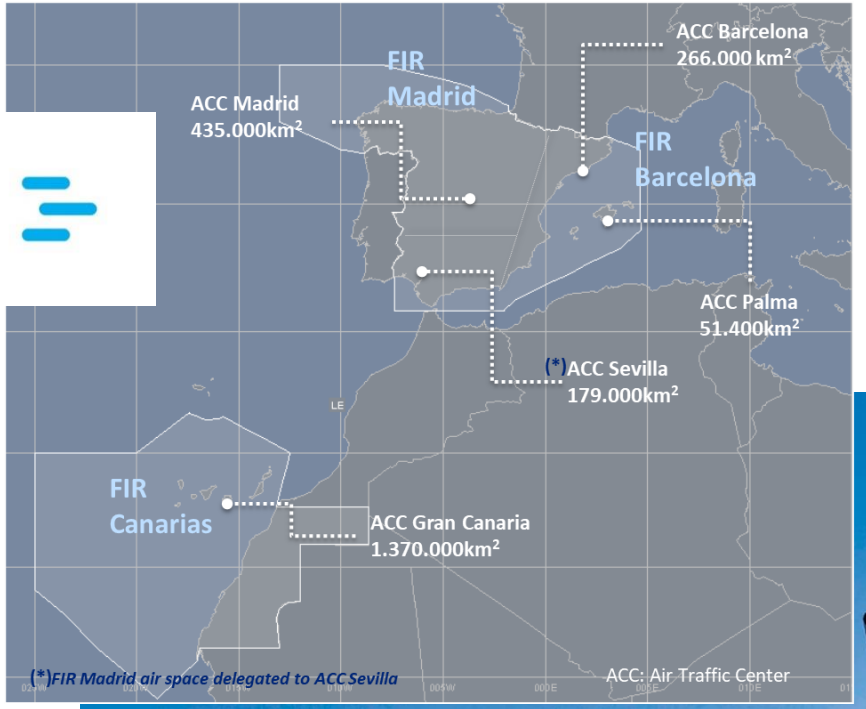

Spanish **public company** depending on Ministry of Transport, … (MITMA).

Leading **air navigation** and aeronautical information **service provider** in Spain, one of the largest in Europe.

Provides en-route, approach and aerodrome **ATC** services, as well as **flight information, alerts and consulting services**.

Provides communications, navigation and surveillance (**CNS**) **services** across the whole of the Spanish airspace.

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Pioneer in the **use of satellite navigation** (ABAS, SBAS, GBAS), supported on its extensive experience in conventional navigation service provision.

Participates in many **international working groups** addressing technical and operational GNSS matters (standardization, robustness, evolutions, use…).

Implements **PBN** (Performance-Based Navigation).

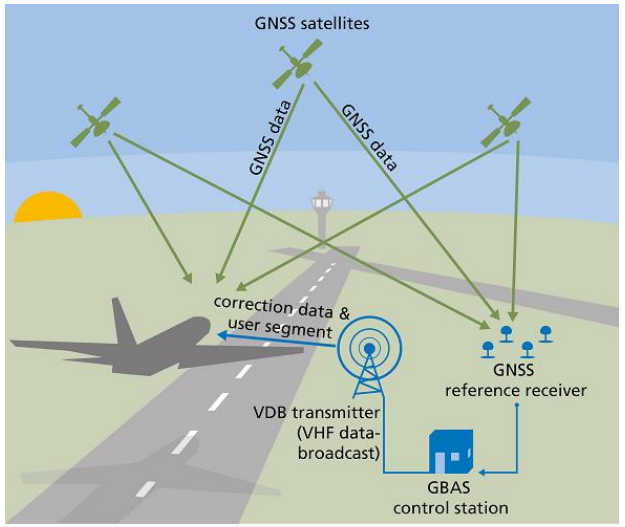
Monitors GNSS **performance** and detects/localizes GNSS **interference** sources with a network of stations (RECNET & DYLEMA). Makes available **space weather** information.

Provides **GBAS** (Ground-Based Augmentation System) navigation **service** enabling precision approaches.

Hosts and operates 1 of the **EGNOS control centers** and 5 of its **monitoring stations** (RIMS).

DYLEMA monitoring station

GBAS system
(source www.dlr.de)



GBAS elements at Malaga Costa del Sol airport

EGNOS overview

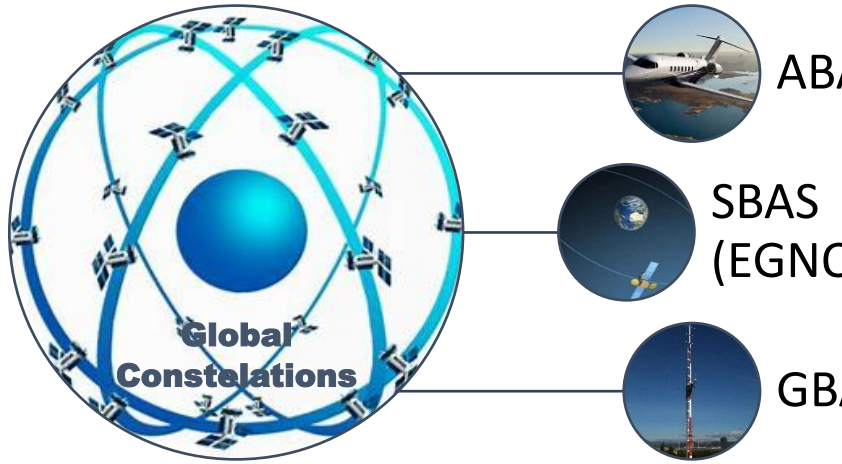
EGNOS (European Geostationary Navigation Overlay Service) is the **European SBAS** (Satellite Based Augmentation System) system providing **positioning and timing services**.

