Planetary Science: Up from the Ashes?

A year of controversy has cleared the air; plans are now afoot for new missions, which could include a Galileo orbiter of Saturn

A year ago the U.S. planetary science program seemed ready for last rites: the White House budget cutters were on the verge of canceling everything but the Voyager flybys of Uranus and Neptune (*Science*, 18 December 1981, p. 1322), and top officials of the National Aeronautics and Space Administration (NASA) seemed disposed to let them. However, the ensuing uproar produced "a lot of bad vibes and a lot of good dialogue," in the words of one observer—"It was a catharsis that forced people to take a hard look at what they were doing and how much it cost." As a result, there is now a sense among planetary scientists that things are turning around.

For example, NASA is proposing a new Venus Radar Mapper mission for the fiscal 1984 budget, which goes to Congress in January. Europe and the United States are deep in negotiations for a joint planetary mission late in the decade. And the "core program" of modestly priced planetary missions recommended recently by NASA's Solar System Exploration Committee (SSEC) seems headed for a warm reception both in the upper reaches of NASA itself and in the White House.

The change from 1981 is striking. NASA's planetary program acquired one of its most vocal critics last year with the appointment of Hans Mark as the agency's own deputy administrator. Pointing to the rapidly escalating cost of new missions—$850 million for Galileo and $600 million for the Venus Orbiting Imaging Radar (VOIR)—he urged that solar system exploration be "deemphasized" while NASA learned to exploit the capabilities of the space shuttle—by building a space station, for example. Meanwhile, the President's science adviser, George A. Keyworth, was saying that he saw much more payoff in space astronomy than in new planetary probes.

Since then, however, both men have endured a firestorm of protest from their constituents in the science community and have changed their tone considerably. "There was never any intention of canceling the planetary program," Keyworth now maintains, while Mark emphasizes the importance of planetary research in NASA's overall program and praises the efforts of the SSEC to find cheaper ways of conducting the missions: "I think it has done a terrific job in understanding the problem and formulating the solution," he says.

Meanwhile, thoughtful planetary scientists now admit that mission costs *have* gotten out of hand and that cost control must become a central concern. Witness the Venus Radar Mapper.

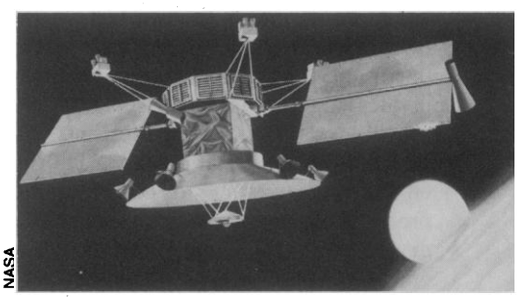
Both the SSEC and the National Academy of Sciences' Space Science Board have ranked the mapping of cloud-wrapped Venus among their highest priorities. Understanding the geophysics of Venus would shed light on the evolution of Mercury, Mars, the moon, and especially the earth. But when the VOIR was indefinitely postponed last year, the program managers at NASA headquarters realized that their only hope of saving it was to slash costs dramatically. So they arbitrarily cut VOIR's $600-million price tag in half and in effect said to the mission designers at Jet Propulsion Laboratory (JPL), "See what you can do."

Clearly, there was no way to answer that kind of challenge without a fundamental rethinking of the mission. The most expensive parts of VOIR's design were driven almost totally by the requirements of its synthetic aperture radar. A sophisticated and costly communications system was needed to handle the radar's enormous output of data. Worse, imaging the planet at 0.1-kilometer resolution meant placing the spacecraft in a circular, polar orbit only 300 kilometers up, which in turn meant finding a way to dissipate the spacecraft's high relative velocity when it arrived from the earth. The idea was that VOIR would carry a massive heat shield and put on the brakes by skimming through Venus's upper atmosphere.

However, technology has recently come along that would allow the processing of radar data from a noncircular orbit. So the JPL engineers made their fundamental change: eliminate the heat shield, forget about the circular orbit, and instead put the spacecraft in a high, slow ellipse around Venus.

It meant sacrificing VOIR's high-resolution capability. The goal is now 1-kilometer resolution over 70 percent of the planet. But it also meant that the same high-gain antenna used to communicate with the earth could now do double duty as the imaging radar itself: during each leisurely outward swing the spacecraft could pivot toward the earth and transmit the data it had recorded only a few hours before when it was close to the planet.

To close the remaining gap in costs, JPL dropped VOIR's upper atmosphere instruments to focus the mission exclusively on geology, and reconfigured the spacecraft around hardware left over from the Viking and Voyager missions of the mid-1970's. The result is the $300-million Venus Radar Mapper. If approved this coming year, it could be in orbit around Venus by late 1988.



NASA

The Venus Radar Mapper

Whether the mapper will actually make it into the budget request this year is anybody's guess—it depends on negotiations between NASA and the White House's Office of Management and Budget. But whatever happens, the mission does seem to represent a good-faith effort to give the Administration what it says it wants: high-payoff science at a minimal cost.

On another front, the spirit of European-American cooperation in space was noticeably soured last year when the Reagan Administration's first budget blitz forced NASA to cancel its portion of the International Solar Polar Mission, an effort to send twin spacecraft simultaneously over the opposite poles of the sun. The Europeans were outraged. They had already sunk millions of dollars into a mission whose scientific return would now be sharply curtailed.

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But apparently they were not put off totally. In late 1981, National Academy of Sciences' president Frank Press received a letter from Hubert Curien, who is president of the European Science Foundation (roughly the European equivalent of NAS), head of CNES, the French space agency, and a member of the board of directors of the European Space Agency. Given the cost of solar system exploration and the proven benefits of scientific cooperation in the past, said Curien, the time is ripe for a joint venture in planetary science.

