Navigation Support Office

Galileo Precise Orbit Determination at ESOC

Prof. Dr.-Ing. Werner Enderle
Dr.-Ing. Erik Schoenemann
Dr. Tim Springer
Dr. Florian Dilssner
Dr. Francesco Gini
Dr. Claudia Flohrer
Volker Mayer

Overview

- Introduction
- Galileo Precise Orbit Determination (POD) Concepts
- Results and Analysis
- Summary

Introduction – Galileo POD Activities

ESOC's Navigation Support Office (NavSO) is involved since 2006 in a variety of POD activities for GIOVE and Galileo

- Galileo Orbit Dynamic Model development - SRP, Albedo, Attitude models, …
- Clock modelling, Clock characterisation
- Meta Data validation - PCV, PCO, DCB, Box-Wing parameter
- Special investigations on issues which directly impacting the Galileo POD
- Analysis of GSS RINEX data
- Galileo signal and service monitoring
- Research Activities (EOP studies, clock modelling, Ambiguity Resolution, GREAT)
- Operational provision of Galileo orbit predictions for ILRS
- Provision of Galileo Geodetic Reference Frame – ESOC is consortium coordinator

Galileo Precise Orbit Determination (POD) Concepts

Batch processing systems - **NAPEOS**

- High-precision orbit and clock determination and prediction
- Estimation of all relevant parameters and products
    - Station coordinates, Earth Orientation Parameters, …

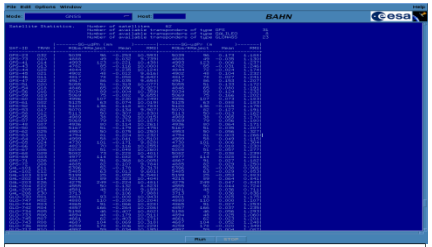
Batch processing systems (experimental status) - **EPODS**

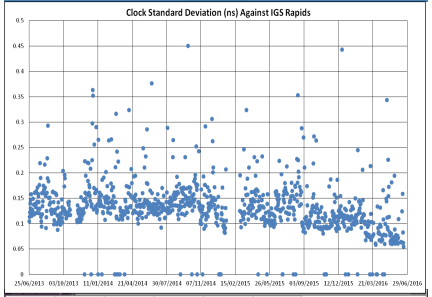
(ESOC Precise Orbit Determination System)

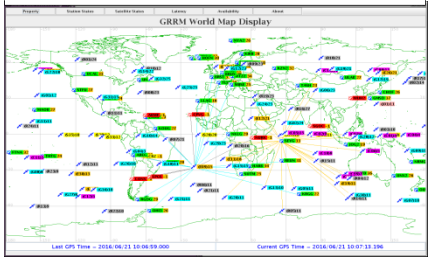
- Processing based on all available GNSS signals (RINEX) – undifferenced observations and no use of linear combinations
- Processing of SLR, DORIS, ISL, VLBI and Altimerty observations
- High-precision orbit and clock determination and prediction
- Estimation of all relevant parameters and products
    - Station coordinates, Earth Orientation Parameters, …

Real Time GNSS processing system - **RETINA**

- Real Time Kalman filter for GNSS clock estimation
- Highly flexible infrastructure for visualisation, monitoring, control and for handling Real Time streams

