

Venus Express

A European Venus Orbiter

SCIENCE MANAGEMENT PLAN

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VENUS EXPRESS MISSION SUMMARY

Scientific Objectives	To carry out a comprehensive study of the atmosphere of Venus, the plasma environment and its interaction with the solar wind, and to study certain aspects of the surface of the planet.
Payload	IR Mapping Spectrometer, Wide Field Imager, IR and UV Spectral Sounders, Plasma Analyser, Magnetometer, Radio Science. Total Payload mass ~ 90 kg.
Spacecraft	Spacecraft 3 axes stabilized 1.7x1.5x1.5 m ³ , 2x2.9m ² solar panels, Available power 970W, 12 Gbit Mass Memory, Data transfer to Earth 500 Mbit/day – 6500 Mbit/day, dry mass : ~660 kg ; propellant: 570 kg. Mars Express design adapted to Venus environmental conditions.
Launcher and launch date	Soyuz/Fregat; Launch Window: 26 October - 24 November 2005. Launch mass: ~ 1270 kg ;
Transfer Trajectory	Direct interplanetary Earth-Venus transfer orbit and hyperbolic Venus approach trajectory. Cruise duration: 5 months
Venus Orbit	Highly Elliptical orbit: pericentre 250 km, apocentre ~ 66000 km. Period : 24 hours. Inclination ~ 90°. Latitude of pericentre ~80° N
Operations	ESA Mission Operations, ESA Science Operations and Archiving. Communications: X-band (65W); S-Band (5W) back up for emergencies. Primary ground station: ESA Cebreros. Operational lifetime at Venus: 2 Venus sidereal days (486 earth days), fuel dimensioned for a possible extension of another 2 Venus days.
Programmatics	Venus Express is the second flexible mission of ESA's scientific programme. ESA will provide the Spacecraft, a Soyuz type Launcher, and the Operations. National space agencies of Europe are expected to provide support for science instruments operations. Additional international partners may participate at different levels.

1 SUMMARY AND SCOPE

After being left unattended for more than a decade Venus will soon be again the focus for detailed studies by an orbiting spacecraft. Venus Express is an ESA mission for an in depth study of the atmosphere and some specific aspects of the surface of the planet. The Venus Express spacecraft will perform precise determination of the atmospheric circulation and composition and study of the interaction of the atmosphere with the interplanetary medium. For the first time the surface will be studied by using the Infrared windows through the atmosphere. Venus Express represents a unique opportunity for Europe to further enhance the experience of exploring the, in several respects, most Earth-like of the planets in our solar system, following the success of Mars Express. It is an outstanding science opportunity that can be implemented at relatively low cost and risk as the mission derives much of its design and the programmatic approach from the Mars Express and Rosetta Programmes. It is an opportunity that was clearly recognised by the scientific community and was seized upon by the Agency.

Venus Express was approved by the ESA Science Programme Committee (SPC) for a launch in November 2005 at its meeting in Paris on 4-5 November 2002. With less than two years from approval to launch Venus Express is, by far, the fastest developed scientific mission of ESA to date.

The spacecraft and its associated infrastructure is developed and will be operated by ESA while the PI provided instruments and all instrument related activities, including operations and data processing/archiving, are the responsibility of the respective national agencies.

This document, the Venus Express Science Management Plan (SMP), replaces the Mars Express Science Management Plan that with regard to the science management approach has implicitly been applied to Venus Express. It outlines the management scheme to be implemented for the scientific programme from the launch through the operational phase to the post operations and archiving phases. The main areas addressed in the plan are the interfaces with the scientific community via external science teams, participation of scientists in the programme and the science operations. It further addresses the rights to and the distribution of the scientific data products from the mission. In particular, the plan defines the responsibilities of the Venus Express Science Working Team and the Principal Investigators. It explicitly excludes the sections on Payload Announcement of Opportunity and Payload Selection and a few other related paragraphs typically found in an SMP, since the Payload was an integral part of the mission proposal.

2 MISSION OVERVIEW

2.1 Introduction

Venus Express, an Orbiter for the study of the atmosphere, the plasma environment, and the surface of Venus was proposed to ESA in response to the *Call for Ideas* to re-use the Mars Express platform issued in March 2001. Venus Express, together with two other missions, Cosmic DUNE and SPORT Express, were selected for parallel Mission Definition Studies. These industrial studies, supported by expert science teams of the three missions, were conducted in parallel by Astrium-SAS (Toulouse, France) from mid-July to mid- October 2001. After study completion, the Venus Express mission was selected based on its science potential and as it best fitted within the given programme boundaries. The mission was eventually approved by SPC in November 2002.