Press responded enthusiastically, as did Keyworth and the top officials in NASA. The upshot was that a joint working group has been formed under chairmen Eugene Levy of the University of Arizona and Hugo Fechtig of the Max Planck Institute in Heidelberg.

"There seems to be a real desire to take a bold, high visibility initiative," says Levy. His working group's job is to find missions that are suitable, one study team looking at potential asteroid or comet missions, while another looks at potential missions to the inner planets.

Obviously, a major international collaboration should be one of high scientific significance, he says. But, just as important, the mission must be one that divides naturally into two separate and roughly equal parts: the participants will want to feel like equal partners, and the engineers will want to minimize the problems of interfacing hardware. An example might be a mission to visit several asteroids, says Levy. One side could build the mother spacecraft and the propulsion system while the other built a series of small probes to be left behind at each stop. Or there could be a Mars mission that involved both an orbiter and surface probes.

"We envision a final report about a year from now," he says, "but we should know the shape of things by spring." If the current enthusiasm lasts, the joint mission should be ready for a new start in fiscal 1986.

Meanwhile, after 2 years of work, the SSEC has formulated recommendations on a core program of planetary missions designed to be conducted within a roughly constant budget of some $300 million per year:

- Venusian surface. The Venus Radar Mapper remains the community's highest priority by far, both because of its scientific import and because it will return data quickly (as soon as 1988). The committee considers the spacecraft an archetype of the low-cost missions in the core program.
- Comets and asteroids. These objects have never been visited, yet they contain chemically primitive material that could offer insight into the formation and earliest history of the solar system. The SSEC puts high priority on a mission that would rendezvous with a bright, short-period comet, and study the nucleus in detail. It also recommends one or more missions to the main belt asteroids in the early 1990's.
- Terrestrial planets. The highest priority in this class goes to the Mars Geophysical/Climatology Orbiter, which would determine the global surface composition of the planet and the role of water in shaping its climate. Other high-priority missions include a Mars Aeronomy Orbiter (probing the physics and chemistry of the upper atmosphere), a Mars Surface Network or Lander, and a Venus Atmospheric Probe. Many of these missions could be adapted from standard spacecraft. It would take surprisingly little effort to turn a communications satellite into a Mars orbiter, for example.

The committee also recommends that the core program include a Lunar Geochemical Orbiter and a Near-Earth Asteroid Rendezvous mission, both with a view toward the ultimate exploitation of near-earth resources. The missions could be made cost-effective by the use of instruments developed for the top-priority Mars Geochemical/Climatology Orbiter.

- Outer solar system. The highest priorities are a systematic study of the atmospheres of Uranus, Neptune, and Saturn, and a study of the atmosphere and surface of Saturn's giant moon Titan. For these missions the committee recommends Galileo-style probes. However, only Saturn and Titan missions are included in the core program. Getting probes to Uranus and Neptune with current launchers would require a swing by Jupiter in 1992, which in turn would require a large commitment of funds to the project in the near term. An additional priority is a further understanding of the rings and satellites of Saturn. Thus, the SSEC recommends a Saturn orbiter, which could be derived quite cheaply from the Galileo orbiter.

The SSEC most recently met in Boulder, Colorado, on 22 to 25 October. Quite a few members went there hoping that the committee would vigorously endorse a new opportunity for a Galileo mission to Saturn. But it was not to be.

The idea first surfaced at JPL last spring. But it was only this summer that it became a real possibility, when Congress approved the Centaur rocket as the booster that would send Galileo on its way toward Jupiter (*Science*, 10 September, p. 1012). The plan to use a less powerful booster was dropped. As Galileo project scientist Torrence V. Johnson points out, however, the Centaur decision does two things.

First, it delays the launch from 1985 to 1986 (the spacecraft will take a faster trajectory and will actually get there sooner). This leaves key personnel with little to do between the time Galileo is finished and the time it is launched. Since they have to be paid anyway, says Johnson, and since a good deal of spare Galileo hardware already exists, why not have them spend that time putting together a duplicate Galileo? It would cost very little, and could stand by as a backup until the original is safely on its way.

But assuming that everything goes well, he says, one then has the choice of either sending the duplicate to the Air and Space Museum or using it—which leads to the second thing that Centaur does. It provides just barely enough power to get the duplicate Galileo into orbit around Saturn. The trajectory would be complex, involving extra loops around the sun and a second swing by the earth. But a launch in 1987 would get the spacecraft there in 1995, with a choice of dropping the probe either into Saturn itself or into Titan.

For the SSEC the idea was enormously appealing. However, it was also quite new, and many committee members argued that the costs are still far too uncertain to make it a centerpiece of the recommendations.

Worse, taking advantage of the 1987 launch opportunity means that the mission would have to go into the budget as a new start in fiscal 1985, which in turn means a commitment of some $50 million in the near future. That would be a big lump to swallow in the current economic climate, particularly when a Saturn orbiter is not the SSEC's highest priority. It is all very well to seize an opportunity, but many members were concerned about the psychological impact on the program if the first thing they ask for is turned down. Some suggested that the duplicate Galileo be used for a comet rendezvous instead.

In the end, the Galileo-Saturn option was reduced to a bare mention in the committee's report, although it is still a live possibility. The committee has suggested to NASA that its own activities be extended for another year, during which it could both examine Galileo-Saturn more carefully and study more ambitious missions that were not appropriate for a core program.—**M. MITCHELL WALDROP**