Administrative Entrepreneurship and Space Technology: The Ups and Downs of "Mission to Planet Earth"

W. Henry Lambright, Syracuse University and Syracuse Research Corporation[1]

How does administrative entrepreneurship operate in a changing policy environment? Using the case history of NASA's "Mission to Planet Earth" (MTPE), W. Henry Lambright reveals how agency leaders contended with changing opportunities and constraints to develop and sustain political support for that program. The perilous and turbulent journey of MTPE illustrates the strengths and limits of administrative entrepreneurship in contemporary American government.

The National Aeronautics and Space Administration (NASA) is an agency seeking to pour new wine into old bottles as the post-Cold War era evolves. NASA is as close to a "pure technology" agency as exists in the U.S. federal government. It conducts and supports research and development (R&D) at the frontier of knowledge. Its work is most visibly associated with missions *from* earth, such as manned space launches and planetary science missions. Yet it is now the locus of a major new program attuned to the global environment called Mission *to* Planet Earth (MTPE).

A study of MTPE gives insights into the difficulties government organizations face in seeking change, and how new large-scale technologies are shaped by the political/policy process. It points up the role of administrative leaders in charting a course for new technology and how their strategies succeed and fail. There is great interest in the subject of administrative entrepreneurship and innovation (Doig and Hargrove, 1987).[2] There is also interest in administrative constraints, barriers that are part of democracy's checks and balances on bureaucracy and the technology it promotes (Wilson, 1991). NASA's Mission to Planet Earth illuminates well the politics of emergent technology in the contemporary era. It reveals how administrative entrepreneurs build political support for their technologies, and the factors that constrain them in keeping that support over time.

Mission to Planet Earth

Proclaimed under another name in 1982, MTPE is a NASA program to develop a sequence of ever-more sophisticated satellites to monitor the ills of the planet. The first MTPE satellite is presently monitoring the ozone depletion problem. Future satellites will probe the ocean dynamics and investigate climate change. The centerpiece of MTPE and by far the dominant element in the program is the Earth Observation System (EOS). EOS is now configured as a group of satellites, flying in formation, providing a relatively comprehensive and simultaneous view of land, sea, atmosphere interactions. This system includes a computer-based element on the ground to collect and disseminate information. EOS is critical to the vision of MTPE, and MTPE is integral to a broader national and international research program called Global Change. It is viewed as essential to answering many policy questions in this area.

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The cost of the full program is uncertain because much of it lies ahead. One can envision a routine system of environmental monitoring in the 21st century. The problem is not the long-term future but the immediate present. Getting to the future takes money, organizational commitment, and agreement from many parties. The future can be delayed a very long time. EOS is in development, and launch of the first elements would not take place until near the end of this century. The present projection is that EOS will cost $8 billion for development between 1992 and 2000, with additional expenditures in the early 21st century. Although substantial, $8 billion is much less than the $17 billion projected for the same period just a brief time ago. That such a great change could occur so quickly is indicative of the uncertain political environment of contemporary technology policy.

The Political Construction of Technology

Virtually everyone welcomes the use of space technology for global environmental problems. The debate is over not whether, but what should constitute MTPE, and who should make the necessary determinations. NASA is the government entrepreneur, but only one actor among a number influencing the course of the technology. In understanding what has happened and why, it is useful to build on a growing body of knowledge called "social construction of technology." This is primarily the work of sociologists and historians, and it is a counter to earlier literature that spoke of technology being out of control or having a life of its own (Bijker *et al.*, 1987; Pinch and Bijker, 1984). Such deterministic views are given much less attention today, although there is no doubt that there are such factors as "technological trajectories" and "momentum."

Trajectories are shaped this way and that by social forces, and government-sponsored technologies, such as MTPE, are shaped by political forces: agencies, President, Congress, and interest groups. Who does the shaping? Who participates; who does not? Is a particular design good or bad—from whose perspective? These questions and their answers matter very much when billions of dollars are involved and the technology relates to the earth's future.

Some sociologists have sought to focus on particular players in the social construction process. There is an "actor-network" theory which identifies "protagonists" working within a network of forces (Law and Callon, 1992). This network includes a "local" set of actors who are part of the technological project (e.g., the agency officials) and a "global network" of external actors (e.g., Congress, President, Office of Management and Budget [OMB], interest groups). Students of science and technology policy, most of whom are political scientists and public administrationists, also are engaged in using concepts of social construction and actor-network theory in analyzing large-scale technology. Their vocabulary is different, but the concepts are similar. For example, their actor is a public entrepreneur, and their network is a coalition (Lambright, 1976). Their emphasis is on political construction, and they give more explicit attention to administrative strategy in the coalition-building process.

