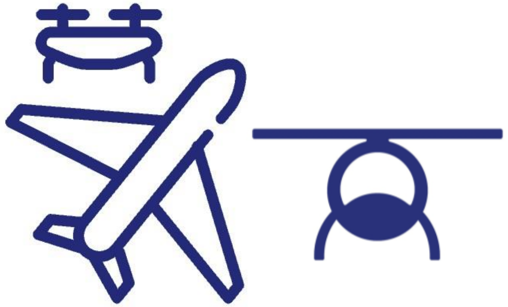
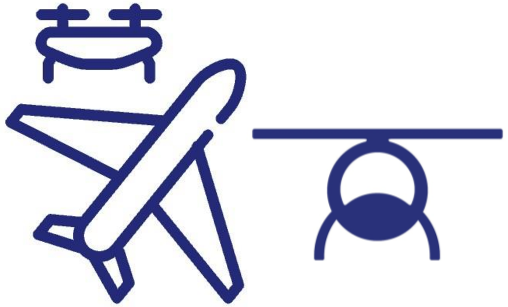


Configure your drone on using Galileo + EGNOS

Online Training

GALILEO EGNOS
NAVIGATION SOLUTIONS
POWERED BY EUROPE



Configure your drone on using EGNOS

SBAS for UAVs

Online Training

GALILEO EGNOS
NAVIGATION SOLUTIONS
POWERED BY EUROPE

What is ESSP

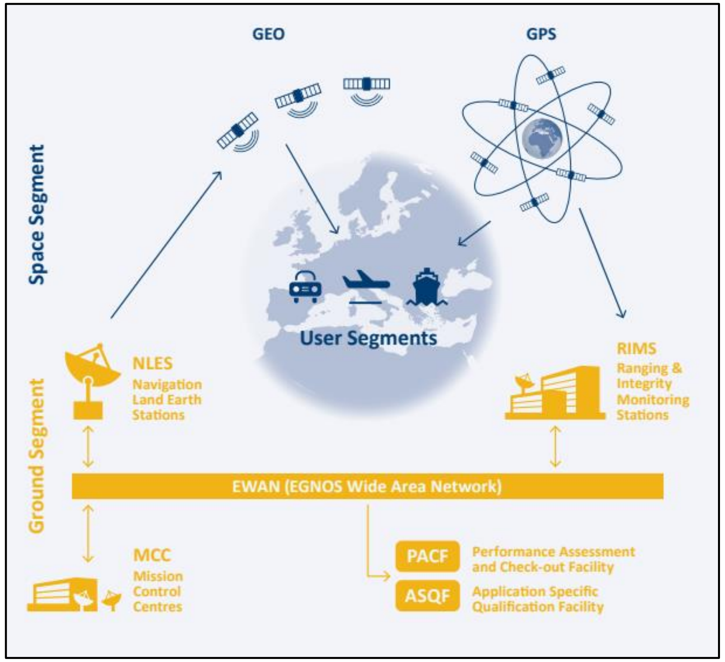

Customer
EUSPA
European Union Agency for the Space Programme
Design Agent
esa
Industry
ThalesAlenia
Space
Safety Authority
EASA
European Aviation Safety Agency
EGNOS Service Provider
ESSP
WE COMMIT TO SAFE
AND CONNECTED WORLDS
Users

What is EGNOS

EGNOS is the European SBAS, improving the performance of Global Navigation Satellite Systems (GNSSs), currently GPS (and Galileo in the future) using the L1 band.

Differential corrections and integrity messages are calculated and broadcast. Users just need compatible GNSS receivers to be able to use it.

Increases accuracy and contributes to the integrity and availability of positioning and navigation information.

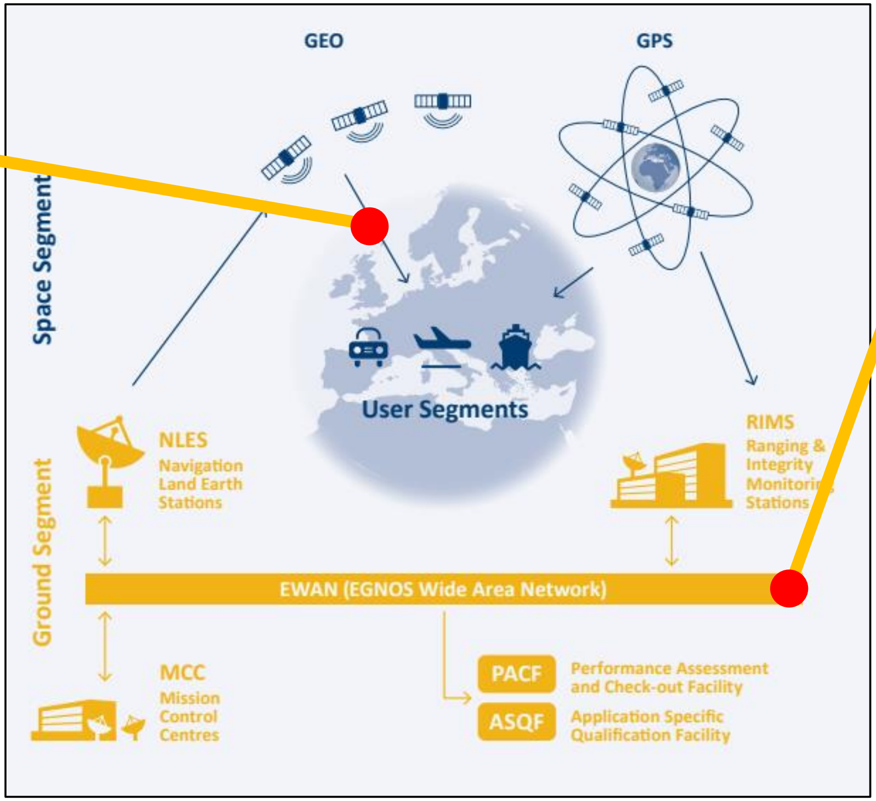


EGNOS system architecture

EGNOS benefits

...as per definition

EGNOS system architecture



EGNOS Signal in Space (SiS)

Open Service (OS)

Safety of Life (SoL)
(integrity)

SiS accuracy (95%)

Horizontal: 3m
Vertical: 4m

EGNOS Data Access Service (EDAS)

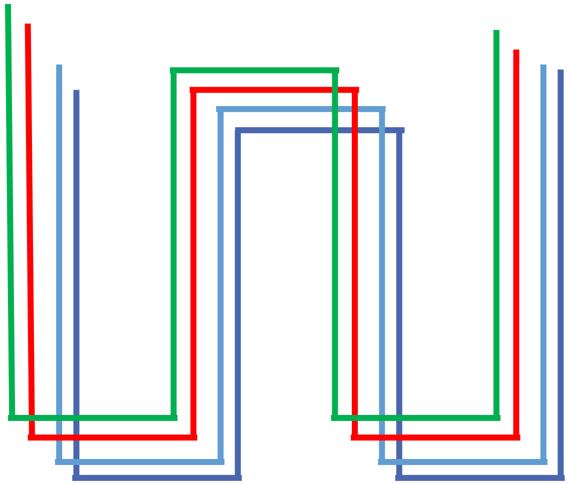
Real Time kinematics (RTK)

RTK accuracy is in the range of centimeters both horizontally and vertically

EGNOS benefits

… in reality

Dynamic "pass-to-pass" flight



EGNOS Signal in Space (SiS)

Total System Error (95th percentile)

	Horizontal	Vertical
GPS (only)	1.53m	2.6m
GPS + EGNOS	0.95m	1.2m

EGNOS Data Access Service (EDAS)

