20TH INTERNATIONAL WORKSHOP ON LASER RANGING

THE COPERNICUS SENTINEL-3 MISSION POD SERVICE

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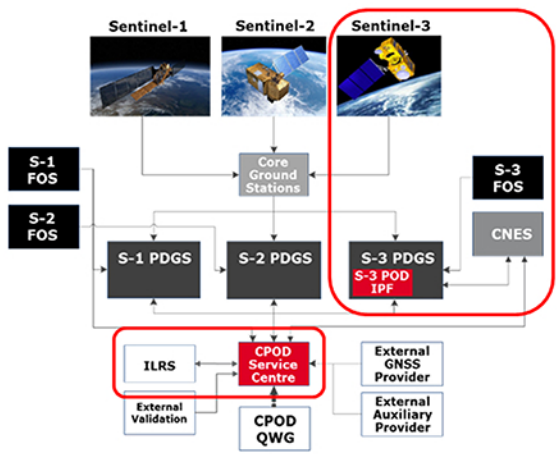
OVERVIEW OF THE COPERNICUS POD SERVICE

Copernicus program facts:

- A joint initiative of the **European Commission** and the **European Space Agency**
- Aims to establish an autonomous European Earth Observation capacity based on Low Earth Orbiting satellites from different missions: Sentinel-1 to -6
- Copernicus POD Service in charge of Sentinel-1, -2 and -3

Copernicus POD Service facts:

- Part of the **PDGS Ground Segment** of the Sentinel missions
- In charge of the generation of **precise orbital products** and auxiliary data files
- **Developed** and **operated** by a **GMV-led consortium**
- **Location:** Operated on **GMV premises** (Tres Cantos, Spain)
- Based on **NAPEOS** (Navigation Package for Earth Orbiting Satellites)
- Responsible for the interface with the **ILRS Community**:
  - In charge of generating CPF orbit files
  - Main user of SLR measurements for independent orbit validation



OVERVIEW OF THE SENTINEL-3 MISSION

- Developed by **ESA**; jointly operated by **ESA** and **EUMETSAT**
- Main applications: monitor Earth's oceans, land, ice and atmosphere to study large-scale global dynamics and provide near-real time information for ocean and weather forecasting
- Main instruments: Radar Altimeter (SRAL), Ocean and Land Colour Instrument (OLCI), Sea Land Surface Temperature Radiometer (SLSRR), and Micro Wave Radiometer (MWR)
- Very demanding **Precise Orbit Determination (POD) requirements** in support of the **altimetry** mission:
  - Nominal POD products based on **GPS** and **DORIS** processing
  - **SLR** measurements required for **independent orbit validation** throughout the entire mission

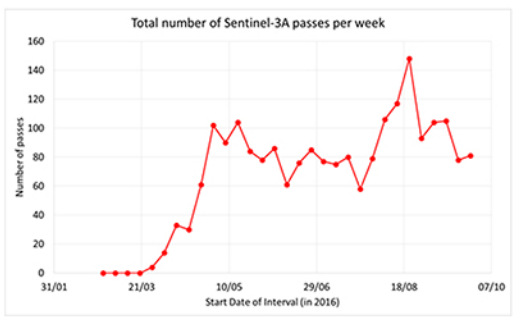
	FACTS AND FIGURES
Launch date	Sentinel-3A: 16th February, 2016 Sentinel-3B: Expected 2017
Mission life	Planned for 7 years (with consumables for 12 years)
Orbit	Polar, Sun-synchronous at altitude of 815 km
Inclination	98.65º
Cycle	27 days
Mass	1250 kg
Instruments for POD processing	2 GPS receivers 1 LRR 1 DORIS receiver

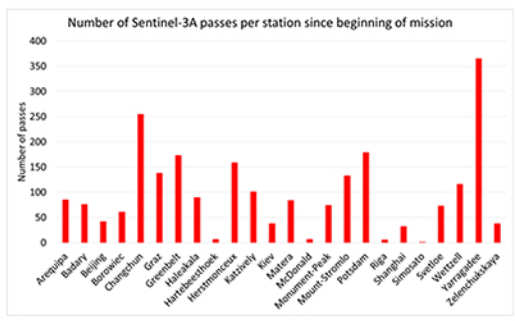
REQUIREMENTS OF SENTINEL-3 ORBITAL PRODUCTS