Clearly, a technology is shaped by those who choose to participate, and some actors are more important than others. Power is a key variable. The entrepreneur's influence is critical, since, without this actor, the process of technological development comes to a halt. There has to be a protagonist. Occasionally, some actors possess unusual power to shape a technology. Historian Thomas Hughes (1990) calls these individuals or organizations "system builders." But most bureaucratic entrepreneurs, most of the time, do not have the "negotiating space" (i.e., autonomy) to accomplish their will. They bargain and compromise. So it is with NASA in the case of Mission to Planet Earth.

Stakes

For NASA, MTPE is a technological program it regards as necessary for its bureaucratic stakes of survival, growth, and extension of "core technologies." Its interests are revealed in its orientation toward the development of large-scale technology on the frontier of research and development. NASA is very close to a "pure technology" agency in the sense that its mission embodies constant innovation: the continual development of new systems of launch devices and spacecraft. It favors technologies that are proven, but often has goals that force it to reach beyond state-of-the-art. Sophisticated and large-scale technologies keep the agency going and not only serve the needs of internal interests (in its program offices and centers), but also outside developers in the aerospace industry. It is seemingly always under pressure to establish long-range goals to guide it, but there is little consensus as to what goals make the most sense.

NASA faces a network of "users" in Mission to Planet Earth. Users may be other agencies, researchers, policy makers, and even the public. Users vary in their stakes vis-a-vis one another. For example, a researcher almost always sees uses in a longer term time frame than a policy maker concerned with the next election. Also, users do not want technologies that are overly sophisticated, complex, and expensive from their standpoint. They are interested in solving their problem, not developing the technology for its own sake, and are interested in having technology friendly to them. Unfortunately, when a problem cuts across many different users and involves planetary ills that are themselves uncertain, it may be impossible to satisfy everyone—developer or users. Thus it is that negotiation, bargaining, or conflict occur over the design of a technology.

The interplay between NASA as developer and other interests as users takes place over time—years for large-scale development projects. This interplay is at the crux of MTPE's political construction. It can be seen in various stages of the process of policy affecting the technology: (1) agenda setting, during which the protagonist conceives and promotes the technology as a program; (2) adoption, at which point the President and Congress decide to develop the technology proposed by the administrative entrepreneur; and (3) implementation, when the agency seeks to actually build the technological system.

What ends up coming out of this process—if anything at all—is usually quite different from that which is envisioned by the entrepreneur at the outset. The key factor is the relative power of the entrepreneur vis-a-vis users. This turns on the resources it has in relation to others, and its strategies in promoting a particular technological view. Three bureaucratic strategies are exemplified by MTPE thus far: (1) the use of rhetoric, such as the words and symbols of technology to attract general good will and adherents; (2) coalition-building, the forging of alliances around a technology to bolster it against opposition; and (3) the seeking of freedom of action or negotiating space within a network of activity.

Over the course of time, entrepreneurs try to build an equilibrium of forces within which they can do their job. This equilibrium constitutes a balance of power among the actor and others in the network, a temporary closure of controversy necessary for forward motion. Unfortunately, larger events at the macropolitical level can disrupt the equilibrium, restructure the network, and change the balance of power within. Relationships must be renegotiated—along with the technological design.

Agenda Setting

The idea of MTPE preceded the program and even the name by years. What has been cited as the moment of conception occurred in 1976. In that year, the Viking spacecraft arrived at Mars. "Viking's intended landing spot was found to be unsuitable.... [This caused NASA] to call in the nation's leading Mars specialists for an intensive three-week meeting covering all aspects of that planet. The meeting led to the selection of a safe landing area. At the end, one of the scientists involved, Michael McElroy of Harvard University, repeated something he had begun to tell other earth scientists: 'You know, we've never done anything like this for the Earth'" (Edelson, 1988, p. 6).

