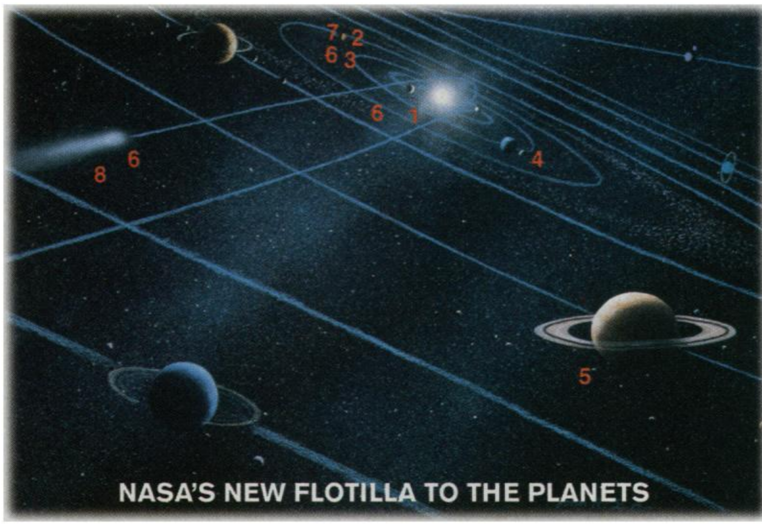
Small Missions Lift Planetary Science

Mars Pathfinder's success and a stable of new missions signal progress in NASA's push for smaller, cheaper, and faster spacecraft. It has also revived the planetary science community

When Jacklyn Green completed her Ph.D. in astronomy in 1989, her professional future looked bleak. With few planetary missions on the books, there seemed little chance for her to pursue her work, including peering into the nuclei of comets. "It was demoralizing coming out of grad school," she recalls. "When I went in, planetary science was a national priority. Then I discovered it's not."

Fortunately for Green and other young planetary scientists, the world has changed again. A quiet revolution that began several years ago is starting to reinvigorate the flagging field. Pathfinder's triumphant landing on Mars in July marked the first in what promises to be a slew of smaller and cheaper missions built at a faster pace (see graphic). NASA's space science budget is no longer in free fall, and the agency has begun a batch of programs to deliver new technologies that could aid future missions. The new era also has changed the way scientists work, forcing researchers into smaller and more nimble alliances. "It's adapt or die," says Green, who is working on a small cometary mission at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California. "Now it's a thrill a minute."



JOHN FOSTER/PHOTO RESEARCHERS

Launch Date	Name	Mission	Cost
1. February 1996	NEAR	asteroid encounter	$183 million
2. November 1996	Mars Global Surveyor	Mars mapper	$231 million
3. December 1996	Mars Pathfinder	Martian lander & rover	$267 million
4. October 1997	Lunar Prospector	Moon mapper	$63 million
5. October 1997	Cassini	Saturn encounter	$3.3 billion
6. July 1998	Deep Space 1	flyby asteroid, Mars, and comet	$140 million
7. January 1999	Mars '98	orbiter and lander	$187 million
includes:	Deep Space 2	Mars microprobe	$26 million
8. February 1999	Stardust	comet sample return	$208 million

Until recently, those thrills were few and far between as NASA focused on massive, expensive, and lengthy projects. Take the upcoming $3.3 billion Cassini mission to Saturn (see p. 1598). It was thought up in the early 1980s and proposed in 1989, yet its first data won't arrive until 2004. Such large missions were designed to study as many aspects of a planet as possible—atmosphere, magnetic field, moons, and surface features. And the results of the Voyager series, the Mars Viking lander, the Magellan mapper of Venus, and the Galileo spacecraft now circling Jupiter proved spectacular.

But enthusiasm and funding for such planetary efforts began to dry up as NASA turned its attention elsewhere—to the international space station, to a network of Earth-orbiting environmental satellites, and to large observatories like the Hubble Space Telescope. The long waits and potential failures inherent in large missions also took their toll. The loss of the $800 million Mars Observer as it reached the Red Planet in 1993, for example, was nothing short of a disaster for a large community awaiting a massive flow of data from its suite of instruments. One researcher likens participation in the huge team of scientists and engineers involved in such projects to "entering a black hole." And those who designed the experiment often played no role in analyzing the results. "That's unhealthy," says Bruce Murray, a planetary geologist with the California Institute of Technology (Caltech) in Pasadena and former JPL director. "Science is about building an experiment and interpreting data. What we had was a bureaucracy doing science. Very few people could participate."

