



Innovation in Transportation: Proceedings of a Workshop, September 24-26, 1979, National Academy of Sciences, Washington, D.C. (1980)

Pages
260

Size
8.5 x 11

ISBN
0309291569

Committee on Transportation; Assembly of Engineering; National Research Council; Industrial Research Institute Research Corporation

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Innovation in Transportation

Proceedings of a Workshop

**September 24-26, 1979
National Academy of Sciences
Washington, D.C.**

***Conducted by*
Committee on Transportation
Assembly of Engineering
National Research Council**

***with the participation of the*
Industrial Research Institute Research Corporation**

**NATIONAL ACADEMY OF SCIENCES
Washington, D.C. 1980**

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NOTICE: This report is a compilation of the presentations and comments of the individual participants in the Workshop on Innovation in Transportation. The views and interpretations are those of the individuals concerned and are not necessarily those of either the supporting agencies and organizations or the National Research Council.

The workshop and this proceedings were supported under Contract No. DOT-RC-92002 between the U.S. Department of Transportation and the National Academy of Sciences.

Available from
Committee on Transportation
Assembly of Engineering
National Research Council
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

Order from
National Technical
Information Service,
Springfield, Va.
22161
Order No. PB 80-

PREFACE

The papers collected in this report constitute the proceedings of a workshop on innovation in transportation organized and convened by the Committee on Transportation of the Assembly of Engineering, National Research Council, September 24-26, 1979, at the National Academy of Sciences in Washington, D.C. The purpose of the workshop was to stimulate wide-ranging discussion among a diverse group of participants concerned with the issues surrounding innovation in transportation, and to isolate some of the most important of these issues for concentrated attention. More than a hundred people (listed by panel under "Participants") took part. The numbers of people from the various transportation sectors were: four from foreign governments, 42 from the U.S. Government, 36 from industry, and 30 from university, not-for-profit organizations, and the legal profession. The interest in having fairly large numbers of participants from each of the major sectors was to obtain balance in the representation and to elicit ideas from as many different sources as possible throughout the transportation community.

These views are those of the participants, are not necessarily consistent with one another, and are not necessarily those of either the supporting agencies and organizations or the National Research Council.

The workshop is part of a comprehensive examination of innovation in transportation undertaken by the committee in the course of advising the U.S. Department of Transportation on matters of policy and technology. The committee has set two preliminary objectives for this examination:

- To identify barriers and incentives to innovation in transportation .
- To develop recommendations for detailed analysis and evaluation the Department of Transportation might undertake to encourage innovation in transportation.

The committee expects to issue a report on its examination in 1980. It should be noted that the ideas presented in this workshop will be considered by the committee, along with ideas developed through other sources. The recommendations made by panel chairmen should be considered preliminary, and the resulting final committee report may have a different emphasis in certain instances.

The subject of the committee's second objective was introduced into the workshop by the keynote speech on the federal role in stimulating innovation in transportation.

To ensure that an ample basis was laid for ensuing discussions, three broad sets of issues were addressed by the principal speakers: the transportation community and the possibilities for innovation in transportation, the external climate for innovation, and labor and public interest considerations.

To inform subsequent panel discussions and narrow their focus, each panel chairman proposed a brief list of items for the panel discussions to follow. The meeting then divided into panels to hear and discuss papers that had been provided to participants before the workshop on five subjects under consideration: the setting for innovation; interactions of government, industry, and academic institutions; economic incentives for innovation in transportation; procurement and independent research and development; and technology and R&D policies to stimulate innovation. Each paper received comment from a discussant.

By this method of presentation, and by providing all research papers to all participants in advance, the committee hoped to prevent an artificial separation of issues that are closely bound and mutually dependent. The economic and other incentives that encourage innovation in transportation, for example, cannot be understood in isolation from the interactions of government, industry, and academic institutions.

Each chairman reported his panel's principal conclusions and recommendations to the assembled participants on the third day of the workshop following the deliberations in panel sessions, and these were discussed.

A brief summary is provided here of significant points raised in the workshop and the panel chairmen's reports and recommendations. The views expressed by the participants (related in the summary) are their own and do not necessarily reflect those of their organizations, the Committee on Transportation, the National Research Council, or the Department of Transportation.

Summary

The workshop was convened to illuminate and discuss the principal issues in innovation in transportation. The summary should be read with that understanding; individual participants may (and do in the recorded proceedings) disagree.