The idea stuck at NASA, and was on the agenda of various members of the Office of Space Science and Applications (OSSA), sponsor of Viking. The trigger for action was the coming of new managers to NASA, with the Reagan administration, in 1981. These included James Beggs, administrator, and Burton Edelson, head of OSSA. Both men were actively involved in seeking new missions for the agency. The Space Shuttle was then seen as moving from R&D to operations, and possibly spinning off to some new entity. As a development agency, NASA needed a major R&D priority to succeed the Shuttle, and the Space Station was the one Beggs selected. But Space Station was at this point a long way from the required presidential approval. Edelson, meanwhile, had the same problem of new missions from his vantage point at OSSA. He listened to people in OSSA, heard about exciting space science projects to explore the solar system and universe. But he fastened on "global monitoring" by satellites as an idea whose time had come, one that would do OSSA *and* NASA the most good. Edelson, an engineer, envisioned the launch of large platforms in space carrying a range of new sensors. Such a program had the scale and growth potential to help keep NASA going if Space Station ran up against delays in approval. Beggs agreed.

Rejection

In 1982, NASA convened a scientific group of potential researchers/users headed by Richard Goody of Harvard to study the concept, and it pronounced the notion feasible and worthy (NASA, 1982). The space agency then moved immediately toward the adoption stage. In that year, at a United Nations Conference on the Peaceful Uses of Outer Space, Beggs announced the new program, dubbed "Project Habitat." He called for "an international cooperative project to use space technology to address natural and manmade changes affecting habitability of Earth." The reaction was almost uniformly negative—not to the idea, but to the perceived motive of the program. "It came across like NASA was trying to take over the world," recalled Edelson (1988, pp. 6-7).

This was a preemptive strategy, and NASA did not have the power in 1982 to be preemptive. Many scientists, other federal agencies, and even other governments were angry that they had not been informed. Some members of the Reagan White House thought Habitat was too much like something President Jimmy Carter and his environmentalists would propose. The idea of a comprehensive earth-monitoring system might have been technically ripe for development, but it was not politically ready for adoption.

Constructing a Coalition

Beggs told Edelson to keep "working" on the earth-monitoring system, but do so quietly, and build support for the program. He did not want more controversy, nor did he want competition with his attempt to sell the Space Station.

There had been a limited outside-scientist assessment prior to the Habitat announcement. Now there was mounted an intense and broader scientific planning stage, a stage that in some respects lasted from 1983 to 1986. NASA set up an Earth System Sciences Committee of largely outside experts from many earth science disciplines to review the status and requirements for a comprehensive earth-monitoring system. In addition, two other agencies were invited to join NASA in the planning endeavor: the National Science Foundation (NSF), which was responsible for most basic research in the earth science field; and National Oceanic and Atmospheric Administration (NOAA), the agency that ran the operational weather satellite system and various ocean programs (Edelson, 1988, pp. 6-7).

While this exercise outside NASA was getting under way, NASA was restructuring for the new mission. In 1984, NASA consolidated its earth sciences disciplines into an Earth Sciences and Applications Division, within OSSA. This indicated a new status and influence for earth sciences in the space agency, placing them organizationally on a par with planetary exploration and astrophysics. At the same time, NASA got an Upper Atmosphere Research Satellite (UARS) approved as a development project within its FY 1985 budget. UARS was to be the first start in the long-term comprehensive earth observation program being planned.

In 1985, that program got a new name. Rhetorical strategy demanded something other than "Habitat," which symbolized failure. In contrast to the United Nations-sponsored international meeting where the agency administrator proclaimed Habitat, the head of OSSA used the forum of an editorial in the prestigious magazine *Science*. He proposed a "Mission to Planet Earth" (Edelson, 1985). The name went over well, conveying the image of NASA bringing its considerable resources to bear on earth's problems. With a new name and an expanding bureaucratic-scientific coalition of potential users behind it, the proposal was well received. In fact, parallel to the NASA-led activity, a larger group of earth scientists, working through the National Academy of Sciences (NAS), were planning an even more comprehensive research effort. This was called the International Geosphere-Biosphere Program, known generally as Global Change. Many of the Global Change scientists were potential users of the space-derived data NASA would provide through its proposed program. There was overlap between the Earth System Sciences Committee planning for NASA and those planning for the Global Change program. By linking to Global Change, NASA further broadened its constituency.

There was more to this than simply bureaucratic strategy. The technical relevance of performing ground-based and space-based research in tandem was given dramatic evidence at this time. In 1985, a scientist using ground-based studies discovered ozone depletion over Antarctica. This same year, NASA satellite observations gave additional evidence that an ozone hole existed, and showed its scale and longevity. The impact on national and international consciousness

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was immediate and profound (Roan, 1989). Environmental problems had been growing as a major public issue for years. Now they got unprecedented attention in the media as *global* issues. The discovery of the ozone hole dramatized that the planet was at risk, and the potential relevance of NASA satellite technology to understanding the risk (Jasani, 1989).

