Mars landing: Message from Puerto Rico

Everything was set. The search for a place to land the Viking 1 spacecraft on Mars seemed at an end, as the probe's cameras showed potentially hazardous surface features to be receding beneath layers of sediment deposits and lava flows. But one factor had not yet been taken into account: radar measurements of the roughness of the site, made with the huge Arecibo radio telescope in Puerto Rico. Suddenly the site known as the "Northwest Territory," near the center of Chryse basin and so tempting in the photographs, had become ambiguous. The "mean slope" of the site, according to G. Leonard Tyler of Stanford University, was about twice the Martian average. A more promising region—to the radar interpreters—existed farther to the west on the opposite slope of the basin.

As an indicator of planetary surface conditions, radar is a controversial tool. It is far from all-seeing. Hephaestus Fossae, for example, a 500-kilometer-long crack up to a kilometer wide in the Martian surface, is almost invisible to radar, Tyler admits, because its reflections are washed out by the stronger return from the smooth terrain on either side. The Viking scientists were far from united on letting radar data demolish their visually desirable site, but the decision was made to seek an area that would look good to cameras and radar alike.

The choice was a spot on the western slope of the Chryse basin, centered at 47.5°W and 22.4°N, about 740 kilometers from the original July Fourth site. The radar showed only modest slopes, and

Viking: Profit from experience

It was more than half a decade ago that Viking officials decided to target the first U.S. landing on Mars for the Bicentennial Fourth of July. The prime landing site in the southeastern Chryse plain was chosen more than three years in advance. Yet just one week after Viking's arrival in orbit around the planet, the whole grandiloquent plan was scrapped—the date postponed, the site tabled as potentially hazardous.

It's easy to imagine, looking at the program from outside, that somebody goofed. Missions at NASA have a way of seeming either to run like clockwork or to blow up—whether from human or mechanical error—in a cloud of money. But when Viking decided to take its time, running through alternative landing sites and dates with exasperating fickleness while dragging the whole 750-member flight team in its wake, it was, in a very real sense, performing exactly the task it had always been intended to do—adapting to its mission. Learning as it went along.

An innocuous phrase. A cliché. But if Viking realizes the goals that have been set for it, that will be the reason. Most space missions are designed to follow preplanned scenarios (particularly the unmanned ones, although the Apollo 11 astronauts had their very footsteps mapped in advance), simply observing and reporting what goes on. The Viking project, however, is fully intended to profit from its own experience, adjusting and rescheduling its numerous scientific experiments as new discoveries are made. "We can completely redesign the mission," says science planning director B. Gentry Lee, "in 16 days."

The landing-site search was conducted by people—scores of them—making deliberate, positive decisions, not patching up a mere deviation from a schedule. The same adaptability will be the rule throughout the mission, a staggering concept when one considers the research permutations of four spacecraft—two orbiters and two landers—on duty at the same time. "I never figured I'd have to work 100-hour weeks," says Lee. "Maybe 60, 65—but not 100."

Nothing in NASA's experience could have prepared it for the complexity of Viking's day-to-day operations. Consider the last U.S. Mars mission, five years ago, in which Mariner 8 was to have gone into an orbit that would pass over the Martian poles while Mariner 9 would map the planet from a near-equatorial path. When a launch problem dumped Mariner 8 into the ocean, the project scientists, with sometimes incompatible goals, had to decide on a compromise orbit for the survivor—"a result," says Carl Sagan, "of the most excruciating negotiation." Then, when the probe reached Mars, it had to wait out a dust storm that blanketed the whole planet. "Everything that was preprogrammed," Sagan says, "was thrown out within the first week." Other problems occurred, and running a two-spacecraft mission with one spacecraft would have been no picnic under the best of conditions. And yet, says Sagan, who is on the Viking team as well, "that was a situation of almost negligible complexity compared to what's going on here."

Viking is a mission of meetings. A typical day will see as many as 30 gatherings of various directorates, teams, squads, committees and working groups. But compounding the effect—and setting Viking apart from all missions before it—is the degree to which their activities and decisions are interlocked. Even on a heavily scientific mission such as Skylab, one group could plan an astronomy experiment, for example, while another worked on materials processing, largely a matter of scheduling the astronauts' time. But for Viking, everything depends on everything else. Planning for a given day's activities begins 18 days in advance, and successive planning cycles must be locked in perfect phase relative to one another, all to be multiplied soon by four spacecraft. A change in one area affects all the rest. The structured flow of activities on Viking is something brand new, says Flight Planning Group director Clancy Hassler of Martin-Marietta Corp., who held a similar post on Skylab. The result is an administration as detailed as that of a large, diverse corporation but all gathered into a few heavily populated rooms at the Jet Propulsion Laboratory. And yet, says Hassler, "The fact that we can adapt is *because* of the structure, not in spite of it." In such a complex mission, says Lee, though it seems paradoxical, the structure is necessary to let individual creativity get in. The scientists seem to agree, even though keeping everything straight requires an Operations Analysis Team—"the OAT"—as large as many a past mission's whole scientific complement.

This is not to say the scientists agree on everything. There are widespread—and often strong—opinions ranging from landing dates to data interpretations. The Viking operations structure has to provide a forum for such conflicts, while still keeping the mission on schedule.

It didn't come easy. For years, NASA has been planning the projects operations scheme, but about two years ago, says OAT leader Darrell Roos, the planners found that the existing system simply couldn't support the mission's needs. The already elaborate structure was stratified some more. Last December, with the Vikings already on their way, the team held a rehearsal. "But," says Lee, "we'd never tried to work it with real people going to real meetings and making real decisions." More changes.

It could have been harder still. It was nearly 1974, says project scientist Gerald Soffen, before Viking officials decided to delay the second landing so as to prevent a two-month overlap of fulltime, high-activity operations by all four spacecraft. Now it is hoped that, even with Viking 1's late touchdown, the first lander will be back to a reduced workload before the second one gets up to steam. Meanwhile, the meetings continue. Viking is no "fly-it-by-the-press-kit" operation. Hundreds of scientists, engineers and technicians are contributing to a real-time structure that makes it all go, the modus operandi of perhaps the most complicated space adventure of any kind ever undertaken. Bureaucracy? Says Lee, "it's a work of art."

—Jonathan Eberhart.