Venus Express is a Principal Investigator (PI) type mission. In order to optimise the over all scientific output from the mission, the Venus Express Science Working Team (VSWT) will establish the rules to balance the resource allocation for the different science investigations during the Venus operational phase.

ESA will be responsible for the overall spacecraft and mission design, spacecraft procurement, spacecraft and payload integration, system testing, launch procurement, mission operations, acquisition and distribution of the science data and for the final data archive. The PIs are responsible for providing the scientific instruments and all services and activities related to these. This includes the operation of the instruments during flight, processing of the acquired data and preparations for the archiving. It is expected that the PIs will receive adequate funding for all activities by the corresponding national agencies.

2.2 Scientific Objectives

The scientific objectives of the Venus Express Mission [Ref. 1] are grouped into seven Scientific Themes, with the aim to carry out a comprehensive study of the atmosphere of Venus and to study to some detail the plasma environment of the planet and its interaction with the solar wind. Dedicated studies of the surface shall be performed as well. A detailed description of the background and justifications for the objectives are given in [Ref.2]. The science requirements are structured in accordance with the themes. The main Science Themes that have been defined are,

- Atmospheric Dynamics
- Atmospheric Structure
- Atmospheric Composition and Chemistry
- Cloud Layer and Hazes

- Radiation balance
- Surface properties and Geology
- Plasma environment and escape processes

The first three themes are divided in to sub-themes that refer to the upper, middle and lower parts of the atmosphere. The corresponding approximate limits for these regions are, above 110 km, between 110km and 60 km, and below 60 km.

In addition to the Science Themes, a number of major scientific questions have been formulated as a part of the science objectives. These questions to some extent go across the boundaries of the individual themes and studying them will ensure that the multi-disciplinary aspect of the mission is maintained.

- What is the mechanism and what is the driving force of the super-rotation of the atmosphere?
- Which are the basic processes in the general circulation of the atmosphere?
- What is the past and present water balance in the atmosphere?
- What is the role of the green house effect in the past, present and future evolution of the planet?
- Is there presently volcanic and/or tectonic activity on the planet?

The answers to these questions, together with the comprehensive studies under the different themes, will lead to an improved understanding of the perhaps most fundamental question of all, namely, ‘Why is Venus so different from the Earth’, in spite of the similarities in terms of size and distance to the sun?

2.3 Payload

The spacecraft is carrying a payload of seven scientific instruments with a total mass of approximately 90 kg. This payload addresses all the major science objectives, described in Section 2.2.

Given the short time scale as announced in the mission AO, which targeted a 2005 launch, existing experiments were encouraged in order to minimize costs and development time. Nevertheless innovative instruments were added when it could be demonstrated that adequate funding was in place and that they were technically mature. The payload was proposed as an integral part of the Venus Express mission proposal and as such, this same payload was studied in the initial competitive industrial study. A list of the selected instruments available from the Mars Express or Rosetta spacecraft and the new developments is shown in Appendix A.1.

2.4 System Requirements

Owing to the innovative, flexible and fast way of implementing the new type of F missions of ESA's Scientific Programme, Industry was asked to bid for a ceiling price contract to design and build a spacecraft inherited from Mars Express, which meets the following requirements:

- 3-axis stabilisation with nadir pointing capability.
- Modifications to the Mars Express system to allow operation in the more demanding Venus environment.
- A pointing and stability performance compatible with the basic payload needs within existing Mars Express capabilities.
- Support a payload up to about 90 kg including the normal services, e.g. Power, data, thermal and pointing.
- On-board data storage of sufficient size to allow storage of scientific data during periods with no communications coverage.
- On-board propulsion sufficient for Venus capture, orbit insertion, station keeping and attitude manoeuvres during a nominal operational period of 2 Venus days (486 earth days) for an extension of the mission of another 2 Venus days.
- The necessary resources to allow navigation during the cruise phase, Venus capture, Venus orbit insertion and Venus orbit maintenance.
- Compatibility to the Soyuz-Fregat launch vehicle.

2.5 Mission Scenario

The Venus Express spacecraft will be launched in October / November 2005 on a Soyuz launch vehicle. The expected launch mass is 1270 kg.