The Earth System Sciences Committee (1986) produced a report that proposed a very extensive R&D program extending well into the 21st century. Although much of the report dealt with scientific aspects, its most important recommendation from a NASA perspective was for an Earth Observation System. This constituted an endorsement of the technology being planned by NASA for MTPE. EOS would provide continuous global observations that simultaneously linked atmospheric, oceanic, and land processes. EOS would consist of two 13-ton platforms carrying a large range of advanced sensing instruments. These platforms would provide the values of simultaneity and comprehensiveness in remote sensing. They would be part of a Space Station system. The large platform idea was not new. It was part of Edelson's original Habitat vision. What was different in 1986 from 1982 was its coupling to the Space Station.

How did the Space Station become linked with EOS, and thus MTPE? This was a function not of technological necessity, but of political construction. Administrator Beggs had provided support to OSSA, but warned that nothing should hurt his effort to sell the Space Station. Beggs had gotten the Space Station approved by President Reagan in 1984, as NASA's top R&D priority.

The Space Station had its own political problems. Strong inside NASA, it needed to enlarge its constituency outside the agency. If it could win the support of earth scientists and be seen as useful to environmental protection, it would improve its chances of long-term success. Coalitions require an exchange of some valued resource among members to work. In this case, Space Station got a potential new external constituency, and MTPE turned a possible internal rival into a partner. Moreover, MTPE got Space Station support with NASA leadership for the substantial budget that EOS would require. By allying with NASA's top priority, MTPE became an asset rather than potential problem for the agency, and MTPE gained the prospect of enhanced resources.

MTPE might at this time have moved rapidly to the adoption stage in 1986, carried as part of an already accepted Space Station, had fate not intervened. This was the year of the Challenger explosion. Virtually all NASA programs were put on hold. NASA had to live through a period of NASA-bashing and technological second-guessing.[3]

Out of the turmoil, however, MTPE emerged as a program deemed a higher priority for NASA. Astronaut Sally K. Ride (1987) produced a report for the new NASA administrator, James Fletcher, on NASA's priorities. Mission to Planet Earth was listed first among four "leadership initiatives" for the future. The Ride report was elevated by post-Challenger NASA executives as a guide to the agency's recovery. It could have been viewed as listing choices, forcing decisions on priorities by NASA and the political system. But few participants in the process wanted to make painful choices. Advocates of MTPE wished to get their priority adopted by the President and Congress. Specifically, this meant EOS, without which MTPE meant little. The EOS budget was now projected at $30 billion over a 15-year development and demonstration period.

Winning Adoption

Adoption for a program of MTPE's scale required presidential approval. To get presidential approval in tight budget times meant getting the Office of Management and Budget (OMB) to go along. To enlist OMB, NASA decided to link its fortunes with other agencies under the mantle of Global Change.

In March 1987, William Graham, President Reagan's science adviser, established the Committee on Earth Sciences, later renamed Committee on Earth and Environmental Sciences (CEES). CEES was a committee of the Federal Coordinating Committee on Science, Engineering, and Technology (FCCSET), a subcabinet-level interagency body. Twelve agencies were members of CEES, including NASA, NOAA, and NSF. Graham's interest was to use a relatively moribund interagency mechanism to coordinate various research programs in the environmental sciences and get answers to questions about the greenhouse effect. It took a while for CEES to get going, but once it did, it was taken seriously by the President's science adviser and, more important, by OMB.

NASA's representative on CEES was Shelby Tilford, head of the MTPE program (second in command at OSSA to Lennard Fisk, who had replaced Edelson in 1987). For Tilford, there was strength in external alliance. NSF and NOAA saw gains for their own global change ventures. NASA, NSF, and NOAA wrote OMB that they wished to have their budgets pertaining to global change considered together. MTPE was thus made part of a proposed interagency Global Change program.

OMB was sensitive to how an alliance of agencies might be leverage to get more money. But it also saw CEES as valuable in planning an emerging national program in global change research. The Reagan administration understood that it had to "do something" about the issue of global environment. It was not just domestic pressure. There was international interest at the highest levels. The ozone hole was an acknowledged issue. Greenhouse warming might be even bigger. From the Reagan administration's perspective, research was preferable to regulation, and a way to satisfy some of the environmentalists' demands. OMB, sensing that spending was going to go up anyway, concluded that CEES would be a device it could use to control what would unfold unevenly, agency-by-agency, otherwise.

