German
DLR Aerospace Center

**News-Archiv**

## Europe's Venus Express to arrive at its enigmatic destination

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For 153 days, Europe's Venus Express has been racing to our nearest planetary neighbour, the hothouse planet Venus. The mission, which started on 9 November 2005 at 04:33 CET on a Soyuz rocket launched from the Russian facility in Baikonur, Kazakhstan, will reach its target on 11 April 2006 at 9:19 CEST after a journey of some 400 million kilometres. The German Aerospace Center (DLR) is playing a key role in the mission's science instrument package as well as the spacecraft hardware.

The Venus Express probe

Arrival at the mysterious and enigmatic planet Venus on 11 April 2006 will be initiated by a braking manoeuvre in which the spacecraft must reduce its speed, approximately 29 000 kilometres per hour, by 1310 metres per second, equivalent to 4716 kilometres per hour, in order to lower itself into Venus orbit.

This critical manoeuvre will start with the firing of the spacecraft's main engine for a burn due to last 50 minutes. The engine was extensively and successfully tested in mid-2003 by DLR's Lampoldshausen test facility, in Heilbronn, Germany.

The robotic mission carries a suite of seven onboard instruments, including a plasma analyser, a magnetometer, three spectrometers including the VIRTIS (Visible and Infrared Thermal Imaging Spectrometer), the VeRa (Venus Radio Science Experiment) and the VMC (Venus Monitoring Camera). DLR and its institutes were deeply involved in building the VMC camera and VIRTIS spectrometer, and will further contribute to analysis of data from the mission.

"Although Venus is our neighbour planet and, at a distance of approximately 40 million kilometres, is relatively close, we actually know very little about it since the surface is hidden beneath a thick cloud cover. With Venus Express, we aim to expose the planet's secrets to a little air," says Dr Ralf Jaumann of DLR's Institute of Planetary Research and the DLR project manager for Venus Express. He adds: "After a solid success with Mars Express, we look forward to obtaining similarly spectacular results from our other neighbouring planet via Venus Express. Today, several fundamental questions about Venus remain undecided, in particular concerning the planet's volcanic activity and its effect on the atmosphere. We would like to know more."

**Venus Express and Mars Express share a common heritage**

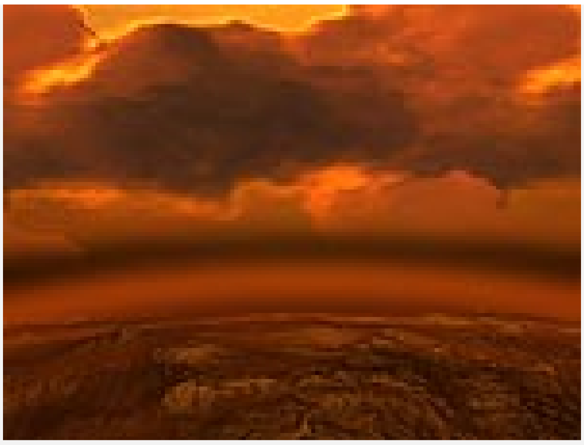
The European Space Agency (ESA)'s Mars Express spacecraft has been in orbit around the Red Planet since Christmas 2003. In addition to similar names, both spacecraft have many components in common, allowing ESA to reduce development time and risk and improve economies of scale. While benefiting from its Mars Express heritage, Venus Express faces additional and unique challenges: to voyage to and conduct scientific data gathering at one of the Solar System's most challenging planets in a harsh environment that is much closer to the Sun than Mars, achieve its mission goals within a strict budget envelope, and to go from inception to orbit entry in a very short time - just a few years.

Germany, as a full member of ESA, has contributed 24 percent of the overall mission costs related to spacecraft construction, launch and mission operation. In total, ESA has budgeted 1640 million euro for the three sister missions, Mars Express, Venus Express and Rosetta. The total cost for Venus Express was only 85 million euro, since the mission gained cost advantages from both the earlier Mars Express and Rosetta missions.

**Careful approach to the Venusian hothouse**

After the main engine burn on 11 April 2006, the initial orbit around Venus will be highly elliptical - with the closest passage over the surface (pericentre) at an altitude of about 250 kilometres and the furthest altitude (apocentre) ranging to approximately 220 000 kilometres over Venus. Five days later, on 16 April 2006, the main engine will again be fired as the spacecraft passes pericentre so as to lower the apocentre to 66 000 kilometres.

