



EU SPACE

Galileo High Accuracy Service (HAS)

ICG – 3PITF, 30/1/24

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European Commission

What is Galileo HAS

Galileo HAS architecture

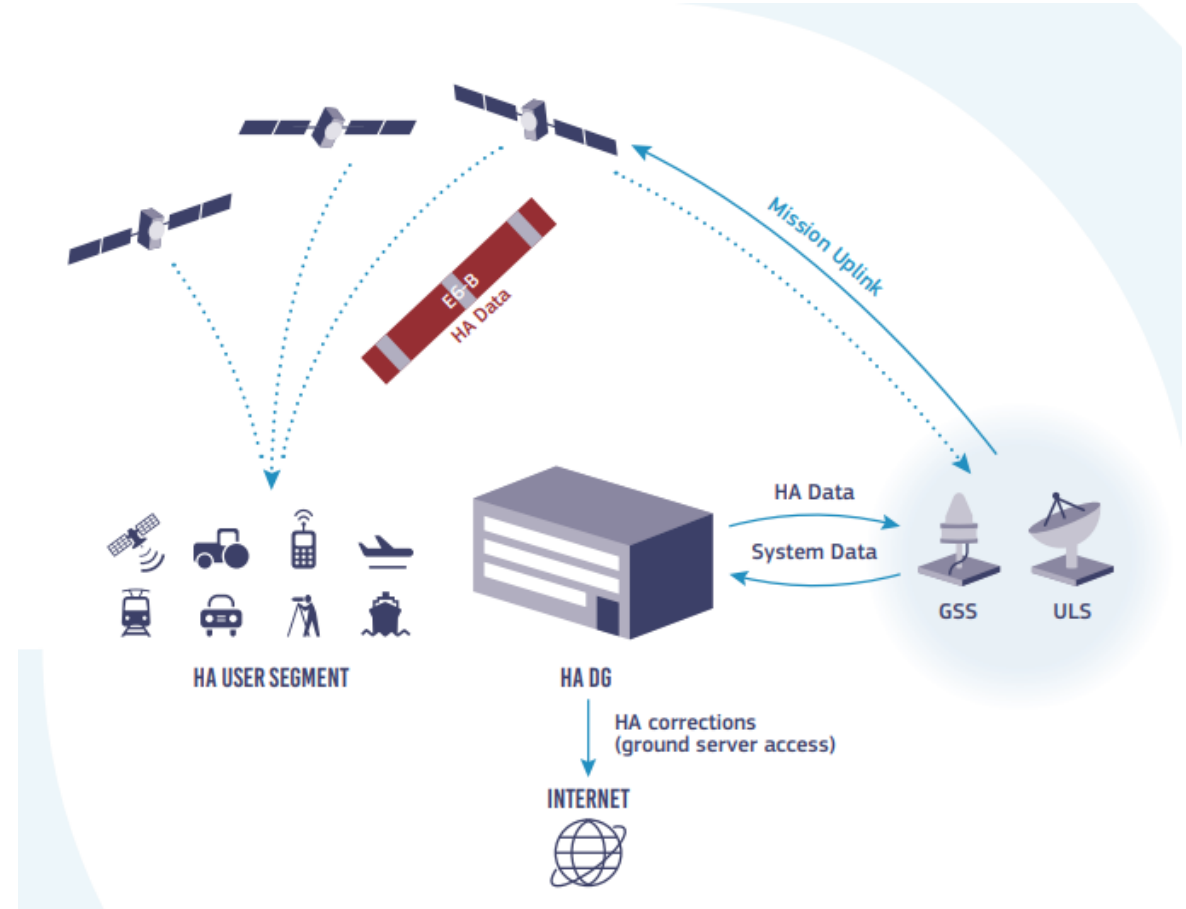
Galileo HAS performance

Galileo HAS roadmap



WHAT IS THE GALILEO 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
- (Almost) global coverage and free



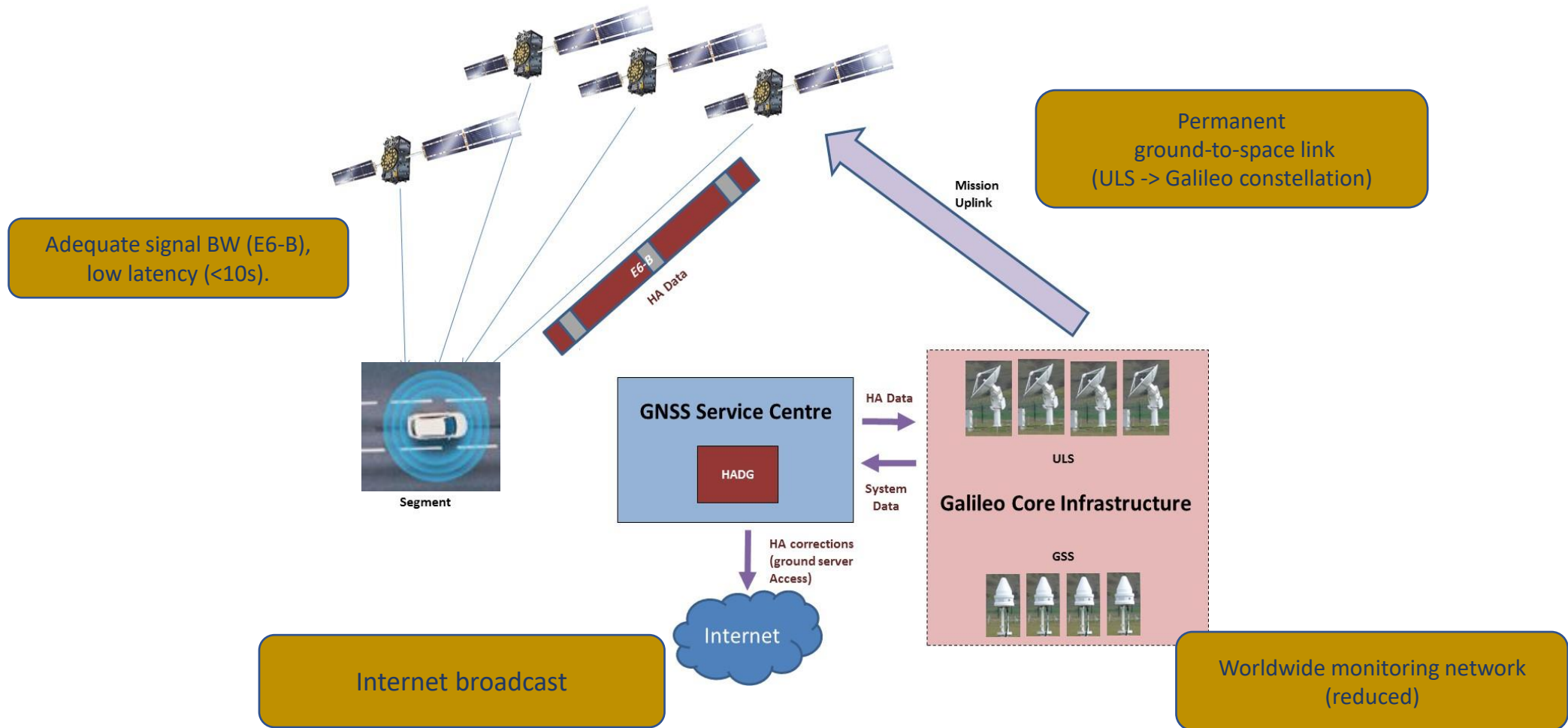
What is Galileo HAS

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GALILEO HAS ARCHITECTURE – High level service architecture



