"Visiting Our Neighbors: A History of Planetary Exploration"

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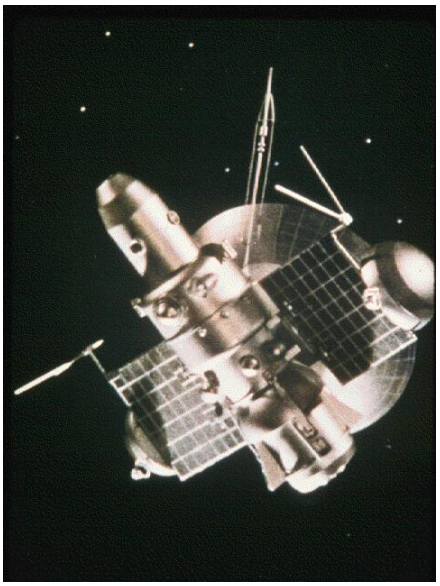
The First Steps

For much of the first half of the Twentieth Century, planetary studies were a quiet backwater in the field of astronomy. But the confluence of rapidly advancing rocket technology and Cold War competition at the dawn of the Space Age was about change that. The technology finally existed to send probes to the planets and make useful close up observations - a development which would totally transform our understanding of all the planets including Earth.

By 1960, NASA planners hoped to flyby Venus in 1962 and Mars in 1964 with heavily instrumented half-ton probes called Mariner using the powerful Atlas-Centaur then under development. Ambitious Soviet engineers intended to send two or more spacecraft towards Mars and Venus during every launch window using their new Molniya rocket. Unfortunately launch vehicle failures doomed the first pair of Soviet Mars flyby probes launched in October of 1960 and stranded their first Venus probe in Earth orbit the following February. Only Venera 1 escaped the Earth on February 12, 1961 but contact was lost five days later when its thermal control system failed.

For subsequent planetary missions, Soviet engineers adopted a unified spacecraft design called "Object MV" to speed development. These one-ton probes were fitted with a "planetary compartment" geared towards a specific mission and target. One type was constructed to carry cameras and other optical sensors to study the target planet during a flyby. The other was designed to separate from the bus and land on the surface of Venus or Mars - a goal that was years ahead of NASA's plans.



This Soviet model is representative of their early Object MV probe design. The planetary compartment at the bottom could carry a package of cameras as here or a simple lander. (NASA)

Before the end of 1961, NASA's plans were already in trouble because of lagging Atlas-Centaur development. With only the Atlas-Agena available, Mariner had to shed half its mass. The solution was to use a modified Ranger lunar probe design carrying a minimal instrument package. While much smaller and less capable than Soviet probes, the Mariner design would pay off handsomely.

The first Mariners launched towards Venus and Mars, Mariner 1 and 3 respectively, failed during the launch phase but their respective sister craft not only survived launch but returned the first close up observations from our neighboring worlds. Mariner 2 confirmed the hellish conditions on Venus during its December 14, 1962 flyby. Mariner 4 secured the first close up images of Mars on July 14,

1965 showing it to be a cratered, Moon-like landscape. Other observations indicated that Mars had an atmospheric surface pressure only 0.6% that of Earth's - less than one tenth of earlier estimates.

Mariner 4 made the first successful flyby of Mars in 1965 returning 21 images taken with the camera visible underneath. This same basic design served as the basis of most American planetary probes for more than a quarter century. (JPL/NASA)

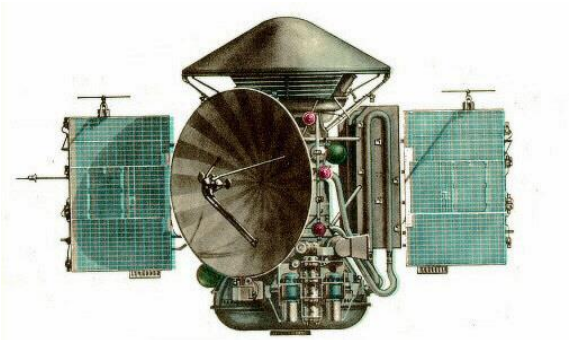
Contemporary Soviet probes were much less fortunate. Between 1962 and 1965, a total of 13 MV-series spacecraft were launched towards Venus and Mars including eight landers. All but four of these spacecraft fell victim to Molniya malfunctions. But even the survivors experienced various problems which doomed them before reaching their targets. Most agonizing of all was the loss of Venera 2 and 3 which failed just hours before they encountered Venus in 1966.

