2019 - GALILEO PROGRAMME UPDATE

GALILEO EGNOS
NAVIGATION MADE IN EUROPE

Dominic HAYES — EUROPEAN COMMISSION
Joerg HAHN — EUROPEAN SPACE AGENCY

ICG 2019 • Bangalore, December 2019

WORKING TOGETHER

European Commission

esa

European Global Navigation Satellite Systems Agency

- New Single EU Space Programme for 2021-2027
  - managed by new DG “DEFIS”
  - exploit synergies of Copernicus, Galileo/EGNOS, GovSatCom, SSA
- EU: a global actor in space
- Excellence and international cooperation remain key

GALILEO OPERATIONAL CONSTELLATION STATUS

22 operational for NAV
23 operational for SAR

Batch	Launch	Satellite	Status	Name
IOV	L1 (21/10/2011)	GSAT 101	Nominal	Thijs
		GSAT 102	Nominal	Natalia
	L2 (12/10/2012)	GSAT 103	Nominal	David
		GSAT 104	SAR only	Sif
FOC	L3 (22/08/2014)	GSAT 201	Elliptic Orbit	Doresa
		GSAT 202	Elliptic Orbit	Milena
	L4 (27/03/2015)	GSAT 203	Nominal	Adam
		GSAT 204	Spare	Anastasia
	L5 (11/09/2015)	GSAT 205	Nominal	Alba
		GSAT 206	Nominal	Oriana
	L6 (17/12/2015)	GSAT 208	Nominal	Andriana
		GSAT 209	Nominal	Liene
	L7 (24/05/2016)	GSAT 210	Nominal	Danielė
		GSAT 211	Nominal	Alizée
	L8 (17/11/2016)	GSAT 207	Nominal	Antonianna
		GSAT 212	Nominal	Lisa
		GSAT 213	Nominal	Kimberley
		GSAT 214	Nominal	Tijmen
	L9 (12/12/2017)	GSAT 215	Nominal	Nicole
		GSAT 216	Nominal	Zofia
		GSAT 217	Nominal	Alexandre
		GSAT 218	Nominal	Irina
	L10 (25/07/2018)	GSAT 219	Nominal	Tara
		GSAT 220	Nominal	Samuel
		GSAT 221	Nominal	Anna
		GSAT 222	Nominal	Ellen

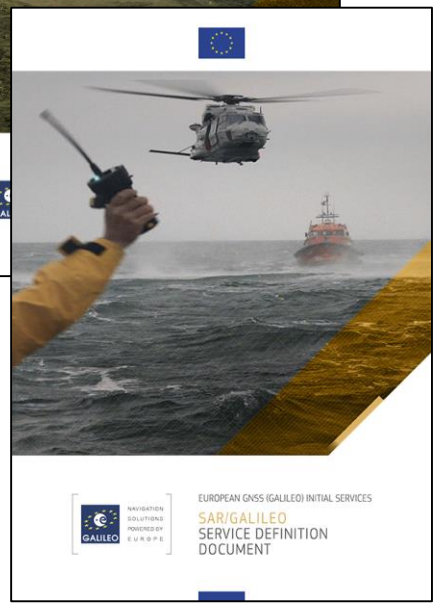
12 additional FOC satellites under manufacturing
First Launch by End 2020

SERVICES ALREADY DECLARED

Galileo OS Service Definition Document

NEW VERSION 1.1 Released on 8th May 2019

UPDATE



Galileo Search and Rescue Service Definition Document

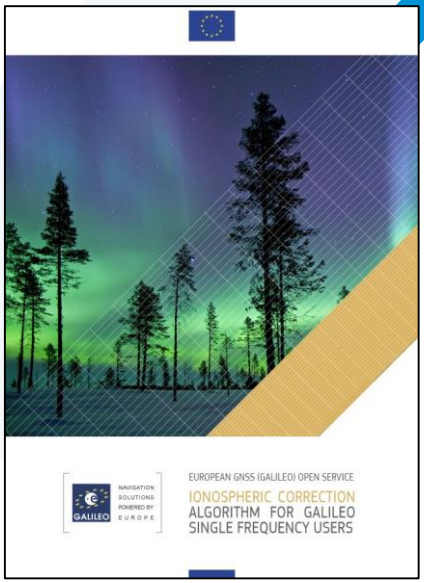
Version 1.0, December 2016

Galileo Open Service Signal In Space Interface Control Document (OS SIS ICD)