GALILEO HAS ARCHITECTURE – Ground Infrastructure



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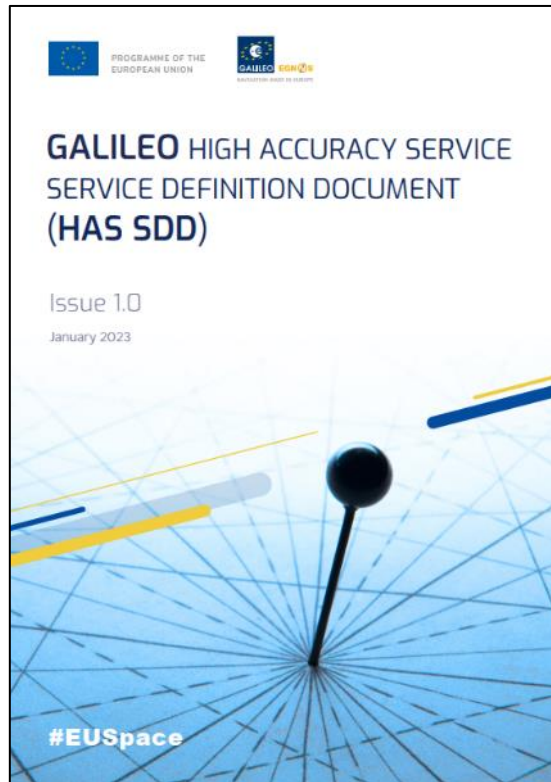
Galileo HAS performance

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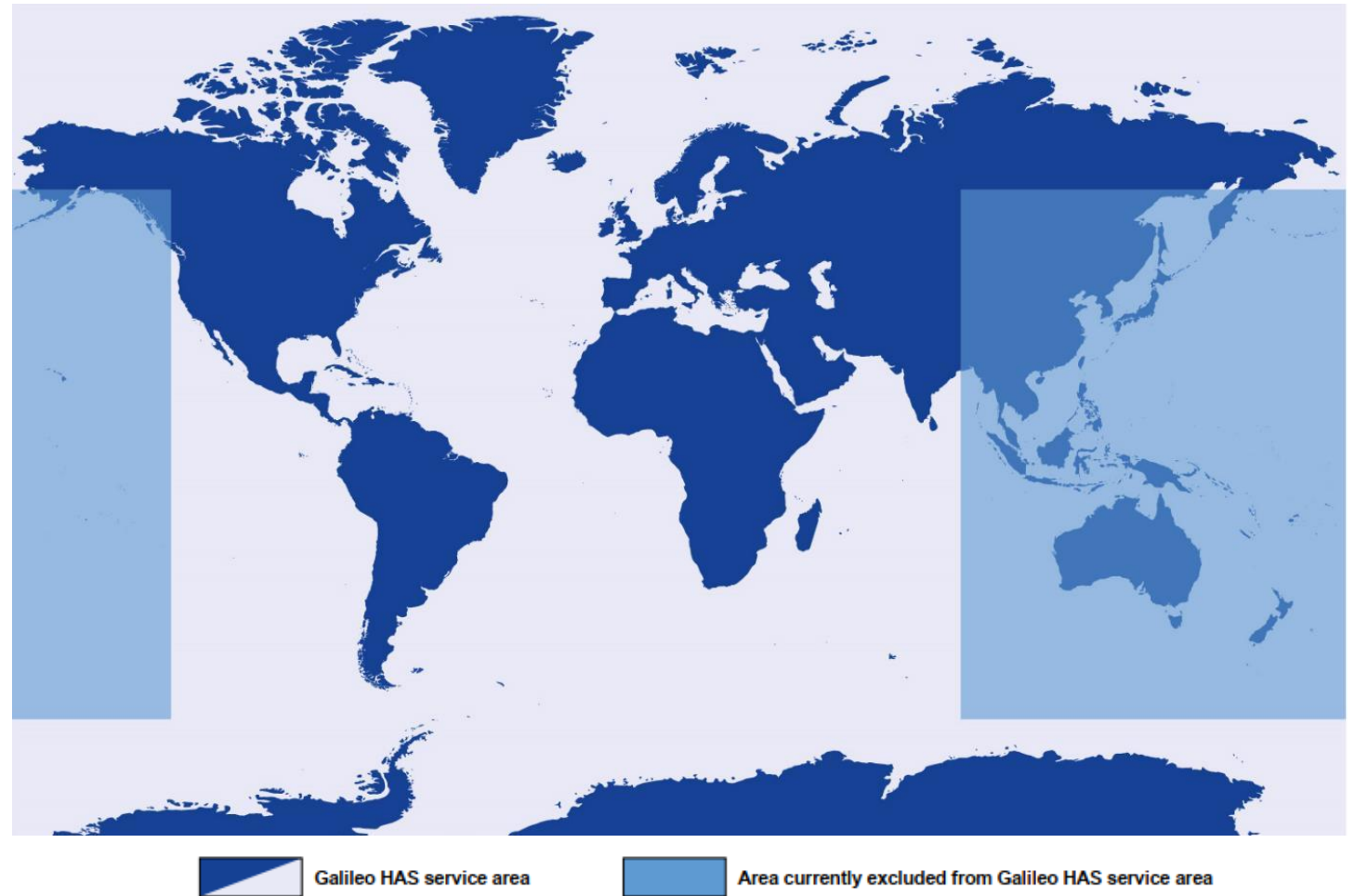
GALILEO HAS PERFORMANCE

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	<20cm
VERTICAL ACCURACY 95%	<40cm	<40cm
CONVERGENCE TIME	<300 s	<100 s
USER HELPDESK	24/7	24/7

GALILEO HAS PERFORMANCE – Initial Service



European Union Agency for the Space Programme (EUSPA), HAS SDD [Online]:
https://www.gsc-europa.eu/sites/default/files/sites/all/files/Galileo_HAS_SDD.pdf



GALILEO HAS PERFORMANCE – Quarterly Performance Reports

European **GNSS** Service Centre

https://www.gsc-europa.eu/sites/default/files/sites/all/files/Galileo-HAS-Quarterly-Performance_Report-Q3-2023.pdf



