Spacecraft Missions to Venus

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Mariner 2

Mariner 2

Operator	NASA
Major contractors	Jet Propulsion Laboratory
Mission type	Flyby
Flyby of	Venus
Launch date	27 August 1962 at 06:53:14 UTC
Launch vehicle	Atlas-Agena B
COSPAR ID	1962-041A
Homepage	NASA NSSDC Master Catalog

Mass	202.8 kg

Mariner 2 (Mariner-Venus 1962), an American space probe to Venus, was the first successful spacecraft in the NASA Mariner program. It was a simplified version of the Block I spacecraft of the Ranger program and an exact copy of Mariner 1. The missions of Mariner 1 and 2 spacecraft are together sometimes known as the Mariner R missions. Mariner 2 passed within 35,000 kilometres (22,000 mi) of Venus on December 14, 1962, becoming the first space probe to conduct a successful planetary encounter.

The Mariner probe consisted of a 100 cm (39.4 in) diameter hexagonal bus, to which solar panels, instrument booms, and antennas were attached. The scientific instruments on board the Mariner spacecraft were two radiometers (microwave and infrared), a micrometeorite sensor, a solar plasma sensor, a charged particle sensor, and a magnetometer. These instruments were designed to measure the temperature distribution on the surface of Venus, as well as making basic measurements of Venus' atmosphere. Due to the planet's thick, featureless cloud cover, no cameras were included in the Mariner unit. Mariner 10 later discovered that extensive cloud detail was visible in ultraviolet light.

The primary mission was to receive communications from the spacecraft in the vicinity of Venus and to perform a radiometric temperature measurements of the planet. A second objective was to measure the Interplanetary Magnetic Field and charged particle environment.

The two-stage Atlas-Agena rocket carrying Mariner 1 veered off-course during its launch on July 22, 1962 due to a defective signal from the Atlas and a bug in the program equations of the ground-based guiding computer, and subsequently the spacecraft was destroyed by the Range Safety Officer. A month later, the identical Mariner 2 spacecraft was launched successfully on August 27, 1962, sending it on a 3½-month flight to Venus. On the way it measured the solar wind, a constant stream of charged particles flowing outwards from the Sun, confirming the measurements by Luna 1 in 1959. It also measured interplanetary dust, which turned out to be more scarce than predicted. In addition, Mariner 2 detected high-energy charged particles coming from the Sun, including several brief solar flares, as well as cosmic rays from outside the Solar system. As it flew by Venus on December 14, 1962, Mariner 2 scanned the planet with its pair of radiometers, revealing that Venus has cool clouds and an extremely hot surface.

The spacecraft is now defunct in a heliocentric orbit.

Spacecraft and subsystems

The Mariner 2 spacecraft was designed and built by the Jet Propulsion Laboratory of the California Institute of Technology. It consisted of a hexagonal base, 1.04 meters across and 0.36 meters thick, which contained six magnesium chassis housing the electronics for the science experiments, communications, data encoding, computing, timing, and altitude control, and the power control, battery, and battery charger, as well as the altitude control gas bottles and the rocket engine. On top of the base was a tall pyramid-shaped mast on which the science experiments were mounted which brought the total height of the spacecraft to 3.66 meters. Attached to either side of the base were rectangular solar panel wings with a total span of 5.05 meters and width of 0.76 meters. Attached by an arm to one side of the base and extending below the spacecraft was a large directional dish antenna.

Launch of Mariner 2

The power system of Mariner 2 consisted of two solar cell wings, one 183 cm by 76 cm and the other 152 cm by 76 cm (with a 31 cm dacron extension (a solar sail) to balance the solar pressure on the panels), which powered the craft directly or recharged a 1000 Watt-hour sealed silver-zinc cell battery. This battery was used before the panels were deployed, when the panels were not illuminated by the Sun, and when loads were heavy. A power-switching and booster regulator device controlled the power flow. Communications consisted of a 3 Watt transmitter capable of continuous telemetry operation, the large high gain directional dish antenna, a cylindrical omnidirectional antenna at the top of the instrument mast, and two command antennas, one on the end of either solar panel, which received instructions for midcourse maneuvers and other functions.

Propulsion for midcourse maneuvers was supplied by a monopropellant (anhydrous hydrazine) 225 N retro-rocket. The hydrazine was ignited using nitrogen tetroxide and aluminum oxide pellets, and thrust direction was controlled by four jet vanes situated below the thrust chamber. Attitude control with a 1 degree pointing error was maintained by a system of nitrogen gas jets. The Sun and Earth were used as references for attitude stabilization. Overall timing and control was performed by a digital Central Computer and Sequencer. Thermal control was achieved through the use of passive reflecting and absorbing surfaces, thermal shields, and movable louvers.

Scientific instruments

Only 40 pounds (18 kg) of the spacecraft could be allocated to scientific experiments. The following scientific instruments were mounted on the instrument mast and base:

- A two-channel **microwave radiometer** of the crystal video type operating in the standard Dicke mode of chopping between the main antenna, pointed at the target, and a reference horn pointed at cold space. It was used to determine the absolute temperature of Venus' surface and details concerning its atmosphere through its microwave-radiation characteristics, including the daylight and dark hemispheres, and in the region of the terminator. Measurements were performed simultaneously in two frequency bands of 13.5 mm and 19 mm. The total weight of the radiometer was 22 pounds (10 kg). Its average power consumption was 4 watts and its peak power consumption 9 watts.

- A two-channel **infrared radiometer** to measure the effective temperatures of small areas of Venus. The radiation that was received could originate from the planetary surface, clouds in the atmosphere, the atmosphere itself or a combination of these. The radiation was received in two spectral ranges: 8 μ to 9 μ (focused on 8.4 μ) and 10 μ to 10.8 μ (focused on 10.4 μ). The latter corresponding to the carbon dioxide band. The total weight of the infrared radiometer, which was housed in a magnesium casting, was 1.3 kg and it required 2.4 watts of power. It was designed to measure radiation temperatures between 200 and approximately 500 K.

- A three-axis **fluxgate magnetometer** to measure planetary and interplanetary magnetic fields. Three probes were incorporated in its sensors, so it could obtain three mutually orthogonal components of the field vector. Readings of these components were separated by 1.9 seconds. It had three analog outputs that had each two sensitivity scales: $\pm 64\ \gamma$ and $\pm 320\ \gamma$ ($1\ \gamma = 10^{-5}$ gauss). These scales were automatically switched by the instrument. The field that the magnetometer observed was the super-position of a nearly constant spacecraft field and the interplanetary field. Thus, it effectively measured only the changes in the interplanetary field.

- An **ionization chamber** with matched **Geiger-Müller tubes** (also known as a cosmic ray detector) to measure high-energy cosmic radiation.

- A **particle detector** (by using an Anton type 213 Geiger-Müller tube) to measure lower radiation (especially near Venus), also known as the Iowa detector, as it was provided by the University of Iowa. It was a miniature tube having a 1.2 mg/cm^2 mica window about 0.3 cm in diameter and weighing about 60 g. It detects soft x-rays efficiently and ultraviolet inefficiently, and was previously used in Injun 1, Explorer 12 and Explorer 14. It is able to detect protons above 500 Kev in energy and electrons above 35 Kev. The length of the basic telemetry frame is 887.04 seconds. During each frame the counting rate of the detector is sampled twice at intervals separated by 37 seconds. The first sampling is the number of counts during an interval of 9.60 seconds (known as the 'long gate'); the second is the number of counts during an interval of 0.827 seconds (known as the 'short gate'). The long gate accumulator overflows on the 256th count and the short gate accumulator overflows on the 65,536th count. The maximum counting rate of the tube is 50,000 per second.

- A **cosmic dust detector** to measure the flux of cosmic dust particles in space.

- A **solar plasma spectrometer** to measure the spectrum of low-energy positively charged particles from the Sun, i.e. the solar wind.

The magnetometer was attached to the top of the mast below the omnidirectional antenna. Particle detectors were mounted halfway up the mast, along with the cosmic ray detector. The cosmic dust detector and solar plasma spectrometer were attached to the top edges of the spacecraft base. The microwave radiometer, the infrared radiometer and the radiometer reference horns were rigidly mounted to a 48 cm diameter parabolic radiometer antenna mounted near the bottom of the mast. All instruments were operated throughout the cruise and encounter modes except the radiometers, which were only used in the immediate vicinity of Venus.

In addition to these scientific instruments, Mariner 2 had a data conditioning system (DCS) and a scientific power switching (SPS) unit. The DCS was a solid-state electronic system designed to gather information from the scientific instruments on-board the spacecraft. It had four basic functions: analog-to-digital conversion, digital-to-digital conversion, sampling and instrument-calibration timing, and planetary acquisition. The SPS unit was designed to perform the following three functions: control of the application of AC power to appropriate portions of the science subsystem, application of power to the radiometers and removal of power from the cruise experiments during radiometer calibration periods, and control of the speed and direction of the radiometer scans. The DCS sent signals to the SPS unit to perform the latter two functions.

Mission objectives

The scientific objectives were:

- Radiometer experiment.
- Infrared experiment.
- Magnetometer experiment.
- Charged particles experiment.

- Plasma experiment.
- Micrometeorite experiment.

Besides the experiments with the scientific instruments, the objectives of both the Mariner 1 and 2 probes included also engineering objectives:

- Evaluation of the attitude control system.
- Evaluation of the environmental control system.
- Evaluation of the entire power system.
- Evaluation of the communication system.

Mission profile

Launch

Mariner 2 was launched from Cape Canaveral Air Force Station Launch Complex 12 at 06:53:14 UTC on August 27, 1962 by a two-stage Atlas-Agena rocket. 5 minutes after lift-off, the Atlas and Agena-Mariner separated, followed by the first Agena burn and second Agena burn. The Agena-Mariner separation injected the Mariner 2 spacecraft into a geocentric escape hyperbola at 26 minutes 3 seconds after lift-off. The NASA NDIF tracking station at Johannesburg, South Africa, acquired the spacecraft about 31 minutes after launch. Solar panel extension was completed approximately 44 minutes after launch. The Sun lock acquired the Sun about 18 minutes later. The high-gain antenna was extended to its acquisition angle of 72°. The output of the solar panels was slightly above the predicted output. As all subsystems were performing normally, as the battery was fully charged, and as the solar panels providing adequate power, the decision was made on August 29 to turn on cruise science experiments. On September 3, the Earth acquisition sequence was initiated and Earth lock was established 29 minutes later.

Midcourse maneuver

The accuracy of the Atlas-Agena was such that a midcourse correction was required to satisfy the mission requirements. The midcourse correction consisted of a roll-turn sequence, followed by a pitch-turn sequence and finally a motor-burn sequence. Preparation commands were sent to the spacecraft at 21:30 UTC on September 4. Initiation of the midcourse maneuver sequence was sent at 22:49:42 UTC and the roll-turn sequence started one hour later. The entire maneuver took approximately 34 minutes.

Due to the midcourse maneuver, the sensors lost their lock with the Sun and Earth. At 00:27:00 UTC the Sun reacquisition begun and at 00:34 UTC the Sun was reacquired. Earth reacquisition started at 02:07:29 UTC and Earth was reacquired at 02:34 UTC.

Loss of attitude control

On September 8 at 12:50 UTC suddenly the spacecraft automatically turned on the gyros and the cruise science experiments were automatically turned off. The exact cause is unknown as attitude sensors went back to normal before telemetry measurements could be sampled, but it may have been an Earth-sensor malfunction or a collision with a small unidentified object which temporarily caused the spacecraft to lose Sun lock. A similar experience happened on September 29 at 14:34 UTC. Again, all sensors went back to normal before it could be determined which axis had lost lock. By this date the Earth sensor brightness indication had essentially gone to zero, however, this time telemetry data indicated the Earth-brightness measurement had increased to the nominal value for that point in the trajectory.

Solar panel output

On October 31 the output from one solar panel (with solar sail attached) deteriorated abruptly. It was diagnosed as a partial short circuit in the panel. As a precaution, the cruise science instruments were turned off. A week later the panel resumed normal function and cruise science instruments were turned back on. The panel permanently failed on November 15, but Mariner 2 was close enough to the Sun that one panel could supply adequate power; thus the cruise science experiments were left active.

Encounter with Venus

On December 14 the radiometers were turned on. Mariner 2 approached Venus from 30 degrees above the dark side of the planet, and passed below the planet at its closest distance of 34,773 km at 19:59:28 UT.

Post encounter

After encounter, cruise mode resumed. Spacecraft perihelion occurred on December 27 at a distance of 105,464,560 km. The last transmission from Mariner 2 was received on January 3, 1963 at 07:00 UTC, making the total time from launch to termination of the Mariner 2 mission 129 days. Mariner 2 remains in heliocentric orbit.

Results

The data produced during the flight consisted of two categories, namely tracking data and telemetry data.

Scientific observations

The microwave radiometer made three scans of Venus in 35 minutes on December 14, 1962 starting at 18:59 UTC. The first scan was made on the dark side, the second near the terminator and the third was located on the light side. The scans with the 19 mm band revealed peak temperatures of 490 ± 11 K on the dark side, 595 ± 12 K near the terminator, and 511 ± 14 K on the light side. It was concluded that there is no significant difference in temperature across Venus. However, the results suggest a limb darkening, an effect which presents cooler temperatures near the edge of the planetary disk and higher temperatures near the terminator. This also supported the theory that the Venusian surface was extremely hot or the atmosphere optically thick.

The infrared radiometer showed that the 8.4 μ and 10.4 μ radiation temperatures were in agreement with radiation temperatures obtained from Earth-based measurements. There was no systematic difference between the temperatures measured on the light side and dark side of the planet, which was also in agreement with Earth-based measurements. The limb darkening effect that the microwave radiometer detected was also present in the measurements by both channels of the infrared radiometer. The effect was only slightly present in the 10.4 μ channel, but was more pronounced in the 8.4 μ channel. The 8.4 μ channel also showed a slight phase effect. The phase effect indicated that if a greenhouse effect existed, heat was transported in an efficient manner from the light side to the dark side of the planet. The 8.4 μ and 10.4 μ showed equal radiation temperatures, indicating the limb darkening effect would appear to come from a cloud structure rather than the atmosphere. Thus, if the measured temperatures were actually cloud temperatures instead of surface temperatures, these clouds would have to be quite thick.

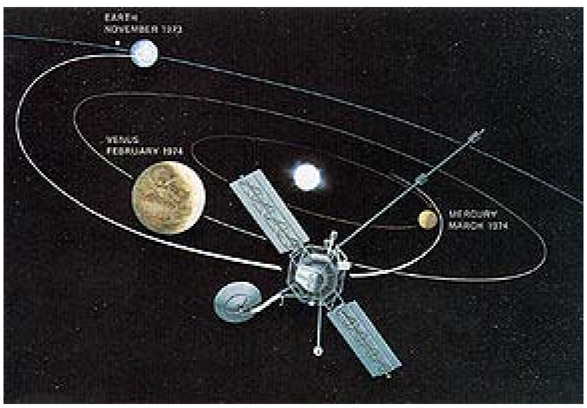
The magnetometer detected a persistent interplanetary magnetic field varying between 2 γ and 10 γ, which agrees with prior Pioneer 5 observations from 1960. This also means that interplanetary space is rarely empty or field free. The magnetometer could detect changes of about 4 γ on any of the axes, but no trends above 10 γ were detected near Venus, nor were fluctuations seen like those that appear at Earth's magnetospheric termination. This means Mariner 2 found no detectable magnetic field near Venus, although that didn't necessarily mean Venus had none. However, if Venus had a magnetic field, it would have to be at least smaller than 1/10 the magnetic field of the Earth. In 1980, the Pioneer Venus Orbiter indeed showed that Venus has a small weak magnetic field.

The Anton type 213 Geiger-Müller tube performed as expected. The average rate was 0.6 counts per second. Increases in its counting rate were larger and more frequent than for the two larger tubes, since it was more sensitive to particles of lower energy. It detected 7 small solar bursts of radiation during September and October and 2 during November and December. The absence of a detectable magnetosphere was also confirmed by the tube; it detected no radiation belt at Venus similar to that of Earth. The count rate would have increased by 10^4, but no change was measured.

It was also shown that in interplanetary space the solar wind streams continuously and the cosmic dust density is much lower than the near-Earth region. Improved estimates of Venus' mass and the value of the astronomical unit were made. Also, research suggested (which was later confirmed by other explorations) that Venus rotates very slowly and in a direction opposite that of the Earth.

Chapter- 2

Mariner 10



Artist impression of the Mariner 10 mission.

