

The background features a dark gradient with a central bright sun-like glow. Several curved lines in cyan, white, and yellow represent orbital paths. On the left, a small orange sphere with a white ring is positioned at the start of a white orbital path that loops around the sun.

Venus Express Ground Segment and Mission Operations



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E*SOC was responsible for developing the ground-segment facilities for both the Rosetta and Mars Express interplanetary missions. The high degree of commonality between those spacecraft and Venus Express, the twin spacecraft of Mars Express, has allowed large-scale re-use of ground-segment elements and the replication of the operations concepts for those spacecraft, resulting in significant cost and risk reductions.*

Ground Segment Systems/Facilities

The Venus Express Ground Segment provides the capabilities for monitoring and controlling the spacecraft and payload during all phases of the mission, as well as for the reception, archiving and distribution of the data gathered by the payload instruments. It therefore consists of (see figure):

- a Ground Station and Communications Network
- a Mission Operations Centre, and
- a Science Operations Centre.

The Ground Station and Communications Network

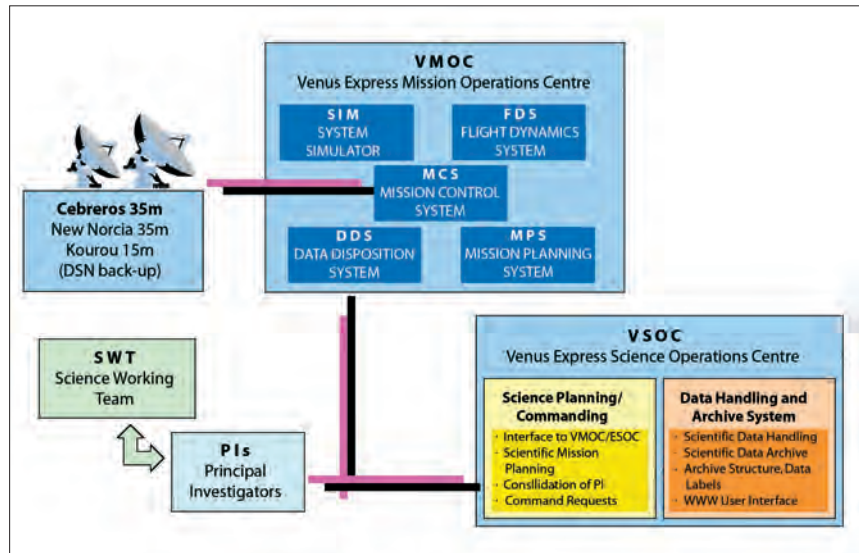
These elements are responsible for performing the telemetry, telecommand and tracking operations for Venus Express, using S/X-band frequencies. Tele-commands and telemetry are sent in either the S- or X-bands, with the possibility to transmit simultaneously in both frequency bands, only one of which will be modulated. The S-band up/downlink is used only during the Launch and Early Operations Phase (LEOP), in support of the Radio Science Instrument (VeRa) campaigns, and in case of an emergency. The ground station used throughout all mission phases will be the new ESA 35 metre installation at Cebreros, near Madrid (Spain) (see accompanying article), complemented by the ESA New Norcia 35 metre station in Western Australia to support the Venus Orbit Insertion and VeRa campaigns, and the Kourou 15 metre station during the LEOP. NASA DSN tracking support is provided as a back-up.

The Communications Network also provides the support services needed for accessing test data obtained during the spacecraft's integration and test programme, for the submittal of command requests to the ESOC/VMOC, for the retrieval of quick-look mission products kept at ESOC, and also for supporting the electronic exchange of scientifically processed data if required.

The Mission Operations Centre

The Venus Express Mission Operations Centre (VMOC) located at ESOC in Darmstadt (Germany), includes:

- the Mission Control System, to support, with both hardware and software, the



The Venus Express Ground Segment

data-processing tasks essential for controlling the mission, as well as spacecraft performance evaluation

- the Data Disposition System, supporting the acquisition and interim storage of raw scientific data, to be accessible together with raw housekeeping and auxiliary data from the instrument Principal Investigators at remote locations, and to provide for production of all data on a raw data medium for archiving purposes
- the Mission Planning System, supporting command request handling and the planning and scheduling of spacecraft/payload operations
- the Flight Dynamics System, supporting all activities related to attitude and orbit determination and prediction, preparation of slew and orbit manoeuvres, spacecraft dynamics evaluation and navigation in general
- the Spacecraft Simulator, to support procedure validation, operator training and the simulation campaign before each major phase of the mission (LEOP, VOI, etc.).

The Science Operations Centre

The Venus Express Science Operations Centre (VSOC) supports the scientific mission planning and experiment command request preparation for

consolidated onward submittal to the Mission Operations Centre (VMOC). The VSOC, which will be co-located with the VMOC during critical mission phases, will make pre-processed scientific data and the scientific data archive available to the scientific community through its Data Handling and Archive Service (DHAS).

The existing ESA/ESOC ground-segment elements and facilities available through the Rosetta and Mars Express missions have been reused to the maximum extent possible, both in terms of hardware and software, for Venus Express.

Flight Operations Concepts and Principles

The Mission Operations Department at ESOC is responsible for the Venus Express mission operations preparation, planning and execution. All Venus Express Operations will be conducted by ESOC according to procedures laid down in the Venus Express Flight Operations Plan, a comprehensive document prepared by the ESOC Venus Express Flight Control Team based on Project/Industry deliverables (User Manual and Database), the Science Operations Plan, and Agreements with the Principal Investigators.

Spacecraft operations during all active mission phases – lasting about 2 years in total, with a possible extension of 1.5 years – will be carried out following an 'off-line'



The Venus Express Mission Control Room at ESOC during the Launch and Early Operations Phase (LEOP)

approach, with all activities being pre-planned and the appropriate telecommands being uplinked to the spacecraft for time-tagged execution (via the onboard mission timeline). The evaluation of telemetry data will also mainly take place off-line, with the possibility of quasi-real-time intervention restricted to certain critical phases and cases of major contingencies.

There will be several communication-blackout periods of up to two weeks duration during the mission, due to the spacecraft-Earth-Sun geometry preventing radio-frequency signal transmission. The round-trip communication time between the ground and the spacecraft will be up to 30 minutes. Contact between the Venus

Express Mission Operations Centre at ESOC and the spacecraft will not be continuous and the periods of contact will be primarily used for the pre-programming of autonomous operations functions on the spacecraft, and for data collection for subsequent offline status assessment. The downlink will normally be configured such that most of the bandwidth is dedicated to the dumping of onboard stored telemetry, with limited housekeeping and/or event telemetry transmitted in real-time during the passes according to spacecraft monitoring requirements.

The Institutes who have developed the scientific instruments are responsible for defining their operation onboard the

spacecraft, with the primary responsibility for developing the payload operations strategy for the scientific mission resting with the Venus Express Science Working Team (SWT).

Mission Products

The mission products made available to the Principal Investigators will include all spacecraft and experiment telemetry data and auxiliary data. Under nominal conditions, all data acquired will be available at the VMOC in engineering format just 1 minute after their reception at the ground station.

