NASA Facts

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Mariner to Mercury, Venus and Mars

Between 1962 and late 1973, NASA's Jet Propulsion Laboratory designed and built 10 spacecraft named Mariner to explore the inner solar system -- visiting the planets Venus, Mars and Mercury for the first time, and returning to Venus and Mars for additional close observations. The final mission in the series, Mariner 10, flew past Venus before going on to encounter Mercury, after which it returned to Mercury for a total of three flybys. The next-to-last, Mariner 9, became the first ever to orbit another planet when it rached Mars for about a year of mapping and measurement.

The Mariners were all relatively small robotic explorers, each launched on an Atlas rocket with either an Agena or Centaur upper-stage booster, and weighing less than half a ton (without onboard rocket propellant). Each of their missions was completed within a few months to a year or two, though one of them outlived its original mission and continued to send useful scientific data for three years.

Early Concept

The Mariner program began in 1960 with a series of JPL mission studies for small-scale, frequent exploration of the nearest planets. They were to take advantage of the soon-to-be-available Atlas launch vehicles as well as the developing capability of JPL's Deep Space Instrumentation Facility (later named the Deep Space Network), a global network of ground stations designed to communicate with spacecraft in deep space.

Each spacecraft was to carry solar panels that would be pointed toward the Sun and a dish antenna that would be pointed at Earth. Each would also carry a host of scientific instruments. Some of the instruments, such as cameras, would need to be pointed at the target body it was studying. Other instruments were non-directional and studied phenomena such as magnetic fields and charged particles. JPL engineers proposed to make the Mariners "three-axis-stabilized," meaning that unlike other space probes they would not spin.

Each of the Mariner projects was designed to have two spacecraft launched on separate rockets, in case of difficulties with the nearly untried launch vehicles. Mariner 1, Mariner 3, and Mariner 8 were in fact lost during launch, but their backups were successful. No Mariners were lost in later flight to their destination planets or before completing their scientific missions.

The Missions

Mariner 2. The first Mariner mission, which was to send two spacecraft to Venus, was authorized by NASA in August 1961. The rocket carrying Mariner 1 went off-course during launch on July 22, 1962, and the spacecraft was destroyed. A month later, Mariner 2 was launched successfully on August 27, 1962, sending it on a 3-1/2-month flight to Venus. On the way it measured for the first time the solar wind, a constant stream of charged particles flowing outward from the Sun. 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 infrared and microwave radiometers, revealing that Venus has cool

clouds and an extremely hot surface (because the bright, opaque clouds hide the planet's surface, Mariner 2 was not outfitted with a camera).

Mariner 4 and 5. The next Mariner project targeted the planet Mars with two spacecraft. Mariner 3 was launched on November 5, 1964, but the shroud encasing the spacecraft atop its rocket failed to open properly and Mariner 3 did not get to Mars. Three weeks later, on November 28, 1964, Mariner 4 was launched successfully on an eight-month voyage to the red planet. The spacecraft flew past Mars on July 14, 1965, collecting the first close-up photographs of another planet. The pictures, played back from a small tape recorder over a long period, showed lunar-type impact craters (just beginning to be photographed at close range from the Moon), some of them touched with frost in the chill Martian evening. The Mariner 4 spacecraft, expected to survive something more than the eight months to Mars encounter, actually lasted about three years in solar orbit, continuing long-term studies of the solar wind environment and making coordinated measurements with Mariner 5, a sister ship launched to Venus in 1967.

Mariner 6 and 7. In 1969 Mariner 6 and Mariner 7 completed the first dual mission to Mars, flying by over the equator and south polar regions and analysing atmosphere and surface with remote sensors as well as recording and relaying hundreds of pictures. By chance, both flew over cratered regions and missed both the giant northern volcanoes and the equatorial grand canyon discovered later. Their approach pictures did, however, show the dark features long seen from Earth, but no canals.