Version 1.3, December 2016

Ionospheric Correction Algorithm for Galileo Single Frequency Users

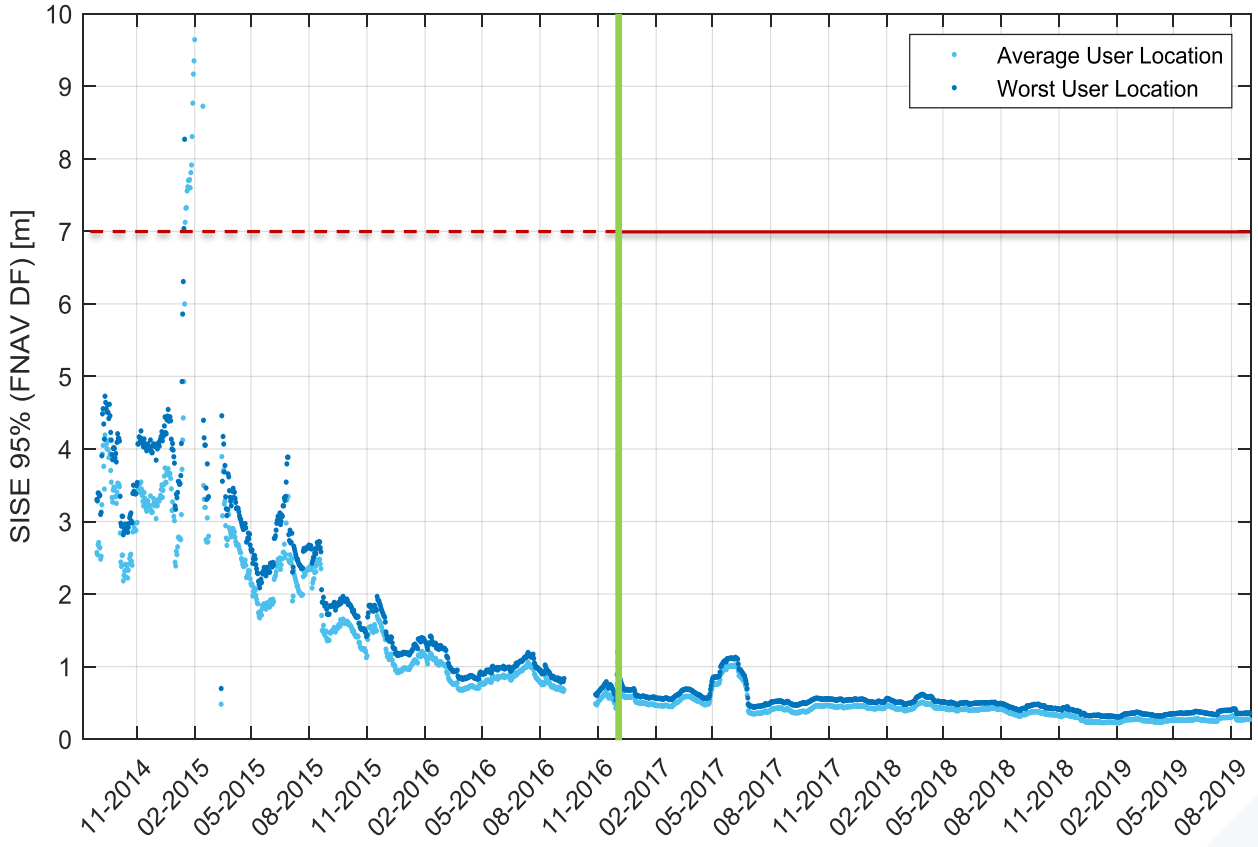
Version 1.2, September 2016



METADATA

UPDATE

EXCELLENT RANGING PERFORMANCE

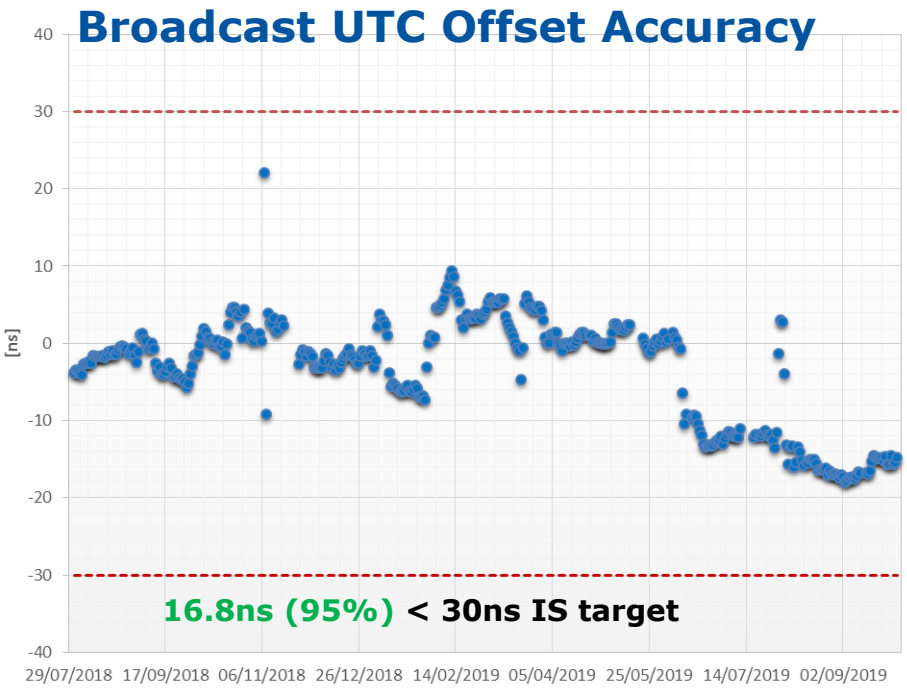


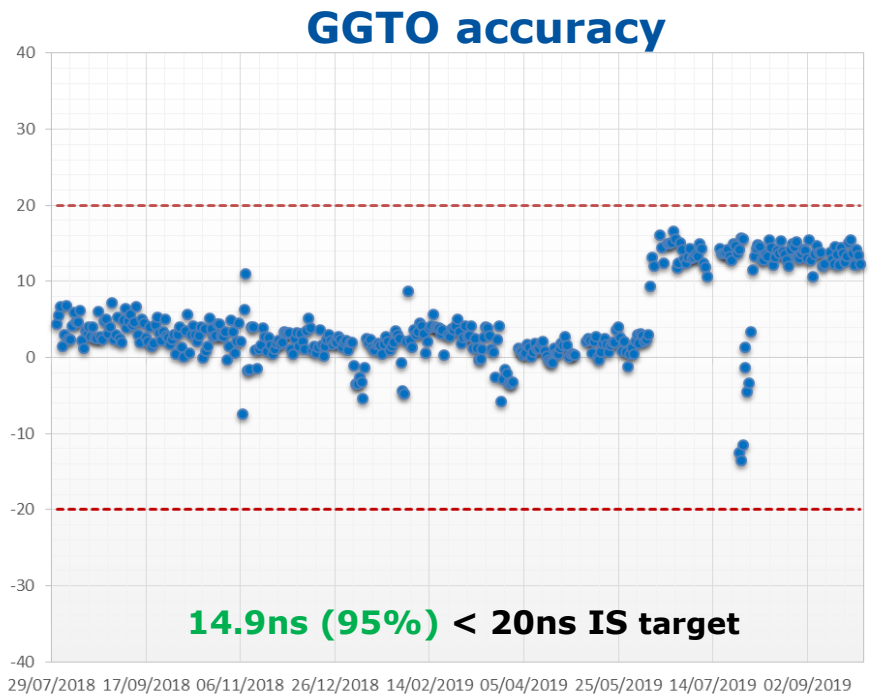
Initial Open Service

Stable accuracy ~25cm

- Decreasing Ranging Error trend due to increasing number of Satellites and G/S improvements
- **Ranging accuracy 0.27m (95%)** all satellites in August 2019 FNAV

TIMING PERFORMANCE (Sept. update)