The Assault on Mars Begins

The discovery of the highly tenuous nature of the martian atmosphere made the Soviet's lander design obsolete forcing them back to the drawing board. The United States was also designing Mars landers to search for life but they needed much more data. With the Atlas-Centaur finally available, NASA made frugal use of their funds by making incremental improvements to the basic Mariner 4 design for additional missions.

Mariner 6 and 7 carried a significantly upgraded suite of instruments which imaged 10% of the Martian surface during flybys in 1969. Next a pair of Mariners now fitted with large propellant tanks were sent in 1971 to study the planet from orbit. Only Mariner 9 survived launch but during its year in orbit, it mapped most of Mars revealing volcanoes, ancient fluvial features and evidence for a complex geologic history. The way was clear for the Viking lander missions.

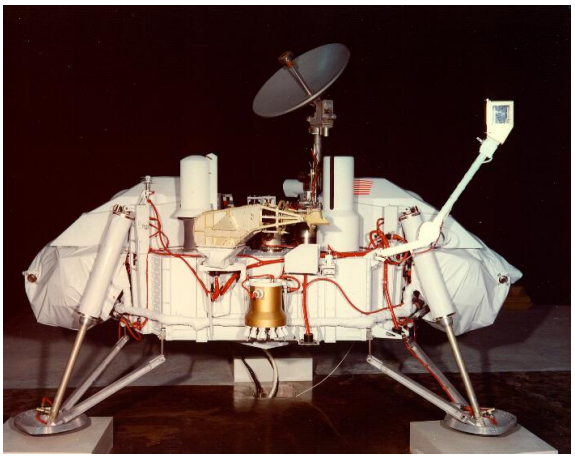
Soviet engineers were still intent on landing on Mars first. They now had the larger Proton rocket with five times the payload capacity of Molniya available. Their first new bus design was launched in 1969 without landers in hopes of reaching Mars orbit first but both Protons exploded. By 1971 a newer, improved bus was ready along with the new lander. A pair of lander-laden probes, Mars 2 and 3, were successfully launched but a landerless bus meant to beat Mariner 9 was stranded in Earth orbit. The Mars 2 landing attempt failed and contact with the Mars 3 lander was lost after 20 seconds. The buses entered orbit around Mars afterwards supplementing Mariner's findings.



The Soviet Union launched four of these second generation landers to Mars in 1971 and 1973. Although none succeeded, the bus did serve as the basis of the highly successful second generation Venera. (Space Research Institute - IKI)

A fleet of four more Mars spacecraft - two landers on flyby buses and a pair of orbiters - were launched in 1973 in a last ditch effort to beat Viking. Only Mars 5 entered orbit as intended in February 1974 returning data for three weeks. The Mars 6 lander returned atmospheric data during its descent but fell silent upon landing. Mars 7 missed Mars all together.

The stage was now set for Viking which consisted of a purpose-built lander carried by a Mariner-class bus fitted with huge propellant tanks. Both Viking 1 and 2 successfully reached Mars and deployed their landers from orbit on July 20 and September 3, 1976 respectively. Neither lander found clear evidence for life but they did return a wealth of new information on the Red Planet. Unfortunately the mountain of new data Viking collected would have to satisfy planetary scientists for some time to come.



A pair of American Viking landers were the first to successfully land on Mars in 1976. It would be 21 years before the next landing on Mars. (JPL/NASA)

Exploring Venus

Despite their early failures, the Soviet Union ultimately dominated the exploration of Venus. By 1967 the Object MV design was radically modified specifically to carry a simple lander to Venus. Of the two craft launched in 1967, only Venera 4 escaped Earth and reached Venus. Before it fell silent during descent, the lander found that the atmosphere was dominated by carbon dioxide instead of nitrogen like the Earth. The day after Venera's encounter, the American Mariner 5 flew past Venus. Basically a modified version of Mariner 4, its data indicated that the surface pressure was 90 atmospheres with a temperature of 480 C. Venera 4 was not designed for these conditions and had been crushed 27 kilometers above the surface.

