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Exploring the Interplanetary Frontier

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The launch of the first Soviet Sputnik satellites caught the United States flat footed. As soon as the magnitude of this international public relations disaster was appreciated, immense efforts were made to catch up and, if possible, surpass the ever lengthening list of Soviet space achievements. In March of 1958 President Eisenhower approved the start of Operation Mona - a plan for the USAF and Army to launch the first probes to the Moon under the sponsorship of the then new Advanced Research Projects Agency (ARPA) (see **Operation Mona: America's First Moon Program** in the April 1998 issue of *SpaceViews*). Even as these first American lunar probes were being prepared for launch, plans were already underway to beat the Soviet Union to the next logical goal: The planets.

America's First Venus Probe - Almost

In 1958 the USAF under the aegis of ARPA started working with the builder of its first Pioneer lunar probes, STL (Space Technology Laboratory - a subsidiary of TRW), to study a probe to reach Venus. Weighing about 170 kilograms (375 pounds), these spin-stabilized, one-meter (39 inch) in diameter spherical probes would carry a suite of instruments powered by four solar panels to study the conditions near Venus during a quick flyby. The Thor-Able launch vehicle used by the first USAF Pioneer lunar orbiters was too small to lift these new probes. Instead, modified versions of the Able upper stages would be married to the larger Atlas D. Not only would the Atlas-Able be used to launch the new Venus probe, it would also carry a planned follow-on lunar orbiter of similar design. All involved were confident that the new probe and its launch vehicle would be ready in time for the June 1959 Venus launch window.

But just as ARPA was about to proceed with the USAF Venus probe plans, a radical change in United States space policy took place. When NASA was founded on October 1, 1958, all pure space science programs run by ARPA were transferred to the new civilian space agency. This included not only the remaining Pioneer lunar probes, but also the follow-on probes the USAF was planning. In November of 1958 NASA essentially adopted the existing USAF Pioneer program and started work to send a probe to Venus during the upcoming launch window.

But these plans were changed almost as soon as they were approved. After the successful launch of Luna 1 in January 1959 and the failure of the first four Pioneer lunar probes (see **Shooting for the Moon** in the January 1, 1999 issue of *SpaceViews*), the near term goals of NASA's Pioneer program were redirected: Instead of going to Venus, the first of the new Pioneers would be sent to the Moon in hopes of beating the Soviet Union into lunar orbit (see **Catching Up in the Moon Race** in the December 15, 1999 issue of *SpaceViews*). The lack of funding as well as a tight supply of Atlas boosters meant that the new mission to Venus would have to be deferred.

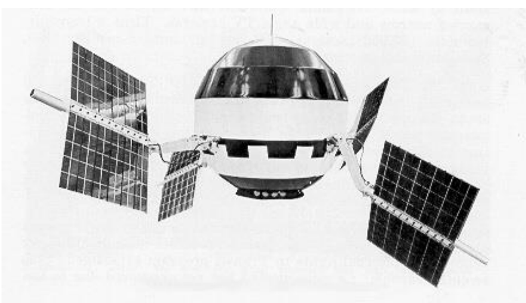
This delay meant that the launch of the first American Venus probes would have to wait until the next launch window in the beginning of 1961. This delay gave the Soviet Union a chance to beat the Americans once again. Still there was an option available to salvage something for the 1959 launch opportunity. The USAF already had a contingency plan laid out to send a much lighter probe to Venus using the less powerful but more readily available Thor-Able space carrier rocket. With the promise of lower mission costs and quicker development, this plan was dusted off and adopted by NASA with the hope that a smaller Pioneer could be launched to Venus in 1959. Like the heavier Pioneers, the new probe would be a spin stabilized spheroid but now only 66 centimeters (26 inches) in diameter – similar to the STL-built Explorer 6 satellite (see **The Early Explorers** in the August 8, 1999 issue of

SpaceViews). It would still use four solar-cell covered paddles to recharge its batteries and power its systems. Because of mass restraints, only minimal instrumentation could be carried.

But even the development of a smaller Venus probe proved to take far longer than the six-months available. In the end delays meant that the June 1959 launch opportunity was missed. Fortunately for America's already bruised prestige, the Soviet Union did not attempt a launch of a Venus probe during this window either. Unknown to the West at the time, the Soviet Union had planned to launch a pair of Venus probes designated Object 1V during June. But delays in building the complex probes and, more importantly, the continued unavailability of a launch vehicle with the needed performance forced the Soviets to wait for 19 months along with the Americans until the next Venus window.

Change of Mission

Despite the fact the chance to reach Venus had been missed, the former Venus probe, now designated P-2 by NASA, could still serve as an important pathfinder for future missions. Instead of being sent to Venus, P-2 would simply be placed into a solar orbit that would approach the orbit of Venus. The less stringent mass limits for this mission also meant that a heavier instrument payload could be carried - 18 kilograms (40 pounds) all together. The fattened, 43 kilogram (94 pound) probe with a design life of one month would now collect data vital to the success of the next Pioneer missions to Venus.



Originally meant to go to Venus, Pioneer 5 was placed into solar orbit serving as a pathfinder for future interplanetary missions. (TRW)

One of the scientific goals of the mission was to resolve the cause of the "Forbush Effect". In 1937 American physicist Scott E. Forbush with the Department of Terrestrial Magnetism at the Carnegie Institution of Washington observed that the intensity of galactic cosmic rays as measured from the Earth decreased soon after a solar flare. Forbush and others conjectured that there were one of two possible causes: Either the flare material itself was somehow blocking the cosmic rays or it triggered some effect in the Earth's magnetic field that blocked them.

