A Brief Galileo Update

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(Space Data Economy and International Cooperation Unit)

European Commission

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GALILEO SERVICES PORTFOLIO

Now, Then, & Next

Open Service (OS)

- Free and Open Positioning Navigation & Timing (3 frequencies)
- Emergency Warning Satellite Service + Timing Service, Space Service Volume

Public Regulated Service (PRS)

- Encrypted, more robust, unlimited & uninterrupted access
- PRS evolutions

Search and Rescue (SAR) - contribution

- Forward link + acknowledgement "return link“
- Remote Beacon Activation + Two Way Communication + Distress Position Sharing

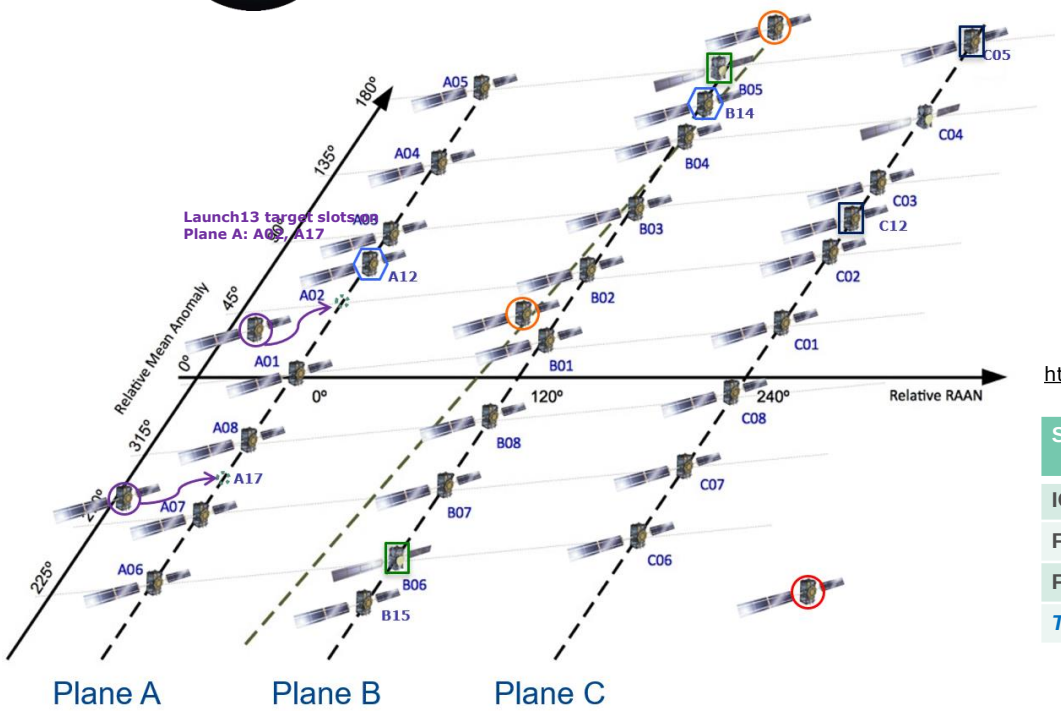
High Accuracy and Authentication

- High Accuracy Service
- OSNMA + Signal authentication services

Safety-of-Life (SoL) - contribution

- Advanced Receiver Autonomous Monitoring (ARAIM)
- SBAS Dual Frequency (EGNOS Version 3)

GALILEO CONSTELLATION STATUS



Navigation (24 in service)
Search and Rescue (23 in service)

32 satellites in orbit
2 marked unhealthy
2 inactive spares
2 no SAR (by design)
2 SAR commissioning (L12)
1 under decommissioning
2 under commissioning (L13)

As of 27 Jan 2025 Latest data here:
https://www.gsc-europa.eu/system-service-status/constellation-information

Satellite Family	Quantity	Average Age (years)	Oldest Satellite (years)
IOV	4 (1)	12.4	12.9
FOC WO1/WO2	22 (4)	7.9	10.1
FOC Batch#3	6 (2)	1.1	2.8
TOTAL	*32 (7)*	*7.2*	*12.9*

( ) not in service for Navigation

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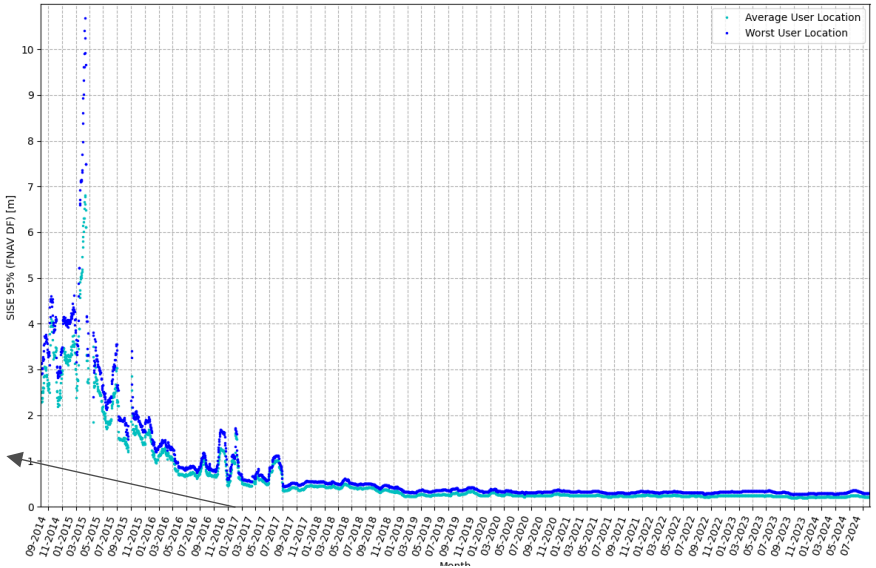
GALILEO DELIVERS OUTSTANDING WORLDWIDE PERFORMANCE

Ranging Performance, As-observed

Galileo Open Service
Initial Service Declaration



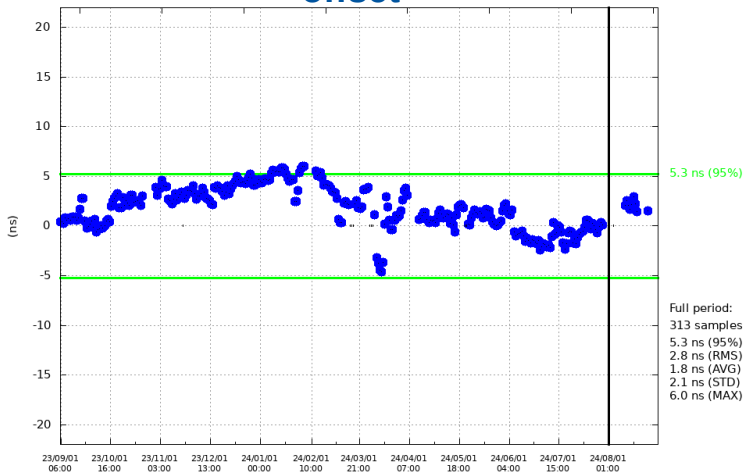
0.20m (95%)
all satellites,
July 2024

- Very stable Signal In Space Ranging Error (SISE) trend
- Largely compliant with the Service Definition Document

GALILEO DELIVERS OUTSTANDING WORLDWIDE PERFORMANCE

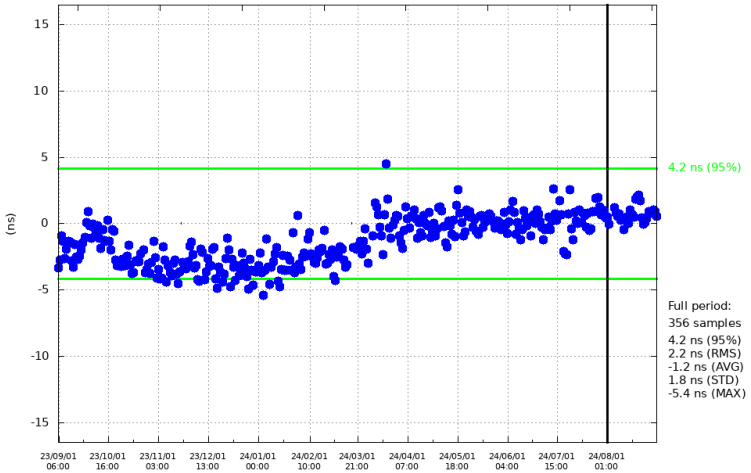
Galileo Timing

Broadcast UTC offset



5.3ns (95%) < 30ns (95%) in Galileo OS SDD

GGTO accuracy



4.2ns (95%) < 20ns (95%) in Galileo OS SDD

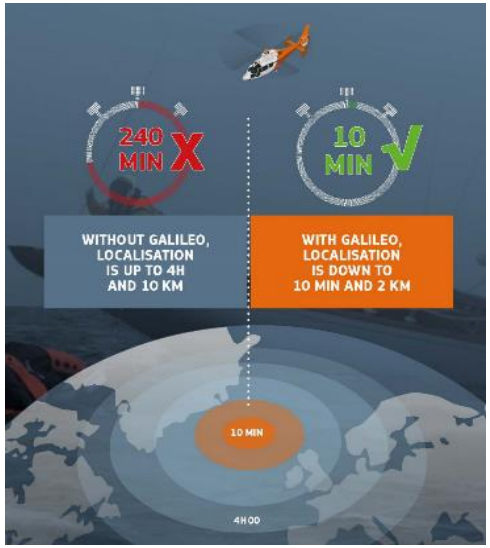
- Very stable and Largely compliant

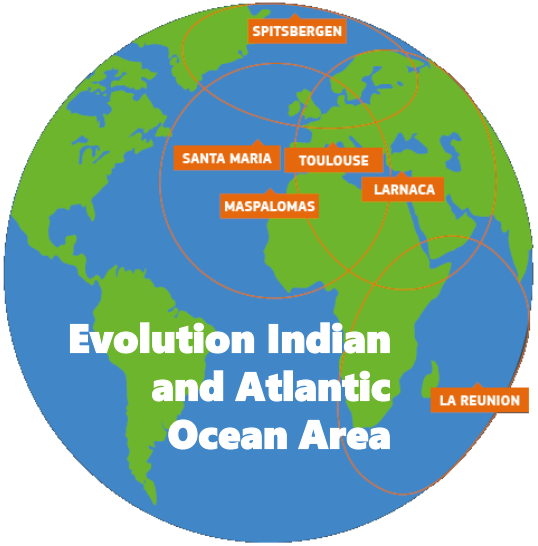
Results evaluated with calibrated timing GPS/Galileo receiver operated in UTC(k) laboratory (PTB, INRIM,