The speakers emphasized that "innovation" is not synonymous with "invention" or "the introduction of novelty," but encompasses the successful introduction into the economy of a new or changed product, service, or manufacturing process resulting from the development of a discovery, or a suggestion arising from review and analysis. Some chose to emphasize particular aspects of this definition for innovation in transportation: the representative of labor, for example, pointed to innovative change in the workplace as equally important to the application of new technology in improving transportation services. The impor-

tance of market demand in creating pressure for innovation was underlined with examples by a number of speakers; others chose specific instances of technological research and development creating pressure for innovation. These were framed in the context of pull and push factors of equal importance by other speakers.

Several problems that encumber innovation in transportation surfaced repeatedly: the extensive, and frequently frustrating, influence of government; the incremental and disjointed nature of innovation in transportation; the decline and overall insufficiency of investment in the activities vital to innovation, compounded by the pressures of inflation. Several avenues to solution were proposed and discussed in the course of the workshop:

- The urgent need to direct attention to the transportation system as a whole, to understand it in the context of present and changing local and national needs, as a fundamental part of our society. The recommendation emerged from various discussions of the workshop to undertake the collection and analysis of information that would lead to a long-range plan for innovation in transportation, to be updated at frequent intervals.
- The need for collaboration among government, industry, academic and other research organizations, and similarly, among regulators, management, and labor, to stimulate innovation.

These were elaborated and discussed in panel sessions and reported in the final plenary session. The preliminary recommendations, as reported by the chairmen, are briefly summarized below. Many of these prompted lively discussion.

Setting for Innovation

The chairman of the panel outlined the barriers to innovation in transportation in government, in industry, and in the university community and listed the panel's suggestions about how these barriers might be overcome.

In the executive branch of the federal government, responsibilities and authority are fragmented; leadership changes bring changes in goals and objectives. There is no long-term plan nor regular, updated transportation policy. Each of these states of affairs may act as a barrier to innovation. The great number and diversity of state and local governments create confusion and hinder progress toward transportation innovation.

In the legislative branch, there are too many oversight, authorizing, and appropriating committees. Organization along these lines gives rise to many constituencies, results in much overlap and compromise, and impedes the appropriation process.

In the industrial and commercial field, the characteristics of large mature companies with massive infrastructures are not conducive to inno-

vation. There is low return on investment in many transportation firms, compounded by the high costs and risks of the full-scale, real-world tests needed for successful marketing.

The mechanisms by which support is gained for research can act against innovative ideas. For example, the request-for-proposal (RFP) process is time-consuming and expensive.

The chairman noted that the panel offered suggestions to improve the setting for innovation. The Department of Transportation should issue an annual long-range (probably looking at least 10 years ahead) National Transportation Plan, identifying goals, initiatives, capital assistance, and research priorities. The department should work with the Office of Management and Budget and the legislative branch to consolidate, or at least to reduce in number, the committees now involved with transportation. It was clearly stated that this would be a very difficult, long-term task. The department should develop even closer cooperation with state and local governments and industry.

Both the executive and the legislative branches need to provide greater stability in goals, programs, and funding to reduce uncertainties in the industrial sector, according to the panel. There is a pressing need for long-term loans, or loan guarantees. A mechanism somewhat analogous to that of the Export-Import Bank might be used to permit local governments or private enterprises to undertake innovative projects. Careful consideration of criteria, and evaluation based on national goals, would guide the selection of recipients.

Interactions of Government, Industry, and Academia

The chairman observed that in the panel's view, university engineers and scientists should play a strong role in the Department of Transportation's formulation of an innovative transportation research program. A long-range pattern of department-university collaboration should be established by stable programmatic policies, and with relatively stable funding levels. The chairman noted that universities should be careful about going too far into the applied research and development that industry is better equipped to pursue. Universities should concentrate on developing intellectual capacity and intellectual capital by training and developing students, and enlarging basic knowledge. An extension of these ideas was a suggestion that there would be a need for establishing "centers of excellence" to conduct applied research and development in selected areas of transportation. These could be R&D organizations outside the universities (although in some cases they might be university affiliated).

Where government has been the developer and buyer, or buyer and user of equipment or systems, it has generally been more successful than when it conducts the R&D, develops an item, then depends on another agency to buy and use it. Examples of the former include the Department of Defense for its systems, the Federal Aviation Administration for its air traffic control equipment and system, and research conducted by the

Department of Transportation related to issuing and enforcing safety, environmental protection, and other types of regulation. A successful government program that might provide guidance for developing inter-governmental relations that encourage innovation is the Federal Highway Program. This effort is supported by competent staffs at state and municipal levels, developed through specific provisions of the Highway Act. State agencies not only share in the cost of highways, but supervise their building. Examples of the case in which the federal government may develop, but not buy and use, a system are the large development and demonstration projects (such as for new buses or rail systems) in intercity or urban transportation where users are expected to be industry, or state and local governments. The chairman suggested that great care be given to research, development, and system evaluations when DOT is not the user.