In 1989, George Bush became President, proclaiming himself the "Environmental President." He chose D. Allan Bromley as his science adviser. The two men inherited an ongoing interagency planning process that had recently produced a report calling for a U.S. Global Change Research Program (USGCRP) (Committee on Earth Sciences, 1989). The report was to accompany the President's FY 1990 budget. Bromley not only embraced as his own the CEES report, but also the CEES-process that produced it. Allying himself with OMB, he said: "Decisions made in the FCCSET [parent organization of CEES] remain made, and don't come unstuck under the final pressures of budget discussions" (Palca, 1991). OMB spoke of "fencing in" the coordinated "national" decisions, so the agencies could not change them.

President Bush went along with his science adviser and OMB, and adopted Global Change as a multi-agency presidential initiative in his FY 1990 budget. Although MTPE was not explicitly spelled out in the interagency report, it was implicit that if there was going to be a national (indeed international) global change program, there was going to be a NASA Mission to Planet Earth, and specifically EOS.

In July 1989, in marking the 20th anniversary of the moon landing, the President publicly heralded MTPE as a new NASA program.

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While Bush made a return to the moon and on to Mars his first space priority, he also said he was going ahead with MTPE. Senator Al Gore, head of the Senate Subcommittee on Space, Science, and Technology, saw the Moon-Mars mission as a "daydream" (Sawyer, 1989). However, as the leading "Environmental Senator," he declared that Mission to Planet Earth was America's true priority in space.

In 1990 (FY 1991), Congress appropriated $191 million to get EOS under way. With EOS funded, MTPE could now be said to be truly launched.

Implementation in a Turbulent Environment

In 1990, the White House adopted EOS (and thus MTPE) as a presidential program. To get adoption, NASA had created for MTPE a coalition of forces internal and external to the agency. It involved Space Station bureaucrats, earth science users, environment-oriented legislators, agencies with Global Change interests, and others. But this coalition was extremely vulnerable. NASA had to find the strategies to keep these forces together. It did not get the time or resources to do so.

There were large (macropolitical) events taking place in 1990 that disrupted NASA and the network of allies it had constructed. The events had to do with the budget deficit, and were embodied in the legislative agreement President and Congress reached in 1990 to set limits on federal spending. All of a sudden, "normal" budget politics, geared to incremental increases, were replaced by a new politics of constraint on overall, government-wide expenditures. To get more money for one program would mean less for another. The change in the environment of NASA and its allies occurred just at the point when EOS needed increased funds for development.

An administrative theory states new organizations must pass a "survival threshold" (Downs, 1967, pp. 5-23). In the life cycle of organizations, a certain momentum (and constituency) must be achieved for an entity to gain a measure of security. To the extent this is true, the quest for survival makes early implementation an especially critical stage in the life of new technologies. It is when an initiating coalition is tightened and molded into a working partnership—or begins to unravel.

The Space Station Decouples

NASA's top priority was Space Station. By allying with Space Station—physically becoming part of it—EOS had solidified internal backing. Now, in the new budget setting, Space Station was being forced to "downsize" by Congress. Space Station found it expedient to decouple EOS from its core apparatus. From a technical standpoint, this was no problem. Indeed, EOS could be placed in space as an independent entity, and perform better in an orbit different from that travelled by Space Station. Thus, the decoupling of EOS from Space Station, which occurred by decision of NASA Administrator Richard Truly, in 1990, did not initially seem to harm MTPE. For MTPE got not only technical independence from Space Station, but also budget independence.

The problem was that competition for funds within NASA between Space Station and MTPE was now possible, even likely—unless NASA's overall budget went up substantially. In 1990, a blue-ribbon commission on the space program, headed by industrialist Norman Augustine, recommended that NASA's budget rise to accommodate both missions *from* and *to* Earth, because both were equally important. This was wishful thinking. Like it or not, NASA could not have two very expensive priorities. The question was which priority had the most clout. The answer was not Mission to Planet Earth (U.S. Advisory Committee on the Future of the U.S. Space Program, 1990).

Scientists Defect

High energy physicists (as seen with Superconducting Super Collider) and astronomers (illustrated by the Hubble Space Telescope) had learned that they had to hold together as a user community if they wanted expensive machines. Earth scientists had much less experience in the political construction of big technology. The concept of "Earth System Science" was part of strategic rhetoric NASA and its scientific advisers used to help get atmospheric, oceanic, and geologic scientists to identify their common concerns in studying the planet. Earth scientists did in fact have different interests, and forcing them all to use the same facility (the EOS platforms) did not sit well with those who preferred more specialized satellites.