Operator	NASA / JPL
Mission type	Flyby
Flyby of	Venus, Mercury
Orbital insertion date	Year-Month-Day Hour:Minute:Second UTC
Launch date	1973-11-03 05:45:00 UTC (37 years, 3 months, and 20 days ago)
Launch vehicle	Atlas-Centaur
Launch site	Space Launch Complex 36A Cape Canaveral Air Force Station
Mission duration	Nov 3, 1973 - Mar 24, 1975 (1 year, 4 months, 22 days)
COSPAR ID	1973-085A

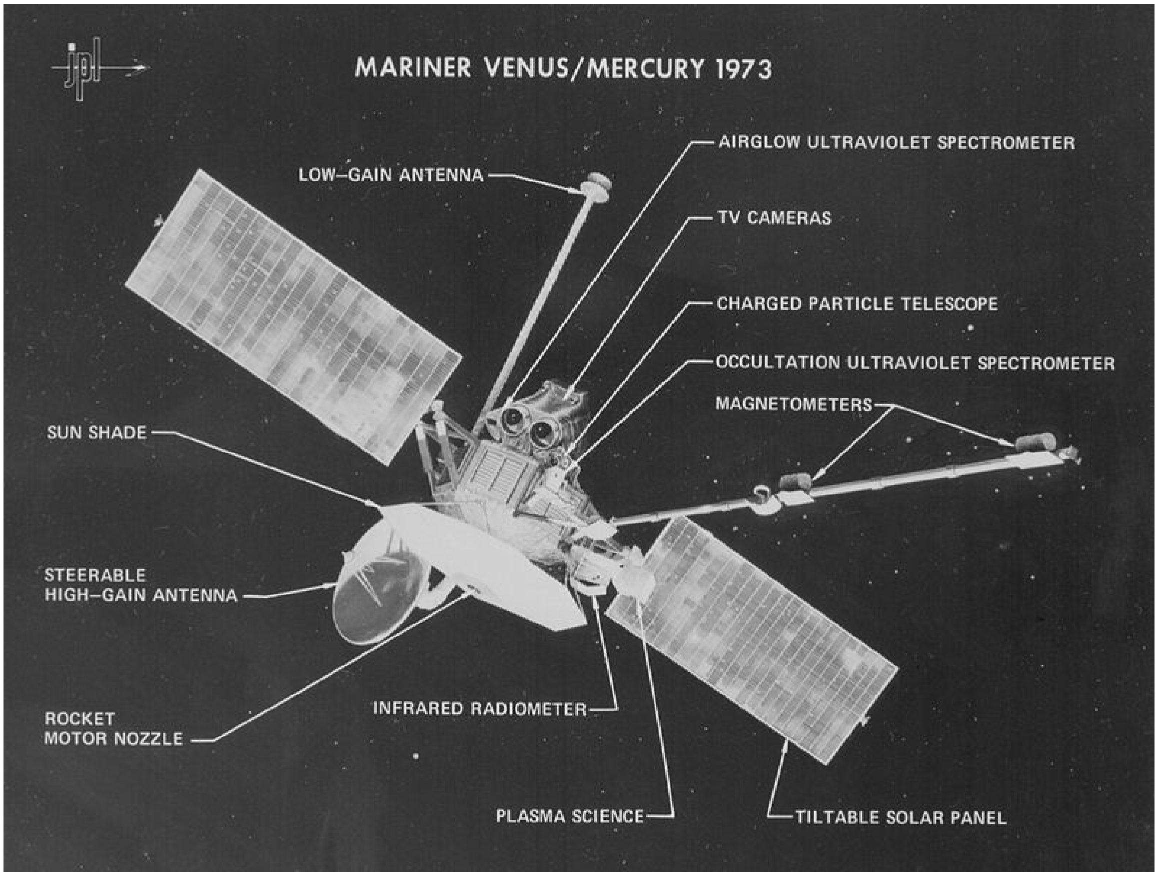
Homepage	Mariner 10 Home
Mass	474 kg (1,045 lb)
Power	(solar array)

Mariner 10 was a robotic space probe launched by NASA on November 3, 1973, to fly by the planets Mercury and Venus. It was launched approximately 2 years after Mariner 9 and was the last spacecraft in the Mariner program (Mariner 11 and 12 were purposed to the Voyager program and redesignated Voyager 1 and Voyager 2). The mission objectives were to measure Mercury's environment, atmosphere, surface, and body characteristics and to make similar investigations of Venus. Secondary objectives were to perform experiments in the interplanetary medium and to obtain experience with a dual-planet gravity assist mission.

Design and trajectory

Mariner 10 was the first spacecraft to make use of an interplanetary "gravitational slingshot" maneuver, using Venus to bend its flight path and bring its perihelion down to the level of Mercury's orbit. This maneuver, inspired by the orbital mechanics calculations of the Italian scientist Giuseppe Colombo, put the spacecraft into an orbit that repeatedly brought it back to Mercury. Mariner 10 used the solar radiation pressure on its solar panels and its high-gain antenna as a means of attitude control during flight, the first spacecraft to use active solar pressure control.

Instruments



An illustration showing Mariner 10's instruments.

Mariner 10 instruments included:

1. Twin narrow-angle cameras with digital tape recorder
2. Ultraviolet spectrometer
3. Infrared radiometer
4. Solar plasma
5. Charged particles
6. Magnetic fields
7. Radio occultation
8. Celestial mechanics

Departing the Earth/Moon system

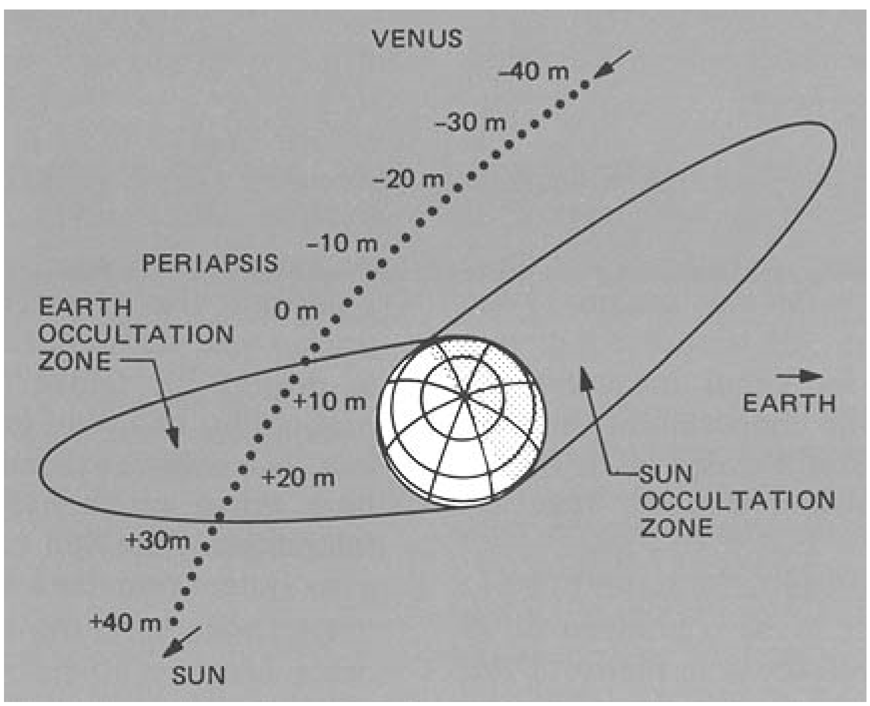
During its first week of flight, Mariner 10 tested its camera system by returning 5 mosaics of Earth and 6 of the Moon. It also obtained photographs of the north polar region of the moon where prior coverage was poor. These provided a basis for cartographers to update lunar maps and improve the lunar control net.

Cruise to Venus

A trajectory correction maneuver was made on November 13, 1973. Immediately following this maneuver the star-tracker locked onto a bright flake of paint which had come off the spacecraft and lost lock on the guide star Canopus. An automated safety protocol recovered Canopus, but the problem of flaking paint recurred throughout the mission, The on-board computer also experienced unscheduled resets occasionally, which would necessitate reconfiguring the clock sequence and subsystems. Periodic problems with the high-gain antenna also occurred during the cruise. In January 1974 Mariner 10 made ultraviolet observations of Comet Kohoutek. Another mid-course correction was made on January 21, 1974.

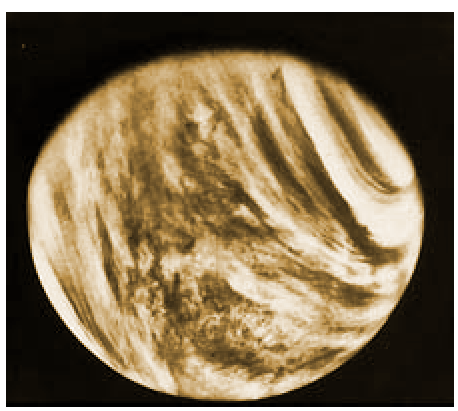
Venus flyby

The spacecraft passed Venus on February 5, 1974, at a closest range of 5768 km at 17:01 UT. Using a near-ultraviolet filter, it photographed the Cytherean chevron clouds and performed other atmospheric studies. It was discovered that extensive cloud detail could be seen via Mariner's ultraviolet camera filters. Venus's cloud cover is nearly featureless in visible light. Earth-based ultra-violet observation did reveal some indistinct blotching even before Mariner 10, but the detail seen by Mariner was a surprise to most researchers.



Venus encounter

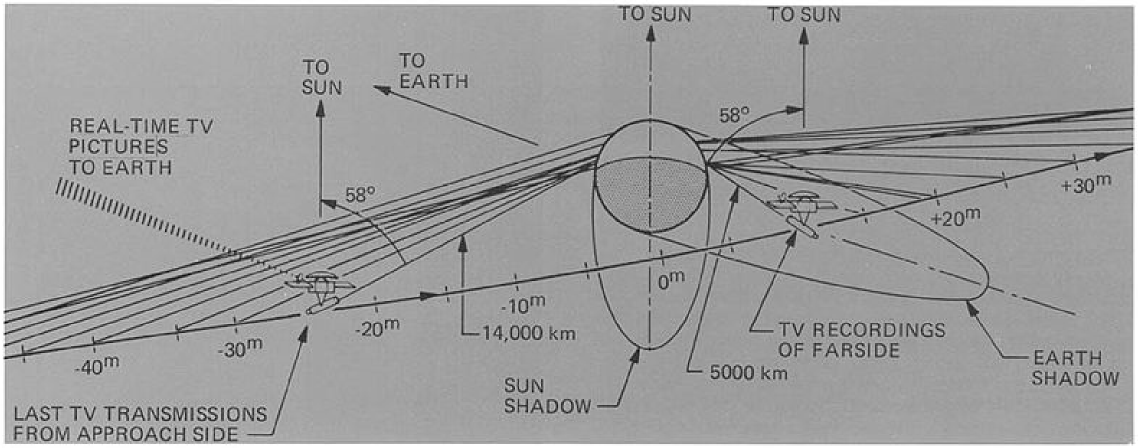
Venus in real colors, processed from clear and blue filtered Mariner 10 images



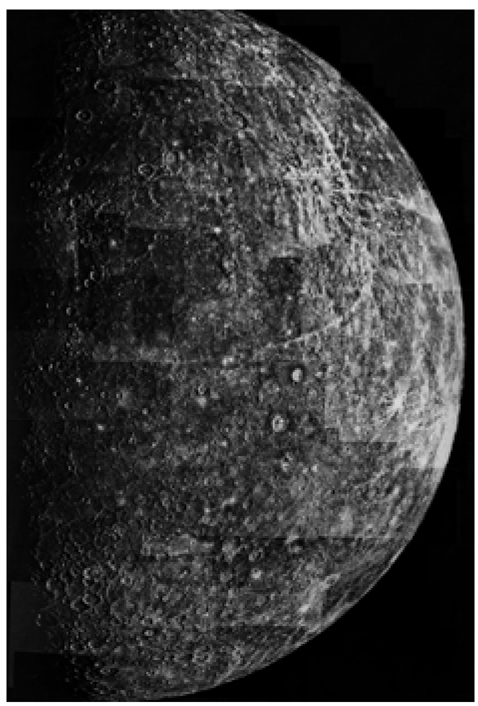
Mariner photograph of Venus in ultraviolet light

First Mercury flyby

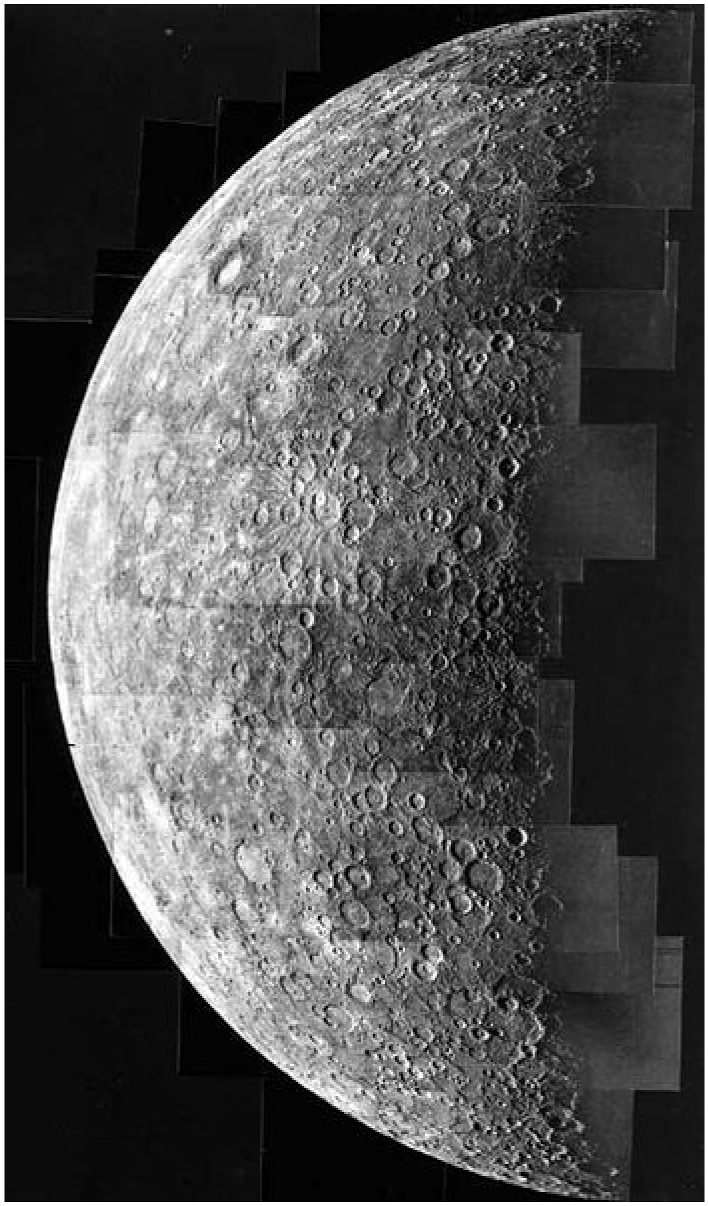
The first Mercury encounter took place at 20:47 UT on March 29, 1974, at a range of 703 kilometres (437 miles), passing on the shadow side.



First Mercury encounter



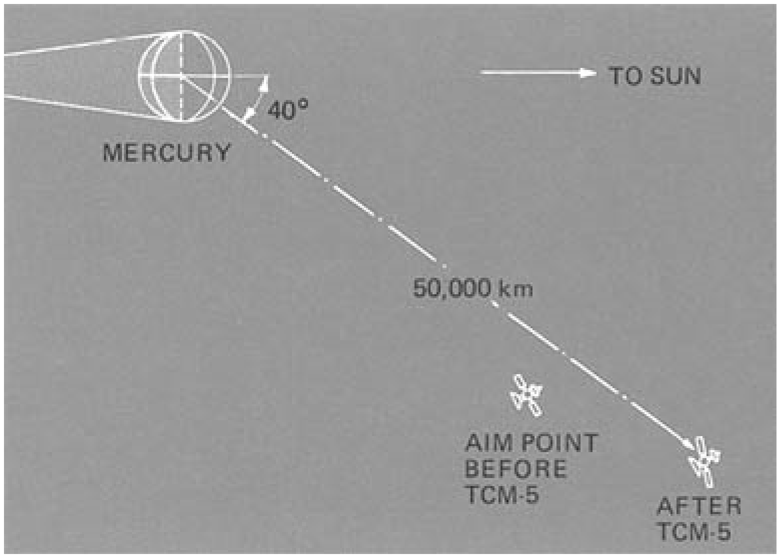
6 hours after closest approach



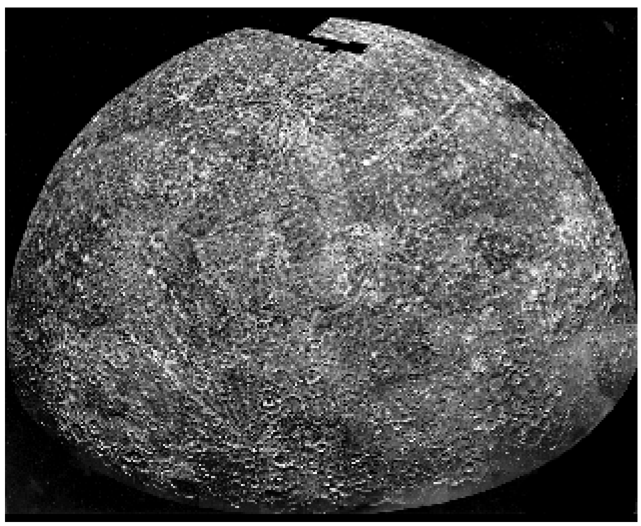
6 hours before closest approach

Second Mercury flyby

After looping once around the Sun while Mercury completed two orbits, Mariner 10 flew by Mercury again on September 21, 1974, at a more distant range of 48,069 km (29,870 mi) below the southern hemisphere.