EUROPEAN GNSS (GALILEO) SERVICES

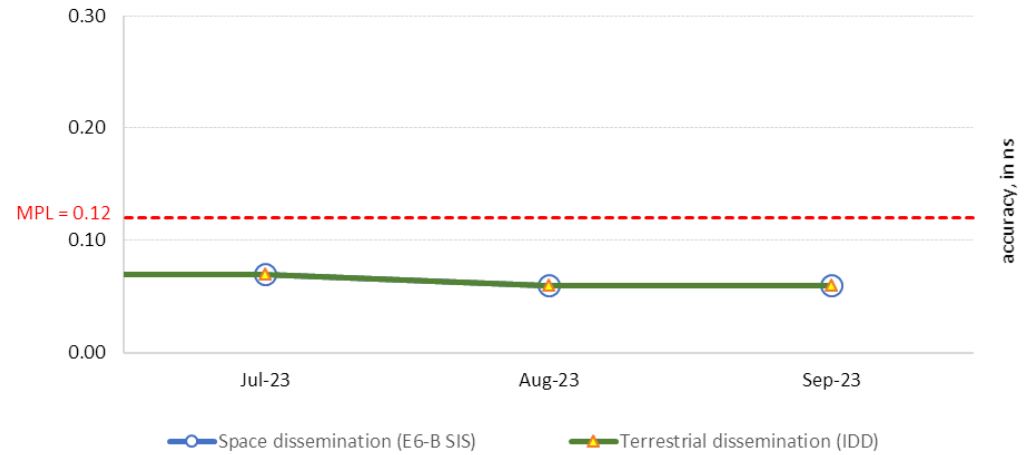
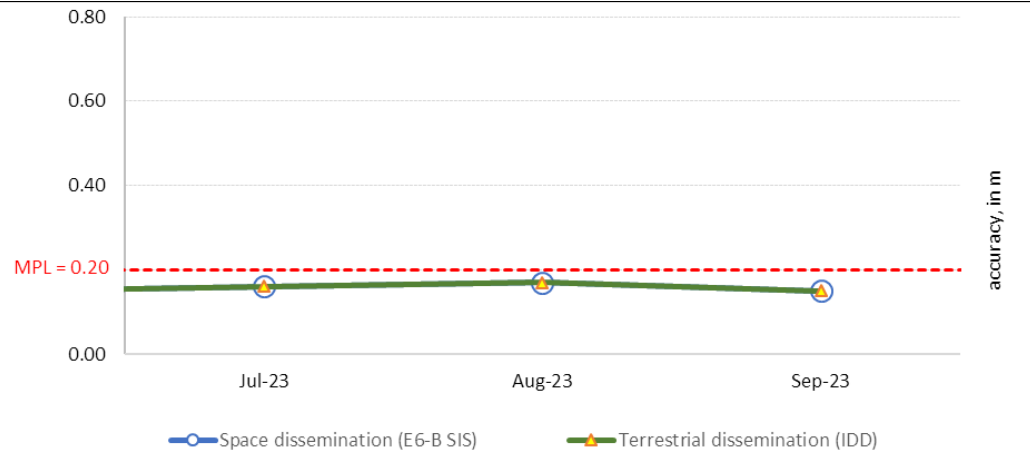
HIGH ACCURACY SERVICE (HAS)

QUARTERLY PERFORMANCE REPORT

JULY – SEPTEMBER 2023

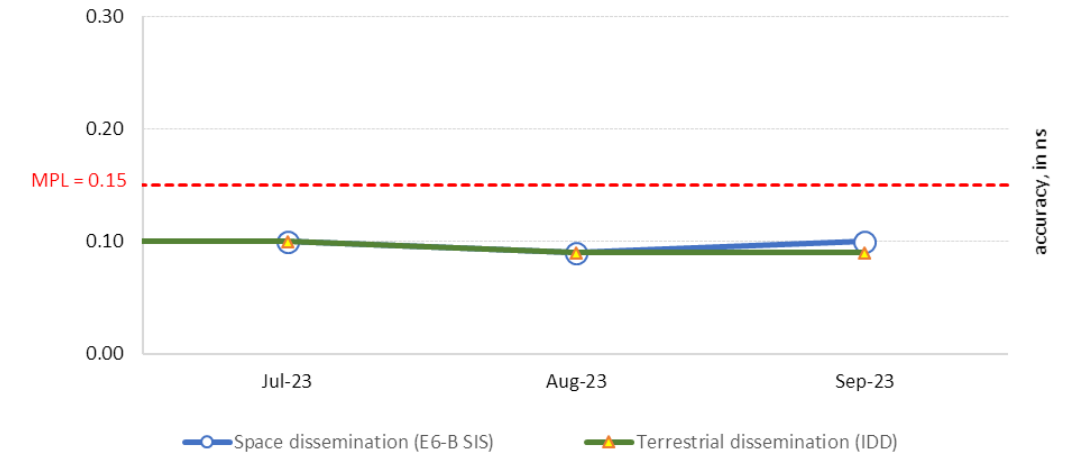
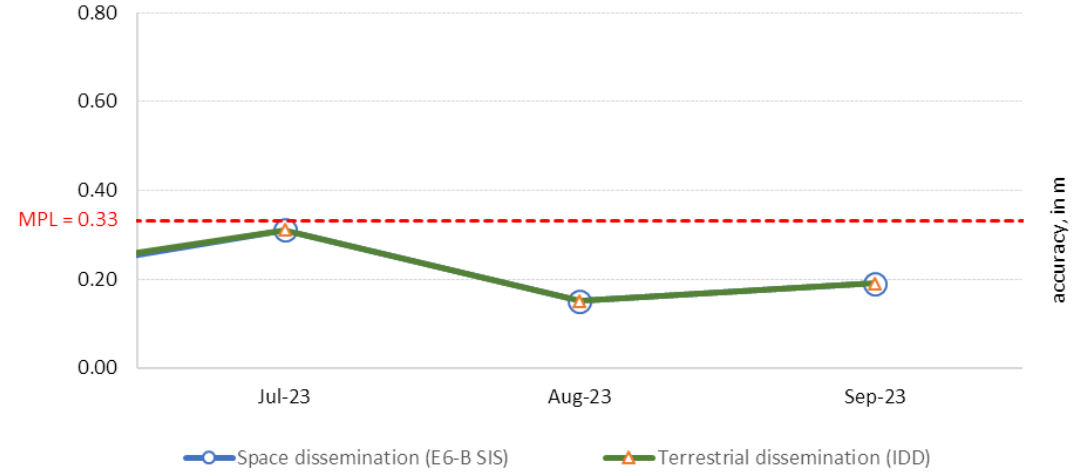
HAS Performance – Product Accuracy

Galileo orbit corrections (95%)



Galileo clock corrections (95%)

GPS orbit corrections (95%)



GPS clock corrections (95%)