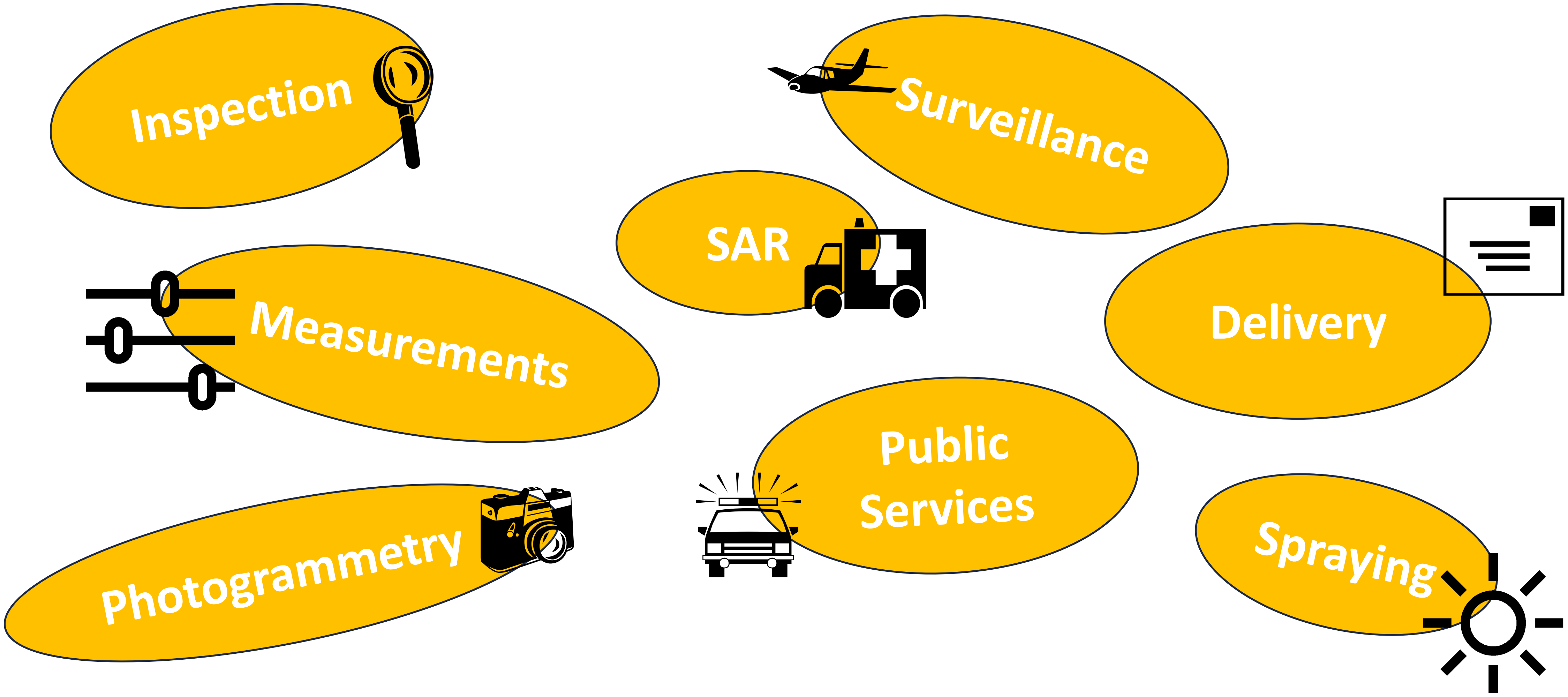
Total System Error (95th percentile)

	Horizontal	Vertical
GPS (only)	3.2m	5.8m
EDAS	0.7m	0.7m

! Test performed during adverse weather conditions (strong wind)

EGNOS benefits

examples



Configuration (EGNOS OS)

Hands-on!

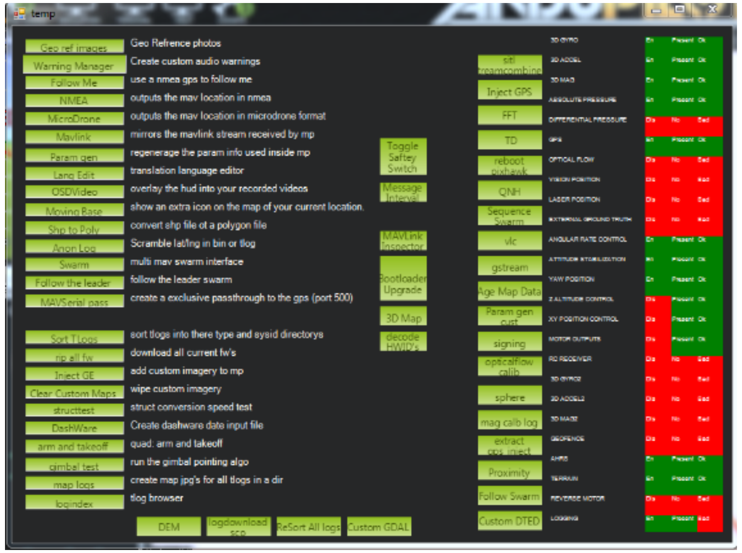
The section marked as “hands-on” is further explained using ESSP’s UAV platform and configuring it in real-time. Access the video here (min 10:19)

In u-blox M8N

Using U-center

1. Make sure the receiver is properly connected to the PC
2. Execute u-center
3. Connect to the receiver

On Mission Planner software, click “CTRL + F” to show the advanced configuration menu:



Click on button “MAVSerial pass”*

A bypass to the receiver will be opened

*Note that Mission Planner will not give any feedback after clicking the button, so please make sure you only click it once.

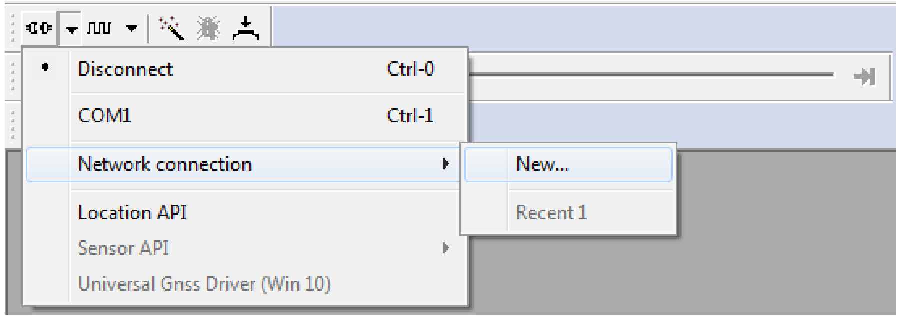
Configuration (EGNOS OS)

Hands-on!

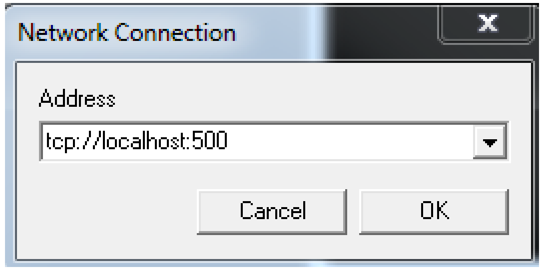
In u-blox M8N

Using U-center

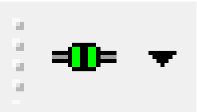
On U-center software, click on “Network connection” → “New”



Write “tcp://localhost:XXX”* and click “ok”



If connected, the icon will turn green



*“XXX” is the port number assigned to communicate to the drone and will depend on the connection.

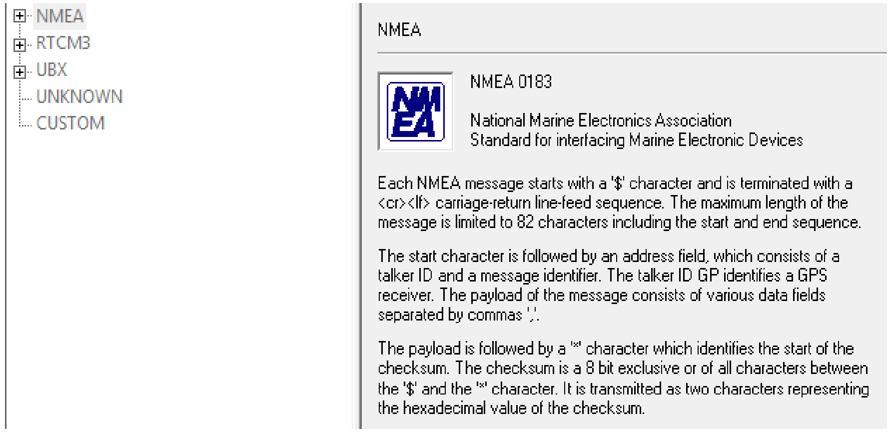
Configuration (EGNOS OS)

Hands-on!

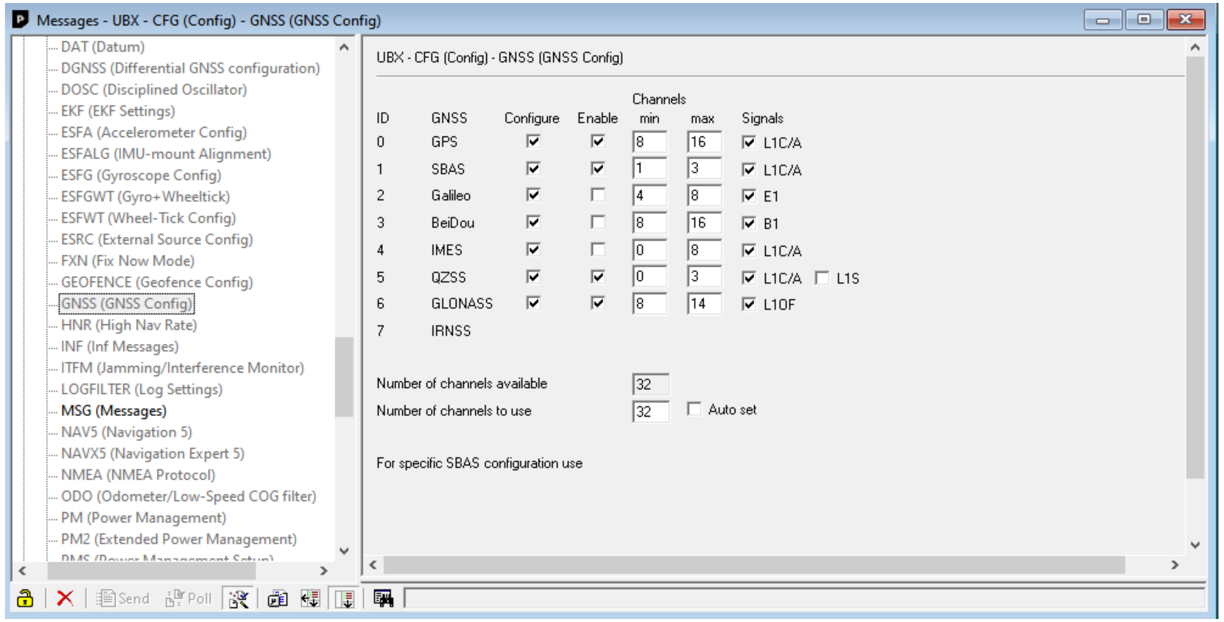
In u-blox M8N

Using U-center

On U-center software, go to menu “view” → “messages view”



Navigate to “UBX” → “CFG (Config)” → “GNSS”



Configuration (EGNOS OS)

Hands-on!

