NASA Mission Gets Down to Earth

The space agency is once again revising its multibillion-dollar constellation of environmental monitoring satellites. But will its more practical approach really fly with skeptical politicians and disgruntled scientists?

The vision was audacious. By the turn of the century, a fleet of huge spacecraft bristling with sophisticated instruments would be circling the globe and transmitting back a torrent of data on every slight change in the planet's biosphere. Like a team of nurses and doctors hovering over a celebrity patient with a chronic illness, scientists from around the world would analyze the data and come up with diagnoses of Earth's condition. Politicians could then use the results of this global checkup to set environmental, economic, and scientific policies well into the 21st century.

That strategy was laid out in 1989, when President George Bush made the multibillion-dollar Earth Observing System (EOS) the centerpiece of the new U.S. Global Change Research Program. But 6 years and three major redesigns later, managers of the National Aeronautics and Space Administration (NASA) program are struggling to define a less ambitious but more down-to-earth vision that will be more popular with politicians and satisfy unhappy scientists. Whether they succeed will become apparent in the coming weeks, when the National Academy of Sciences (NAS) releases a comprehensive report on the program's status and Congress determines the program's 1996 budget.

Much is riding on the outcome. The EOS program nearly rivals the space station in cost—estimates vary from $7 billion to $33 billion—and complexity. It funds thousands of researchers investigating the interaction of land, sea, and atmosphere and how human activity figures into the equation. But the NASA effort lacks strong and broad support from the scientific community, and it now faces a tough challenge in Congress. Many House Republicans dislike it both for its expense and its environmental focus. In addition, they fear the results could lead to more regulation of the environment.

To counter both the political and scientific criticism, NASA managers intend to shift the balance of the program from long-term monitoring to research on shorter term effects. That means a move away from studying decadal global change—modeling and geodynamics, for example—and toward acquiring information immediately useful to such groups as farmers and the fishing industry. They also plan to shrink further the instruments and spacecraft and are considering use of commercial communications satellites.

"You had this grand comprehensive vision that started EOS off," says Charles Kennel, NASA's associate administrator for Mission to Planet Earth (MTPE), of which EOS is a part. "But people said, 'Hey—what will EOS do for us next year?' " Robert Price, who heads the mission at Goddard Space Flight Center in Maryland, agrees that the early rhetoric was too esoteric. "There is [immediate] societal value that we never emphasized," he says. "We made it seem there would be no results for 15 years. We didn't do a good job of showing there would be short-term results."

The changes are meant to make EOS seem more practical to lawmakers. Senators from farm states are particularly enthusiastic about the shift to a shorter payoff and the focus on climate. And researchers say the near-term focus is more realistic, given the complexity of the global system. "What we want is for EOS to be the springboard for a long-term monitoring system," says Dudley Chelton, an Oregon State University oceanographer.