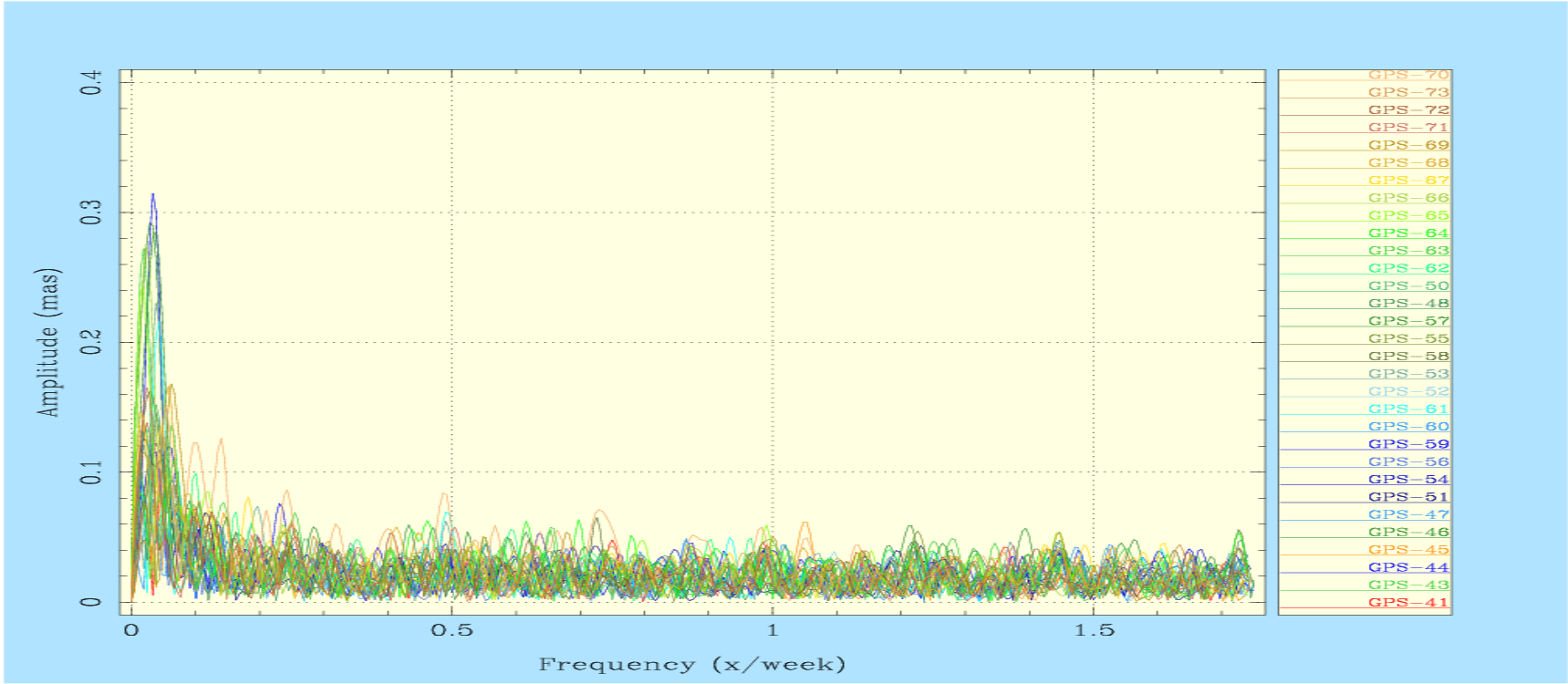






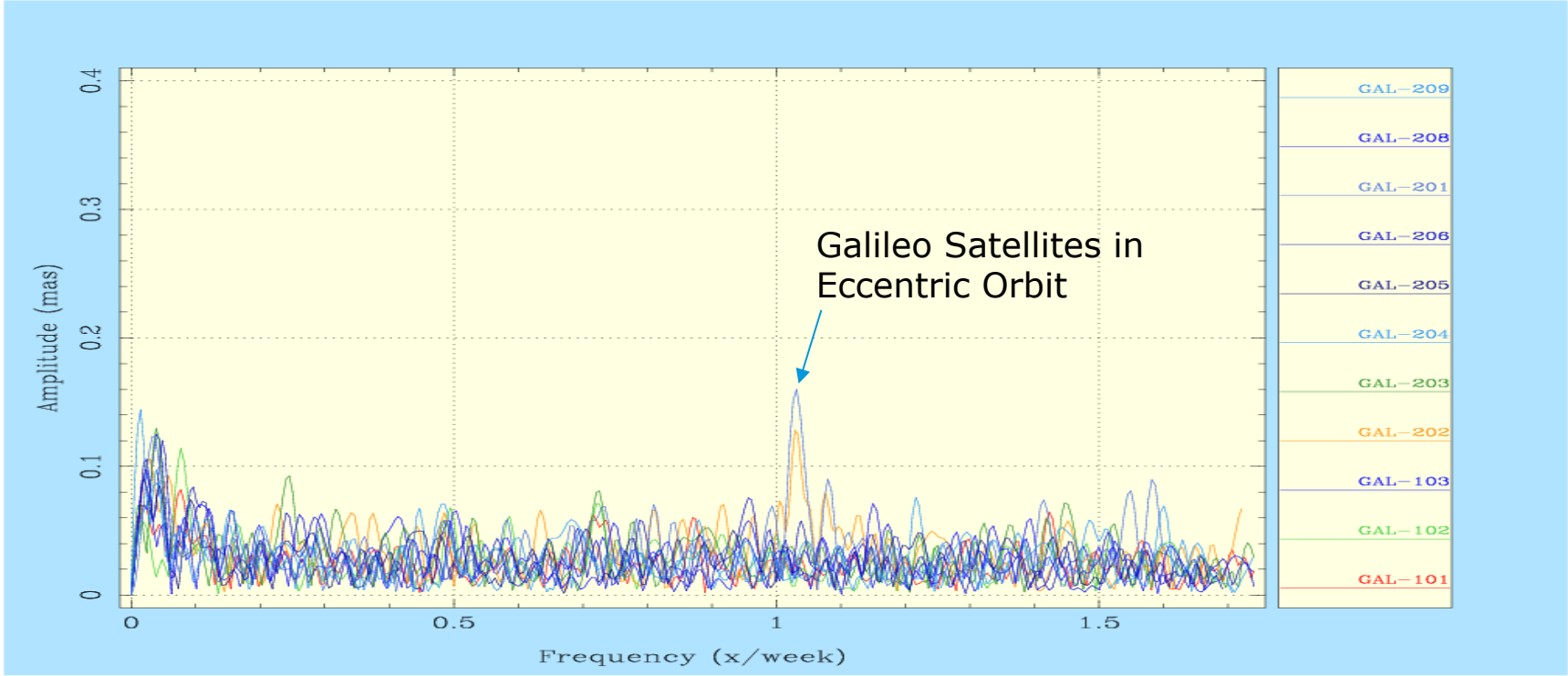
Results – Galileo Dynamic Model Quality

