principal executive officer of a corporation must sign the application, and Ruckelshaus later told *Science* that he was amazed at the emphasis placed on potential "cheaters" under the program, since "few businessmen, no matter how black their hearts, will be willing to sign a false statement that could land them in jail for 5 years."

Ruckelshaus also said that the new permit program, in spite of the criticisms levied against it, will, for the first time, give the government an accurate assessment of the amount of wastes being dumped into the nation's waterways. Thus, he said, the emphasis on pollution control will shift to specific water quality standards rather than to vague notions about too much pollution. He added that "if conservation groups, or anyone else, object to our water quality standards they should tell us—by lawsuit if it makes them happy—and we'll try to improve them."

Ruckelshaus noted that some of the criticism he had heard of the Administration's new program was actually contradictory. And this is hardly surprising since some of the conservationists' motives for protesting the program are not entirely based on the program's specifics. As one conservation lawyer put it: "The program itself isn't all that bad. It's just that we don't trust the Nixon Administration to regulate industry."

—ROBERT J. BAZELL

R&D Conversion: Former NASA Lab Now Working on Transportation

Cambridge, Mass. At a time when both employment and morale in the science and engineering professions are dropping, the Transportation Systems Center (TSC) in Cambridge stands out as an example of where U.S. technological manpower *could* go from here. Formerly a facility of the National Aeronautics and Space Administration (NASA), TSC is now putting 450 highly trained employees, mainly electronic engineers, to work on the more mundane problems of transportation. And it is facing the resulting problems—and benefits—of "conversion."

The Center was conceived in 1962 as the Electronics Research Center (ERC) for NASA and was to be the space agency's most forward-looking research arm. Plans called for 14 buildings and 2100 employees. The location was to be near the Massachusetts Institute of Technology, a decision alleged to be a sop to Edward M. Kennedy's 1962 campaign pledge that "he can do more for Massachusetts." But logically, the Center was planned to benefit from and boost one of the country's largest clusters of electronics industries around Boston's ring road, route 128. The city of Cambridge drew up renewal plans for the rather rundown industrial neighborhood around the site. Ground was broken for ERC construction in November 1966, and by December 1969 six buildings were completed and 850 people hired, including 100 Ph.D.'s. Even then the new Center was barely in operation; only one of the new buildings, an optics research lab, was occupied, and the remaining employees were working in rented space nearby.

Thus, it was a shock when NASA Administrator Thomas O. Paine came to Cambridge on 29 December 1969 and announced that, owing to budget cutbacks, the newborn center would close on 30 June. "We are simply faced with the hard fact that NASA cannot afford to continue to invest broadly in electronics research as we have in the past," he said. The announcement launched a period of frantic consultations by ERC brass with industry and government to find a new sponsor, public hand-wringing by state politicians embarrassed by Washington's sudden reversal, and loud agonizing by Cambridge officials fearful for their investment in urban redevelopment. Finally, on 25 March 1970, John A. Volpe, Secretary of the Department of Transportation (DOT) and former governor of Massachusetts, announced that DOT would take over the facility on 1 July. He was quoted then as saying that "a substantial majority" of the employees would stay on at the center.

But DOT's 1971 budget had already been "put to bed"—and, aside from NASA pledges of some continuing support, there was no additional money to pay for retaining the 850 employees. The Volpe announcement launched a second round of consultations—this time between ERC staff and the agencies within DOT, to see how much work could be lifted out of existing projects and transferred to the Center. The result was a potpourri of 56 projects, totalling $22.5 million, including $6 million in continued NASA funds and $6.9 million in outside contracts. By 30 June, there were 611 employees left at ERC. On 1 July, only 425 of these were formally hired by DOT. Total attrition over the whole 6-month period was one-half, or 406 ERC employees. The most significant loss was the scientists—mainly physicists. Work for electrical engineers willing to make the switch was relatively easy to find within DOT; basic research, on the other hand, was not. In effect, although drastically reduced, ERC continued intact, but without its "pure" research wing. Some of the scientists who lost their jobs are still unemployed.

DOT's assumption of the Center implied a commitment to research and development—independent of any of the agencies within the department. Previously, the department had only four so-called "research" facilities: the High Speed Ground Test Facility in Pueblo, Colorado, run by the Federal Aviation Administration (FAA); the Aeronautical Center in Oklahoma City, Oklahoma, also run by the FAA; the National Aviation Facilities Experimental Center (NAFEC) in Atlantic City, New Jersey, run by the FAA; and the Fairbanks Research Station in McLean, Virginia, run by the Federal Highways Administration. But the primary purpose of these facilities is to test equipment built by industry for road, rail, or aircraft use. In Atlantic City, for example, NAFEC tests airplane equipment against FAA regulations; the Oklahoma City center trains air traffic controllers. Neither is equipped to do advanced technical work, research on relationships among alternative types of transport, or basic, long-range planning

and analysis. The Cambridge center is equipping itself to do all three. In the words of Robert H. Cannon, Jr., assistant secretary for Systems Development and Technology, TSC "will become the Houston of the Transportation Department." Becoming another Houston isn't easy—especially when the sponsoring agency is DOT, not NASA, and when the staff is trained in aerospace technology, not the earthy problems of ground transportation policy. "We're on probation," says one TSC staffer of this first year. TSC must complete its 56 immediate, short-term projects—some of which employ only one or two people—while at the same time it persuades DOT's own agencies, the Office of Management and Budget, and Congress that advanced electronics can make a difference in the transportation crisis. Director James C. Elms told *Science* that TSC hopes eventually to have fewer but larger projects. Robert W. Wedan, whose Transportation Systems Development division will eventually bring the large mission-oriented projects to the implementation stage, says, "The future of the Center will depend pretty heavily on how well we do this year."

