SCIENCE NEWS of the week

Giotto's Perilous Probe of Comet Halley

It has been called a suicide mission, a *kamikaze* mission and more — and it may turn out to be just that. Yet even if the audacious plan, the European Space Agency's (ESA's) first attempt to send a spacecraft beyond earth-orbit, ends by transforming the little probe called Giotto into a pile of useless junk, its other results may be both spectacular and unique. For of all the deep-space probes, earth-orbiting instruments and ground-bound observatories being marshalled by the nations of earth on the occasion of an event that last occurred three-quarters of a century ago, only Giotto, launched July 2, is being sent to risk death by approaching the head of Comet Halley.

No terrestrial emissary has been close to a comet, but countless earthlings throughout history have seen at least pictures of the fuzzy head ("coma") and tail generated from a comet's icy nucleus by the heat of the sun. What has yet to be seen is the nucleus itself, hidden by scattered sunlight and the source of a yet unknown number of ice chips, dust particles and possibly even chunks of rock — any of which could be potentially deadly to an investigating spacecraft.

Nobody knows. "It is estimated," says one ESA publication, "that the probability for surviving the flyby is greater than 90 percent," and a number of scientists agree. On the other hand, according to a different ESA document — and there are researchers with this view too — "it is not expected that the spacecraft will survive beyond the point of closest approach to the comet." That concern, in fact, is manifested in the design of Giotto itself, which comes *without* a tape recorder of the sort used by many interplanetary probes to play back data gathered more rapidly than can be directly passed along by radio. "Because Giotto runs a risk of being destroyed at the time of the encounter, or very soon afterwards," notes yet another ESA report, "all the images and measurements will be transmitted back to earth real time."

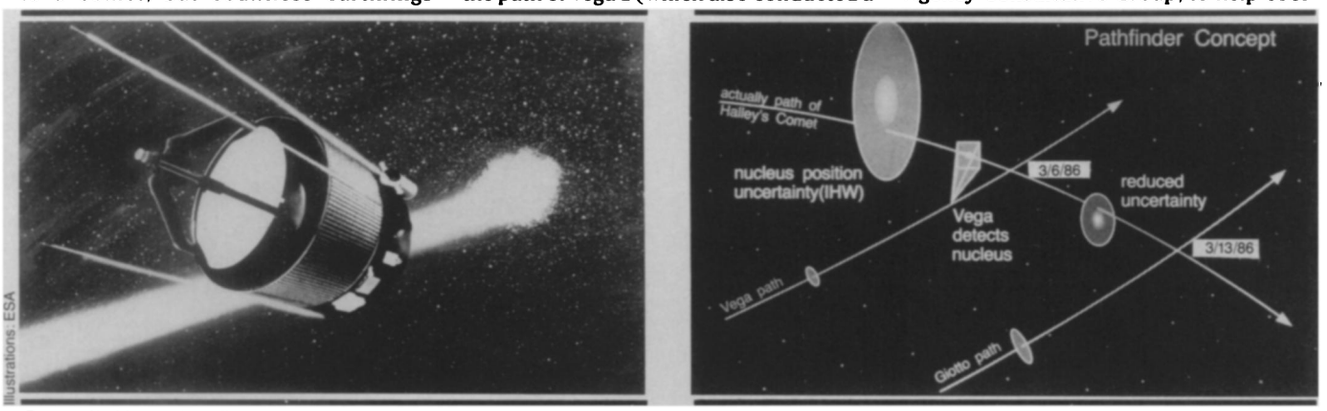
Giotto's risky journey is to carry it 500 kilometers (about 300 miles) from the head of the comet next March 13. Five other spacecraft will fly past during the preceding week, but none will come so close. Japan's *Sakigake* (primarily a solar-wind monitor, whose name essentially means "harbinger") and Planet A will come only to within about 7 million and 200,000 km, respectively, on March 11 and 8. The Soviet Union's more sophisticated Vega 1 craft, which recently dropped off a wind-measuring balloon and a landing craft at Venus on the way (SN: 6/22/85, p. 388) is aimed to pass within 10,000 km on March 6. Assuming that Vega 1 survives, the path of Vega 2 (which also conducted a Venus stopover) may be carefully shifted in to fly by as close as 3,000 km — still six times farther from the comet than Giotto will go only four days later.

Giotto will be in the thick of the coma, being blasted by its particles at a relative velocity of nearly 250,000 kilometers per hour, about 50 times faster than a bullet from a gun. At that speed, notes ESA, even a 0.1-gram grain of dust "can cut through a sheet of aluminum 8 centimeters thick." Such a shield for Giotto, however, would weigh about 600 kilograms (1,320 pounds), more than doubling the spacecraft's 520-kg weight. Instead, the designers have banked on a two-layer system, with an outer, sandwich-like blanket of Kevlar (used in bulletproof vests) separated by a gap from a thin aluminum sheet. The hope is that the outer layer will vaporize impacting particles, whose resultant gas will spread throughout the intervening gap, offering a much lighter impact to the aluminum.

