SENTINEL-1 AND SENTINEL-3-OLCI PAC AT DLR

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ABSTRACT

GMES / Copernicus is the European Earth Observation Programme, conducted jointly by the EC, ESA, EUMETSAT and the member states. The Sentinel satellites (Copernicus space segment) are expected to be launched in 2014 (Sentinel-1A, -2A, and -3A). The core payload data ground segment (PDGS) is managed by ESA and operated by national partners.
In this core ground segment, the DLR German Remote Sensing Data Center (DFD) was selected to install and operate Processing and Archiving Centers (PACs) for Sentinel-1 and Sentinel-3-OLCI. This paper describes the current status of the project “Preparation and Operations of the Sentinel-1 and Sentinel-3 OLCI Off-line Processing and Archiving Centre at DLR Oberpfaffenhofen (S1-PAC / S3-OLCI-PAC)”.

1. Mission Context: the Copernicus Architecture

Global Monitoring for Environment and Security (GMES / named Copernicus since December 2012) is an initiative led by the EU [1]. The major Copernicus building blocks are: the Space Infrastructure, to be implemented by ESA with Sentinels, EO missions developed by ESA specifically for Copernicus; complemented by Contributing Missions, EO missions built for purposes other than Copernicus, but offering part of their capacity to Copernicus (EU/ESA Missions, EUMETSAT, commercial, international); the In-Situ Infrastructure, coordinated by the EEA; the Services Component in support of the large and diverse user community offering Copernicus Services coordinated by the EC and User (Downstream) Services, intended to be provided by commercial entities.
DLR is contributing to the development and implementation of the Copernicus system in various fields since the start of the programme [2], [3].

2. Sentinel Space and Payload Data Ground Segment (PDGS) Infrastructure

The Sentinel Space Infrastructure as central part of the Copernicus Architecture is composed of the Sentinel Space Segment and the Sentinel Ground Segment consisting of the Flight Operations Segment and the Payload Data Ground Segment (PDGS).
The Sentinel Space Segment is composed of three series of two satellites each: Sentinel-1A/B polar orbiting satellites, each carrying a C-Band SAR to ensure the data continuity of the ERS-1/-2, Envisat (ASAR) and Radarsat missions [4]; the Sentinel-2A/B polar orbiting satellites equipped each with a 13-channel Multi-spectral Imager to provide enhanced continuity of SPOT- and Landsat-type data [5]; the Sentinel-3A/B polar orbiting satellites with several sensors (SLSTR, OLCI, and SRAL) for ocean and land applications building on ERS-2 (AATSR), Envisat (MERIS), and Cryosat (SRAL) heritage sensor technology [6].

The Sentinel satellites are currently under development. The first Sentinel satellites are expected to be launched in 2014 (Sentinel-1A, -2A, and -3A). In parallel, the development of the associated PDGS for each Sentinel is under way [7], [8].

The Sentinel PDGS will consist of the following major constituents (see Fig. 1): Four X-Band Core Ground Stations (CGS) to receive all Sentinel-1/2/3 payload data; seven Processing and Archiving Centers (PAC); three Mission Performance Centres (MPC); a Data Circulation and Dissemination Network (WAN); a Payload Data Management Centre (PDMC); the Coordinated Data Access System (CDS).

Four Core Ground Stations will receive payload data in X-Band. Each ground station is able to receive data from all Sentinels. All Core Ground Stations are offering Near-Real Time (NRT) processing services. The CGS are located in Norway, Italy, Spain, and North America.

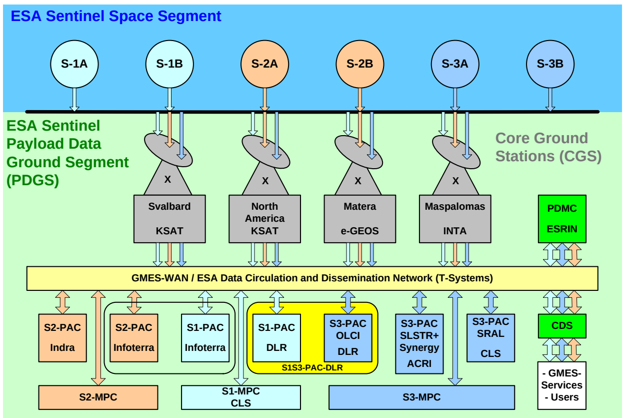

Figure 1: Overall structure of the Copernicus Payload Data Ground Segment: Ground Stations and PACs

Seven Processing and Archiving Centers are located as follows: Sentinel-1 PAC (UK); Sentinel-1 PAC (DLR Oberpfaffenhofen/Germany); 2 Sentinel-2 PACs (UK and Spain); Sentinel-3 OLCI-PAC (DLR Oberpfaffenhofen/Germany); Sentinel-3 SLSTR and Synergy PAC (France); Sentinel-3 SRAL-PAC (France). The S1-PAC and the S3-OLCI-PAC are collocated at DLR's Earth Observation Center in Oberpfaffenhofen/Germany and are integrated, operated and maintained by an experienced team of experts from the DFD institute.