With little time before the 1969 window, Soviet engineers slightly modified the next landers in hopes of probing deeper into the atmosphere. Venera 5 and 6 successfully reached Venus and returned data before they were also crushed. By 1970, a more robust lander was available. Of the pair launched, only Venera 7 successfully escaped its parking orbit to reach Venus on December 15, 1970. This time the lander survived the descent to the surface and confirmed the oppressive surface conditions. Of a subsequent pair of probes launched in 1972, Venera 8 successfully reached Venus confirming its predecessor's findings.

After years of effort, the Soviet Venera 7 became the first probe to successfully land on another planet. Along with its near twin, Venera 8, these probes gathered information needed for more advanced missions. (A.J. LePage)

While the Soviets passed up the 1973 Venus window to finish a new Proton-launched probe design, the Americans launched Mariner 10. Spectacular ultraviolet images of Venus' clouds and other data were collected during the flyby on February 5, 1974. Mariner 10 was then flung towards Mercury to explore that planet for the first time. Data returned from the March 29 flyby revealed Mercury to have a Moon-like surface but an Earth-like magnetic field. A pair of subsequent passes at six-month intervals allowed almost half of Mercury to be mapped.

By 1975 the new Soviet Venus lander carried by a modified second generation Mars probe bus was ready. The highly advanced Venera 9 and 10 landers returned a wealth of information on Venus and took the first pictures from its surface. The Venera 11 and 12 landers launched in 1978 faired much worse because of a series of equipment malfunctions but some useful data were still returned. Venera 13 and 14 launched in late 1981 performed much better securing the first surface images in color.

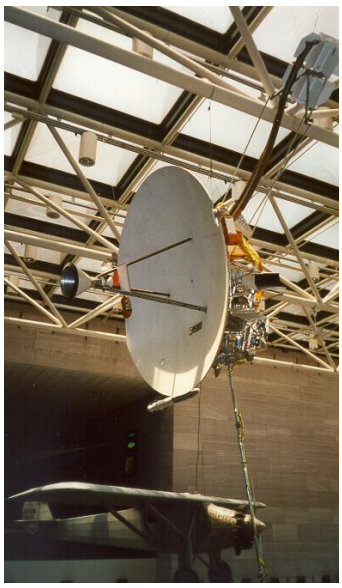
Carried to Venus inside the sphere mounted on the bus in the background, the new Venera lander in the foreground allowed for more thorough investigations of the Venusian atmosphere and surface. (Space Research Institute - IKI)

Along with Venera 11 and 12, the United States launched it own pair of Venus probes. Pioneer-Venus 1 was a highly-instrumented craft designed to observe Venus from orbit. Pioneer-Venus 2 carried a quartet of entry probes designed to make direct measurements of the atmosphere. Both craft and all four atmospheric probes operated successfully adding to Venera's findings. Pioneer-Venus 1 continued to observe Venus from orbit until 1992 producing the first global radar map of Venus albeit at low resolution.

Much higher resolution radar data were needed by geologist to understand Venus. In June of 1983, the Soviet Union launched Venera 15 and 16. Instead of landers, these spacecraft carried radar imaging systems and enough propellant to enter orbit around Venus. These orbiters mapped almost a third of Venus at 1 to 2 kilometer resolution which, along with limited Earth-based maps, were the best views of the planet until 1990s.

