

Galileo Authentication and High Accuracy IGS - 23 May 2023 Ignacio Fernandez Hernandez European Commission

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• Galileo Open Service Navigation Message Authentication (OSNMA)

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# What is Galileo OSNMA

- What is Galileo OSNMA?
  - Stands for Open Service Navigation Message Authentication
  - Mechanism to authenticate the Galileo data used to calculate a position: satellite orbits and clock corrections, satellite status flags, time...
  - Equivalent to a Galileo "digital signature"
  - Transmitted in 40 bits every other second in the Galileo I/NAV message, E1B component, 1575.42 MHz
  - Makes the signal unpredictable



E1-B									
Even/odd=1	Page Type	Data (2/2)	OSNMA	SAR	Spare	CRC	Reserved 2	Tail	Total (bits)
1	1	16	40	22	2	24	8	6	120
			HKROOT	MACK					
			8	32					

### • Why OSNMA?

## Why OSNMA



### The OSNMA protocol































### OSNMA availability



Availability of 4-satellite I/NAV authentication, 80-bit tags (recommended: 40 bits), 120s. March 2023

### OSNMA accuracy





Average difference between legacy and OSNMA vertical and horizontal position accuracy (95%) measured at each TGVFx GESS from 1<sup>st</sup> May until 30<sup>th</sup> June 2022



### OSNMA Status and Next Steps

- OSNMA Service ICD and Guidelines published in Dec'2022
- SIS switch from 'Public Testing' to 'Service' (still in 'test' mode) foreseen by Jun 2023
- Operational cryptographic data to be published in Q3-Q4 2023
- Initial Service Declaration (signal switch to 'operational' mode) foreseen by end 2023







- Galileo Open Service Navigation Message Authentication (OSNMA)
- Galileo High Accuracy Service (HAS)



## **Overview of Galileo HAS**

- Galileo HAS provides precise corrections, allowing PPP worldwide and for free
- Corrections provided for orbits, clocks, code biases and soon phase biases: Galileo I/NAV, E1, E5a,E5b, E6B/C; GPS CNAV, L1C/A, L2C, L2P
- SIS dissemination through E6B (1278.75 MHz) and ground dissemination channel through a real-time connection in RTCMlike format





## HAS current status

- •Three phases:
  - Phase 0 (testing)
  - Phase 1 (initial service)
  - Phase 2 (full service)
- HAS SIS ICD available since May 22
- Phase 1 (Initial Service) declaration on 24 Jan 2023! incl. SDD publication
- User Algorithm to be published in the next months
- Phase 2 will include global coverage, better accuracy (more stations), ionospheric corrections in Europe, authentication and error characterization



## Galileo HAS phases and performance targets

	Phase 0 SIS Testing	Phase 1 Initial Service	Phase 2 Full Service
Coverage	EU+	EU+	Global
Clock biases	Y	Y	Y
Phase biases	Ν	Y	Y
Galileo corrected signals	E1, E5a, E5b, E6	E1, E5a, E5b, E6	E1, E5a, E5b, E5, E6
GPS corrected signals	L1, L2P	L1, L2P, L2C	L1, L2C, L5
Horizontal accuracy requirement 95%	N/A	<20 cm TBC	<20 cm
Vertical accuracy requirement 95%	N/A	<40 cm TBC	<40 cm
Availability	N/A	99% TBC	99%
Convergence time requirement Global, no ionosphere (SL1)	N/A	<300 s TBC	<300 s
EU, Ionosphere corrections (SL2)	N/A	N/A	<100 s
Ground channel	Ν	Y	Y
Authentication	Ν	Ν	Y
Start	2020	2022-23	2024+



GALILEO HIGH ACCURACY SERVICE SERVICE DEFINITION DOCUMENT (HAS SDD)

Issue 1.0 January 2023 #EUSpace

<u>Galileo-HAS-SDD\_v1.0.pdf (gsc-</u> europa.eu)

## HAS orbit & clock correction accuracy

- HAS orbit and clock with live signals between May 2021 and June 2022
- Septentrio PolaRx5S rx with Trimble Zephyr 2 antenna @JRC EC (Italy)
- HAS broadcasted test signals (not yet representative of operational service)











### HAS PPP user performance

- User PPP accuracy from HAS signal tested worldwide
- Conditions: static, open sky (GMV's monitoring network)
- Performance measured in stationary mode after convergence
- RMS and 95th percentile of errors from 6 days: 31/8-6/9
- PPP configuration used:
  - Multiconstellation GAL+GPS
  - Double frequency E1-E5a and L1C/A-L2CL (Iono-free + ionospheric estimation)
  - PPP float



## HAS PPP user performance

Europe &	En	rors RMS (o	:m)	Europe &	Errors p95 (cm)		
Africa	North	East	Height	Africa	Horizontal	Vertical	
SPTR	4.5	6.6	13.8	SPTR	19.5	26.5	
ROBU	5.7	6.6	14.0	ROBU	17.3	26.8	
SWOJ	6.5	6.1	14.6	SWOJ	13.5	28.3	
NAWI	4.0	5.3	14.4	NAWI	18.1	25.3	

Vertical 32.9 38.1 36.1 40.7

America	En	ors RMS (d	:m)	Amorica	Errors p95 (cm)	
America	North	East	Height	America	Horizontal	Vertic
USNA	6.0	8.3	17.5	USNA	19.8	32.9
CABU	6.1	9.0	21.9	CABU	21.4	38.1
CHSA	8.8	13.7	24.0	CHSA	26.5	36.1
FRTA	9.1	9.7	24.2	FRTA	27.0	40.7

	Err	ors RMS (o	:m)	Acia	Errors p95 (cm)	
Asia	North	East	Height	ASId	Horizontal	Vertical
INKO	5.8	8.7	21.8	INKO	19.1	35.7
ΤΑΤΑ	8.6	15.9	27.0	ΤΑΤΑ	33.1	52.2





A. Chamorro, et al. "Early Demonstration of Galileo HAS user Performances", IONGNSS+ 2022

### Summary

- OSNMA offers data authentication and signal unpredictability for Galileo
- OSNMA is already in the SIS and is expected to be operational by end 2023
- HAS is a PPP corrections service for GPS/Galileo. It aims at 20/40cm (V/H) 95% accuracy
- HAS initial service is operational since Jan 2023
- Next steps:
  - OSNMA/HAS full operational capability
  - Spreading code authentication in E6



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Acknowledgements: Galileo OSNMA/HAS teams (EC, EUSPA, ESA, PAULA, HADG, GSC...)