RAAN Amplitude Spectrum for GPS



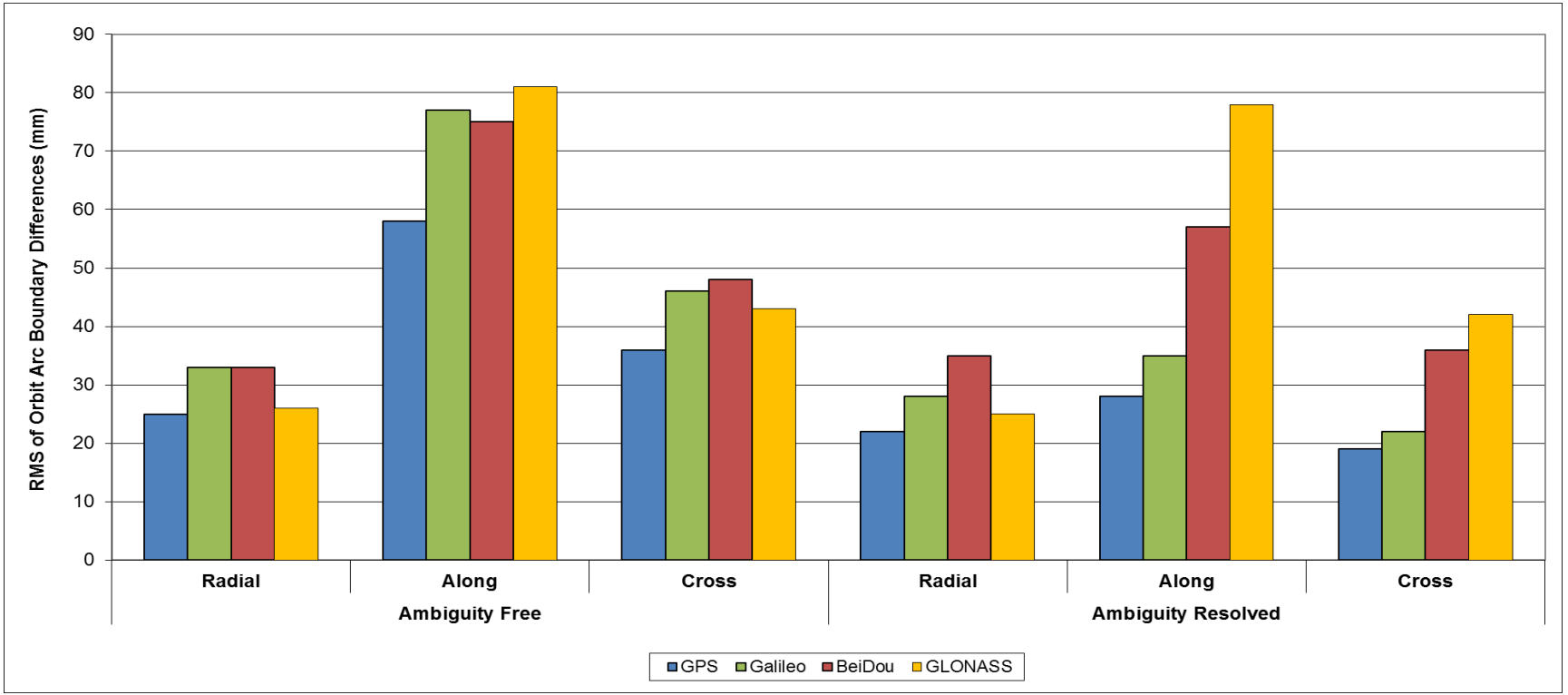
Results – Galileo Dynamic Model Quality

RAAN Amplitude Spectrum for Galileo

