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SATELLITES AND POLITICS: WEATHER, COMMUNICATIONS, AND EARTH RESOURCES

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Since its founding in 1958, the National Aeronautics and Space Administration (NASA) has concentrated its effort in developing practical uses for spaceflight, or space applications, in three programs: weather, communications, and Earth resources satellites. Weather satellites and communications satellites have been tested and improved so that they have now reached the stage of routine or operational use, but Earth resources satellites are still experimental.

With applications satellites, NASA had to solve an extra problem not present in most other space projects: these satellites were developed for users outside of NASA. W. Henry Lambright, among others, has pointed out that conflict often arises when the agency developing a new technology is not responsible to the agency that will actually use it. The history of the three applications satellite programs shows different kinds of problems that can arise from this situation depending on the relative power of the various players, the divergence of their interests, and uses to which the satellites can be put.

For weather satellites, problems between NASA and the user agency arose only when the program was nearly ready to make the transition to an operational system. This was true not because of effective cooperation with the user, the Weather Bureau, but because of lack of coordination.

Weather satellites use a television-type camera to take pictures of cloud cover and then radio the pictures to Earth. Two types of weather satellites are now used: low altitude satellites, which rapidly orbit the Earth taking pictures of various areas, and geosynchronous satellites, which orbit at such an altitude that they always remain over the same point of the Earth's surface and therefore provide continuous monitoring of the weather on one half of the globe. Communication technology has been improved so that the satellites now continuously broadcast the television pictures they take. These pictures can be received and used by anyone with an inexpensive antenna and printer. The first weather satellites proved immediately useful for tracking hurricanes and other large-scale features difficult to observe as a whole from the ground. The benefits to routine weather forecasting have been limited, however, by the lack of a model of the atmosphere exact enough to provide completely accurate predictions even from plentiful data.

Research on the possibility of using satellites to monitor weather started as a military project. The project was transferred to NASA in 1959, under President Eisenhower's commitment to put as much of the space program as possible in civilian hands. The Weather Bureau had little voice in NASA's program; NASA formed an interagency advisory committee, but it had little influence. When the first weather satellite, Tiros, was launched in 1960, NASA asked the Weather Bureau to analyze the data. Meteorologists found the data very useful, and within a few days the Weather Bureau started making cloud-cover maps from satellite data and distributing them to meteorologists to aid in making routine forecasts.

NASA planned to follow the experimental Tiros project with a more sophisticated series of proto-operational satellites called Nimbus. The Weather Bureau, however, found the Tiros data satisfactory and was suspicious of the plans for Nimbus because it was very expensive and might not be ready before the last Tiros satellite reached the end of its useful life. The Weather Bureau did not want to commit itself to an expensive satellite program which, once operational, would be paid for entirely from the Bureau's small budget. On September 27, 1963, the Weather Bureau officially notified NASA that it was withdrawing from the Nimbus programs and the existing interagency agreement, and proposed an interim operational satellite based on Tiros and a new agreement making NASA and the Weather Bureau equal partners. The Weather Bureau, a weak agency without much support from its parent institution, the Department of Commerce, could afford to make such a move only because it had found a backer. The Department of Defense offered to cooperate with the Weather Bureau and provide the necessary expertise with space hardware if NASA refused to meet the Weather Bureau's terms. Defense was jealous of NASA for taking over projects from the military space program and was concerned about the possibility of a gap between the Tiros and Nimbus programs that would leave the military without storm-warning information it already depended on. Faced with losing the whole program, NASA negotiated a new agreement with the Weather Bureau for a Tiros operational system.

In this case the political conflict grew out of the divergence of interests of the research agency and the user agency. NASA wanted to develop a second generation of satellites employing the most sophisticated technology, while the Weather Bureau wanted to use the simpler, less expensive system already in hand and not yet fully utilized. The Weather Bureau wanted one sort of satellite and NASA wanted another, but instead of compromising, NASA simply ignored the Weather Bureau. This naturally resulted in trouble when the time came for the Weather Bureau to start planning to take over the system from NASA. The location of the research function in the operating agency, the Weather Bureau, would have slowed down the advance of new technology, but perhaps learning to use the old technology better would have been (and was) more productive. Research groups tend towards independence, whether they are separate or located in operating agencies, and researchers can rarely see that more sophisticated technology is not necessarily more useful.

In the case of communications satellites, the problem of transition from an experimental to an operational system was compounded by conflict over who would be the operational user. The communications industry saw the possibility of large profits, and the Congress had to deal with tricky philosophical issues of public versus private control.