Galileo Open Service - Service Definition Document (OS SDD) – Issue 1.3, November 2023

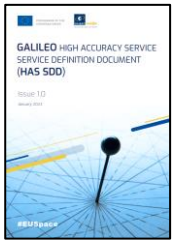
Search and Rescue (SAR)

- European Contribution to Cospas-Sarsat
- Worldwide coverage
- Free of charge
- Unprecedented accuracy and speed





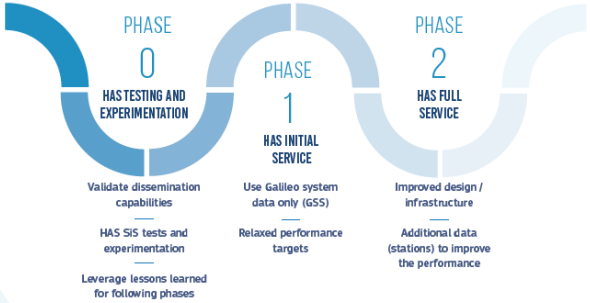
High Accuracy Service Status



- Service Operational since January 2023 – Initial Service
- HAS Service Definition Document available

Galileo-HAS-SDD_v1.0.pdf (gsc-europa.eu)

- HAS Phase 2 (Full Service) expected in 2026



Initial Service

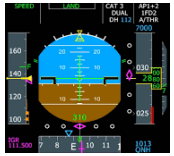
- Targets 20/40cm horizontal/vertical accuracy (95%)
- Very good performance since start of Service
- “Convergence” accuracy in a few minutes
- Large demand after the HAS Declaration - current status: 300+ registered users including (Google Inc., Broadcom US, Furuno, Kongsberg, Fugro, Trimble, U-Blox, Samsung, etc.)

Open Service Navigation Message Authentication (NMA)

- OSNMA - Long awaited GNSS feature
- OSNMA SIS ICD and guidelines published in 2022
- Transition to final signal broadcast in July 2023
- Public Testing Phase formally closed, broadcast continues
- Initial Service very, very soon!

Galileo Signal Authentication Service (SAS)

- Allows derivation of fully authenticated Position, Velocity and Timing solutions
- Initial Service: Assisted through terrestrial dissemination (GSC)
  - Testing started in 2024
  - Initial Capability later in 2025
- Previously known as “Commercial Authentication Service”



Galileo Contribution to Safety of Life

- Galileo already recognized for Civil Aviation
  - Formal adoption by ICAO of the Aviation Standards in March 2023
- Galileo will support Advanced Receiver Autonomous Monitoring
  - Initial Service, based on ARAIM parameters commitments, will follow OS FOC Declaration
- Galileo will support Dual Frequency Multiconstellation SBAS
  - Initial Service, based on Galileo Commitments towards EGNOS, will follow OS FOC Declaration

Galileo Emergency Warning Satellite Service

- Service offered to National Civil Protection Authorities to broadcast alerts and associated guidance to targeted areas within minutes
- Demonstration with Civil Protection Authorities performed in 2023 and 2024: simulated Alerts broadcast with Test signals from Operational Galileo satellites

Next steps:

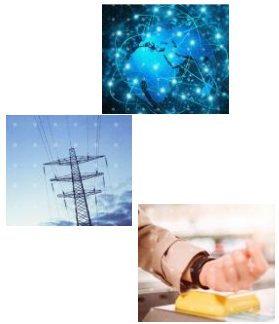
- Start and support the pilot phase in MS (Step 0)
- Ensure real-time interfacing of civil protection authorities with Galileo (Step 1)
- Ensure implementation in user segment (eg in smartphones)
- EWSS Initial Service Declaration in G1G in 2025

Galileo Timing Service

- Timing Service in the mission of Galileo Second Generation
- Dedicated monitoring for 3 Service Levels and dedicated message
  - TSM OSD published April 2024
  - Version 1.1 soon to be published

Galileo Timing Service Message Operational Status Definition (TSM OSD v1.0)

- First Standard for Galileo Timing Receivers developed under CEN/CENELEC
  - Publication before end of year



- Galileo recognition by BIPM
  - Galileo added to the Circular T since June 2024

Section 4:

4 – Relations of UTC and TAI with predictions of UTC(k) disseminated by GNSS.

[UTC-UTC(USNO)_GPS] = C0', [TAI-UTC(USNO)_GPS] = 37 s + C0'
[UTC-UTC(SU)_GLONASS]= C1', [TAI-UTC(SU)_GLONASS]= 37 s + C1'

For this edition of Circular T, S0'= 1.0 ns, S1'= 6.8 ns

2023	0h UTC	MJD	C0'/ns	N0'	C1'/ns	N1'
	AUG 28	60184	1.6	81	42.5	86
	AUG 29	60185	0.3	81	43.6	89
	AUG 30	60186	-0.5	81	42.0	85
	AUG 31	60187	0.9	83	40.6	88
	SEP 1	60188	1.3	81	43.2	84

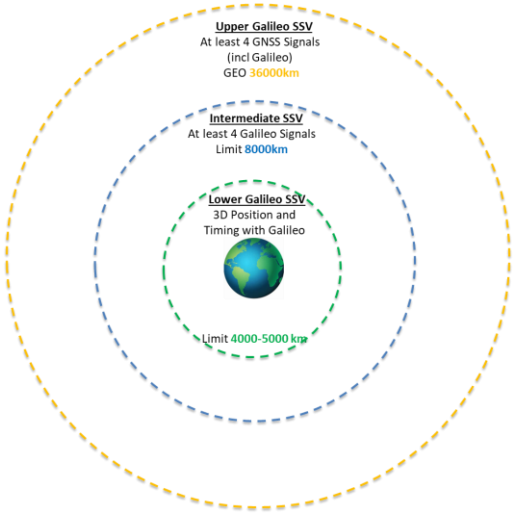
…

4 – Relations of UTC with predictions of UTC broadcast by GNSS.

For this edition of Circular T:
sigma_GPS = 5 ns
sigma_GLO = 5 ns
sigma_GAL = 5 ns
sigma_BDS = 5 ns

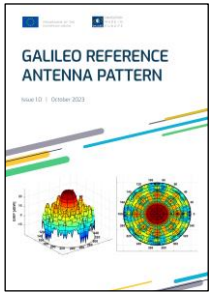
DATE 0h UTC	MJD	UTC-bUTC_GNSS /ns			
		GPS	GLO	GAL	BDS

Galileo Space Service Volume



- Galileo stand alone 3D Position and Timing up to around 4500 km
  - Covers higher orbits than GPS dues to higher MEO altitude
- Unique Galileo services fully available in LEO
- Multi-constellation for higher orbits

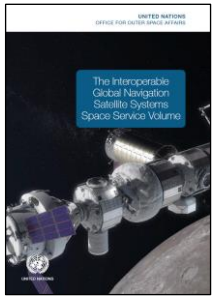
- Galileo Reference Antenna Pattern,
  Issue 1.0, May 2024

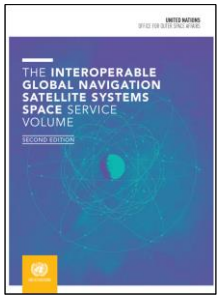


https://www.gsc-europa.eu/sites/default/files/sites/all/files/Galileo_Reference_Antenna_Pattern_v1.0.pdf

International Cooperation

- UN International Committee on GNSS defines, promotes an Interoperable GNSS SSV for the benefit of GNSS space users





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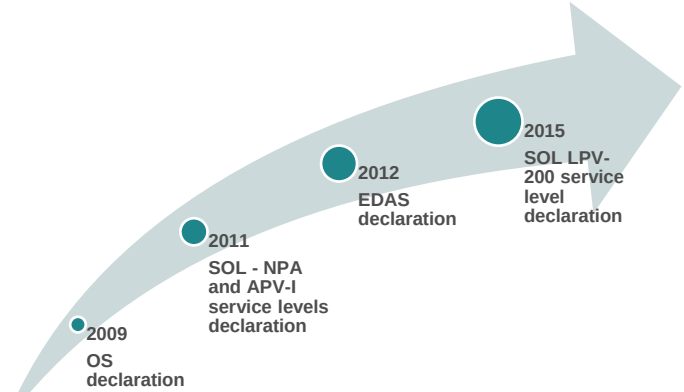
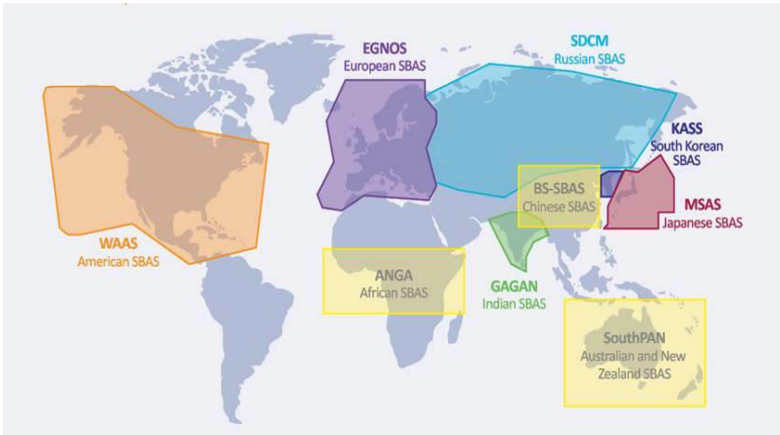
EGNOS

- **E**uropean **G**eostationary **N**avigation **O**verlay **S**ervice
- Equivalent to Australia/NZ's SouthPan
- Augments GPS signals over Europe:
  - Better performance (accuracy and integrity)
  - Certified for use in Safety-Of-Life applications, eg aviation