After launch, injection into earth escape trajectory and a five months cruise phase, the spacecraft will perform a sequence of orbit manoeuvres during the Venus approach phase (about 10 days prior arrival) to deliver it for the capture manoeuvre into an initially highly eccentric orbit (apocentre around 350000 km) at Venus. The arrival hyperbola will be such to inject into a polar orbit. The apocentre altitude will then be reduced in several steps by manoeuvres at pericentre. This procedure will be carried out with chemical propulsion.

During observations an attitude strategy will be flown such that the instruments can be pointed towards nadir or to a prescribed direction not far from nadir. The earth communications are assumed to be done during missions phases in which the observation payload will not be operated (e.g. after pericentre at ascending arc) by turning the spacecraft high gain antenna into the earth direction. The spacecraft will have the necessary data storage, capacity and the necessary autonomy for both remote sensing and communications relay operations.

3 PROGRAMME PARTICIPATION

3.1 Introduction

The fast way of implementing the Venus Express mission required a fast selection of the scientific payload. The payload was therefore proposed and selected as an integral part of the mission proposal. This represents a substantial saving of time compared to previous study cycles of medium-size missions of the Scientific Programme.

3.2 Schedule

VENUS EXPRESS PROGRAMME SCHEDULE	
Issue of request for proposal for Mars Express Re-use	March 2001
End of review process and recommendation to SPC. SPC recommendation for Pre-Phase B study to ensure feasibility.	November 2001
SPC conditional approval for implementation pending payload funding resolution	July 2002
Full SPC approval for implementation	November 2002
System Requirements Review	November 2002
Preliminary Design Review	March 2003
Critical Design Review	April 2004
Flight Acceptance Review	1 July 2005
Shipment to Baikonur	5 August 2005
Launch	26 October – 24 November 2005
Arrival at Venus	April 6 2006
Mission Commissioning Review	4 July 2006
End of nominal mission	24 Sept 2007
End of extended mission (if approved)	22 Jan 2009

Table 3.2: Venus Express Programme Schedule

The baseline Venus Express programme schedule is outlined in Table 3.2. Indeed, with less than three years between the final SPC decision to go ahead, and the launch, Venus Express by far is the fastest developed scientific mission within ESA. Additional solicitations to broaden the further involvement of the scientific community will include the issue of an AO for Interdisciplinary Scientists and Supporting Investigators.

3.3 Status of the Project

Venus Express will be launched in October 2005. The spacecraft has passed all the major environmental tests and is now in its final check-out phase before the Flight Acceptance Review which will review the overall status of the mission before shipment of the spacecraft to the launch site.

The ground segment is well developed and planning for science operations are in an advanced state. There are no major technical hurdles to overcome at present and the implementation of the mission awaits the launch.

Once in orbit around Venus an intensive period of commissioning and initial science operations will be conducted. The analysis of the science data generated is not assured at the moment and requires a firm commitment by the national agencies to support the PI teams.

3.4 Further Scientific Participation in the Mission

In order to further enhance the scientific output of the mission the scientific community will be invited to participate in the Venus Express mission in a number of additional ways :

- Interdisciplinary Scientist proposals may be submitted by individuals – in response to a specific ESA AO – for specific tasks in support of the multidisciplinary nature of the Venus Express objectives. The selected IDSs will become full members of the Venus Express Science Working Team.
- Supporting Investigators will be encouraged to submit proposals for various Studies in support of the mission, and to participate in the data analysis. This can include e.g. studies of physical and chemical properties of atmospheric gasses at Venus like conditions. Also ground based telescopic studies will fall in this category. These scientists will not be official members of the VSWT but may attend the VSWT meetings.

All the above individuals together with the Principal Investigators will have to support a strong ESA communications and public relations effort during all phases of the mission.

3.5 Potential International Collaboration

NASA has allocated limited funding in order to support US based scientists contributing to the Venus Express mission. A NASA Announcement of Opportunity has been issued and selections should be completed in time for the NASA 2006 fiscal year. ESA will take part in the selection of these CoI:s.

4 SCIENCE AND PROJECT MANAGEMENT

4.1 Science Working Team Composition

The Venus Express Science Working Team (VSWT) is composed of the PIs of the seven investigations on board the spacecraft. The Interdisciplinary Scientists, once selected, will become full members of the VSWT. The VSWT is chaired by the Venus Express Project Scientist. The Venus Express Science Working Team monitors and advises ESA on all aspects of Venus Express that affect its scientific performance. The VSWT aims to make decisions based on consensus, but where voting will be necessary each investigation (PI) and IDS will have one vote (PI) and the chairman has the decisive vote at an equal number of votes.