HAS Performance – Product Accuracy

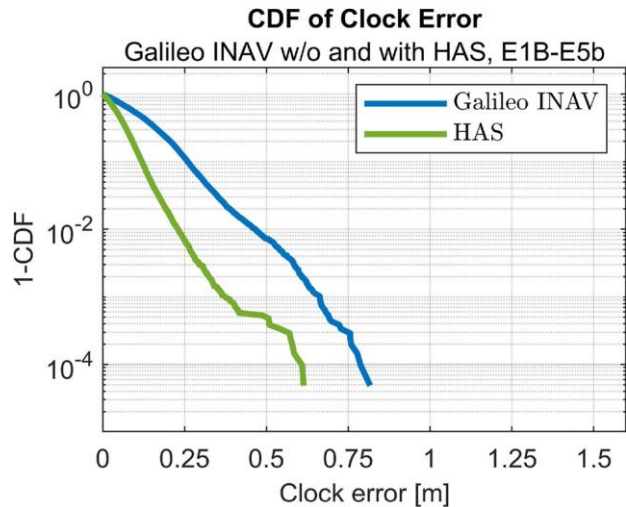
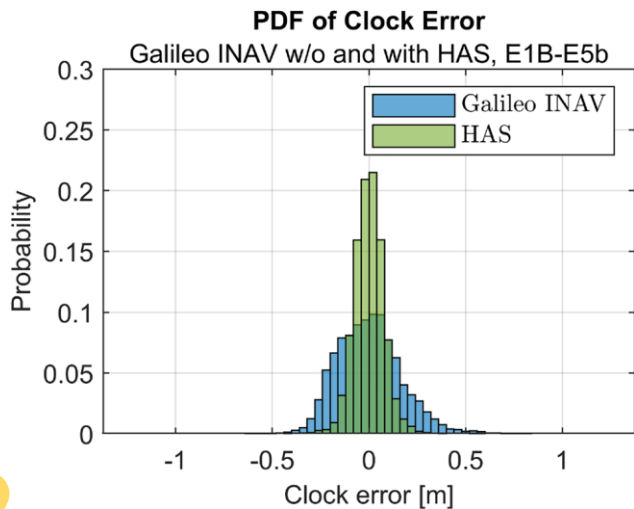
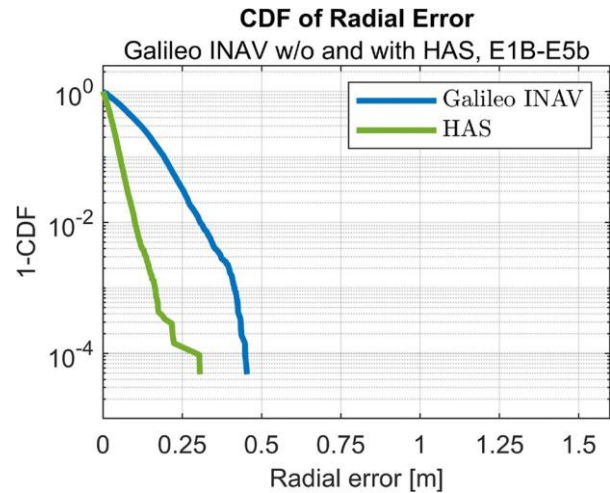
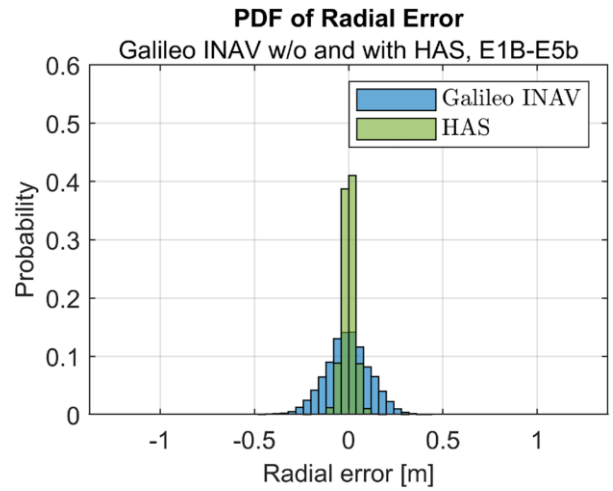


Table 4 Average and 95th percentile SISE—Galileo E1-E5a (left) and GPS L1C/A-L2P (right), September 11, 2020.

Satellite	Average [m]	P95 [m]
E12	0.057	0.118
E24	0.045	0.076
E09	0.067	0.167
E04	0.059	0.114
E08	0.047	0.079
E30	0.039	0.069
E13	0.032	0.061
E07	0.029	0.055
E15	0.029	0.055
E11	0.083	0.186
E26	0.042	0.071
E33	0.050	0.100
E03	0.047	0.111
E31	0.028	0.075
E02	0.037	0.06
E36	0.047	0.108
E27	0.038	0.082
E25	0.038	0.088
E21	0.035	0.073
E05	0.064	0.149
E19	0.056	0.103
Gal all-sat avg	0.046	0.095
G15	0.055	0.110
G11	0.097	0.426
G09	0.056	0.107
G03	0.069	0.148
G22	0.051	0.100
G17	0.066	0.229
G18	0.101	0.239
G13	0.069	0.155
G12	0.056	0.102
G20	0.052	0.113
G21	0.057	0.107
G27	0.095	0.190
G19	0.124	0.193
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G05	0.042	0.078
G28	0.060	0.102
G31	0.072	0.117
G07	0.043	0.080
G10	0.093	0.285
G30	0.150	0.224
G16	0.066	0.129
G32	0.050	0.096
G06	0.116	0.200
G25	0.058	0.153
G01	0.093	0.169
G26	0.089	0.196
G08	0.081	0.150

Satellite	Average [m]	P95 [m]
GPS all-sat avg	0.075	0.160

Fernandez-Hernandez et al. "Galileo high accuracy service: initial definition and performance", GPS Solutions, 2022

Martini et al. "Galileo high accuracy service performance and anomaly mitigation capabilities", GPS Solutions, 2024

HAS Performance – Product Accuracy

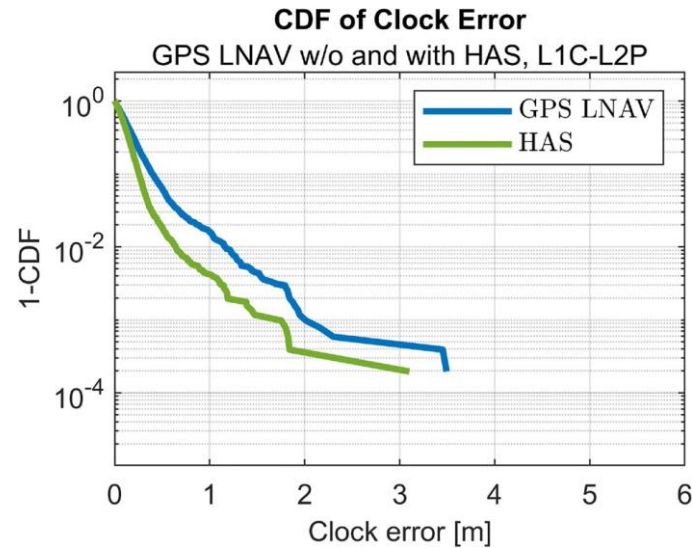
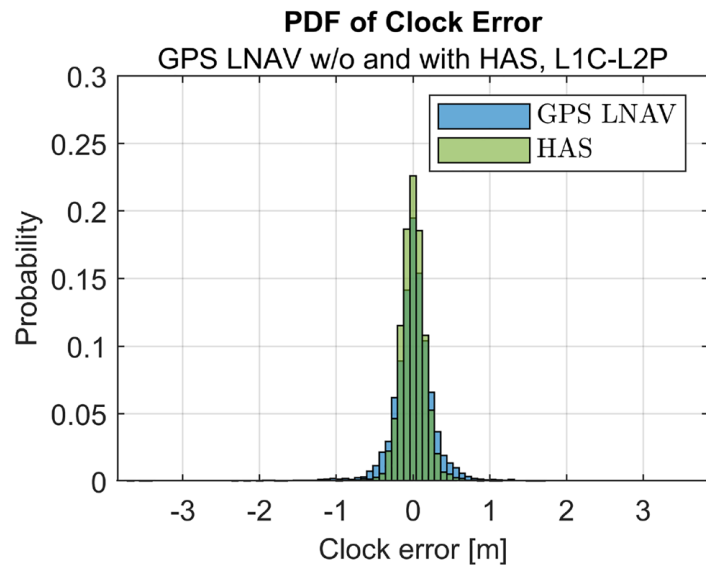
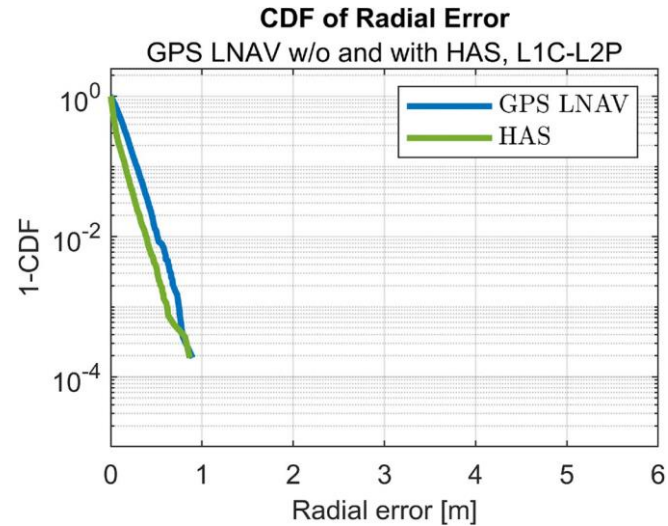
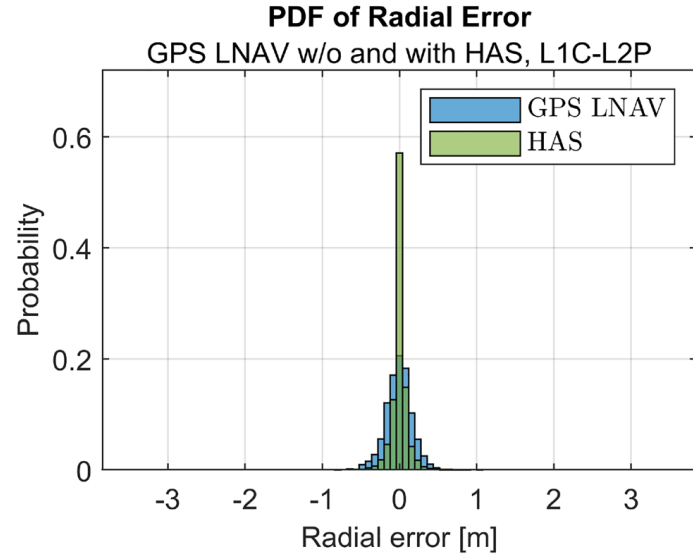