- Inter-operable with other regional systems:
  - Operational: WAAS (USA), MSAS (Japan), GAGAN (India), SouthPAN (Australia/NZ),
  - Under deployment: SDCM (Russia), KAAS (South Korea)
  - Under development: ANGA (Africa), BS-SBAS (China)

- EGNOS V3 under development will augment also Galileo





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EU SPACE

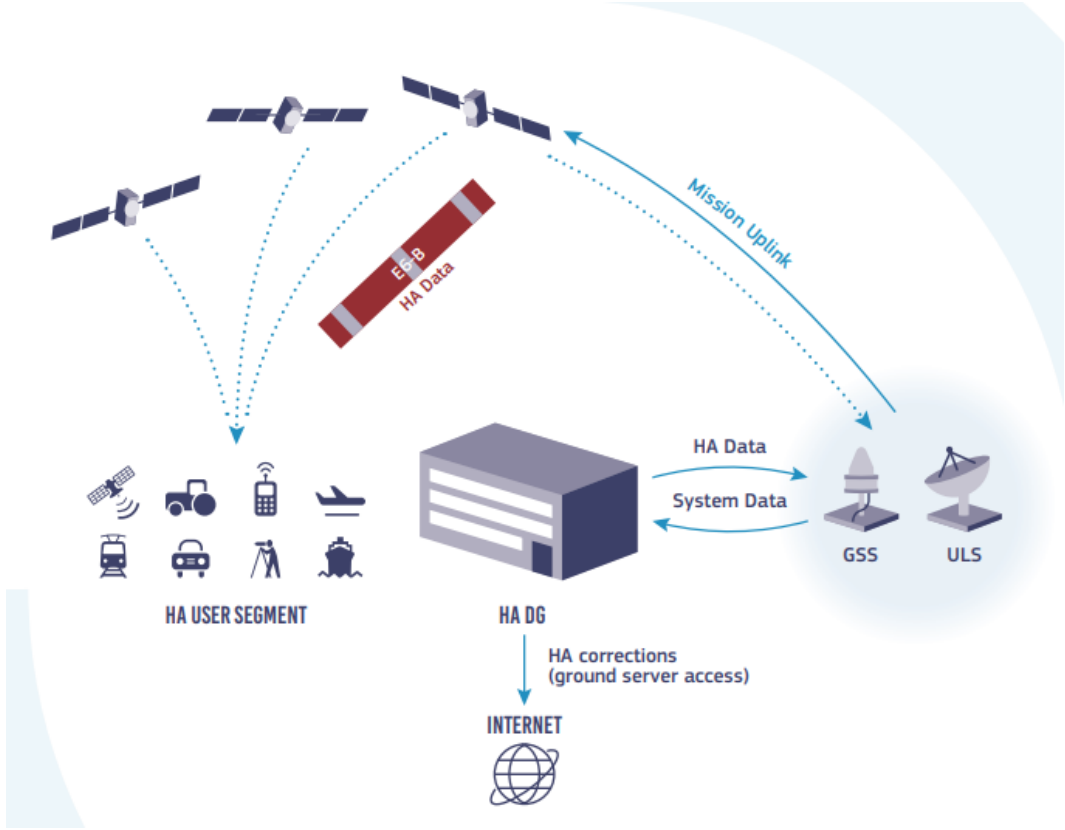
Galileo High Accuracy Service

ICG GNSS Training - 27 Jan 2025

Ignacio Fernandez-Hernandez, European Commission DG DEFIS

GALILEO HIGH ACCURACY SERVICE (HAS)

- Galileo HAS provides precise corrections for satellite orbit, clock and signal biases
- Galileo HAS corrections distributed via
  - Galileo satellites, E6-B signal (1278.75 MHz)
  - Internet
- Typical accuracy in the decimetre level (after convergence), with Precise Point Positioning (PPP) receivers
- Global coverage and free

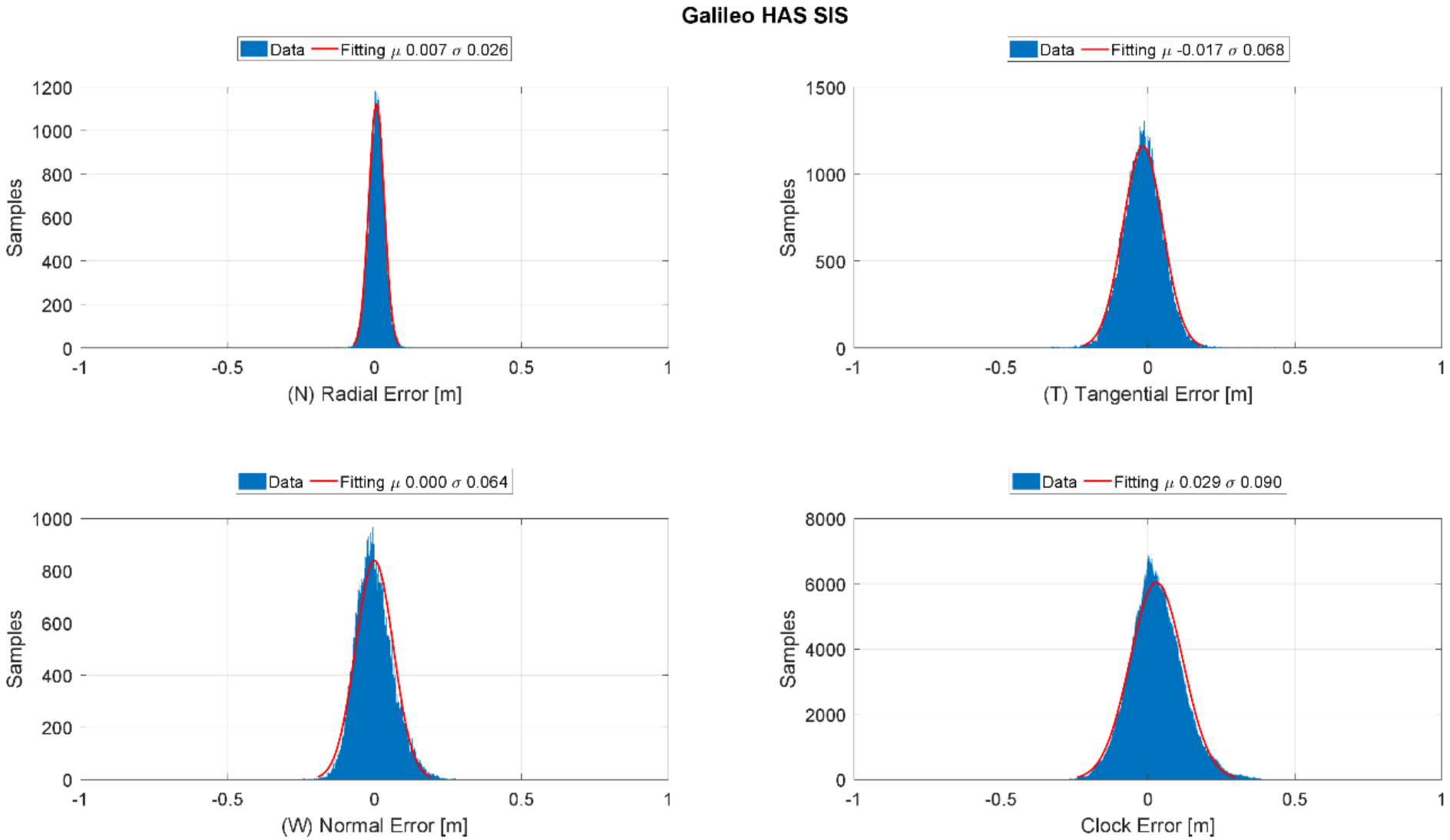


GALILEO HIGH ACCURACY SERVICE (HAS): SERVICE LEVELS

HAS	SERVICE LEVEL 1	SERVICE LEVEL 2
COVERAGE	Global	European Coverage Area (ECA)
TYPE OF CORRECTIONS	PPP - Orbit, clock, biases (code and phase)	PPP - Orbit, clock, biases (code and phase) incl. atmospheric corrections
CORRECTIONS DISSEMINATION	SIS (Galileo E6-B) and IDD (Ntrip)	SIS (Galileo E6-B) and IDD (Ntrip)
SUPPORTED CONSTELLATIONS & FREQUENCIES	Galileo E1/E5a/E5b/E6; E5 AltBOC GPS L1/L5; L2C	Galileo E1/E5a/E5b/E6; E5 AltBOC GPS L1/L5; L2C
HORIZONTAL ACCURACY 95%	<20 cm	<20 cm
VERTICAL ACCURACY 95%	<40 cm	<40 cm
CONVERGENCE TIME	<300 s	<100 s
USER HELPDESK	24/7	24/7