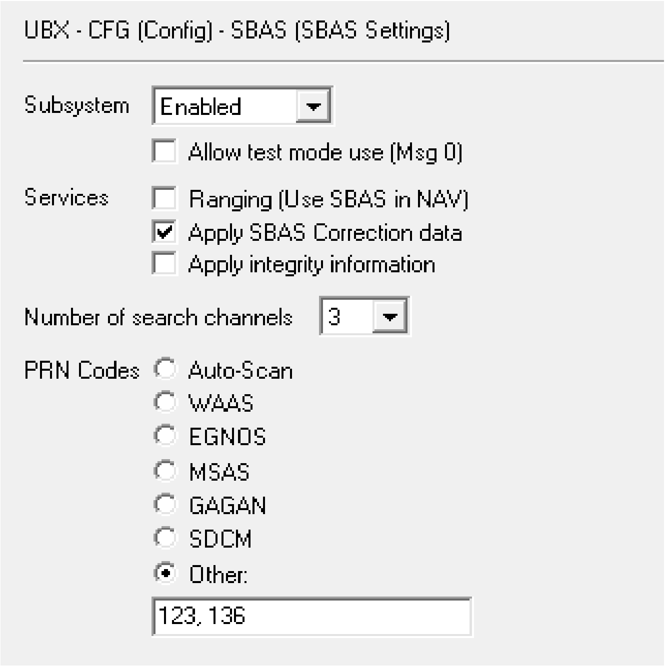
In u-blox M8N

Using U-center

Navigate to “UBX” → “CFG (Config)” → “SBAS (SBAS Settings)” to access the configuration window

On the configuration window set up the following details:

- **Subsystem:**
  Enabled
- **Services:**
  Apply SBAS Correction data
- **PRN Codes:**
  Other; 123, 136*



*Note that these are the active GEO Satellites. The numbers may change depending on the specific configuration at any given moment. You can check the active GEO Satellites on the Home page of [the EGNOS User Support Website.]

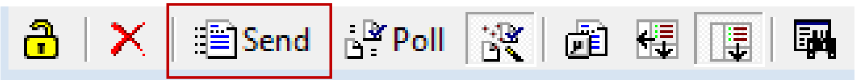
Configuration (EGNOS OS)

Hands-on!

In u-blox M8N

Using U-center

When the details have been filled, write the configuration on the receiver by clicking on the “Send” button on the bottom-left corner of the U-center application



At this point, the receiver is configured and should now be able to receive the EGNOS signal.

Configuration (EGNOS OS)

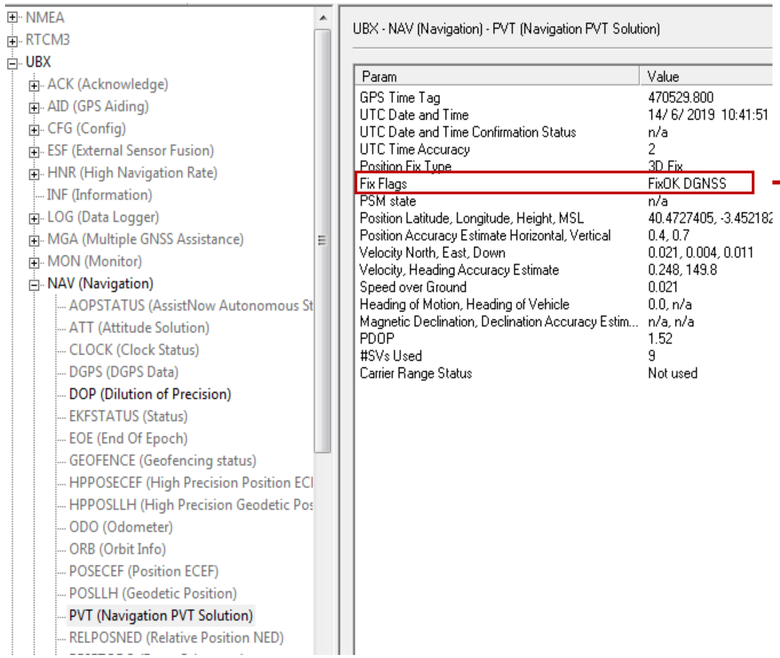
Hands-on!

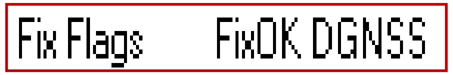
In u-blox M8N

Test SBAS signal reception

<u>Messages reception on u-center:</u>

On the "Messages" window, navigate to "UBX" → "NAV (Navigation)" → "PVT (Navigation PVT Solution)"





If SBAS has been correctly configured and EGNOS signal is being received, **The parameter "Fix Flags" shall show a value of "FixOK DGNSS"**

Although it is not usual, the signal may take some minutes to converge, so it is recommended to let the drone acquire the signal for 5 to 7 minutes.

Configuration (EGNOS OS)

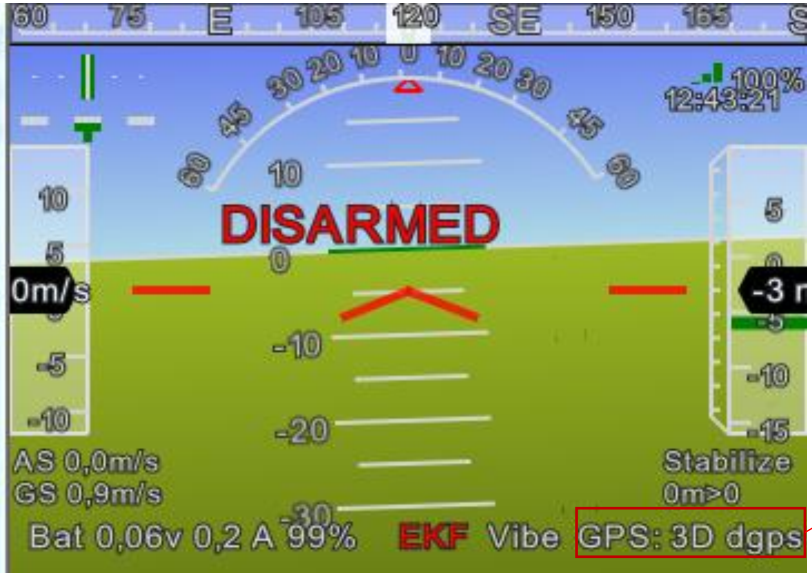
Hands-on!

In u-blox M8N

Test SBAS signal reception

<u>Messages reception on mission planner:</u>

In the bottom right corner of the Primary Flight Display (PFD), you may find a GPS status indicator:

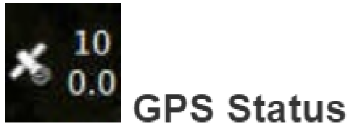


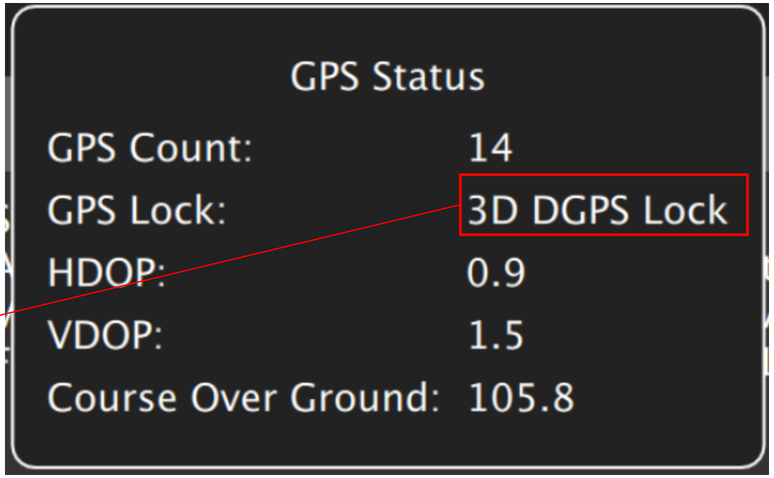
If SBAS has been correctly configured and EGNOS signal is being received, **The parameter "GPS" shall show a value of "3D dgps".**