3. Sentinel-1 and Sentinel-3-OLCI PAC at DLR

In 2011, ESA started a series of procurement actions to select European providers to offer their facilities for the set-up and operations of the PDGS elements. Within this competitive selection process DLR was selected by ESA for the role of a PAC operator of the Sentinel-1 and Sentinel-3 (OLCI instrument) missions.

3.1. Tasks of the Sentinel PAC

High-level tasks of the DLR Sentinel PAC are:

- receive Sentinel data from Core Ground Stations via electronic link (GMES WAN);
- ingest these data into the short-term archive (STA) and mid-term archive (MTA) of the Sentinel PGDS;
- in addition ingest these data in a long-term archive (LTA) for a period of more than 7 years;
- perform consolidation and re-assembly of level-0 data received from CGS facilities;
- perform systematic and request-driven processing of Sentinel data to higher-level products;
- host Sentinel data products within a layered architecture of on-line dissemination elements that will facilitate the direct access of end-users via public networks;
- share and exchange any locally processed data with a second partner PAC for the purpose of redundancy;
- capability to reprocess large amounts of data.

According to the GCS operations concept the Sentinel PDGS will become operationally embedded in the GMES Space Component Data Access (GSCDA) System that is progressively being implemented by ESA in support of GMES/Copernicus Service Projects and their users.

3.2. Project Phases

The project is structured in a phased approach (see Fig. 2): The Site Preparation Phase (SPP) started at DLR in Sept. 2012. The Deployment and Test Phase (DTP) started in Q2/2013. The Commissioning Operations Phase (COP) is expected to start mid-2014, whereas the Routine Operations Phase (ROP) will start around Q4/2014.

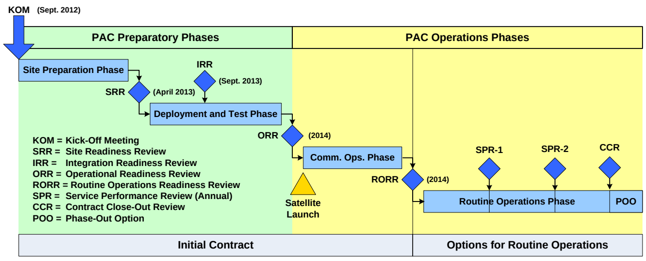

Figure 2: Sentinel PAC Project Phases and Major Reviews

The main technical tasks of the project phases are summarized as follows:

SPP: The Sentinel PAC facility rooms are being prepared to host the Sentinel PDGS equipment. The machine rooms which host the LTA are being prepared for the implementation of all required LTA upgrades. The LAN infrastructure concept to fulfil all ESA defined architectural, performance and security requirements is finalized. The identified LAN hardware and software is procured (by T-Systems, Germany). This phase ends with the Site Readiness Review at DLR to provide evidence that sites and associated infrastructure is ready for the subsequent deployment of the Sentinel PDGS.

DTP: Installation of procured LAN hardware, configuration and tuning of LAN subnets in order to be able to demonstrate the accomplished level of performance and security. Deployment of Sentinel PDGS hardware and installation of software with subsequent training of DLR-DFD personnel. Three months after the start of the DTP the LTA will be ready for Integration with PDGS. This will be demonstrated at the Integration Readiness Review (IRR) to be held at DLR in order to demonstrate LTA Service functions and the availability of all required documentation.
After successful completion of the IRR (foreseen to commence from September 2013), further integration and test of all Sentinel PAC equipment will take place, thus supporting the Sentinel Ground Segment Overall Validation (GSOV). The reprocessing capability with ESA provided test data sets will get demonstrated. The DTP ends with the Operational Readiness Review (ORR) at DLR to present all results of deployment and tests, to demonstrate end-to-end PAC operations based on complete procedures and documentation and a trained operations team. All systems and infrastructure shall be ready for Commissioning Operations.

COP: Support all satellite commissioning operations. Perform all Sentinel PAC functions and monitor service performance. The COP ends with the Routine Operations Readiness Review with the objective to demonstrate readiness of the DLR PAC to undertake the routine operations.