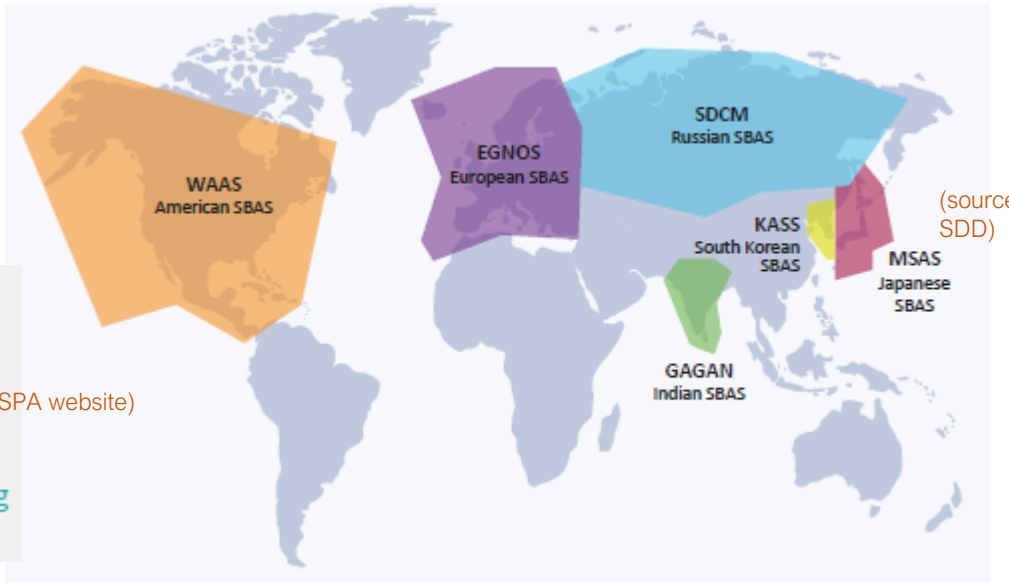
3 core services:

- **Open service** (OS): improves positioning **accuracy** (within 1-2 meters 99%)
- **Safety of Life Service** (SoL): for safety-critical transport applications, which require enhanced and guaranteed performance and an **integrity** warning system
- EGNOS **Data Access Service** (EDAS): EGNOS data transmitted via satellite is accessible through **Internet**

User communities:

(source: EUSPA website)





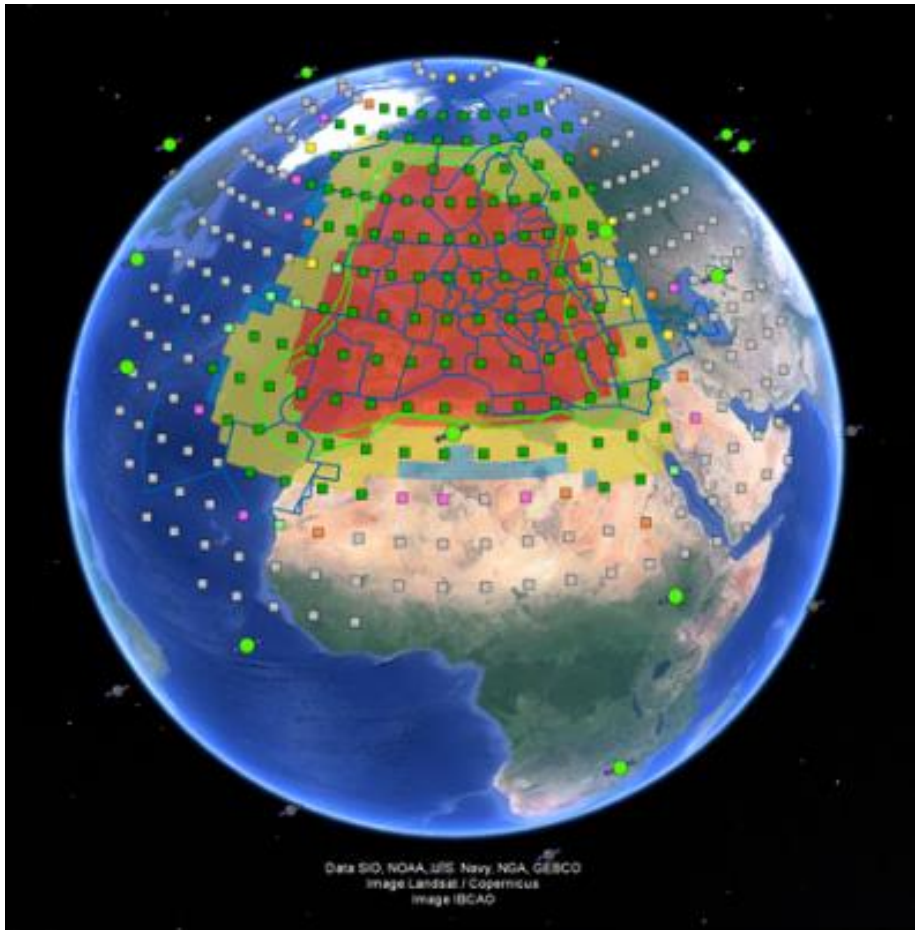
(source: EGNOS SoL SDD)

EGNOS overview

EGNOS SoL service available from March 2nd, **2011**.

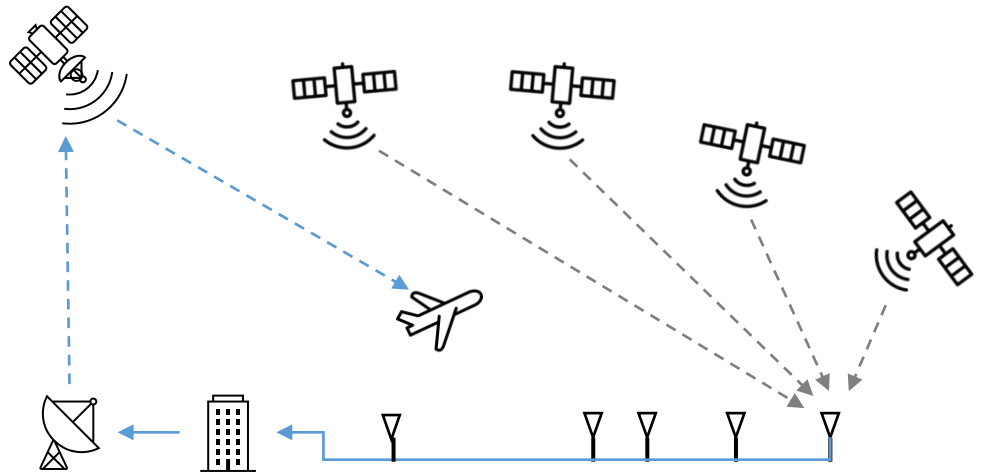
Enhances GPS Standard Positioning Service (SPS) provided on **GPS L1 C/A** signals providing:

- GPS **satellites health status** (for the user to exclude faulty satellites)
- **Ephemeris and clock corrections** for each GPS satellite, and **ionospheric corrections** in a geographical grid of points
- **Bounds** to compute the residual errors associated to these error sources after applying these corrections



(source: essp-sas.eu webpage)

EGNOS overview



Augmentation data timely broadcasted from geostationary satellites (GEOs) in an GPS L1 alike signal.