GPS: 3D dgps

<u>Messages reception on QGroundControl:</u>

You may access the GPS status tool clicking on the corresponding button





In summary

ESSP offers dedicated assistance to interested operators

- We support operators study how EGNOS benefits particular cases
- We analyse how to setup EGNOS in particular platforms
- Follow-up implementation and deploy tests
- Analyse data logs to get real specific values
- We remain at your disposal to provide all of the above completely for free: Service.Adoption@essp-sas.eu

Configure your drone on using Galileo

Galileo HAS & OSNMA for Drones

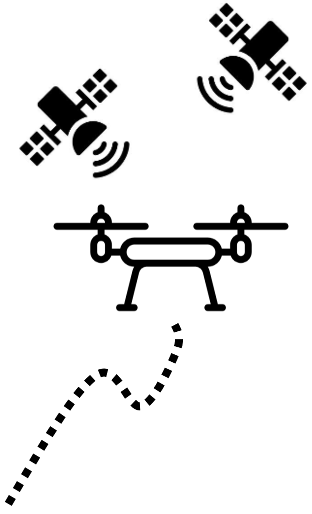
Online Training

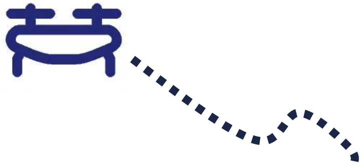
GALILEO

Quick remark on Galileo

Galileo Services for Drones

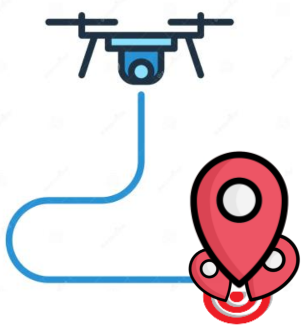
Galileo is the European GNSS offering a wide range of Services, also for Drones



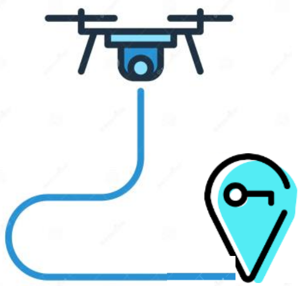


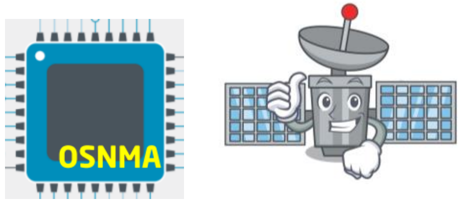
Most of the **UAS** (drones) **Operations** mainly **rely on GNSS** for the **Positioning, Navigation and Timing (PNT)** functions

Galileo Differentiators are those services **only provided by Galileo**, since no other GNSS Constellation offers similar features, like **Galileo HAS** and **Galileo OSNMA**



High Accuracy Service





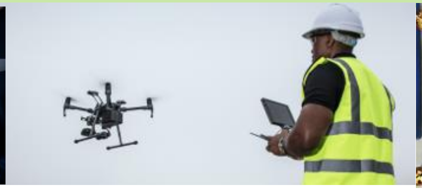
OSNMA Authentication Service

Quick remark on Drone operations

Typical GNSS architecture for Low Risk UAS Operations

LOW RISK UAS OPERATIONS

(Open Category and Specific Category SAIL I and SAIL II)


Typical Operations

- VLOS over low populated areas
- Open Sky (high number of Satellites in View – SV)

Typical Drones involved

- Light and rather small drones
- EASA list: light and ready-to-fly multicopters

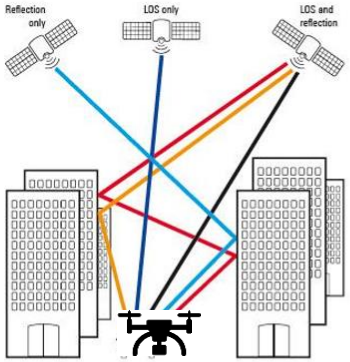
Typical GNSS architecture on-board

- Single GNSS module, MC + DF/MF
- GNSS "black-box" approach:
  - Factory configuration and settings
  - Most of the users and Drone operators might not be able to change settings

What GNSS module is inside your drone?



Typical built-in UAS GNSS receiver



Multi-Constellation (MC)

- Improved accuracy, availability and continuity
- Protection against single system blockage
- Compatible with all GNSS constellations:
  - GPS+GAL+BDS+GLO (concurring 3-4 constellations)

Dual-Frequency (DF) or Multi-Frequency (MF)

- Improved accuracy, availability and continuity
- Against degradation or blockage of specific frequencies

MC + DF/MF

- Mitigates multi-path effects

Other common features

- At least 96-184 channels
- SBAS compatible (but not always enabled)

UAS with CE Class Markings: C0, C1, C2, C3, C4 & C5, C6

Galileo compatibility

Class	Designed by	Type Category	Commercial Name	Galileo
C0	DJI	Multi-rotor	Mini 2 SE	✓
			Mini 3; Mini 3 Pro	✓
			Mini 4; Mini 4 Pro	✓
	Potensic		ATOM, ATOM LT	✓
C1	DJI	Multi-rotor	Mini 4 Pro	✓
			Air 2S; Air 3	✓
			Avata 2	✓
			Mavic 3	✓
C2	DJI	Multi-rotor with low-speed mode	Mavic 3 (3E, 3T, 3M)	✓
			Matrice M30, M30T	✓
	AgEagle	Fixed-wing	Sensefly eBee	✓
C3	DJI	Multi-rotor	Matrice M350	✓
			Inspire 3	✓
	Quantum-Systems	Fixed-wing	Trinity F90+	✓
	Wingtra		WingtraOne GenII	✓
C4	ABZ Innovation	Multi-rotor	M12	✓

GOOD NEWS…

GALILEO

Class	Designed by	Type Category	Commercial Name	Galileo
C5	Objectif drone	Multi-rotor	Chronos Mini+	✓
			Chronos	✓
			ARES	✓
			ATLAS	✓
	Aeotic		Aerobotic Spray S	✓
			Aerobotic Spray L	✓
			Aerobotic Agri X4	✓
	DJI + Dronavia (kit)		Mavic 3 + Kronos MVC3	✓
			Matrice M350 + Kronos M350	✓
	DJI + Flyingeye (kit)		Mavic 3 Flysafe	✓
			Matrice M350 Flysafe	✓
C6	Objectif drone	Multi-rotor	ARES	✓
			ATLAS	✓
	Aeotic	Multi-rotor	Aerobotic Spray S	✓
			Aerobotic Spray L	✓
	Delair	Fixed-wing	Delair UX 11	✓
	Vector Robotics		FireHound FH-0	✓

Source: EASA Approved Drones for EU Operations (**Updated as of 30th September 2024**)

…all of the listed CE Class Marked Drones are Galileo enabled!

#EUSpace

Quick remark on Drone operations

Typical GNSS architecture for Medium Risk UAS Operations

MEDIUM RISK UAS OPERATIONS

(Specific Category SAIL III and SAIL IV)

Typical Operations – NEW CHALLENGES

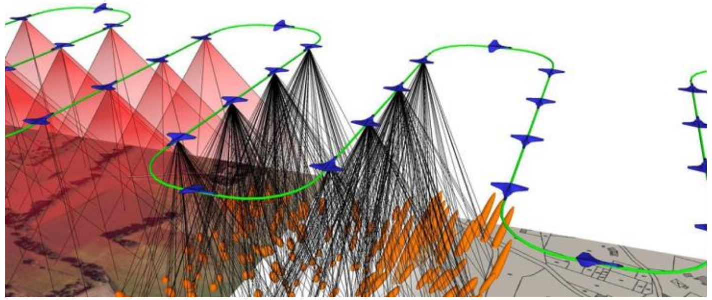
- SAIL III: BVLOS over un-populated and low populated areas (mostly relying in SORA Methodology):
  - Open Sky (high SV) with ocassional bad geometry (high DOP) and interferences
  - Sub-metrical accuracy might be required to define new aerial routes for drones
- SAIL IV: urban scenarios are introduced. On top of SORA, the role of U-space and USSPs can be decisive:
  - Potential complex terrains and urban canyons (mask angles)
  - GNSS integrity will become a major requirement for most of the operations
- Need to understand and study each operational scenario:
  - Technology and operational procedures to mitigate GNSS interferences and signal degradation
  - Increasing jamming and spoofing events: reporting and sharing
  - GNSS performance forecast analyses (recommended)

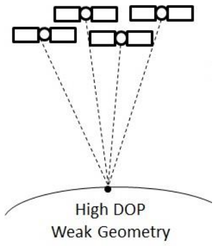
Typical Drones involved – HIGH-END PLATFORMS

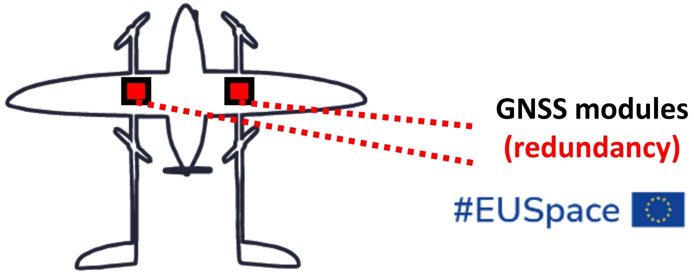
- Light and medium sized (payloads) hybrid e-VTOLs and multicopters
  - SAIL III operations: EASA is planning to publish a list of pre-qualified Drones
  - SAIL IV operations: the pre-qualified drones follow a Design Verification Review (DVR)

Typical GNSS architecture on-board – NEW FEATURES

- Drones embarking multiple MC-MF GNSS modules (redundancy)
  - High Accuracy solutions embarked (GNSS based and sensor-fusion)
  - Authentication features embarked against spoofing events. Anti-jamming solutions.
- Operators might be able to change settings with the support of the manufacturers







#EUSpace

Galileo differentiators in support of Drone operations' challenges

Galileo HAS for Drones

The High Accuracy challenge for Drone operations

New drone applications, as Drone Delivery, require higher levels of positioning, navigation and timing accuracy and improved coverage (availability, continuity) during the whole UAS operation, typically in BVLOS scenarios with a changing environment.