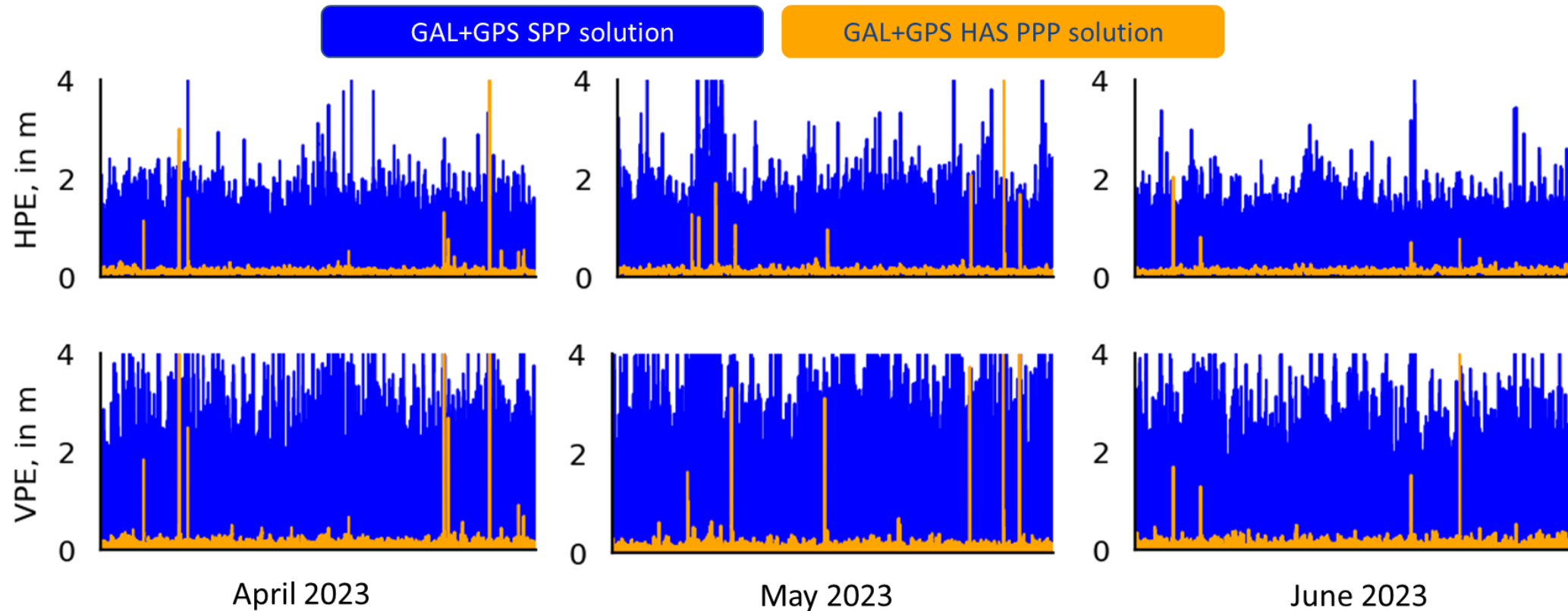
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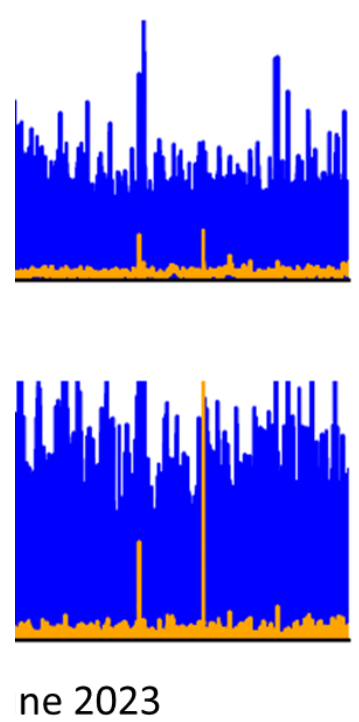
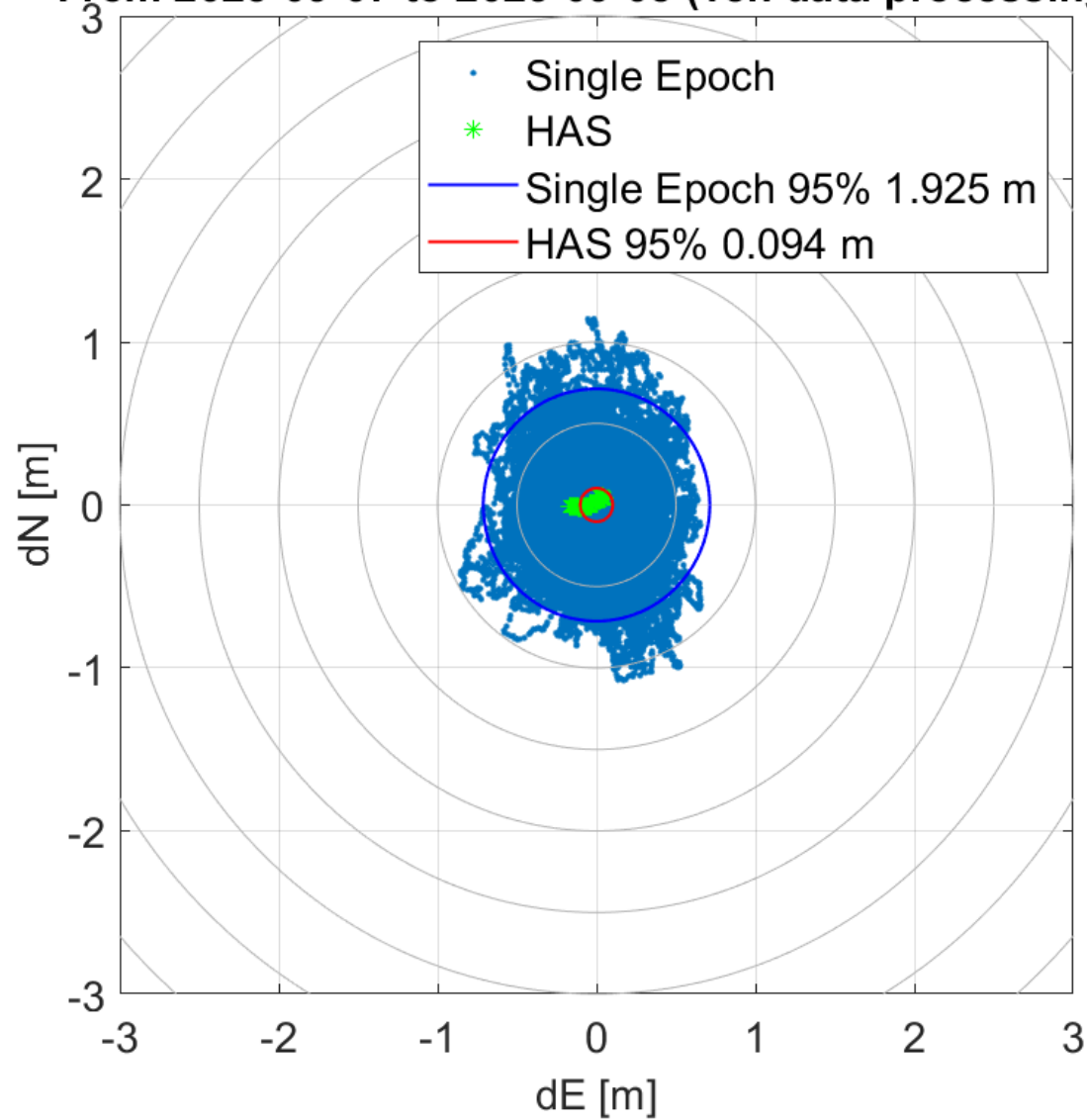
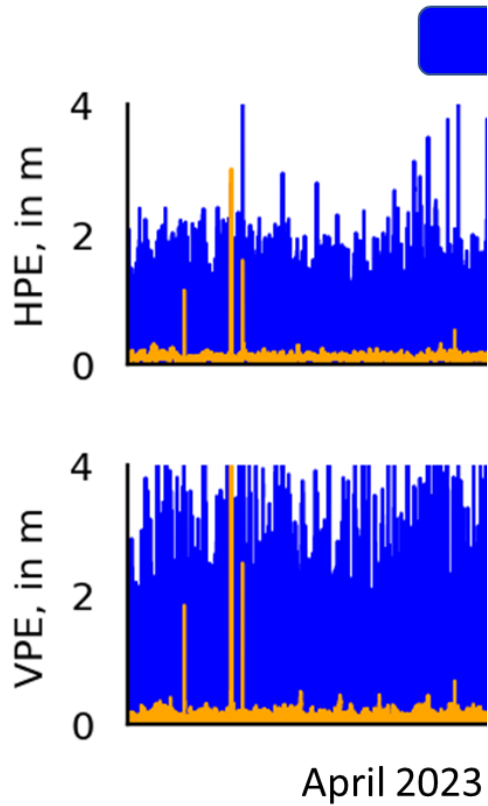
HAS Performance – Receiver PPP Accuracy