Demise of the mainframe

The time was ripe for a change, and former industry executive Dan Goldin proved to be a willing catalyst. Named to head NASA in 1992, Goldin has forced managers to scale back on the size and cost of their missions, demanded that data be placed on the World Wide Web for all to see, and channeled money into efforts aimed at developing new technologies for planetary spacecraft. During one visit to JPL, he pointed at a model of the $250 million (in 1977) Voyager and declared there would be no more such hefty spacecraft. "It froze my blood," one researcher recalls.

Planetary scientists feared that the loss of major missions would cripple the field. But Wes Huntress, NASA space science chief, says the move made scientific as well as financial sense. "We're moving away from the mainframe era of planetary missions," he says. "Now we're in the workstation era—and we're trying to get to that of the personal computer."

To do that, the agency has set up two new programs, along with a long-term Mars exploration effort. One, called Discovery, is a radical departure from NASA's former centralized, bigger-is-better approach. Instead of announcing a target—such as Saturn—and enlisting teams to plan a multibillion-dollar mission, NASA is asking small groups of university and industry researchers and engineers to propose their own targets and present a 3-year mission plan for under $183 million. Competition is stiff: Next month NASA will announce one or two winners for the fifth round of funding, chosen from a pool of 70 entries.

The New Millennium program, by contrast, seeks new technology that could benefit future science missions. Three of the four planned flights in this program, to be overseen by JPL, involve planetary science; their focus will be on the development of innovative spacecraft systems to lower the cost and time involved in reaching distant planets. NASA also plans a series of Mars missions to build on the success of Mars Pathfinder. Also led by JPL, this program hopes to put an orbiter and lander on the planet every 2 years, culminating in a sample-return mission in 2005. In addition, Huntress hopes to win funding for a new mission to one of three regions—Pluto and the Kuiper Belt, the sun, or Europa, Jupiter's intriguing moon—to ensure continued exploration of the outer solar system.

The fact that NASA is able to make such plans while its budget appears to be shrinking is the result of a remarkable turnaround: After suffering a cut of nearly $200 million last year, NASA's annual budget for all space science now seems likely to hold steady, at $2 billion. Credit goes to the budget deal between Congress and the White House and to the success of Mars Pathfinder and the Near Earth Asteroid Rendezvous mission—both of which are Discovery efforts. In particular, Discovery's 1998 budget is likely to rise from $77 million to the requested $107 million, while New Millennium would increase from $49 million to $76 million. Huntress insists he can deliver a productive program on a flat budget by streamlining operations, using new technologies, and replacing large spacecraft with smaller ones.

Tough transition

The first real proof that Goldin's gamble with the planetary program could pay off was the successful 4 July landing on Mars by the $267 million Pathfinder. Planetary scientists hope they're on a roll. A mapping spacecraft was due to arrive in Mars orbit this week, while a probe to the moon is slated for launch on 23 October. Work is also under way on visits to comets, asteroids, and additional visits to Mars. And that list doesn't include the launch of Cassini.

The pace has lifted the somber mood that has prevailed for a decade. "There is a lot of activity and excitement," says Lou Lanzerotti, a geophysicist at Lucent Technologies in New Jersey. "It's a fundamental change," concurs University of California, Los Angeles, space physicist Christopher Russell. Looking across subdisciplines ranging from geology to atmospheric chemistry, he observes, "there isn't a single community that should be upset."

A Leaner, Faster Jet Propulsion Lab

PASADENA, CALIFORNIA—They were called Rose Bowl floats because of their similarity to the extravagant platforms built for this city's famous New Year's Day parade. And for a quarter century, the massive spacecraft built here at NASA's Jet Propulsion Laboratory (JPL) have indeed dazzled the public with Technicolor images of Saturn's rings, the dusty red surface of Mars, and the wildly varied moons of Jupiter. Like the floats, however, the probes required huge amounts of time and effort for a relatively brief moment of glory. So when tight budgets and demands for a quicker payoff led NASA to abandon large spacecraft for smaller and cheaper missions that could be launched faster and built anywhere, many thought that the agency had rained on the lab's billion-dollar-a-year parade.

But 5 years later, JPL officials have demonstrated that the show can go on. A leaner lab is emerging from that troubled time with a string of new programs and a widely hailed Mars mission under its belt. "It was a very traumatic change," says JPL director Ed Stone. But the recent success of the Mars Pathfinder lander marked a turning point. "It demonstrated we could do something new," he says.

