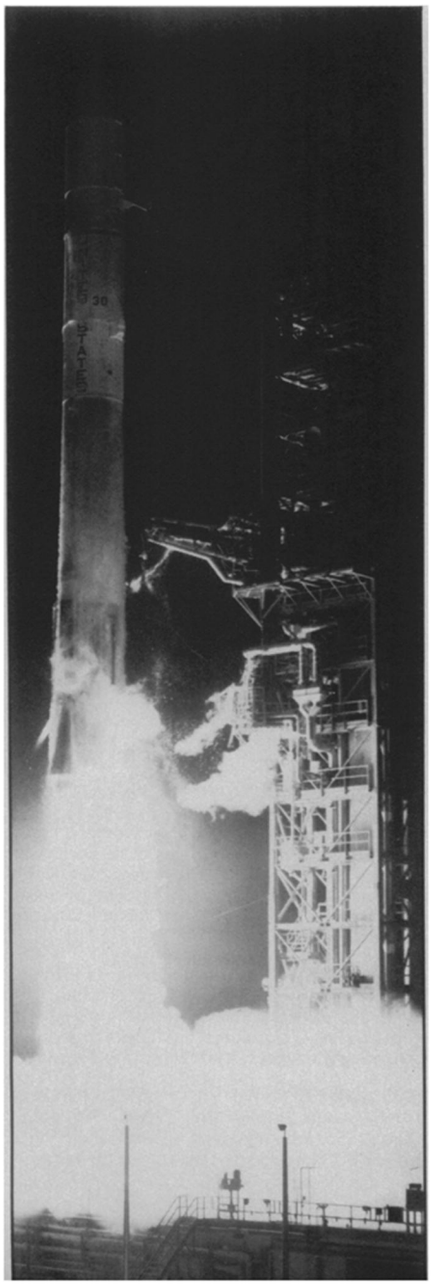
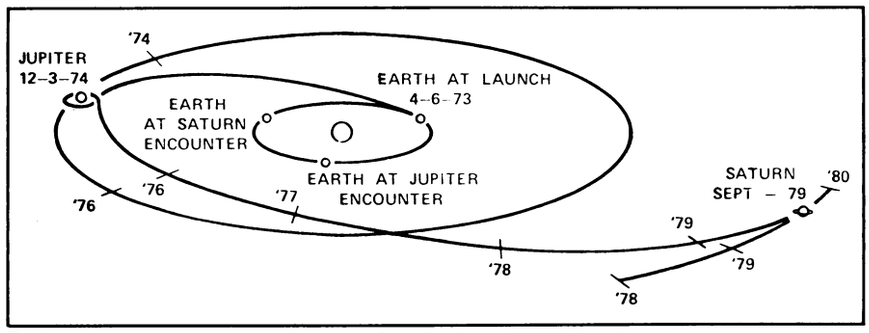
# 6+ Years to Saturn

## A little probe called Pioneer 11 blazes a 3-billion-kilometer trail

BY JONATHAN EBERHART



*Pioneer 11 begins its long journey from Florida's Kennedy Space Center in 1973.*




Illustrations: NASA

*Trajectory map shows route from earth to Jupiter, and across the solar system to Saturn.*

Amid all the planetary spectaculars of recent years — landings on Mars, the discovery of active volcanoes on Io — it's almost startling to recall that it has been more than half a decade since a planet was visited for the first time by a spacecraft. In late March of 1974, Mariner 10 flew by on the first of its three encounters with Mercury. Since that time — despite their monumental exploratory achievements — the Viking Mars probes, the Pioneer Venus mission and the Voyager 1 and 2 flights to Jupiter (plus Soviet flights to Mars, Venus and the moon) have all been repeats. On Sept. 1, however, another world will be added to the list, as Pioneer 11 becomes the first emissary from earth ever to take a close look at Saturn.