Architecture:

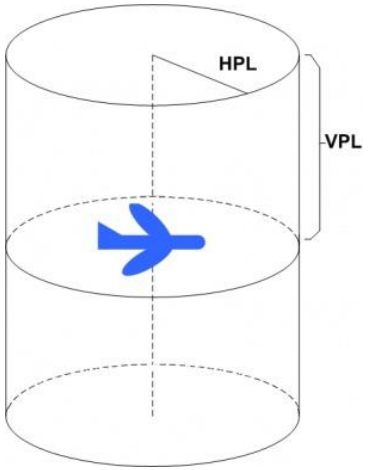
- a network of ground **monitoring stations** (RIMS) to collect data for monitoring satellites and ionosphere
- 2 **mission control centers** (MCC) computes corrections and integrity information
- 2 or more **GEO**s to broadcast this information

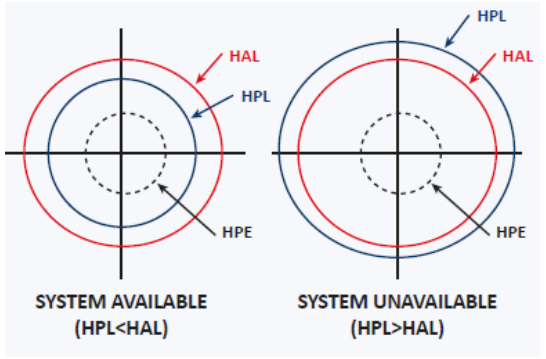
RIMS
(source: EGNOS SoL SDD)

EGNOS overview

SBAS **user equipment**:

- Tracks and process the GPS L1 C/A and EGNOS GEO signals and their messages
- Timely computes:
  - **Position and time with improved accuracy** (OS & SoL services)
  - plus associated Horizontal and Vertical Protection Levels (**HPL & VPL**) (SoL service)
    - Considering all the error sources for the range measurement and position computation (noise, multipath, tropo, iono, satellites geometry, etc.)



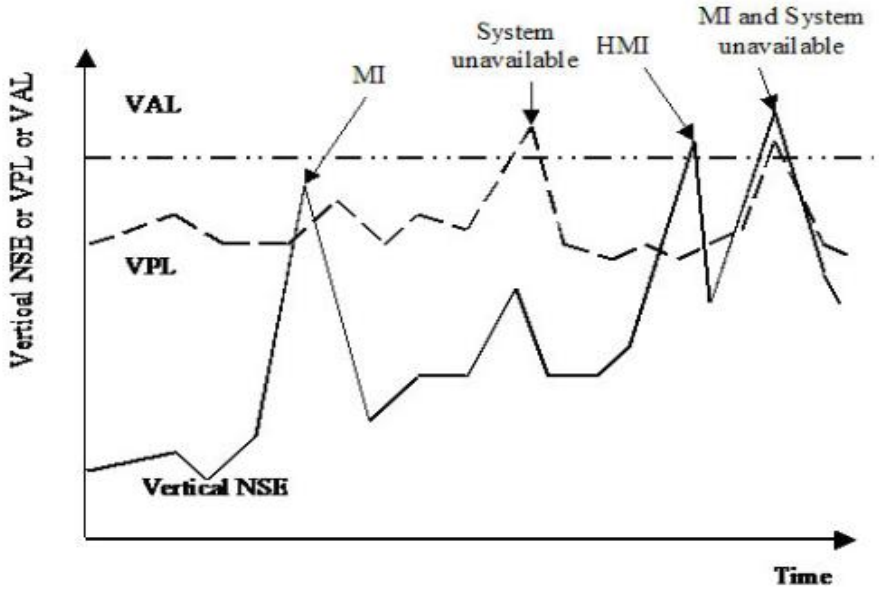


(source: EGNOS SoL SDD)

PLs provide **bounds** of the potential position error with the required **confidence level** for the supported SoL application.

Each **SoL application** has associated **Alert Limits** (HAL and VAL), position error tolerances not to be exceeded without issuing an alert.

- **When PLs exceed ALs** an alert is issued, and the application is not supported (system unavailable)