Ironically, the most visible scientific dissenter was within NASA (part of the local network, to use the vocabulary of actor-network theory). This was James Hansen, Director of the Goddard Institute of Space Studies, a unit of NASA. Hansen was an outspoken scientist in general. He had testified in 1988 before Congress that global warming was here, thereby attracting considerable publicity from the media and criticism from his colleagues. In 1989, he wrote MTPE management that before deploying machines in space, NASA should augment the "brain power" to use them. Mission to Planet Earth, he charged, "is described in terms of number of pieces of hardware in the sky" (Marshall, 1989, p. 1249).

Later that year, NASA heard similar criticism from a gathering of 500 scientists it had invited to a meeting at Goddard to discuss the uses of EOS. The general question asked was whether Mission to Planet Earth was a commitment to science or satellite building. NASA was accused of having a "compulsion to spend billions of dollars on new technology, even if it produces 'horrendous' floods of digital data at a time when the information system is already swamped and support for creating new scholars to use the data is 'minimal.' Before pouring money into flashy new hardware, the critics argued, NASA should shore-up basic research and help the existing earth-monitoring systems, especially those with archives that could be used in climate research" (Marshall, 1989, p. 1248).

In April 1990, an NAS panel that Bromley had asked to review the Global Change program reported. In looking at the overall program, it especially examined the single largest component, EOS. It found the two-platform concept NASA proposed for its design more than necessary. One platform, not two, would be sufficient for the simultaneous observations desired. The instruments on the second platform might better be arrayed on a number of smaller satellites (National Academy of Sciences, 1990).

Hansen, having lobbied unsuccessfully inside, now took his case outside, publishing an article in *Issues in Science and Technology*. He argued that EOS was indeed needed, but would be years in development, and the greenhouse warming could not wait. He proposed an interim small satellite system, which he called Climsat, that could be placed in orbit sooner, and be addressed specifically to the climate

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problem (Hansen *et al.*, 1990). NASA was not happy, to say the least. Indeed, it already had an interim program planned—called Earth Probes—that would represent a different technical approach than Hansen's proposal.

The scientific dissent—from both inside and outside users—had the effect of interrupting the momentum NASA had built for Mission to Planet Earth and raising questions for the policy makers.

Policy Makers Back Off

The MTPE constituency included environment-friendly legislators. However, even the strongest supporter, Senator Gore, was concerned about the long lead times of EOS. As a user, he wanted answers to policy questions sooner than later. The President had endorsed MTPE as both a space policy and global change policy. But Bush's interest and commitment did not appear to run deep. The fact was that MTPE's political/policy level support was fragile. The elected officials needed to see something for them in the system, and the policy-oriented answers would be years away for EOS.

Also contributing to the dilution of support from both scientists and politicians was the bad image EOS was getting from the media. EOS was being painted in the rhetoric of Big Science. Instead of being an enabling technology for solving the planet's ills, EOS was presented as another megaproject. Big Science was said to squeeze little science, as well as federal programs in housing, education, and other fields. The major issue of the day was budget reduction, and budget talk skewed the way technology was presented. OMB, previously willing to go along with EOS as part of Global Change, now pressed CEES to see if there might be some savings to the interagency budget by restructuring EOS. Thus, relations within the coalition were growing strained.

Now a new actor entered the growing debate over EOS. This was the National Aeronautics and Space Council, headed by Vice President Dan Quayle. The Space Council had not played a significant role in the MTPE policy process up to this point, having deferred to CEES. Along with OMB, the Space Council was alarmed by budget projections. EOS would be "ramping up" at a time when NASA needed money for Space Station, Space Shuttle, and other programs. It pressed for another "outside" look at the EOS design. An Engineering Review Board, composed of leading non-NASA scientists and engineers familiar with space technology, was appointed. Its task was to study EOS during the spring and summer of 1991, and determine if primary values offered by EOS—simultaneity and comprehensiveness—could be gained through simpler, cheaper technology that could go up sooner.

At the same time, in a way indicative of how larger macropolitical issues of budget were overwhelming those of MTPE at this point, legislators from the appropriations committees became more active. Robert Traxler, Chair of the House Appropriations Subcommittee concerned with NASA's budget, wanted NASA—and the President—to choose among space priorities. To force the issue, he moved to terminate the Space Station, and won committee acceptance. There was a bitter debate in Congress, during which President Bush personally had to defend the Space Station to keep it alive. Aerospace industry and foreign governments (partners) lobbied for the station. At the same time, many scientists spoke out against the Space Station to protect their interests in other programs they saw as threatened by the giant program (such as MTPE). NASA was caught in the middle. In the end, the Space Station prevailed, but within a relatively static NASA budget. More money for Space Station meant less for MTPE (Kenworthy, 1991; Asker, 1991).