After further firings, a 24-hour polar orbit will be achieved, marking the entry of Venus Express into its operational orbit early in May. The duration of the orbit was selected to facilitate operation of the mission's ground segment on Earth and the gathering of science data. Once in operational orbit around the planet, fine control of the spacecraft will be maintained through firing the eight small, 10-Newton thrusters as required.



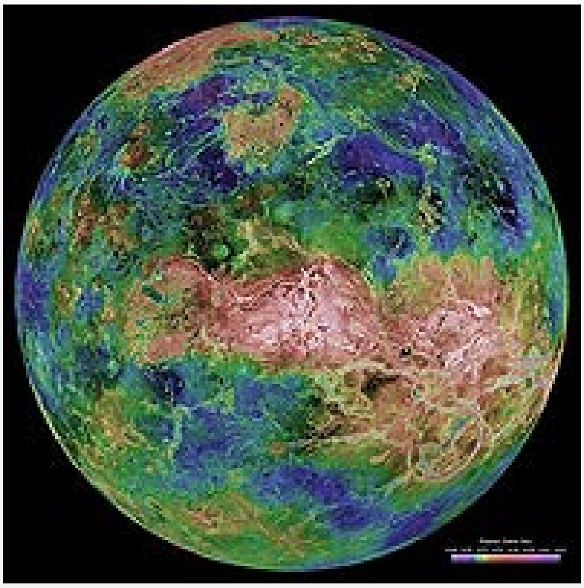
The surface of Venus

**Volcanoes, clouds, winds: A hot, hostile world full of mysteries**

Similar to Earth in size, mass and distance from the Sun, Venus was expected to be very similar to our planet when the first Russian and American space probes approached it in the early 1960s and started returning data about its atmosphere. Observers soon realised that Venus is an entirely different, exotic and inhospitable world, hidden behind dense clouds of noxious gases. It has an atmosphere mainly composed of carbon dioxide, with crushing surface pressure and burning-hot temperatures. The question quickly arose: why did a planet apparently so similar to Earth evolve in a way so radically different over the last four thousand million years?

By the mid 1990s, many ground observatories and more than 20 spacecraft had attempted to explore Venus. Orbiters and descent probes - including the Soviet Venera-series and the Vega balloons and landers, and the US Mariner, Pioneer Venus and the 1990-94 Magellan missions - tried to penetrate this hostile world to find solutions to the giant puzzle that Venus represented for scientists.

Many missions were lost and many landers were destroyed under the high pressures and temperatures of the Venusian atmosphere; nonetheless, past missions provided solid initial information about the planet, lifting the veil of mystery. For years, scientists were prevented from seeing what lays below the dense atmosphere and the thick cloud cover blocked any view below, hindering attempts to understand the nature of the Venusian surface.



Venus - false colour image

The atmospheric pressure at the surface of Venus was found to be over 90 times greater than that on Earth. Further, the composition and dynamics of the two planets' atmospheres are completely different. On Venus, almost no wind occurs at the surface, but higher up - in clouds of sulphuric acid - winds blow at hurricane-force speeds, circling the planet in just four days - much faster than Venus turns on its axis.

The atmosphere comprises a mixture of carbon dioxide, sulphur and traces of water vapour, with the carbon dioxide causing an intense 'greenhouse' effect, trapping the strong solar energy and helping generate a surface temperature of 480 degrees Celsius, hot enough to melt lead. Any water on the surface would immediately boil away and as a result the planet is a bone-dry desert.

The mission aims to gather data that will help scientists create an overall characterisation of the planet, and will look at Venus's structure, composition and dynamics. In addition to studying the immediate environment of Venus and its interaction with the intense solar wind, Venus Express is particularly designed to study the planet's atmosphere.

Scientists have many questions, including:

- What is the chemical composition of individual layers of the atmosphere?
- What physical characteristics do these layers have, and what drives global wind circulation -- particularly in the fast upper cloud layers?
- How, exactly, does the greenhouse effect occur on Venus? And how has this developed over billions of years?
- Was Venus already quite hot, or has the greenhouse effect made it hotter yet?
- Did the strong greenhouse effect develop only later in planetary evolution, and were conditions on Venus perhaps less extreme in earlier phases?
- Was there ever water on the surface?
- What types of rocks are on the surface and what do they tell us about development of volcanism?
- Are there still active volcanoes on the Venus?

