Space Science on the Rebound?

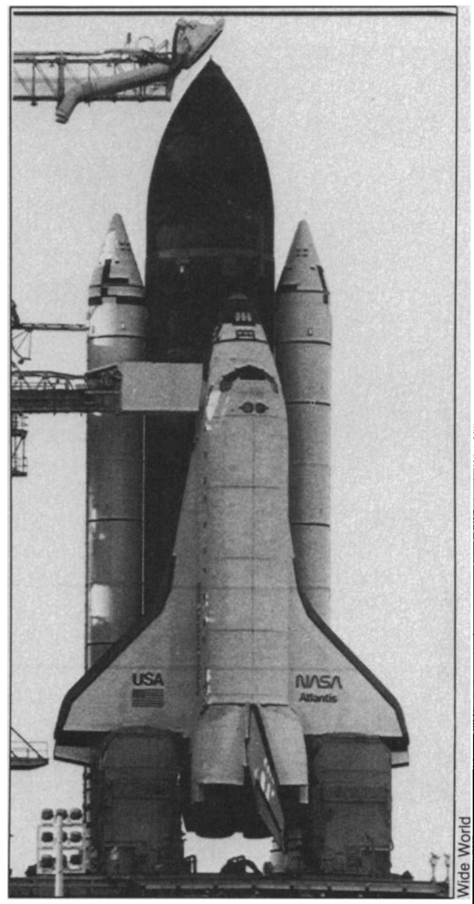
NASA is planning the most vigorous series of space science missions since the 1960s; but will it be able to carry them out?

WHEN THE LAUNCH of the space shuttle Atlantis was aborted 31 seconds before ignition on the afternoon of 28 April, space scientists held their collective breath. With the Magellan radar mapper mission to Venus tucked into its payload bay, Atlantis was carrying what Brown University geologist James Head calls "the flagship of planetary science." Magellan, he says, "is what gets space science back on schedule."

Indeed, the launch of Magellan promises to be pivotal for all concerned. In the aftermath of the 1986 Challenger disaster, the National Aeronautics and Space Administration (NASA) is anxious to prove that its renovated shuttles can meet the demands of a time-critical launch. Fortunately, Magellan's launch window for getting to Venus extends until 28 May. But if the agency somehow fails to meet that deadline, then Magellan will have to be trucked off to a warehouse for two more years while the planets crawl back into position for another attempt—at an additional cost of about $100 million. As *Science* goes to press, NASA has pushed back the launch of Atlantis until 4 May at the earliest.

For the scientists themselves, meanwhile, Magellan has become much more than just another mission. Assuming that Atlantis lifts off in time, it will be a symbol of rebirth. Not only will Magellan be NASA's first major science launch since the Challenger disaster of 1986—and the first U.S. planetary launch of any kind since Pioneer Venus in 1978—it will inaugurate what NASA space science chief Lennard A. Fisk is calling "the Second Golden Age of Space Science": the most ambitious series of space research missions since the glory days of the 1960s. The current schedule calls for the launch of 45 science and applications payloads over the next 5 years. "The whole complexion of the community is going to change," says Fisk.

When Magellan finally reaches Venus, the flood of data coming back from its radar—4 trillion bits, enough to fill 500,000 library volumes—will far exceed the data returned from all previous planetary missions put together. And when the output from all the other missions starts pouring in on top of that, says Fisk, then scientists who have



Wide World

Atlantis unlaunched.

spent the 1980s feeling parched for fresh data are suddenly going to find themselves drowning in data. "When I was a working scientist you'd go to meetings and people would be analyzing data from missions 10 years ago," he says. "But in the next 5-year interval, you'll find that there's been one or two major launches *between* meetings."

Indeed, in 1989 alone the current launch manifest calls for three major science launches after Magellan: the Cosmic Background Explorer in June; the Galileo mission to Jupiter in October; and the Hubble Space Telescope in December, or possibly early next year. Then in succeeding years the manifest continues with the Gamma Ray Observatory; the Ulysses mission to the polar regions of the sun; the Mars Observer; the Upper Atmospheric Research Satellite; the Topex/Poseidon ocean sensing satellite; the multiple satellites of the International Solar-Terrestrial Physics mission; a whole new series of small Explorers; and nearly two dozen Spacelab flights.