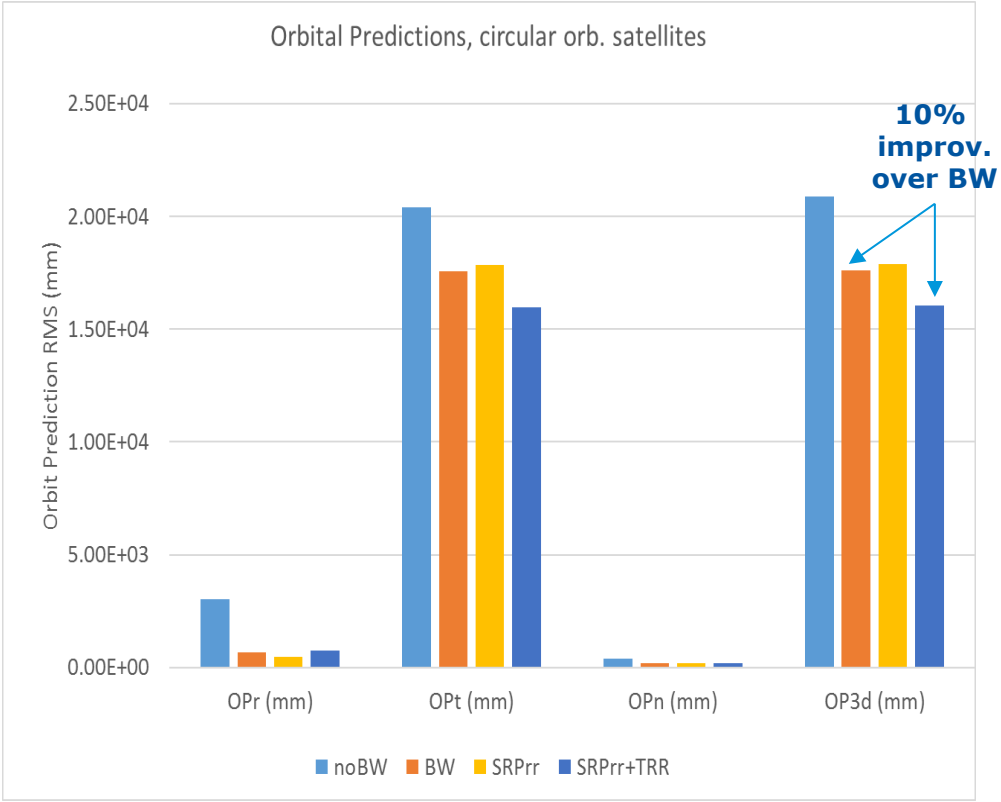


Results – Galileo Dynamic Model Quality

Orbit Overlap – Network Solution