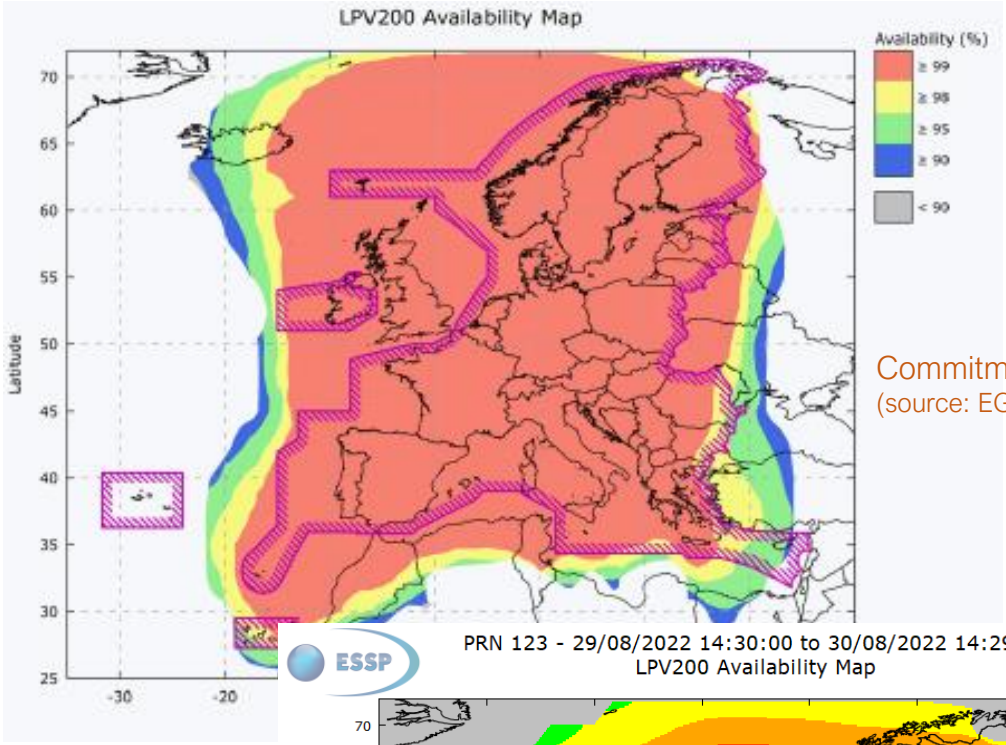


EGNOS overview

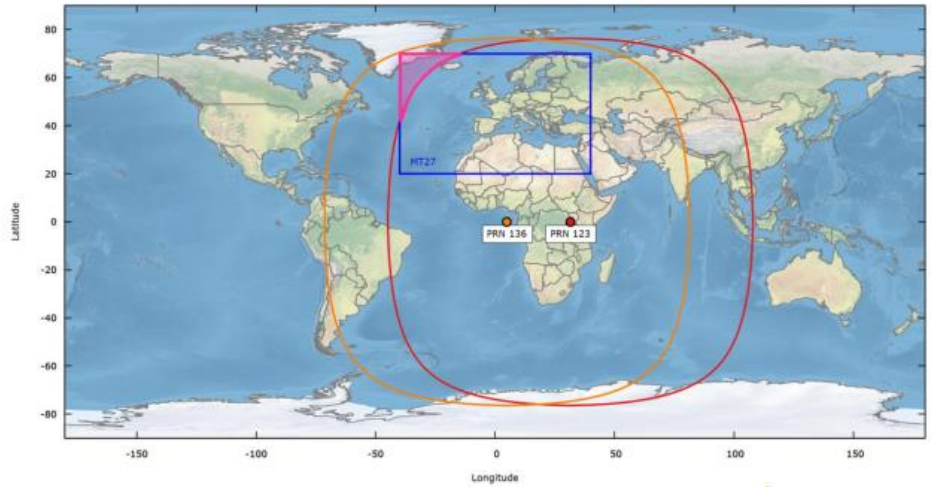
EGNOS **Signal** In Space format is compliant with the **ICAO SARPs** for SBAS.

EGNOS **areas** when using compliant equipment in fault-free conditions:

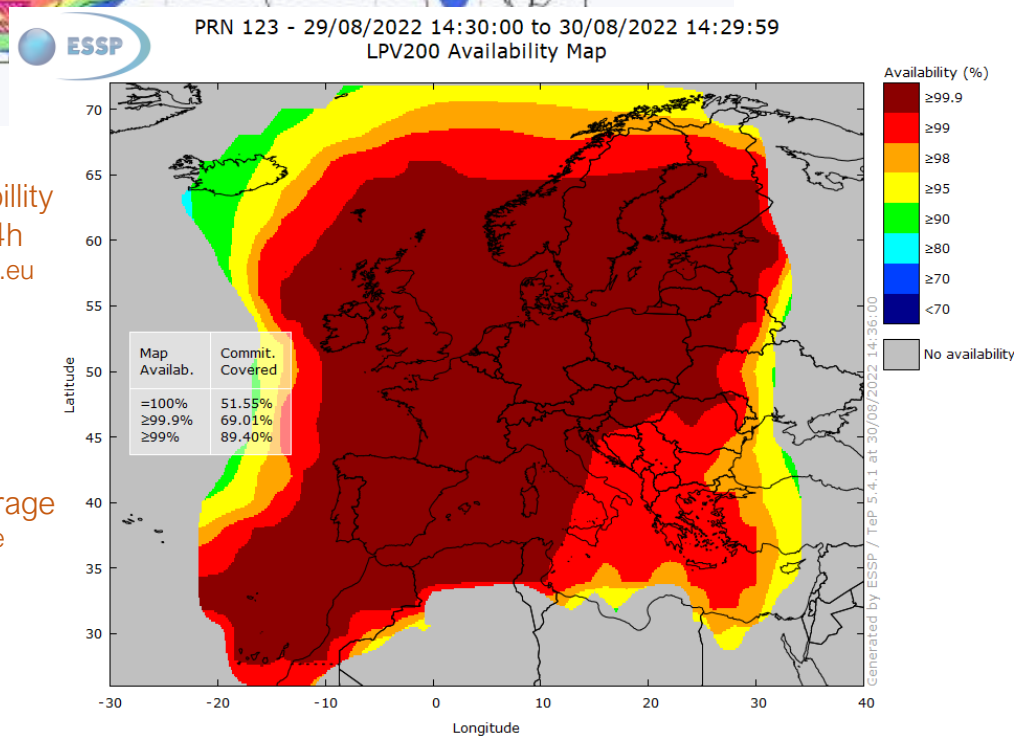
- GEO satellite **coverage** area
- Service **commitment** area: minimum availability performance that can be expected from EGNOS for a service
- Service **real time** performance maps



Commitment area
(source: EGNOS SoL SDD)



EGNOS GEOs coverage
(source: EGNOS Service Notice #22)



Current availabillity over the last 24h
(source: essp-sas.eu webpage)

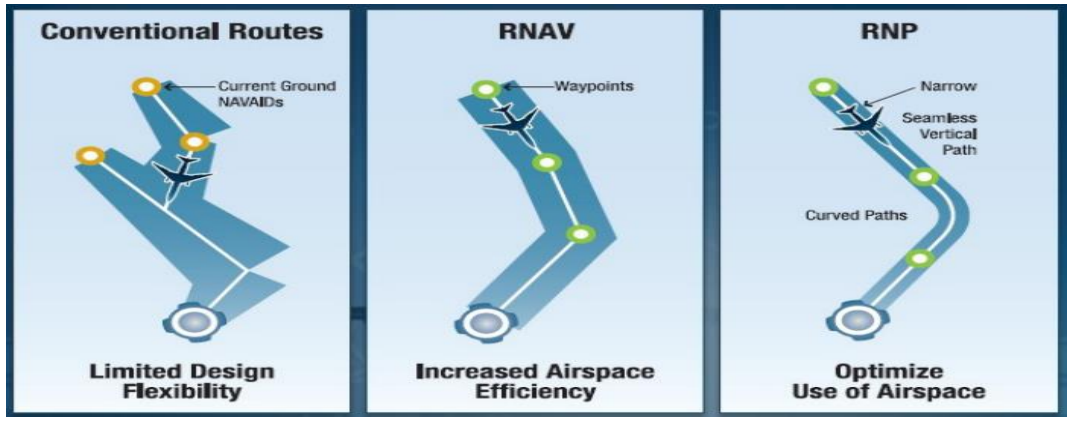
EGNOS interest for aviation

EGNOS was **designed for aviation**. Its **terrestrial reference frame** is almost equivalent to the one adopted by the civil aviation community. It is already **certified** for civil aviation in Europe.

PBN is a global aviation community priority.

- Allows to define **any desired flight path** (area navigation), key method of navigation enabling improved air navigation concepts.
- Allows using **different systems for a same operation** as far as complying with needed performances (accuracy, integrity, continuity, availability, and functionalities).
- Extends **from en-route** navigation down **to** CAT I **precision approach** (LPV-200).

