Copernicus POD – Overview and Status

ESA Living Planet Symposium 2022
23-27 May 2022, BONN

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ABSTRACT

The **Copernicus Precise Orbit Determination (CPOD)** Service delivers, as part of the Ground Segment of the Copernicus Sentinel-1, -2, -3, and -6 missions, **orbital products** and auxiliary data files for their use in the corresponding Payload Data Ground Segment (PDGS) processing chains and by external users through the ESA Copernicus Open Access Hub (COAH).

The CPOD Service has been operational since 2014, after the launch of Sentinel-1A. Currently, after more than seven years, the CPOD Service generates routinely precise orbital products of **seven Copernicus Sentinel satellites**, using state-of-the art models which have been updated several times over the past years. The precise orbital products have different accuracy and latency requirements varying for the different missions. Prediction, near real-time, short-time critical or non-time critical orbital products are delivered for the satellites.

The CPOD Service is supported by the **CPOD Quality Working Group (QWG)**, composed by leading experts on GNSS and Low Earth Orbit (LEO) POD. Independent orbit solutions are provided from these members to support quarterly and yearly Regular Service Reviews. These reviews guarantee a continuous and independent quality control of the orbital products generated operationally by the CPOD Service. In addition, the CPOD QWG regularly meets to discuss recent developments and enhancements in the field of LEO POD and the applicability to the service operations.

- The CPOD Service has also evolved over the years to support new user needs and technologies, for instance:
  - The provision of a web-based tool to monitor the operations and performance of the service.
  - The reduction of the latency for near-real time products for Sentinel-3 and Sentinel-6 from 30 to 10 minutes.
  - The migration of the Sentinel-3 NRT orbit generation from the PDGS to the CPOD Service Centre.
  - New technologies based on HTTPS API-REST are required for the interface with the PDGS.
  - Readiness to include new Sentinel-C & -D units, Sentinel-6B as well as Copernicus Expansion missions.

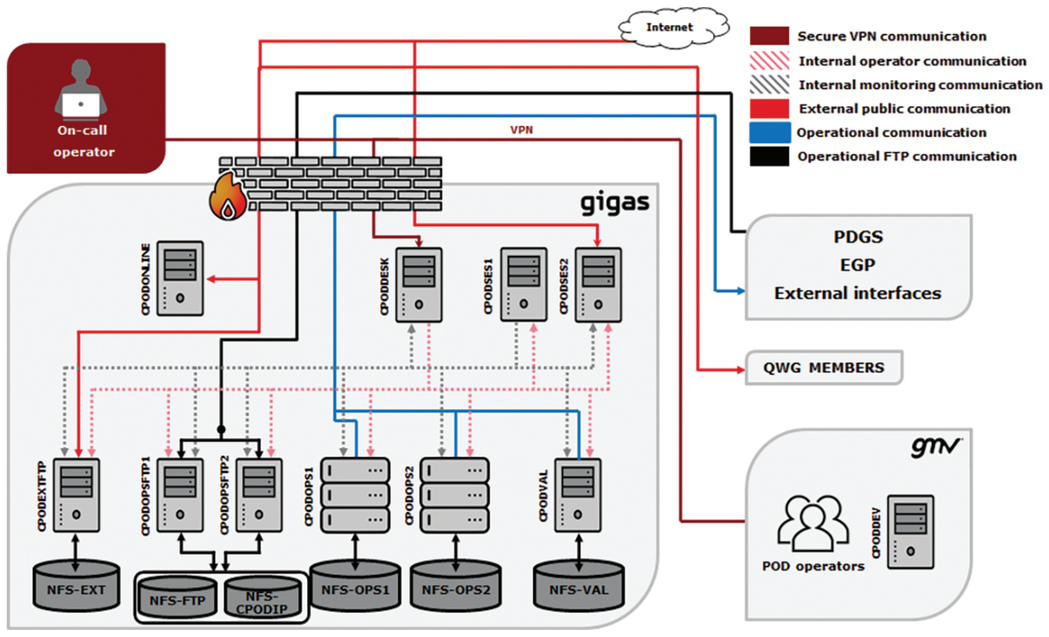
An overview of the current status of the CPOD Service is presented in terms of organisation, design, operations and performance supporting the four Copernicus missions and seven satellites.

PHYSICAL DESIGN

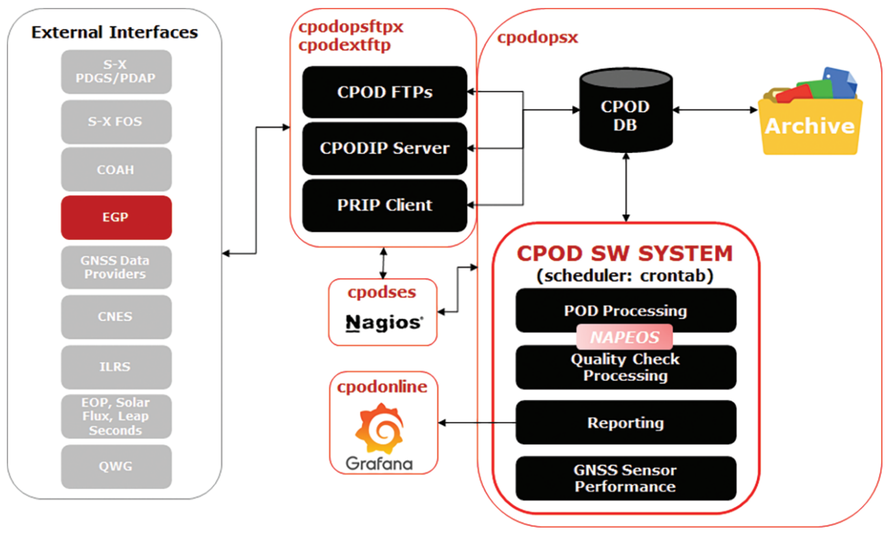
CPOD Service in the Cloud (GIGAS)