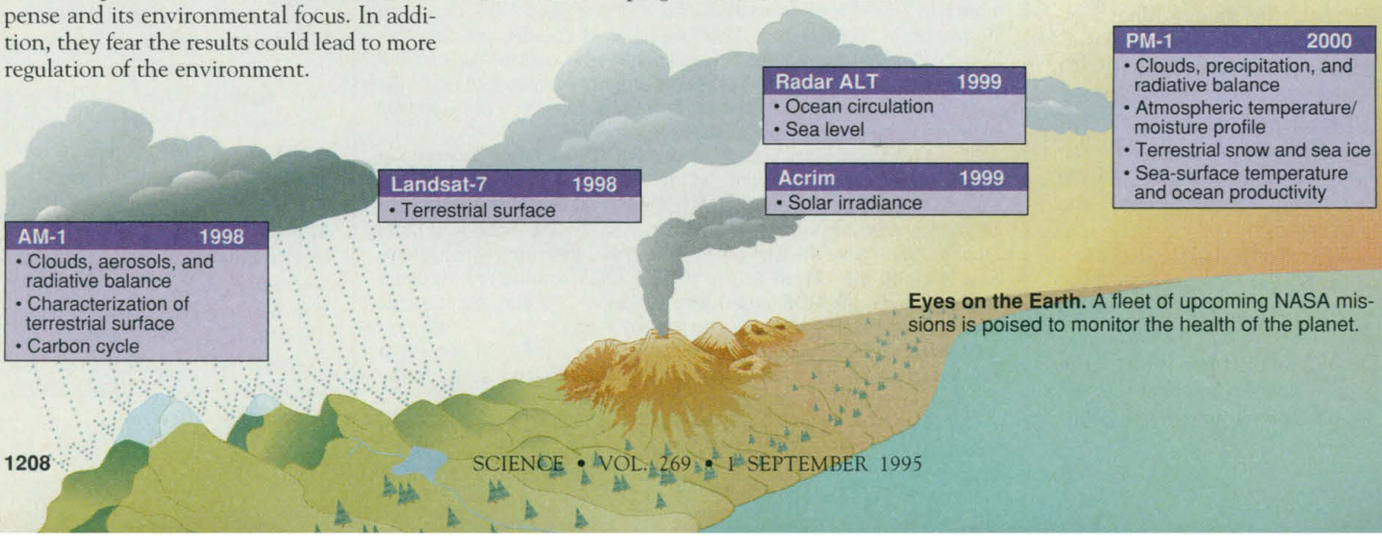
Even so, some want NASA to consider more fundamental changes. *Science* has learned that the draft NAS study, scheduled for release this month, urges NASA to rethink the EOS program after it launches the first three major satellites (see graphic). That could mean fewer and smaller spacecraft than the agency now plans. And even if the program survives with only minor reductions in 1996, House members are likely to resume the attack next year.

Thinking big

EOS was conceived in the early 1980s by a loose coalition of geophysicists, atmospheric researchers, and oceanographers. The idea that emerged from a 1982 NASA workshop, chaired by Harvard University atmospheric physicist Richard Goody, was for a satellite initiative to collect data on the oceans, atmosphere, ice sheets, and land. Newly elected President Bush endorsed the approach, in part to combat criticism that the government was ignoring the potential threats of ozone depletion and global warming.

NASA's original plan was tied to the space station program to arouse enthusiasm among scientists for the human space effort. It included a series of bus-sized satellites that would be serviced by the space shuttle, as well as the most complex civilian data system ever conceived (*Science*, 27 September 1991, p. 1481).

But change has been as common to EOS as it is to the global climate it is designed to study. NASA's Earth observation programs, notes a recent National Research Council (NRC) report, "have been in a state of annual redesign for more than 5 years." Since 1990, EOS's budget, reflecting activities through the end of the decade, has been whittled down from $17 billion to $7.25 billion; gone are the massive 13-ton spacecraft in the original



Eyes on the Earth. A fleet of upcoming NASA missions is poised to monitor the health of the planet.

plan, along with many of the instruments that were to be on board. Kennel insists the changes will not fundamentally alter the kinds of data that researchers receive.

Despite the cuts, EOS remains the largest single component of the U.S. global-change research program, which includes 18 federal agencies and several White House offices. It makes up most of the $1.3 billion annual budget for global-change research at NASA, which receives about two thirds of the annual budget for the government's overall global-change program. Administratively, EOS is part of MTPE, which embraces small environmental probes as well as the larger satellite constellation and its data system. The space agency is also coordinating its effort with the remote-sensing plans of Japan, Europe, Russia, and Canada.

"Liberal claptrap"

Republicans in Congress paid little heed to the program until this year. But the new majority, opposed to many Democratic-backed environmental programs and looking for budget savings, zeroed in on global-change research in general and, in particular, MTPE. In April, House Science Committee Chair Robert Walker (R–PA) questioned the scientific underpinnings of the program and asked the academy to review its status. Walker thought MTPE might be preoccupied with global warming, a bogus issue in the eyes of many conservatives. For example, at a press briefing on 7 June, Representative Dana Rohrabacher (R–CA), who chairs the Science Committee's energy and environment panel, derided the U.S. global-change effort as "scientific nonsense." Global warming, he said, is at best "unproven, and at worst ... liberal claptrap."