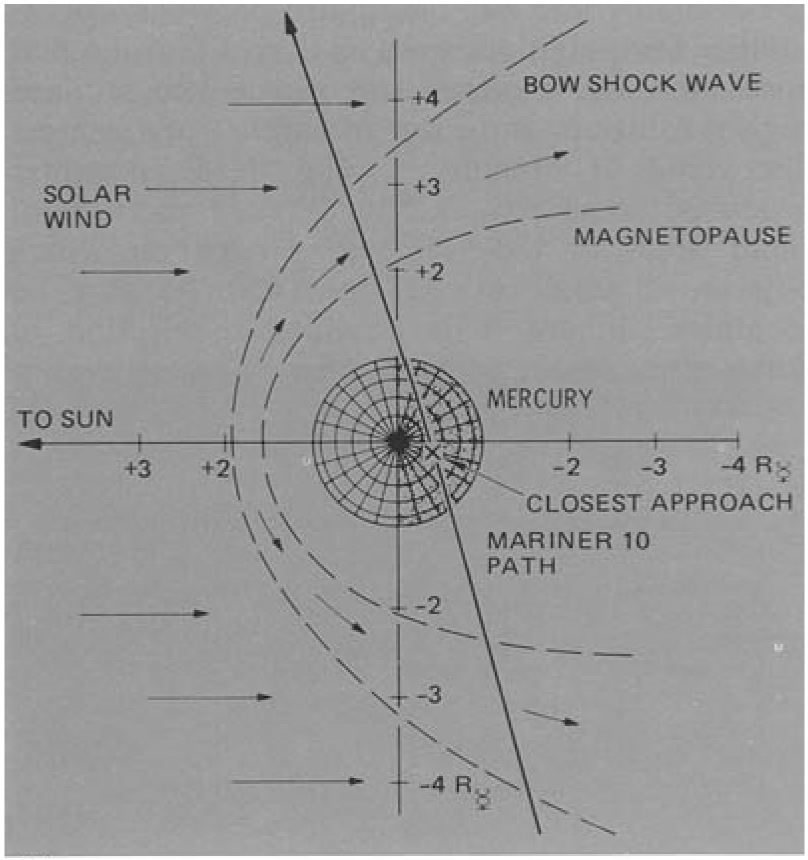
Second Mercury encounter



Mosaic of images from the second encounter, covering the equator to the south pole

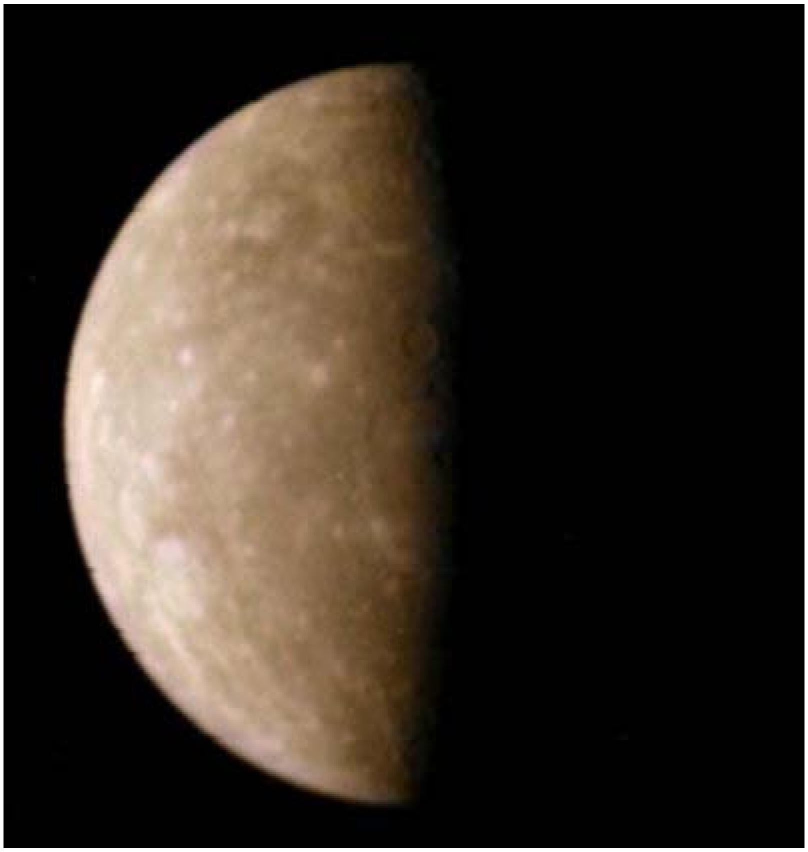
Third Mercury flyby

After loosing roll control in October 1974 a third and final encounter, the closest to Mercury, took place on March 16, 1975, at a range of 327 km (203 mi), passing almost over the north pole.

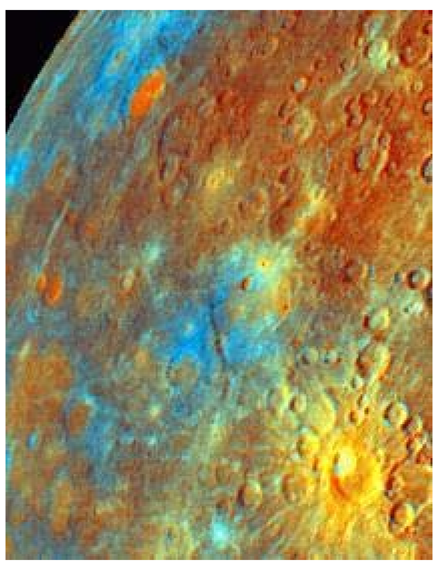


(a)

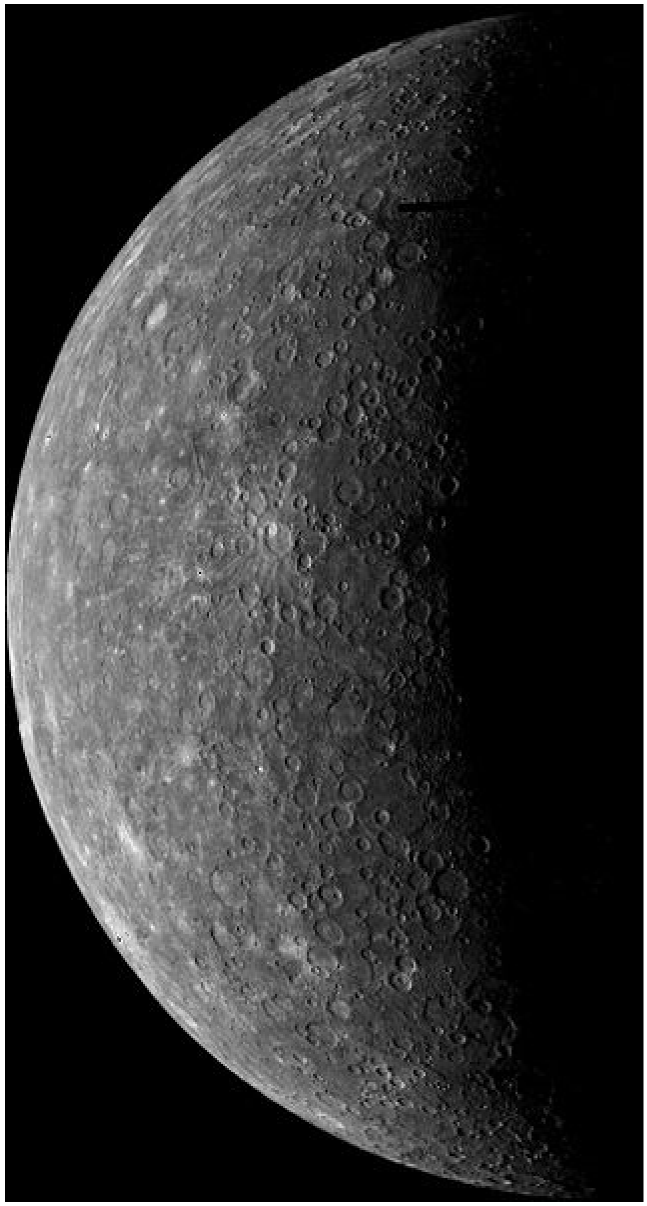
Third Mercury encounter



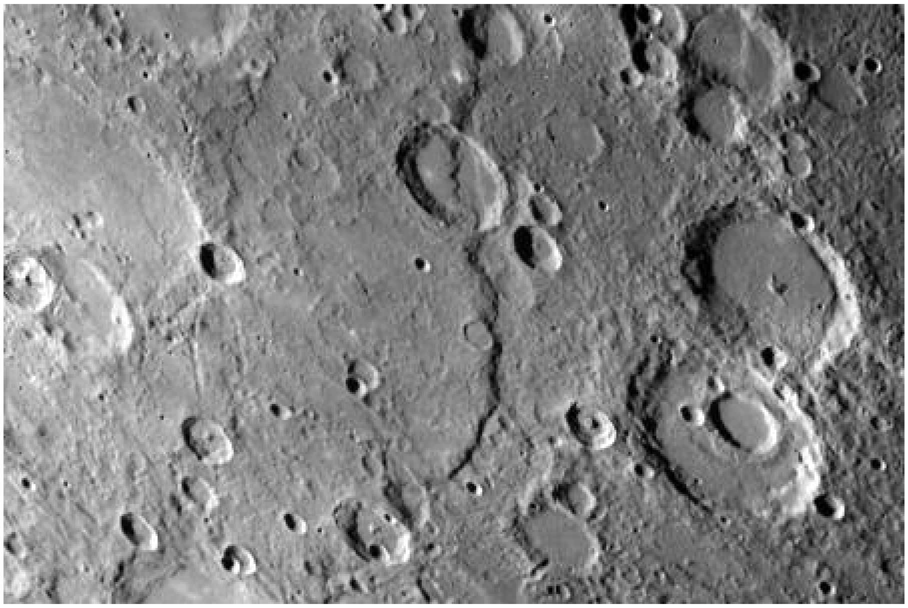
Mercury in color



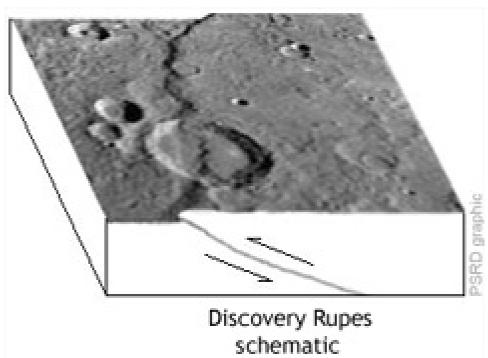
Mercury in false-color



Mercury in black and white



A prominent scarp, Discovery Rupes, photographed during first flyby

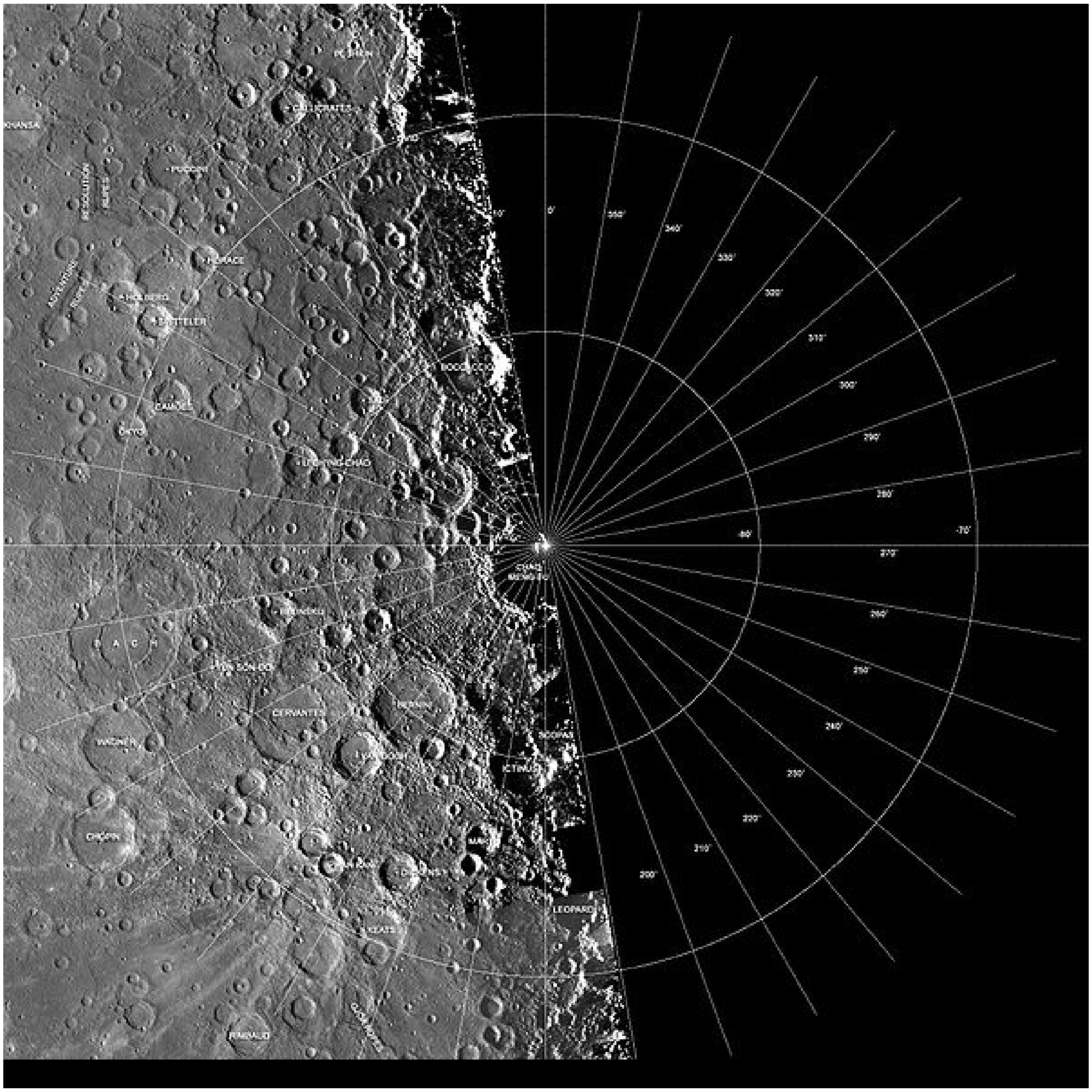


Representation of the thrust fault at Discovery Rupes

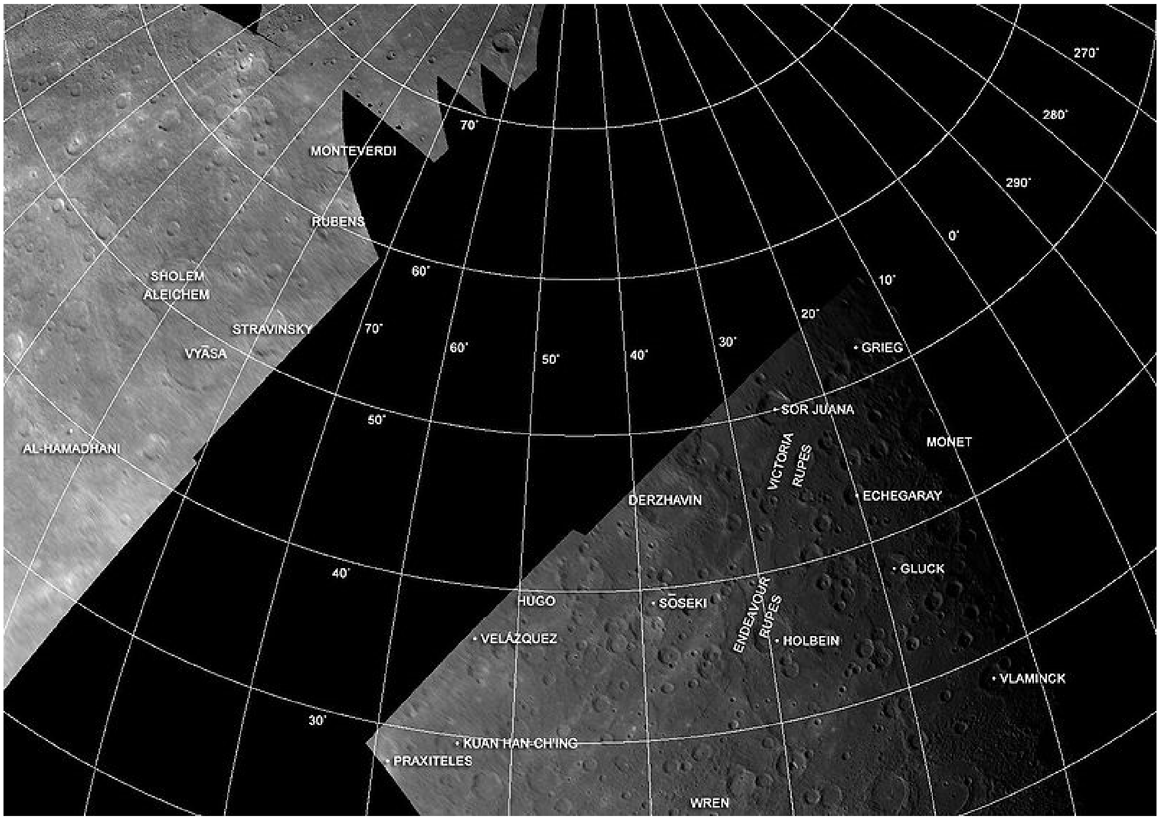
End of mission

With its maneuvering gas just about exhausted, Mariner 10 started another orbit of the Sun. Engineering tests were continued until March 24, 1975, when the final depletion of the nitrogen supply was signalled by the onset of an un-programmed pitch turn. Commands were immediately sent to the spacecraft to turn off its transmitter, and radio signals to Earth ceased.

