GALILEO System Status
Galileo Project Office
UNOOSA ICG 9, Prague, 9 November 2014
IOV has validated in-orbit the full system and demonstrated Galileo-only 3D User positioning and timing.
Ranging Accuracy impacted by

- Satellite maintenance operations (e.g. clock swap)
- Navigation message aging due to u/l stations maintenance/deployment
- GSAT0103/4 expired messages b‘cast

<table>
<thead>
<tr>
<th>Satellite</th>
<th>67% [m]</th>
</tr>
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<tbody>
<tr>
<td>GSAT0101</td>
<td>1.09</td>
</tr>
<tr>
<td>GSAT0102</td>
<td>0.96</td>
</tr>
<tr>
<td>GSAT0103</td>
<td>1.06</td>
</tr>
<tr>
<td>GSAT0104</td>
<td>1.21</td>
</tr>
</tbody>
</table>

Overall ranging accuracy (67 percentiles)
Galileo FOC constellation
Both spacecraft are safe and in stable conditions:
- solar array wings deployed
- nominal sun pointing
- all equipment healthy
- payload off (as planned)
- Satellites hand-over to GCC-D on 27-28 Sep
Target Orbit: Resonant 37 rev / 20 days

(+ 20 days repeat cycle, easy insertion in routine planning (!)
Ground track first 10 days sat 5 = second 10 days sat 6
(+ 37 revolutions, good global coverage, similar to 19/10
(+ Perigee is higher than other resonant candidates

Final Preferred Solution

<table>
<thead>
<tr>
<th></th>
<th>Reference</th>
<th>Current</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-major axis [km]</td>
<td>29599.801232</td>
<td>26180.99</td>
<td>27484.8</td>
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<tr>
<td>Eccentricity</td>
<td>0.0001</td>
<td>0.2326</td>
<td>0.156</td>
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<tr>
<td>Inclination [deg]</td>
<td>56</td>
<td>49.80</td>
<td>49.8</td>
</tr>
<tr>
<td>Apogee height [km]</td>
<td>23224.624</td>
<td>25892.55</td>
<td>25394.29</td>
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<tr>
<td>Perigee height [km]</td>
<td>23218.704</td>
<td>13713.29</td>
<td>16819.17</td>
</tr>
</tbody>
</table>
SiS Analysis on Target Orbit

★ **Test User Receivers (TUR) and TGVF GESS capable to perform** the required satellite navigation **performance testing**

★ **Expectations confirmed by preliminary test** campaign to be completed for commercial receivers

★ **Signal in space could be usable by most of the commercial receivers** (e.g. mass market) with minimal impact on performance

★ **Impact of the Doppler range is expected to be limited**, but very much dependent on the implemented technology. This may result in an increasing cold acquisition time or an reduced satellite SIS availability.

★ Potential **lack of valid almanac or increased cold sky search** time is expected to be **anyway very much mitigated** in real operational scenarios by the availability of alternative orbital elements.
Average user location performances are excellent

>80% Improvement up to L8 when using Sat 5/6
★ Orbit Raising Manoeuvres started for one FOC satellite
★ In-Orbit-Testing in target orbit to follow
★ Preparation of Programme Decision to provide Navigation and SAR services, after completion of In-Orbit-Testing. Target scenario:
   ★ Synchronised satellite with nominal RF signals, but broadcast of Dummy Nav Msg
   ★ Allows for Position Fix using **assisted navigation message.**
FOC Satellites

**Overall Spacecraft**
- Mass at Launch: 733kg
- Power Consumption: 1900 W
- Dimensions: 2.5 x 1.1 x 14.7 m wing span
- Lifetime: 12 years
- Orbit Injection: Direct into MEO orbit
- Attitude Profile: Yaw Steered

S/C Prime Contractor: OHB Systems GmbH
P/L Prime Contractor: SSTL Ltd
WO1 + WO2 = 22 satellites

**Galileo Constellation**
Walker 24/3/1 constellation plus 6 in-orbit spares
- Semi-major axis: 29600.318 km
- Inclination: 56 deg
- Period: 14h 4m 42s
- Ground track repeat cycle: 10 days / 17 orbits
Galileo FOC Satellite Qualification at ESA, NL
Launch Campaign at CSG Kourou

Autonomous Operations

Satellites Integration on the Launcher Dispenser

Satellites Encapsulation in the Launcher fairing
FOC Satellites Production Status (5 Sep’14)

★ **FM3** and **FM4** under testing at ESA ESTEC Test Facility till mid Nov.’14
★ **FM5** in ESA ESTEC Test Facility since 29 Oct.’14
★ **FM6** in OHB SAR-LUPE (island 6) and planned to arrive in ESA ESTEC TF by mid December 2014
★ **FM7** in OHB SAR-LUPE Hall (island 5a)
★ **FM8** in OHB Galileo Hall (island 4b)
★ **FM9** in OHB Galileo Hall (island 3b)
★ **FM10** in OHB Galileo Hall (island 4a)
★ **FM11** in OHB Galileo Hall (island 3a)
★ **FM12** in OHB Galileo Hall (island 2)
FOC Current Operational Sites

Galileo Control Centre
Fucino, I

Launch & Early
Ops Centre,
ESOC
Darmstadt, D

TTC Station
Kiruna, S

Uplink Station
Svalbard, N

TTC & Uplink
Station Noumea, F

TTC & Uplink
Station Kourou, F

TTC & Uplink
Station Reunion, F

IOT and TTC Station Redu, B

Satellite Manufacturer
OHB Bremen, D

Kourou Launch Site

Galileo Control Centre
O’pfaffenhofen, D

TTC Station
Kourou, F

Uplink Station
Noumea, F

TTC & Uplink
Station Reunion, F
Enhanced Launch capability

SOYUZ

ARIANE 5
Galileo SSV characterization is currently ongoing following the conventions identified by ICG WG-B regarding

**Relevant User Orbits**
- LEO (represented by sphere at 3000 km altitude above earth)
- MEO (represented by sphere at 8000 km altitude above earth)
- GEO/HEO (represented by sphere at 36000 km altitude above earth)

**Availability Evaluation**
- Availability of 1 satellite and availability of 4 satellites
- Availability evaluation done per user on a sphere at relevant radius over time
- Availability to report is the minimum out of the best 95% of all user locations

**SSV Characteristics Reporting**
- User received power (not necessarily constrained by data demodulation threshold) at GEO altitude and corresponding off-boresight angle
- Availability evaluation at GEO altitude
- Availability evaluation at MEO altitude (based on off-boresight angle specification for GEO altitude)
Off-boresight angles expected during In-Orbit Testing (IOT) of GSAT0202/0202

Assuming future Galileo satellites in Nominal Orbit with very similar Antenna pattern: Galileo SSV characterisation up to altitude of 2100 km (LEO) is supported by ground measurements!
SSV Conclusions and Way Forward

★ Importance of an interoperable GNSS SSV is fully recognized

★ Characterization of Galileo’s contribution to an interoperable GNSS SSV is currently ongoing

★ Planned In-Orbit Testing (IOT) of GSAT0201/0202 gives unique opportunity to characterise SSV-relevant antenna off-boresight range from ground

★ Results of GSAT0201/0202 need to be awaited before Galileo SSV characteristics are published

★ Publication of Galileo SSV characterization for FOC satellites can be expected for Spring 2015