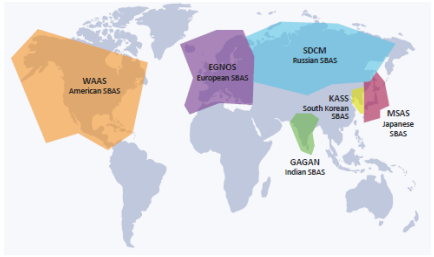
EGNOS supports PBN in **all phases of flight** whereas inside the required service area (**NPA, APV-I, LPV-200**).



USER OPERATION	EGNOS SoL Service Levels									
	NPA								APV-I	LPV-200
Performance Requirements Annex 10 - Vol I - Chapter 3 Table 3.7.2.4-1:	PBN Navigation Specification									
	RNAV 10 **	RNAV 5*	RNAV 2*	RNAV 1*	RNP 4 **	RNP 2*	RNP 1*	RNP 0.3	RNP APCH* 3D, Type A***	RNP APCH* 3D, Type B***

EGNOS interest for aviation

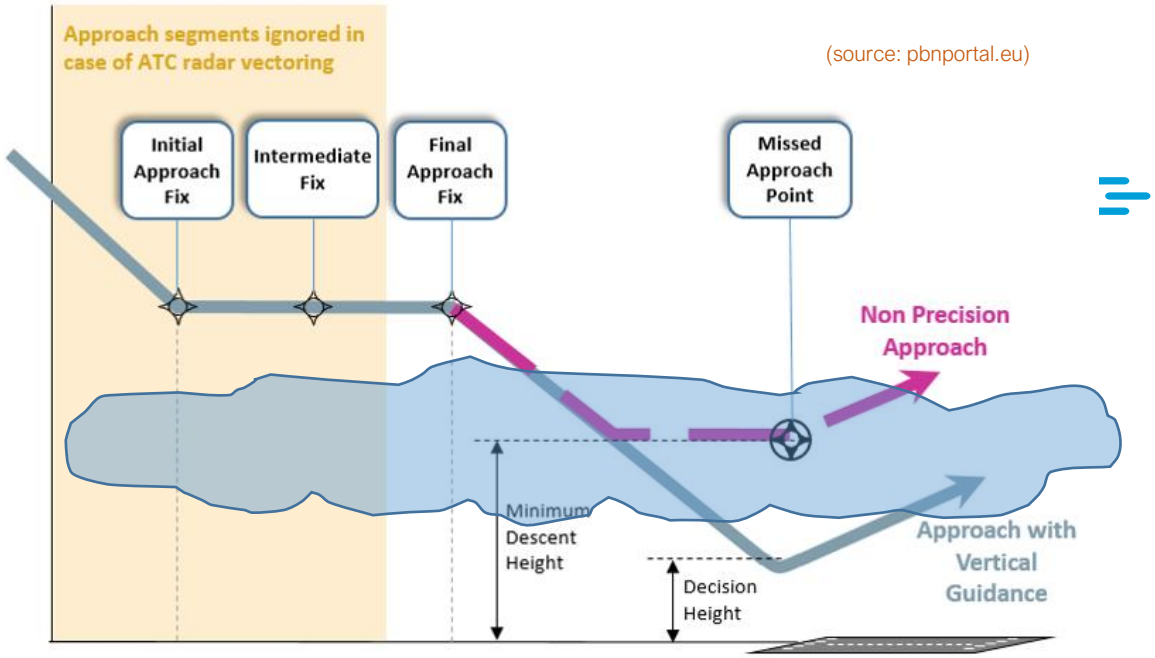
Regional service area (minimum infrastructure and high coverage), **standardized** (other SBAS services).

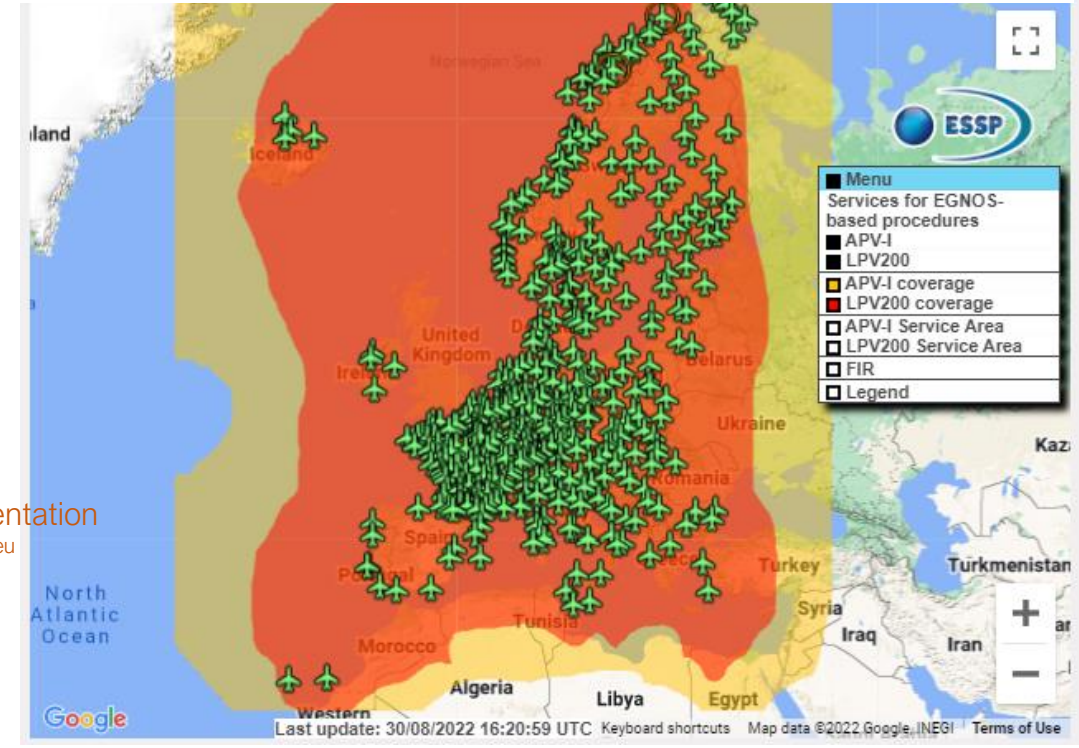


High performance, including **approaches with vertical guidance (3D) down to CAT-I minima** (inside LPV-200 service area) **without the need of costly ground infrastructure at all landing sites**:

- Supports implementation of vertical guidance approaches in all landing sites:
  - **Enhances safety** due to vertical guidance
  - **Increases accessibility** due to lower minima; **reduction of flights cancelled**, delayed or diverted due to bad weather conditions
  - ILS **backup**

(source: pbnportal.eu)





LPV implementation
(source: essp-sas.eu webpage)