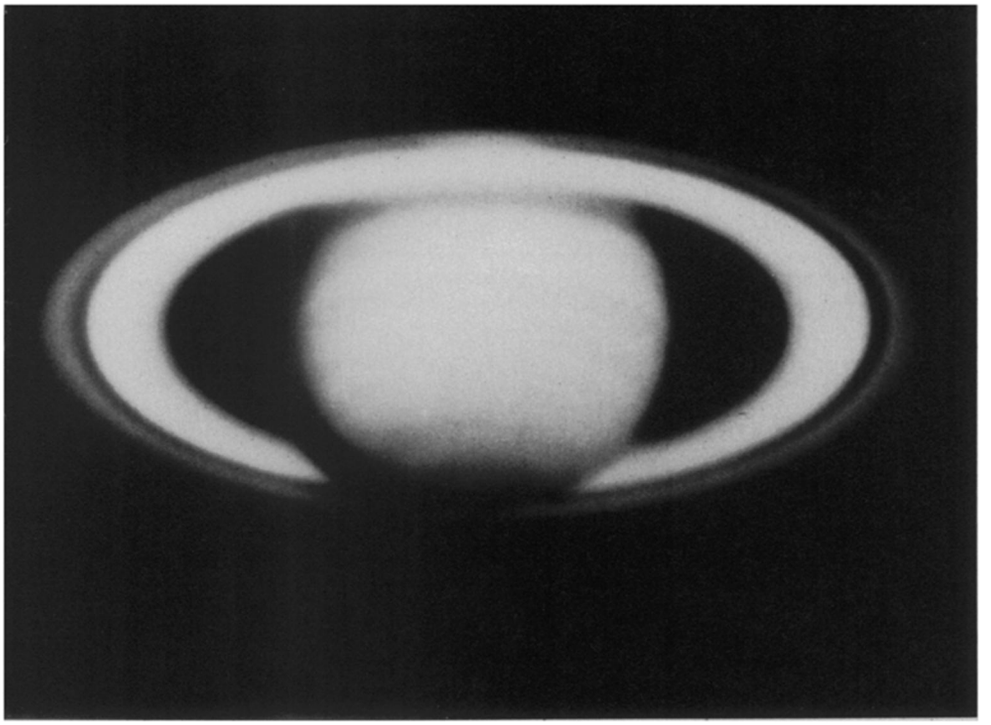
It will have been a long journey. Launched on April 6, 1973, the little (270-kilogram) probe first spent 20 months en route to Jupiter, studying the giant planet and using its gravity for a "slingshot" to whip the spacecraft back across the solar system for another 57 months to Saturn — a total trek lasting nearly six and a half years and covering more than 3 billion kilometers. Other space probes have operated for as long, but none with major planetary missions ahead of them. Voyagers 1 and 2, by comparison, are both now on the way to Saturn after their own Jupiter encounters, but thanks to more favorable planetary positions, they will have taken only 38 and 48 months, respectively, to get there.

Compared to the Voyagers, Pioneer 11 is a relatively unsophisticated vehicle. Instead of holding its orientation in space by means of a three-axis stabilization system, for example, it simply spins, maintaining its position like a gyroscope. Its nuclear power supply, used because the sunlight at such distances is too weak for efficient solar panels, provides barely a third of Voyager's wattage. Because of this, plus the fact that it transmits in the so-called S-band rather than in the higher-frequency, more efficient X-band that the Voyagers use, Pioneer 11 will be sending data from Saturn to earth at only 1,024 bits per second compared to the 44,800-bit rate possible with the Voyagers. This means that fewer measurements will be possible, and that photos will be less sharp. Pioneer 11, in fact, will take only 50 to 100 photos of the Saturnian system, versus thousands for each Voyager.

But despite its limitations, the probe appears to be in excellent condition to carry out its Saturn mission, which was just an extremely tentative option at the time it left the earth. Back then, engineers estimated that 105 watts would be needed at Saturn, and that the degradation rate of the power supplies would leave exactly that amount available when the time came. Instead, the degradation rate seems to have slowed down year by year, so that there will probably be more than 120 watts for the task. The other "consumable" is the propellant in the spacecraft's attitude-control system; there will probably be about three times the needed minimum. Furthermore, one of the two scientific instruments on board that had become inoperative since the Jupiter encounter (the spacecraft carries a dozen) was reactivated last year after three years of unsuccessful attempts. It is the plasma sensor, designed to study the solar wind, leaving the only non-working sensor now an asteroid-meteoroid detector, which was deliberately turned off when its detector cells became too cloudy for use.

The Saturn encounter began, in a sense, on Aug. 4, when the probe's camera — actually an imaging photopolarimeter — took its first picture of the planet. Another sort of beginning will occur on Aug. 27, when Pioneer 11 enters the true Saturnian system by crossing the orbit of Phoebe, Saturn's outermost known moon. But the mission's real tensions — including two literally do-or-die situations — will all be compressed into a four-hour period on the morning of Sept. 1, beginning with what one NASA timeline describes as *"mission's most critical event."* (Emphasis NASA's.)

A major question for Pioneer 11 has been whether it would be sent past the outside of Saturn's readily visible rings or inward, between the rings and the planet. Earth-based evidence has indicated that there may be additional material orbiting inside the main rings, and a collision with a single chunk could possibly end the mission abruptly with the destruction of the spacecraft. Despite this, the project's scientists voted nearly unanimously to go inside, in some cases rationalizing that



"half a mission" that close to the planet would be more worthwhile than the completed flyby at a much greater distance. The scientists were overruled by NASA officials, however, who chose the outside route primarily so that Pioneer 11 could serve as a pathfinder for the two Voyagers, which will be re-aimed to cross the plane of the rings at a still more distant point if this probe doesn't make it.

Thus, at 7:35 a.m. PDT on Sept. 1, Pioneer 11 will swoop down through the plane of the rings at more than 85,000 kilometers per hour, about 34,000 km outside the main ring structure. For the next 85 minutes — the time it will take for a radio signal to get from the spacecraft to the control room at NASA's Ames Research Center in California — scientists and NASA officials alike will be biting their nails. And there are bets on both sides.