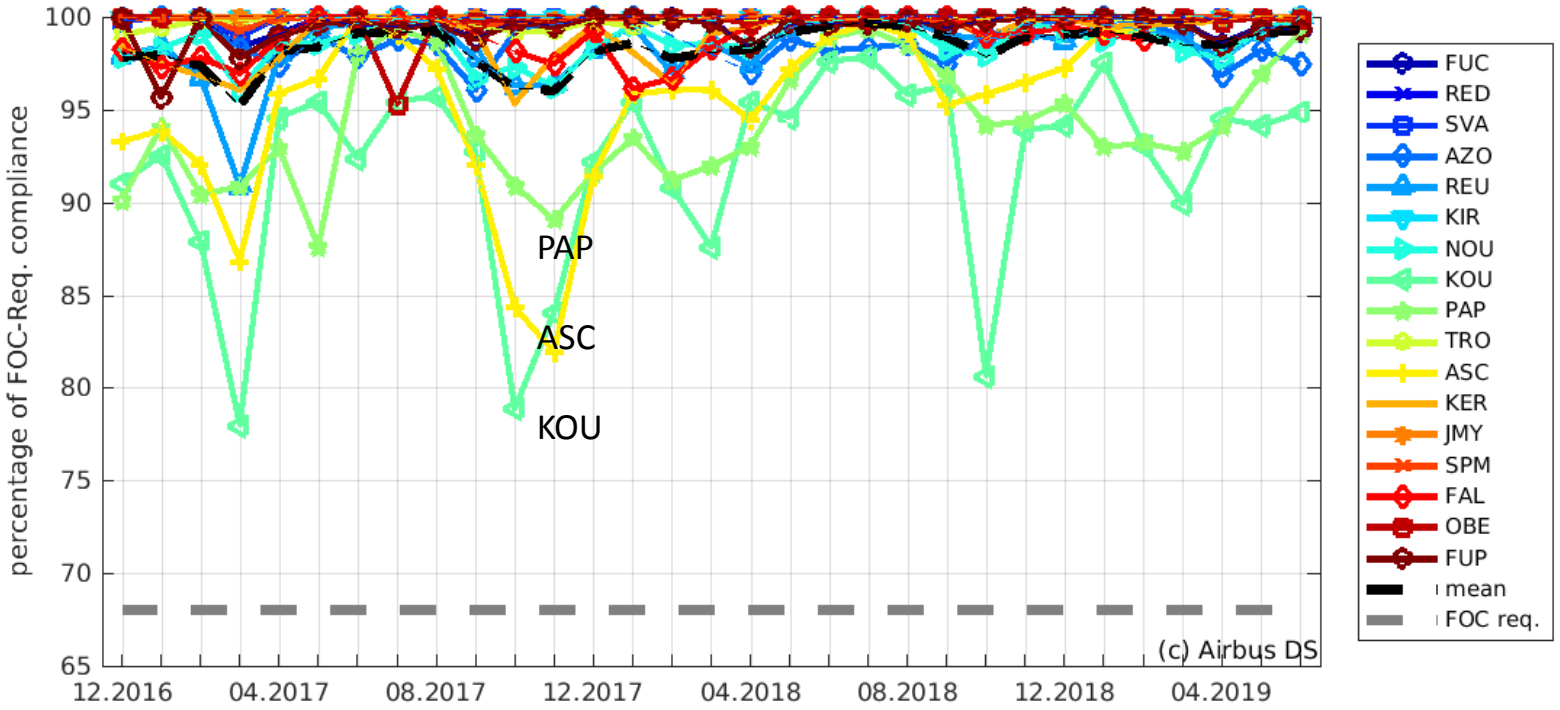


Evaluated with **calibrated timing GPS/Galileo receiver** operated in UTC(k) laboratory (PTB, INRIM)

10-15ns bias since mid June is caused by residual calibration offset in GSS-PTF D1