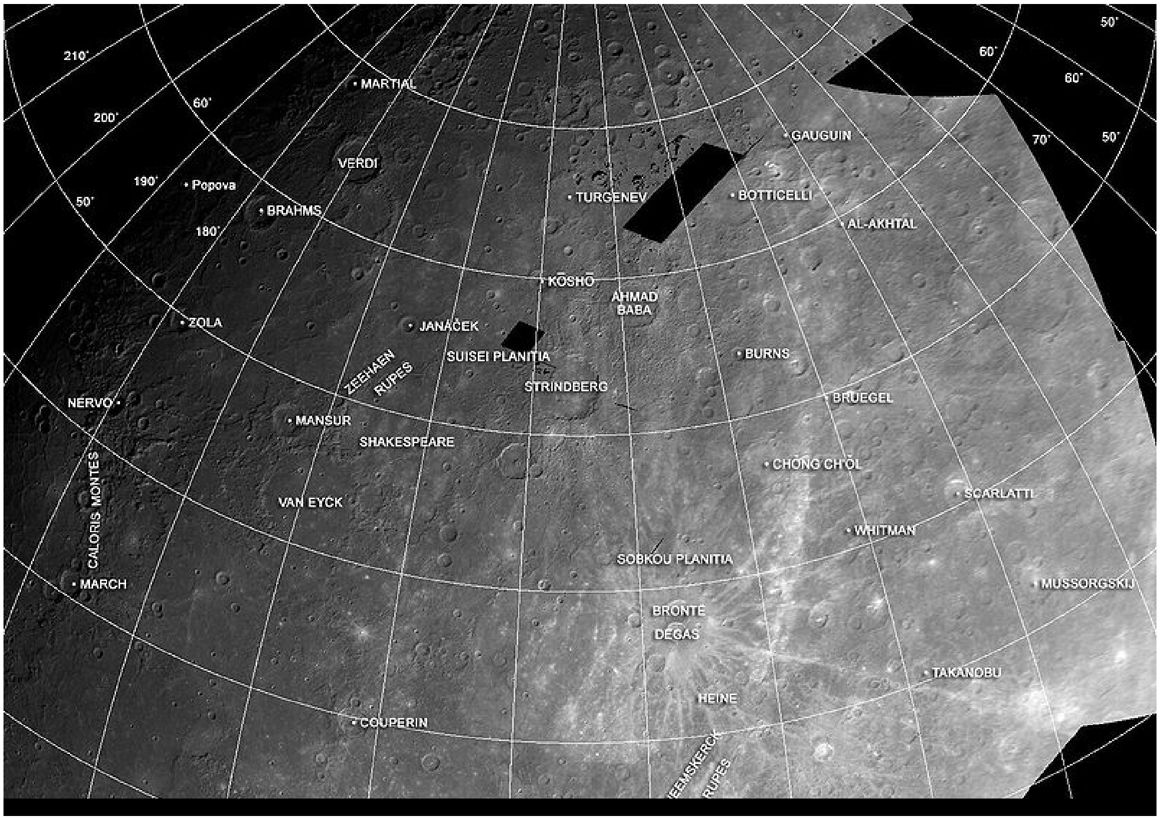
Presently, Mariner 10 is still orbiting the sun, although its on-board electronics have probably been damaged by the sun's radiation.



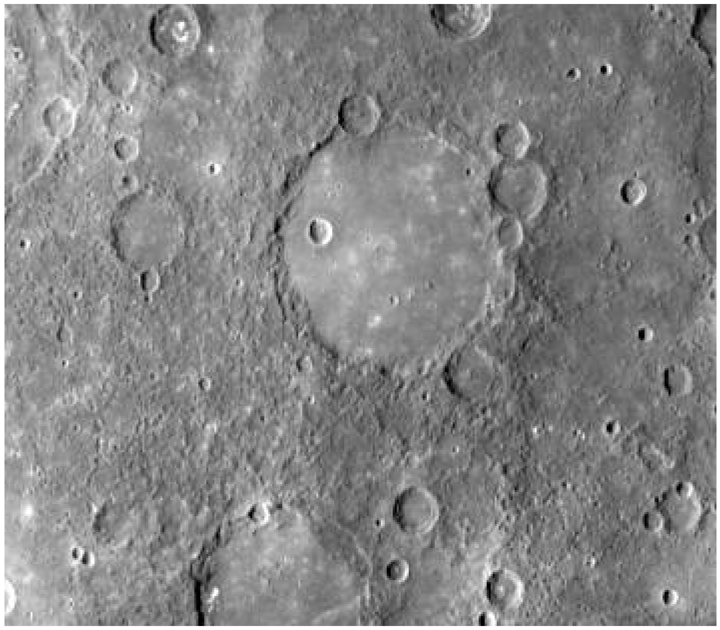
Australia region



Aurora region



Caduceata region



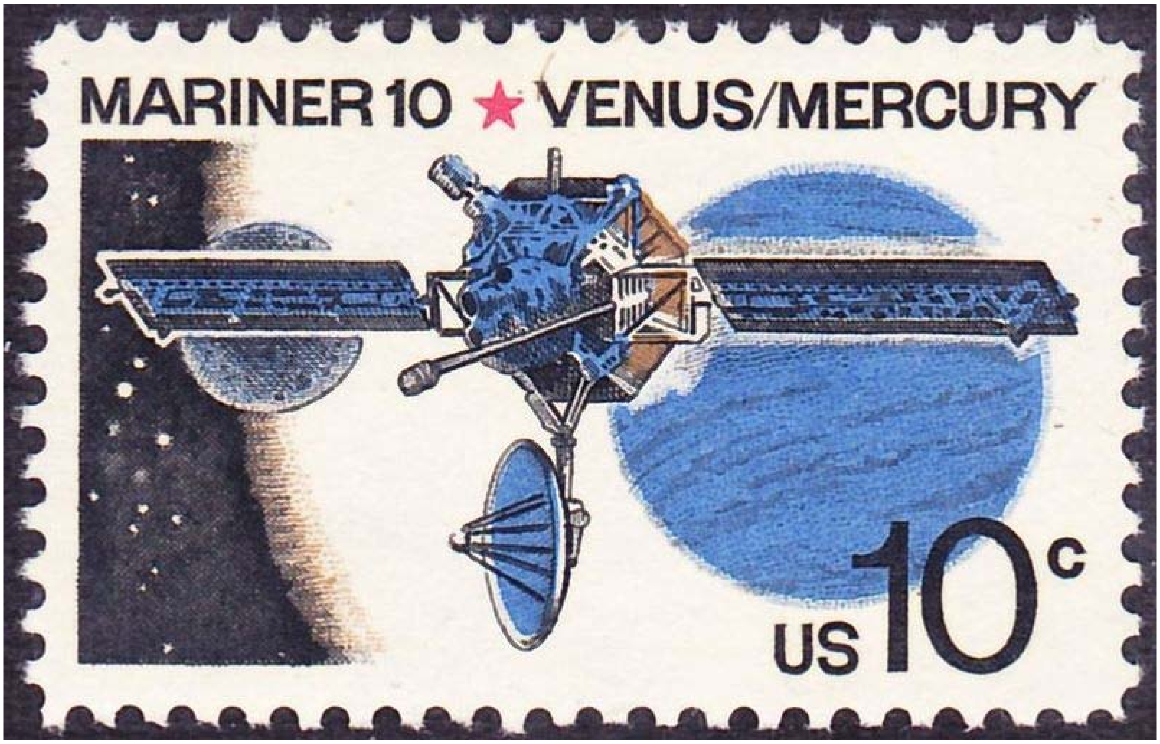
Old basin, 190 km in diameter, filled by smooth plains. The basin's hummocky rim is partly degraded and cratered by later events

Discoveries

During its flyby of Venus, Mariner 10 discovered evidence of rotating clouds and a very weak magnetic field.

Mariner 10 flew past Mercury three times in total. Owing to the geometry of its orbit — its orbital period was almost exactly twice Mercury's — the same side of Mercury was sunlit each time, so it was only able to map 40-45% of Mercury's surface, taking over 2,800 photos. It revealed a more or less moon-like surface. It thus contributed enormously to our understanding of the planet, whose surface had not been successfully resolved through telescopic observation. The regions mapped included most or all of the Shakespeare, Beethoven, Kuiper, Michelangelo, Tolstoj, and Discovery quadrangles, half of Bach and Victoria, and small portions of Solitudo Persephones, Liguria, and Borealis.

Mariner 10 also discovered that Mercury has a tenuous atmosphere consisting primarily of helium, as well as a magnetic field and a large iron-rich core. Its radiometer readings suggested that Mercury has a night time temperature of -183°C (-297°F) and maximum daytime temperatures of 187°C (369°F).



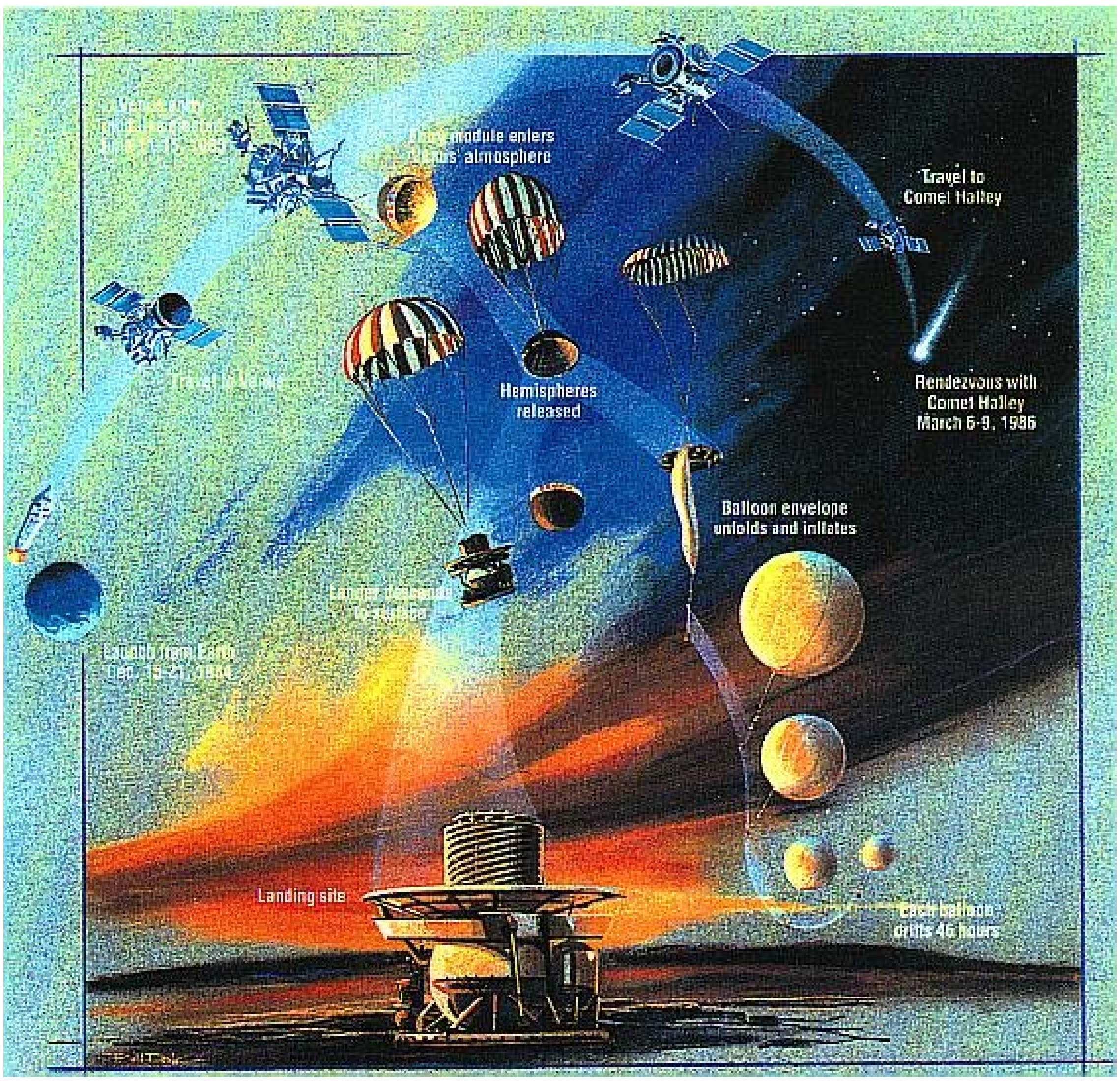
Mariner 10 Space probe, Issue of 1975

Mariner 10 Commemoration

On February 10, 1975, the US Post Office issued a commemorative stamp featuring the Mariner 10 space probe. The 10-cent Mariner 10 commemorative stamp was issued on April 4, 1975, at Pasadena, California.

Chapter- 3

Vega Program



Vega mission description

The **Vega program** were a series of Venus missions which also took advantage of the appearance of Comet Halley in 1986. Vega 1 and Vega 2 were unmanned spacecraft launched in a cooperative effort among the Soviet Union (who provided the spacecraft and launch vehicle) and Austria, Bulgaria, Hungary, the German Democratic Republic, Poland, Czechoslovakia, France, and the Federal Republic of Germany in December 1984. They had a two-part mission to investigate Venus and also flyby Halley's Comet.

The flyby of Halley's Comet had been a late mission change in the Venera program following on from the cancellation of the US Halley mission in 1981. A later Venera mission was cancelled and the Venus part of the Vega 1 mission was reduced. Because of this, the craft was designated Vega, a contraction of "Venera" and "Gallei" (Russian words for "Venus" and "Halley", respectively). The spacecraft design was based on the previous Venera 9 and Venera 10 missions.

The two spacecraft were launched on December 15 and December 21, 1984, respectively. With their redesignated dual missions, the Vega probes became part of the Halley Armada, a group of space probes that studied Halley's Comet during its 1985/86 perihelion.

The Vega spacecraft

Vega solar system probe bus and landing apparatus (model)

Vega 1 and 2 were identical sister ships. The spacecraft was a development of the earlier *Venera* craft. They were designed by Babakin Space Center and constructed as 5VK by Lavochkin at Khimki. The craft was powered by twin large solar panels and instruments included an antenna dish, cameras, spectrometer, infrared sounder, magnetometers (MISCHA), and plasma probes. The 4,920 kg craft was launched by a Proton 8K82K rocket from Baikonur Cosmodrome, Tyuratam, Kazakh SSR. Both Vega 1 and 2 were three-axis stabilized spacecraft. The spacecraft were equipped with a dual bumper shield for dust protection from Halley's comet.

Bus Instruments

1. imaging system
2. infrared spectrometer
3. ultraviolet, visible, infrared imaging spectrometer
4. shield penetration detector
5. dust detectors
6. dust mass spectrometer
7. neutral gas mass spectrometer
8. APV-V plasma energy analyzer
9. energetic-particle analyzer
10. magnetometer
11. wave and plasma analyzers

The Venus mission

Vega 1 arrived at Venus on June 11, 1985 and Vega 2 on June 15, 1985, and each delivered a 1,500 kg, 240 cm diameter spherical descent unit. The units were released some days before each arrived at Venus and entered the atmosphere without active inclination changes. Each contained a lander and a balloon explorer.

Descent craft

The landers were identical to that of the previous five *Venera* missions and were to study the atmosphere and surface, each had instruments to study temperature, pressure, a UV spectrometer, a water concentration meter, a gas-phase chromatograph, an X-ray spectrometer, a mass spectrometer and a surface sampling device.

The Vega 1 lander's surface experiments were inadvertently activated at 20 km from the surface by an especially-hard wind jolt, and so failed to provide results. It landed at 7.5°N, 177.7°E.

The Vega 2 lander touched down at 03:00:50 UT on 15 June 1985 at 8.5° S, 164.5° E, in eastern Aphrodite Terra. The altitude of the touchdown site was 0.1 km above the planetary mean radius. The measured pressure at the landing site was 91 atm and the temperature was 736 K. The surface sample was found to be an anorthosite-troctolite. It transmitted data from the surface for 56 minutes.

Payload

- Meteocomplex T,P sensors
- Sigma-3 gas chromatograph
- LSA particle size spectrometer
- IFP aerosol analyser
- VM-4 hygrometer
- ISAV-A nephelometer / scatterometer
- Malakhit-V mass spectrometer
- ISAV-S UV spectrometer
- GZU VB-02 drill + BDRP-AM25 soil X-ray fluorescence spectrometer
- GS-15-STsV gamma ray spectrometer
- PrOP-V penetrometer
- MSB small solar batteries

Balloon

The two balloon aerobots were designed to float at 54 km from the surface, in the most active layer of the Venusian cloud system. The instrument pack had enough battery power for sixty hours of operation and measured temperature, pressure, wind speed and aerosol density. Both Vega-1 and Vega-2 balloons operated for more than 46 hrs from injection to the final transmission.