Galileo HAS currently in Phase 1 since 24/1/23, providing most SL1

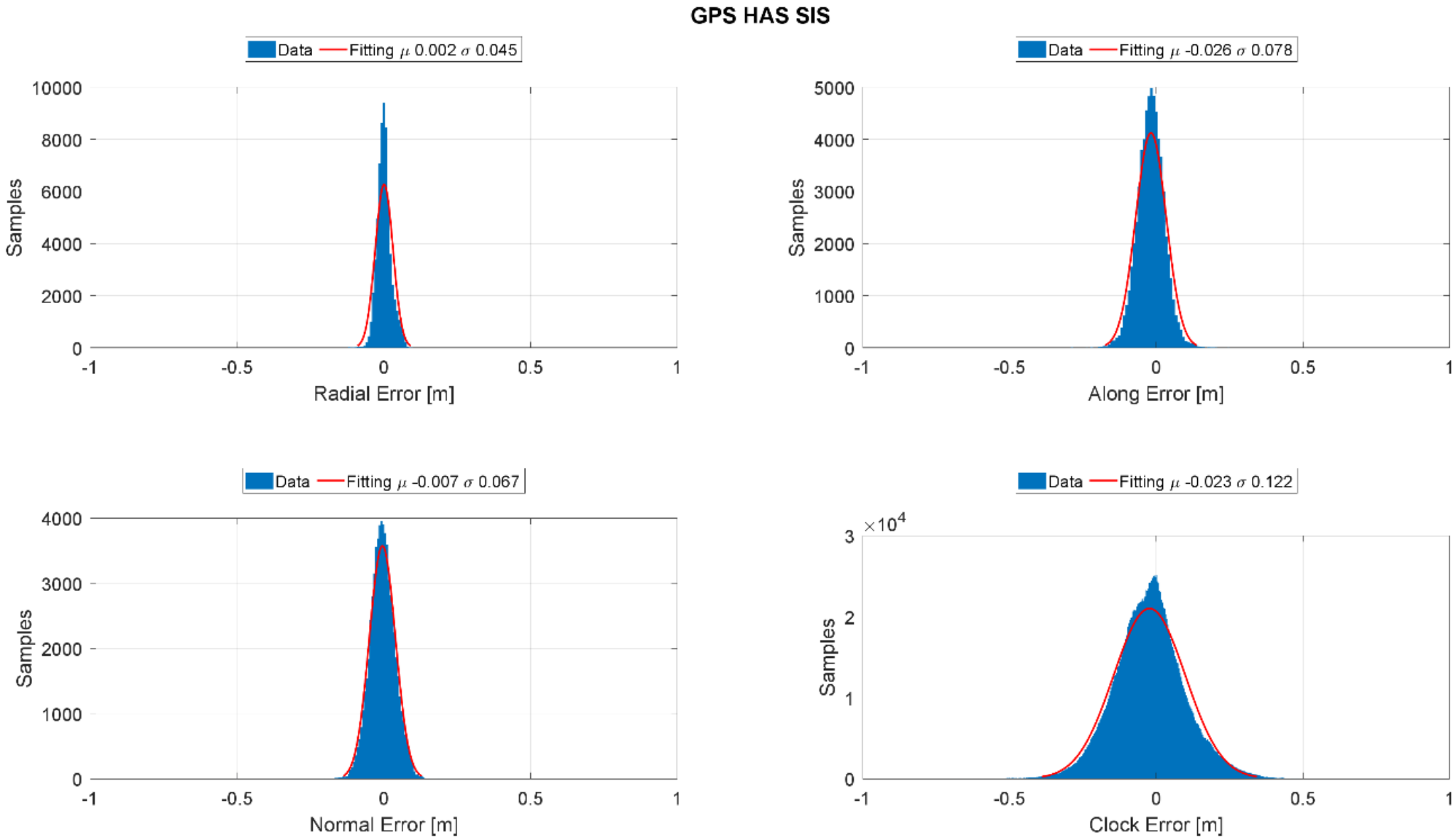
GALILEO HIGH ACCURACY SERVICE (HAS): PRODUCTS ACCURACY



10 days (22-31/12/23, comparison vs. MGEX (CODE), NTW (radial, along/tangential, cross/normal)

Zoccarato et al., *Galileo High Accuracy Service Reference User Algorithm Formulation and Verification,* IONGNSS+2024

GALILEO HIGH ACCURACY SERVICE (HAS): PRODUCTS ACCURACY



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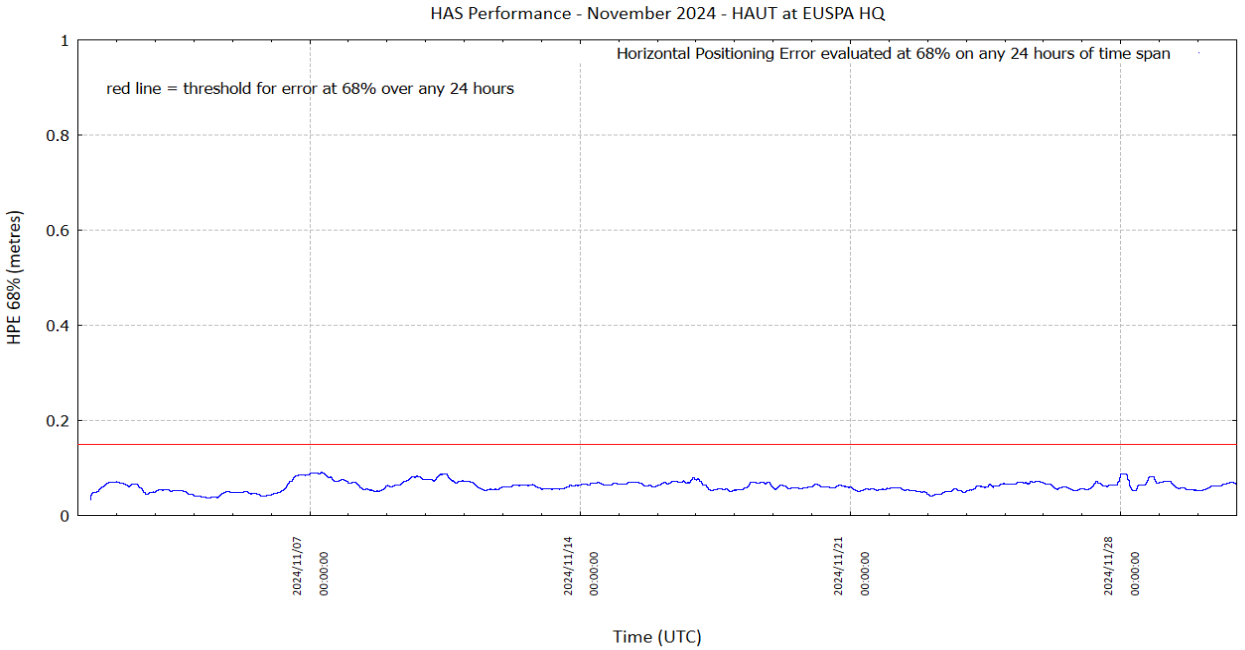
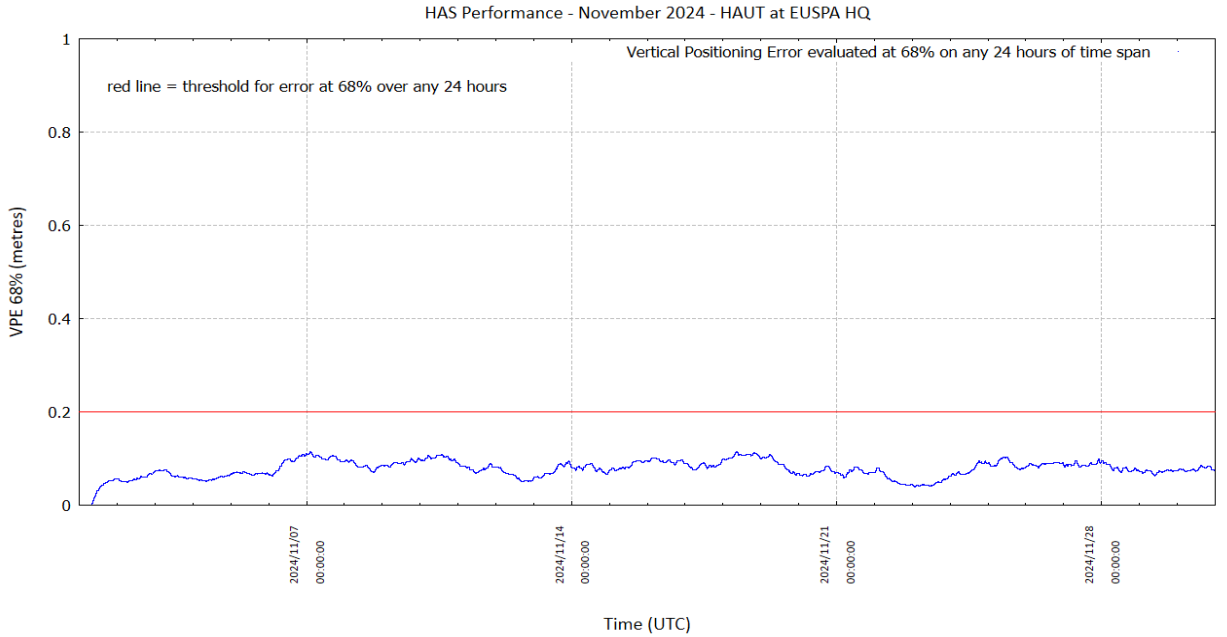
Zoccarato et al., *Galileo High Accuracy Service Reference User Algorithm Formulation and Verification,* IONGNSS+2024

GALILEO HIGH ACCURACY SERVICE (HAS): USER ACCURACY



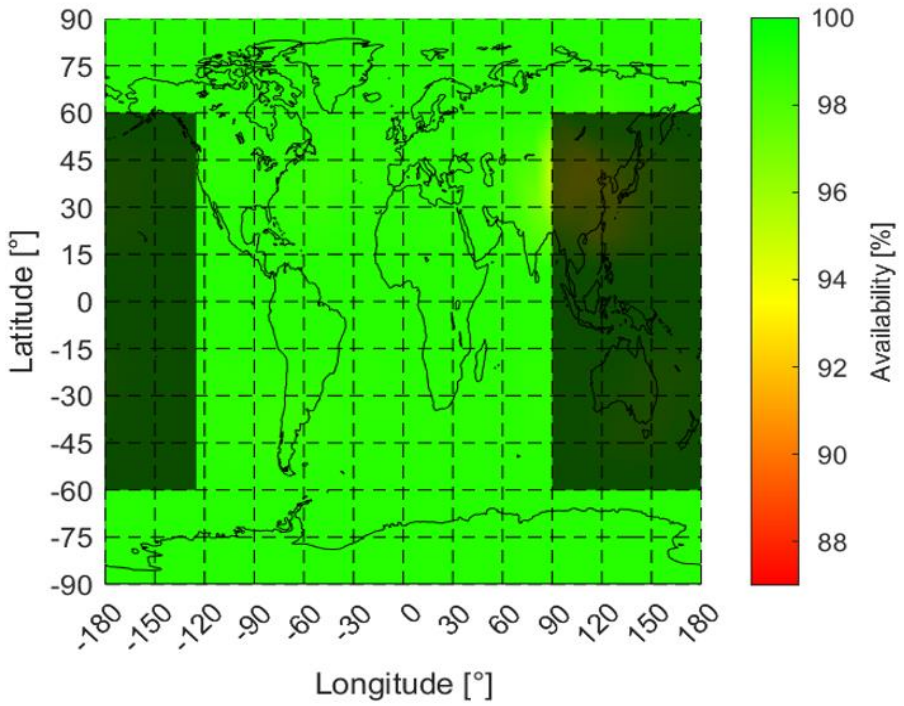


"Galileo + GPS" multi-constellation mode: Galileo E1+E5a, GPS L1+L2C, HAUT (High Accuracy User Terminal), November 2024