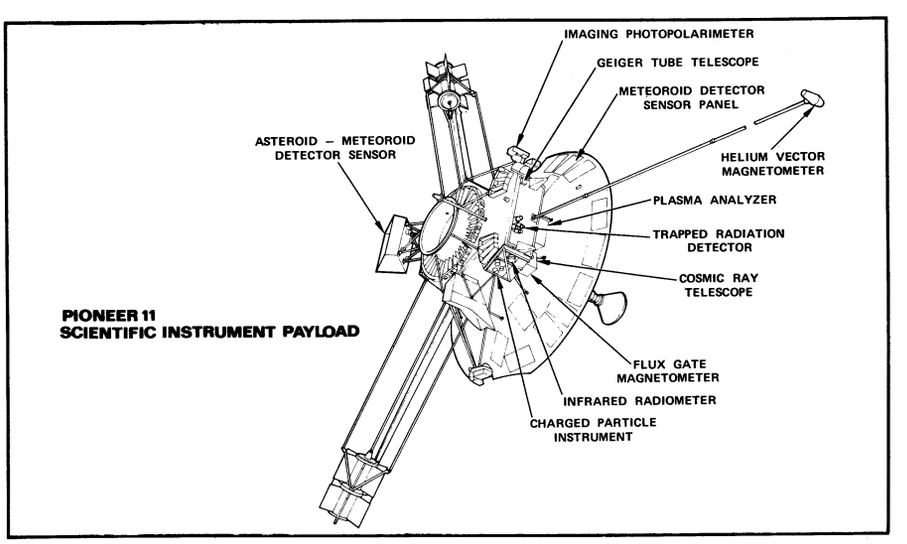
Because there is also evidence for material *outside* the main rings. Microdensitometer scans made in 1966, when the rings were edge-on to earth, were reported as indicating the presence of material in the ring plane extending to "more than twice the known ring diameter" — in other words, at least 100,000 km farther outboard than Pioneer 11's crossing point. In addition, says project scientist John Wolfe, radar studies have shown doppler shifts characteristic of "sizable chunks" of material as far out as 50 times Saturn's radius, a total of 3 million kilometers.

And if the probe survives the first crossing, three hours and 59 minutes later it will face another one, as it ascends back through the ring plane at a similar radial distance.

Between the two crossings there will be another period of tension, but of a type typical of interplanetary missions and which seems almost tame compared with the ring adventures. At 9:34 a.m. PDT, almost exactly midway between the two crossings, the spacecraft will make its closest approach to Saturn, flying under the rings to within 21,600 km of the planet's banded, Jupiterish cloud tops. Less than a minute and a half later, the probe's radio signals to earth will be abruptly cut off as it passes behind Saturn for 78 minutes of forced radio silence. Spacecraft handlers never like to be out of touch with their charges, but there is no particular reason that something should happen to Pioneer 11 while it is out of contact, and the 40 minutes between the restoration of the signal and the second ring-plane crossing are likely to do a considerably better job of tightening the screws.

Ironically, with all the concern and interest in the rings (which are still the spectacular of the solar system, even with the newly discovered rings of Uranus and Jupiter for competition), it is unlikely that Pioneer 11 will be able to photograph the particles that compose them. The craft will simply be moving too quickly for its camera to see even kilometer-sized chunks by the time it is close enough to resolve them. There will, however, be visible-light, ultraviolet and infrared measurements of the rings' "bulk brightness," leading to an estimate of the size distribution of the particles. Also, the probe's radio signal will pass briefly through the region outside the main rings, possibly revealing whether there are additional particles there (if it hasn't already been resolved the hard way).

Besides the rings and the planet itself, of course, there are a host of other targets: Saturn's satellites, of which there are variously 9, or 10 (if you acknowledge Janus), or 11 (if you include one reported — but without a unique orbit determination—by University of Arizona astronomers Stephen Larson and John Fountain in 1977). Key among them, and a major target for the mission (as well as for Voyager), is Titan, bigger than Mercury and believed to have a substantial atmosphere. Estimates of Titan's surface temperature and atmospheric pressure vary widely, as do interpretations of evidence that it may have substantial quantities of organic material. But there is also Iapetus, several times brighter on one side than on the other, and the other moons as well. And no successful interplanetary mission yet flown has failed to turn up some surprises. □




## Pioneer 11 Saturn Timeline

| Date | Time* | Event | Distance |
|---|---|---|---|
| Aug. 27 | 0102 | Phoebe | 9,453,000 km |
| 28 | 2305 | Iapetus | 1,039,000 |
| 31 | 0531 | Hyperion | 674,000 |
| Sept. 1 | 0735 | ring plane crossing | |
| | 0904 | Dione | 291,100 |
| | 0927 | Mimas | 103,400 |
| | 0934 | Saturn | 21,600 |
| | 1128 | Tethys | 331,700 |
| | 1133 | ring plane crossing | |
| | 1133 | Enceladus | 225,200 |
| | 1534 | Rhea | 341,900 |
| Sept. 2 | 1105 | Titan | 356,000 |

*Times are PDT at spacecraft. For event-receipt times at earth, add about 85 minutes.