Results – Galileo Orbit Prediction



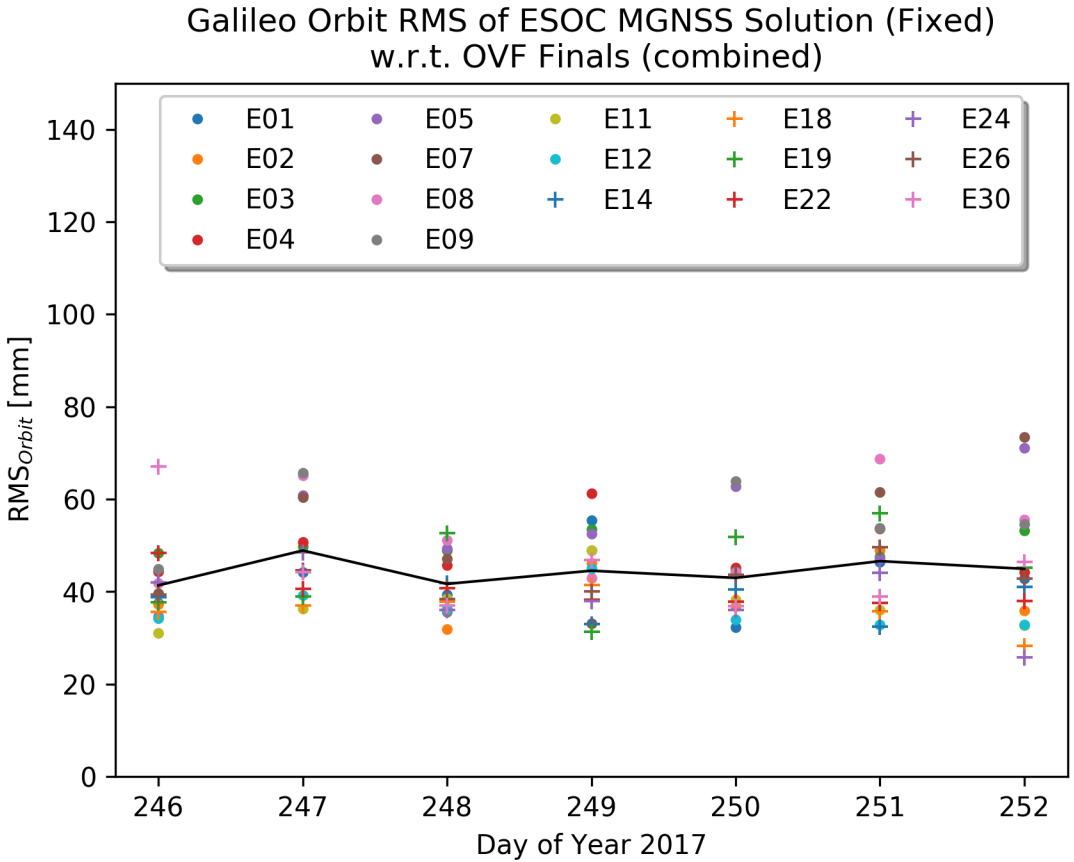
ARPA
Aerodynamic and
Radiation **P**ressure **A**nalysis
(ray-tracing tool)

