Galileo Precise Orbit and Clock Determination, POD concept at ESOC

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ESA/ESOC – Navigation Support Office

Tour de l’IGS 6th Stop: Galileo Constellation Spotlight, 23/05/2023
Our primary Galileo activities cover different POD aspect:

- Routine Galileo Precise Orbit Determination products
- Models development:
  - Satellite Orbit Dynamic modelling
  - Attitude and Clock modelling
- Special Orbit and Clock products for scientific analyses (e.g., Relativistic studies)
- Further analyses for Galileo such as:
  - metadata test & validation
  - clocks performance analysis
Dynamic POD approach, based on daily batch processing

Important for the accuracy of the Galileo products:
- Quality of the Galileo signals
- Satellite modelling
- Stations network geometry

Galileo Modelling at ESOC:
- Galileo orbital error is driven by the high area-to-mass ratio property
- ESOC models are considered of very good quality
- Galileo dynamic modelling in continuous improvement (in the upcoming slides)

<table>
<thead>
<tr>
<th>GNSS SV</th>
<th>∆A/m [m²/kg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Galileo FOC</td>
<td>0.0028</td>
</tr>
<tr>
<td>GPS III</td>
<td>0.0021</td>
</tr>
<tr>
<td>GPS IIR</td>
<td>0.0017</td>
</tr>
<tr>
<td>BDS-3 SECM</td>
<td>0.0016</td>
</tr>
<tr>
<td>GPS IIF</td>
<td>0.0015</td>
</tr>
<tr>
<td>BDS-3 CAST</td>
<td>0.0014</td>
</tr>
</tbody>
</table>

Box-Wing

Raytracing
IGS station network combined with EGON for Galileo and other GNSS processing
SLR residuals of Galileo FOC* - continuously improved modelling

*Galileo IOV performs similarly

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ESA’s Non-Gravitational Force Models for One-Centimetre Orbit Determination Accuracy of Galileo Spacecraft, F. Dilssner et al, 8th International Colloquium. 2022
Galileo FOC orbit error – continuously improved modelling

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**Orbital Overlaps (mm)**

- ECOM–2 only: 19.3 mm
- ECOM–1 + BW_PUB: 17.7 mm
- ECOM–1 + Fourier: 15.9 mm
- ECOM–1 + BW_NEW: 11.9 mm
- ECOM_LIGHT + BW_NEW: 11.5 mm

**Orbital Prediction error after 1 day (cm)**

- ECOM–2 only: 33.4 cm
- ECOM–1 + BW_PUB: 26.1 cm
- ECOM–1 + Fourier: 22.2 cm
- ECOM–1 + BW_NEW: 20.0 cm
- ECOM_LIGHT + BW_NEW: 21.1 cm

**Orbital Prediction error after 14 days (m)**

- ECOM–2 only: 35.7 m
- ECOM–1 + BW_PUB: 33.8 m
- ECOM–1 + Fourier: 31.7 m
- ECOM–1 + BW_NEW: 30.4 m
- ECOM_LIGHT + BW_NEW: 30.8 m

*Note: graphics have different scales and units*

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*ESA’s Non-Gravitational Force Models for One-Centimetre Orbit Determination Accuracy of Galileo Spacecraft, F. Dilssner et al, 8th International Colloquium. 2022*
Continuous improvement of Galileo products

Development of Galileo orbit quality

Orbit overlaps at dayboundary Constellation Mean 3D RMS [mm]

Epoch

Number of Satellites


0 5 10 15 20 25 30
Galileo performance compared to other constellations

Statistics based on ESOC MGNSS Final Products, 2022

Multi-GNSS day-boundary overlaps (mm)
Conclusions

The ESA/ESOC Navigation Support Office is dedicated to:

• continuously enhancing the quality and performance of Galileo and other GNSS products.
• actively contributing to the IGS by publishing and providing support for Galileo, GPS, and GLONASS products (IGS FINAL).
• offering Multi-GNSS products encompassing all constellations.

The products are published and accessible on our webpage: http://navigation-office.esa.int/

For the latest updates and communications regarding the release of new products, please monitor the following:

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To further enhance its services, the ESA/ESOC Navigation Support Office has embraced the Galileo measured Phase Center Offset (PCO) and Variations (PCV) from the public metadata*, following the upgrade to the new ITRF2020 realization.

This approach is considered to have a more realistic interpretation, capturing the physical characteristics with greater accuracy.

*see Metadata presentation by F. Gonzales (ESA)
Conclusions

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Thanks for your attention.