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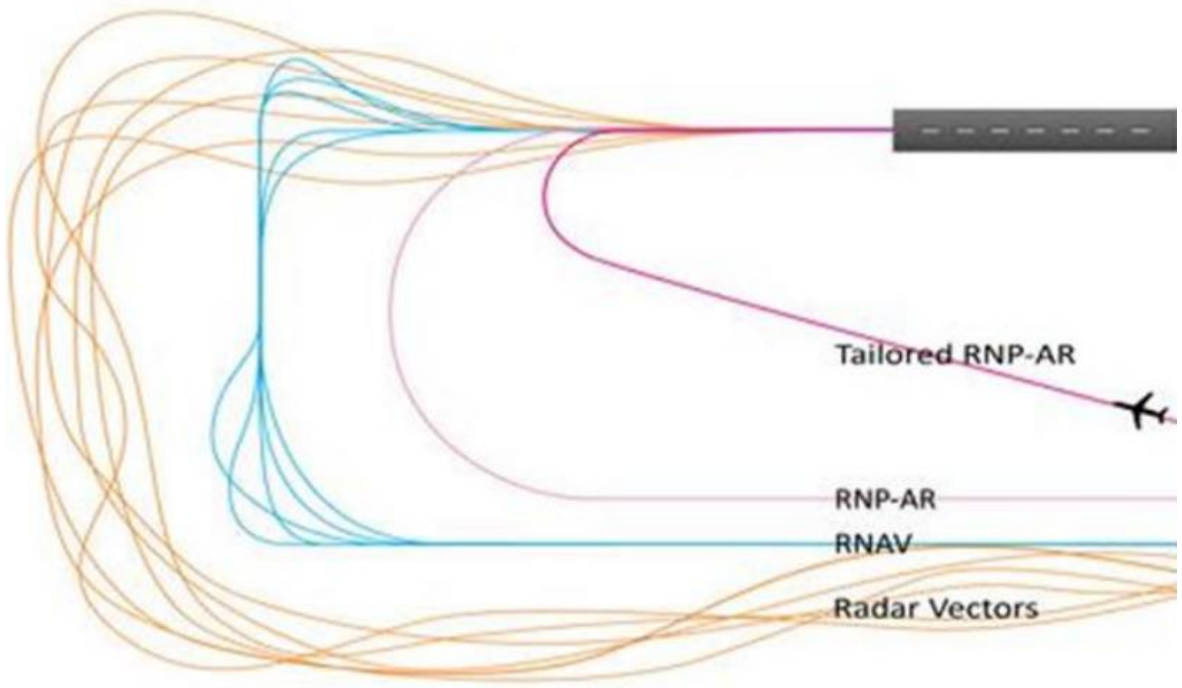
EGNOS interest for aviation

- Supports the implementing **improved air navigation concepts**: free route, optimized low-level routes for rotorcraft, curved & advanced approaches, …
  - Enables improving **efficiency** of flight operations (lower fuel consumption), **reduction of emissions** (CO_2), reduction of **noise** over populated areas, etc.

Radio navigation aids **rationalization** (enabling VOR, NDB, ILS Cat I removal/back-up).

High performance position **source for ADS-B Out** (surveillance system using aircraft transmitted own position).



(source: EASA presentation)

EGNOS use in aviation

EGNOS system and **services** (over the service areas: NPA, APV-I, LPV200) must* **comply with aviation standards** (ICAO SARPs).
* exists waiver for continuity

EGNOS **service provider** (ESSP) must be **certified** by aviation authorities.

Air Navigation service providers implementing EGNOS based procedures must sign an EGNOS **Working Agreement** (EWA) with the ESSP:

- **SoL SDD** (service definition) https://egnos-user-support.essp-sas.eu/new_egnos_ops/documents/egnos-sdd/egnos-safety-life-service-sdd
- **NOTAM** proposals (un-availabilities notices to aviation users)
- **Service notices** (others)

ANSPs are normally requested to do also a **safety assessment** for each specific implementation.

Users use **certified equipment**.
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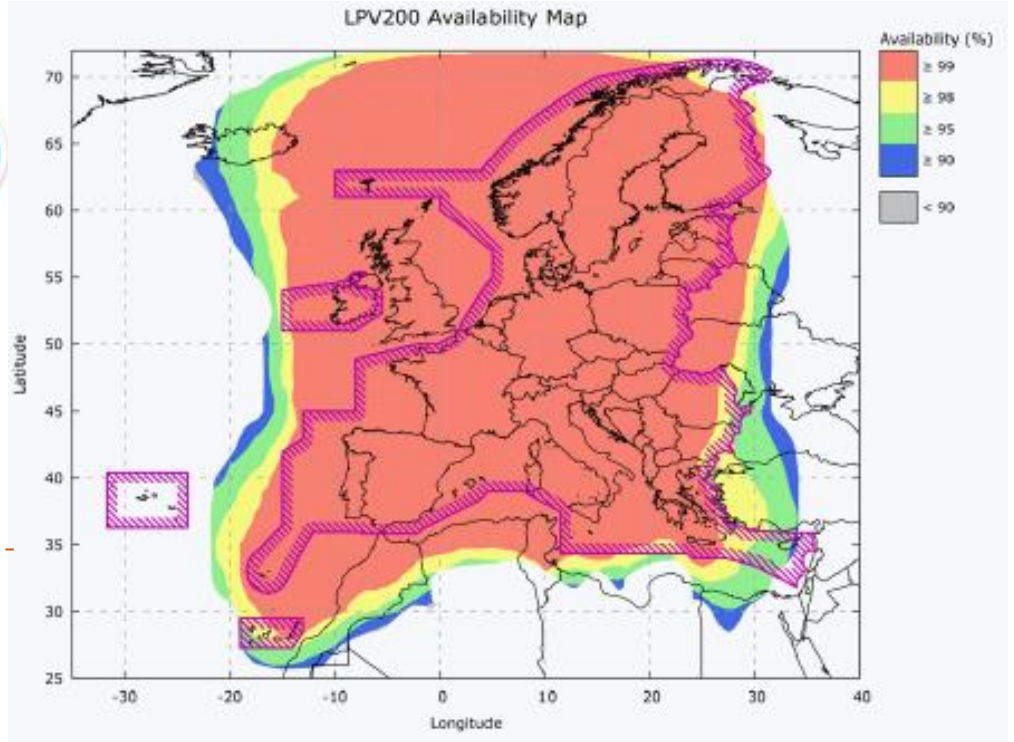