Communications satellites relay radio waves carrying telephone, television, and data signals from one point on Earth to another. NASA tested three varieties. Passive satellites, like Echo, simply provide a reflective surface for radio waves to bounce off. Echo is just a giant mylar balloon. Active satellites, which come in two types, receive the signal from the ground, amplify it, and retransmit it to its destination. Low altitude active satellites, like Relay and Telstar, move rapidly relative to the surface of the Earth. This means that the antenna on the ground must be pointed to follow the satellite and a number of satellites are needed so that one is always available above the horizon. Geosynchronous active satellites, like Syncom, are placed in such an orbit that they remain always over the same point on the Earth's surface. This more distant orbit requires more powerful transmitters and more sensitive receivers on the satellite and the ground, but the advantages of the fixed position are more important. Almost all of the many operational communications satellites currently in use are of this type.

NASA started out with a limited role in communications satellite research—first only passive satellites, then only low-altitude satellites—because of a division of responsibilities with the Department of Defense. Unlike other applications programs, however, this type of satellite was clearly going to be profitable to private industry, which therefore set the pace. American Telephone and Telegraph (AT&T) and, on a smaller scale, other companies spent their own funds on communications satellite research in hopes of getting lucrative contracts later, or, in the case of AT&T, in hopes of gaining a monopoly. AT&T developed its own low-altitude, active, experimental satellite, Telstar, and requested that NASA launch it. This would have put AT&T in a strong position to launch the first communication satellite system as a private venture.

Because of concerns about monopoly, diplomacy, and giving away the fruits of government research, private industry did not get the free rein it wanted. NASA insisted that a government-funded and government-controlled experimental communications satellite, to be developed under a contract awarded by competitive bidding (to Hughes Aircraft Co.), be planned first. NASA envisioned that after its experimental program, Relay, an operational communications satellite system would be owned by private industry. NASA launched AT&T's satellite in July 1962 after awarding the contract for Relay, but before its launch. Meanwhile, the Congress fought over details of the institutional arrangements for the operational system. The Department of State was concerned over a private company controlling the U.S. share of an international communications system; liberals did not want to see government research given away for private profit; conservatives wanted the government out of a function that private industry could handle; and communications and aerospace firms wanted as much of the control and profits as possible. The end result was COMSAT, a private company with some board members appointed by the President, carefully defined federal jurisdictions, and broad ownership by communications and aerospace firms and the general public.

This political fight slowed the development of the technology and altered its character. During the political controversy, NASA proceeded with research on a geosynchronous communications satellite, too advanced for the private companies to risk on their own. The tests of this satellite, Syncoms I and II, launched in February and July 1963, proved very successful. For the first operational communications satellite system, COMSAT chose to develop not the system of low altitude satellites that AT&T and the other communications companies had planned on, but rather a much less expensive system of geosynchronous satellites. In this case, unlike that of meteorological satellites, the users were grateful for the advanced technology that NASA had developed despite their initial lack of interest.

The transition from an experimental to an operational system of communications satellites was disrupted by disagreements more over political philosophy than over technology. The technology was affected, however, when the political arguments provided extra time during which a new technology proved to be superior. AT&T had wanted to gain control over the system by being the first to develop the technology. The company failed to get economic control or contracts for its technology as a whole, but the effort no doubt strengthened its position in Comsat and the component market.

For Earth resources satellites, NASA had to deal with a wide variety of users, leaving the goals of the program uncertain. Without a clear idea of who would use the satellite for what, choices of technology were controversial.

Earth resources satellites provide wide-scale, repetitive pictures of the surface of the Earth for the survey and monitoring of resources. The first *Landsat* satellite was launched in 1972; the second and third are still functioning and carry two sensors: a kind of television camera and a scanner that provides more precise color data. The satellite radios the data to Earth, where it is printed on photographic film or analyzed by a computer. Even at the present coarse resolution of 60 to 100 meters, the satellite radios down 15 million bits of data per second. Processing, storing, and extracting information from this flood of data have proved to be the most difficult technological challenge of the project. The data have been used successfully, at least on an experimental scale, to detect large geological features associated with oil and minerals, to measure the areas planted in different crops (to help predict harvests), to monitor water distribution and snow cover to predict flooding, and to make maps of land use. Users include federal, state, and local government agencies and private firms.