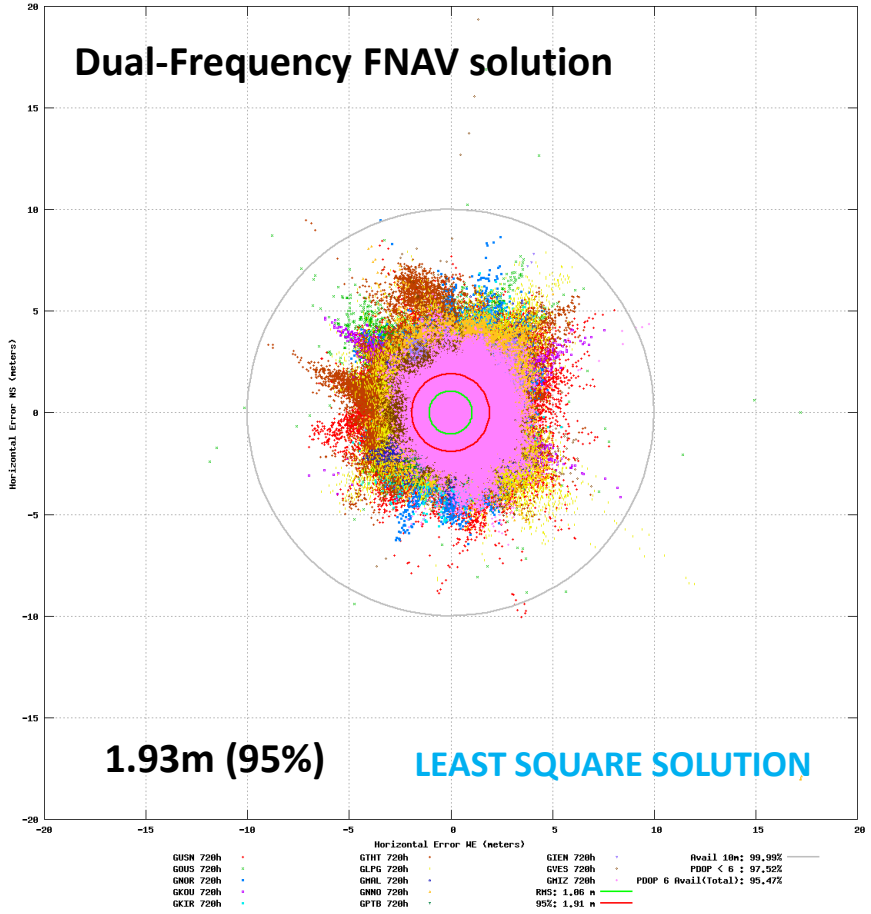
NEQUICK CORRECTION PERFORMANCE

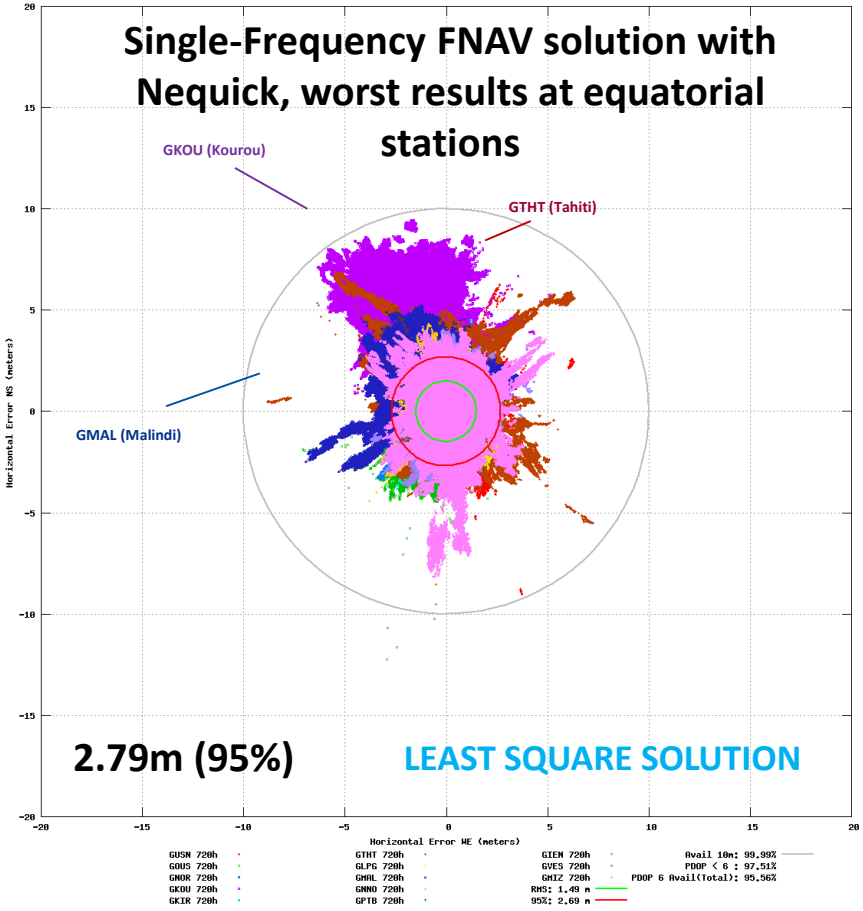
- **Ionospheric delay correction performance continues to be significantly better than the target requirement (averaged over all TEC values)**
- Performance benefits from ongoing week solar activity
- Performance better for high-latitude stations compared to equatorial stations (as expected)



SINGLE FREQUENCY POSITIONING PERFORMANCE

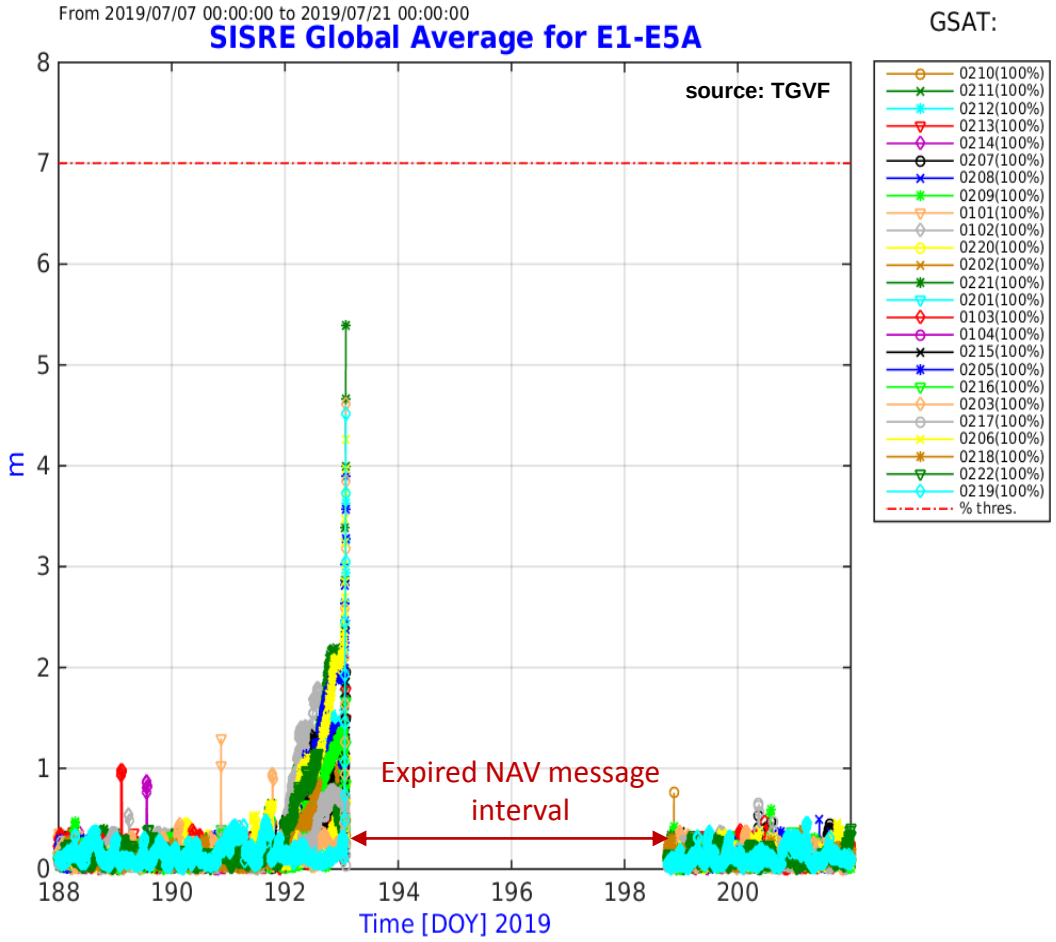
- SF Performance better for high-latitude stations compared to equatorial stations (as expected)





SERVICE INCIDENT JULY 2019

- **OS SDD MPL:** ≤ 7m (95%) per satellite, global average, over all AODs
  (calculated over a period of 30 days; propagation and user contributions excluded)



→ largest instantaneous peak < 7m

→ **Minimum Performance Level (MPL) not exceeded**

→ owing to the rejection of expired NAV messages

→ **Users were protected through the receiver-level check of Age of Time of Ephemeris** as the Initial Service SDD indicates that the maximum nominal broadcast period of a healthy data set is 4 hours.