The balloons were spherical superpressure types with a diameter of 3.54 meters (11.6 ft) and filled with helium. A gondola assembly weighing 6.9 kilograms (15.2 pounds) and 1.3 meters (4.26 ft) long was connected to the balloon envelope by a tether 13 meters (42.6 ft) long. Total mass of the entire assembly was 21 kilograms (46 pounds).

The top section of the gondola assembly was capped by a conical antenna 37 centimeters (14.6 inches) tall and 13 centimeters (5 $^1/_8$ inches) wide at the base. Beneath the antenna was a module containing the radio transmitter and system control electronics. The lower section of the gondola assembly carried the instrument payload and batteries.

The instruments consisted of:

- An arm carrying thin-film resistance thermometers and a velocity anemometer. The anemometer consisted of a free-spinning plastic propeller whose spin was measured by LED-photodetector optointerrupters.
- A module containing a PIN diode photodetector to measure light levels and a vibrating quartz beam pressure sensor.
- A package at the bottom carrying the batteries and a nephelometer to measure cloud density through light reflection.

The small low-power transmitter only allowed a data transmission rate of 2,048 bits per second, though the system performed data compression to squeeze more information through the narrow bandwidth. Nonetheless, the sampling rate for most of the instruments was only once every 75 seconds. The balloons were tracked by two networks of 20 radio telescopes in total back on Earth: the Soviet network, coordinated by the USSR Academy of Sciences and the international network, coordinated by CNES.

The balloons were dropped onto the planet's darkside and deployed at an altitude of about 50 kilometers (30 miles). They then floated upward a few kilometers to their equilibrium altitude. At this altitude, pressure and temperature conditions of Venus are similar to those of Earth, though the planet's winds moved at hurricane velocity and the carbon dioxide atmosphere is laced with sulfuric acid, along with smaller concentrations of hydrochloric and hydrofluoric acid.

The balloons moved swiftly across the night side of the planet into the light side, where their batteries finally ran down and contact was lost. Tracking indicated that the motion of the balloons included a surprising vertical component, revealing vertical motions of air masses that had not been detected by earlier probe missions.

1985 USSR miniature sheet dedicated to the program, depicting Vega 1 spacecraft, Comet Halley and Intercosmos logo.

The Halley mission

After their encounters, the Vegas' motherships were redirected by Venus' gravity to intercept Comet Halley.

Vega 1 made its closest approach on March 6, around 8,890 km from the nucleus, and Vega 2 made its closest approach on March 9 at 8,030 km. The data intensive examination of the comet covered only the three hours around closest approach. They were intended to measure the physical parameters of the nucleus, such as dimensions, shape, temperature and surface properties, as well as to study the structure and dynamics of the coma, the gas composition close to the nucleus, the dust particles' composition and mass distribution as functions of distance to the nucleus and the cometary-solar wind interaction.

In total Vega 1 and Vega 2 returned about 1,500 images of Comet Halley. Spacecraft operations were discontinued a few weeks after the Halley encounters.

The on-board TV system was created in international cooperation of the scientific and industrial facilities from the USSR, Hungary, France and Czechoslovakia. TV data were processed by international team, including the USSR, Hungary, France, GDR and USA scientists. The basic steps of data acquisition and preprocessing were performed in IKI using the image processing computer system, based on PDP11/40 compatible host.

Vega 1 and 2 are currently in heliocentric orbits.

Chapter- 4

Vega 1 & Vega 2

Vega 1

Vega 1 spacecraft	
Operator	USSR
Mission type	Flyby, balloon and lander
Flyby of	Venus, Halley
Flyby date	June 11, 1985 (Venus) and March 6, 1986 (Halley)
Launch date	1984-12-15 at 09:16:24 UTC
Launch vehicle	Proton 8K82K rocket
COSPAR ID	1984-125A
Mass	4920 kg

Vega 1 (along with its twin Vega 2) is a Soviet space probe part of the Vega program. The spacecraft was a development of the earlier *Venera* craft. They were designed by Babakin Space Center and constructed as 5VK by Lavochkin at Khimki.

The craft was powered by twin large solar panels and instruments included an antenna dish, cameras, spectrometer, infrared sounder, magnetometers (MISCHA), and plasma probes. The 4,920 kg craft was launched by a Proton 8K82K rocket from Baikonur Cosmodrome, Tyuratam, Kazakh SSR. Both Vega 1 and 2 were three-axis stabilized spacecraft. The spacecraft were equipped with a dual bumper shield for dust protection from Halley's comet.

The Venus mission

Vega 1 arrived at Venus on June 11, 1985 delivering a 1500 kg, 240 cm diameter spherical descent unit. The units were released some days before each arrived at Venus and entered the atmosphere without active inclination changes. Each contained a lander and a balloon explorer.

Descent craft

Vega 1 Descent Craft	
Operator	USSR
Mission type	Venus Lander
Launch vehicle	Vega 1
COSPAR ID	1984-125E

The landers were identical to that of the previous five *Venera* missions and were to study the atmosphere and surface, each had instruments to study temperature, pressure, a UV spectrometer, a water concentration meter, a gas-phase chromatograph, an X-ray spectrometer, a mass spectrometer and a surface sampling device.

The Vega 1 lander's surface experiments were inadvertently activated at 20 km from the surface by an especially hard wind jolt and so failed to provide results. It landed at 7°12′N 177°48′E / 7.2°N 177.8°E in the Mermaid Plain north of Aphrodite Terra.

Balloon

Vega 1 Balloon	
Operator	USSR
Mission type	Venus balloon
Launch vehicle	Vega 1 Descent Craft
Mission duration	11 June to 13 June 1985
COSPAR ID	1984-125F
Mass	21.5 kg

The Vega 1 Lander/Balloon capsule entered the Venus atmosphere (125 km altitude) at 2:06:10 UT (Earth received time; Moscow time 5:06:10 a.m.) on 11 June 1985 at roughly 11 km/s. At approximately 2:06:25 UT the parachute attached to the landing craft cap opened at an altitude of 64 km. The cap and parachute were released 15 seconds later at 63 km altitude. The balloon package was pulled out of its compartment by parachute 40 seconds later at 61 km altitude, at 8.1 degrees N, 176.9 degrees east. A second parachute opened at an altitude of 55 km, 200 seconds after entry, extracting the furled balloon. The balloon was inflated 100 seconds later at 54 km and the parachute and inflation system were jettisoned. The ballast was jettisoned when the balloon reached roughly 50 km and the balloon floated back to a stable height between 53 and 54 km some 15 to 25 minutes after entry. The mean stable height was 53.6 km, with a pressure of 535 mbar and a temperature of 300-310 K in the middle, most active layer of the Venus three-tiered cloud system. The balloon drifted westward in the zonal wind flow with an average speed of about 69 m/s at nearly constant latitude. The probe crossed the terminator from night to day at 12:20 UT on 12 June after traversing 8500 km. The probe continued to operate in the daytime until the final transmission was received at 00:38 UT on 13 June from 8.1 N, 68.8 E after a total traverse distance of 11,600 km. It is not known how much farther the balloon travelled after the final communication.

The Halley mission

After their encounters, the Vegas' motherships were redirected by Venus' gravity to intercept Halley's Comet.

Images started to be returned on March 4, 1986, and were used to help pinpoint Giotto's upcoming close flyby of the comet. The early images from Vega that showed two bright areas on the comet, which were initially interpreted as a double nucleus. The bright areas would later turn out to be two jets emitting from the comet. The images also showed the nucleus to be dark, and the infrared spectrometer readings measured a nucleus temperature of 300 K to 400 K, much warmer than expected for an ice body. The conclusion was that the comet had a thin layer on its surface covering an icy body.

Vega 1 made its closest approach on March 6 at around 8,889 kilometers (at 07:20:06 UT) of the nucleus. It took more than 500 pictures via different filters as it flew through the gas cloud around the coma. Although the spacecraft was battered by dust, none of the instruments were disabled during the encounter.

The data intensive examination of the comet covered only the three hours around closest approach. They were intended to measure the physical parameters of the nucleus, such as dimensions, shape, temperature and surface properties, as well as to study the structure and dynamics of the coma, the gas composition close to the nucleus, the dust particles' composition and mass distribution as functions of distance to the nucleus and the cometary-solar wind interaction.

The Vega images showed the nucleus to be about 14 km long with a rotation period of about 53 hours. The dust mass spectrometer detected material similar to the composition of carbonaceous chondrites meteorites and also detected clathrate ice.

After subsequent imaging sessions on 7 and 8 March 1986, Vega 1 headed out to deep space. In total Vega 1 and Vega 2 returned about 1500 images of Comet Halley. Vega 1 ran out of attitude control propellant on 30 January 1987, and contact with Vega 2 continued until 24 March 1987.

Vega 1 and Vega 2 are currently in heliocentric orbits.

Vega 2

Vega 2 spacecraft	
Operator	USSR
Mission type	Flyby, balloon and lander
Flyby of	Venus, Halley
Flyby date	June 15, 1985 (Venus) and March 9, 1986 (Halley)
Launch date	1984-12-21 at 09:13:52 UTC
Launch vehicle	Proton 8K82K rocket
COSPAR ID	1984-128A
Mass	4920 kg

Vega 2 (along with Vega 1) is a Soviet space probe part of the Vega program. The spacecraft was a development of the earlier *Venera* craft. They were designed by Babakin Space Center and constructed as 5VK by Lavochkin at Khimki. The craft was powered by twin large solar panels and instruments included an antenna dish, cameras, spectrometer, infrared sounder, magnetometers (MISCHA), and plasma probes. The 4,920 kg craft was launched by a Proton 8K82K rocket from Baikonur Cosmodrome, Tyuratam, Kazakh SSR. Both Vega 1 and 2 were three-axis stabilized spacecraft. The spacecraft were equipped with a dual bumper shield for dust protection from Halley's Comet.

The Venus mission

Vega 2 arrived at Venus on June 15, 1985. Its 1500 kg, 240 cm diameter spherical descent unit was released some days before arrival and entered the atmosphere without active inclination changes. It contained a lander and a balloon explorer.

Descent craft

Vega 2 Descent craft

Operator	USSR
Mission type	Venus lander
Launch vehicle	Vega 2
COSPAR ID	1984-128E

The Vega 2 lander touched down at 03:00:50 UT on 15 June 1985 at around 7°08′S 177°40′E / 7.14°S 177.67°E, in the northern region of Aphrodite Terra. The altitude of the touchdown site was 0.1 km above the planetary mean radius. The measured pressure at the landing site was 91 atm and the temperature was 736 K. The surface sample was found to be an anorthosite-troctolite rock, rarely found on Earth, but present in the lunar highlands, leading to the conclusion that the area was probably the oldest explored by any Venera vehicle. It transmitted data from the surface for 56 minutes.

Balloon

Vega 2 Balloon

Operator	USSR
Mission type	Venus ballon
Launch vehicle	Vega 2 Descent craft
Mission duration	15 June to 17 June 1985
COSPAR ID	1984-128F
Mass	21.5 kg

The Vega 2 Lander/Balloon capsule entered the Venus atmosphere (125 km altitude) at 2:06:04 UT (Earth received time; Moscow time 5:06:04 a.m.) on 15 June 1985 at roughly 11 km/s. At approximately 2:06:19 UT the parachute attached to the landing craft cap opened at an altitude of 64 km. The cap and parachute were released 15 seconds later at 63 km altitude. The balloon package was pulled out of its compartment by parachute 40 seconds later at 61 km altitude, at 7.45 degrees S, 179.8 degrees east. A second parachute opened at an altitude of 55 km, 200 seconds after entry, extracting the furled balloon. The balloon was inflated 100 seconds later at 54 km and the parachute and inflation system were jettisoned. The ballast was jettisoned when the balloon reached roughly 50 km and the balloon floated back to a stable height between 53 and 54 km some 15 to 25 minutes after entry. The mean stable height was 53.6 km, with a pressure of 535 mbar and a temperature of 308-316 K in the middle, most active layer of the Venus three-tiered cloud system. The balloon drifted westward in the zonal wind flow with an average speed of about 66 m/s at nearly constant latitude. The probe crossed the terminator from night to day at 9:10 UT on 16 June after traversing 7400 km. The probe continued to operate in the daytime until the final transmission was received at 00:38 UT on 17 June from 7.5 S, 76.3 E after a total traverse distance of 11,100 km. It is not known how much further the balloon traveled after the final communication.

The Halley mission

After their encounters, the Vegas' motherships were redirected by Venus' gravity to intercept Halley's Comet.

The spacecraft initiated its encounter on March 7, 1986 by taking 100 photos of the comet from a distance of 14 million kilometers.

Vega 2 made its closest approach at 07:20 UT on March 9, 1986 at 8,030 km. The data intensive examination of the comet covered only the three hours around closest approach. They were intended to measure the physical parameters of the nucleus, such as dimensions, shape, temperature and surface properties, as well as to study the structure and dynamics of the coma, the gas composition close to the nucleus, the dust particles' composition and mass distribution as functions of distance to the nucleus and the cometary-solar wind interaction.

During the encounter, Vega 2 took 700 images of the comet, with better resolution than those from the twin Vega 1, partly due to the presence of less dust outside of the coma at the time. Yet Vega 2 recorded an 80% power loss during the encounter as compared to Vega 1's 40%.

After further imaging sessions on 10 and 11 March 1986, Vega 2 finished its primary mission. Vega 1 ran out of attitude control propellant on 30 January 1987, and contact with Vega 2 continued until 24 March 1987.

Vega 2 is currently in heliocentric orbit.

Chapter- 5

Venera 11, Venera 12 and Venera 13

Venera 11

Venera 11

Venera 11 lander

Operator	USSR
Mission type	Flyby and Lander

Flyby date	December 25, 1978
Satellite of	Venus
Launch date	9 September 1978 at 3:25:39 UTC
Launch vehicle	Proton Booster Plus Upper Stage and Escape Stages
COSPAR ID	1978-084D
Mass	4940 kg
	Orbital elements
Periapsis	6.62 RV (flight platform)

The **Venera 11** (Russian: Венера-11) was a USSR unmanned space mission part of the Venera program to explore the planet Venus. Venera 11 was launched on 9 September 1978 at 3:25:39 UTC.

Separating from its flight platform on December 23, 1978 the lander entered the Venus atmosphere two days later on December 25 at 11.2 km/s. During the descent, it employed aerodynamic braking followed by parachute braking and ending with atmospheric braking. It made a soft landing on the surface at 06:24 Moscow time (0324 UT) on 25 December after a descent time of approximately 1 hour. The touchdown speed was 7 to 8 m/s. Landing coordinates are 14°S 299°E / 14°S 299°E. Information was transmitted to the flight platform for retransmittal to earth until it moved out of range 95 minutes after touchdown.

Flight platform

After ejection of the lander probe, the flight platform continued on past Venus in a heliocentric orbit. Near encounter with Venus occurred on December 25, 1978, at approximately 34,000 km altitude. The flight platform acted as a data relay for the descent craft for 95 minutes until it flew out of range and returned its own measurements on interplanetary space.

Venera 11 flight platform carried solar wind detectors, ionosphere electron instruments and two gamma ray burst detectors - the Soviet-built KONUS and the French-built SIGNE 2. The SIGNE 2 detectors were simultaneously flown on Venera 12 and Prognoz 7 to allow triangulation of gamma ray sources. Before and after Venus flyby, Venera 11 and Venera 12 yielded detailed time-profiles for 143 gamma-ray bursts, resulting in the first ever catalog of such events. The last gamma-ray burst reported by Venera 11 occurred on January 27, 1980

List of flight platform instruments and experiments:

- 30-166 nm Extreme UV Spectrometer
- Compound Plasma Spectrometer
- KONUS Gamma-Ray Burst Detector
- SNEG Gamma-Ray Burst Detector
- Magnetometer
- 4 Semiconductor Counters
- 2 Gas-Discharge Counters
- 4 Scintillation Counters
- Hemispherical Proton Telescope

The mission ended in February, 1980.

Lander

The lander carried instruments to study the temperature and atmospheric and soil chemical composition. A device called Groza detected lightning on Venus. Both Venera 11 and Venera 12 had landers with two cameras, each designed for color imaging, though Soviet literature does not mention them. Each failed to return images when the lens covers did not separate after landing due to a design flaw. The soil analyzer also failed. A gas chromatograph was on board to measure the composition of the Venus atmosphere, as well as instruments to study scattered solar radiation. Results reported included evidence of lightning and thunder, a high Ar^{36}/Ar^{40} ratio, and the discovery of carbon monoxide at low altitudes.