EGNOS SoL SDD - Commitment area

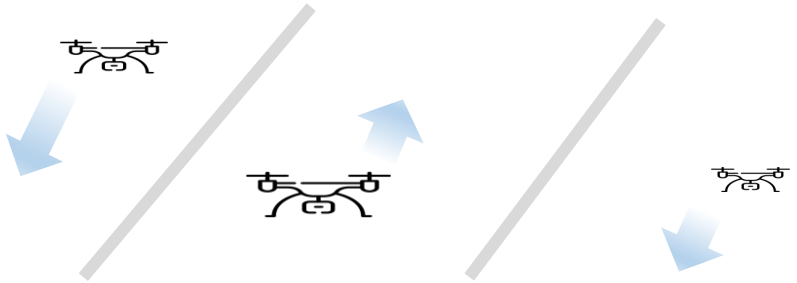
	Accuracy		Integrity				Continuity	Availability
Typical operation	Horizontal Accuracy 95%	Vertical Accuracy 95%	Integrity	Time-To-Alert (TTA)	Horizontal Alert Limit (HAL)	Vertical Alert Limit (VAL)		
Category I precision approach	16.0 m (52 ft)	6.0 m to 4.0 m (20 ft to 13 ft)	$1 - 2 \times 10^{-7}$ in any approach	6 s	40 m (130 ft)	35.0 m to 10.0 m (115 ft to 33ft)	$1 - 8 \times 10^{-6}$ per 15 s	0.99 to 0.99999

SARPs Signal-in-space performance requirements – CAT I

EGNOS use in aviation

Future:

- 4D navigation (precise trajectory and timing).
- Potential (TBC) for supporting **more demanding operations** like Autoland and CAT-II (LPV-100)
- Solution for **UAS** for medium or higher SAIL (specific assurance and integrity level) operations demanding high performances:
  - PBN-like concept under development

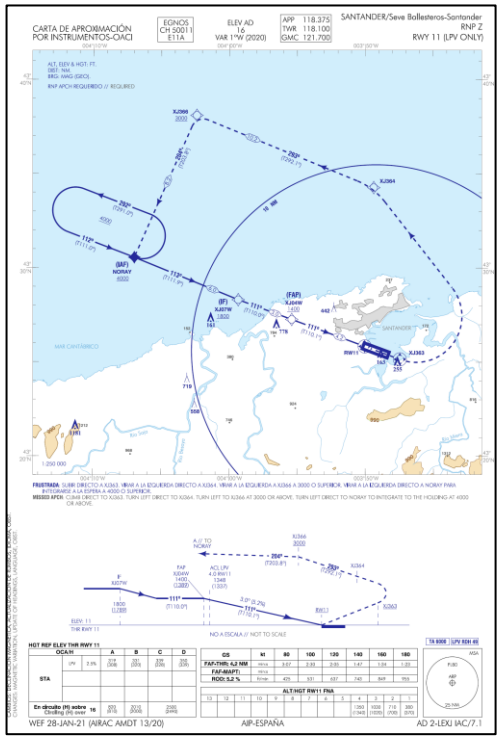


Examples of EGNOS benefits and precautions

Lower approach minima:

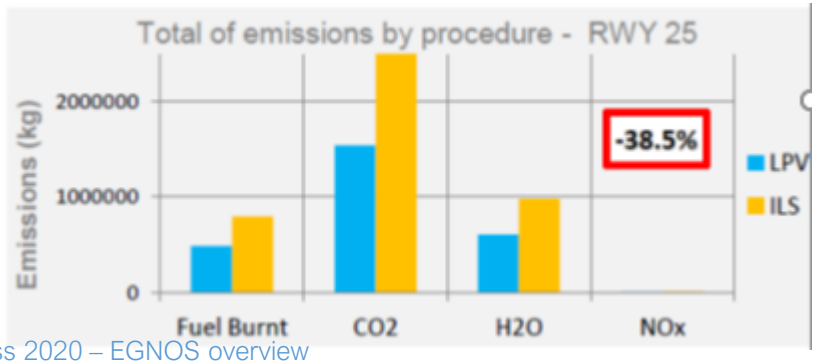
- Santander (LEXJ) RWY 11
  - NDB OCH = 1390 ft [MDH]
  - VOR OCH = 750 ft [MDH]
  - LNAV (GPS) OCH = 680 ft [MDH]
  - LNAV/VNAV (GPS) OCH = 680 ft [DH]
  - LPV (**EGNOS**) OCH = **328** ft [DH] C

https://aip.enaire.es/AIP/#LEXJ



Reduction of environmental impact (noise, fuel burnt):

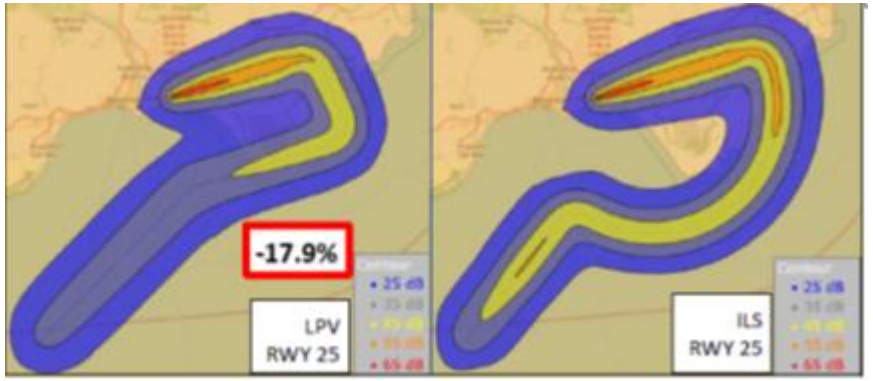
- LEAM (Almeria, Spain)



Noise área

Emissions

(source: EUSPA, ESSP)



Examples of EGNOS benefits and precautions

Where GNSS based aviation operations are approved, there is a **responsibility to ensure the usable GNSS services meet the required performances and warn AUs and ATC when not met** (e.g. via NOTAMs).