10	Machines
80	Cores
120 GB	RAM memory
1.2 TB	Hard disk memory
10 TB	Archive space

The CPOD Service is located in a public cloud provided by the company GIGAS. The physical architecture is designed to fulfil all requirements, and it is capable of increase resources (e.g., cores, RAM, hard-disk) with minimal intervention.



LOGICAL DESIGN & INTERFACES



- The CPOD Service interacts with the external interfaces using different communication protocols:
  - An FTP service, supporting different secure protocols (FTPS, SFTP, HTTPS).
  - A CPOD Interface Point (CPODIP) server, using HTTPS API REST technology to disseminate CPOD products.
  - An HTTPS API REST client to connect to the Sentinel´s Production Services (PRIP)
- The interfaces include among others, the Sentinel´s production services (S-X PDGS/PDAP), the External GNSS Provider (EGP), the Copernicus Open Access Hub (COAH), or the Quality Working Group (QWG).
- The processing chains in charge of generating the products are scheduled through crontab, which launches the processes required at each time.
- The inputs and products are archived into the physical infrastructure and they are accessed through a DB.
- The POD processing and quality control is currently done with the NAPEOS SW.
- Finally, the performance of the system can be monitored by the client through a web-based system using Grafana technology, and by the CPOD 24x7 operators using Nagios tools.

ONLINE MONITORING – GRAFANA

The on-line monitoring interface can show, with little latency, the following relevant information: Overall status of the system per Sentinel mission, Inputs and products availability, Processing metrics, Orbit comparisons, SLR metrics, GNSS sensor performance, KPIs, etc.

RECENT EVOLUTIONS

CPODIP/PRIP: The adoption of HTTPS API REST technologies to: get inputs from the production services of each Sentinel (PRIP) and to disseminate CPOD products through the CPODIP.

Reduced timeliness of NRT products: Optimize each step of the chain to reduce the time to generate NRT products to less than 10 min, including retrieval of inputs and dissemination of products. With S-6A, the typical time to generate the NRT products is less than 7 minutes

S-6A with GPS+GAL: Sentinel-6A includes a GNSS receiver capable of tracking GPS and GALILEO signals. The CPOD Service has been enhanced to process not only the GPS signals, but also the GALILEO signals; this requires adaptations also in the EGP to get GALILEO products.

Readiness to include new missions: The CPOD Service is already capable to supporting the next Sentinel-1, 2, 3 and 6 missions that will be launched in the next years, including the decoding of the GNSS data (GPS+GAL) and its processing.

ORBITAL ACCURACY

This table shows the orbit accuracy requirement (first value) and the results obtained by CPOD Service when compared against a combined orbital solution. Second value is the 1-sigma over the products computed on Q1 2022.

Product	Sentinel-1 (3D)	Sentinel-2 (3D)	Sentinel-3 (Radial)	Sentinel-6 (Radial)
Predicted orbit (first orbit)	100 / 12 cm	300 / 48 cm		
Restituted orbit	10 / 2.8 cm	100 / 2.8 cm	8 / 1.4 cm	5 / 1.1 cm
Preliminary orbit			3 / 0.8 cm	
Precise orbit	5 / 0.6 cm		2 / 0.3 cm	

COPERNICUS OPEN ACCESS HUB

Products available to external users through the Copernicus Open Access Hub (https://scihub.copernicus.eu/gnss/#/home).

Product	Predicted orbit	Restituted orbit	Precise orbit	RINEX daily	Quaternions
Sentinel-1	Pending	Yes	Yes	Yes	Yes
Sentinel-2		Pending			
Sentinel-3		Yes	Yes	Yes	Yes
Sentinel-6		Pending		Pending	

CPOD QWG SUPPORTING ORBIT QUALITY CONTROL

CPOD QWG institutions supporting the orbital quality control by providing independent orbit solutions.

Institution	AIUB	CLS	CNES	DLR	ESOC	EUMETSAT	GFZ	GMV	GSFC	JPL	TUD	TUM
POD SW	Bernese v5.3	GINS / DYNAMO	ZOOM v6.0	GHOST v2276	NAPEOS v4.7	Bernese v5.3	EPOS-OC v6.74	**NAPEOS**	GEODYN	GIPSY-OASIS v6.4	GIPSY-X v1.7	Bernese v5.3
Tracking	GNSS	DORIS	GNSS + DORIS	GNSS	GNSS	GNSS	GNSS	**GNSS**	DORIS + SLR	GNSS	GNSS	GNSS
Missions	ALL	S-3, S-6	S-3, S-6	ALL	ALL	S-3, S-6	ALL	**ALL**	S-6	S-3, S-6	ALL	ALL

Acknowledgements

The Copernicus POD Service is financed under ESA contract no. 4000132155/21/I-BG, which is gratefully acknowledged.

The work performed in the frame of this contract is carried out with funding by the European Union. The views expressed herein can in no way be taken to reflect the official opinion of either the European Union or the European Space Agency.