List of lander experiments and instruments:

- Backscatter Nephelometer
- Mass Spectrometer - MKh-6411
- Gas Chromatograph - Sigma
- X-Ray Fluorospectrometer
- 360° Scanning Photometer - IOAV
- Spectrometer (430-1170 nm)
- Microphone/Anemometer
- Low-Frequency Radio Sensor
- 4 Thermometers
- 3 Barometers
- Accelerometer - Bizon
- Penetrometer - PrOP-V
- Soil Analysis Device
- 2 Color Cameras
- Small solar batteries - MSB

Venera 12

Venera 12

Venera 11 lander

Operator	USSR
Mission type	Flyby and Lander
Flyby date	December 19, 1978
Satellite of	Venus
Launch date	14 September 1978 02:25:13 UTC
Launch vehicle	Proton Booster Plus Upper Stage and Escape Stages
COSPAR ID	1978-086A
Mass	4940 kg
Orbital elements	
Periapsis	6.62 RV (flight platform)

The **Venera 12** (Russian: Венера-12) was an USSR unmanned space mission to explore the planet Venus. Venera 12 was launched on 14 September 1978 at 02:25:13 UTC. Separating from its flight platform on December 19, 1978, the lander entered the Venus atmosphere two days later at 11.2 km/s. During the descent, it employed aerodynamic braking followed by parachute braking and ending with atmospheric braking. It made a soft landing on the surface at 06:30 Moscow time (0330 UT) on 21 December after a descent time of approximately 1 hour. The touchdown speed was 7–8 m/s. Landing coordinates are 7°S 294°E / 7°S 294°E. It transmitted data to the flight platform for 110 minutes after touchdown until the flight platform moved out of range. Identical instruments were carried on Venera 11 and 12.

Flight platform

Venera 12 flight platform carried solar wind detectors, ionosphere electron instruments and two gamma ray burst detectors - the Soviet-built KONUS and the French-built SIGNE 2. The SIGNE 2 detectors were simultaneously flown on Venera 12 and Prognoz 7 to allow triangulation of gamma ray sources. Before and after Venus flyby, Venera 11 and Venera 12 yielded detailed time-profiles for 143 gamma-ray bursts, resulting in the first ever catalog of such events. The last gamma-ray burst reported by Venera 12 occurred on January 5, 1980. Venera 12 used its ultraviolet spectrometer to study Comet Bradfield on 13 February 1980, and reported spectrophotometric data until 19 March 1980.

List of flight platform instruments and experiments:

- 30-166 nm Extreme UV Spectrometer
- Compound Plasma Spectrometer
- KONUS Gamma-Ray Burst Detector
- SNEG Gamma-Ray Burst Detector
- Magnetometer
- 4 Semiconductor Counters
- 2 Gas-Discharge Counters
- 4 Scintillation Counters
- Hemispherical Proton Telescope

The mission ended in April, 1980.

Lander

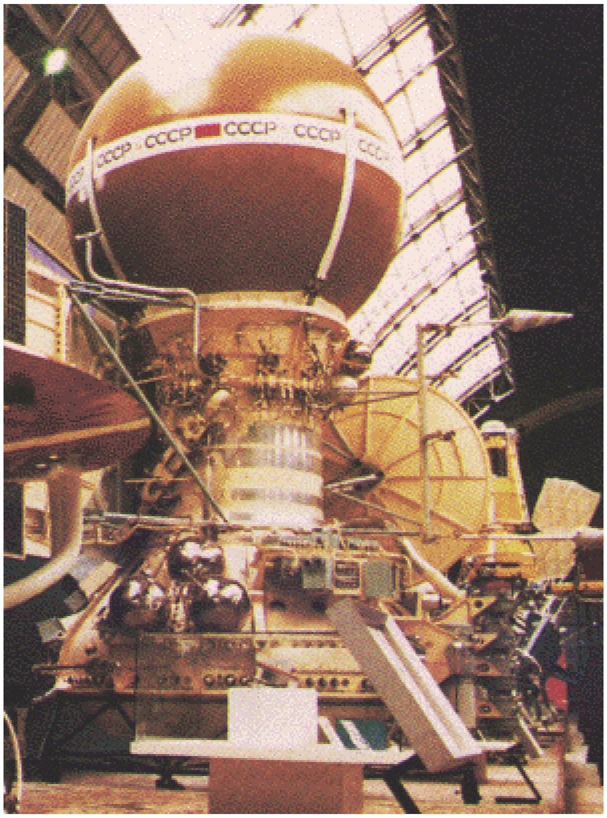
The Venera 12 descent craft carried instruments designed to study the detailed chemical composition of the atmosphere, the nature of the clouds, and the thermal balance of the atmosphere. Among the instruments on board was a gas chromatograph to measure the composition of the Venus atmosphere, instruments to study scattered solar radiation and soil composition, and a device named Groza which was designed to measure atmospheric electrical discharges. Results reported included evidence of lightning and thunder, a high Ar^{36}/Ar^{40} ratio, and the discovery of carbon monoxide at low altitudes. Both Venera 11 and Venera 12 had landers with two cameras, each designed for color imaging. Each failed to return images when the lens covers did not separate after landing due to a design flaw.

List of lander experiments and instruments:

- Backscatter Nephelometer
- Mass Spectrometer - MKh-6411
- Gas Chromatograph - Sigma
- X-Ray Fluorospectrometer
- 360° Scanning Photometer - IOAV
- Spectrometer (430-1170 nm)
- Microphone/Anemometer
- Low-Frequency Radio Sensor
- 4 Thermometers
- 3 Barometers
- Accelerometer - Bizon
- Penetrometer - PrOP-V
- Soil Analysis Device
- 2 Color Cameras
- Small solar batteries - MSB

Venera 13

Venera 13



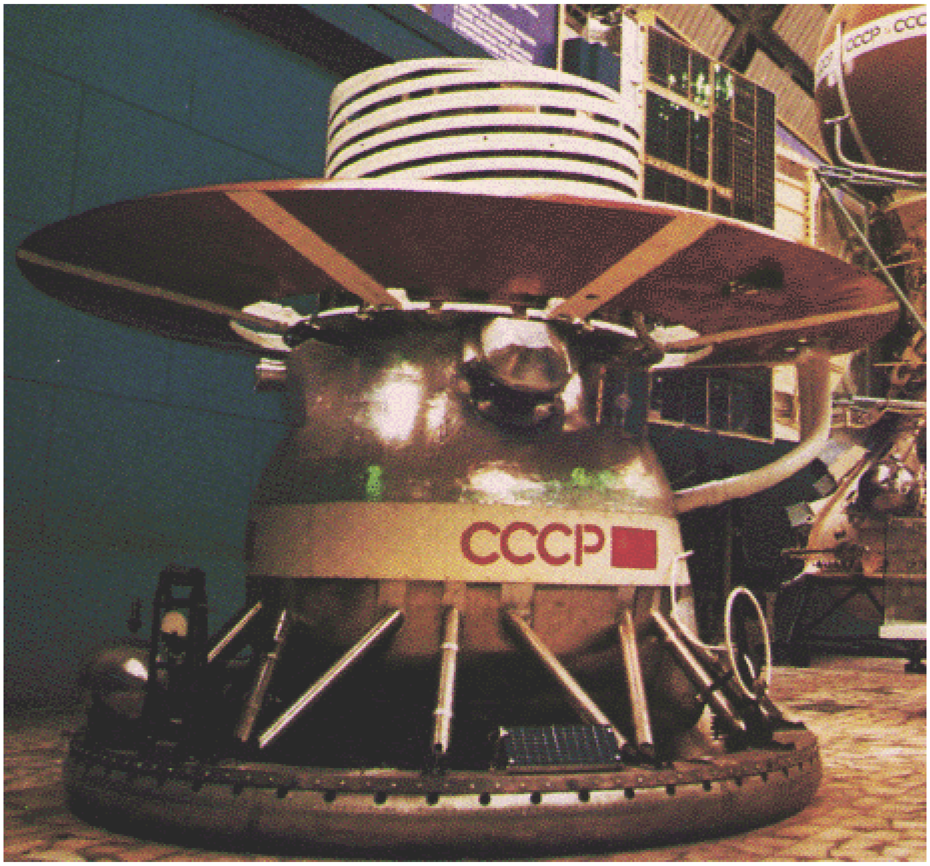
Venera 13 orbiter

Operator	USSR
Mission type	Flyby and Lander
Flyby date	March 1, 1982
Satellite of	Venus
Launch date	1981-10-30 at 06:04:00 UTC
Launch vehicle	Proton Booster Plus Upper Stage and Escape Stages
COSPAR ID	1981-106A
Mass	760 kg

Venera 13 (Russian: Венера-13) was a probe in the Soviet Venera program for the exploration of Venus.

Venera 13 and 14 were identical spacecraft built to take advantage of the 1981 Venus launch opportunity and launched 5 days apart, Venera 13 on 1981-10-30 at 06:04:00 UTC and Venera 14 on 1981-11-04 at 05:31:00 UTC, both with an on-orbit dry mass of 760 kg.

Design



Venera 13 lander

Each mission consisted of a bus and an attached descent craft. The descent craft/lander was a hermetically sealed pressure vessel, which contained most of the instrumentation and electronics, mounted on a ring-shaped landing platform and topped by an antenna. The design was similar to the earlier Venera 9–12 landers. It carried instruments to take chemical and isotopic measurements, monitor the spectrum of scattered sunlight, and record electric discharges during its descent phase through the Venusian atmosphere. The spacecraft utilized a camera system, an X-ray fluorescence spectrometer, a screw drill and surface sampler, a dynamic penetrometer, and a seismometer to conduct investigations on the surface.

List of lander experiments and instruments:

- Accelerometer, Impact Analysis - Bison-M
- Thermometers, Barometers - ITD
- Spectrometer / Directional Photometer - IOAV-2
- Ultraviolet Photometer
- Mass Spectrometer - MKh-6411
- Penetrometer / Soil Ohmmeter - PrOP-V
- Chemical Redox Indicator - Kontrast

- 2 Color Telephotometer Cameras - TFZL-077
- Gas Chromatograph - Sigma-2
- Radio / Seismometer - Groza-2
- Nephelometer - MNV-78-2
- Hydrometer - VM-3R
- X-Ray Fluorescence Spectrometer (Aerosol) - BDRA-1V
- X-Ray Fluorescence Spectrometer (Soil) - Arakhis-2
- Soil Drilling Apparatus - GZU VB-02
- Stabilized Oscillator / Doppler Radio
- Small solar batteries - MSB

Landing

After launch and a four month cruise to Venus the descent vehicle separated from the bus and plunged into the Venusian atmosphere on March 1, 1982. After entering the atmosphere a parachute was deployed. At an altitude of about 50 km the parachute was released and simple airbraking was used the rest of the way to the surface.

Venera 13 landed at 7°30′S 303°00′E / 7.5°S 303°E, about 950 km northeast of Venera 14, just east of the eastern extension of an elevated region known as Phoebe Regio.

The lander had cameras to take pictures of the ground and spring-loaded arms to measure the compressibility of the soil. The quartz camera windows were covered by lens caps which popped off after descent.

The area was composed of bedrock outcrops surrounded by dark, fine-grained soil. After landing an imaging panorama was started and a mechanical drilling arm reached to the surface and obtained a sample, which was deposited in a hermetically sealed chamber, maintained at 30 °C and a pressure of about 0.05 atmosphere (5 kPa). The composition of the sample determined by the X-ray fluorescence spectrometer put it in the class of weakly differentiated melanocratic alkaline gabbroids.

The lander survived for 127 minutes (the planned design life was 32 minutes) in an environment with a temperature of 457 °C (855 °F) and a pressure of 89 Earth atmospheres (9.0 MPa). The descent vehicle transmitted data to the bus, which acted as a data relay as it flew by Venus. It is probable that the probe or its remains have been severely degraded by the high surface temperature and pressure and the presence of corrosive supercritical carbon dioxide in the Venusian atmosphere.

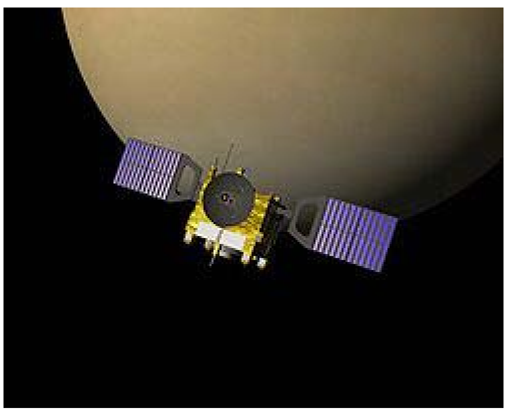
Image processing

American researcher Don P. Mitchell has processed the color images from Venera 13 and 14 using the original digital telemetry data. The new images are based on a more accurate linearization of the original 9-bit logarithmic pixel encoding.

Chapter- 6

Venus Express

Venus Express



Operator	ESA
Major contractors	EADS Astrium, Toulouse, France, leading a team of 25 subcontractors from 14 European countries.
Mission type	Orbiter
Satellite of	Venus
Launch date	9 November 2005 03:33:34 UTC
Launch vehicle	Soyuz-FG/Fregat
Mission duration	150 days enroute; 1,000 days in orbit 5 years, 3 months, and 12 days elapsed
COSPAR	2005-045A

ID	
Homepage	www.esa.int/SPECIALS/Venus_Express
Mass	1,270 kg
	Orbital elements
Semimajor axis	39,468.195 km
Eccentricity	0.8403
Inclination	89.99 deg
Orbital period	24 h

Venus Express (*VEX*) is the first Venus exploration mission of the European Space Agency. Launched in November 2005, it arrived at Venus in April 2006 and has been continuously sending back science data from its polar orbit around Venus. Equipped with seven science instruments, the main objective of the mission is the long term observation of the Venusian atmosphere. The observation over such long periods of time has never been done in previous missions to Venus, and is key to a better understanding of the atmospheric dynamics. It is hoped that such studies can contribute to an understanding of atmospheric dynamics in general, while also contributing to an understanding of climate change on Earth. The mission is currently funded by ESA through 31 December 2012.

History

The mission was proposed in 2001 to reuse the design of the *Mars Express* mission. However, some mission characteristics led to design changes: primarily in the areas of thermal control, communications and electrical power. For example, since Mars is approximately twice as far from the Sun as Venus is, the radiant heating of the spacecraft will be four times greater for *Venus Express* than *Mars Express*. Also, the ionizing radiation environment will be harsher. On the other hand, the more intense illumination of the solar panels will result in more generated photovoltaic power. The *Venus Express* mission also uses some spare instruments developed for the *Rosetta* spacecraft. The mission was proposed by a consortium led by D. Titov (Germany), E. Lellouch (France) and F. Taylor (United Kingdom).

The launch window for *Venus Express* was open from 26 October to 23 November 2005, with the launch initially set for 26 October 4:43 UTC. However, problems with the insulation from the Fregat upper stage led to a two week launch delay to inspect and clear out the small insulation debris that migrated on the spacecraft. It was eventually launched by a Soyuz-FG/Fregat rocket from the Baikonur Cosmodrome in Kazakhstan on 9 November 2005 at 03:33:34 UTC into a parking Earth orbit and 1 h 36 min after launch put into its transfer orbit to Venus. A first trajectory correction maneuver was successfully performed on 11 November 2005. It arrived at Venus on 11 April 2006, after approximately 150 days of journey, and fired its main engine between 07:10 and 08:00 Universal Time (UTC) to reduce its velocity so that it could be captured by Venusian gravity into a nine day orbit. The burn was monitored from ESA's Control Centre, ESOC, in Darmstadt, Germany.

Seven further orbit control maneuvers, two with the main engine and five with the thrusters, were required for *Venus Express* to reach its final operational 24-hour orbit around Venus.

Venus Express entered its target orbit at apocentre on 7 May 2006 at 13:31 UTC, when the spacecraft was at 151 million kilometres from Earth. Now the spacecraft is running on an ellipse substantially closer to the planet than during the initial orbit. The orbit now ranges between 66,000 and 250 kilometres over Venus and it is polar. The pericentre is located almost above the North pole (80° North latitude), and it takes 24 hours for the spacecraft to travel around the planet.

Venus Express is studying the Venusian atmosphere and clouds in detail, the plasma environment and the surface characteristics of Venus from orbit. It will also make global maps of the Venusian surface temperatures. Its nominal mission was originally planned to last for 500 Earth days (approximately two Venusian sidereal days), but the mission has been extended three times: first on 28 February 2007 until early May 2009; then on 4 February 2009 until 31 December 2009; and then on 7 October 2009 until 31 December 2012. On-board resources are sized for an additional 500 Earth days.

Venus Express is outfitted mostly with spare parts and designs from the *Mars Express* and *Rosetta* missions, but has been adapted to cope with the high radiation and thermal environment surrounding Venus.

Instruments

ASPERA-4: An acronym for "**A**nalyzer of **S**pace **P**lasmas and **E**ne**r**getic **A**toms," ASPERA-4 will investigate the interaction between the solar wind and the Venusian atmosphere, determine the impact of plasma processes on the atmosphere, determine global distribution of plasma and neutral gas, study energetic neutral atoms, ions and electrons, and analyze other aspects of the near Venus environment. ASPERA-4 is a re-use of the ASPERA-3 design used on *Mars Express*, but adapted for the harsher near-Venus environment.

VMC: The **V**enus **M**onitoring **C**amera is a wide-angle, multi-channel CCD. The VMC is designed for global imaging of the planet. It operates in the visible, ultraviolet, and near infrared spectral ranges, and maps surface brightness distribution searching for volcanic activity, monitoring airglow, studying the distribution of unknown ultraviolet absorbing phenomenon at the cloud-tops, and making other science observations. It is derived in part by the *Mars Express* High Resolution Stereo Camera (HRSC) and the *Rosetta*

Optical, Spectroscopic and Infrared Remote Imaging System (OSIRIS). The camera includes an FPGA to pre-process image data, reducing the amount transmitted to Earth. The consortium of institutions responsible for the VMC includes the Max Planck Institute for Solar System Research, the Institute of Planetary Research at the German Aerospace Center and the Institute of Computer and Communication Network Engineering at Technische Universität Braunschweig.