The week after Rohrabacher's salvo, the General Accounting Office (GAO) produced a report for Walker that calculated EOS would cost $33 billion, including launch and operations costs, between 1991 and 2022—a figure comparable to the price tag for the space station. "It is clear the original price of this program must be scaled down," Walker said upon receiving the GAO report. "We have to make the decisions today that will lead to long-term savings." His prescription is a less elaborate data system and instruments that could ride aboard commercial satellites rather than more expensive government-built spacecraft.

Meanwhile, the House virtually eliminated the global-change research efforts in the Commerce and Interior departments. And the budget resolution that the House passed in June would trim EOS by a total of $2.7 billion during the next 7 years. While that legislation is not binding on appropriators, it reaffirmed Republican distaste for the effort. Despite a warning from NASA Administrator Dan Goldin that the proposed cut "would dismantle the national approach to U.S. global-change research" and cripple EOS, in July the House slashed the 1996 budget for NASA's MTPE from $1.3 billion to $1 billion. "If this is a down payment for the $2.7 billion cut," says Kennel, "it basically stops EOS in its tracks" after the first satellite is launched in 1998.

EOS supporters are counting on the Senate to restore much of the money. And NASA officials are shoring up their support by emphasizing immediate rather than long-term effects of the research. If MTPE lives up to its promise, says Senator Conrad Burns (R–MT), "the program will easily pay for itself in lives and property saved and improved water management."

Burns, who chairs the Senate Commerce subcommittee that authorizes NASA funding, included the full $1.3 billion requested for MTPE in his NASA authorization bill. His chair, Larry Pressler (R–SD), is another fan, in no small part because the EROS Data Center in Sioux Falls, South Dakota, stands to play a major role in the global-change effort. "I believe Mission to Planet Earth is NASA's most relevant program," he says.

One advocate who isn't from a farm state is Senator Barbara Mikulski (D–MD), the ranking minority member of the subcommittee that appropriates NASA funding. Her support is tied to the fact that Goddard in Greenbelt, Maryland, plays the central role in coordinating the program. Staff aides predict that the Senate will grant the full $1.3 billion, and that House and Senate members will then reach a compromise as part of an overall spending bill for NASA and several other agencies. "They'll split the difference," predicts one NASA manager. But House staffers say that next year they may try to cap the program at $1 billion a year.

"Pretty disgusted"

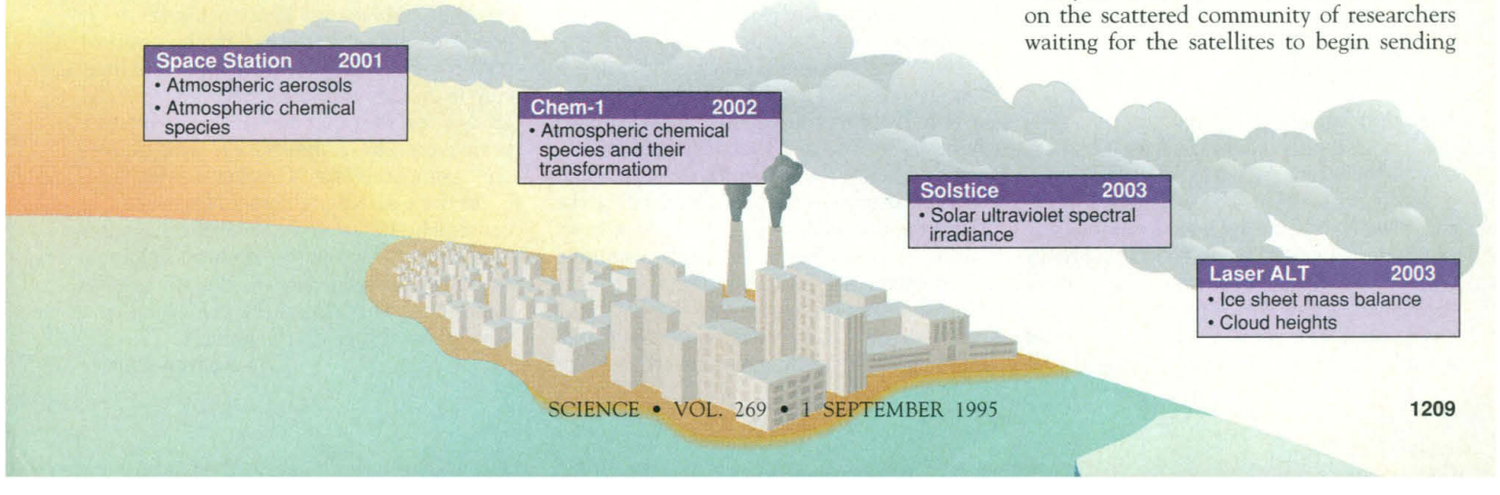
Criticism of the program is not confined to Republican members of Congress, however. The years of confusion have taken their toll on the scattered community of researchers waiting for the satellites to begin sending