→ **Impact to service availability and continuity, not accuracy.**

IS YOUR RECEIVER GALILEO COMPATIBLE?

GALILEO EGNOS
NAVIGATION MADE IN EUROPE

1 143 751 ± 4 15

Estimated number of Galileo-enabled smartphones today

USEGALILEO.EU

FIND A GALILEO-ENABLED DEVICE TO USE TODAY

ENGLISH (EN)

ON THE ROAD
ON THE WATER
ON THE TRAIN
IN THE AIR
ON TIME
INTERNET OF THINGS
GOING MOBILE
ON THE FARM
ON THE MAP
DURING AN EMERGENCY
SPACE APPLICATIONS
ABOUT
TEXT SEARCH
CONTACT

SEARCH AND RESCUE – TOWARDS Return Link Service

- Early Operational Capability (EOC) for MEOSAR declared COSPAS SARSAT in December 2016
  - Faster Beacon Detection (4hrs –> 5mins)
  - Better position accuracy (10km -> 1km)
  - Major Contribution by Galileo

- EU Coverage 3 MEOLUTs / 4th Station is under deployment in Indian Ocean

- Return Link Service ready to be commissioned

Successful Demonstrations – Remarkable Latency

Testing with beacon manufacturers ongoing

Successful test at sea with US Coastguard, near Maryland

FOUR NEW SERVICES IN PREPARATION

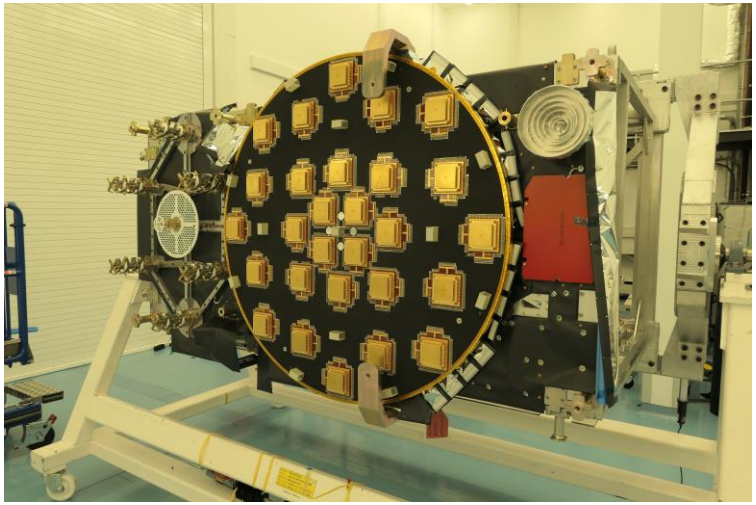
- Open Service Navigation Message Authentication
  → Better confidence of signal provided by ‘real Galileo’
  → Demonstration followed by initial services in 2020

- High Accuracy Service
  → 20cm accuracy target
  → New applications, eg autonomous vehicles
  → Gradual global introduction, from end 2020 in Europe

- Commercial Authentication Service on E6
  → Signal level encryption on E6

- Emergency Warning Service
  → Emergency situations (civil protection authorities)
  → Operational Service date not yet confirmed

Batch 3 Satellites



12 additional FOC satellites currently under production, ready for launch end 2020