Category	Latency	Orbit Accuracy
NRT (S3 POD IPF)	30 min.	10 cm radial RMS 1-sigma (target of 8 cm)
STC	1.5 days	4 cm radial RMS 1-sigma (target of 3 cm)
NTC	25 days	3 cm radial RMS 1-sigma (target of 2 cm)

ILRS STATIONS STATISTICS – SENTINEL-3A

Map with statistics on ILRS stations tracking Sentinel-3A. Only those that signed the Sentinel-3 tracking agreement based on power restrictions are included.

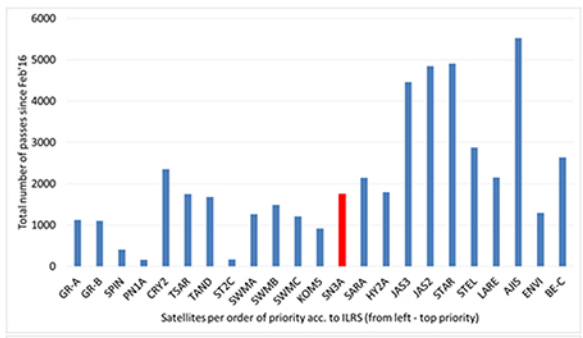


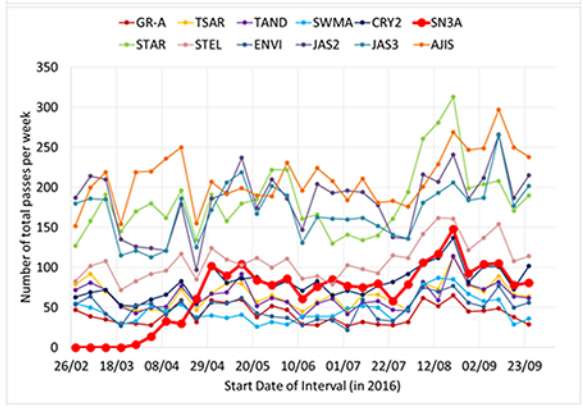


ILRS STATIONS STATISTICS – OVERVIEW OF ALL MISSIONS

Sentinel-3 Mission Status for the ILRS Community:

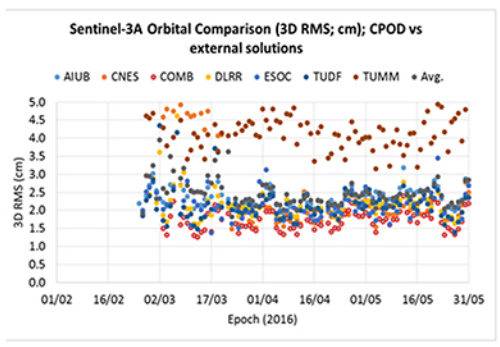
- Sentinel-3A has been assigned medium priority. Does the priority list take into account the scientific and operational need of the missions? Altimetry missions (e.g. CryoSat, Sentinel-3A, Jason-2/-3) have a critical need for SLR measurements
- For the time being, the **order of priority** does not reflect the number of tracked passes per mission
- The temporal evolution of number of Sentinel-3A passes per week has stabilised with values similar to Swarm, TerraSAR-X /TanDEM-X and CryoSat-2
- There are significant discrepancies with respect to other **altimetry missions**, like Jason-2 / Jason-3, and with other gravimetric missions like Starlette and Ajisai
- Sentinel-3 mission requires the support of **SLR measurements** for independent orbit validation throughout its entire life to ensure the demanding **accuracy requirements** for altimetry processing are regularly met. Thus, the **contribution from the ILRS Community** is crucial for the full success of the altimetry mission within the Copernicus Programme

