U.S. space probe heads for a comet

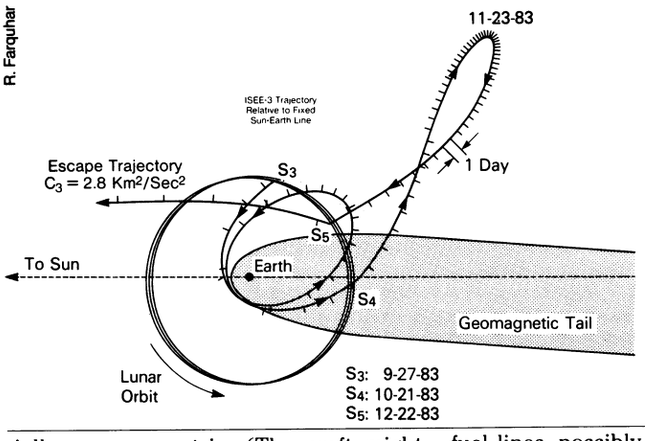
It was never designed to go to a comet—or anywhere else, for that matter, other than its original duty station. But on Dec. 22, a U.S. probe will head off toward the first-ever visit with a comet. When the probe reaches its destination, it will precede by half a year an international armada of spacecraft — two Soviet, two Japanese and one European — scheduled to fly past comet Halley for a close look in March of 1986.

The United States' International Sun-Earth Explorer 3 (ISEE-3), launched in 1978, was placed in a bizarre "halo" orbit around a point on the imaginary line between the sun and earth, nearly a million miles sunward of the planet, where the gravity of the two bodies is essentially balanced. It was instrumented to study the solar wind in its raw form, as a source of baseline data for the other ISEEs, studying the wind's subsequent effects from earth-orbit. The National Aeronautics and Space Administration called the halo "the most unusual orbit ever proposed for a NASA space mission." And to keep the plane of the hato normal to the sun-earth line, ISEE-3 carried a rocket engine.

That rocket carried a good deal more of its hydrazine propellant than needed, however, for the satellite's planned three years in the halo. ISEE-3 was, in a sense, free to travel.

Robert Farquhar, of NASA's Goddard Space Flight Center in Maryland, had been thinking about where it might go even before it was launched. When refined design calculations suggested that the hydrazine tank might be bigger than needed for the halo job, Farquhar lobbied for keeping the excess. A year before the launching, he checked out the possibility of sending it to comet Halley, but found that its transmissions would be too weak to get data to earth from Halley's distance. Another possibility, however, was a comet called Giacobini-Zinner, which, though smaller than Halley, would come closer. Yet another possibility was to send the probe down the tail of earth's magnetic field, where its instruments could make extended measurements of a part of the magnetotail that had only been briefly sampled two or three times before. In fact, Farquhar found, the tail and comet missions could be combined.

It was an exceedingly complex endeavor, involving not only the use of the rocket engine but close flybys of the moon so that the lunar gravity would help redirect the probe in the proper direction. And it was a mixed blessing. If it went down the magnetotail, ISEE-3 could still return to the halo, where some scientists hoped it would resume its sun-watching duties for more of the solar cycle, but the voyage to comet Giacobini-Zinner would be essentially a one-way trip. (The craft might come back, Farquhar says, in about 30 years, but would it still be working?)



The ISEE-3 space probe's elaborate route (hatchmarked line) to comet Giacobini-Zinner is shown in this trajectory diagram, indicating where it will pass close to the moon on Dec. 22 (S_5) so that the moon's gravity can place it on an escape trajectory toward the comet.

A U.S. comet mission, however, was a tempting possibility, and the majority of the project's scientists, as well as NASA management, gave their approval. On June 10 of last year, ISEE-3's engine was fired, moving it out of the halo and around behind the earth to explore the magnetotail. Coming back "up-tail" again, the probe was then sent to swing by the moon, which redirected it into a carefully calculated figure-8 that went even farther down the tail ("We've spent about nine months in the tail," says project scientist Tycho von Rosenvinge of Goddard), followed by two more lunar swingbys to set up the Dec. 22 maneuver.

On that day, ISEE-3 will pass what Farquhar calculates to be only about 116 kilometers from the lunar surface, while the moon's gravity shifts the probe's path toward an encounter with the comet on Sept. 11, 1985. ISEE-3 is instrumented for the study of charged particles and electromagnetic fields — the stuff of solar physics. It does not carry a camera. But if there were a camera, says von Rosenvinge, "we probably wouldn't be going to the comet." The reason is that the camera-equipped probes planned for Halley will have to pass their comet on its sunlit side for photography — which is the side away from the comet's tail. ISEE-3, with no such constraint, will be free to fly right through Giacobini-Zinner's tail, giving it a chance for a whole family of measurements denied to the more sophisticated craft. In addition, it will be in a position to recap its original role from its years in the halo orbit, by monitoring the raw solar wind as an aid to the oncoming Halley fleet.

First, however, it must survive its Dec. 22 swing around the moon. During that time, ISEE-3 will spend about 28 minutes in the moon's shadow, where it will run the small but real risk of essentially freezing to death. It carries heaters, but the probe's battery failed two years ago, so the heaters only work in sunlight, when they are receiving electricity directly from the solar panels. In that 28 minutes, the very hydrazine that fuels the rocket making the whole mission possible could freeze in the fuel lines, possibly causing them to rupture. Before the craft goes into shadow, flight controllers at Goddard will turn the heaters on maximum to pre-warm the lines and other components, and the engineers who built the propulsion system believe that it should emerge unfazed. The craft has only been in shadow once before, however, shortly after it was launched, and the battery was working then. With no past experience, the engineers can only give confident estimates.

Another major uncertainty is associated with the other end of the trip. The orbital motion of comet Giacobini-Zinner is imperfectly known, and although there will be chances to modify ISEE-3's trajectory on the way, it is not impossible that it could miss the comet's tail completely. In fact, says Farquhar, "that's the thing I'm most worried about."

The ISEE-3 team is confident, however, and this first-ever comet mission is also something of an economic wonder. ISEE-3 was paid for long ago, so the cost of the comet mission will be primarily that of tracking the spacecraft from NASA's stations on the ground. And doesn't this elaborate, multiple-lunar-flyby approach suggest other possibilities for the future? "Yeah," says Farquhar, "I'm thinking about them." —*J. Eberhart*

Shuttle fire under study

NASA engineers this week are investigating a small fire that broke out on the space shuttle Columbia apparently just moments before its Dec. 8 landing from the 10-day Spacelab mission. Evidence of the fire, discovered when the engineers went aboard to check out the premature shutdown of two of the craft's auxiliary power units (APUs), included charring of the APUs and damage to the APU fuel-control valves, indicating that hydrazine in the valves had exploded. In addition, investigation was also underway of whatever caused the shutdown of two of the craft's five main computers about six hours before the scheduled landing, prompting NASA officials to delay the landing for about eight hours while they tried unsuccessfully to diagnose the problem. □