Mariner 9. The first artificial satellite of Mars was Mariner 9, launched in May 1971. Its launch mass was nearly doubled by the onboard rocket propellant needed to thrust it into orbit around Mars, but otherwise it closely resembled its predecessors. Achieving orbit in November 1971, Mariner 9 observed that a great dust storm had obscured the whole globe of the planet. Since 1969, Mariner spacecraft operations such as science sequencing and pointing had been programmable, using simple flight computers with limited memory, and the spacecraft used a digital tape-recorder rather than film to store images and other science data. The spacecraft was thus able to wait until the storm abated, the dust settled and the surface was clearly visible before compiling its global mosaic of high-quality images of the surface of Mars. It also provided the first closeup pictures of Mars' two small, irregular moons, Phobos and Deimos.

Mariner 10. Two years after Mariner 9's orbital pioneering, the last Mariner took off on the first two-planet exploration. With the scorched inner planet Mercury as its ultimate target, Mariner 10 pioneered the use of a "gravity assist" swing by the planet Venus to bend its flight path. Using a near-ultraviolet filter, it produced the first clear pictures of the Venusian chevron clouds and performed other atmospheric studies before moving to the small, airless, cratered globe of Mercury. Here a fortuitous gravity assist enabled the spacecraft to return at six-month intervals for close mapping passes over the planet, covering half the globe (Mercury's slow rotation left the other half always in the dark when Mariner returned).

The Results

What did we learn from the Mariner projects?

First, JPL engineers learned that interplanetary flight and scientific exploration were feasible using relatively small, low-cost spacecraft launched by medium-sized launch vehicles based on the Atlas guided missile. They could be developed in a few years, could survive in space for up to a few years, and could collect valuable scientific information about the Earth's planetary neighbors and nearby interplanetary space.

Second, scientists learned a great deal about the surfaces of Mars and Mercury, as well as some details about the atmospheres of Mars and Venus and about the solar system environment. All three of the planets visited proved to be greatly different from Earth. Venus, whose surface was not observable by the spacecraft, has a dense carbon dioxide atmosphere topped by marked, opaque clouds and covering a hot surface made even hotter by the atmosphere's "greenhouse effect." Mercury, not quite so hot as Venus, has an airless, cratered surface like the Moon, but (so far as Mariner 10 could see) without the plains or "maria" which appear on the Moon. Mars, looking strongly cratered to the earliest Mariners, revealed its other features, great volcanoes and valleys, to Mariner

9. It has a very thin, cold atmosphere, mostly of carbon dioxide. Magnetic fields of the three planets were negligible.

Finally, the engineering and science learning from the Mariner projects laid the groundwork for all the solar sysem exploration that followed.

Mariner Mission Summary

❑ **Mariner 2**, launched 8/27/62, Venus flyby 12/14/62; mass 203 kg (446 lb); microwave and infrared radiometers, cosmic dust, solar plasma and high-energy radiation, magnetic fields.

❑ **Mariner 4**, launched 11/28/64, Mars flyby 7/14/65; mass 261 kg (575 lb); camera with digital tape recorder (about 20 pictures), cosmic dust, solar plasma, trapped radiation, cosmic rays, magnetic fields, radio occultation and celestial mechanics.

❑ **Mariner 5**, launched 6/14/67, Venus flyby 10/19/67; mass 245 kg (540 lb); ultraviolet photometer, cosmic dust, solar plasma, trapped radiation, cosmic rays, magnetic fields, radio occultation and celestial mechanics.

❑ **Mariner 6-7**, launched 2/2469 and 3/27/69, Mars flybys 7/31/69 and 8/5/69; mass 413 kg (908 lb) each; wide- and narrow-angle cameras with digital tape recorder, infrared spectrometer and radiometer, ultraviolet spectrometer, radio occultation and celestial mechanics.

❑ **Mariner 9**, launched 5/30/71, orbited Mars 11/13/71 to 10/27/72; mass 998 kg (2,200 lb); wide- and narrow-angle cameras with digital tape recorder, infrared spectrometer and radiometer, ultraviolet spectrometer, radio occultation and celestial mechanics.

❑ **Mariner 10**, launched 11/3/73; Venus flyby 2/5/74, Mercury flybys 3/29,74, 9/21/74 and 3/16/75; mass 433 kg (952 lb); twin narrow-angle cameras with digital tape recorder, ultraviolet spectrometer, infrared radiometer, solar plasma, charged particles, magnetic fields, radio occultation and celestial mechanics.