**Ground-breaking areful technology developed by DLR, partners and institutes**

Of the seven experiments onboard, six share a common heritage with the two previous ESA missions, Mars Express and Rosetta. Only one instrument, the Venus Monitoring Camera, had to be newly developed to help answer the scientific questions above. All the highly sensitive instruments, as well as the spacecraft itself, had to be specially adapted to operate in the harsh environment around Venus, where the Sun's radiation and the solar wind are much stronger than by Earth or Mars. Excessive irradiation will be avoided by carefully selecting the spacecraft's orbit, while ensuring robust opportunities for science data gathering.

The **Venus Monitoring Camera (VMC)** was developed by the Max Planck Institute for Solar System Research in Lindau, Germany. The VMC is a wide-angle multichannel camera that will gather light in the visible, ultraviolet and near-infrared spectrum; data will be analysed by DLR's Institute for Planetary Research and will be used to generate images of Venus's dynamic atmosphere. VMC images will also help in the identification of phenomena seen by other instruments.

The VMC may also be able to gather images of the Venusian surface. The VMC principal investigator (PI) is Dr Wojciech Markiewicz of the Max Planck Institute.

To investigate the chemical composition of the Venusian atmosphere, including temperature and dynamics, scientists will use three onboard spectrometers.

First is the **Planetary Fourier Spectrometer (PFS)**, led by an Italian team. The PFS will be able to measure the temperature of the atmosphere between altitudes of 55-100 kilometres at a very high resolution, and also obtain measurements of the surface temperature and thus, by implication, gather evidence for volcanic activity.

Next is the **Ultraviolet and Infrared Atmospheric Spectrometer (SPICAV/SOIR)**, operated by scientists from France, Belgium and Russia. SPICAV will assist in the analysis of Venus's atmosphere. In particular, it will search for the small quantities of water expected to exist in the atmosphere. It will also look for sulphur compounds and molecular oxygen in the atmosphere. It will determine the density and temperature of the atmosphere at 80-180 kilometres altitude.

The third spectrometer is the **VIRTIS (Visible and Infrared Thermal Imaging Spectrometer)**, which will also study the atmosphere. VIRTIS is an imaging spectrometer (VIRTIS-M) for the visual (0.25-1µm) and the near-infrared range (1-5µm) combined with a high resolution IR-spectrometer (VIRTIS-H) for the spectral range from 2-5µm. The VIRTIS instrument was developed by DLR Adlershof, together with Kayser Threde GmbH.

VIRTIS can also use the so-called 'spectral windows' that exist at certain wavelengths in the atmosphere to look through to the surface of the planet. VIRTIS scientists plan to create a chemical and mineralogical map of the surface using this technique. "It would be even more exciting," says DLR scientist Dr Joern Helbert, who is part of the investigation team, "if VIRTIS succeeds in discovering active volcanoes on Venus by virtue of their thermal radiation or due to gases ejected from volcanoes being detected in the atmosphere." DLR Adlershof, in Berlin, is also responsible for evaluation and analysis of VIRTIS data.

Venus Express also carries:

- **ASPERA (Analyser of Space Plasma and Energetic Atoms)** experiment, led by the Institute of Space Physics in Kiruna, Sweden ASPERA aims to investigate the interaction between the solar wind and the atmosphere of Venus.
- **MAG (Venus Express Magnetometer)**, led by the Space Research Institute in Graz, Austria MAG will examine the interaction between the solar wind and Venus's atmosphere.
- **VeRa (Venus Radio Science Experiment)**, led by the University of the Federal Armed Forces in Munich, Germany VeRa will use the powerful radio link between the spacecraft and Earth to investigate the upper levels of the atmosphere of Venus by analysing radio signals that transit through the ionosphere.

### German involvement in the development of the engine

In addition to key onboard instruments, DLR has been intimately involved in testing one of the spacecraft's most important components: the main engine.

Long before this week's crucial live firing that will initiate Venus orbit entry, the main engine was proven on the test stands at DLR Lampoldshausen.

In June 2003, engineers from DLR's Institute of Propulsion Technology successfully operated the engine in acceptance tests under vacuum conditions, including engine re-ignition with a running time of 20 minutes. The testing at DLR Lampoldshausen's Test Stand P1.0 was conducted in cooperation with EADS Space Transportation, manufacturer of the engines for Venus Express.

The engine operates using nitrogen tetroxide ($N_2O_4$) and monomethylhydrazine (MMH) as fuel. These require extremely careful handling as they are hypergolic reactants, i.e. they will spontaneously catch fire upon contact with each other. The engine, about as big as a shoebox, developed a thrust of some 400 Newtons (N), the force of which was transferred to the test mountings which had to be anchored against this pull, equal to approximately 850 Horsepower (HP).

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