Presentation of Public ESA Multi-GNSS Products

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ESOC Navigation Support Office

- Located at ESOC in Darmstadt

- Providing high precision GNSS orbit and clock products since 1992:
  - IGS (GPS+GLONASS)
  - GRAS GSN
  - GGSP/OVF (+Galileo)
  - Sentinel
  - etc.
Multi-GNSS

• All projects push to exploit advantages of Multi-GNSS

<table>
<thead>
<tr>
<th></th>
<th>In Operation</th>
<th>In Orbit</th>
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</thead>
<tbody>
<tr>
<td>GPS</td>
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<tr>
<td>GLO</td>
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<td>26</td>
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<tr>
<td>BEI</td>
<td>16</td>
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<td>QZS</td>
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<tr>
<td>Total</td>
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Multi-GNSS Efforts at ESOC

- Daily processing routine of multi-GNSS, based on IGS routine
  - Minimal-constraint 24 hours network-solution of all operational GNSS satellites
  - Started in 2005 as experiment to study characteristics of the new constellations

- Centre-piece of ongoing development work at ESOC:
  - Orbit & Clock modelling
  - Cycle Ambiguity resolution
  - Differential Code/Carrier Biases
  - L-Band signal combinations (all available signals)
  - ESA Earth Orientation Parameters (based on GNSS, VLBI, SLR and DORIS)
  - POD of Formation Flying and Constellations
  - GNSS Space Service Volume
Day-boundary orbit differences (worst case)

ESOC MGNSS Products
01.2018 - 06.2018

RMS of 3D orbit difference at day boundary [mm]

PRN

BeiDou
Galileo
GPS
QZSS
GLONASS
GALILEO Radiation Pressure Modelling
SLR Residuals with only ECOM (empirical model)

Credit: T. Springer
GALILEO Radiation Pressure Modelling
SLR Residuals with Box-Wing model (physical model)

Credit: T. Springer
Next Generation Radiation Pressure Model
ARPA (Aerodynamics and Radiation Pressure Analysis)

- **In Testing:**
  Replacement of Box-Wing model by **Raytracing** Procedure

- Detailed information about satellite geometry and surface properties allows improved modelling of **Radiation Pressure** and **Air Drag** (LEO)

**Galileo FOC.**
Credit: ESA-P. Carril

**Ray-Source simulating the Sun or the Earth**
Credit: F. Gini
QZSS – Cooperation with JAXA

- **Ongoing** bilateral project to improve QZSS products of JAXA and ESOC

Day boundary differences of ESOC products
Latest improvements
Zero-Mean Reference Clock

- New logic to overcome clock datum defect:

**Old:**
Fix Station clock with best linear fit as Reference clock

**New:**
Ensemble Clock
Zero-mean constraint on the stations with best linear fit to reduce systematics
ESOC MGNSS Final Products

- Final products with 13 – 6 days delay

<table>
<thead>
<tr>
<th>Products</th>
<th>Format</th>
<th>Ext.</th>
<th>Interval</th>
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- Available at:
  - [http://navigation-office.esa.int](http://navigation-office.esa.int)
  - (soon) GNSS Science Support Centre [https://gssc.esa.int](https://gssc.esa.int)
Application of MGNSS solution at ESOC

- Test environment and template for future projects

- Performance Monitoring for:
  - ESA’s GNSS Observation Network (EGON)
  - UTC(ESA)
  - Reference solution for external projects

- Galileo Predictions for the ILRS

- IGS-IGMA Pilot Project (International GNSS Monitoring and Assessment)