Both of these possibilities were debated at a symposium in Washington, DC held in April of 1959. In order to sort things out, the scientists proposed to measure the cosmic ray intensity from a vantage point far removed from the influence of the Earth's magnetic field to see what would happen during a solar flare. The scientists at the time knew that the Forbush Effect was one of many pieces of evidence for the Sun's possible influence on the Earth and interplanetary space. P-2 offered the ideal platform for such an investigation.

The suite of instruments carried by P-2 included a proportional counter telescope built by the Laboratory for Applied Science at the University of Chicago under John A. Simpson. This omni-directional sensor would detect protons and electrons with energies exceeding 75 and 13 MeV respectively. An ion chamber and an Anton 302 Geiger tube with quasi-omnidirectional sensitivity would also detect protons and electrons at thresholds as low as 25 and 1.6 MeV respectively. These instruments would be able to monitor not only the flux of galactic cosmic rays but also high energy solar and terrestrial radiation. The Geiger tube was similar to those carried by earlier Explorer satellites and Pioneer probes allowing easier comparison of the data sets.

Another key instrument carried by P-2 was a search-coil magnetometer built by a team at STL headed by C.P. Sonnett. This instrument would provide data on the variations in the local magnetic field strength in the one microgauss to 12 milligauss range. This instrument was similar to that flown on the STL-built Pioneer 1 and Explorer 6. The last experiment was micrometeorite spectrometer designed to measure the numbers and momentum of interplanetary dust particles between the orbits of Earth and Venus.

The data were transmitted back to Earth in analog or digital form using a five-watt transmitter. Weight limitations did not allow the transmitter enough power to be used continuously. Instead about four communication sessions of about 25 minutes duration each would take place each day when the probe was in view of the tracking station in Hawaii or the huge 300-foot radio telescope at Jodrell Bank in England. More sessions could be occasionally held during times of special interest such as after a solar flare occurred. An experimental 150-watt transmitter was also carried to conduct long range communication tests in support of the still-planned Pioneer missions to Venus. Temperature sensors and other engineering measurements were also made. The tiny P-2 promised to return much new information about the little explored interplanetary realm.

The launch of Thor-Able 4 from Cape Canaveral which successfully sent Pioneer 5 into solar orbit on March 11, 1960

The Mission

Nine months after its originally planned launch date, P-2 and its launch vehicle were finally ready. On March 11, 1960 (40 years ago this month), Thor-Able 4 lifted off smoothly from the Atlantic Missile Range in Florida. For only the second time in its career as a satellite launch vehicle, the Thor-Able worked as intended boosting the tiny probe, now renamed Pioneer 5, to a speed of 11.03 kilometers (6.86 miles) per second permanently escaping the Earth. Once free of Earth's gravitational influence, Pioneer 5 assumed a heliocentric orbit with an aphelion of 148.5 million kilometers (92.3 million miles) and a perihelion of 120.5 million kilometers (74.9 million miles) with an inclination of 3.35 degrees to the ecliptic. With an orbital period of 311.6 days, the healthy Pioneer 5 was on its way. The only noteworthy loss was the micrometeorite spectrometer whose data system became saturated resulting in no usable data being returned.

On March 13, Pioneer 5 passed the 658,000 kilometer (409,000 mile) mark breaking the communication record set a year earlier by Pioneer 4. The tiny probe continued on its journey day after day setting new records and collecting new data. Finally on March 30, Pioneer 5 had a chance to prove itself. Solar astronomers noted the eruption of a huge solar flare at 14:55 UT followed by a magnetic storm on the Earth 21 hours later.

Just as predicted, the Forbush effect was observed at a monitoring station at Deep River, Canada. At the same time, Pioneer 5 also noted a decrease in cosmic rays from its vantage point about 5 million kilometers (3 million miles) from the Earth. Simultaneously the probe's magnetometer noted an order of magnitude increase in interplanetary magnetic field strength. A mass of plasma from the solar flare was traveling along a spiral path from the Sun at about 1000 kilometers (600 miles) per second. This solar storm produced a magnetic bottle that blocked galactic cosmic rays after it engulfed the Earth.

Pioneer 5 was not instrumented to detect this plasma directly but properly equipped Soviet Luna probes and high flying American Explorer satellites had detected hints of this "solar wind" earlier when they penetrated Earth's magnetopause and entered interplanetary space. Two days later a second big solar flare occurred and its effects were observed by Pioneer 5. Unlike the first flare, a burst of 100 MeV protons were detected by the probe's instruments indicating that the fast-moving protons were traveling along the curved field lines inside the magnetic bottle still remaining from the first flare. The Forbush effect was explained but scientists were now beginning to get a taste of the true complexity of the interplanetary particle and fields environment.

Pioneer 5 continued returning data to Earth throughout April surpassing its design life. But as its distance increased, its signal weakened making it more difficult to extract usable data. By April 30, 1960 the signal had weakened so much that Pioneer 5 ceased normal operations and afterwards infrequently returned data from its instruments. On May 8 Pioneer 5 successfully performed a communication test using its 150-watt transmitter from a range of 12.3 million kilometers (8.0 million miles). Pioneer 5 made its last report back to Earth on June 26, 1960 from a range of 36.2 million kilometers (22.5 million miles) - a communication record that would stand for two years.

By almost any measure, the Pioneer 5 mission was an outstanding success having lasted for 106 days - over three times its design life. It returned over three million bits of data during a total of 139 hours of operation. But the follow-on Pioneer probes to fly to Venus never materialized. By the summer of 1960 NASA had cancelled these probes and adopted a new plan to build much larger, three-axis stabilized spacecraft to be launched on the Atlas-Centaur then under development. The first of this new series of probes, Mariner A, would be launched to Venus in the summer of 1962. It would be several years before the Pioneer-series was revived and new probes launched into interplanetary space.

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