The solution provided by Galileo: High Accuracy Service (HAS)

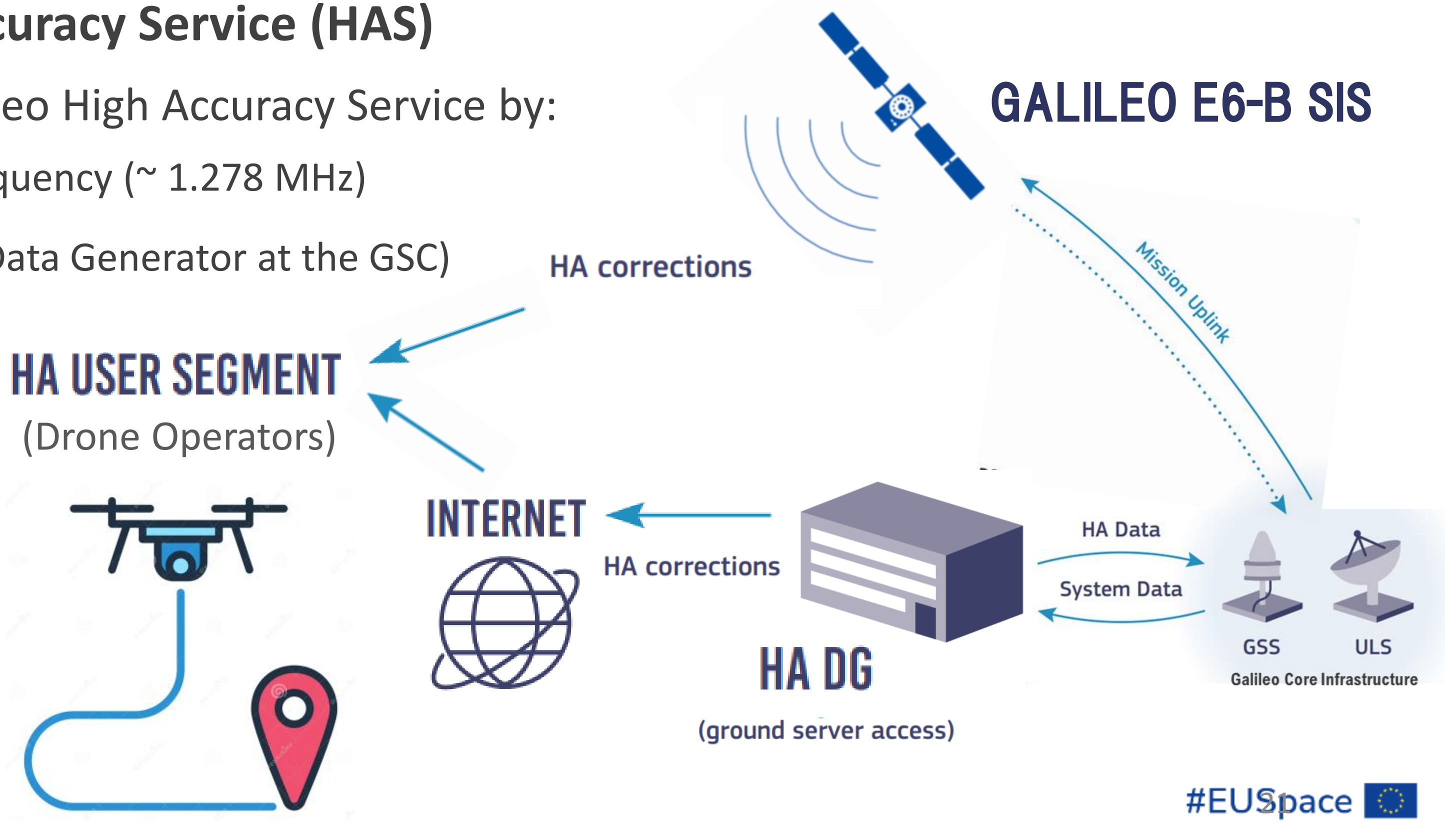
Drone operators can access the benefits of Galileo High Accuracy Service by:

- SIS = Signal-in-Space (through the Galileo E6-B frequency (~ 1.278 MHz)
- IDD = Internet Data Distribution (through the HA Data Generator at the GSC)

HAS, a Galileo differentiator…

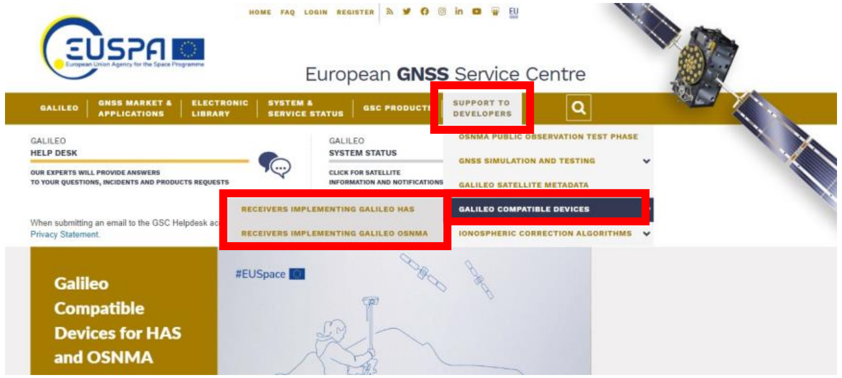
- Free of charge PPP service
- Almost global coverage
- At least 20cm (H) and 40cm (V) accuracy

…a very promising service for Drones!!



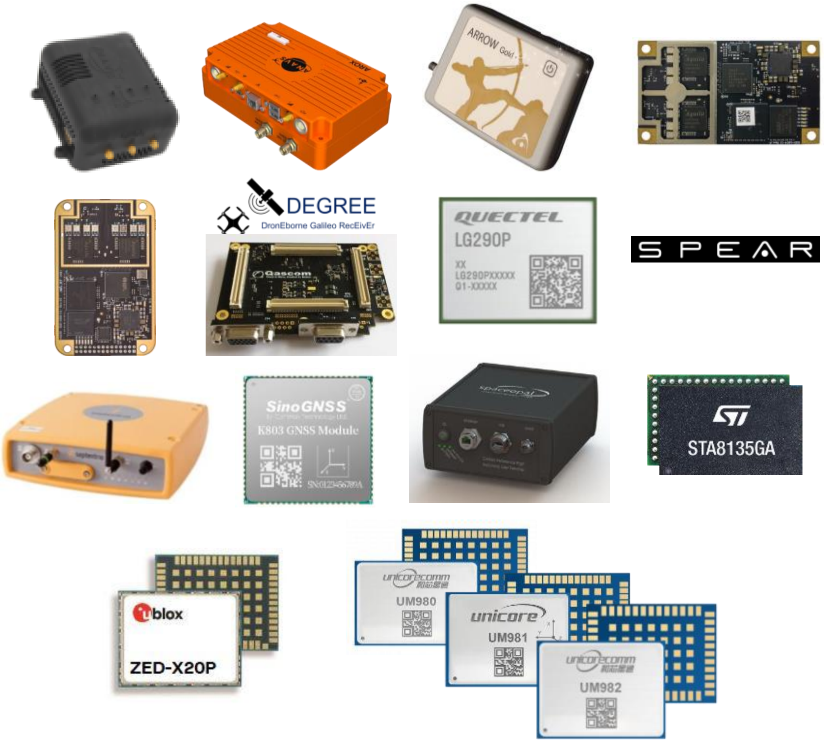
Galileo HAS receivers for Drones – Overview

(Updated as of 2024-Q4)



GSC website (www.gsc-europa.eu)