GLOBAL CHANGE SATELLITES AROUND THE WORLD

Name	Origin	Launch Status	Purpose
ERS-1	European	In Orbit	Data on ice patterns, land and sea surface temperatures
ERS-2	European	In Orbit	Also contains ozone-mapping and -monitoring instruments
JERS-1	Japan	In Orbit	Data on land, atmosphere, and sea
Radarsat	Canadian	1995	Measurements of Earth's surface
ADEOS	Japan	1996	To study the chemistry of troposphere and stratosphere, collect land and sea data
Meteor 3M-1	Russia	1998	To study atmospheric aerosols and chemical species
ADEOS II	Japan	1999	To study the surface wind speed and direction over the global oceans
NOAA Series	U.S.	Continuous	Weather satellites that also gather global-change data.
DMSP Series	U.S.	Continuous	Defense weather satellites for visible, infrared, and passive microwave measurements of sea, land, and air

SOURCE: NASA

ILLUSTRATION: K. SUTLIFF SOURCE: NASA



back data. "Most of them are pretty disgusted," says Robert Watson, associate director of environment within the White House Office of Science and Technology Policy and a former science director for MTPE. Adds John McElroy, dean of engineering at the University of Texas, Arlington, and a strong supporter of the mission: "They are fed up; they are dropping out; they are saying the government doesn't really want to do this. The younger group is turning its attention elsewhere."

One reason is money. Last November a NASA science advisory panel blasted the agency for reducing the share of the EOS budget devoted to research rather than hardware. The money, which goes to about 1700 principal investigators around the country, is divided fairly evenly between NASA scientists and university-based researchers. It supports work on a host of global-change topics, using data already beamed from space and other climate information to prepare researchers for using EOS. The agency's 1996 request for EOS research is $128 million, a tenth of the total requested for MTPE and almost 30% below the 1994 level. The cuts pose "a serious loss" to the program, the Earth system science and applications advisory committee stated in a November 1994 report.

It galls some researchers that the cuts come at the same time that funding for the program's hardware and software has been on the rise. And a congressional staffer warns that there is not enough money to keep the community together until EOS spacecraft are transmitting data. "We're going to give them a gift of data they may not be able to use," he says. Watson calls the reductions "an appalling and fundamental error. There is going to be a huge increase in data, and if anything, the budget needs to go up."

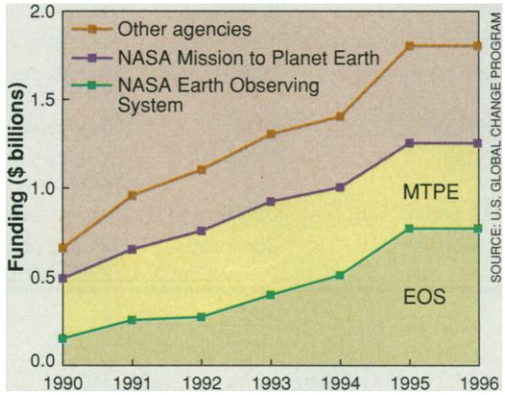
NASA managers say they are aware of the problem but that it was unavoidable. "There has been a lot of pain out there because of the reductions," admits Robert Harriss, chief scientist for MTPE. "We've had to cut off some people in the middle of their work." Harriss has since consolidated several different pots of research funding, raising the program's visibility within the agency in preparation for the next budget cycle. But Watson and others aren't convinced. "It's just a way to play with the numbers," Watson says.

