2019 - GALILEO PROGRAMME UPDATE

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ICG 2019  •  Bangalore, December 2019
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**

<table>
<thead>
<tr>
<th>Batch</th>
<th>Launch</th>
<th>Satellite</th>
<th>Status</th>
<th>Name</th>
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<tbody>
<tr>
<td>IOV</td>
<td>L1 (21/10/2011)</td>
<td>GSAT 101</td>
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<td>L2 (12/10/2012)</td>
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<td>Sif</td>
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<td>Doresa</td>
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<td>Anna</td>
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<tr>
<td></td>
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<td>GSAT 222</td>
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**12 additional FOC satellites under manufacturing**
**First Launch by End 2020**
SERVICES ALREADY DECLARED

Galileo Open Service Signal In Space Interface Control Document (OS SIS ICD)
Version 1.3, December 2016

Galileo Search and Rescue Service Definition Document
Version 1.0, December 2016

Ionospheric Correction Algorithm for Galileo Single Frequency Users
Version 1.2, September 2016

Galileo OS Service Definition Document
NEW VERSION 1.1 Released on 8th May 2019
EXCELLENT RANGING PERFORMANCE

- 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

Initial Open Service

Stable accuracy ~25cm
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
• 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)

**Dual-Frequency FNAV solution**

- 1.93m (95%)

**Single-Frequency FNAV solution with Nequick, worst results at equatorial stations**

- 2.79m (95%)

JUNE 2019
**SERVICE INCIDENT JULY 2019**

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

→ **largest instantaneous peak** $< 7\text{m}$
→ **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?

1 143 751

Estimated number of Galileo-enabled smartphones today

Click here to find out if your phone is Galileo-enabled

USEGALILEO.EU
FIND A GALILEO-ENABLED DEVICE TO USE TODAY
SEARCH AND RESCUE – TOWARDS Return Link Service

• Early Operational Capability (EOC) for MEOSAR declared by 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

2016

2017

2018

14

18

22

26
Future Launch services
Long-Term Constellation Deployment

L10
(FOC FM19,20,21,22)

FOC Batch 3
(FOC FM23 - FM36)

G2G Transition Batch

G2G Procurement Process

G2G Satellites Development

Launch of G2G Competition

Batch 3 Satellites Contract

Option not exercised yet

Transition 1 & 2

Transition 3 & 4

Transition Options Or G2G

Transition Options Or G2G
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.)
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:**

- \( t_{\text{RLSP-Beacon_MIN}} = 11 \text{ s} \)
- \( t_{\text{RLSP-Beacon_AVG}} < 16 \text{ s} \)
- \( t_{\text{RLSP-Beacon_MAX}} = 153 \text{ s} \)

- **Availability:**
  - RLM Delivery = 99.8%

*Well within the expected performance*