> Support to developers > Galileo compatible devices



Receivers implementing Galileo HAS suitable for Drones

Manufacturer	Model	GNSS module application for Drones		E6b	IDD	Status
		Navigation core (embarked)	Others (Payload)			
ANAVS	Multi-Sensor RTK/PPP Module	✗	✓	✓	✗	Available
ANAVS	A-ROX PPP	✗	✓	✓	✓	Available
Eos	Arrow Gold+™	✗	✓	✓	✗	Available
Hemisphere	Vega	✗	✓	✓	✗	Available
Hemisphere	Phantom	✗	✓	✓	✗	Available
Qascom	QN400 Pro "DEGREE"	✓	✓	✓	✗	Available
Quectel	LG290P	✓	✓	✓	✗	Announced
Rokubun	SPEAR (SDK SW engine)	✗	✗	✗	✗	Available
Septentrio	AsteRx-U	✗	✓	✓	✗	Available
SinoGNSS	K803 GNSS OEM	✓	✓	✓	✗	Available
Spaceopal	HAUT	✗	✓	✓	✓	Available
ST Microelectronics	Teseo V STA8135GA	✓	✓	✓	✗	Available
u-blox	X20P	✓	✓	✓	✗	Announced
Unicore Communications	UM980, UM981 and UM982	✓	✓	✓	✗	Available

***Note:** The number of devices implementing Galileo differentiators keeps growing. EUSPA is aware of the following receivers supporting Galileo HAS. The readiness of receivers is listed as stated by manufacturers (i.e. not tested by EUSPA). This list is not exhaustive and is being regularly updated, therefore may not necessarily reflect the full picture of the market.*

#EUSpace

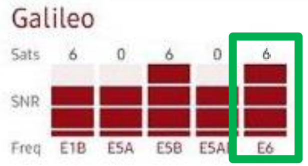
HAS service activation in your GNSS receiver

Common steps provided by the European GNSS Service Centre (GSC)

GALILEO HAS AND DRONES

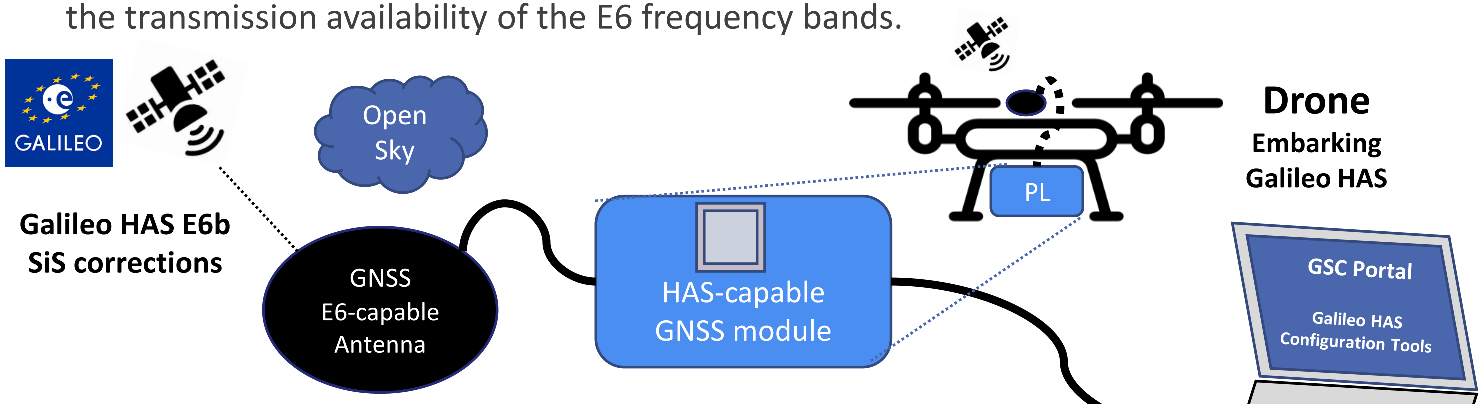
- It is expected that the **next generation of drones** will benefit from the **Galileo HAS** features directly from their integrated GNSS modules.
- As of today, there is no ready-to-fly drone in the market integrating a HAS-capable GNSS receiver for real-time navigation implementing HAS corrections.
- Currently, the **“HAS for Drones” projects**, flight tests, validation campaigns and success cases are being announced using **customized UAS platforms** (or ready-to-fly drones with sufficient payload capacity) integrating ad-hoc solutions (HAS capable receivers and antennas, data-loggers, …etc).
- Most of the activities involve the PNT signal recording and **post-processing** with **HAS corrections**.
- Many potential **applications of HAS for Drones** are currently undergoing: surveillance, inspection & calibration, GIS, precision agriculture and operations where Internet, 4G/5G signals and RTK solutions might not be available nor feasible.
- The **GSC is ready provide support to the drone operators**, developers and all drone users willing to implement Galileo HAS capabilities in their solutions.
- It is also recomendable to **contact each manufacturer** and get specific guidance.

COMMON STEPS FOR GALILEO HAS ACTIVATION



GALILEO HAS E6 Signal-in-Space activation (plug-&-play):

- Insert a SD card or connect the module to a compatible data-logger to record the Galileo HAS data
- Connect the system to a E6-ready antenna
- Connect the HAS-capable GNSS receiver to a computer (USB port, Ethernet, Bluetooth) to make sure that the last drivers’ package is installed, including also the software tools that might help to set up the receiver and extract the HAS data.
- Make sure, in open sky conditions, of monitoring the spectrum of GNSS signals, and check the transmission availability of the E6 frequency bands.



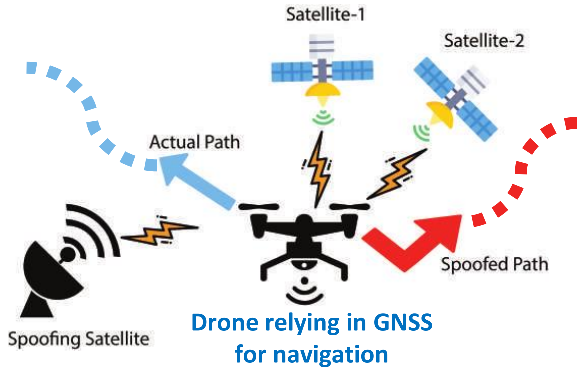
GALILEO HAS IDD (Internet Data Distribution) activation:

- Log-in or register your account on the GSC website (https://gsc-europa.eu)
- Request access to HAS IDD products and receive the credentials for the HAS NTRIP caster
- Introduce the credentials into the NTRIP tab of the main menu of your receiver
- You are **ready and connected to the HAS corrections** caster!

#EUSpace

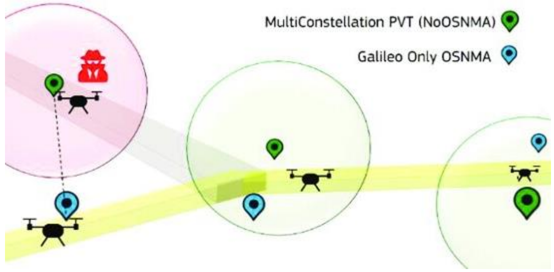
Galileo differentiators in support of Drone operations' challenges

Galileo OSNMA for Drones



The "GNSS spoofing" challenge for Drone operations

- Spoofing is a sophisticated form of interfering and falsifying GNSS navigation signals
- GNSS signal falsification can have disastrous impacts on applications and market sectors that rely on precise navigation such as drones
- GNSS spoofing distorts the location perceived by drones



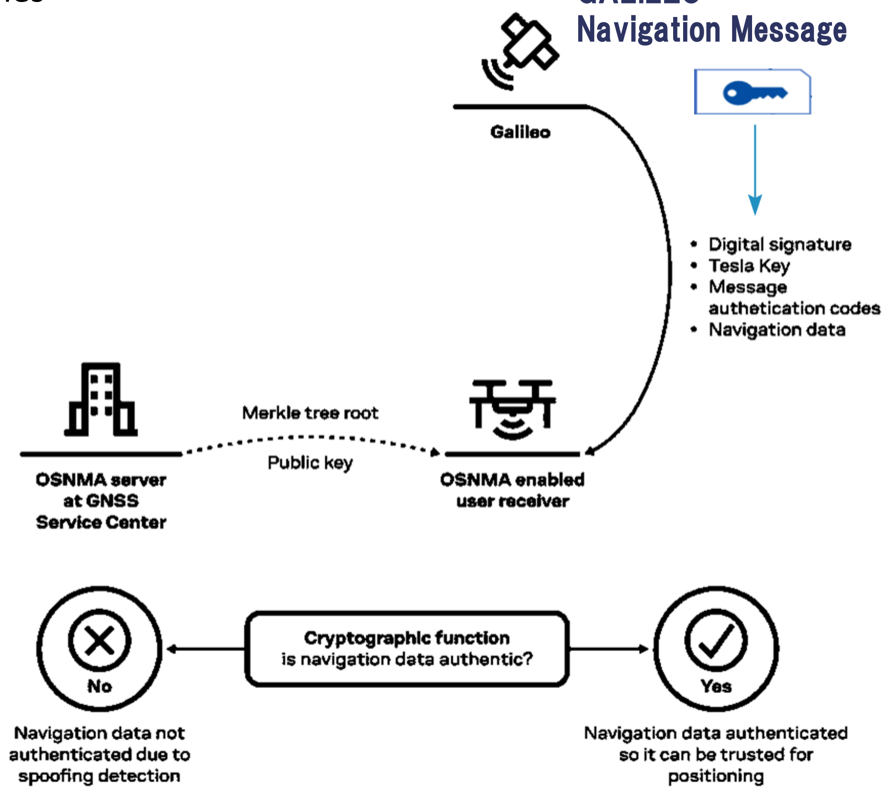
The solution provided by Galileo:
Open Service Navigation Message Authentication (OSNMA)

OSNMA is a Galileo service providing a GNSS-embedded feature that ensures secure end-to-end transmissions from Galileo satellites to GNSS receivers.