Source: EUSPA

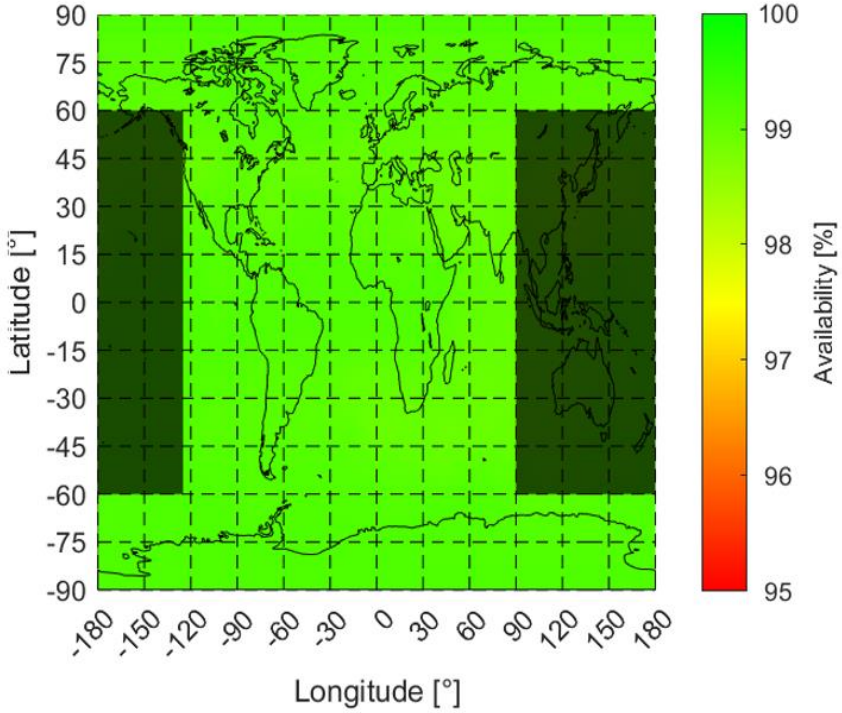
GALILEO HIGH ACCURACY SERVICE (HAS): COVERAGE AND AVAILABILITY

HAS service coverage, November 2024. “Galileo-only”, 5+ SVs corrected



Grid map: min=92.97%, mean=98.69%
Service area: min=94.91%, mean=98.86%

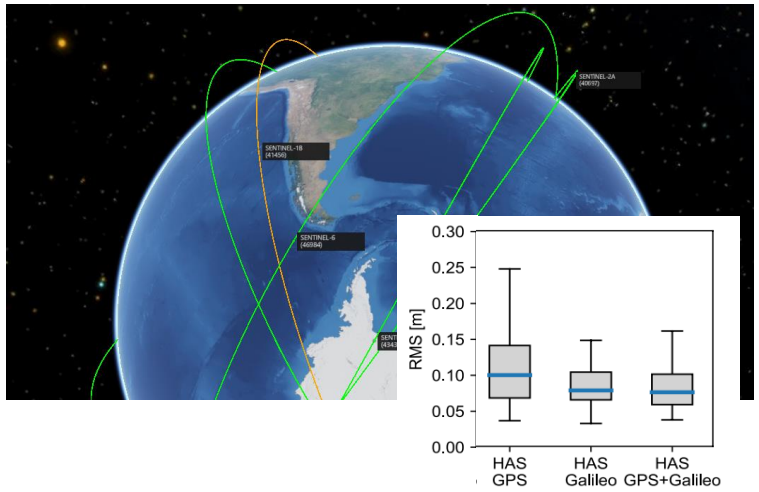
HAS service coverage, November 2024. “Galileo + GPS”, 8+ SVs corrected

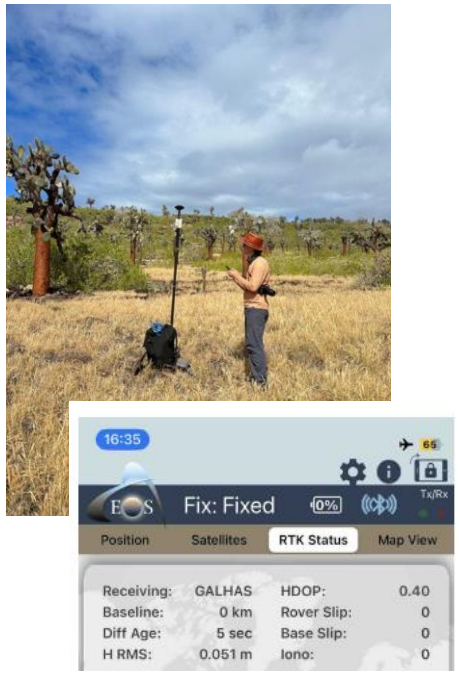


Grid map: min=98.69%, mean=99.08%
Service area: min=98.91%, mean=99.10%

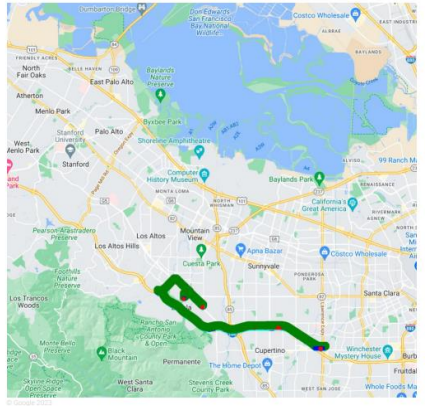
GALILEO HIGH ACCURACY SERVICE (HAS): APPLICATIONS

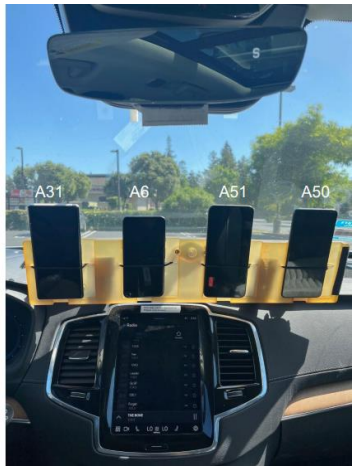
- Galileo HAS is being gradually incorporated in receivers and applications

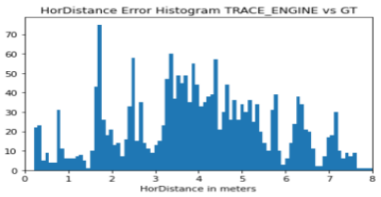




Drive test, Samsung Galaxy A-series

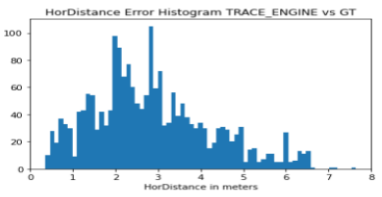






Stand-alone

mean 3.279 m
50% 3.371 m
95% 5.671 m



HAS SSR

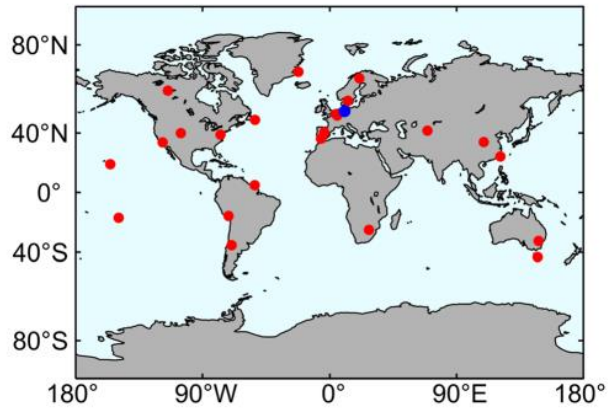
mean 1.766 m
50% 1.615 m
95% 3.633 m

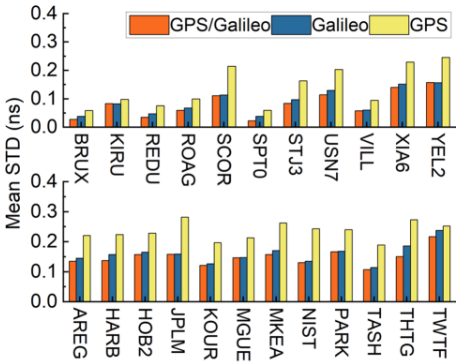
SatNav Africa JPO
1.287 seguidores
3 semanas • Editado •

Successful Test of Galileo High Accuracy Service (HAS) on the African Continent – Dakar (Senegal)

Following the Declaration of **Galileo HAS** Initial Service on the 24th of January 2023, users within the service area with compatible receivers can achieve improved user positioning performance in real-time by exploiting the HAS data delivered in the Galileo E6-B signal and by terrestrial means (i.e. Internet).