The Outer Planets

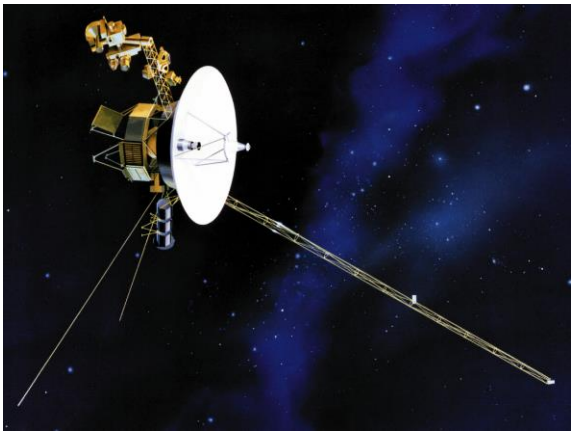
With the initial survey of the inner planets underway, NASA began planning to send probes to Jupiter and beyond in 1969. As luck would have it, an upcoming rare alignment of the outer planets would make it possible for a spacecraft to use Jupiter's gravity to boost it towards several more distant planets in succession. But before this "Grand Tour" could be attempted, more information was needed about the Asteroid Belt as well as Jupiter.



Pioneer 10 and 11 made the first reconnaissance of the outer solar system in the 1970s. These pathfinder missions help to make the Voyager mission a success. (A.J. LePage)

To get this information NASA launched Pioneer 10 towards Jupiter on March 3, 1972 with its twin, Pioneer 11, following 13 months later. Travelling faster than any previous spacecraft, Pioneer 10 exited the Asteroid Belt unscathed in February 1973. Data returned during the closest approach to Jupiter on December 5 helped gauge the hazards of Jupiter's intense radiation belts and close up images secured by a simple scanner were the best yet of the planet. Pioneer 11 repeated the feat a year later at even closer range where Jupiter's gravity flung the probe high above the ecliptic plane and towards

Saturn. This first flyby of Saturn on September 1, 1979 likewise made important discoveries that would help future missions.



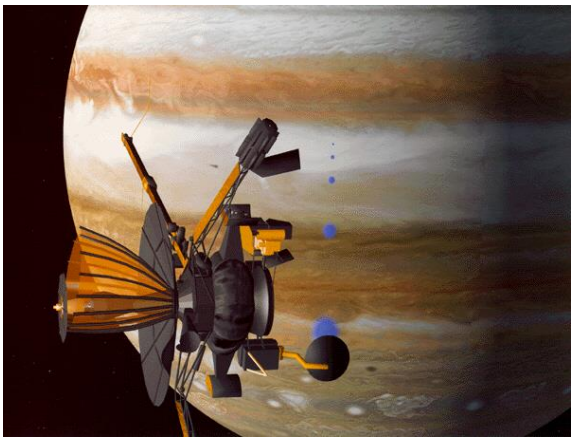
The pair of Voyager spacecraft managed to visit all of the outer planets except Pluto during a dozen year mission. Today they continue to return valuable data on their way into interstellar space. (JPL/NASA)

NASA's final Grand Tour plan called for a pair of Mariner-class probes to perform a Jupiter-Saturn flyby mission with an option for Uranus if the spacecraft survived. Named Voyager, the probes were launched in the summer of 1977 on the most exciting planetary mission to date. The Voyagers reached Jupiter one after the other in 1979 returning the sharpest views of the planet. The previously unexplored Galilean moons held there own surprises showing them to be complex worlds in their own right.

Reaching Saturn in November of 1980 and August of 1981, Voyagers 1 and 2 made even more discoveries including a nitrogen atmosphere on the moon Titan denser than Earth's. Voyager 2 continued on to Uranus in 1986 and exceeded all expectations by reaching Neptune in 1989. Demonstrating the versatility of its design, Voyager returned the only close up observations of these distant worlds, moons and ring systems. Because of their great speed after their encounters, the Pioneer and Voyager spacecraft escaped the solar system returning much new data along the way. To this day the Voyagers continue to operate as they search for the heliopause where the Sun's influence gives way to interstellar space. But while the Voyagers explored the Jovian planets, the American government's commitment towards planetary exploration waned dangerously.

Overcoming Hard Times

As NASA's budget decreased in the wake of the Apollo lunar missions, planetary missions became fewer and their cost spiraled upwards. One of the first casualties was NASA's Comet Halley rendezvous mission. With extensive international collaboration, the Soviet Union launched a pair of Vega probes towards Halley. Essentially modified Veneras, Vega's mission included dropping landers and French-built balloon probes at Venus in route to the famous comet. And now other nations launched interplanetary missions for the first time. The Giotto probe launched by ESA came within 500 kilometers of Halley's dust spewing nucleus. A pair of Japanese probes, Sakigake and Suisei, observed Comet Halley from a safe distance. NASA only attained the honor of the first comet flyby by redirecting the ISEE-3 probe, renamed ICE, to reach Comet Giacobini-Zinner in September of 1985.