The feature assures GNSS receivers that the Galileo navigation message comes from the system itself and has not been tampered with, enhancing the GNSS receiver's robustness by increasing its ability to detect spoofing attempts.

OSNMA, a Galileo differentiator that makes possible to:

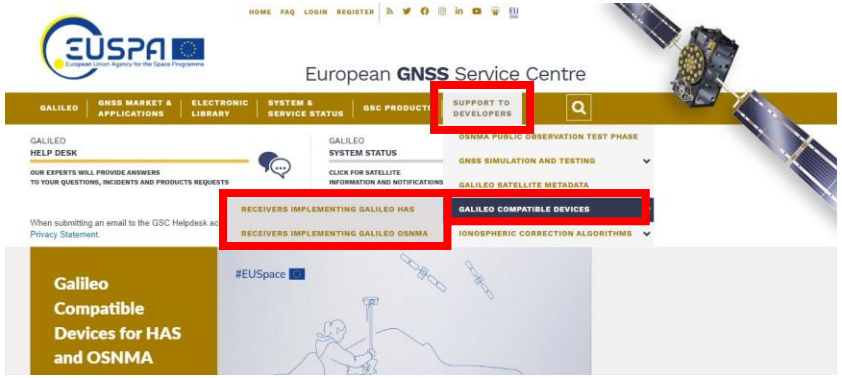
- Protect the authenticity of navigation messages transmitted by the Galileo satellites.
- Enhance the reliability of GNSS positioning and timing.
- Mitigate spoofed signals by selecting others.
- Cross-check other constellations.



u-blox © vision on OSNMA for Drones

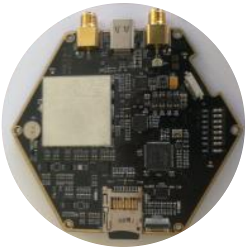
Galileo OSNMA receivers for Drones – Overview

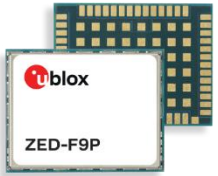
(Updated as of 2024-Q4)



GSC website (www.gsc-europa.eu)

> **Support to developers** > **Galileo compatible devices**





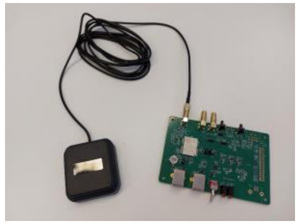
Receivers implementing Galileo OSNMA suitable for Drones

Manufacturer	Model	GNSS module application for Drones		Status
		Navigation core (embarked)	Others (Payload)	
Chipcraft	NaviSoc IC CCNV2 B1	✔	✔	Available
FDC (ST Microelectronics)	DracoNAV (Teseo III)	✔	✔	Available
Rokubun (u-blox)	Medea (ZED-F9P)	✔	✔	Available
Septentrio	Mosaic-X5	✔	✔	Available
ST Microelectronics	Teseo-V IC3	✔	✔	Available
u-blox	F9P	✔	✔	Available
u-blox	X20P	✔	✔	Announced
Quectel (ST Microelectronics)	LC99T (Teseo-V)	✔	✔	Available

Note: *The number of devices implementing Galileo differentiators keeps growing. EUSPA is aware of the following receivers supporting Galileo OSNMA. The readiness of receivers is listed as stated by manufacturers (i.e. not tested by EUSPA). This list is not exhaustive and is being regularly updated, therefore may not necessarily reflect the full picture of the market.*

Septentrio Mosaic X5 (Evaluation Kit)

u-blox ZED-F9P (Evaluation Kit)



Quectel LC99T (Evaluation Kit)

The GSC has specific information and steps for the configuration of some OSNMA capable receivers for Drones available at the Center.

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OSNMA service activation in your GNSS receiver

Common steps provided by the European GNSS Service Centre (GSC)

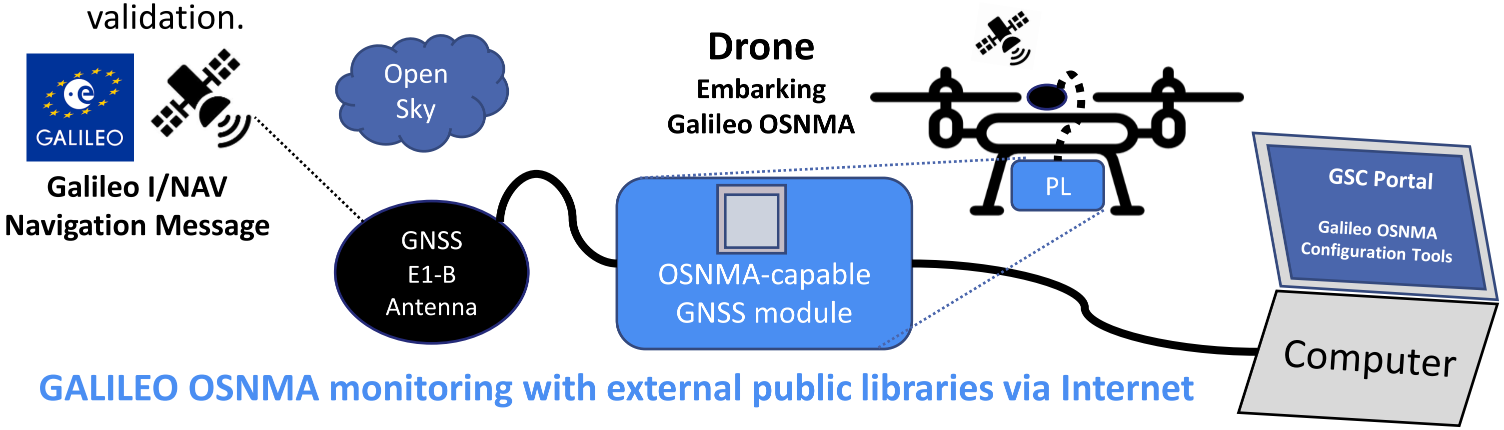
GALILEO OSNMA AND DRONES

- The common OSNMA service activation and receiver configuration steps are available at the **GSC web portal**, as a **Support for Developers**, receivers' manufacturers, integrators and advanced users/operators.
- It is advisable to **subscribe to** the official announcements and updates from the **GSC OSNMA portal** and assure having installed the last available **cryptographic OSNMA resources**.
- Anyhow, the **GSC's staff provide guidance** to the global community of Galileo users (through the GSC helpdesk and the GSC web portal).
- Additionally, some GNSS receivers' **manufacturers have already published specific guidelines** to support the users on how to activate and configure OSNMA features in their compatible modules.
- We invite all users to **review the steps for each specific receiver model**, paying attention to the manufacturer's publications and the official GSC's announcements too.

COMMON STEPS FOR GALILEO OSNMA ACTIVATION

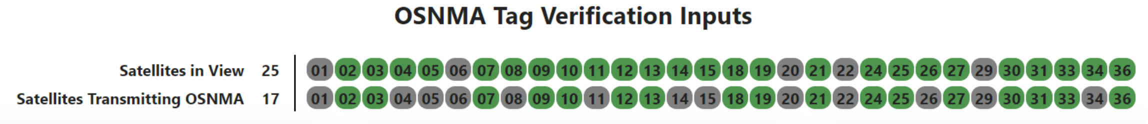
GALILEO OSNMA activation (plug-&-play)

- Insert a SD card or connect the module to a compatible data-logger to record the Galileo I/NAV data and the OSNMA authentication process.
- Connect the system to a Galileo E1-B frequency (~ 1.575MHz) compatible antenna
- Connect the OSNMA-capable GNSS receiver to a computer (USB port, Ethernet, Bluetooth) to make sure that the last drivers' package is installed, including also the software tools that might help to set up the receiver and extract the OSNMA data.
- Make sure, in open sky conditions, of monitoring the spectrum of GNSS signals, and check the transmission availability of the E1-B frequency and the OSNMA authentication validation.