Trimming its sails

But money is only part of the reason for academic discontent with NASA's role in the global-change effort. These concerns came to a head in July during a workshop held at the Scripps Institution of Oceanography in La Jolla, California, to hammer out a set of recommendations for the sweeping global-change study requested by Walker. The panel was asked to pay particular attention to EOS.

A draft report resulting from the meeting praises NASA's efforts, according to participants, but calls for the agency to review program plans after the launch of its first three major satellites—AM-1, PM-1, and Chem-1. Those three are too far along in planning to be altered significantly, but the second half of the program could be simplified, it notes. The draft, however, is short on specifics of what should be done.

Meeting participants also tackled the thorny issue of the EOS data system. NASA plans to build nine centers to process the data beamed back from the spacecraft and prepare them for scientific use. A series of independent reviews has been highly critical of the system. An NRC study released in January 1994, for example, concluded that the plan was too centralized, too inflexible, and likely to become obsolete quickly. Researchers, the report stated, "will receive data in forms over which they will have little control and which may be difficult to manipulate."



Global change$. EOS is the major element of global change research at NASA, which gets the lion's share of federal funds for the initiative.

Although NASA officials have been reworking the plan to make it more accessible to users, many researchers remain uncomfortable with its generally centralized approach, says John Dutton, dean of the college of earth and mineral sciences at Pennsylvania State University. Dutton's panel discussed the idea of operating the centers more as private entities than as NASA facilities, according to participants, in an attempt to remove red tape, increase access, and foster innovative uses of the data.

NASA's Harriss used the meeting to sketch out a more short-term approach to EOS research. He proposed reducing work on longer term studies into geodynamics and global climate modeling and redirecting research into such near-term goals as understanding the flow of pollution downwind from Asia, measuring atmospheric ozone, and examining phenomena like volcanoes and El Niño. Harriss also envisions a system that combines satellite data with information from probes in a farmer's field, leading to more efficient use of fertilizer. Satellite monitoring of vineyards can spot the spread of some diseases better than visual inspection on the ground, he notes, giving California grape-growers a potential edge over foreign competitors.

NASA chief Goldin has encouraged program managers to take this more applied approach to EOS data, says Harriss, who believes that the two approaches can coexist. "You have to do the short-term work anyway to get to a long-term understanding of the climate," Harriss says.

Is it enough?

Some scientists worry that the sudden emphasis on short-term applications for EOS will be viewed as a transparent attempt to mollify politicians. "This program was mispackaged as a global-change program, and now we are losing a lot of credibility because it appears we're changing our story," says oceanographer Chelton. And even if EOS is placed on a firmer scientific and political footing, the program will not be out of the woods. Many House Republicans will likely remain suspicious at best, and the fight for a slice of a shrinking NASA budget—which nevertheless protects the multibillion-dollar space station and space shuttle programs—is certain to intensify. Moreover, global-change researchers enter the ring with a poor record.

"The space science community is more concentrated and more politically savvy," says Texas's McElroy, referring to the community's successful lobbying this summer against a plan to cancel the Cassini mission to Saturn and close several NASA centers (*Science*, 14 July, p. 156). In contrast, says a House Republican staffer, the global-change community "is not big enough, politically influential enough, or popular enough for people to put big bucks into this." And White House officials say the community's most influential voice, Vice President Al Gore, is preoccupied with other matters.

But there is more to global-change politics than a scramble for increasingly scarce taxpayer dollars, Kennel insists. EOS observations have a down-to-earth quality that is missing from other NASA missions aimed at the planets and distant stars. "The results," he points out, "concern absolutely everybody. And the publication of scientific results is going to lead to a response in the political system"—for example, the suggestion to limit carbon dioxide emissions. That's exactly the kind of reaction that concerns conservative lawmakers like Rohrabacher, who derides environmentalists as "Chicken Littles."

In the end, Kennel says, politicians must decide whether to act on scientific diagnoses of Earth's condition. Researchers only hope that lawmakers will agree first on the need to understand what makes the planet tick and what, if anything, ails the patient.

–Andrew Lawler