HAUT Rx, Rome (IT)



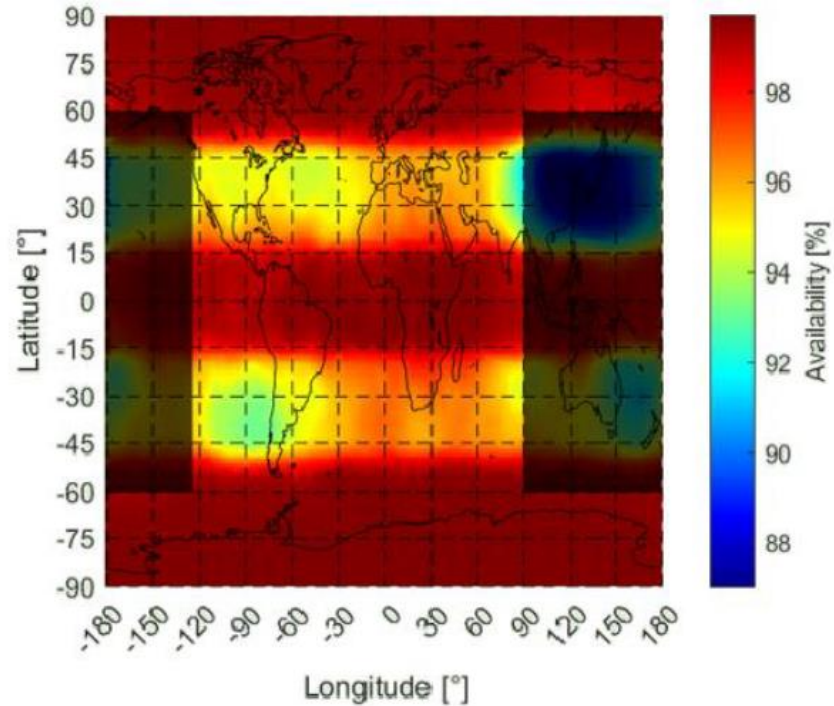
HAS Performance

Receiver PPP Accuracy
Scatter plot comparison. HAS E1+E5b L1+L2C
From 2023-09-07 to 2023-09-08 (18h data processing)