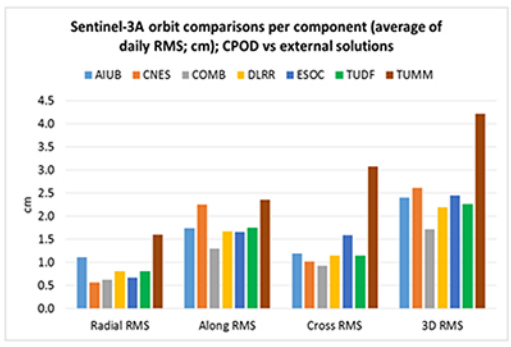




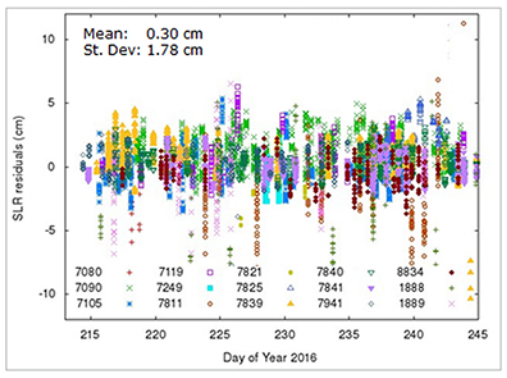
ANALYSIS OF ACCURACY – SLR RESIDUALS AND CPF FILES

- **The accuracy of CPOD NTC** orbits is typically in the order of **3 cm in 3D RMS** against external solutions based on GPS processing, with **radial RMS** around **1 cm**.



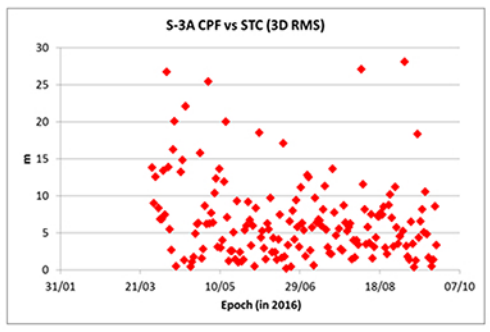


- NTC orbits are compared against **SLR measurements** for **independent orbit validation**. For this purpose, they are not taken into account in the orbit determination process; instead, once the orbit has been obtained, the residuals between the SLR measurements and the orbits are computed. The SLR residuals vs NTC orbits for August 2016 shown in the figure have a **standard deviation of 1.78 cm and a mean offset of 0.3 cm**. This confirms the excellent performance of the NTC orbits and allows identifying biases between different techniques and centres.



ANALYSIS OF CPF FILES ACCURACY AND CONCLUSIONS

- **Consolidated Prediction Format (CPF)** files delivered to the ILRS Community are based on an orbit propagation from the STC product for 5 days into the future.
- Accuracy of the CPF files is assessed by comparison to the STC product with the coverage of the first predicted day of the CPF. Results show that the CPFs accuracy is typically below **10 m 3D RMS**.



CONCLUSIONS

- **The Copernicus POD Service** is responsible for the generation of Precise Orbit products for the Sentinel-3 mission, which has **very demanding accuracy requirements** in support of the altimetry processing.
- There is an important need for **independent validation** of the precise orbits throughout the entire mission span to ensure that there are no unexpected biases in the orbital products which might have a negative impact on the altimeter results. **SLR measurements** perfectly fit this purpose.
- The **Copernicus POD Service** serves as the **interface** with the ILRS Community, and is in charge of the generation of the CPF orbit files with the adequate latency and accuracy requirements. Moreover, it is responsible for the routinely use of the SLR measurements from all stations to validate the generated orbital products.
- It is in the best interest of the mission to understand the needs of the **ILRS Community** and how their **support**, gratefully acknowledged, could be **encouraged** for Sentinel-3. The situation in perspective with other scientific missions has been presented to gain an idea about the global situation of SLR tracking, focusing on those with altimetry applications.
- Finally, an **example of the orbit validations** using the Copernicus POD Service orbits has been presented, showing that indeed there is a very close agreement between the obtained precise orbits and the SLR measurements.

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