Magnetometer

MAG: The magnetometer is designed to measure the strength of Venus's magnetic field and the direction of it as affected by the solar wind and Venus itself. It will be able to map the magnetosheath, magnetotail, ionosphere, and magnetic barrier in high resolution in three-dimensions, aid ASPERA-4 in the study of the interaction of the solar wind with the atmosphere of Venus, identify the boundaries between plasma regions, and carry planetary observations as well (such as for lightning). MAG is derived from the *Rosetta* lander's ROMAP instrument.

Spectrometer

PFS: The "**P**lanetary **F**ourier **S**pectrometer" operates in the infrared between the 0.9 μm and 45 μm wavelength range and is designed to perform vertical optical sounding of the Venus atmosphere. It will perform global, long-term monitoring of the three-dimensional temperature field in the lower atmosphere (cloud level up to 100 kilometers). Furthermore it will search for minor atmospheric constituents that may be present, but have not yet been detected, analyze atmospheric aerosols, and investigate surface to atmosphere exchange processes. The design is based on a spectrometer on *Mars Express*, but modified for optimal performance for the *Venus Express* mission.

SPICAV: Short for "**Sp**ectroscopy for **I**nvestigation of **C**haracteristics of the **A**tmosphere of **V**enus," SPICAV is an imaging spectrometer that will be used for analyzing radiation in the infrared and ultraviolet wavelengths. It is derived from the *SPICAM* instrument flown on *Mars Express*. However, SPICAV has an additional channel known as **SOIR** (**S**olar **O**ccultation at **I**nfra**r**ed) that will be used to observe the Sun through Venus's atmosphere in the infrared.

VIRTIS: VIRTIS (**V**isible and **I**nfra**r**ed **T**hermal **I**maging **S**pectrometer) is an imaging spectrometer that observes in the near-ultraviolet, visible, and infrared parts of the electromagnetic spectrum. It will analyze all layers of the atmosphere, surface temperature and surface/atmosphere interaction phenomena.

Radio science

VeRa: **Ve**nus **Ra**dio Science is a radio sounding experiment that will transmit radio waves from the spacecraft and pass them through the atmosphere or reflect them off the surface. These radio waves will be received by a ground station on Earth for analysis of the ionosphere, atmosphere and surface of Venus. It is derived from the Radio Science Investigation instrument flown on *Rosetta*.

Science

Climate of Venus

Venus is the most Earth-like planet in our solar system. Starting out in the early planetary system with similar sizes and chemical compositions, the history of the two planets have diverged in spectacular fashion. It is hoped that the *Venus Express* mission can contribute not only to an in-depth understanding of how the Venusian atmosphere is structured, but also to an understanding of the changes that led to the current greenhouse atmospheric conditions. Such an understanding may contribute to the study of climate change in on Earth.

Search for life on Earth

Venus Express is used also to observe signs of life on Earth from Venus orbit. In the pictures, Earth is less than one pixel in size, which mimics observations of Earth-sized planets in other solar systems. These observations are then used to develop methods for habitability studies of extra-solar planets.

Important events and discoveries

- 3 August 2005: *Venus Express* completed its final phase of testing at Astrium Intespace facility in Toulouse, France. It flew on a Antonov An-124 cargo aircraft via Moscow, before arriving at Baikonur on 7 August.
- 7 August 2005: *Venus Express* arrived at the airport of the Baikonur Cosmodrome.
- 16 August 2005: First flight verification test completed.
- 22 August 2005: Integrated System Test-3.
- 30 August 2005: Last Major System Test Successfully Started.
- 5 September 2005: Electrical Testing Successful.
- 21 September 2005: FRR (Fuelling Readiness Review) Ongoing.
- 12 October 2005: Mating to the Fregat upper stage completed.
- 21 October 2005: Contamination detected inside the fairing — launch on hold.
- 5 November 2005: Arrival at launch pad.
- 9 November 2005: Launch from Baikonur Cosmodrome at 03:33:34 UTC.
- 11 November 2005: First trajectory correction maneuver successfully performed.
- 17 February 2006: The main engine is fired successfully in a dress rehearsal for the arrival maneuver.
- 24 February 2006: Second trajectory correction maneuver successfully performed.
- 29 March 2006: Third trajectory correction maneuver successfully performed - on target for 11 April orbit insertion.

- 7 April 2006: Command stack for orbit insertion maneuver is loaded on the spacecraft.
- 11 April 2006: The Venus Orbit Insertion (VOI) is completed successfully, according to the following timeline:

	spacecraft time (UTC)	**ground receive time (UTC)**
Liquid Settling Phase start	07:07:56	07:14:41
VOI main engine start	07:10:29	07:17:14
pericentre passage	07:36:35	
eclipse start	07:37:46	
occultation start	07:38:30	07:45:15
occultation end	07:48:29	07:55:14
eclipse end	07:55:11	
VOI burn end	08:00:42	08:07:28

Period of this orbit is nine days.

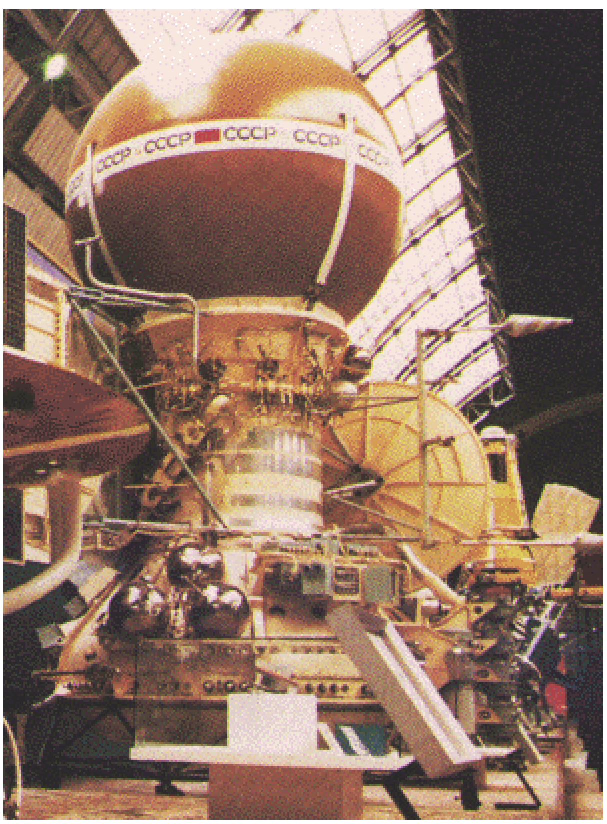
- 13 April 2006: First images of Venus from *Venus Express* released.
- 20 April 2006: Apocentre Lowering Manoeuvre #1 performed. Orbital period is now 40 hours.
- 23 April 2006: Apocentre Lowering Manoeuvre #2 performed. Orbital period is now approx 25 hours 43 minutes.
- 26 April 2006: Apocentre Lowering Manoeuvre #3 is slight fix to previous ALM.
- 7 May 2006: *Venus Express* entered its target orbit at apocentre at 13:31 UTC
- 14 December 2006: First temperature map of the southern hemisphere.
- 27 February 2007: ESA agrees to fund mission extension until May 2009.
- 19 September 2007: End of the nominal mission (500 Earth days) - Start of mission extension.
- 27 November 2007: The scientific journal *Nature* publishes a series of papers giving the initial findings. It finds evidence for past oceans. It confirms the presence of lightning on Venus and that it is more common on Venus than it is on Earth. It also reports the discovery that a huge double atmospheric vortex exists at the south pole of the planet.
- 20 May 2008: The detection by the VIRTIS instrument on *Venus Express* of hydroxyl (OH) in the atmosphere of Venus is reported in the May 2008 issue of Astronomy and Astrophysics.
- 4 February 2009: ESA agrees to fund mission extension until 31 December 2009.
- 7 October 2009: ESA agrees to fund the mission through 31 December 2012.

Chapter- 7

Other Spacecraft Missions to Venus

Venera 14

Venera 14



Venera 14 orbiter

Operator	USSR
Mission type	Flyby
Satellite of	Venus
Launch date	1981-11-04 at 05:31:00 UTC
Launch vehicle	Proton Booster Plus Upper Stage and Escape Stages
COSPAR ID	1981-110A

Venera 14 (Russian: Венера-14) was a probe in the Soviet Venera program for the exploration of Venus.

Venera 14 was identical to the Venera 13 spacecraft and built to take advantage of the 1981 Venus launch opportunity and launched 5 days apart. It was launched on 4 November 1981 at 05:31:00 UTC and Venera 13 on 30 October 1981 at 06:04:00 UTC, both with an on-orbit dry mass of 760 kg.

Design

Each mission consisted of a bus and an attached descent craft.

As it flew by Venus the bus acted as a data relay for the lander and then continued on into a heliocentric orbit. It was equipped with a gamma-ray spectrometer, UV grating monochromator, electron and proton spectrometers, gamma-ray burst detectors, solar wind plasma detectors, and two-frequency transmitters which made measurements before, during, and after the Venus flyby.

The descent lander was a hermetically sealed pressure vessel, which contained most of the instrumentation and electronics, mounted on a ring-shaped landing platform and topped by an antenna. The design was similar to the earlier Venera 9–12 landers. It carried instruments to take chemical and isotopic measurements, monitor the spectrum of scattered sunlight, and record electric discharges during its descent phase through the Venusian atmosphere. The spacecraft utilized a camera system, an X-ray fluorescence spectrometer, a screw drill and surface sampler, a dynamic penetrometer, and a seismometer to conduct investigations on the surface.

List of lander experiments and instruments:

- Accelerometer, Impact Analysis - Bison-M
- Thermometers, Barometers - ITD
- Spectrometer / Directional Photometer - IOAV-2
- Ultraviolet Photometer

- Mass Spectrometer - MKh-6411
- Penetrometer / Soil Ohmmeter - PrOP-V
- Chemical Redox Indicator - Kontrast
- 2 Color Telephotometer Cameras - TFZL-077
- Gas Chromatograph - Sigma-2
- Radio / Microphone / Seismometer - Groza-2
- Nephelometer - MNV-78-2
- Hydrometer - VM-3R
- X-Ray Fluorescence Spectrometer (Aerosol) - BDRA-1V
- X-Ray Fluorescence Spectrometer (Soil) - Arakhis-2
- Soil Drilling Apparatus - GZU VB-02
- Stabilized Oscillator / Doppler Radio
- Small solar batteries - MSB

Landing

Venera 14 lander

The Venera 14 lander was identical to Venera 13

Operator	USSR
Mission type	Venus Lander
Launch vehicle	Venera 14 bus
COSPAR ID	1981-110D
Mass	760 kg

After launch and a four month cruise to Venus the descent vehicle separated from the bus and plunged into the Venusian atmosphere on March 5, 1982. After entering the atmosphere a parachute was deployed. At an altitude of about 50 km the parachute was released and simple airbraking was used the rest of the way to the surface.

Venera 14 landed at 13°15′S 310°00′E / 13.25°S 310°E (about 950 km southwest of Venera 13) near the eastern flank of Phoebe Regio on a basaltic plain.

The lander had cameras to take pictures of the ground and spring-loaded arms to measure the compressibility of the soil. The quartz camera windows were covered by lens caps which popped off after descent. Venera 14, however, ended up measuring the compressibility of the lens cap, which landed right where the probe was to measure the soil.

The composition of the surface samples was determined by the X-ray fluorescence spectrometer, showing it to be similar to oceanic tholeiitic basalts.

The lander survived for 57 minutes (the planned design life was 32 minutes) in an environment with a temperature of 465 °C and a pressure of 94 Earth atmospheres (9.5 MPa). It is probable that the probe or its remains have been severely degraded by the high surface temperature and pressure and the presence of corrosive supercritical carbon dioxide in the Venusian atmosphere.

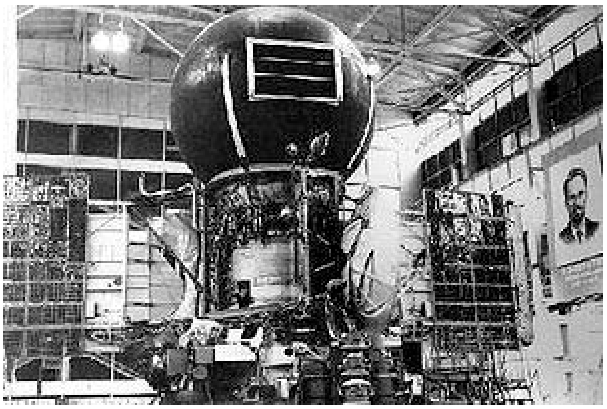
Fictional references

Venera 14 is visited by a Russian cosmonaut in BBC's *Space Odyssey: Voyage To The Planets*.

Image processing

American researcher Don P. Mitchell has processed the color images from Venera 13 and 14 using the raw original data. The new images are based on a more accurate linearization of the original 9-bit logarithmic pixel encoding.

Venera 9

Venera 9 (4V-1 No. 660)	
	
Venera 9 orbiter	
Operator	USSR
Mission type	Orbiter and Lander
Satellite of	Venus
Orbital insertion date	October 20, 1975
Launch date	June 8, 1975 from Baikonur Cosmodrome Site 81
Launch vehicle	Proton Booster Plus Upper Stage and Escape Stages
Mission duration	June 8, 1975 to ~December 25, 1975?
COSPAR ID	1975-050D
Mass	2015 kg
Orbital elements	
Eccentricity	.89002
Inclination	29.5°
Apoapsis	19.51 RV
Periapsis	1.26 RV

Orbital period	48.3 h

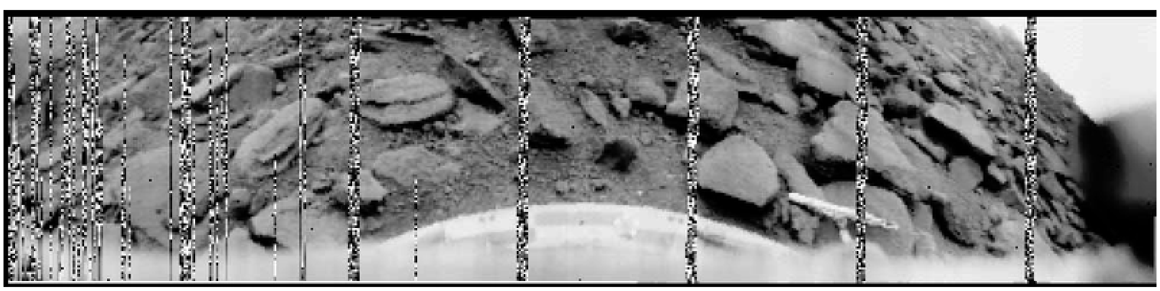
Venera 9 (Russian: Венера-9) (manufacturer's designation: 4V-1 No. 660) was a USSR unmanned space mission to Venus. It consisted of an orbiter and a lander. It was launched on June 8, 1975 02:38:00 UTC and weighed 4,936 kg (10,884 lb). The orbiter was the first spacecraft to orbit Venus, while the lander was the first to return images from the surface of another planet.

Orbiter

The orbiter consisted of a cylinder with two solar panel wings and a high gain parabolic antenna attached to the curved surface. A bell-shaped unit holding propulsion systems was attached to the bottom of the cylinder, and mounted on top was a 2.4 meter sphere which held the lander.

The orbiter entered Venus orbit on October 20, 1975. Its mission was to act as a communications relay for the lander and to explore cloud layers and atmospheric parameters with several instruments and experiments. It performed 17 survey missions from October 26, 1975 to December 25, 1975.