HAS Performance - Availability

- availability of at least 5 corrected Galileo satellites in view



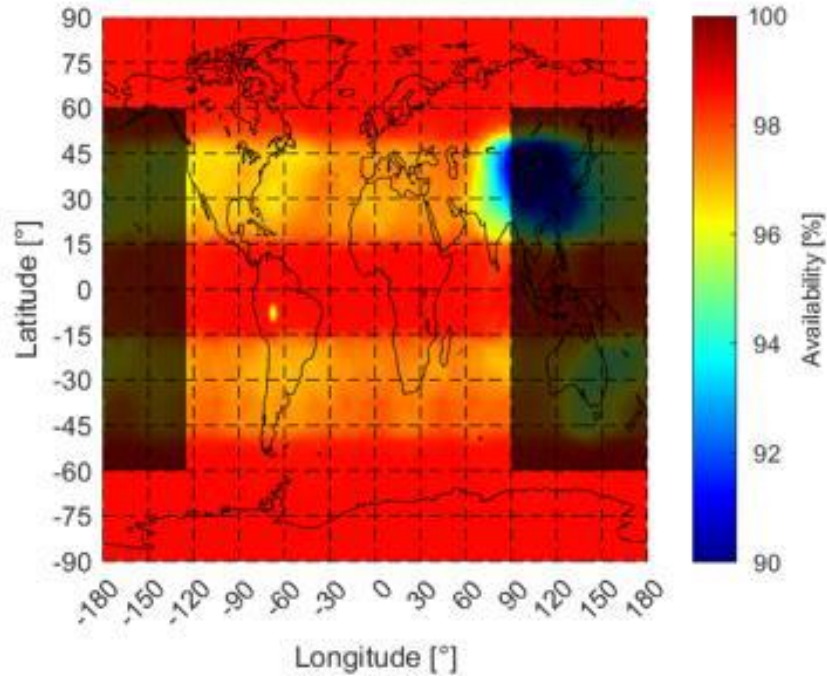
Dissemination via SIS

Grid map: min=87.03%, mean=96.93%
Service area: min=91.47%, mean=97.74%

March 2023

HAS Performance - Availability

- availability of at least 5 corrected Galileo satellites in view



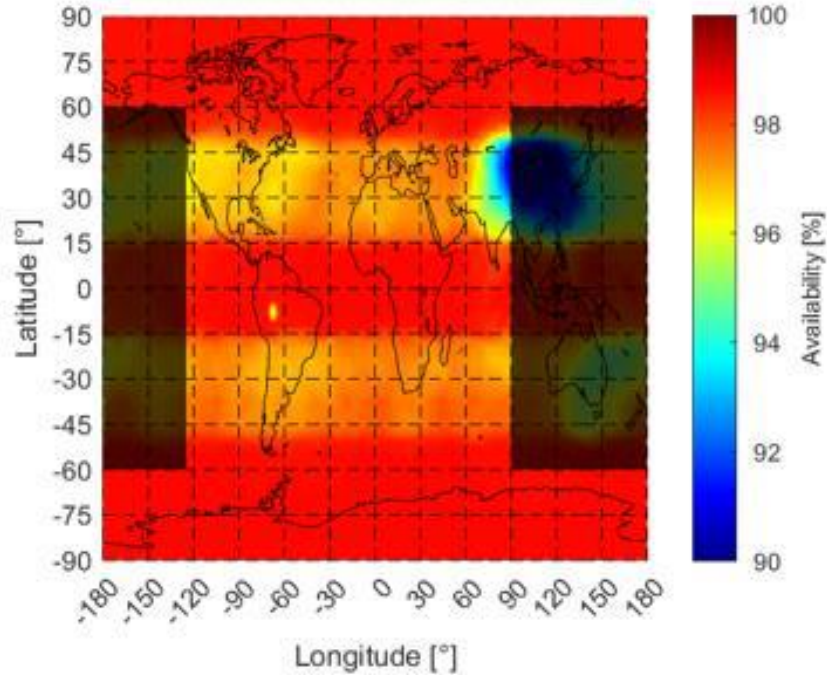
Dissemination via SIS

Grid map: min=88.84%, mean=97.50%
Service area: min=90.37%, mean=97.91%

September 2023

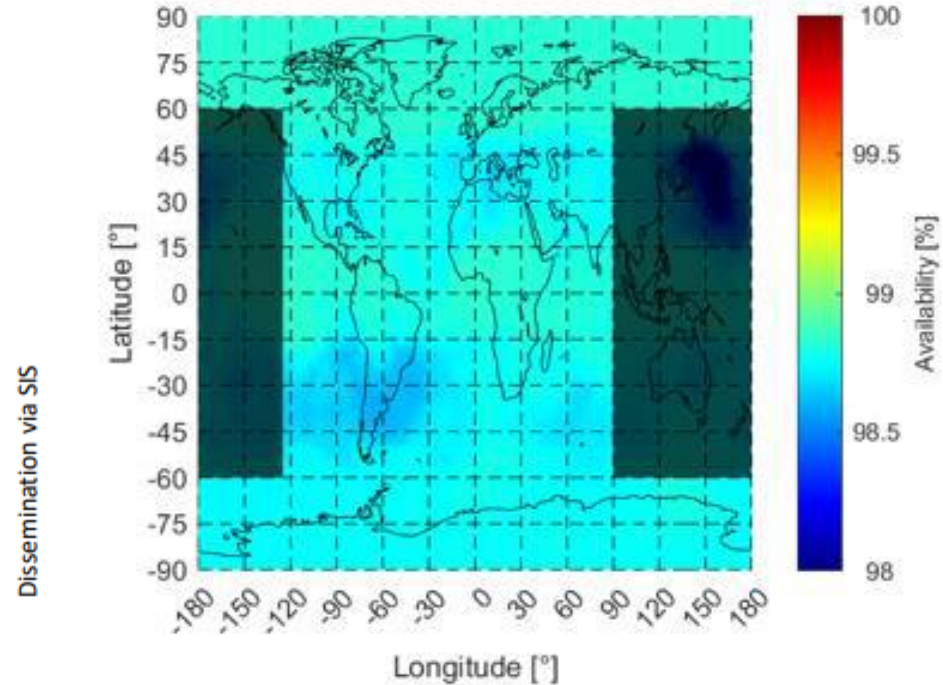
HAS Performance - Availability

- availability of at least 5 corrected Galileo satellites in view



Grid map: min=88.84%, mean=97.50%
Service area: min=90.37%, mean=97.91%

- availability of at least 8 Galileo and/or GPS satellites in view.



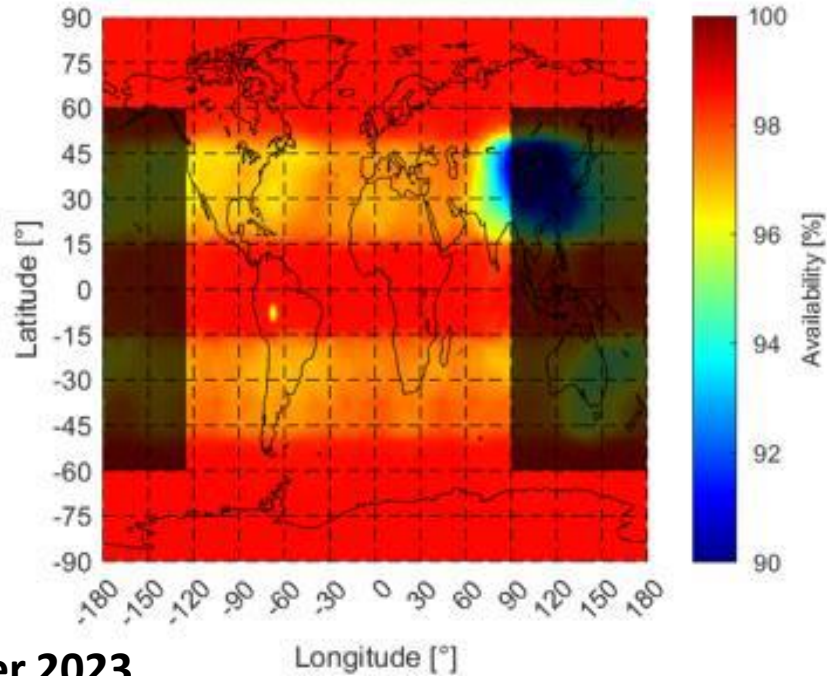
Grid map: min=98.06%, mean=98.74%
Service area: min=98.58%, mean=98.76%