In this changing political context, the Engineering Review Board and NASA negotiated technical design. In the summer of 1991, the key technical question was whether a valuable Mission to Planet Earth (i.e., EOS) could be carried out with more affordable smaller platforms (or a cluster of satellites) carrying fewer instruments. Could NASA get enough simultaneity from a group of satellites flying in formation? The answer, according to the Engineering Review Board, was yes.

The Engineering Review Board produced a report recommending EOS redesign, calling for the twin 13-ton platforms to be converted into a fleet of smaller satellites. It also proposed that NASA confer with the Department of Defense (DOD), and the Department of Energy (DOE), which had expertise in smaller satellites (*Report of the Earth Observing System Engineering Review Committee*, 1991). The implication was that NASA had a "not-invented-here" problem and could save money by transferring technology within government. The *New York Times* editorialized approvingly: "Smaller is Better in Space" (1991). Congress, meanwhile, provided $271 million for EOS ($65 million less than requested). More important, it wrote into the legislation providing the funds a cap on the program through FY 2000 at $11 billion. This was $6 billion less than NASA had projected during this period as necessary for the two-platform design it favored. In addition, Congress provided funds for interim Mission to Planet Earth efforts prior to EOS—the Earth Probes Program NASA wanted, *and* the Hansen-inspired Climsat mission that it did not want (Conference Report, 1991).

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Restructuring the Program

In March 1992, NASA sent a report on the restructuring of EOS to Congress, informing the legislators of its actions. Instead of two large platforms, there would be a fleet of six satellites. These satellites would carry fewer instruments than the platforms. Hence, this would not be the comprehensive technology, capable of carrying sensors from all disciplines relevant to Earth System Science. NASA had to cut back. Not all uses were equally useful. For example, less attention would be given to ozone depletion (because it could be argued that UARS was in space and was already monitoring this problem) and to solid geophysics (because earth's geology changed so much slower than the other concerns that policy makers wanted to have studied) (NASA, 1992).

That decision seemed to settle the issue of the space portion of EOS, at least for the time being. It would be downsized, simplified, and it was hoped, accelerated. NASA would try to get the first EOS satellite into orbit by June 1998. This would be half a year earlier than NASA had originally projected for the initial EOS platform—a date many believed overly optimistic.

The new approach conformed to the philosophy of the latest in the string of NASA administrators, Daniel Goldin. Goldin was sworn

> *As the coalition weakened, NASA lost much control of the program, at least temporarily.*

in as leader of NASA on April 1, 1992, replacing Truly. Truly had been fired by President Bush, on the advice of the Space Council, for resisting White House policies. Goldin announced that his managerial philosophy was to find ways to perform space technology smaller, cheaper, and faster (Covault, 1992). He argued NASA's culture as an organization had to change to reflect the new times.

In June, Goldin initiated an internal exercise aimed at cutting programs to fit the flat budgets expected the rest of the decade. Again, the Space Station was relatively protected, but not MTPE. In September 1992, it was revealed that the Goldin exercise would save another $3 billion in EOS. Much of the savings would result from giving EOS spacecraft a common design. Also, $1 billion would come from further deferrals and deletions of science instruments from EOS missions ("Goldin's Reviews Prompt Broad NASA Reforms," 1992).

EOS had now gone from $17 billion to $11 billion to $8 billion in estimated 1992-2000 expenditures in less than one year.

In October, Goldin announced an organizational restructuring of NASA to assist in the changes he sought. This included the abolishment of OSSA in favor of two co-equal offices, one for planetary science and astrophysics and the other for MTPE. In organizational terms, this was an improvement in status for MTPE and could be said to have marked the full emergence of earth science as a space agency priority. Whether the move was actually a promotion in practice remained to be seen. That depended on resources that would be made available. The head of OSSA, Lennard Fisk, was moved to the position of Chief Scientist under the reorganization and later left NASA. Shelby Tilford, long-time head of the MTPE division of OSSA and its principal individual entrepreneur over the years, now served as acting head of the new independent Office of Mission to Planet Earth.