SatNav Africa JPO in collaboration with the Association Sénégalaise des Professionnels de la Géomatique (ASPG) undertook a demonstration on the use of Galileo HAS. ... más



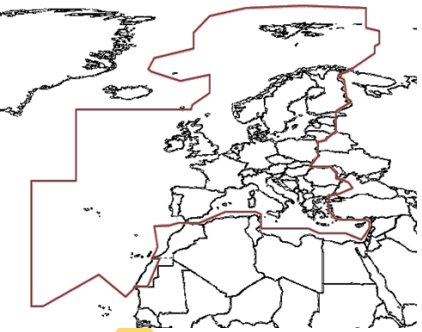


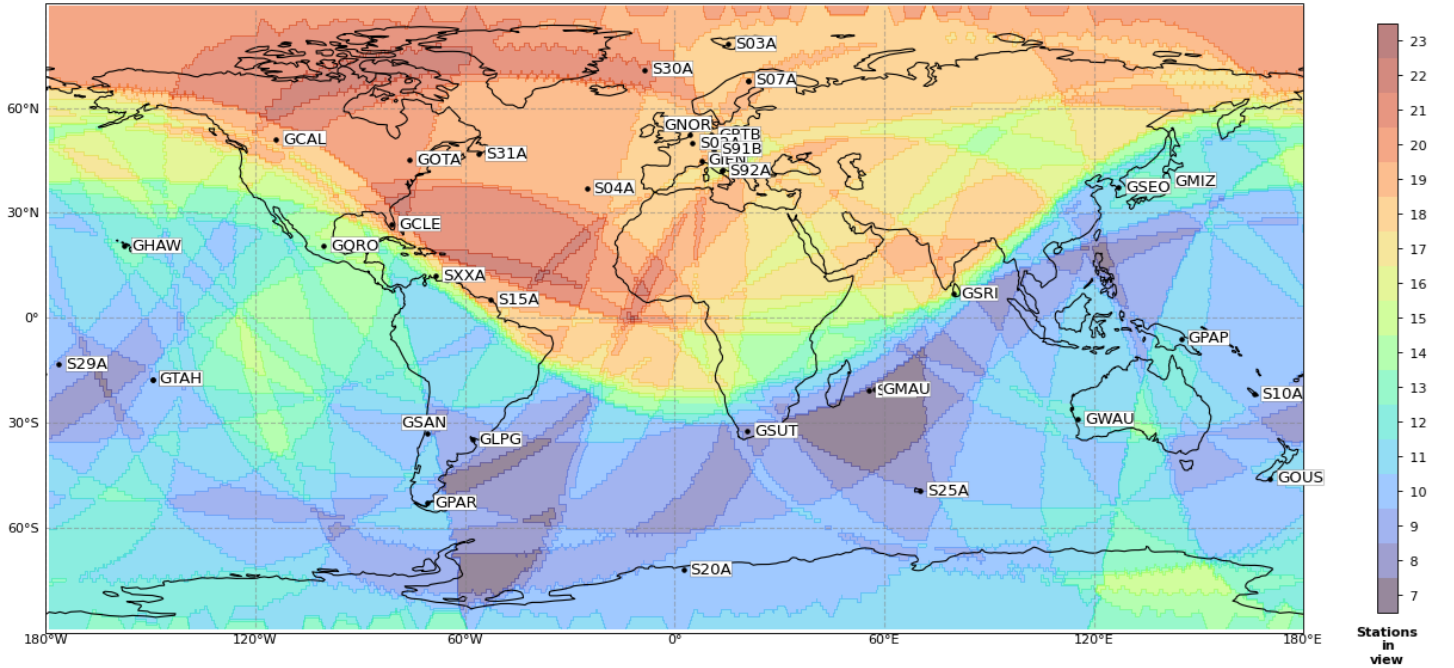
- Hauschild, A., et al. Orbit determination of Sentinel-6A using the Galileo high accuracy service test signal. *Gps Solutions*, *26*(4), 120.
- Zhang, R., et al., Initial and comprehensive analysis of PPP time transfer based on Galileo high accuracy service. *GPS Solutions*, *28*(2), 94.
- https://satnav-africa.com
- van Diggelen, F., et al., Evaluation of Galileo High Accuracy Service (HAS) with Android Smartphone Data, ENC 2023https://eos-gnss.com/successes/galapagos

GALILEO HIGH ACCURACY SERVICE (HAS): PHASE 2

- Includes full SL1 worldwide and SL2 in Europe
- Additional infrastructure foreseen includes EGNOS RIMS, G2STB stations, new ODTS + ionosphere
- Additional data includes ionospheric corrections (in Europe), Satellite Corrections Accuracy, Message Authentication
- Expected in 2nd half of 2026

HAS	SERVICE LEVEL 1	SERVICE LEVEL 2
COVERAGE	Global	European Coverage Area (ECA)
TYPE OF CORRECTIONS	PPP - Orbit, clock, biases (code and phase)	PPP - Orbit, clock, biases (code and phase) incl. atmospheric corrections
CORRECTIONS DISSEMINATION	SIS (Galileo E6-B) and IDD (Ntrip)	SIS (Galileo E6-B) and IDD (Ntrip)
SUPPORTED CONSTELLATIONS & FREQUENCIES	Galileo E1/E5a/E5b/E6; E5 AltBOC GPS L1/L5; L2C	Galileo E1/E5a/E5b/E6; E5 AltBOC GPS L1/L5; L2C
HORIZONTAL ACCURACY 95%	<20 cm	<20 cm
VERTICAL ACCURACY 95%	<40 cm	<40 cm
CONVERGENCE TIME	<300 s	<100 s
USER HELPDESK	24/7	24/7





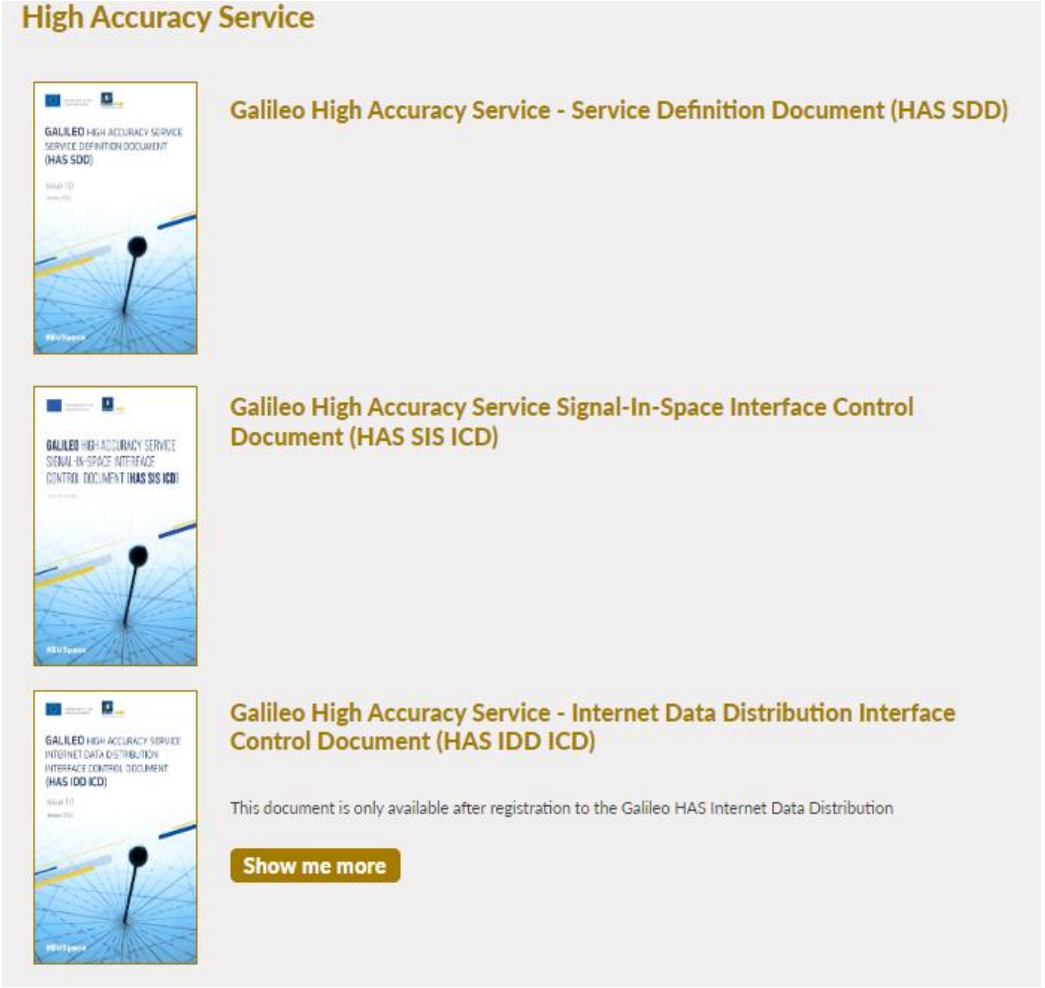
GALILEO HIGH ACCURACY SERVICE (HAS): SUMMARY AND NEXT STEPS

- Galileo HAS (High Accuracy Service) provides decimeter-level accuracy worldwide for free
- It is based on transmitting accurate orbit, clock and bias corrections to Galileo and GPS satellites, and applying PPP (Precise Point Positioning) algorithms in the receiver
- Initial service (Phase 1) launched in Jan’23 and signals provided (almost) uninterruptedly
- Full service (Phase 2) foreseen by 2026, including better coverage, ionosphere (Europe), authentication, quality indicators and other data
- Relevant complement to receivers and applications in many sectors : automotive, professional, consumer, scientific, timing, space, and others

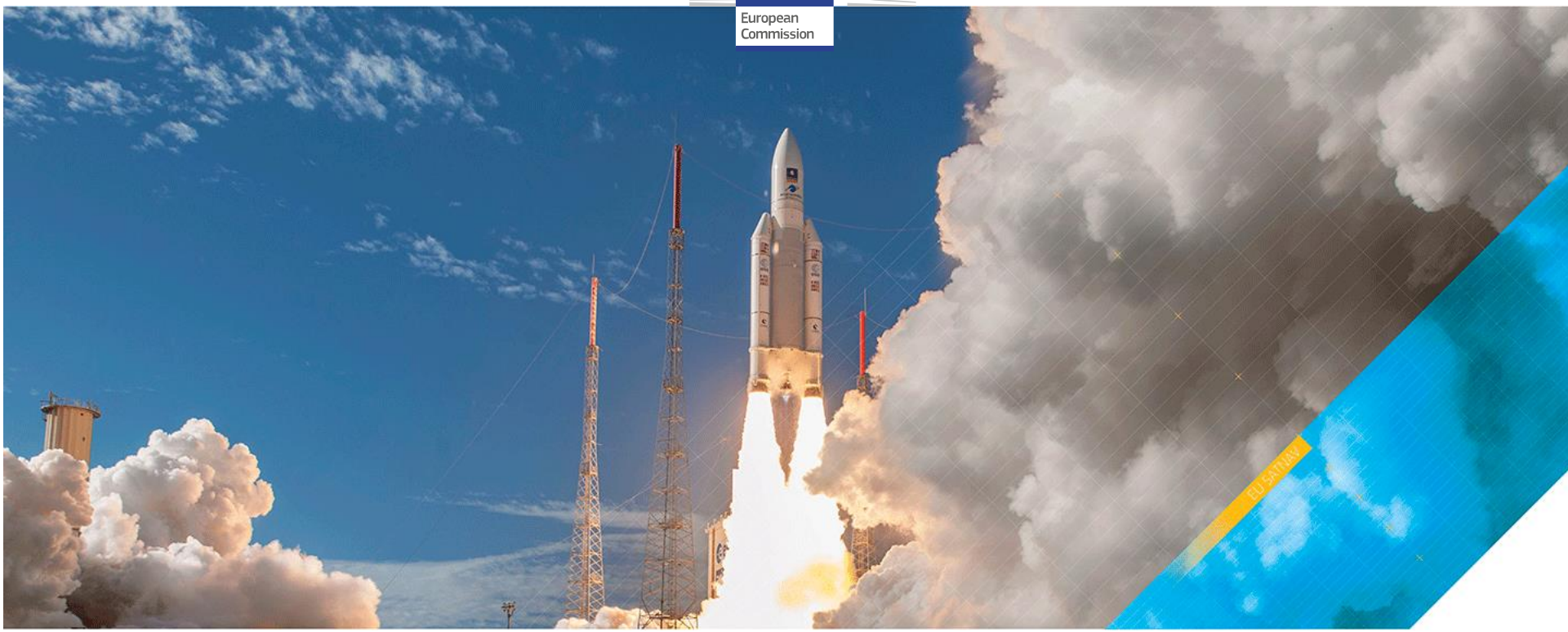
GALILEO HIGH ACCURACY SERVICE (HAS): FURTHER INFORMATION

- Galileo Reference Documents: https://www.gsc-europa.eu/electronic-library/programme-reference-documents#ACCURACY