September 2023



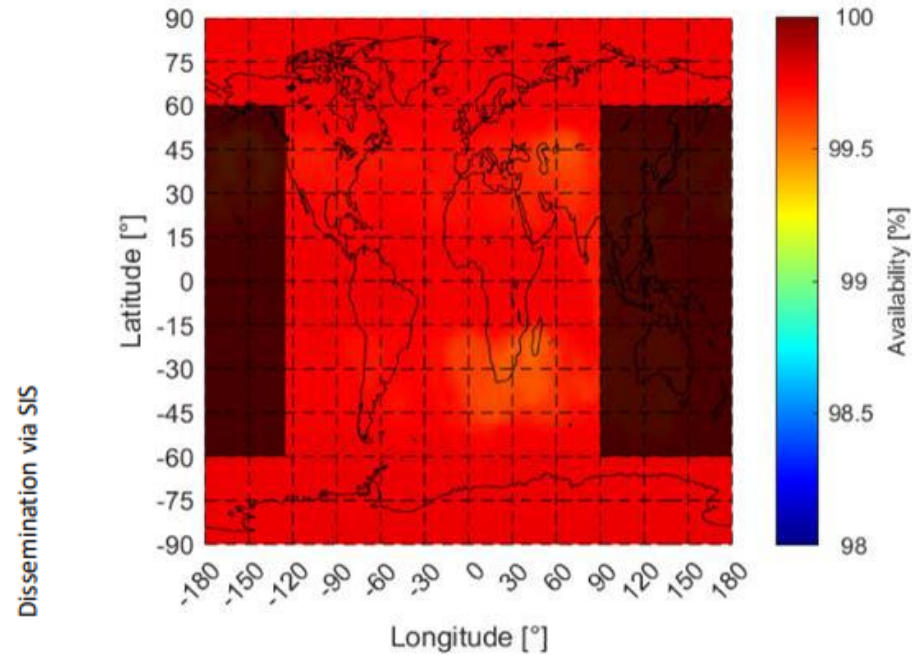
HAS Performance - Availability

- availability of at least 5 corrected Galileo satellites in view



Grid map: min=88.84%, mean=97.50%
Service area: min=90.37%, mean=97.91%

- availability of at least 8 Galileo and/or GPS satellites in view.



Grid map: min=99.53%, mean=99.73%
Service area: min=99.53%, mean=99.73%

July 2023

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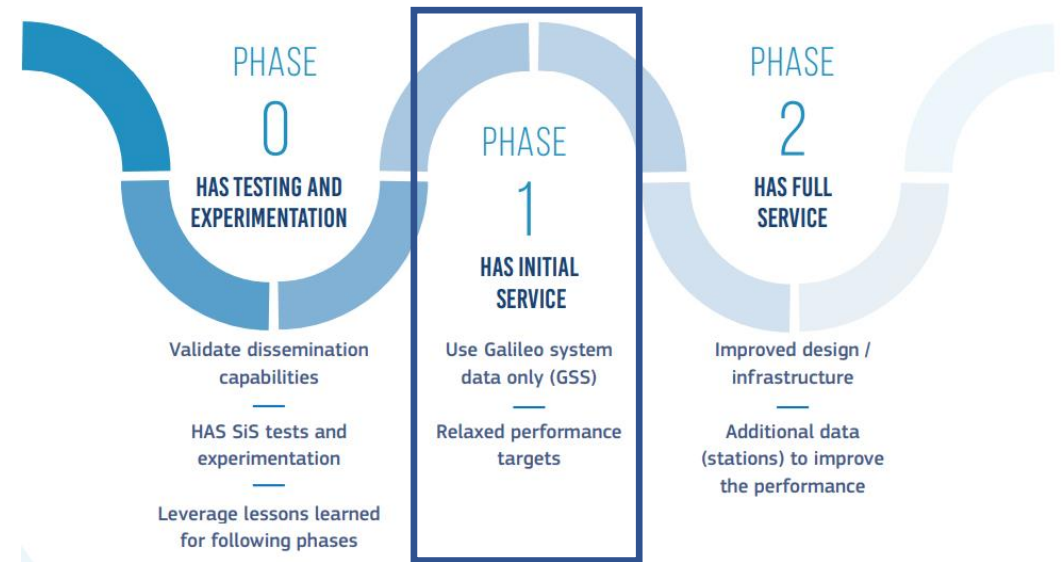
GALILEO HAS ROADMAP – What comes next?

■ Progress since last 3PITF

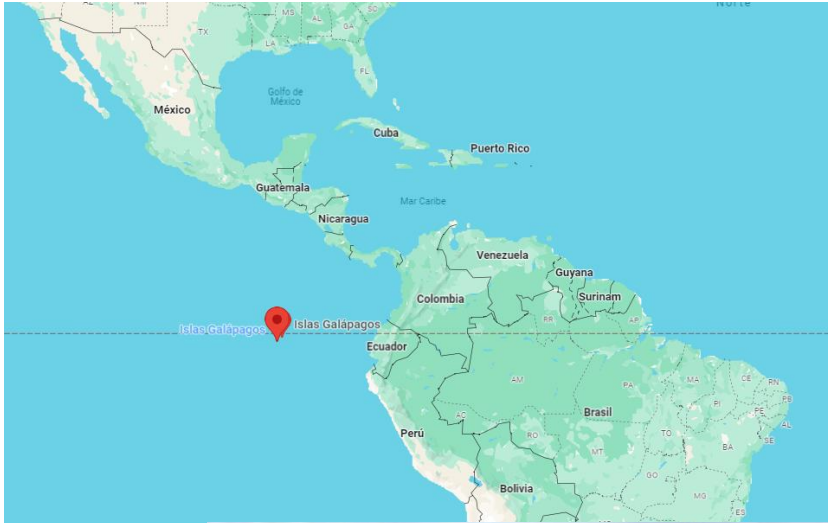
- One more station deployed (Wallis)
- Another station in deployment (Bonaire)
- Infrastructure improvements
- Internal definition of Phase 2 ongoing: New stations, new messages and blocks (iono, confidence levels, authentication...)
- Anniversary of HAS Initial Service, with continuous PPP corrections delivered since then

■ Next steps

- Publication of User Algorithm (incl. software lib and test vectors)
- Addition of phase biases
- Continuous performance and infrastructure improvements
- Phase 2 deployment by 2026



GALILEO HAS Use cases



“The precision with [the Arrow Gold+ and Galileo HAS] was incredible. I will use one for every project I ever do, ever.”
Charles Lehen, Ecologist, University of Southern California

<https://eos-gnss.com/successes/galapagos>



THE FUTURE

REGULATORY AND RESCUE SERVICE

European GNSS Service Center

And many more...



EU SPACE

Galileo High Accuracy Service (HAS)

ICG 3PITF – 29/1/24

Ignacio Fernandez-Hernandez
European Commission
(based on previous EC/EUSPA presentations)