First, however, Giotto must find its target. So far, says ESA, ground-based observations have been able to pin down the location of Halley's nucleus to no better than about 32,000 km within its surrounding haze of scattered light. By the time of the encounter next March, astrometric measurements from the ground should have reduced the uncertainty by 98 percent, to about 640 km. But Giotto is to zip past only *500* km from the nucleus — which means that a 640-km uncertainty would include the possibility of a crash landing on the comet. (The impact, scientists note, would be unlikely to shatter or measurably deflect the nucleus.)

Coming to the rescue with only days to spare, however, will be...the Soviet Union. In 1981, the same year that ESA approved the Giotto mission, the American, Soviet, European and Japanese space agencies formed an association called the Inter-Agency Consultative Group, to help coordinate the wide variety of space-based activities being planned for Halley's appearance. One of the IACG's divisions was a "Spacecraft Navigation and Mission Optimization Working Group," to share data about problems common to the various missions that would actually go to the comet. ESA's plans for Giotto indicated that one issue could be of particular importance, and in December of 1983, the "mission optimization" group was dissolved and replaced by one whose official purpose got right to the point: "Pathfinder Implementation."

Former U.S. hopes to send a probe directly into the nucleus had fallen by the wayside, and the envisioned Japanese craft would pass much too far away for even a clear look. The Soviet Vegas will pass through the coma, but still at distances perhaps too far from the nucleus to let it be photographed clearly, or to allow analyses of the close-in "parent molecules" that come off of the nucleus before they begin changing or recombining into other forms in the coma's outer reaches. Cometary scientists have long wanted a truly close look, and the best



Giotto (left), the first European spacecraft sent beyond earth-orbit, will pass only 500 km from the nucleus of Comet Halley. To aid the precise targeting, Soviet officials will provide photos taken only days before by their two Vega probes (only Vega 1 is shown).

chance would be Giotto's, particularly if there could be a way of finding out — before the actual encounter — where the nucleus is actually hiding in all that reflected glare.

Enter the Vegas. Vega 1 will encounter the coma on March 6, followed on March 9 by Vega 2. The last chance for ground controllers to adjust Giotto's course will be on March 11, only two days before it, too, makes its close approach. The plan now calls for Soviet officials to provide ESA with data on the exact position of the nucleus, based on the last possible images from the cameras aboard the Vegas. Precise tracking information about the positions of the spacecraft — necessary to locate the nucleus from the photos — will be aided by means of radio interferometry, using signals received from the craft by Soviet, European and U.S. tracking stations, including those of the U.S. Deep Space Network. (A version of the same international array was used to track the balloons and landing craft released from the Vegas into the atmosphere of Venus.) It will be a task of formidable complexity: The Vegas will take their pictures, as the interferometry group races to determine the exact distances and angles from which they were taken. The data will then be passed on to Giotto's control center at Darmstadt, W. Germany, where they in turn will be figured into the computerized navigation instructions radioed up to re-aim Giotto itself. After that, it will be a tense two days of waiting until the already vast and growing numbers of Halley hopefuls around the world find out whether the European probe has (a) crashed into the nucleus, (b) passed too far away, so that the scattered sunlight and outpouring particles render the nucleus still invisible, or (c) been sandblasted into oblivion, either with or without providing the unique close-ups.

The camera with that responsibility will be approaching much as Jason confronted the serpent-headed Medusa. The only difference will be that Jason viewed his antagonist's reflection in a polished shield — for to view her directly was to be turned to stone — while Giotto's camera will be aimed at an angled mirror to prevent damage from direct particle impacts. The camera itself is also steerable, so that it can track the nucleus as Giotto approaches, and possibly take additional photos — barring (a) or (c) above — after the point of closest approach. At a distance of 500 km from the nucleus, the telescope-equipped, charge-coupled-device camera should be capable of seeing details as small as 10 meters across, about the length of a moving van.

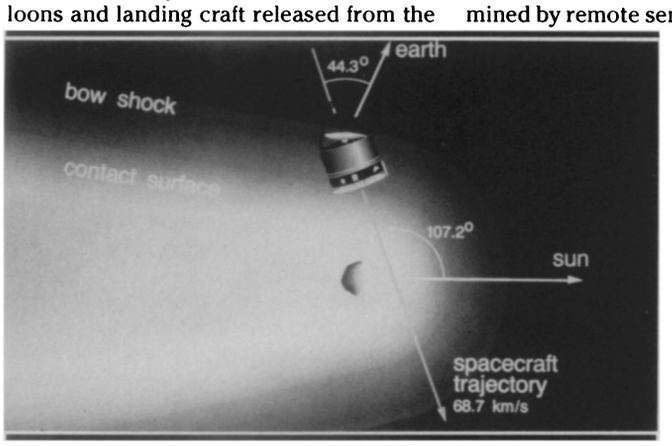
Besides the camera, Giotto carries nine other experiments: A neutral mass spectrometer will measure the elements and isotopes of neutral gases in the coma, in part to see how the mixture changes with increasing distance from the nucleus. An ion mass spectrometer includes a sensor especially calibrated to study the turbulent region where the outer coma interacts with the solar wind — although the accuracy of such calibrations, like everything else about a comet that cannot be determined by remote sensing, has been a matter of educated guesswork.