ROP: In the Routine Operations Phase the following services will be available at full operational scope: Network Services, LTA Service, Production and Dissemination Service, and Support Operations such as System Administration, Database Management and Logistics.
The LAN infrastructure is operated in terms of a managed service and will be continuously monitored.
The LTA Service covers: Systematic ingestion of Sentinel data from the Sentinel PDGS; retrieval of archived data products for the dissemination to end-users on request of ESA‘s next generation user services; bulk retrieval of data to be used as input for reprocessing activities; systematic ingestion of data generated in the context of reprocessing campaigns; LTA maintenance activities such as archive monitoring and archive refreshment and data re-transcription
The Production and Dissemination Service covers systematic processing and generation of Sentinel data products of all levels; transfer of received and processed data into STA, MTA, LTA; circulation of data products to partner centers via the multi-Sentinel WAN; request-driven dissemination of data products to Sentinel end-users.

Fig. 3 gives an overview about the high-level structure of DLR’s Sentinel PAC showing the components of the LAN Service (operated by T-Systems, Germany), the LTA Service, and the Sentinel-1 and Sentinel-3 OLCI Production and Dissemination Service.

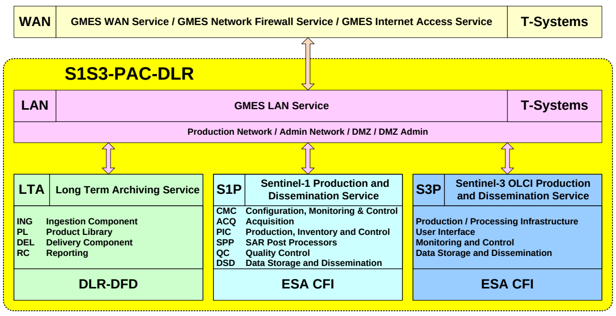

Figure 3: Overall structure of the Sentinel-1 and Sentinel-3-OLCI PACs at DLR-DFD

4. Enhancements of DLR’s existing LTA

In the scope of the Sentinel-PAC project, DLR’s existing data archive will be enhanced. As of Q3/2013 DLR will have a robotic storage library available that will be able to manage about 10,000 storage slots (Fig. 4). The storage tape technology to be utilized is the new T10000C tape drive standard of Oracle through which it is possible to store up to 5 TB of data natively on one single cartridge. In its final target configuration DLR’s tape archive will be able to host 50 PB of data. DLR expects the following Sentinel data capacity requirements per year:

- approx. 1076 TB for Sentinel-1A data products;
- approx. 400 TB for Sentinel-3A OLCI data products.

Fig. 5 and 6 show the expected data volume growth in DLR’s archive for the years 2014 until 2028 (including bulk ingestions originating from reprocessing campaigns).

Figure 4: DLR’s StorageTek SL 8500 Robotic Tape Library

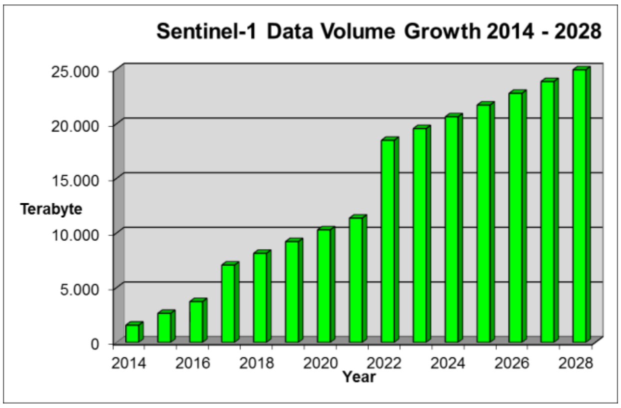

Figure 5: Expected Sentinel-1 Data Volume Growth at DLR-PAC 2014 – 2028

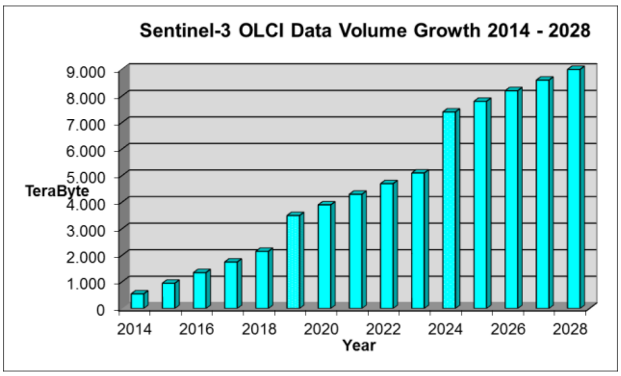

Figure 6: Expected Sentinel-3 OLCI Data Volume Growth at DLR-PAC 2014 – 2028

5. Reprocessing concept of DLR's Sentinel PAC

DLR has about 20 years of experience in the reprocessing of diverse instrument data gained by ESA satellite missions (ERS, Envisat) and also by the German national satellite mission TanDEM-X.