- Other references (among many!):
  - HAS initial definition and performance: https://link.springer.com/article/10.1007/s10291-022-01247-x
  - HASlib open source tool: https://github.com/nlsfi/HASlib
  - HASlib integration with RTKLIB: https://link.springer.com/article/10.1007/s10291-024-01617-7
  - HAS user performance (incl. convergence time): https://link.springer.com/content/pdf/10.1007/s10291-023-01410-y.pdf




THE FUTURE
gmv
European GNSS Service Center
And many more…



The Emergency Warning Satellite Service in Galileo

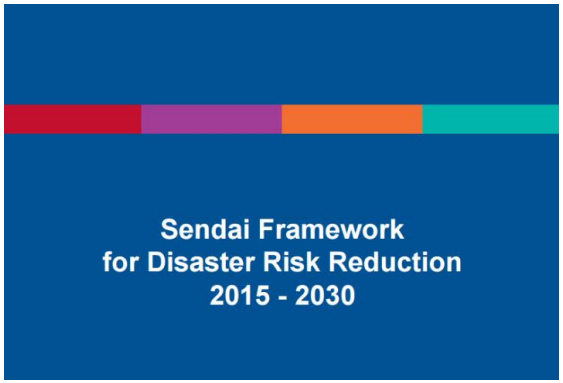
Eric Guyader

European Commission, Galileo and EGNOS programme

ICG Workshop • Kathmandu, 27 January – 1 February 2025

Eric.Guyader@ec.europa.eu

Global trend to develop Disaster Risk Reduction technologies

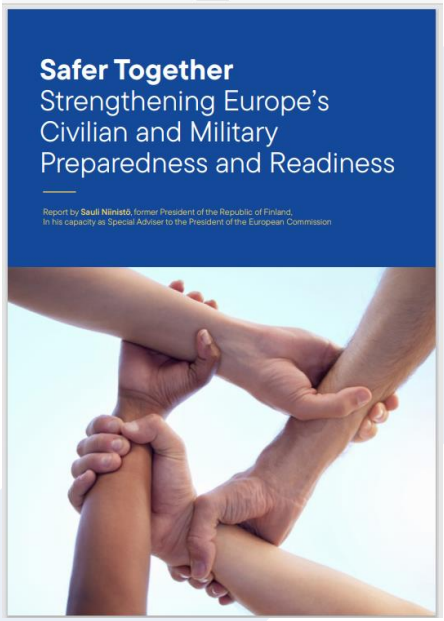


Target G of the Sendai Framework

« Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030 »

Niinistö report

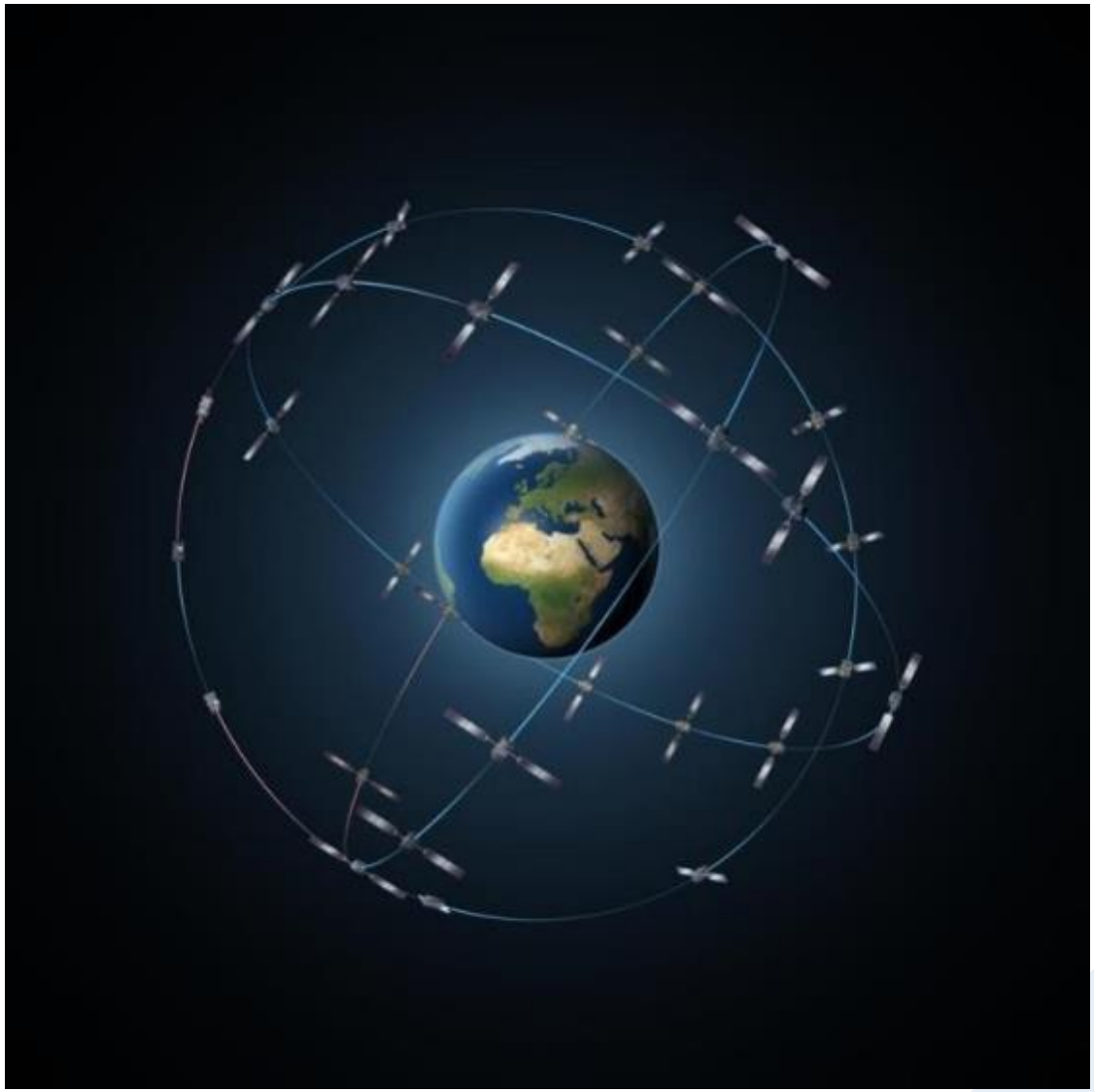
« Reinforce crisis and emergency communications with citizens by improving alert mechanisms and early warning systems to ensure a capacity to reach citizens under all conditions »



Galileo contribution to these targets:

Emergency Warning Satellite Service (EWSS)

GALILEO TODAY



– 32 satellites in orbit

– Remarkable performance

– Operational services, or in roll-out phase

– Strong link with users, market and industry

– Modernization on-going

SERVICE CONCEPT

National Emergency Centre

DECISION

CAP / XML

Galileo Emergency Service Interface

EWS Message Bit level

L-band signals

L-band signals

ALERT

Civil protection

Galileo Ground Segment

Population

(smartphone, car navigator, Handheld, smartwatch, public display, sirens, etc)

The service is realised by three components:

Civil Protection Authorities **Galileo infrastructure** **end users**

EWSS TEASER

Click to play

WARNING CONCEPT

Type of alert

Type of hazard

Severity of hazard

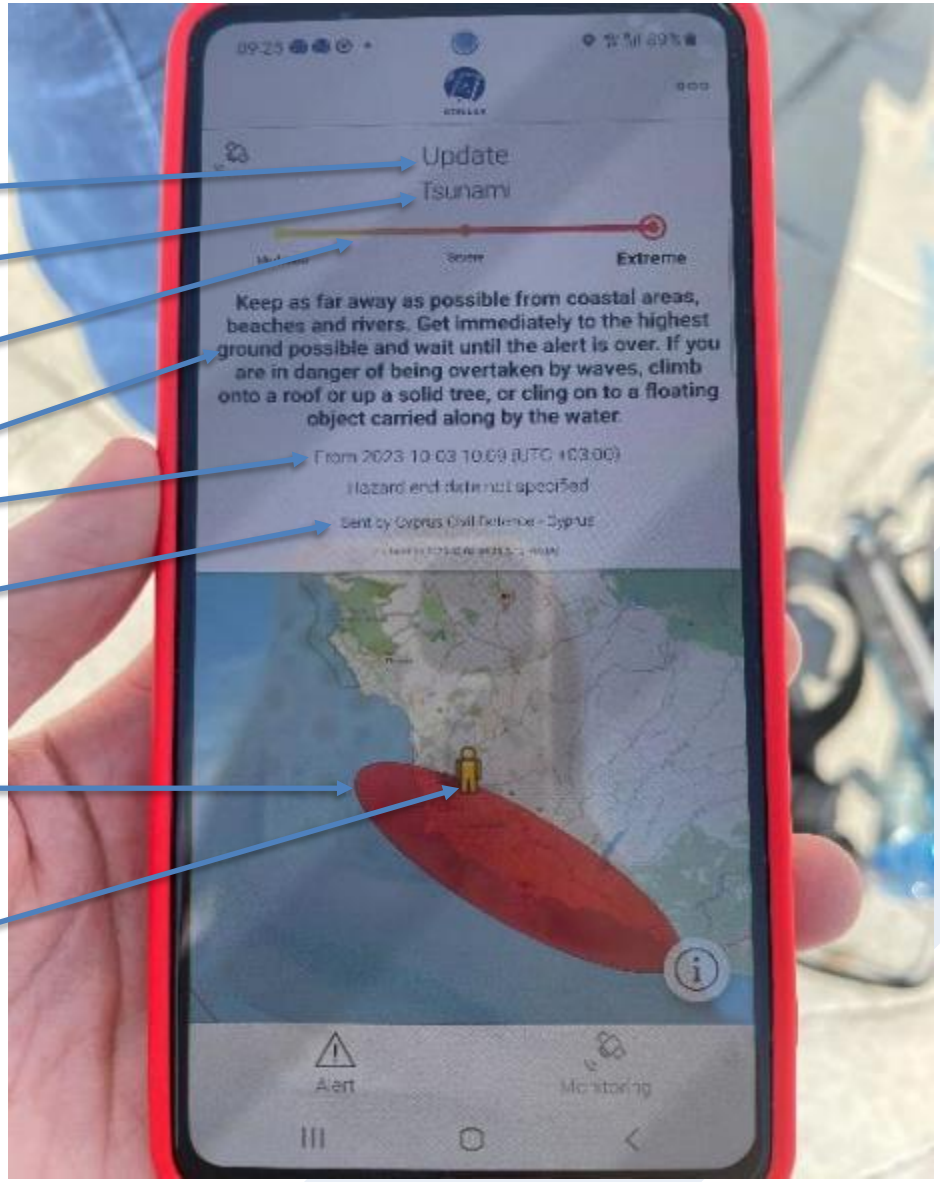
Instruction

Chronology of hazard

Originator of alert

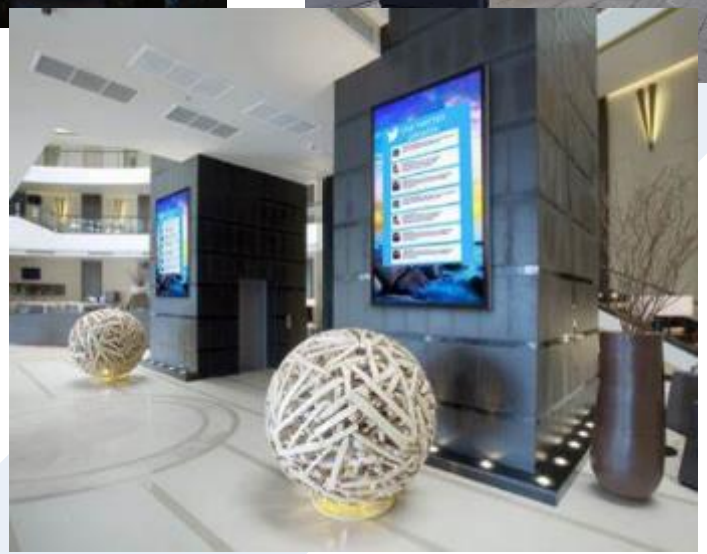
Alert area (ellipse)

YOUR POSITION



TARGET AUDIENCE

GALILEO EGNOS
NAVIGATION MADE IN EUROPE



WHERE WE ARE

- **In-field demonstration campaign finished**
  - 4 locations in EU (FR, DE, CY, BE/LU). All very successful !
  - Different scenarios tested each time: floods, fire, tsunami, industrial accident
  - Demo format: 1 team in the crisis room generating the alert, 1 team outside with the smartphone waiting for the broadcast

- **Message format specification available***
  - Joint effort EU-Japan (Galileo-QZSS)
  - Instructions available in 24 languages

- **Introduction of the capacity in the Galileo system**
  - Connections of civil protection agencies to Galileo + national tests: on-going as we speak !
  - Service declaration: 2025

- **Smartphone app' available in 2025 (Android + iOS)**

* https://www.gsc-europa.eu/electronic-library/programme-reference-documents#EWSS

INTERNATIONAL COOPERATION (1)

- **EC supports standardisation efforts of GNSS-based alert service**
  - Continue cooperation with Japan/QZSS + extend to other interested GNSS nations
  - Develop receiver standards to ease adoption in markets

- **Regular coordination with United Nations initiatives & bodies**
  - UNESCO International Oceanographic Commission
  - EW4ALL programme (WMO, ITU, UNDRR)
  - Panel at COP28
  - ICG (annual meetings, workshops)

- **Contribution of partners constellations under assessment**
  - Opportunity to alleviate limitations: more bandwidth, free text, higher signal power, etc

INTERNATIONAL COOPERATION (2)

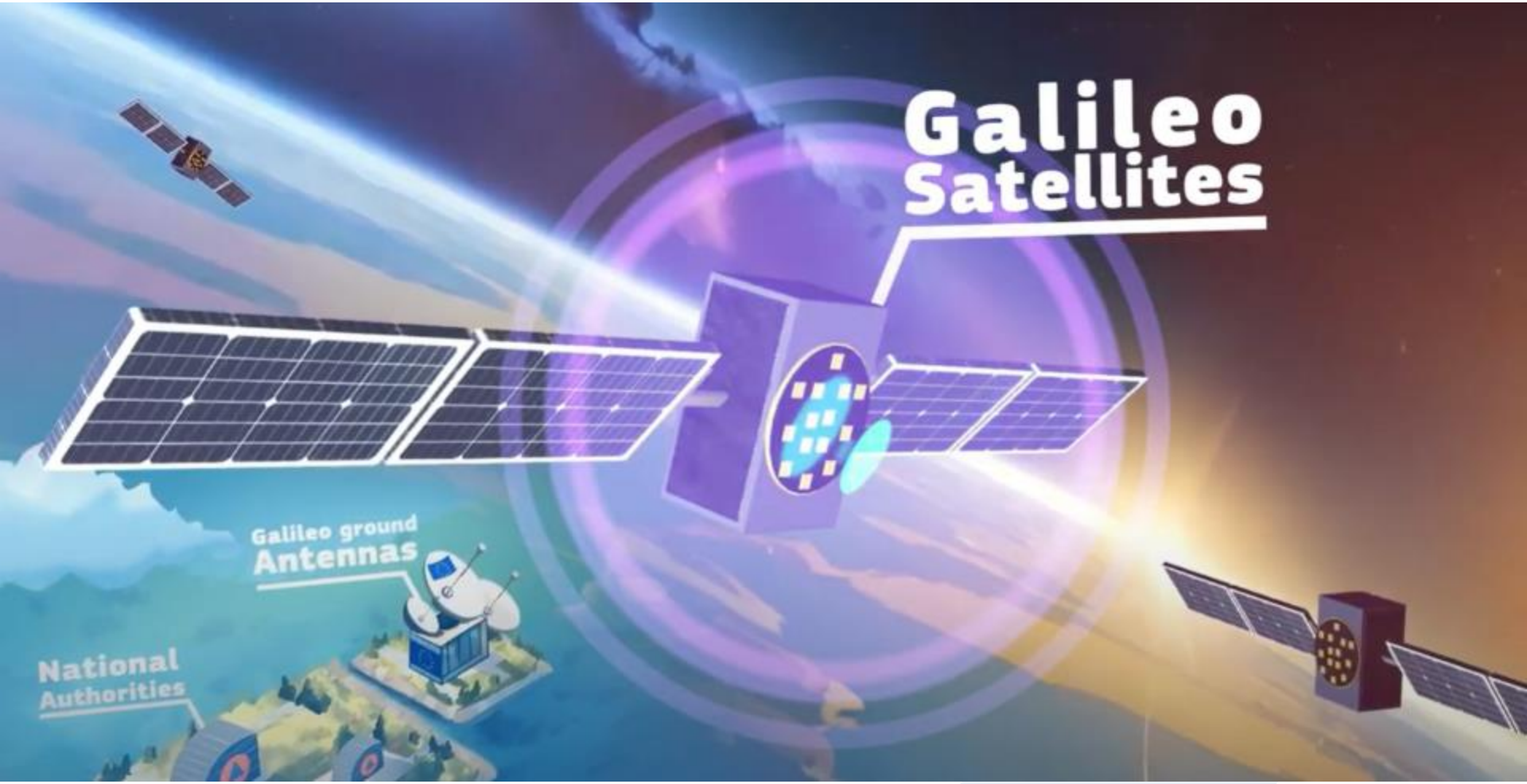
- **Use of Galileo EWSS solution at the benefit of 3rd parties is under assessment at EU level**
  - Take advantage of **global coverage** of Galileo for saving lives
  - Need to identify a unique operational interface for triggering an alert
    - ❑ *At EU level ? At UN level ?*
  - Operational concept to be further studied (who, how, liabilities, etc)

- **SUNSHINE project just started (January 2025)**
  - Promote a mindset in national civil protection authorities to use the space component for disaster prevention and management
    - ❑ Training on use of space capacities in the field of disaster management
    - ❑ EWSS simulation exercises with civil protection community
    - ❑ On-site technical assistance to help integrate EWSS in national alert systems
    - ❑ Assessment of opportunities and cooperations

STAY TUNED IN 2025 !

SUMMARY

- **Service coverage:** Global
- **Robust to disasters:** no terrestrial base station
- **Multi-language alert service:** thanks to the use of libraries
- **GNSS-based positioning in the user equipment enables geofenced message limited to the devices in affected area**
  - Size of alert area: diameter 50 m < Ø < 5000 km
  - Precision: that of GNSS !
- **Time to disseminate:** ~ 1 minute
- **No dedicated, exotic equipment needed:** GNSS-enabled device with a screen is sufficient
  - Mobile (smartphone, car navigator, handheld)
  - Stationary (billboard, digital panels, bus stop, subway station, etc)
- **By nature, a subject for international cooperation…**


Galileo
Satellites
Galileo ground
Antennas
National
Authorities

THANK YOU