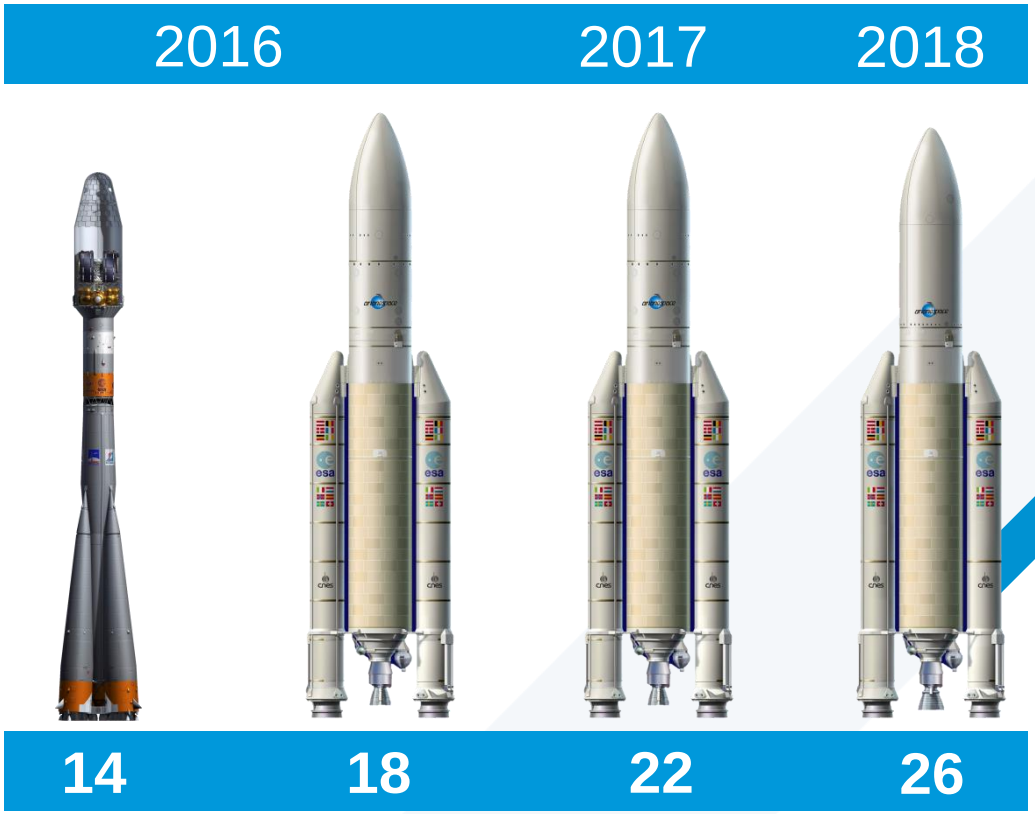
TOWARDS FULL OPERATIONAL CAPABILITY

- Entry into service of satellites in elliptical orbit
- Declaration of SAR RLS
- ICD update: signal improvements for robustness and TTFF
- New service commitments in OS SDD
- First Batch-3 satellite launches

Launch services

4 IOV & 10 FOC
satellites launched
with **Soyuz**

12 FOC
satellites launched
with **Ariane 5**



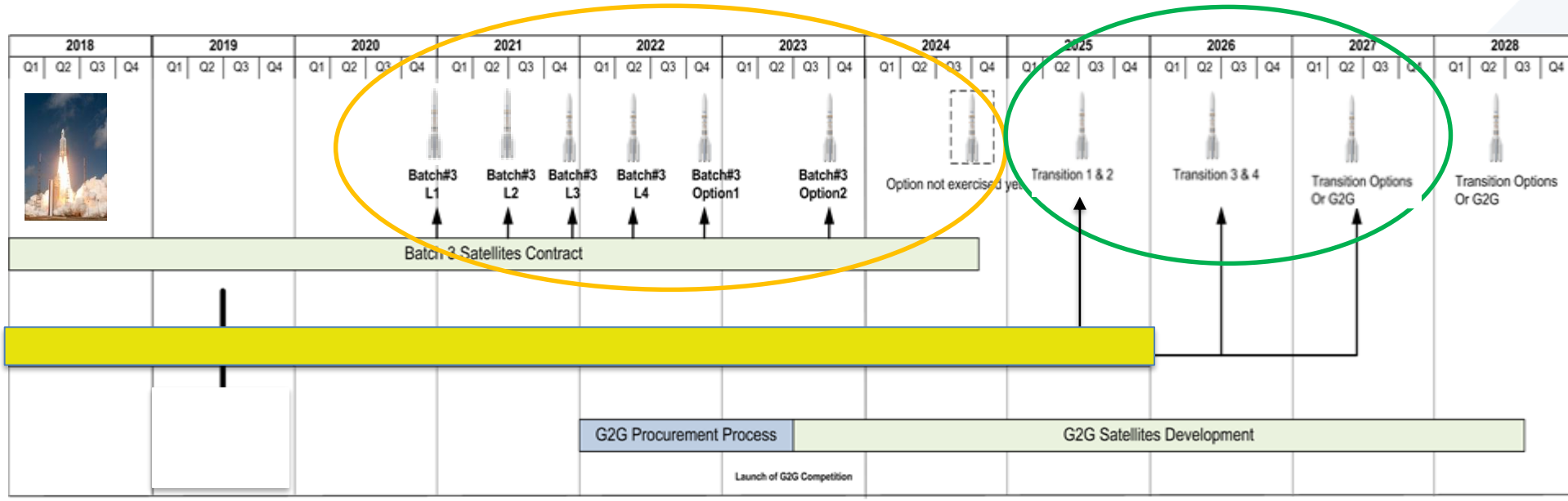
Future Launch services

Long-Term Constellation Deployment

L10
(FOC FM19,20,21,22)

FOC Batch 3
(FOC FM23 - FM36)

G2G
Transition Batch



GALILEO 2nd GENERATION

Service Portfolio and High Level Mission Objectives agreed with Programme Stakeholders

Service evolutions include:

- Advanced **Timing** Services
- **Space** Service Volume
- **ARAIM** – coming back to serving SoL communities
- **Emergency Warning Services**
- **Search And Rescue** – innovative service based on the return link
- **Ionosphere** Prediction Service
- **Signals** Evolution – increased performance at user level (TTFF, accuracy, authentication, etc.)

