EGNSS Services Status and Evolutions

Space Downstream Innovation Days

Alvaro Mozo – GNSS Services Engineering Manager
## EGNOS Operational System Configuration

### SPACE

<table>
<thead>
<tr>
<th>SERVICE BROADCAST*</th>
<th>TEST / BACK-UP</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEO-1: SES-5 PRN-136</td>
<td>Inmarsat 4F2 PRN-126</td>
</tr>
<tr>
<td>GEO-2: ASTRA-5B PRN-123</td>
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</tbody>
</table>

### IN TEST

| GEO-3: E5WB PRN-121 |

### SYSTEM RELEASE 2.4.2-A since 18 October 2021

### GROUND

<table>
<thead>
<tr>
<th>NLES</th>
<th>MCC CIAMPINO</th>
<th>MCC TORREJON</th>
<th>SC TORREJON</th>
<th>OCC TOULOUSE</th>
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<tbody>
<tr>
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<td>CPF + CCF</td>
<td>ASQF</td>
<td>PACF</td>
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<tr>
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<td>Agadir</td>
<td>Aalborg</td>
<td>Alexandria</td>
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<tr>
<td>Djerba</td>
<td>Egilsstadir</td>
<td>Glasgow</td>
<td>Golbasi</td>
<td>Gavle</td>
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<td>Lisbon</td>
<td>Svalbard</td>
<td>Madeira</td>
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<tr>
<td>Reykjavik</td>
<td>Roma</td>
<td>Santiago de C.</td>
<td>Sofia</td>
<td>Swanwick</td>
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</tbody>
</table>

| RIMS: 39 RIMS in Operations |
Excellent performances delivered over the past period
EGNOS Service Performance – Sept 21

EGNOS Safety of Life Availability at Airports – APV-1 level

EGNOS Safety of Life Availability at Airports – LPV-200 level

Availability (%)
- 100%
- ≥99%
- ≥98%
- ≥97%
- ≥96%
- <96%
- No availability
Services Evolution and New Services

- Regular SDD updates following status of infrastructure, including GPS constellation
- Dual-Frequency Multi-Constellation SBAS
  - EGNOS V3 under development (service 2027)
  - Augmentation of GPS and Galileo, L1-L5 – E1-E5 for increased performance and robustness
- EGNOS Maritime Service
  - Definition on-going
  - Pseudorange service using existing signals, with specific information tailored to maritime users
  - First service based on EGNOS V2 in 2023, evolution with EGNOS V3 to be studied
- EGNOS Service for Rail
  - Regular ERGO meetings to consolidate the user needs
Galileo Space Infrastructure in Service

Space Segment: 26 Satellites in Orbit
- 22 in service for Navigation
- 24 in service for SAR
- 2 Auxiliary not in Service
- 1 Inactive Spare
- 2 Nominal Slots free for next launches
Galileo Ground Infrastructure in Service

- 2 x redundant Galileo Control Centers (GCC)
  - Ground Control Segment (GCS) prime at GCC-D
  - Ground Mission Segment (GMS) prime at GCC-I
- Remote Sites disseminated around the world on EU sites
  - 13 x Galileo Sensor Stations (GSS) + Wallis + Bonaire + new site
  - 6 x Telemetry and racking Control Facilities (TTCF) + Kourou
  - 5 x Uplink Station (ULS)
    - 2 x redundant Galileo Security Monitoring Centre (GSMC)
      - Prime centre in France and back-up centre in Spain
    - GNSS Service Centre (GSC) in Spain
    - Galileo Reference Centre (GRC) in the Netherlands
    - Galileo ILS Centre (GILSC)
Galileo Open Service

From Initial Services to FOC -> Evolution of Services following System completion

Initial Services Declaration
OS SiS ICD 1.3
OS SDD 1.0
Dec 2016

OS SiS ICD 2.0
OS SDD 1.1
May 2019

OS SDD 1.2
Q4 2021

OS SDD 2.0
Q4 2022

Full Operational Capability
Open Service – Minimum Performance Levels

**Signal**
- Ranging Accuracy (Worst Satellite and Constellation Average)
- Per Slot Healthy SIS Availability

**Timing**
- UTC Time and Frequency Dissemination Accuracy
- UTC Time Dissemination Availability
- UTC Time Determination Availability

**Positioning**
- Availability of PDOP
- Availability of position (Horizontal and Vertical at Worst and Average User Location)

**Interoperability**
- GST-GPS Time Offset Accuracy
- GST-TPS Time Offset Availability

**User Notifications**
- Timeliness of NAGU publication (Planned and Unplanned)
OS SiS ICD 2.0 (January 2021)

- New features for robustness and TTFF
- Backwards compatible
- **Document** and **presentation** at GSC
  - Enable development
  - Testing capability will be offered through JRC
OS Accuracy Performance (examples)

MPL on Ranging Accuracy - Any Satellite

GST-UTC Time Offset Dissemination Accuracy [ns] - MPL
OS Availability Performance (examples)

MPL on Constellation-Averaged Availability of OS Signals

Availability [%] of PDOP <= 6 - MPL

Worst satellite, not annually normalised availability
- E5a-E1 MOVING AVERAGE
- E5b-E1 MOVING AVERAGE
- E1 MOVING AVERAGE
- E5a MOVING AVERAGE
- E5b MOVING AVERAGE

