Aerospace by Charles B. Stevens

To catch a comet

The ICE satellite intercept with Giacobini-Zinner demonstrated major aerospace technology with unexpected scientific results.

On Sept. 11, 1985 at 7:00 a.m. EDT, humanity had its first close encounter with a comet. This is when the seven-year-old International Sun-Earth Explore (ISEE-3) swept through the tail of the Giacobini-Zinner Comet. While a poor substitute for the previously planned U.S. probe of Halley's Comet in 1986, a program which was killed by the Reagan administration for "budget trimming" reasons, the mission proved to be an aerospace technological tour de force with "unexpected" scientific results.

The U.S. fly-by with ISEE-3, which has been renamed the International Cometry Explore (ICE), took place 44 million miles from Earth and six months before Soviet, European, and Japanese spacecraft will reach Halley's Comet in March 1986.

The spacecraft started its orbital life seven years ago with the mission to monitor the solar wind upstream from the Earth. (The solar wind is a plasma stream driven by the pressure of the sun's radiation.) With this task fulfilled, both the spacecraft and the sensors aboard it were still in good shape. Therefore, with the cancelation of the Halley mission, NASA scientists proposed to fly the ICE mission.

Giacobini-Zinner is one of 900 comets known to travel through the solar system. It was first discovered in 1900. The biggest and brightest comet in our solar system is Halley's comet, which reappears in our sky every 76 years.

A comet has a nucleus of primeval rock, ice, and snow a mile across, surrounded by a "coma" of 50,000 miles of exotic gas and dust. It has a yellow dust tail about 300,000 miles long, and a second tail, of electrified gas—the plasma tail—at least 1 million miles long.

In order to carry out this mission, the Jet Propulsion Laboratory had to organize a worldwide effort to simply recover ICE's radio transmissions. At the range of 44 million miles ICE would be operating at a power level 2,500 times weaker than that for which it was designed.

But, before ICE could make its 20-minute transit of the comet's tail, it had to be redirected on a billion-mile intercept trajectory. The complex set of course-changes involved no fewer than five gravitational-assist lunar fly-by maneuvers—the last took it within 75 miles of the Moon's surface. Apprehension over a possible power loss due to comet dust covering over the satellite's solar cells during the intercept led NASA scientists to shut down ICE's internal heaters, risking a propellant freeze, so that its sensors remained energized.

"Just from the cursory looks we have had at the data, I think a lot of people are inclined to believe they do not show the kinds of effects we expected to see and will cause us to rethink what kinds of things are going on in comets," noted Jet Propulsion Lab scientist Edward Smith.

In the first place, ICE made a perfectly symmetric transit of the comet tail, but the comet tail proved to be asymmetric by a wide margin, without any existing explanation. And while some instruments saw clear signs of a "bow shock," most found complex and unpredicted readings. One Los Alamos scientist noted, "We first saw evidence that there might be a bow shock," but the readings were so unusual that it is not known what kind of shock wave it was. The TRW group, which had a plasma wave diagnostic aboard, reported, on the other hand: "It is remarkable that it looked so typical and strong to us but does not appear that way in the other instruments. . . . As we came farther in, we detected increasing levels of plasma wave turbulence that suggest that the plasma was breaking up into beams and the filaments were all colliding with each other."

According to JPL: "We see some kind of phenomena that looks like it could be associated with a shock, but we have difficulty identifying it as a shock." In other measurements, scientists found regions with much higher plasma densities than expected. One TRW scientist noted: "We thought a comet might be a benign object, but it appears to be extremely active."

While the data is still being processed, this "pure science" encounter with a comet could have direct and major implications on such current technologies as hypersonic aircraft and x-ray laser nuclear weapons. The history of shock waves demonstrates that they are closely related to the advanced end of self-organized plasma phenomena. This connection has become increasingly imperative, as the recent computational breakdown of complex computer codes at U.S. national weapon laboratories reveals.

But in-depth follow-up will be left to the Soviets as they fly by Halley's Comet in 1986. In any case, ICE did survive its trip through the comet tail.