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# Design of a Science Operations Centre for the ExoMars 2016 Trace Gas Orbiter Mission

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## Abstract

This contribution describes the design of the Science Operations Centre being developed at the European Space and Astronomy Centre (ESAC) for the ExoMars 2016 Trace Gas Orbiter mission. This technical contribution describes the assumptions and design decisions that have been taken in order to meet all the scientific requirements of the mission considering the tight schedule imposed by the launch date in early 2016. In order to meet all the requirements, the system design takes advantage of the existing expertise and the tools available from previous planetary missions, which will serve as a solid starting point for the development of the core critical elements of the science operations uplink system. Additionally the system design is taking advantage of the collaboration with other development frameworks existing at ESAC for future planetary missions and the further support obtained by the Russian collaboration establishing synergies and improving the baseline core system with advanced state-of-the-art techniques and methods.

## 1. ExoMars 2016 Mission

The first mission of the ExoMars programme consists of a Trace Gas Orbiter plus an Entry, Descent and Landing Demonstrator Module (EDM) that will be launched together in January 2016 on a Proton rocket and will fly to Mars in a mated configuration scheduled for arrival after a 9-month cruise phase. Three days before reaching the atmosphere of Mars, the EDM will be ejected from the Orbiter entering the Martian atmosphere and landing on the surface of the planet. The ExoMars Trace Gas Orbiter will be inserted into an elliptical orbit around Mars and then sweep through the atmosphere during a long aerobraking phase of several months to finally settle into a circular, ~400km altitude orbit ready to conduct its scientific mission starting in late 2017. The main objectives of this mission are to search for evidence of trace atmospheric gases that could be signatures of active biological or geological processes and to test key technologies in preparation for ESA's contribution to subsequent missions to Mars. The Trace Gas Orbiter will also serve as a data relay asset for the 2018 rover mission of the ExoMars programme until the end of 2022.

## 2. Science Operations Centre Design

The ExoMars 2016 Science Operations Centre is designed to follow the Science Implementation Requirements [1] and Science Operations and Data Handling Concept [2]. The three main modules of the SOC are described in the following sections.

A high level simplified view of the stakeholders is shown in the figure below that encapsulates the main information flow from the perspective of the Science Operations Centre at ESAC. The operational flow originates from the mission science objectives defined by the Science Working Team (SWT), including interactions with the Mission Operations Centre and Instrument Teams for the nominal operations, and ending in the archived science data in the Planetary Science Archive (PSA).

Note that the detailed interfaces with the Russian SOC (NNK) are not explicitly shown in this simplified figure as the detailed collaborations are described in each system section.

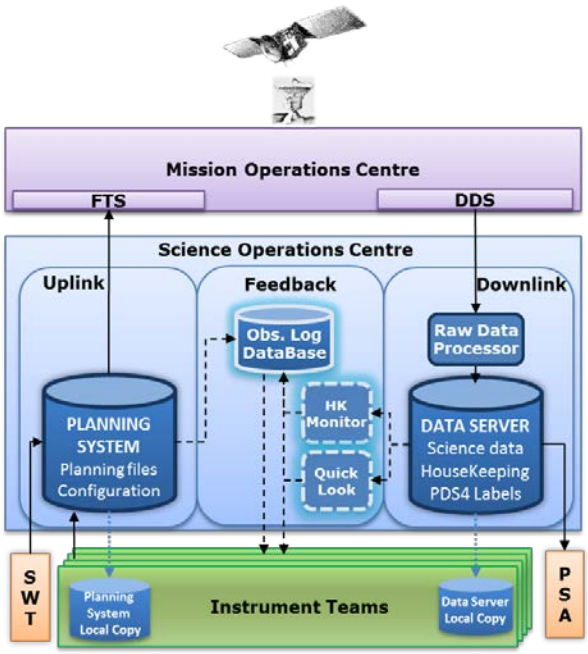

Figure 1: Basic SOC System Design and Interfaces

## 2.1 SOC Uplink System

The uplink system is designed to ensure the success of the science operations and the baseline re-uses the expertise and tools from previous planetary missions, in particular Mars Express and Venus Express, with a centralized planning system at ESAC for the preparation and generation of operational products that are then delivered to the ESOC File Transfer System (FTS) for uplink to the spacecraft. The ESAC planning system is distributed to all instrument teams and fully visible to the whole Science Ground Segment including the Russian SOC.

The following sub-systems are defined in the SOC Uplink System: Opportunity Analysis, Planning and Scheduling, Plan Validation, Product Generation, Auxiliary Data Conversion and Operations Data Management.

## 2.2 SOC Downlink System

The downlink system is not only designed based on expertise from previous missions, but it also counts on more advanced concepts thanks to the existing commonalities with other planetary missions in development at ESAC, in particular Bepi Colombo, Solar Orbiter and JUICE. The main conceptual improvement is that the ExoMars downlink system foresees a centralized approach where the data retrieval and processing up to the raw level (edited data in digital units, not calibrated) is done directly in a collaboration between the ESAC and Russian SOCs with support from the instrument teams. Moreover the data format follows the new Planetary Data System Standard PDS4.

The first sub-system in the Downlink system is the Data Handling and covers the retrieval of telemetry data from the ESOC Data Dissemination System (DDS) and the automatic data processing of the telemetry up to the raw level. These data are then stored in PDS4 format and made available to the instrument teams. The Archiving sub-system takes the raw data generated by the SOC and calibrated data produced by instrument teams to generate PDS bundles that are then validated and ingested into the Planetary Science Archive (PSA). All the data in the PSA is later mirrored to the Russian Deep Archive.

## 2.3 SOC Feedback System

The feedback system covers all the aspects that interconnect the Uplink and Downlink systems. Note that all components in this system are currently not on the development baseline because of the limited time and resources but the main components are still taken into account in the development phase so as to be considered for further improvement of the SOC capabilities, considering again the collaboration with the Russian SOC and the existing synergies with other planetary missions in development like Bepi Colombo, Solar Orbiter and JUICE.

The Feedback system is divided in the following subsystems: Observation Log Database, covering the traceability of operations and data processing; Science Quick-look, to visualize the scientific data allowing for identification of operational issues; and Housekeeping Monitoring, to perform engineering checks on the instrument operational performance.

## References

[1] ExoMars Trace Gas Orbiter Science Implementation Requirements Document (SIRD), ESA, 2014.

[2] ExoMars 2016 SGS Science Operations and Data Handling Concept, EM16-SOC-SP-003, ESA, 2014.

[3] ExoMars 2016 Science Operations Centre System Design Document, EM16-SOC-SP-004, ESA, 2014