Amidst these organizational shifts, debate continued over the design of the technological system. The dispute was now focused on the ground-receiving facility of EOS, called EOSDIS. The Engineering Review Board had said that in view of changes in the space part of the system, EOSDIS needed a second look. In February 1992, a General Accounting Office (GAO) report concluded that there were substantial development risks in EOSDIS that NASA had not addressed, and that new technology would be needed to fulfill EOSDIS goals (General Accounting Office, 1992). Given the data generated from space, EOSDIS would have to be able to store 1,000 times the amount of text in the Library of Congress, take in 2,000 billion bits of data every day from EOS—more information in two weeks than had been collected from all the satellites launched since the 1960s. The cost: $3 billion of the EOS $8 billion budget (Marshall, 1992). A National Academy of Sciences (NAS)panel pointed out the importance of EOSDIS: "If EOSDIS fails, so will EOS, and so may the USGCRP" (Pittman, 1992).

In January 1993, Bill Clinton became President of the United States and Al Gore his Vice President. MTPE was expected to have much more attention because of Gore's interest in global environment issues. In 1989, an equilibrium of interests had been established sufficient for adoption. In implementation, however, there was turbulence. The coalition survived, but with losses. As the coalition weakened, NASA lost much control of the program, at least temporarily. With no one else capable of being protagonist, the ingredients for future technological failure were in place unless the White House shored up the administrative entrepreneur. Whether that would happen was a question for later resolution.

Conclusion

The case of NASA's Mission to Planet Earth illuminates a number of issues relating to government technology policy: the importance of an administrative entrepreneur and its power; the necessity to hold the allegiance of actors in the agency (the local network) while building support from outside constituents (the global network); the dilemmas of maintaining a technological momentum when unforeseen accidents (Challenger) and macro-political debates (e.g., the budget deficit) can disrupt timing and relationships; and the unwillingness of the political system to make hard choices (President Bush, for example, wanted simultaneously the Space Station, MTPE, a Moon-Mars expedition, and other space projects, but he could not or would not get the money for everything). The process of government-sponsored technological innovation is only in the broadest sense linear. There are stops, starts, zigs, and zags. Using rhetoric, coalition-building, and other strategies, an administrative entrepreneur can achieve adoption. But what is adopted can be modified greatly in implementation, especially if the technological coalition weakens in early implementation, when a program must be structured for the long haul. It is in implementation that the costs of technology become most evident, and one program is forced into open competition with another. The real problem in the American system is fulfilling the goals that are adopted.

There are enormous strains on the ability of any administrative entrepreneur to stay the course. Technological termination is always a possibility if the entrepreneur loses too much control of the process. Virtually no one is "against" MTPE in principle. Yet once the downward spiral begins, and a political coalition cracks, at what point does a new equilibrium emerge and something of value get saved?

Protagonists need to control the political process if they are to realize a technological innovation like MTPE. Only then can they get the negotiating space required for success. The case of MTPE shows that they get that control only for brief moments. Hence, the constraints on administrative entrepreneurs are revealed as much as are the opportunities by MTPE. Protagonists move when they can, with what allies they can get. It is two steps forward, one backward. What matters as much as technological brilliance is bureaucratic resilience.

The technological vision of the administrative entrepreneur is inevitably compromised under normal conditions. Habitat came and went. MTPE has gone through successive renditions. It will not be attached to the Space Station. It will not consist of two large platforms in space. It may be a constellation of satellites flying in formation, but how many satellites will ultimately be built, with what sensors aboard, and when they will be launched remains to be seen. If budget problems continue, EOSDIS will likely be reoriented and downsized.

Small may well be beautiful. Or it may not be. What is smaller, cheaper, faster is not necessarily better. Also, technological downsizing leads to constituency reduction. As support diminishes, the technology gets less money and at some point may be too parsimonious to produce much that users value. The danger is not that there will fail to be a Mission to Planet Earth. NASA will survive, the rhetoric will continue, and satellites will no doubt be launched. The concern is that the rhetoric will not be matched by technological reality. As coalitions deconstruct, so also does technology.

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W. Henry Lambright is professor of political science and public administration at the Maxwell School, Syracuse University, and Director of the Science and Technology Policy Center, Syracuse Research Corporation. He is author of numerous books and articles in the field of science, technology, and public policy, including *Governing Science and Technology* and *Presidential Management of Science and Technology: The Johnson Presidency.*

Notes

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2. NASA had as its leader in the 1960s one of the most formidable administrative entrepreneurs the United States has produced, James Webb (Lambright, 1993).
3. For a judicious study of Challenger, see Barbara S. Romzek and Melvin J. Dubnick (1987).

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