EVOLUTIONS - ROADMAP

- New Satellites – Transition Batch Procurement Ongoing
- First Launch in the 2025 timeframe; using Ariane 6
- Block evolution of the ground segment
- New Operations and Service Provision Concept
- Gradual introduction of improved capabilities and new services
- IOC around 2030 – FOC around 2035

Conclusions

- Excellent ranging and timing performance
- Priority: reinforce Galileo PVT availability and service continuity
- System nearing FOC
- Next satellite batch well under way
- Galileo E5 boosting GNSS dual-frequency market
- INAV, OS NMA, High Accuracy, SAR RLSP coming
- Transition towards Second Generation

ACCURACY (PLUS RELIABILITY & TRUST) MATTERS

Dominic HAYES (EC)

Joerg HAHN (ESA)

http://ec.europa.eu/galileo

Galileo E1-B I/NAV Navigation Message Optimisation

- Three new technical solutions to be made available to **all Galileo OS users**
  - Reduced Clock and Ephemeris Data (**Reduced CED**): compact set of clock and ephemeris data
  - FEC2 Reed-Solomon Clock and Ephemeris Data (**RS CED**): improved data demodulation robustness
  - Secondary Synchronization Pattern (**SSP**): rapid reconstruction of the Galileo System Time (GST)
- Improvement of the Galileo E1 Open Service performance in terms of **Robustness** and **Timeliness**
- Significant **TTFF improvement** in challenging environments both **unassisted** and **assisted GNSS**
- **Backward compatibility** guaranteed (no impact on legacy or non-participative receivers)
- **Low complexity** at transmitter and receiver side
- New issue of **OS SIS ICD** to be published soon

Authentication & High Accuracy

- **AUTHENTICATION** will be based on:
  - Navigation Message Authentication

    Integrated in E1 OS.

    Consumer users, free of charge
  - Commercial Service Authentication

    E6C Spreading Code Encryption

- **HIGH ACCURACY** based on PPP transmission in E6B
  - Gradual introduction (regional/global, accuracy target, convergence time…), free of charge
  - ICD under final consolidation

SAR/Galileo Return Link Test Campaign

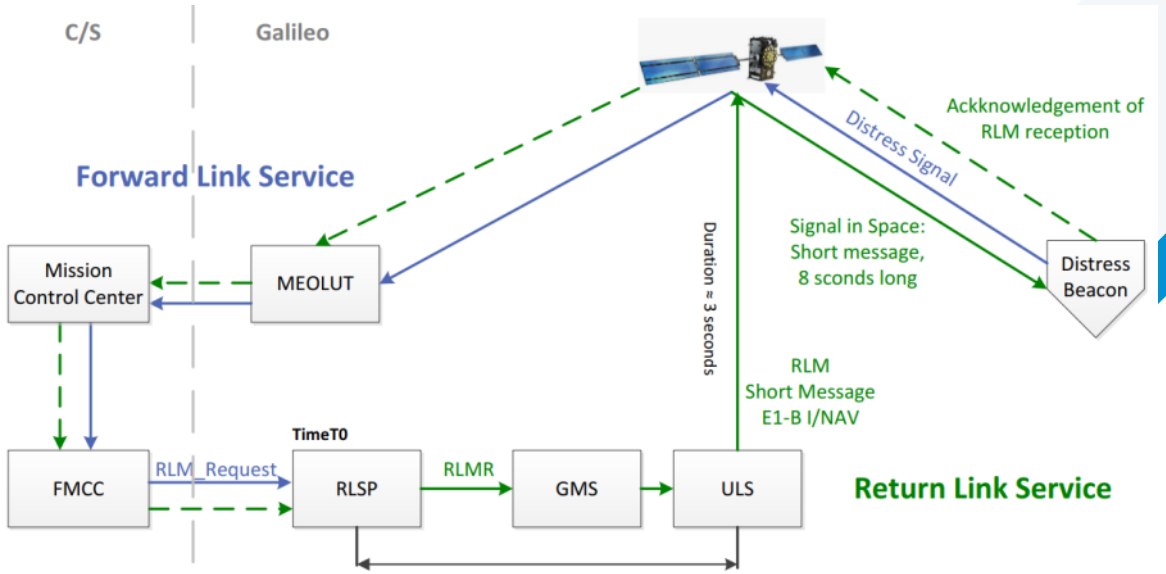
Return Link Service Provider (RLSP) system integration & validation campaign, and Return Link system (RLS) performance validation test campaign

Preliminary statistics for Galileo SAR Performance:

- $t_{RLSP\text{-}Beacon\_MIN}$ = 11 s
- $t_{RLSP\text{-}Beacon\_AVG}$ < 16 s
- $t_{RLSP\text{-}Beacon\_MAX}$ = 153 s

•Availability:

- RLM Delivery = 99.8%



Well within the expected performance