The federal agencies were the only users with a voice in the development of the first satellite. NASA set up a program in 1964 to investigate the use of space vehicles to study Earth resources and transferred money to the departments of the Interior and Agriculture to consider what use they could make of the data. The Department of the Interior developed so much enthusiasm for the idea that when NASA moved slowly in making plans for an experimental satellite, Interior pushed the project along by announcing its own satellite program. An independent satellite project was vetoed by the President because experimental satellites were NASA's domain, but NASA speeded up its project. The Department of Agriculture proposed a different sensor from that desired by Interior. Each agency pushed for a small, simple satellite with the sensor that would make the satellite most useful to the agency. NASA compromised by flying both sensors and choosing spectral bands useful for the widest possible range of applications. Some users have complained that these spectral bands make the data difficult to use because they are not optimal for any application. Compromises were also made in the choice of orbit and NASA settled for two sensors instead of the more elaborate experiment it had originally proposed.

To further complicate the situation, NASA soon realized that some of the greatest benefits from *Landsat* would come from improved resource management on the state and local level. NASA had developed the satellite without consulting these users, and it proved difficult to persuade them to use the new information. NASA set up a technology transfer program for *Landsat*, which started out just publicizing information but has gradually developed joint projects that are effective in convincing states to use *Landsat* data. The states have been reluctant to participate because of distrust of sophisticated technology, which NASA as an agency seems to symbolize, and because they did not want to make an investment until the program had settled into a final operational form. Because of the lack of immediate benefits and wide use after the 1972 launch of the first satellite, the Office of Management and Budget has opposed the transition of *Landsat* from an experimental project into an operational program. The commitment to an operational program, to be managed by the National Oceanic and Atmospheric Administration, was made only in late 1979.

In the case of *Landsat*, NASA successfully played the users off against each other so that none had control, but the result was a project with a shortage of goals and support. The users NASA was most interested in, state and local governments, had not asked for the project or shaped the system into something useful to them. Because of this and their lack of technological sophistication, they had little interest in adopting the new techniques NASA had developed. Perhaps with more involvement of the users in the design and more understanding of the diffusion of new techniques, the project would have brought more benefits by now. In any case, the politics of balancing the demanding agency users and the concept of future state and local users forced NASA to choose the most neutral technology—useful to everyone but ideal for no use. NASA provided different technology than individual users wanted in order to make one satellite serve the whole range of users. The combination satellite is not completely satisfactory, but the Office of Management and Budget would probably not have approved more than one satellite.

NASA has found the process of developing satellite programs for other agencies fraught with controversy. The space agency has, probably unavoidably, looked after its own interests in expanding its research program and pursued advancing technology without much sensitivity to the needs of the eventual users. The problem is a tricky one, however, because NASA can claim with some validity that the users, because they are not technologically sophisticated, do not realize the potential benefits of new technology. The three cases of applications satellites show the users as sometimes grateful and sometimes not for the technology developed despite their wishes. The answer, I believe, lies not in a better balance between the users' demands and NASA's ideas, but in taking the trouble to educate the users to participate in the development of the technology.

Source Notes

My information on weather satellites comes from Richard LeRoy Chapman's excellent dissertation (Syracuse University, 1967) *A Case Study of the U.S. Weather Satellite Program: The Interaction of Science and Politics*. Chapman, like W. Henry Lambridge in *Governing Science and Technology* (New York: Oxford University Press, 1976), emphasizes the transition from an experimental to an operational system as a key policy problem.

My discussion of communications satellites is based mostly on Jonathan F. Galloway *The Politics and Technology of Satellite Communications* (Lexington, Mass.: Lexington Books of D.C. Heath and Co., 1972), and Delbert D. Smith, *Communication Via Satellite: A Vision in Retrospect* (Leyden, Boston: A.W. Sijthoff, 1976). I also looked at Michael E. Kinsley, *Outer Space and Inner Sanctums: Government, Business, and Satellite Communications* (New York: John Wiley & Sons, 1976), a Nader report; J.R. Pierce, *The Beginning of Satellite Communications* (San Francisco: San Francisco Press, 1968), giving the AT&T view; and Roger A. Kvam, "Comsat: The Inevitable Anomaly," in Stanford A. Lakoff, ed., *Knowledge and Power: Essays on Science and Government* (New York: The Free Press, 1966).

There are no useful secondary sources on the history of Earth resources satellites except for W. Henry Lambright, "ERTS: Notes on a 'Leisurely' Technology," *Public Science Newsletter* (Aug.-Sept. 1973), pp. 1–8. The information presented here is based on archival research at NASA and the Department of the Interior for my dissertation, "The Politics of Technological Change: A History of Landsat" (University of Pennsylvania, 1984).

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