Galileo Terrestrial Reference Frame (GTRF)

Activities performed by GGSP Consortium presented by Werner Enderle (ESA/ESOC)
Outline

- GGSP Consortium
- GGSP Function
- GTRF Implementation
- Results
- Conclusion
The Galileo Geodetic Service Provider (GGSP) Consortium consists of 5 partners:

- **AIUB**  
  Astro. Institute University of Bern  
  Switzerland

- **BKG**  
  Bundesamt fuer Kartogr. und Geodaesie  
  Germany

- **ESOC**  
  European Space Operations Centre  
  ESA

- **GFZ**  
  Geo Forschungszentrum Potsdam  
  Germany

- **IGN**  
  Intitute Geographique National  
  France

Consortium Leader is ESOC

The GGSP FOC activities are managed since Sept. 2013 by ESA – Galileo Project through the EC TGVF-OVF contract. Prime contractor for the TGVF contract is GMV, Spain
Main GGSP Functions

- Realisation and maintenance of a highly precise and stable Galileo Terrestrial Reference Frame (GTRF), the basis for all Galileo products and services

Requirement for GTRF:
- The GTRF shall be compatible with the International Terrestrial Reference Frame (ITRF) at a precision of 3 cm (2 Sigma)
- Provide positions and velocities for all Galileo Sensor Stations (GSS)

Additional GGSP products:
- Generation of precise products for
  - Satellite orbits
  - Clock parameters for satellites and stations
  - Earth Rotation Parameters (ERPs)

- Monitoring the quality of products of the Galileo Mission Segment (GMS)
GTRF13v01 network.
blue squares: ITRF/IGS stations
red triangles: GESS/GSS sites
GTRF Implementation

- Weekly solutions (station positions and ERPs) generated by 3 independent Processing Facilities (PF) (AIUB, GFZ and ESOC)

- Weekly combination of station positions and ERPs
  - Detailed analysis with summary report
  - Combined solution provided in SINEX
  - Quality assessment
  - Transformation to ITRF

- Weekly orbit and clock combination

- Initial GTRF (station positions & velocities) and its updates:
  - Latest GTRF releases
    - GTRF13v01 – on 18 May 2013
    - GTRF13v02 – update of GTRF 13v01 on 27 May 2013
Combination Strategy

- Use Normal Equations from the 3 independent PFs
- Analyse and combine a 3 solutions
- Combine TRF using Minimum Constraint
Origin and Scale

TX (mm)

TY (mm)

TZ (mm)

Scale (mm)
Repeatability – Internal Precision

**cs_ Weekly WRMS (mm)**
- East
- North
- Up

**p1_ Weekly WRMS (mm)**
- East
- North
- Up

**p2_ Weekly WRMS (mm)**
- East
- North
- Up

**p3_ Weekly WRMS (mm)**
- East
- North
- Up
GESS Residuals

- GCAL_49101M001
- GIEN_12724M003

Graphs showing residual data for GCAL_49101M001 and GIEN_12724M003 in EAST, NORTH, and UP dimensions from 2011.5 to 2014.0.
**Comparison of GTRF13v01 to ITRF2008**

Transformation parameters from GTRF13v01 to IGb08 (ITRF2008)

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<th>T1 (mm)</th>
<th>T2 (mm)</th>
<th>T3 (mm)</th>
<th>D (10^-9)</th>
<th>R1 (mas)</th>
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Rates:

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RMS differences between GTRF13v01 and IGb08 (ITRF2008) station coordinates and velocities

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<th>RMS-Pos.</th>
<th>Epoch</th>
<th>RMS-Vel.</th>
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<td>N (mm)</td>
<td>U (mm)</td>
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Orbit Combination

Orbit RMS agreement btw PFs and combined (co_) orbits for GPS satellites
- mostly in the level of 5-10 mm
- co_ difference to the IGS Final is at the same level
Clock Combination

agreement for the clocks shows RMS of about 15 to 25 ps (all biases subtracted)
Conclusion

Very good performance of PFs and GTRF combined solutions repeatability:
- 1 - 2 mm Horizontal
- 2 - 5 mm Vertical

Good agreement between PF solutions in origin and scale

GTRF Maintenance
- Maintenance as planned
- The latest release of the GTRF is GRTF13v02
- Performance meets requirements (with very good margin)

Perfect alignment to the ITRF at the sub-mm level