List of orbiter instruments and experiments

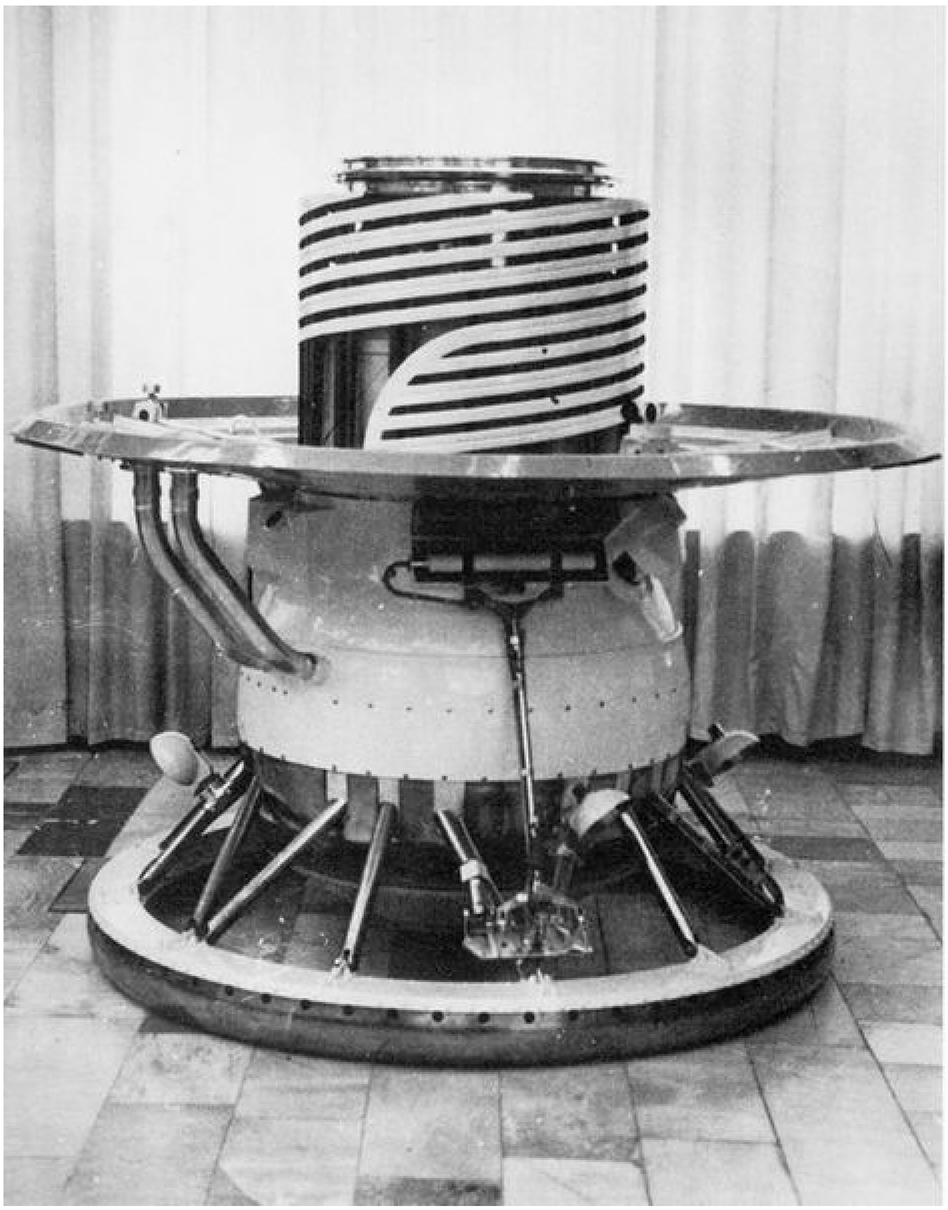


180-degree panorama taken by Venera 9 of the surface of Venus

- 1.6-2.8 μm IR Spectrometer
- 8-28 μm IR Radiometer
- 352 nm UV Photometer
- 2 Photo-polarimeters (335-800 nm)
- 300-800 nm Spectrometer
- . Lyman-α H/D Spectrometer
- Bistatic Radar Mapping
- CM, DM Radio Occultations
- Triaxial Magnetometer
- 345-380 nm UV Camera
- 355-445 nm Camera
- 6 Electrostatic Analyzers
- 2 Modulation Ion Traps

- Low-Energy Proton / Alpha detector
- Low-Energy Electron detector
- 3 Semiconductor Counters
- 2 Gas-Discharge Counters
- Cherenkov Detector

Lander



Venera 9 lander

On October 20, 1975, the lander spacecraft was separated from the orbiter, and landing was made with the Sun near zenith at 05:13 UTC on October 22. Venera 9 landed within a 150 km radius of 31°01′N 291°38′E / 31.01°N 291.64°E, near Beta Regio, on a steep

(20°) slope covered with boulders (suspected to be the slope of the tectonic rift valley, Aikhulu Chasma). The entry sphere weighed 1,560 kg (3,440 lb) and the surface payload 660 kg (1,455 lb).

It was the first spacecraft to return an image from the surface of another planet. The Soviet space program had far more success with Venus landers than Mars landers, possibly because the mechanics of landing on Venus involve fewer steps than Mars due to the much thicker atmosphere.

A system of circulating fluid was used to distribute the heat load. This system, plus pre-cooling prior to entry, permitted operation of the spacecraft for 53 minutes after landing, at which time radio contact with the orbiter was lost. During descent, heat dissipation and deceleration were accomplished sequentially by protective hemispheric shells, three parachutes, a disc-shaped drag brake, and a compressible, metal, doughnut-shaped landing cushion. The landing was about 2,200 km from the Venera 10 landing site.

Venera 9 measured clouds that were 30–40 km thick with bases at 30–35 km altitude. It also measured atmospheric chemicals including hydrochloric acid, hydrofluoric acid, bromine, and iodine. Other measurements included surface pressure of about 90 atmospheres (9 MPa), temperature of 485 °C, and surface light levels comparable to those at Earth mid-latitudes on a cloudy summer day. Venera 9 was the first probe to send back black and white television pictures from the Venusian surface showing shadows, no apparent dust in the air, and a variety of 30 to 40 cm rocks which were not eroded. Planned 360-degree panoramic pictures could not be taken because one of two camera lens covers failed to come off, limiting pictures to 180 degrees. This failure recurred with Venera 10.

Lander Payload

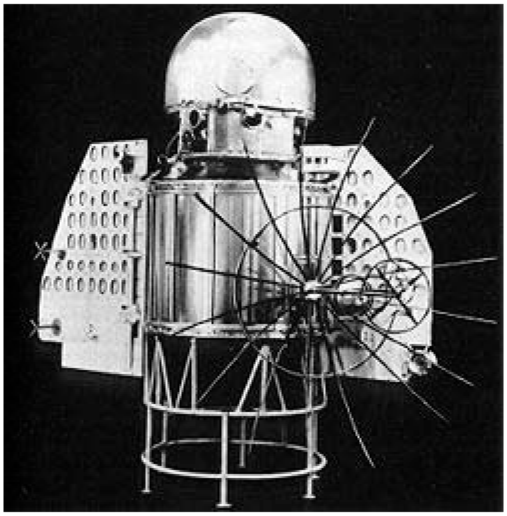
- Temperature and pressure sensors
- Accelerometer
- Visible / IR photometer - IOV-75
- Backscatter and multi-angle nephelometers - MNV-75
- P-11 Mass spectrometer - MAV-75
- Panoramic telephotometers (2, with lamps)
- Anemometer - ISV-75
- Gamma ray spectrometer - GS-12V
- Gamma ray densitometer - RP-75
- Radio Doppler experiment

Image processing

Don P. Mitchell recently came across the original Venera imaging data while researching the Soviet Venus program, and reconstructed the images using modern image processing software.

Venera 1

Venera 1



Venera 1 spacecraft

Operator	USSR
Mission type	Fly-by of Venus
Flyby date	May 19, 1961
Launch date	February 12, 1961
Launch vehicle	Modified SS-6 (Sapwood) with 2nd Generation Upper Stage + Escape Stage
COSPAR ID	1961-003A
Mass	643.5 kg

Venera 1 stamp

On February 12, 1961, 00:34:36 UTC, was the first planetary probe launched to Venus by the Soviet Union. The Venus-1 Automatic Interplanetary Station, or **Venera 1**, was a 643.5 kg probe consisting of a cylindrical body 1.05 meter in diameter topped by a dome, totaling 2.035 meters in height. This was pressurized to 1.2 atmospheres of dry nitrogen, with internal fans to maintain even distribution of heat. Two solar panels extended from the cylinder, charging a bank of silver-zinc batteries. A 2 meter parabolic wire-mesh antenna was designed to send data from Venus to Earth on 922.8 MHz. A 2.4 meter antenna boom was used to transmit short-wave signals during the near-Earth phase of the mission. Semidirectional quadrapole antennas mounted on the solar panels provided routine telemetry and telecommand contact with Earth during the mission, on a circularly-polarized decimeter radio band.

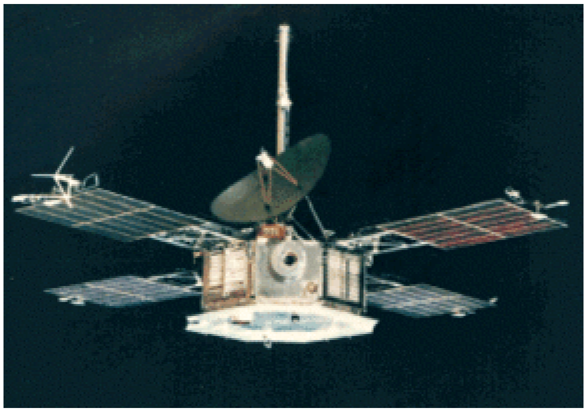
The probe was equipped with scientific instruments including a flux-gate magnetometer attached to the antenna boom, two ion traps to measure solar wind, micrometeorite detectors, and Geiger counter tubes and a Sodium Iodide scintillator for measurement of cosmic radiation. An experiment attached to one solar panel measured temperatures of experimental coatings. Infrared and/or ultraviolet radiometers may have been included. The dome contained a KDU-414 engine used for mid-course corrections. Temperature control was achieved by motorized thermal shutters.

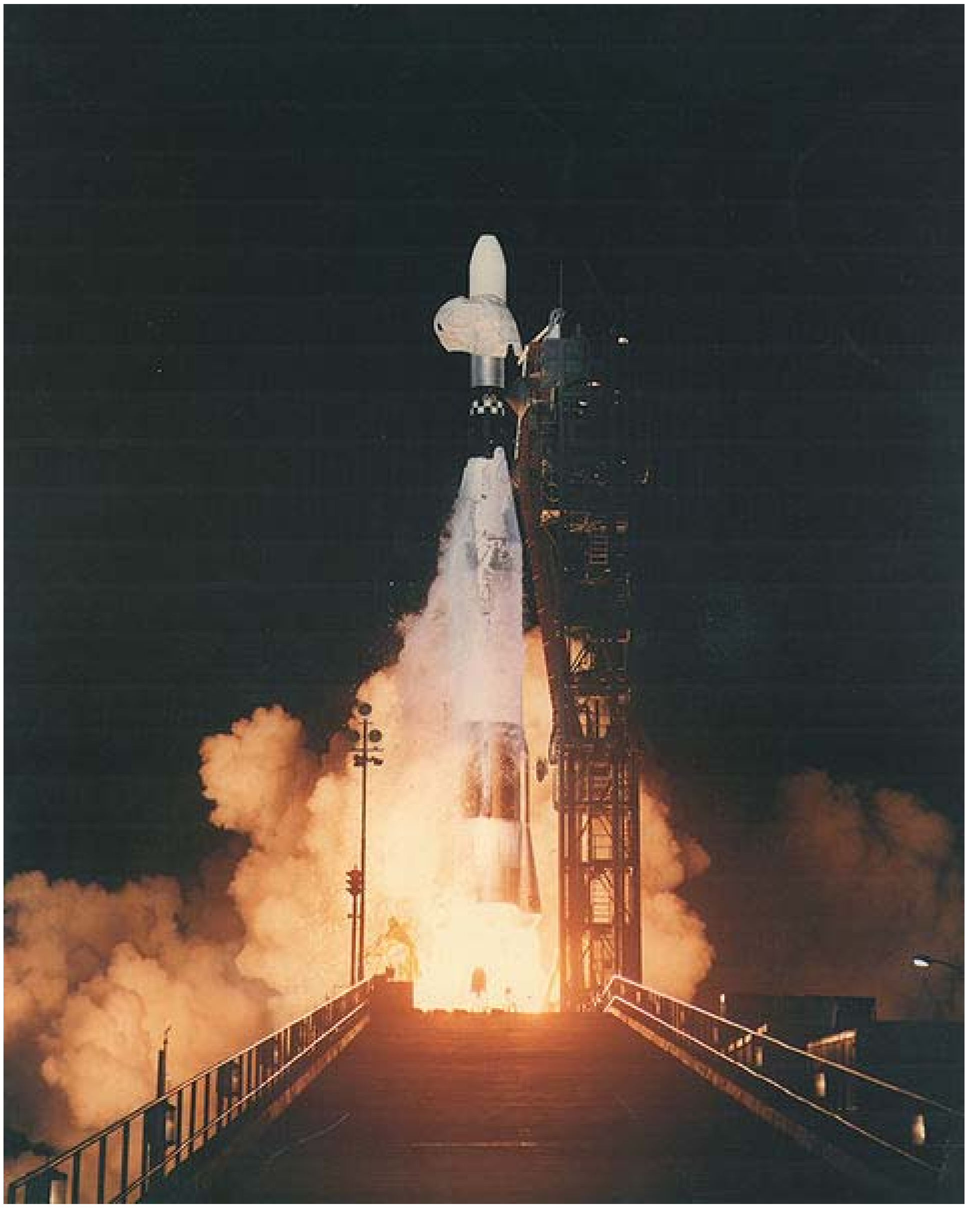
The Venera 1 spacecraft was the second of two attempts to launch a probe to Venus, immediately following the launch of its sister ship Venera-1VA, which failed to leave Earth orbit. Soviet experts launched Venera-1 in two steps, first placing the 7-ton Sputnik 8 into terrestrial parking orbit with a Molniya launcher. From a 229 × 282 km orbit, the automatic interplanetary station was launched towards Venus with a fourth stage engine. This was the first demonstration of the highly efficient maneuver of launching from orbit. The 11D33 engine was the world's first staged-combustion-cycle rocket engine, and also the first use of a ullage engine to allow a liquid-fuel rocket to start under weightlessness.

Three successful telemetry sessions were conducted, gathering solar-wind and cosmic-ray data near Earth, at the Earth's magnetopause, and on February 19 at a distance of 1,900,000 km. After discovering the solar wind with Luna-2, Venera-1 provided the first verification that this plasma was uniformly present in deep space. Seven days later, the next scheduled telemetry session failed to occur. On May 19 and 20, 1961, Venera 1 passed within 100,000 km of Venus and entered a heliocentric orbit. With the help of the British radio telescope at Jodrell Bank, some weak signals from Venera-1 may have been detected in June. Soviet engineers believe that Venera-1 failed due to the overheating of a solar-direction sensor.

Although it failed to function before reaching Venus, Venera-1 was an important milestone in spacecraft design—the first truly modern planetary probe. During most of its flight, it was spin stabilized. It was the first spacecraft designed to perform mid-course corrections, by entering a mode of 3-axis stabilization, fixing on the Sun and the star Canopus. Had it reached Venus, it would have entered another mode of 3-axis stabilization, fixing on the Sun and Earth, and using for the first time a parabolic antenna to relay data.

Mariner 5

Mariner 5	
	
Operator	JPL - NASA
Mission type	Fly-by
Flyby of	Venus
Launch date	14 June 1967 at 06:01:00 UTC
Launch vehicle	Atlas-Agena D
Mission duration	June 14, 1967 to November, 1967
COSPAR ID	1967-060A
Mass	244.9 kg
Power	170 W
Orbital elements	
Periapsis	4,000 km from Venus



Launch of Mariner 5

Mariner 5 (Mariner Venus '67) was a spacecraft of the Mariner program that carried a complement of experiments to probe Venus' atmosphere by radio occultation, measure the hydrogen Lyman-alpha (hard ultraviolet) spectrum, and sample the solar particles and magnetic field fluctuations above the planet. Its goals were to measure interplanetary and Venusian magnetic fields, charged particles, plasmas, radio refractivity and UV emissions of the Venusian atmosphere.

Mariner 5 was actually built as a backup to Mariner 4, but after the success of the Mariner 4 mission, it was modified for the Venus mission by removing the TV camera, reversing and reducing the four solar panels, and adding extra thermal insulation.

It was launched toward Venus on June 14, 1967 from Cape Canaveral Air Force Station Launch Complex 12 and flew by the planet on October 19 that year at an altitude of 3990 kilometres (2480 miles). With more sensitive instruments than its predecessor Mariner 2, Mariner 5 was able to shed new light on the hot, cloud-covered planet and on conditions in interplanetary space.

Radio occultation data from Mariner 5 helped to understand the temperature and pressure data returned by the Venera 4 lander, which arrived at Venus shortly before it. After these missions, it was clear that Venus had a very hot surface and an atmosphere even denser than expected.

The operations of Mariner 5 ended in November 1967 and it is now defunct in a heliocentric orbit.

Further communication attempts

Further communication attempts were tried, in a joint spacecraft solar wind / solar magnetic fields investigation with Mariner 4, back in communication with Earth after being out of telemetry for about a year or more around superior conjunction. During the experiment, both spacecraft were going to be on the same idealized magnetic field spiral carried out from the sun by the solar wind.

Between April and November 1968 NASA tried to reacquire Mariner 5 to continue probing interplanetary conditions. Attempts to reacquire Mariner 5 during June, July, and early August 1968 yielded no spacecraft signal.

On October 14, the receiver operator at DSS 14 obtained a lock on the Mariner 5 signal. A carrier wave was detected, but outside expected frequency limits and varying in wavelength. Signal strength changes indicating the spacecraft was in a slow roll. Nevertheless, it was possible to lock the spacecraft to an uplink signal, but no response was observed to any commands sent to it. Without telemetry and without any signal change in response to commands, there was no possibility to repair or continue to use the spacecraft. Operations were terminated at the end of the track from DSS 61 at 07:46 GMT on November 5, 1968.

Instruments

1. Two-Frequency Beacon Receiver
2. S-Band Occultation
3. Helium Magnetometer
4. Interplanetary Ion Plasma Probe for E/Q of 40 to 9400 Volts
5. Celestial Mechanics