In each Sentinel mission systematic reprocessing campaigns are anticipated. The reprocessing will affect higher-level products (L1/L2) only; no new L0 data will be generated.
DLR's reprocessing infrastructure for Sentinel-1 and Sentinel-3-OLCI data will utilize elements from the Core PDGS – e.g. the Inventory and Data Storage element, the Processing Management function embedding the valid version of the respective instrument processing algorithms - in conjunction with functions covered by the long-term archiving (LTA) service provided by DLR.

The following section is giving a prototypical overview of the basic approach and interaction steps that have to be set out when carrying out a reprocessing campaign. DLR's reprocessing concept is based on the assumption that all level-0 data are fully available in the LTA and the corresponding auxiliary datasets are located with their matching data revision/version either directly within the processing facility itself or alternatively will be retrieved as well from the LTA. The basic operational steps for a reprocessing campaign are depicted in Fig. 7 and described in more detail hereinafter.

- The operator defines the type of dataset to be reprocessed (e.g. level-0 data from Sentinel-1 SAR Stripmap mode) and groups the input data in feasible input data chunks that shall be managed by a given reprocessing batch (e.g. all SM_RAW__0N data from the sensing period Jan. through Feb. 2015). A bulk data query will get directed to the local inventory in order to determine the input items fulfilling the meta-data's search criteria.
- The Inventory function determines from its catalogue the file identificators of the required items and submits corresponding file retrieval requests to DLR'S LTA.
- On each retrieved LTA level-0 archive item a production work order will be launched by the Processing Management function that will activate a processing schema defining, amongst others: the ID of the primary input product, the output product type to be produced, the type and version of all auxiliary data required for the reprocessing, additional re-processing parameters, and the replacement strategy for output products.
- The processing management function is utilizing a suitably dimensioned buffer area named processing cache that is interfaced to the LTA and will store the input products and work order areas for a configurable number of requests that can be executed in parallel. Also it is managing the availability status of the hosts on which the reprocessing software is installed. On each such processing host it will launch a processing task that will bundle the received input data in its processing cache, prepare and execute the work order file,

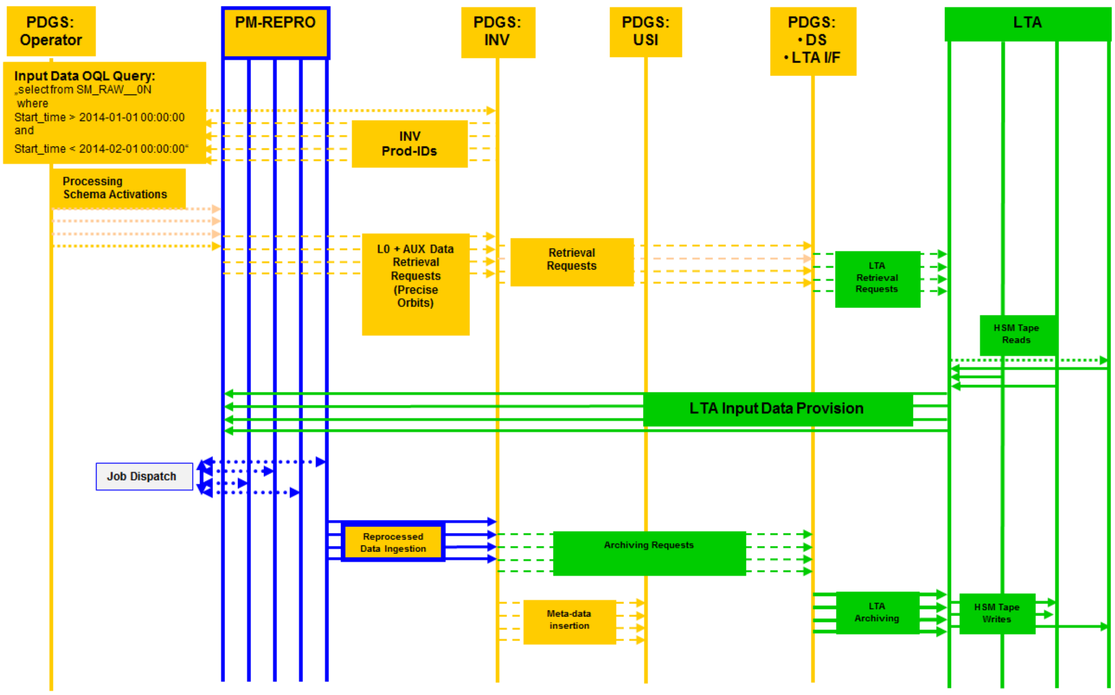

Figure 7: Reprocessing concept of DLR's Sentinel PAC

manage and collect the execution logs and production reports, receive the resulting output data files and make them ready for ingestion either to the LTA itself or the native dissemination or storage infrastructures of the PDGS.

In the estimations for the data volumes in Fig. 5 and 6 of the previous chapter it is assumed that in each Sentinel mission at least two reprocessing campaigns will be carried out during the first 10 years.

6. References

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