GALILEO OSNMA monitoring with external public libraries via Internet

- https://OSNMAlib.eu/galmon



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OSNMA testing, validation and visualization

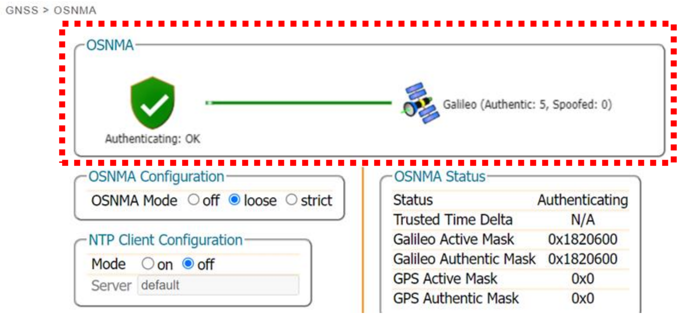
Comments and recommendations provided by the European GNSS Service Centre (GSC)

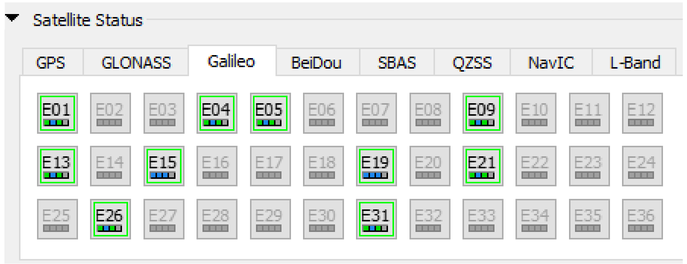
GALILEO OSNMA AND DRONES

- There are **already many drones** (ready-to-fly and customized) that **embark GNSS modules that potentially could benefit from the OSNMA** service and its features.
- On the other hand, these GNSS modules **might require a firmware upgrade** (not always possible, depending on the drone manufacturer) to **activate the OSNMA features.**
- In any case, it is expected that the **next generation of mass market drones will integrate OSNMA** as a preset configuration **by default**.
- Currently, the **"OSNMA for Drones" projects**, flight tests, validation campaigns and success cases are being announced using customized UAS platforms (or ready-to-fly drones with sufficient payload capacity) integrating ad-hoc solutions (OSNMA capable receivers and antennas, data-loggers, …etc) as a payload.
- The next wave of testing will involve **OSNMA authentication** directly with the **navigation GNSS** module embarked in the drones.
- One of the OSNMA explored applications for drones is the **Authenticated Tracking Service**, in support of **BVLOS and Drone Delivery operations.**

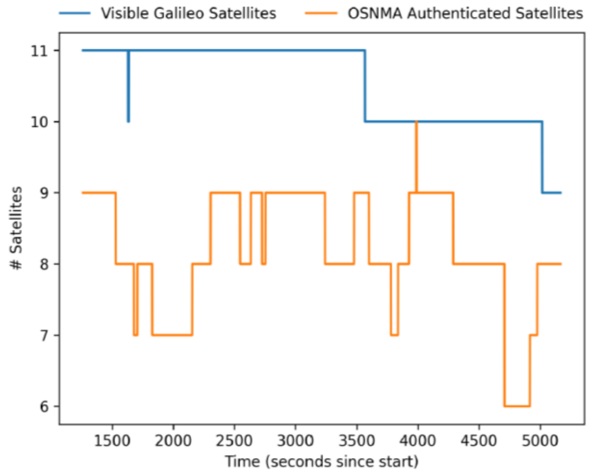
OSNMA VISUALIZATION AND MODES (OFF, LOOSE, STRICT)

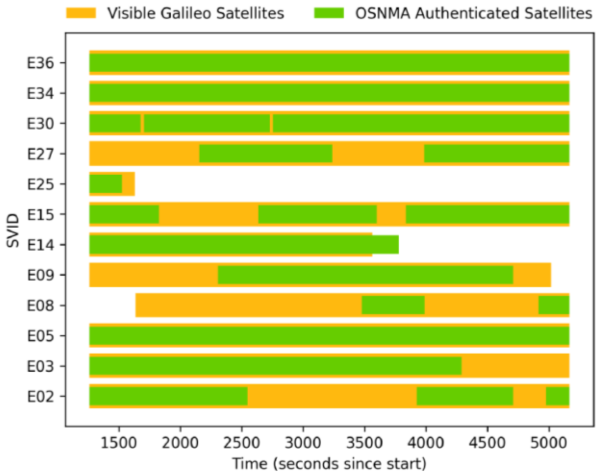
- It is possible to compare the visible Galileo satellites against the OSNMA Authenticated Galileo satellites during a flight test. There are already many visualization tools developed.





- Depending on the criticality of the mission, different OSNMA modes can be activated:
  - "**Loose**" OSNMA mode: in the PNT solution are included both, the authenticated satellites and the unknown authenticated satellites
  - "**Strict**" OSNMA mode: only the authenticated satellites are included in the PNT solution





Galileo for Drones

Summary

The Galileo satellites orbit Earth at an altitude of 23.222km

Summary of what Galileo offers for drones

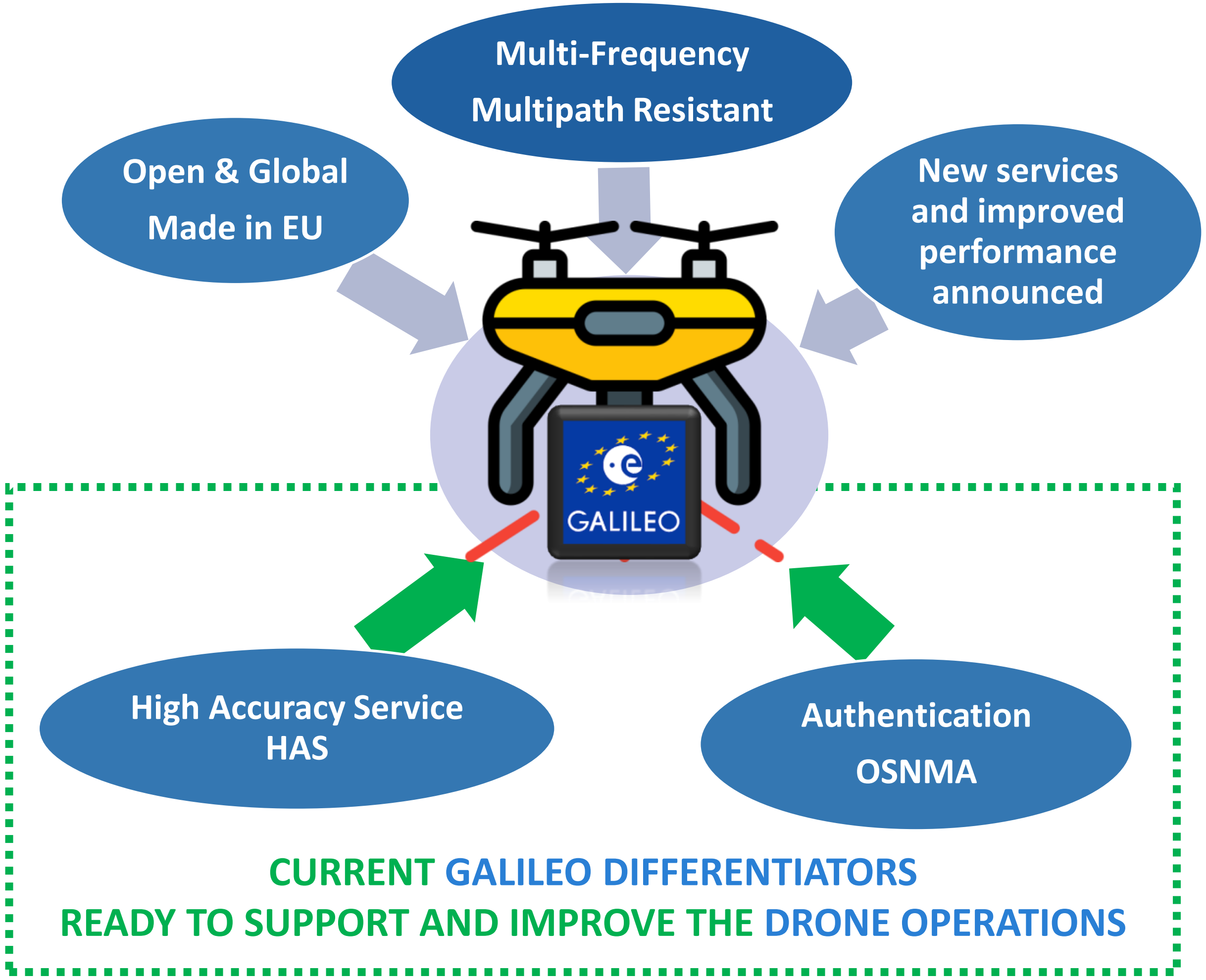
Galileo key differentiators

Galileo as the best performing and most reliable of all GNSS systems

- Worldwide navigation system "**made in EU**" under civilian control.
- Open Service free of charge, delivering multiple frequencies with a modern signal which is more **resistant to multipath.**

Galileo key differentiators, also for drone operations

- **Global High-Accuracy Service (HAS) for free delivering down to 20cm accuracy**, 95% of the time.
- Only constellation that provides **Signal and data authentication (OSNMA)** offering trustability for civilians.



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