Communications Research

Whether or not TSC succeeds on its own ambitious terms, the fact remains that, after years of virtual neglect, some basic research and development *is* being done in many areas of transportation, including the increasingly vital area of communications. And aerospace brains are probably as well suited to launch the effort as any other. At one end of the transition is reapplication of principles. About four men are working on a microwave device that senses approaching trains and triggers warnings to vehicle intersections. The microwave instrument is far more reliable, apparently, than the present buried-cable devices. Whether it will be cheaper is unknown. As another straightforward example of "conversion" of knowledge, a 35-man telecommunications team, which was designing L-band satellite communications systems for the 1980's under NASA, is now developing a satellite, to be launched around 1973. This satellite will operate on both L-band and present very high frequencies over the West Coast–Hawaii and the North Atlantic heavily trafficked air corridors. There are several projects for upgrading communications systems in the present ("third generation") air traffic control system. Another team of 30 is developing specifications for the next ("fourth generation") air traffic control system. ERC's work on the V/STOL (Vertical Short Take-Off and Landing vehicle) was transferred out when ERC closed; but the ERC V/STOL team is now working on STOL, a version of the same vehicle for city-to-suburb and suburb-to-suburb use.

Can advanced electronics *really* change the face of our transportation problems? One small project at TSC is to develop new devices by which police can test for drunkenness on the road rather than at the police station. A second phase of this project is an alcohol-interlock system: a testing device linked to a car's ignition which automatically prevents an inebriated person from turning on the ignition. Conceivably, if the legal questions of installation are resolved, the device could save a large percentage of the 50,000 people killed and 500,000 hurt annually on the highways.

For those who decided to stay at the Center, "conversion" means different things. Ed Spitzer of the Guidance, Navigation, and Control section, who worked previously in strap-down gyroscope technology, has switched fields; he is now working on microwave scanning for instrument landing systems for aircraft. More typical, however, is a switch not in basic knowledge but in approach. Leo M. Keane, director of Telecommunications, describes the outlook of some technicians who are used to "defining their own terms, closing the door, and working their problem. . . . It's hard to get people to worry about the reactions of the airlines to their invention or to recognize the existence of the civil aviation authorities." The need for engineers who can cope with the factors of public policy, cost, acceptance, and other "soft" criteria affects hiring. "You need someone who can think and talk policy as well as technology," says James P. Andersen, head of Guidance, Navigation, and Control. And Mr. Keane says, "This partly technical, partly political arena is new to us—but it's got to become second nature."

ERC has lost through "conversion" some of its important community ties. A youth campaign with a local technical high school had successfully employed graduates who were training in electronics. This program was dropped before ERC closed. But at TSC there are neither the funds nor the certainty of direction to try again—yet. "We're too much up in the air right now," explains James Dennison, special assistant to the director. In addition, the internal education programs for employees have slowed since the DOT take-over. A personal tie was Director Elms' membership on one of the boards of the Boston Model Cities program, which he has now dropped.

Shift Toward Development Work

Another manpower loss has been the scientists—but the question of whether TSC should hire a basic research team is barely surfacing. "We are now so involved in immediate, short-term priorities that all we can do is raise the question of basic research," says Mr. Wedan. "It's a national problem," echoes John D. Hodge, director of the youngest "planning" division, Transportation Systems Concepts. "I'm sure in 20 years the transport field will need some basic research—I'm not sure in which areas. Possibly this is a job for the universities." TSC, he explains, isn't really a "research and development" facility. "With NASA it was more of a research plant, and under DOT we have moved more into development."

Director Elms says that the Center will not have its own slot in DOT's 1972 budget, and maybe even not the following year. This means it will get money and expand from its present, piecemeal work only through other DOT agencies or through the Office of the Secretary. Thus, the key to an anticipated future budget of $30 million will be TSC's ability to mesh gears with the more traditional divisions and agencies within DOT. And these are unaccustomed to TSC's NASA-style highly sophisticated management and development techniques. One TSC staffer explained, "In the old days, if the government wanted a job done, it just wrote out a contract and hired industry to do it. We learned at NASA that you have to define the problem yourself, and work part of it, in order to be able to contract out and ensure quality performance by industry. The transportation agencies aren't used to this approach." This is the conflict behind TSC's mild-sounding statements about "providing an inhouse technical capability" for DOT. And it remains to be seen how well the federal bureaucracy can absorb and support this kind of "conversion."—DEBORAH SHAPLEY

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