ESA organises regularly VSWT meetings, generally to take place at ESTEC. All VSWT members are expected to provide their own funding to attend the VSWT meetings.

4.2 Science Working Team Tasks

The tasks of the Venus Express Science Working Team are :

- To assist the Project Scientist in maximising the scientific return of Venus Express within the established boundary conditions.
- To act as a focus for the interest of the scientific community in Venus Express.

These tasks will be achieved by :

- Reviewing the scientific goals of Venus Express at regular intervals taking into account recent results while considering the technical boundary conditions of the spacecraft/ground segment.
- Advising on the scientific aspects of the development of the Venus Express spacecraft.
- Establishing a baseline payload operations scenario based on the scientific objectives of Venus Express.
- Participating in the major project reviews.
- Performing specific tasks as needed during the development of the projects..

The VSWT will review the tasks and activities of the Venus Express Science Operations Centre (see section 5.3). In particular, the VSWT will be responsible for :

- Optimising the science return from a science operations point of view.
- Advising on the development of the science ground segment including the Venus Express Science Operations Centre with particular reference to the payload operational scenario, software, ancillary data products and the Venus Express science database and archive,

4.3 The Project Scientist

The ESA Venus Express Project Scientist will be the Agency's interface with the Principal Investigators for scientific matters. Within ESA, he will liaise with the Venus Express Project Manager until completion of the satellite in-orbit commissioning and thereafter with the Mission Operations Manager.

During all phases of the project, the Project Scientist (PS) will coordinate all scientific issues with the project team. In particular, the Project Scientist will advise the ESA project on technical matters when they affect scientific performance. During the development and operational phases, the Project Scientist will monitor the state of implementation and readiness of the instrument operations and data processing infrastructure. After the completion of the in-orbit operations the Project Scientist will coordinate the creation of the scientific products, their archiving and distribution to the scientific community.

The ESA Project Scientist will act as the Chairman of the Venus Express Science Working Team (VSWT) and as such coordinate its activities (see sections 4.1 and 4.2).

4.4 The Project Team

ESA will maintain a Venus Express Project Team, directed by a Project Manager, until completion of the satellite in-orbit commissioning phase. ESA, via the Project Manager and his Project Team, will retain overall responsibility for the mission. ESA is employing similar procurement approaches as used previously on Mars Express.

The Project Team is responsible for the procurement of the spacecraft, instrument integration into the spacecraft, system testing, launch and mission operations, acquisition and transmission of the spacecraft data to the Mission Operations Centre. The Mission Operations Centre will distribute the scientific data to the relevant Principal Investigator teams and to the Science Operations Centre.

The Project Team monitors and controls the work of the Venus Express industrial contractors and determines the launch date. During the development phase of the mission, the Project Team will also monitor the development of the instruments and ensure their readiness by monitoring the adherence of development plans to agreed-to schedules. In addition, the Project Team monitors and controls all interface specifications; these include technical specifications between the instruments and the spacecraft, as well as data and information exchange specifications among all parties involved (ESA, PIs, Launcher and Industry). Within the scope of this procurement approach, the Project Team may decide to delegate the execution of all or some of the above tasks to industrial contractors.

4.5 The Mission Manager

After the completion of the spacecraft and payload commissioning, which is concluded by the Mission Commissioning Results Review (MCRR), the management of the mission is transferred to the Mission Manager in the Research and Scientific Support Department (RSSD).

4.6 Monitoring of Instrument Development

ESA monitors the progress of the design, development and verification of all Venus Express scientific instruments. The PIs and their experiment managers have to demonstrate to ESA, in regular reports and during formal reviews, compliance with the scientific mission goals, the spacecraft constraints, the spacecraft interfaces and the programme schedule as defined in the mutually agreed interface documentation with industry.

The Project Team is not responsible for supporting the development of tools / services in the PI institutes for conducting scientific analysis of the instrument data.

5 OPERATIONS AND SCIENTIFIC DATA

Venus Express will be operated as a Principal Investigator (PI) type mission.

The Venus Express ground segment consists of two major elements: The Venus Express Mission Operations Centre (VMOC, located at ESOC) and the Venus Express Science Operations Centre (VSOC, located at ESTEC).