A third mass spectrometer is designed specifically to analyze the composition of individual dust particles. In addition, a trio of impact sensors will report on the numbers of particles of different masses, from tiny ones the size of smoke particles to others the size of peas. At a quarter-million km per hour, of course, even an undernourished pea might turn out to produce effects far more dramatic than numbers in a stream of data. Other sensors will measure magnetic fields (do some comets actually have their own?), electric and electrostatic fields and more.

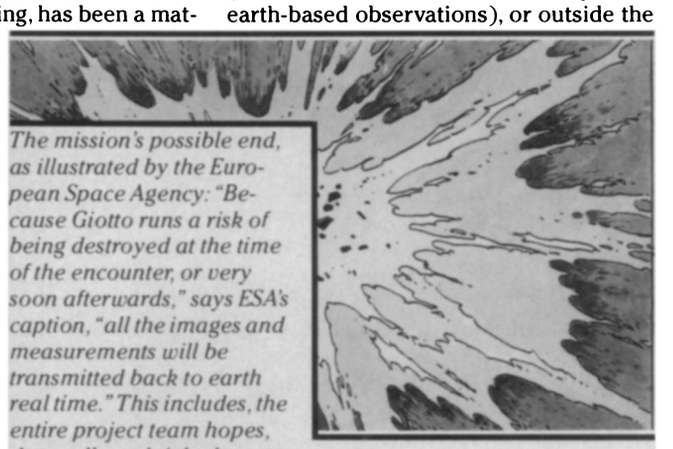
Even if Giotto survives the natural hazards of its encounter, its working life will be short. It is powered by batteries (which in turn are charged by solar panels), and the period of operation around the closest approach to the comet, with all the instruments operating at their highest rates, will use the limited power so rapidly that the amount of heat being dissipated by the spacecraft will nearly triple. Though some of the instruments will be turned on about 30 hours before the closest approach, the "encounter phase" itself will begin with only 3 hours and 45 minutes to go. If the comet itself doesn't end it, ESA estimates, heat-dissipation may do the job as little as 15 minutes after encounter. (Mario Acuña of the NASA Goddard Space Flight Center in Greenbelt, Md., one of the mission's 240 participating scientists, speculates that the craft might hold up for as long as two more hours.) Sooner or later, however, Giotto's signal will be lost anyway, since its curving trajectory will angle its transmission antenna away from the earth.

The last time an earth-spawned spacecraft was sent toward a deep-space encounter that was so formidable yet so unknown was in the late 1970s, when the U.S. Pioneer 11 probe was being prepared for the first flight of an artificial object through the plane of the rings of Saturn. There, the question was whether the craft should be sent between the planet itself and the inner edge of the visible rings (which could be determined only from earth-based observations), or outside the rings for safety. One set of observatory photos suggested that there *might* be a *little* material "inside," but it was questionable at best. Even if it would be a fatal decision for the spacecraft, however, some of the project's scientists favored it anyway, arguing that they would rather get "half a mission" from the much closer flyby distance than a "whole mission" beyond the rings. Two years before the "fly-through," 6 of the project's 13 principal scientists favored the inside route, 6 preferred outside, and 1 had no preference (SN: 10/15/77, p. 249). A month later, their vote was almost unanimous for the dangerous but scientifically exciting inside path (SN: 11/12/77, p. 315). The final decision was NASA's own, however, and the agency chose the outside route anyway, in order to use Pioneer 11 as a "pathfinder" for the more elaborate Voyager missions to follow (SN: 12/10/77, p. 390). As hoped, the probe survived its 1979 trek.

For Giotto, no one has chosen an "outside" route past Comet Halley. The craft may indeed provide only "half a mission," but that half, to many comet scientists, may be the whole point. —*J. Eberhart*



Passing the nucleus, Giotto is likely to be struck by ice and dust particles from the hazy "coma" at nearly 250,000 km/hr.



The mission's possible end, as illustrated by the European Space Agency: "Because Giotto runs a risk of being destroyed at the time of the encounter, or very soon afterwards," says ESA's caption, "all the images and measurements will be transmitted back to earth real time." This includes, the entire project team hopes, data collected right down to the last possible second.