# Toward a National Technology Policy

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As we look back over the past decade, we have good reason to be uncomfortable with our national investment in technology. Lack of support is not the cause; in fact, there has been no diminution in the magnitude of technology expenditures over these 10 years. Nor is the magnitude of the total national effort the critical issue now. My own reasons for concern are twofold:

First, it seems to me we have given far too little support to the creation of new technologies, including too little toward the support of science itself. Rather, we have spent our dollars—and the energies of our technical people—on the exploitation of given features of the old technologies, principally through scale-up and increasing reliability.

Second, our technical priorities have held relatively stable, despite the fact that the world about us is undergoing enormous change. During this past decade, to cite one specific fact, our national government has invested some 3 billion to 4 billion man-years in research and development (R & D) programs; less than 1 percent of this enormous investment has gone toward R & D support relating to such critical problems as housing, crime, the urban environment, and ground transportation.

As we correct this imbalance and begin now to channel a larger part of our technical effort toward programs of social significance, we must remember one of the important lessons of our recent past: the history of the space program, it seems to me, is a lesson in the mastery of the institutional techniques necessary to bring together the segments of the intellectual, industrial, and technological community needed to fulfill goals in a timely fashion. If we choose to ignore this, if we set aside the space program's experience as nothing more than a $20-billion waste, then by our irrationality we will endanger the ultimate achievement of such important societal objectives as better housing and the renewal of our inner cities.

## Managing the Technology-Creating Process

The formula that worked for the National Aeronautics and Space Administration is clear and straightforward. It is a four-step process:

1) Identify clear-cut goals.

2) Institutionalize the mechanisms for achieving these goals.

3) Engage all segments of society whose talents and resources are needed to fulfill these goals.

4) Create a market to receive the new output (and new technology).

Consider applying the formula to an area where new social needs have arisen. As a test case, let us try it in the field of transportation. To begin with, clear-cut goals do not exist and have never existed. Even the supersonic transport was smuggled into the "system"—not because of its relevance as a component of our long-range transportation programs, but for extraneous rationales about national prestige, trade balance deficits, and aerospace unemployment. For urban mass transport and rail transport in general, the planning process has been fragmented and, consequently, ineffectual. We boast of our great mobility, and yet our current planning effort for the future of this mobility is not nearly sufficient to the task before us.

If we can agree that the optimization of multimodal transportation is a desirable goal for our nation, we can then identify and spell out our transportation goals. Having defined them, we must then step up to the need to institutionalize the mechanisms for evolving the technologies that could help meet those major goals. What we may need is something akin to an Office of Naval Research (ONR) for transportation or, alternatively, something patterned after but broader in outlook than the old National Advisory Committee for Aeronautics that played so important a role in making possible the growth of our civilian air transport industry by providing technical support both through its considerable in-house capabilities and by contracting for outside technical expertise.

It is a fact that often the most creative talents for a field under development lie outside the original institutional scope of the group charged with its development. Such talents may reside in other industries, universities, at the research institutes, or wherever. A mechanism has to be found for involving them and for attracting their input into the evolving system. The Commerce Technical Advisory Board report (1967) "Innovation, its environment and management" speaks eloquently on this point.

The military, and later the space program managers, found the way. Looking at one of today's specific problems, we may ask why a bright theoretical physicist with clever ideas on transportation systems analysis should have to scrounge around to find $10,000 to support his exciting researches. This man, and others like him, are the people who can see how the world could be, rather than how it is. Such people should be made a part of the technical input apparatus, much as the U.S. Navy Department, in the days of ONR, came to have at its disposal the expertise that it needed in undersea warfare. The wisdom and management skill of ONR made that possible. And that is the third step of our process: Engage all segments of the society that can contribute to the achievement of the goals, with special efforts toward coupling the academic with the industrial community, and both with the government.

Finally, all this will come to naught if there is not an established market for the product. In our example, transportation, I think it no accident that this field is one of the hard currency producers in which the United States is threatened by foreign suppliers. Our government may have to create the market for new transportation products and services that will, in turn, stimulate the creation of technologies to fill that market.