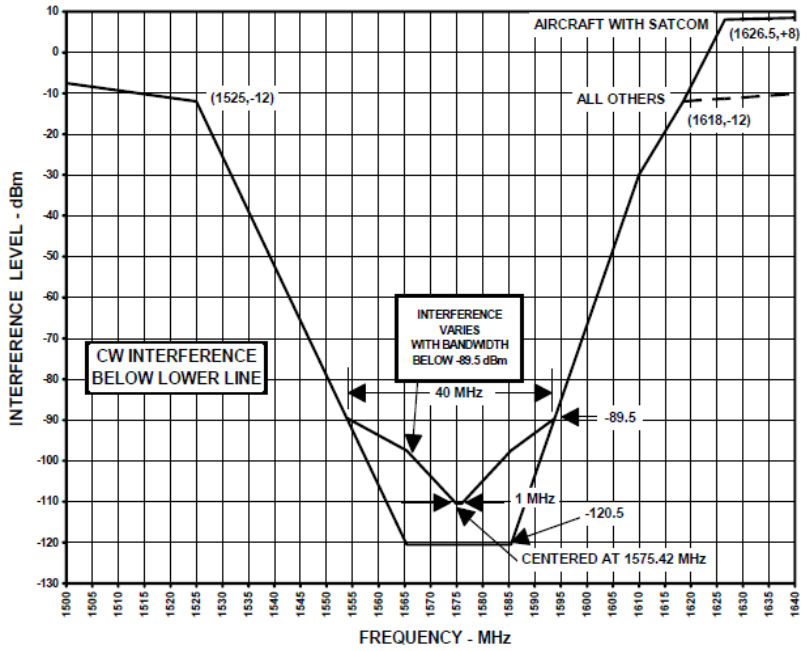
GNSS signals are protected internationally but easily jammed (GNSS signals received with very low power):

- Potential for **service degradation or loss**
- Deployment of **network of stations for monitoring** of GNSS **performance** and detection & localization of GNSS **interference** (RFI)

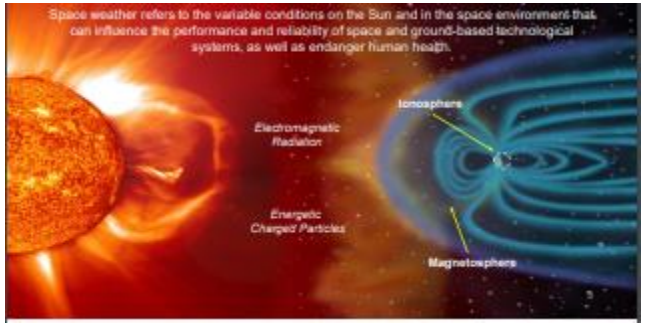
Dependance on GPS core constellation status.

Space weather potential for service degradation and loss (mainly during **solar cycle peaks**):

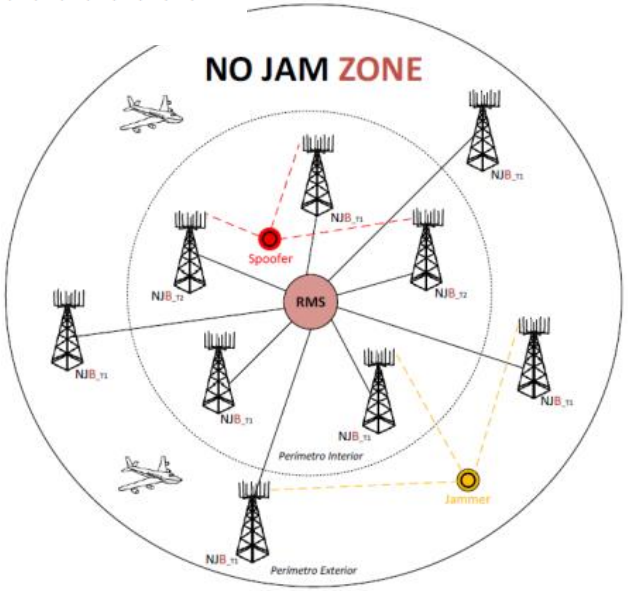
- **ICAO** global space weather **centers** / services, Publish **advisories** (detection and forecasting)



RF interference environment
(source RTCA DO-229 MOPS)



(source: FAA presentation)

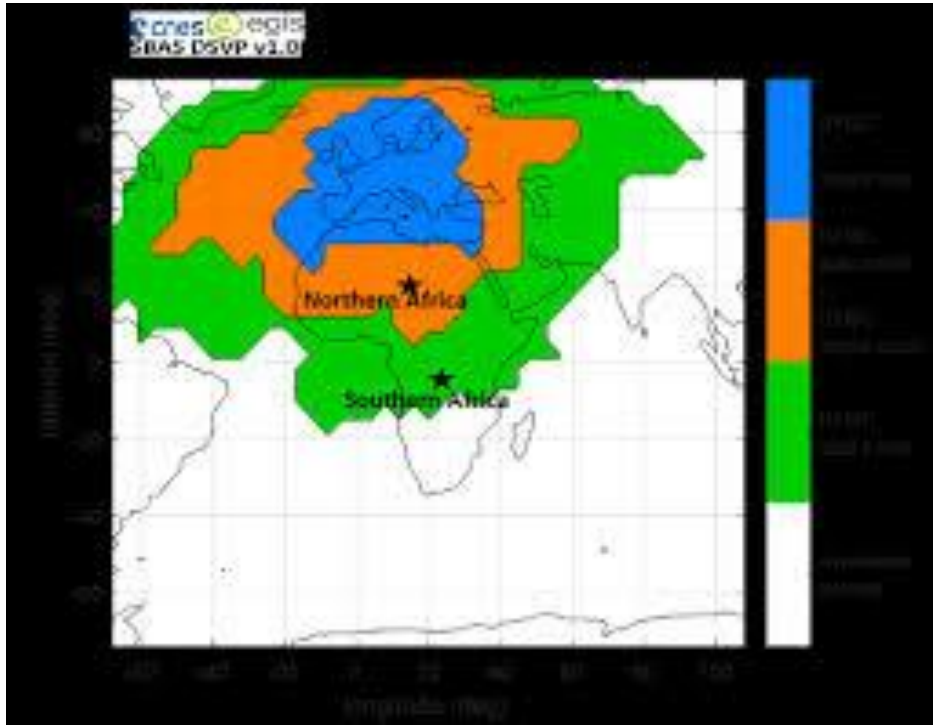


EGNOS evolution

Planned additional **EGNOS DFMC service** (Dual Frequency Multi Constellation, GPS+GAL) (broadcast on new signal, L5):

- **Iono free measurements, additional satellites and constellations**
- **Enhanced performance** (free of ionospheric errors, better satellite geometry)
- **Increased robustness** against
  - Ionospheric scintillation
  - Constellation failure
  - Poor satellite geometry
- **Larger service area** (without the burden to monitor and provide corrections for ionosphere delay)

EGNOS signal **authentication** (protection against **spoofing**).



Potential (TBC) service área increase with EGNOS DFMC
- EGNOS L1 + GPS
- EGNOS DFMC + 1 Core constellation (GAL or GPS)
- EGNOS DFMC + 2 Core constellations (GAL & GPS)

(source: EUSPA, ESSP)

¡Gracias por su atención!

Thanks for your attention!

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