Galileo FOC Orbit Prediction – 14 Days

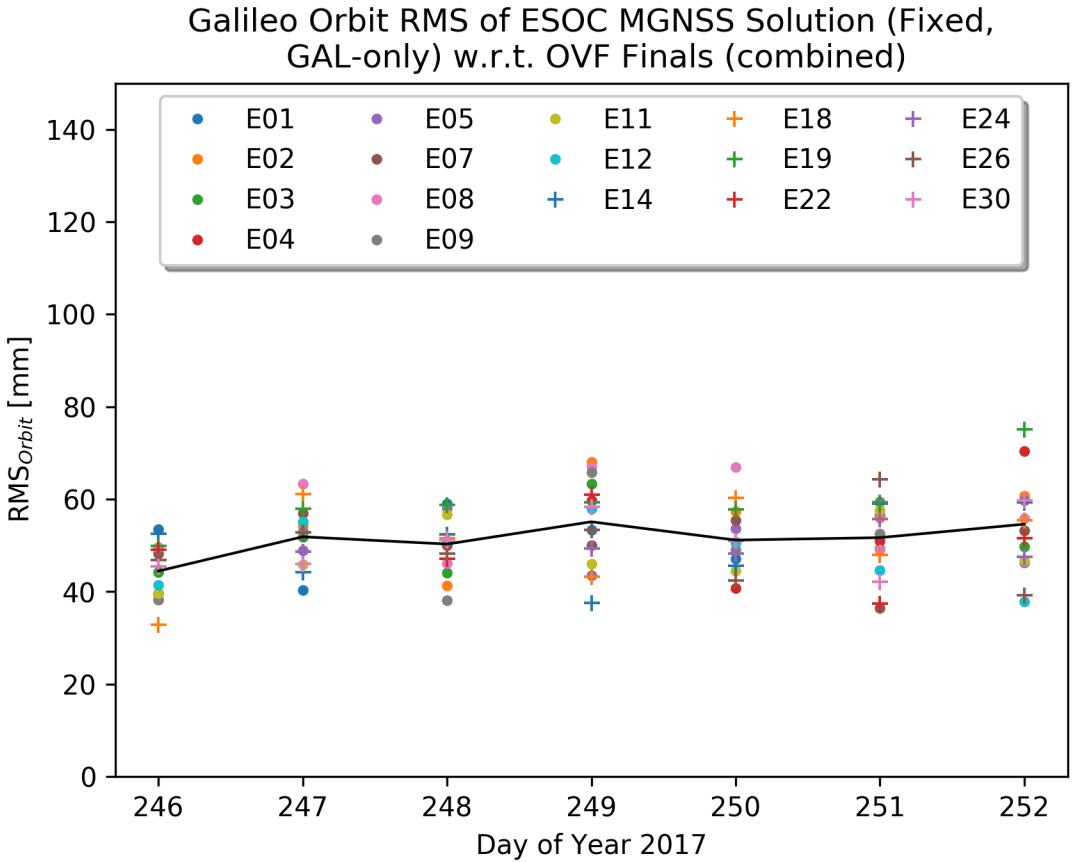
Comparison between:

- no a-priori model (ECOM-2 model only)
- Box-Wing (BW)
- SRP-ARPA
- SRP-ARPA + Thermal re-radiation