The primary responsibility for developing the payload operations strategy for the Venus Express scientific mission will be the Venus Express Science Working Team (see section 4.2).

5.1 Mission Operations

ESA will conduct the mission operations of the Venus Express mission via the Mission Operations Centre. The basic operations are classified as:

- Spacecraft operations consisting of mission planning, spacecraft monitoring and control and all orbit and attitude determination and control.
- Conduct scientific instrument operations commensurate with spacecraft and ground segment constraints, although the individual instrument operations will be under the responsibility of the Principal Investigators.

Mission operations commences at separation of the Venus Express spacecraft from the launcher and continues until the end of the mission when ground contact to the spacecraft is aborted. Mission operations include the following tasks:

- Mission planning.
- Spacecraft monitoring and control
- Orbit and attitude determination and control.
- On-board software maintenance.
- Operations support for the scientific instruments/experiments.
- Distribution of scientific data.

The prime ground station for Venus Express will be the 35 m X-band station at Cebreros (Spain), which is currently being built for Venus Express.

5.2 Mission Operations Centre

The Venus Express Mission Operations Centre (VMOC) is responsible for the spacecraft operations including all real time contacts with the spacecraft and payload, the overall mission planning, flights dynamics and payload data handling and distribution. In addition the VMOC will,

- Directly supply the Principal Investigators with raw science telemetry from their respective instruments, housekeeping and relevant auxiliary spacecraft data in an agreed format over communication links in near real time.
- Provide the Science Operations Centre with all science instrument data and spacecraft data as specified above.
- Perform anomaly checks (out of limit checks) for a set of parameters for both spacecraft and payload in real time and to notify the Science Operations Centre on payload anomalies.

In general the VMOC follows a time line agreed with the VSOC. The timeline is uploaded to the spacecraft well in advance of the execution of the listed commands. The timeline commands are executed autonomously without any involvement from ground operators. No real time responses to experimenter requests are required. All command sequences and science operation timelines shall be prepared in advance by the science operations team. Under nominal conditions no experiment adjustments will be foreseen after the verification and commissioning phase as long as there are no anomalies and emergencies reported or declared.

5.3 Science Operations Centre

The Venus Express Science Operations Centre (VSOC) will be responsible for the Science Operations of the mission which include the following functions and responsibilities:

- Optimising the science return from the Venus Express mission by defining and implementing an efficient and cost effective science ground system.
- The definition of scientific operations for all mission phases.
- Planning and implementation of instrument operation schedules and command sequences as input to the FOP.
- Coordination and pre-checking of command sequences generated by the spacecraft Investigator teams for the operation of their payload before submission to the VMOC.
- Creating together with the Principal Investigators at regular intervals or for mission highlights a summary of the main scientific results.
- The preparation of guidelines for science data archiving and the creation of the Venus Express Scientific Data Archive (VSDA) as a part of the ESA Planetary Science Archive (PSA).
- Making pre-processed data and the Venus Express scientific data archive available to the scientific community in accordance with approved procedures.

It is the responsibility of the PI teams to provide timely input to the VSOC to support these tasks.

5.4 Data Rights and Scientific Data Archive

The ownership, access, use, and dissemination of raw and calibrated data resulting from the Scientific Instruments on Venus Express mission shall be governed by Chapter III, Section II paragraph 1 through 3 of the Rules on Information, Data and Intellectual Property, ESA/C/CLV/Rules 5 (Final), as adopted by the ESA Council Resolution on the Rules concerning Information, Data and Intellectual Property, ESA/C/CLV/Res. 4 (Final) [Ref 4]. The duration of the proprietary period as mentioned under paragraph 3 (b) in the referenced document shall be 6 month after reception of the data by the PI.

After this period, the scientific data products (both the raw data, together with relevant calibration data and the documentation necessary to use the data, and calibrated and processed data) from the mission shall become accessible by the scientific community. The Principal Investigator is responsible for the timely delivery of all products specified in Venus Express Archiving Interface Control Document (ICD). The funding for these

activities are considered to be a part of the funding for the instrument cost at completion and therefore under the responsibility of the PI.

The Science Operations Centre will prepare the final Venus Express Scientific Data Archive (VSDA) within one year of the receipt of the complete data sets from the individual Venus Express science investigations. The present standard for the Planetary Science Archive is compatible with the NASA Planetary Data System (PDS) standard. The VSDA will be freely accessible online for scientists in all member states and in any additional participating countries.