The lab, owned by NASA but operated by the nearby California Institute of Technology, until now held a virtual monopoly on building and operating those planetary spacecraft. Nestled in the mountains just northeast of Los Angeles, the lab had an annual budget exceeding $1 billion at its 1992 peak. And its 7600 scientists, engineers, and technicians made it the undisputed center of U.S. robotic exploration. So when NASA shifted gears, it plunged the lab into crisis. "It's been rough—morale was very low," says one JPL official. There are 800 fewer people at the lab today than in 1992, and the number of staff members is likely to shrink by another 1000 within 3 years.

JPL is also fighting to preserve its title as king of the planetary science hill. It has been the lead partner in only two of the first four Discovery missions, NASA's attempt at smaller, cheaper, and faster exploration of the inner solar system. (Johns Hopkins University's Applied Physics Laboratory near Baltimore and NASA Ames Research Center in Mountain View, California, are each in charge of one other mission.) What's more, those efforts—which cannot exceed $183 million and must be built and launched within 3 years—provide far less work for the lab than NASA's old-style planetary probes, such as the $3.3 billion Cassini mission scheduled for launch next month after 8 years of intensive effort (see sidebar).

The uncertainty and turmoil of the past few years prompted many older researchers and engineers to retire, while others left to join the aerospace industry or universities. Moreover, the large, hierarchical teams that were the hallmarks of programs like Cassini have broken up into smaller teams that work more closely with outside academics and companies. "In the old days, we either did the work in-house or contracted out," says Stone. "In the new world, we are doing whatever is needed."

JPL's rebirth was evident in July, when the Mars Pathfinder—a Discovery mission—landed on Mars. A daring display of high-tech wizardry on a comparatively shoestring budget of $267 million, the mission captured the attention of the U.S. public and calmed worried lab workers. "It was a major event that affected everybody here," says Stone.


Dirt cheap. JPL's Mars '98 lander will be the second in a series of smaller missions to the planet.

NASA/JPL

JPL's renaissance isn't likely to end with Pathfinder. The lab has a role in two of the five proposals now being considered by NASA as finalists in the next round of Discovery missions, and individual JPL scientists are involved with the other candidate projects. It is also handling the New Millennium program, NASA's attempt to develop advanced technology for upcoming missions. The first Millennium mission will rendezvous with an asteroid, a comet, and Mars, while another will send tiny penetrators into the martian surface and a third will visit a comet. The lab will also continue to operate NASA's Deep Space Network and oversee Mars exploration. "There are missions on the books, there is more work, and the mood has changed," a JPL researcher says. "And it's now a very entrepreneurial place."

While the work may keep JPL's plate full, it leaves some researchers with a bad taste in their mouths. "JPL went out and sold a couple of technology programs that will do a little science," says Christopher Russell, a space physicist at the University of California, Los Angeles. "But we're not getting science return for the dollars." Stone, however, argues that smaller and cheaper missions need new technology to reach the outer solar system.

The shift to smaller probes is not just a good idea for JPL, Stone adds; it's the right way to do planetary science these days. "It's better to have a mission to Mars every 2 years than every 2 decades," he says. "It's a new era—if we want to explore the surface of a planet, we need to go there more often. You don't need the large, comprehensive missions now." –A.L.

Cassini Faces Last-Minute Hurdles

While planetary scientists are excited about new opportunities to explore the solar system (see main text), last week the team preparing for the launch of the Cassini mission to Saturn was preoccupied with earthly concerns that threaten the mission. A technical glitch and a growing outcry from antinuclear protesters are a telling reminder of the complexity and visibility of large and intricate spacecraft.

Of immediate concern is a tear in the insulation of a probe attached to Cassini, caused by a surge of air from the spacecraft's air-conditioning unit. The Huygens probe, contributed by the European Space Agency, is designed to parachute through the thick atmosphere of Titan, the only moon in the solar system with one. The repair work will push back the 6 October launch date by at least a week.

NASA/JPL

Megamission. The Italian antenna is lowered onto Cassini, with the gold-covered European Huygens probe already attached.

The mission has a 4-week launch window for arriving at Saturn in July 2004. Its path involves an elaborate series of slingshots to Venus, back to Earth, and on to Jupiter before heading to the saturnian system. A launch after that date would force the 2-ton spacecraft to take a longer route that would require more fuel and, thus, leave less time to collect data once it arrives.