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## Defining Goals for Technology

The mechanisms for assessing the needs, defining the goals, and creating the markets necessitate some high order systems analyses that put into perspective the cost-benefit relationships: the implications of environmental effects (air pollution, noise), economics, and raw material conservation, for instance. The private sector left to its own devices—at least in this field—has not performed. Nor is it likely to perform this function in an objective manner. If it had, we would have a suitable rail system, good urban mass transit, and electric cars available right now. But the stimuli have been lacking. If we had had a Rand Corporation for the Department of Transportation, and a billion dollars a year for procurement of new, alternative transportation systems (developed in parallel, as weapons systems were), we might not have a transportation problem today. It seems almost incredible to realize that our $50-billion federal highway program has gone forward without such national systems analysis—with the result that our total transport network is overbalanced in favor of the automobile, to the detriment of other transport modes. And I think the analogs in housing, urban development, health care, crime control, energy, water resources, and such, are obvious.

In the absence of this kind of mechanism, we will see the perpetuation of misplaced emphasis and lack of balance and lack of choice in the efforts and resources our society elects to expend on its technical choices: in energy, the dominance of oil and gas; in urban transportation, the dominance of the car; in health care, the dominance of the classical hospital; in housing, the dominance of single-family suburban dwelling; and the ancient Roman sewerage for waste disposal.

The first element of the first step, then, in the articulation of a set of national goals for technology, is to make specific the uses toward which we wish to apply that technology. This is a role suited to the federal government; in fact, the federal government is in the best position to give wide credibility and gain consensus and acceptance for the set of goals in the diverse set of social areas. For example, no group outside the federal government could have set up the landing of a man on the moon as a goal for U.S. technology in the 1960's. This is not to say that the goal-setting role should be the exclusive province of the federal government; rather, it is to point out its responsibility for leadership. Nor do I say that goal-setting will be easy. Establishing goals in the civil areas, each fraught with powerful preexisting vested interests, is likely to be more difficult than it was in the new field of space exploration. Hence all the more reason for beginning to exercise judiciously the federal leadership responsibility today, as a principal means for bringing together the analytical, evaluative, and synthesis skills of the widest possible range of institutions.

## Adapting to New Conditions

The technology story has another side that I have not yet touched upon; it also bears some analysis. It is observed by many, most recently by the Haggerty panel of the President's Science Advisory Council, that our economy is moving steadily toward dominance by the service sector. Where once we were predominantly an agricultural economy, and subsequently an industrial economy, now the production of services exceeds the production of physical goods: the values of services are now a larger component of our gross national product than the values originating from manufactured goods. For a country that established its position of world leadership largely through its wealth of natural resources, plus the initiative to exploit those resources efficiently through advances in manufacturing technique and in productivity, this is indeed a major change. All indications point to further dominance by the service sector.

This remarkable evolution has important implications for technology. It tells me that the impact of technology on the economy in the next decades will not come primarily from technology's function of enhancing manufacturing productivity. Rather, I believe technology will be directed toward the improvement of services, or, more broadly expressed, improving the quality of life. Perhaps this is an even more demanding area for application of technology.

## New Values Added

Concomitantly, we must ask ourselves whether such a redirection of technological goals will enable us to maintain a position of international preeminence. I believe it will. By utilizing technology to perform more efficiently the services made possible by the artifacts of the preceding technology, we not only raise the "quality of life" within our own borders, but we also add new value to the services we already export to the rest of the world. In the past we have found the same pattern both fulfilling and enriching. We gave to the world an agricultural revolution; we have contributed dramatically to health care, pharmaceutical technology, and synthetic materials, in each field reducing man's dependence on material resources. As sources of new value-added functions that we can export to the rest of the world we might look to transportation, pollution abatement, energy, health, and education. The higher the technology content of the products or services we can evolve, the more likely we are to maintain some measure of advantage in international economics. In applying our technology and innovation we must recognize the economic, social, and political trends; in fact, technology should help us lead those trends, whenever we are perceptive enough to see them coming.

## Federal Technology Policy

To set the current thinking about technology policy in perspective, we should examine the federal government's response to the new social goals. As a measure of that response, I shall take the distribution of the federal R & D budget. An analysis of this area was completed a few months ago by Paul Shapiro of the Sloan School, as part of a summer study led by J. Herbert Hollomon of Massachusetts Institute of Technology. That study shows that, from 1961 to now, the federal government supported (i) 2 million man-years of defense R & D, (ii) about 1 million man-years of space R & D, and (iii) about 175,000 man-years of noncivilian nuclear R & D.

In contrast: (i) the total of all housing, urban social, and crime research that the federal government has ever funded is less than 13,000 man-years; (ii) the total R & D sponsored by the federal government for nonaviation transportation is of the order of 10,000 man-years; (iii) since 1969, 53,000 man-years of R & D have been expended by the federal government for environmental improvement.