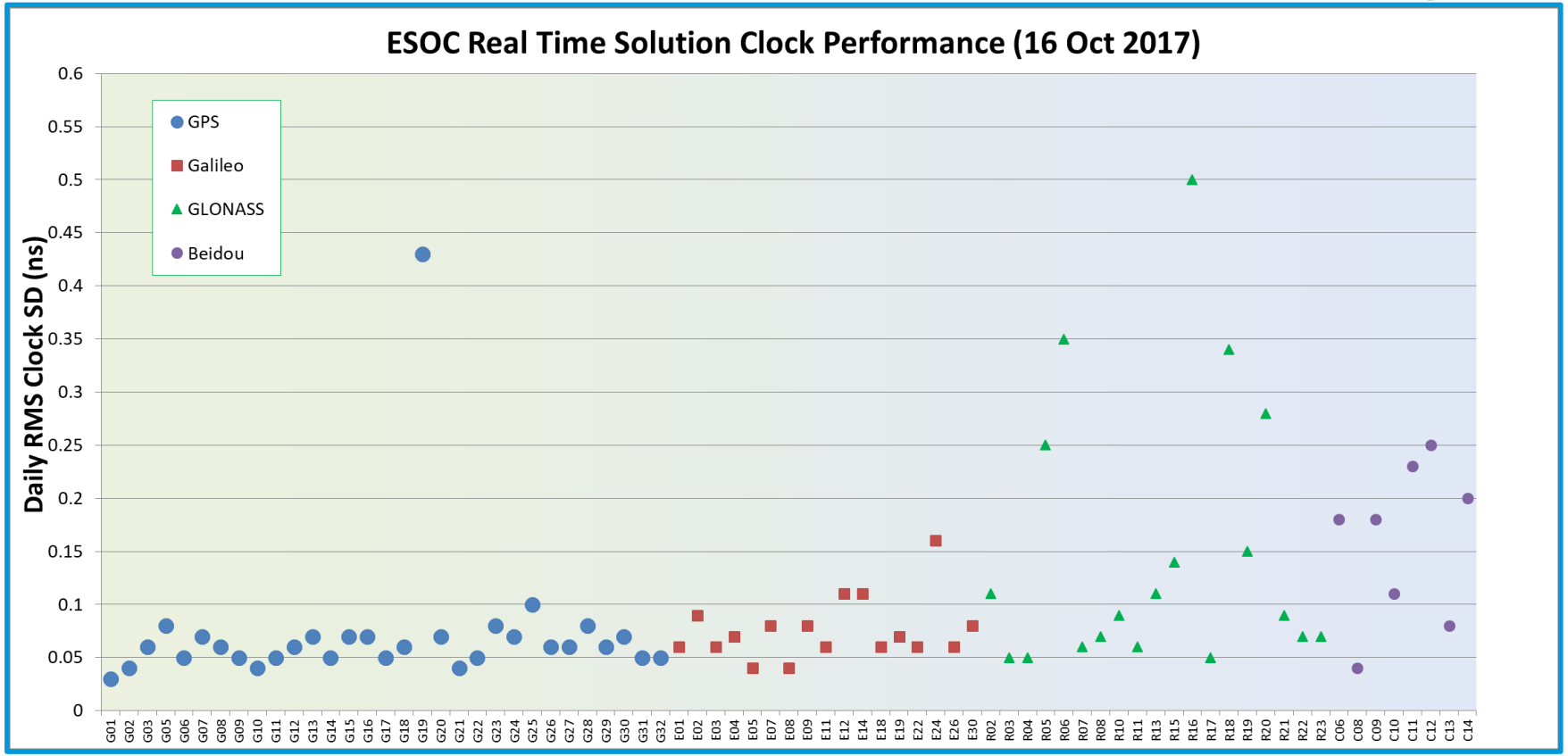
Results – Galileo Orbit Estimation



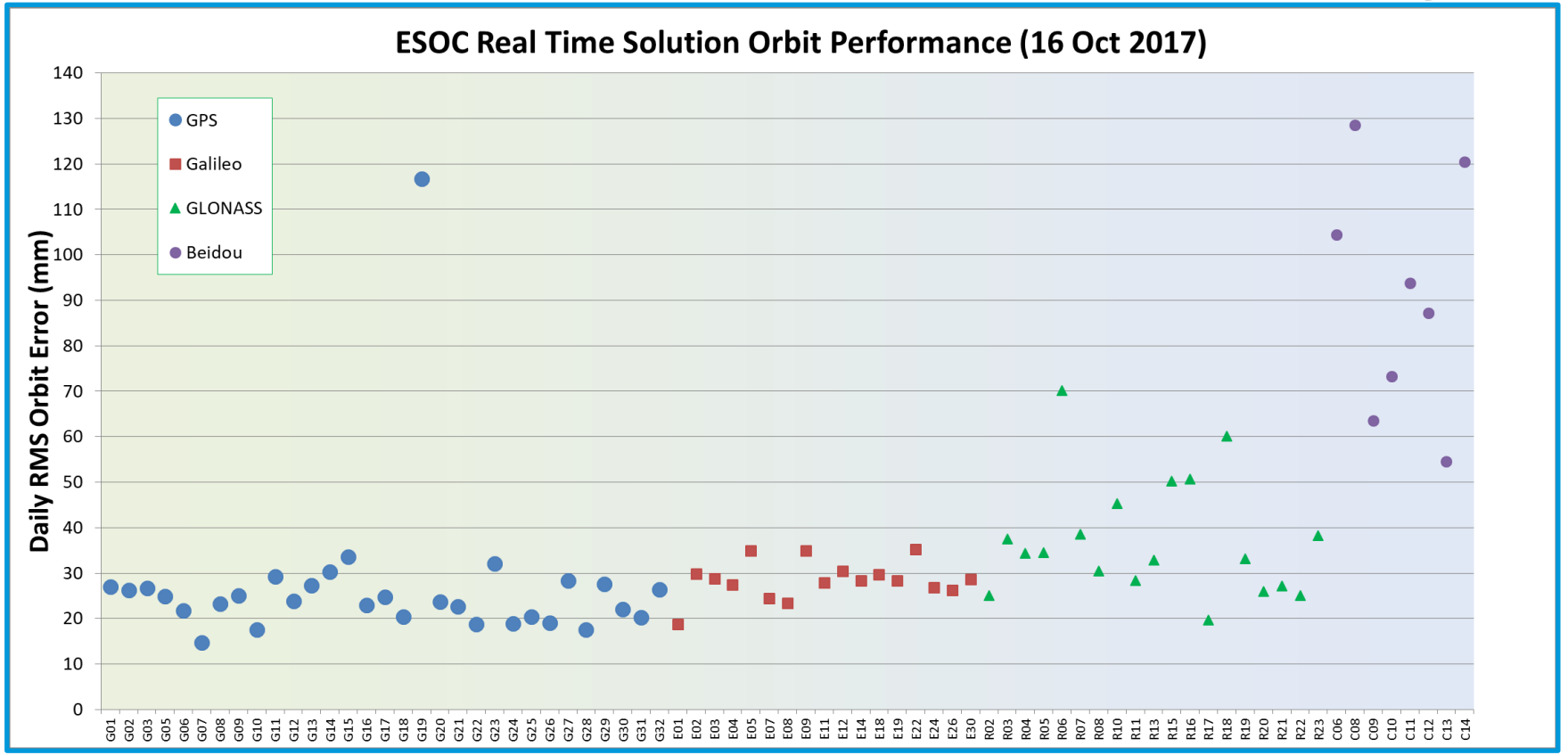
Results – Galileo Orbit Estimation



Results – GNSS Real Time Processing



Results – GNSS Real Time Processing



Analysis

POD Concepts:

- Batch Processing
  - POD based on dual freq. Iono Free Galileo observations provides very good results
  - POD based on multi freq., multi signal undifferenced and no linear combinations are applied to the observations (Raw Method) is closer to physical reality and will improve the POD accuracy even further
  - For multi GNSS the Raw Method has the potential to change the approach for POD, by allowing to take advantage of the strength of the individual GNSS (e.g. clocks of Galileo)
  - Ambiguity fixing for Galileo is implemented and improves the accuracy significantly
- Real Time
  - The Real Time clock estimation is strongly depending on the quality of the estimated orbits
  - High quality orbit modelling is important
  - Number of stations, geometry and quality of observations is essential

Analysis

Galileo Dynamic Model

- Galileo dynamic modelling is considered as very good and stable
- Areas for further improvements have been identified, e.g. Radiation, clock models

Galileo Orbit Prediction

- Orbit prediction accuracy performance is considered as very good
- Galileo radial error is driven by the mass/area property – Galileo satellite is relatively light

Galileo Orbit Estimation

- Important for the accuracy performance is the number of stations, geometry of the stations and also the quality of the observations
- Galileo orbit estimation is on the same level as GPS, despite the fact that for the Galileo network solution we have only the half of the number of satellites

Summary

- ESOC has a long standing and very good cooperation with the Galileo Project in ESTEC and the Galileo Science Office
- ESOC has the capability to generate Galileo and also multi GNSS precise orbits and clocks in batch processing and in Real Time
- ESOC considers the Raw Method as the future processing concept for multi GNSS
- ESOC's Galileo orbit and clock products are the #1

Note: Galileo orbit and clock products will be made available on:

http://navigation-office.esa.int