Irrespective of the proprietary period, any data that ESA considers useful for its communications and public relations effort shall be made immediately available to the Agency.

5.5 Communications and Public Relations Plan

The Venus Express mission will attract much public interest. Hence, careful advance planning of communications and public relations activities are of great importance. Each Principal Investigator must provide material for public relations and other public communications (e.g. World Wide Web) in real time. Dedicated media and communications experts will coordinate such activity.

During the development phase of the mission, ESA supports a Web home page on the Venus Express mission as an information tool for the scientific community and the general public. After launch, a more elaborated home page will include the latest news on the mission as well as preliminary scientific results obtained by the instruments as soon as they become available.

ESA will have overall responsibility for planning and carrying out Communications and Public Relations (CPR) activities related to Venus Express. A general outline of CPR activities will be provided in the form of a Communications and Public Relations Plan (CPRP). This plan must be formally agreed and adhered to by the PIs. However, for the definition and detailed implementation of the CPRP, ESA will make use of professional communications and public relations experts who will be selected at an appropriate time of the mission. These experts will work under ESA supervision and in full coordination with the scientific individuals responsible for the mission (Project Scientist and Principal Investigators).

The active cooperation of all scientists involved in the Venus Express mission is essential for the success of the related CPR activities. For this purpose, the Project Scientist will initiate and identify opportunities for publishing project related progress reports and scientific results. CPR materials suitable for release to the public will be provided by the members of the VSWT upon their own initiative or upon request from the Project Scientist at any time during the development, operational and post-operational phases of the mission. The specific nature of this material, if not specified in the CPR plan, is to be defined at the appropriate time.

6 ACRONYMS

AO	Announcement of Opportunity
Co-I	Co-Investigator
CPR	Communications and Public Relations
CPRP	Communications and Public Relations Plan
EID	Experiment Interface Document
EGSE	Electronic Ground Support Equipment
ESA	European Space Agency
ESOC	European Space Operations Centre
ESTEC	European Space Research and Technology Centre
FOP	Flight Operations Plan
IDS	Interdisciplinary Scientist
IVEWG	International Venus Exploration Working Group
ITT	Invitation to Tender
LOI	Letter of Intend
MGSE	Mechanical Ground Segment Equipment
NASA	National Aeronautics and Space Agency
PDD	Payload Definition Document
PDS	Planetary Data Systems (NASA)
PI	Principal Investigator
PS	Project Scientist
PSA	Planetary Science Archive
SDT	Science Definition Team (Study Phase)
SMP	Science Management Plan
SPC	ESA's Science Programme Committee
SSAC	ESA's Space Science Advisory Committee
SSWG	ESA's Solar System Working Group
TRP	Technology Research Programme (ESA)
VMOC	Venus Express Mission Operations Centre
VSWT	Venus Express Science Working Team
VSDA	Venus Express Science Data Archive
VSOC	Venus Express Science Operations Centre

7 REFERENCES

[Ref 1] Venus Express Science Requirements Document	VEX-RSSD-SP-002_1_0
[Ref 2] Venus Express Mission Definition Report	ESA SCI(2001)6, Oct. 2001
[Ref 3] Venus Express Mission Requirements Document	VEX-EST-RS-0022_2_0
[Ref 4] ESA Council Information Document	ESA/C(2002)3

8 APPENDICES

A. 1 INSTRUMENTS FOR SPACECRAFT

Instrument Name	Heritage	Build History
ASPERA-4	Mars Express	Rebuild Flight Spare
MAG - Magnetometer	Rosetta	Build new instrument
PFS – Planetary Fourier Spectrometer	Mars Express	Rebuild Flight Spare
SPICAV / SOIR	Mars Express / new	Rebuild Flight Spare / new instrument
VeRa – Venus Radio Science	Rosetta	Build copy with minor changes
VIRTIS	Rosetta	Rebuild Flight Spare
VMC – Venus Monitoring Camera	New Instrument	New Instrument

Table 7.1: Available Instruments for Venus Express

A. 2 RESPONSIBILITIES OF PRINCIPAL INVESTIGATORS AND EXPERIMENT MANAGERS

The responsibilities of the Principal Investigator (PI) shall include, but are not necessarily limited to the following:

Management

- Take full responsibility for the investigations at all times and to retain full authority within the instrument team over all aspects related to instrument procurement and execution of the programme. In this context the PI shall be able to make commitments and make decisions on behalf of all other participants in the instrument team.
- Establish together with his/her experiment manager an efficient managerial scheme which will be used for all aspects of the instrument programme.
- Define the role and responsibilities of each Co-Investigator (Co-I).
- Identify (by name) key team members responsible for science management, technical management and operational management.
- Organise the effort, assign tasks and guide other members of the team of investigators.
- Provide the formal managerial interface of the instrument to the ESA Project office and support ESA management requirements. This will entail providing material for and participation in instrument progress reviews and spacecraft and mission programme reviews. In addition, other management requirements (e.g. change procedures, product assurance etc.) will be defined in the EID.

Science

- Attend meetings of Venus Express SWT to report on instrument development and to take a full and active part in their work. This will include specific reviews to assess the instrument scientific capability with respect to the performance defined in the proposals in response to this AO.
- Ensure adequate calibration analysis of all parts of the instrument both on ground and also in orbit.
- Support the Venus Express Science Operations Centre in the definition of the Science Operations.
- Participate in the definition of the payload operations timeline.
- Exploit to full depth the scientific results of the mission.
- Provide the raw and calibrated scientific data sets from his/her instrument together with complete calibration data in a useable form to the Science Operations Centre for inclusion in the Venus Express Science Data Archive.
- Provide through all mission phases adequate and active support to the public relation activities of ESA.

Hardware

- Define the functional requirements of the instrument and its ancillary equipment (e.g. MGSE, EGSE).
- Ensure the development, construction, testing and delivery of the instrument. This shall be in accordance with the standards, technical and programmatic requirements outlined in the AO including its annexes and subsequently reflected in the approved Experiment Interface Document.
- Ensure adequate calibration of all parts of the instrument both on ground and also in orbit.
- Ensure that the design and construction of the instrumentation and its development test and calibration programmes are appropriate to the objectives and lifetime of the mission and reflect properly the environmental and interface constraints under which the instrumentation must operate.
- Provide any data storage memories and/or instrument dedicated data handling capability that are required for the instrument.
- Ensure that all procured hardware is compliant with the requirements as defined in the EID through participation in technical working groups and control boards as requested (e.g. cleanliness control board) and to ensure that the hardware allows system level performance compatibility to be maintained.
- Provide overall documentation during the project as defined in the EID.

Software

- Ensure the development, testing and documentation of all instrument specific software (e.g. necessary for the control, monitoring, testing, simulation, operation and data reduction / analysis etc) in accord with procedures and schedules as defined in the EID.
- Ensure the delivery of such instrument specific software and its documentation including user manuals to the Science Operations Centre in accord with procedures and schedules as defined in the EID.
- Support the instrument specific software integration and operation activities at the Science Operations Centre.
- Ensure the development, testing, documentation and delivery of on-board software and software required during instrument system level tests in the real time or off line mode including auxiliary software (individual EGSE and interfaces) as defined in the EID.
- Maintain and update all software for the duration of the mission including a post-operations (archiving) phase.

Product Assurance

- Provide product assurance functions that are compliant with the requirements of the EID.

Payload Operations

Operational phases include pre-launch activities (e.g. instrument software design and development, instrument calibrations), nominal operational phase and post-mission phases with a breakdown as follows,

- (a) Pre-launch phase until launch minus two years.
- (b) Full operational phase from launch minus two years until arrival at Venus and the full instrument operations in orbit. Extended mission TBD if approved.

The PI for an instrument will be responsible for,

- Supporting all operational phases by providing the necessary inputs, manpower and/or expertise (training) to the Venus Express Project Team and supporting the Mission Operations Centre / Science Operations Centre with flight operations inputs and expertise. The level of support shall be defined with the ESA Project Office and will be indicated in the EID.
- Making the Experiment Ground Support Equipment (EGSE) including software available at the Mission Operations Centre during critical mission phases to enable real-time scientific data analysis.
- Supporting operations through his/her expertise including resolution of anomalies and malfunctions of the instrument including recalibrations etc. as required.

Finances

- Ensuring (together with his/her Co-Is if necessary) that adequate funding is available at the required time(s) for all aspects of the instrument and its support including, in particular, the tools and resources necessary for in flight operations and analysis of the scientific data produced by his/her instrument.

Communications and Public Relations

- The PIs shall provide active support to the Communications and Public Relations activities of ESA.