The second problem relates to the craft's use of radioisotope thermal generators filled with plutonium-238 as an energy source. Antinuclear protesters contend that the power supply, used instead of solar panels because of the craft's distance from the sun, poses a health and safety threat if the launch fails or the spacecraft burns up in the atmosphere. They want President Bill Clinton to exercise his authority to cancel the mission.

NASA officials say that extensive in-house and external analyses as well as failure simulations show that any release of material is highly unlikely during a launch failure, while a release during an Earth swing-by is extremely small—less than one in a million. "I'll have my family at the launch," says Beverly Cook, the Department of Energy (DOE) program manager of the generator systems. "And I certainly wouldn't do that if I thought I was putting them in danger."

But protesters and a handful of researchers dispute this assessment. They say NASA and DOE—which is responsible for the generators—are underestimating the threat and putting the residents of south Florida at risk. "NASA bureaucrats have done a self-serving analysis," says Michio Kaku, an American Physical Society fellow and City University of New York theoretical physicist who is a leader in the effort to stop the launch. He added that tests to simulate the failure of the generators were inadequate. Opponents hope to block the mission either through a possible court injunction or by sending boats into the safety zone off the coast shortly before launch.

Space agency officials say they are confident that neither the tear in the Huygens probe nor the protesters pose a real threat to the program, which has been 8 years in the making and marks the last of a long series of major planetary spacecraft. But they underscore the technical and political difficulties in orchestrating such missions.

A successful and timely launch would send the spacecraft on a tour of Saturn's famous rings, its 18 moons, and the swirling dense cloud system of the planet itself. After releasing Huygens, the Cassini orbiter will continue its way among the moons and rings, with its dozen scientific instruments ranging from cameras to radars to spectrometers transmitting data through an Italian-built antenna. **–A.L.**

But the new era is hardly utopian. The big programs of the past "had more budget slack and could support more people," says one science administrator in close touch with the planetary community. The newer ones, by contrast, are smaller and more competitive. "If you're one of the lucky ones who gets a [Discovery] mission, everything is rosy," he adds. But the odds are long. "The dark side is that everyone is exhausted—and there's a lot of wasted effort" if you lose. At the same time, says Caltech's Murray and others, a shake-out was unavoidable. "There was an overproduction [of planetary scientists] compared to what the market could bear," he says. And although the largess is being spread around, some disciplines are more likely to prosper than others. The focus on possible life beyond Earth has put the spotlight on geological questions, for instance, while areas such as magnetic fields have less appeal to funding agencies.

The new approach has also forced planetary scientists to become more well rounded. In the past, says Murray, "there were too many modelers who had never designed an experiment and carried out the observations." Now, scientists must have a broader view of a planetary mission and are forced to build partnerships with other universities and companies. Green, for example, started as a modeler, but describes herself now as "an engineering-oriented scientist." The shift, she says, "was a matter of survival."

Ironically, the rising tide of opportunities has created an unforeseen problem: It's threatening to swamp the peer-review system. With virtually every planetary scientist involved in bidding for a Discovery mission, it's difficult for NASA to find enough qualified reviewers who don't have a conflict of interest. There is also concern that NASA's fascination with new technology will limit the scientific payoff. Moreover, most planetary scientists continue to believe that the government is underfunding their field. "It's still a fragile situation," warns Jonathan Lunine, a planetary physicist at the University of Arizona, Tucson. "We could lose a couple of missions, and we'd be back to where we were in the mid-1980s."

But Huntress has little patience with such criticism. "I'm sorry, but I think we're doing pretty good," he says. "We'll have more missions and more data, and there won't be long hiatuses," he says. "And the public is more engaged."

Goldin, meanwhile, already is thinking about a flotilla of space-faring vessels that will take NASA well into the 21st century. At a recent speech in Cambridge, Massachusetts, he described sails, 20 meters on a side, that are driven by the sun's energy and attached to robots that could darken the skies of Mercury, Venus, and Mars. He also mentioned aquabots swimming underneath Europa's icy crust—assuming, of course, that there really is liquid there—a system of seismic detectors on Mars, and an extra–solar system probe traveling at speeds of nearly 1 billion miles a year. Then there are spacecraft built in one piece, rather than as separate systems of instruments, propulsion, and communications. "This will create great angst among scientists" who are reluctant to work more closely with engineers, he warned. "But it's going to happen."

Whether this ambitious vision becomes reality will depend on continued funding, new technology, and cutting-edge science. But there's no doubt that things are looking up for a field that has been down in the dumps for a long time. Says Green: "Now when I go to work, there's something always hopping."

–Andrew Lawler