So the list is undeniably exciting—on paper. The question, however, is whether it will ever come to pass in reality.

Among veteran space scientists outside of NASA, a certain cynicism is inevitable: the last time NASA proclaimed "the Year of Space Science"—1986—the promises exploded 73 seconds into the last, fatal flight of Challenger. If the NASA science manifest looks impressive now, they point out, it is largely because the payloads that should have started flying then have instead been piling up in high-tech warehouses. Indeed, their enthusiasm tends to be distinctly muted. "I think we're potentially in a period of renewal of the activity and excitement [of space science]" says planetary scientist Sean C. Solomon of the Massachusetts Institute of Technology, chairman of an ad hoc committee of budgetary watchdogs known as the Space Science Working Group. "In general, I'd like to say things are very positive," says space plasma physicist Thomas M. Donahue of the University of Michigan, the former chairman of the National Academy of Sciences' Space Science Board.

On the other hand, even the most cautious of them have to admit that NASA's science programs look a lot healthier today than anyone would have thought possible 3 years ago. As recently as last year, for example, Donahue was saying in public that his conscience would not allow him to encourage any more graduate students to go into space science; now, he says, "Things are really looking up."

One reason for that turnaround is that NASA seems sincere in abandoning its exclusive dependence on the shuttle as a launch vehicle—the policy that left the U.S. space program so thoroughly grounded in the aftermath of Challenger. It is too late to reconfigure Magellan, Galileo, and Ulysses for expendable rockets. But by 1991 almost the only science payloads left on the shuttle will be Spacelab missions, which are designed for it. All in all, 15 of the 43 payloads scheduled by the end of 1993 will go aloft on expendable rockets.

A second reason for renewed optimism is Fisk himself, who from all reports has given NASA's science and applications programs a sense of coherence and purpose that has been conspicuously lacking for more than a decade. In an effort to keep the momentum going after the current flurry of missions, for example, Fisk has laid out NASA's first 5-year strategic plan for space science. Among other things, the very fact that the plan contains a prioritized list of candidates for new major missions means that a perennial source of bickering and infighting among the various space science disciplines has been eliminated. "It gives people a sense of where they are," says Louis Lanzerotti of AT&T Bell Laboratories, Donahue's successor as chairman of the National Academy's Space Science Board.

No matter how clever Fisk is as a planner, however, he may well find himself stymied by the federal deficit. The brutal fact is that carrying out NASA's current wish list, which includes flying the existing science missions, starting new science missions, *and* building a $16-billion space station, would require an annual budget about twice what the agency had before Challenger. Officially, NASA is still ramping up to that level: President Bush has promised to move toward a plateau of roughly $15 billion. But the chances of NASA's ever getting there seem dim. "Bush is all supportive of space—but he doesn't want new taxes," says David Moore, space analyst at the Congressional Budget Office.

Like many other knowledgeable observers on Capitol Hill, Moore thinks the agency will get cost of living increases, at best—say, $11.5 billion this year. And that means that NASA may soon have to make a fundamental choice: either give up the space station, or decimate everything else it does.

It is hard to say how NASA officials would respond to that choice. On the one hand, as Fisk points out, "A space station without space science would be foolishness. You'd be building a warehouse in the sky—with nothing to put in it." But on the other hand, he says, "space science without human exploration, I suspect, is unstable. A $10-billion space program that only does science lacks what the political system has demonstrated that it feels essential: extending human presence into the solar system."