During the current fiscal year, federal R & D expenditures are supporting the equivalent of 230,000 scientists and engineers for noncivilian purposes and about 84,000 scientists and engineers for civilian purposes, a ratio of about 3 to 1. In 1961, that ratio was 6 to 1, also with 230,000 scientists supported for noncivilian purposes. Could there be hope for reaching parity someday?

But, even within the federally supported civilian R & D area, we must point out that there has not been a balance of funding among all fields. Health is the largest single component here: of the $4.2-billion civilian R & D in 1970, only $2.4 billion were for nonhealth purposes. Of a $15.2-billion total, less than $2 billion of federal funds was allocated for R & D for the total of the principal remaining civilian purposes: education, housing, nonaviation transportation, urban social problems, crime control, agriculture, natural resource development, basic research via the National Science Foundation, and civilian nuclear power. Distressing as these numbers may be, it should at least be said that nonhealth, nonaviation civilian R & D has grown at an average rate of 12 percent per year since 1961.

However, with less than $2 billion per year expended for R & D in these civilian areas, most of which are not subject to the supply-demand-profit relationships of classical markets, it is not surprising that we are not receiving the shot in the arm required to couple technology for the benefit of the public/civilian sector.

**National Technology Policy**

But let me underscore that national technology policy is more than federal R & D allocation practices. We must encourage all segments of our society—the academic, the industrial, the governmental, and the public at large—periodically to redefine the goals toward which technology should be applied, and to reassess objectives as the environment undergoes change or as we change it.

The initial condition, then, for developing a technology policy must be a reassessment of goals. In the emergence of national goals during the past two decades, whether imposed externally by such cataclysmic events as the cold war, or sputnik, or internally more calmly, by goals commissions or deliberate private efforts, technology for social benefit has always come out at the small end of the horn. What emerges is a feeling that more intense and coherent social forces will be needed to foster the translation of technology into these areas.

Lest it be a source of confusion, we must remember the salient difference between science and technology. Science is both a means and an end. Technology is only a means. To develop a technology policy, we must identify the ends for which technology will be the means. Technology has no meaning in the abstract, only in relation to specified goals. If, as a society, we can specify these goals, technology can be applied to achieve them, appropriately guided or channeled according to the time-tested processes mentioned earlier.

To help this process operate efficiently, the technical community at large must also effect some discipline and brush away some of the old polemics: the schism between the scientist and the engineer for one. Created by some artificially imposed pecking order, this so-called distinction has tended to impose some sort of special favor on the scientist during the last quarter century. But it served no useful purpose then, and we certainly do not need it now, especially in the new social environment. We need the respective contributions of both the scientist and the engineer; they must work together under conditions that allow both to reach their most creative levels. John Gardner put it in its proper perspective when he wrote: "A society that scorns excellence in plumbing because plumbing is a humble profession and exalts mediocrity in philosophy because philosophy is thought to be a noble profession—such society is doomed to failure. Neither its pipes nor its theories will hold water."

**NEWS AND COMMENT**

# Nuclear Safety (IV): Barriers to Communication

Amid all the other difficulties that have plagued the Atomic Energy Commission's safety research program in recent years—the upheavals in its management, the fluctuations in its budget, the long delays in getting major projects done—a number of laboratory workers have come to suspect that the AEC has tried to suppress discussion of reactor safety issues, not only before the public but within the nuclear profession as well.

Specifically, the researchers allege that on three occasions the AEC has prevented them from meeting with foreign reactor experts to talk over problems of mutual interest; that the AEC tried last fall to block a professional symposium on reactor safety scheduled by the American Nuclear Society next March; and that for years the AEC's Division of Reactor Development and Technology (RDT) sharply limited the circumstances under which even its top-level safety researchers could speak directly with the AEC's own regulatory authorities on matters pertaining to the licensing of nuclear power plants. Thus, "freedom of speech" joins the bundle of other issues raised by the years of unhappy relations between those who conduct safety research in the laboratories and those in Washington who hold the purse strings and set the course of the laboratories' work.

Allegations that the AEC had tried to limit discussion of safety issues in professional circles were made by several scientists, engineers, and research managers during a series of interviews at the National Reactor Testing Station in Idaho, the AEC installation where most of the nation's reactor safety studies are carried out. In some respects, the charges are reminiscent of those made 2 years ago by John Gofman and Arthur Tamplin, the AEC scientists