Availability [%]
Towards G1 OS FOC

- **Lessons learned** process to improve following the past incidents
- **Adoption** in user community steadily growing
- Completion of **ground infrastructure**
- Continued deployment of **space segment**

augmentation service providers that support Galileo
Search and Rescue

From Initial Services to FOC -> Evolution of Services following System completion

Initial Services Declaration
SAR SDD 1.0
Dec 2016

SAR SDD 2.0
Jan 2020

Full Operational Capability
SAR SDD 3.0
SAR/Galileo – Minimum Performance Levels

**Forward Link**
- Service Availability
- MEOLUT Availability
- Detection Probability
- Location Probability, Single and Multi Burst
- Availability of Localization Accuracy, Single and Multi Burst
- Transponder Availability

**Return Link**
- Service Availability
- Message Delivery within 15 min
- Reception Probability
SAR/Galileo Performance (examples)

SAR/Galileo FLS Availability

Availability [%]

SAR/Galileo RLS Availability

Availability [%]

Availability of Successful Location within 5 [km] - Single Burst

Location Probability - From 1 to 12 bursts
Towards G1 SAR/Galileo FOC

• **Lessons learned** process to improve following the past incidents
• **Adoption** in user community steadily growing – Beacons available
• Expansion of **ground infrastructure** – 4\textsuperscript{th} MEOLUT
• Continued deployment of space segment
Galileo Public Regulated Service

From Initial Services to FOC -> Evolution of Services following System completion

- **Initial Services Declaration**
  - PRS SDD 1.0
  - Dec 2016

- **Initial Operational Capability**
  - PRS SDD 2.0
  - Q4 2023

- **PRS SDD 1.1**
  - Q4 2021

- **Full Operational Capability**
  - PRS SDD 3.0
Towards G1 PRS IOC and FOC

- Infrastructure completion and implementation of evolutions
- Implementation and validation of operational procedures
- Development of pre-operational equipment
- Support to MS activities
  - Joint Test Activities
Galileo Services Information

- Programme documents (SDD, SiS ICD)
- Service Notices
- Constellation Status
- NAGUs
- Satellite characteristics
- Quarterly Performance Reports
- HelpDesk, Incident Reporting

www.gsc-europa.eu
G1 Services Evolution – OS NMA

• OS Navigation Message Authentication
  – Verify authenticity of INAV OS Navigation Messages
  – Specific data blocks broadcast in SiS
  – Backwards compatible with legacy receivers

• Digital signature with TESLA protocol
  – Root key to be retrieved from GSC

• Public observation phase in Q4 2021
OS NMA Public Observation

• OSNMA test signal, global coverage.
• Open access (following registration process at GSC to get access to key material)
• Continuous signal provision

* Highest quality of test signal will be pursued, without associated commitments
OS NMA Public Observation

Step 1
• Galileo OSNMA Info Note
• GSC web section (FAQ)

Step 2
• Service Notice with start date for Test Phase

Step 3
• GSC news, banners, email notification, web update
• OSNMA User ICD for Test Phase
• OSNMA Receiver Guidelines for Test Phase
• OSNMA Typical Performance presentation
• User registration form to participate on Test Phase (access to key material)
G1 Services Evolution – HAS

• High Accuracy Service
  – Corrections for Precise Point Positioning broadcast on E6
  – Ground dissemination in parallel

• 2 Service Levels
  – Global
  – Regional (European, faster convergence)

• Initial Service over Europe with relaxed performance
  – Testing phase until 30/09 with interested entities (CfI published in Q2 2021)
Galileo HAS test campaign

OBJECTIVES

- Validation of critical HAS service elements (ICD).
- Independent assessment of performance*

- Engage stakeholders
- Build a strong relationships with future HAS users
- Foster HAS adoption

- Gather lessons learned and recommendations towards HAS Full Service

* Test campaign supported by a demonstrator which is not fully representative of the future operational service infrastructure; the tests performed and results obtained are not representative of the performance of the final service.
Galileo HAS Test Campaign

- Test results under evaluation
  - Extrapolation of performance targets
  - Inputs for infrastructure consolidation
  - Inputs for preparation of service documentation

GALILEO HAS MESSAGE TRANSMISSION

- Transmitted in E6B (1278.75 MHz), C/NAV, at 448 bps.
- Format similar to CSSR (Compact State Space Representation) RTCM standard with some novelties:
  - Flexible message content (can transmit orbits & clocks in the same message or at different rates).
  - Flexible update/validity intervals.
  - Sub-satellite mask for refreshing faster satellites with less stable clocks.
  - Outer layer coding scheme.

<table>
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<td>24</td>
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Other evolutions of G1 Services

• Use of Galileo for **SoL applications** (EGNOS V3, ARAIM)

• CAS
  – Authenticated ranging signals in E6
  – Initial step: Assisted Authentication

• SAR Evolutions
  – Beacon Command Service
  – Two-Way Communication

• Emergency Warning Service Initial Implementation
The European Union Agency for the Space Programme is hiring!

Apply today and help shape the future of #EUSpace!