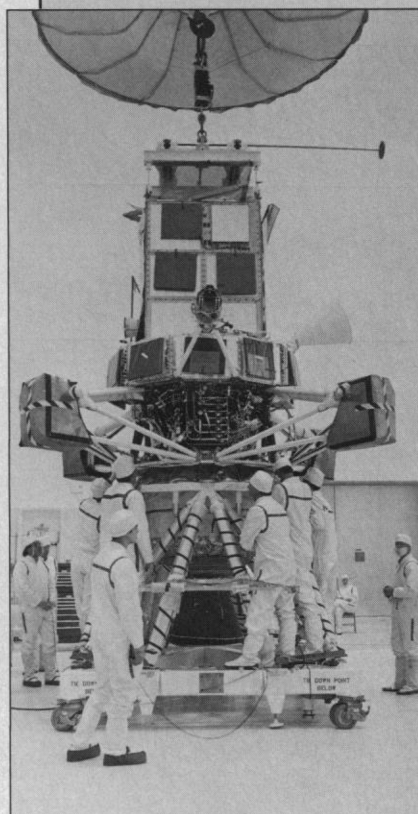
And yet, if Moore is correct in his assessment of the coming budget crunch, it is hard to see how the choices can be avoided much longer.

■ M. Mitchell Waldrop

The Unveiling of Venus

When the planet Venus started out life some 4.6 billion years ago, it had essentially the same size and composition as the infant Earth. And yet it evolved into something totally different: a bone-dry rock shrouded in clouds of sulfuric acid, with a surface hot enough to melt lead. Why? Was it simply that Venus was closer to the sun and therefore hotter? Or were there more subtle, internal processes at work?

Magellan will try to provide some of the answers. Once it arrives at Venus on 10 August 1990 and goes into orbit, it will point its 4-meter radar dish downward through the clouds and systematically start to map the surface. "We're going after the global questions on Venus, looking for the analog of plate tectonics and plate spreading," says Steven Saunders, who serves as Magellan project scientist at NASA's Jet Propulsion Laboratory.


National Aeronautics and Space Administration

Magellan. *The spacecraft undergoes a pre-launch checkout.*

The hints from previous missions have been tantalizing. In the late 1970s the Pioneer Venus radar altimeter produced a crude global map of Venus with roughly 100 kilometers resolution. It shows "continents" rising out of vast rolling plains, which seem more or less analogous to the sea floors on Earth. Then in 1983, the Soviet Union's Venera 15 and 16 orbiters produced radar maps of the planet's north polar regions at a resolution of about 1.5 kilometers, good enough to suggest the existence of mountainous fold belts, volcanoes, lava flows, and—possibly—tectonic spreading centers.

Magellan, however, will give scientists a global geologic map of Venus at resolutions of 100 to 300 *meters*. Moreover, its radar altimeter will map the Venusian landforms with a height resolution of 30 meters. On Earth, such a map would show individual hillsides, fields, and ravines. In fact, says Saunders, from an overall perspective, Magellan's maps of Venus will actually be better than those we have for Earth—because three-fourths of our planet is underwater.

In addition to being a science mission, however, Magellan is also a case study in creative cost-cutting. In 1984, after a more sophisticated and complex mission known as the Venus Orbiting Imaging Radar had been canceled on budgetary grounds, JPL designers found a way to salvage the concept by cutting the original $600-million price tag in half. They did it in two ways: by simplifying what the spacecraft had to do, and by scrounging spare parts from other spacecraft wherever possible.

The result was Magellan. Its 4-meter main antenna, which will do double duty as the mechanism for beaming radar pulses at the Venusian surface and for communicating with Earth, was left over from the Voyager mission, which was launched in 1977. The ten-sided spacecraft "bus," which holds computers, tape recorders, and other electronics, is likewise a Voyager spare. The gyroscope design is taken from the Viking mission that went to Mars in 1976. Other parts use designs developed for the upcoming Galileo mission to Jupiter. And at least one component, a small antenna used for communication with Earth during Magellan's outward journey to Venus, is left over from the Mariner 9 Mars mission in 1972.

Thus, Magellan is a highly sophisticated product of the string-and-sealing wax school of experimental design, in which the apparatus is cobbled together from whatever is lying around the laboratory. But with any luck, say Saunders and his colleagues, the data it returns will be equal in quality to what the original design could have obtained; the imaging radar technology has advanced that much in a decade. "We'll be doing as well or better with the imaging by working smarter," he says.

■ M.M.W.