Although off to a rocky start, Galileo has contributed much to our understanding of Jupiter and its family of moons. During its circuitous journey to Jupiter, it also made valuable observations of Venus, the Moon, and made the first flyby of two asteroids. (JPL/NASA)

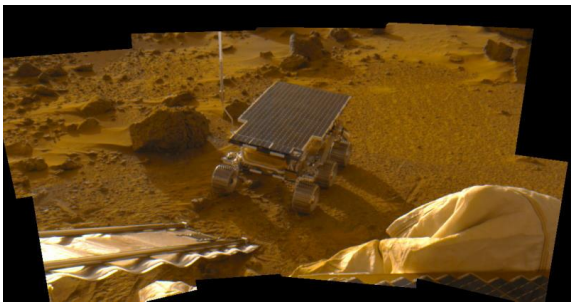
By the early 1980s NASA's budget shrank to the point where only the Galileo program to Jupiter continued. But budget problems and reliance on the Space Shuttle delayed its launch until

1989. NASA had to economize if planetary exploration was to continue. Magellan, NASA's first cost cutting effort, was designed to produce a high resolution global radar map of Venus from orbit. It was built on the cheap using spare parts from other programs where ever possible. Launched in 1989, Magellan surpassed expectations and revolutionized our view of Venus.

In the Soviet Union, engineers were designing a new generation of planetary probes. Learning from their experience with Vega, the Soviets planned to mount a series of ambitious Mars missions with international collaboration. The first pair of spacecraft were to study the Martian moon Phobos and deploy small landers in 1988. Phobos 1 failed in route to Mars and Phobos 2 suffered a fatal computer malfunction in martian orbit just two weeks before its Phobos encounter. But before the next Mars missions could be launched, the Soviet Union dissolved. During the ensuing economic chaos, further missions were postponed and deferred eventually leaving just one. After the launch failure of the Mars 96 mission, the former Soviet planetary exploration program sank into limbo where it remains today.

Back in the United States, NASA formulated plans for narrowly focused, less expensive Planetary Observer missions. A small number of more versatile and expensive Mariner Mk. II spacecraft were also proposed. But only a single mission from the Observer series was ever launched. Called Mars Observer, it was lost in 1993 just one week before reaching the Red Planet because its "off-the-shelf" propulsion system was not suited for long interplanetary flights. After the budget axe fell, only a single Mariner Mk. II, the Cassini mission to orbit Saturn and study Titan, was ever built. Launched in 1997, Cassini will probably be NASA's last large planetary spacecraft for many years.

Next NASA tried the Discovery program with the goal of being "faster, better, and cheaper". Its first mission was Mars Global Surveyor (MGS) which carried some backup instruments from Mars Observer. Already in the works was the Mars Pathfinder (MPF) mission designed to test cheaper ways of landing on Mars. In 1997 both spacecraft reached the Red Planet. While technically an engineering mission, MPF returned a wealth of new scientific data. MGS continues to orbit Mars and is revolutionizing our view of that planet. Rising interest in Mars exploration resulted in NASA committing to a series of missions to the Red Planet with the goal of returning samples within the next few years.



Here we see the Sojourner rover moving away from MPF. The new technologies proven in missions like these should help scientist learn even more about our planetary neighbors. (NASA)

The new, cost effective Discovery series also produced NEAR (Near Earth Asteroid Rendezvous) currently studying 433 Eros, Stardust, and more missions are to come. NASA also started the New Millennium Program to flight test new technologies originally as part of the Deep Space series. But with decreased cost come increased risks. This was demonstrated all too clearly in the recent failure of the Mars Climate Orbiter followed by the Mars Polar Lander which also carried a pair of penetrators from the New Millennium Program. While there will be continued efforts to reign in the costs of planetary exploration, the availability of new technologies and growing international collaboration should allow a robust program to continue for some time to come.

Author

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