There is now no individual within DOT at the level of assistant secretary who has the responsibility for coordinating and overseeing the technical affairs of the department. Adding such a technical person at that level could help improve the innovation process.

The chairman noted that, in his view, the transportation industry's primary role is to produce and operate the systems that people use. It was his opinion, and that of a number of other participants, that the free market is still the most sensitive barometer of public acceptance, and it is for this reason that industrial talents, experience, and attitudes should be enlisted to support innovative concepts at the earliest practicable stage. Some important areas of applied research and development could fail to receive the sustained attention they deserve. Finally, it was suggested that industry, as well as government, contribute financial support, and join in continuing dialogue with faculty and students in universities to develop better understanding and interchange of ideas.

Economic Incentives

The panel concentrated on regulatory, tax, and antitrust matters. The panel noted that, over the past three decades, prices for transportation have seldom reflected true costs. Now, rising fuel costs and increased capital investments to meet safety and environmental standards have overburdened the limited, internally developed capital available in some of the auto industries, and in others. The chairman reported that the panel endorsed Executive Order 12044. In essence, that order requires that the public be made aware of the risks, costs, and benefits of regulations before they are enacted; that priorities be established; that alternative choices be made clear; and that the regulations be systematically reevaluated. The chairman noted that the panel concurred with the prevailing tax rules applied to R&D, but urged early moves to liberalize depreciation rules on equipment and machinery. There were several views expressed about the actual number of years on which depreciation should be based, but the suggested reconsideration of such existing provisions was agreed to in general. Although there was general agreement that reconsideration of present depreciation rules should be undertaken, there were views expressed questioning the overall



effectiveness of such a move as a stimulant to innovation. While a liberalization of the depreciation rules on equipment and machinery should increase capital funds available, it should be pointed out that this would not necessarily guarantee that such funds would be earmarked for expenditure on innovation. Careful study of all aspects should be included in the reconsideration. The suggestion was made that as the Civil Aeronautics Board (CAB) and possibly the Interstate Commerce Commission (ICC) are gradually phased out, the Department of Justice may assume many of their residual responsibilities. It was suggested that Justice consider allowing the formation of some integrated, intermodal transportation companies--a step that could stimulate more efficient services.

Procurement and Independent Research and Development (IR&D)

The chairman reported consensus on the panel that the Department of Transportation should take an interest in all contractor programs where there might be an element of Independent Research and Development (IR&D), to identify it as an important part of the contractor's activity, to maintain respect for the importance of independence in IR&D, and to encourage the contractor to direct some portion of this IR&D into activities of interest to DOT. IR&D is now associated with the federal procurement part of transportation funds and these are less than a fourth of DOT's budget. About \$12 billion of the department's annual \$17 billion budget is expended in the form of capital, or other types of grants. In making grants to states or local agencies, the department might add a condition that a small portion be used for innovative analysis. Such an approach might be an additional tool in encouraging innovation.

The chairman noted that the provision in procurement contracts requiring that the contractor repay the R&D costs of ideas developed under contract from which they make money discourages innovation. The department was urged to follow the new Federal Acquisition Regulations (FAR) that eliminate cost-sharing on goods or services developed for government use, and that provide for R&D recoupment, only if it is clearly in the national interest. The general thrust of the regulations is that recoupment should rarely be required.

The chairman suggested that changes are needed in patent and data rights, and noted with approval a bill now before Congress that would impose a uniform policy on all federal agencies. The proposed policy is that the ownership of patents and data rights remains with the contractor. The government gets royalty-free rights.

The chairman reported that the panel urged the adoption of a proposed Federal Acquisition Regulation that encourages submission and expeditious handling of unsolicited proposals. The practice has been to translate unsolicited proposals into requests for proposals, to publish them, and invite bids. This discourages those who have novel

ideas from seeking support. Finally, DOT was urged to streamline the administrative process of procurement that is now unduly lengthy.

Technology and R&D Policies to Stimulate Innovation


The panel remarked that the percentage of its budget spent by the Department of Transportation for research and development is much smaller than the percentage spent by other agencies, such as the Department of Defense or the Department of Energy. The department's efforts in research and development need strengthening, according to the panel, and it reaffirmed the recommendation of other panels for a high-level officer and supporting personnel in research and development. This new function should be designed with a great deal of care. To provide outside views, the panel recommended that the department set up a full-time scientific advisory board to provide critical appraisal and ideas. The panel urged the department to develop a set of objectives and performance requirements, rather than solutions, and to bring its criteria for research grants and contracts into line with these objectives and requirements.

The panel called for an annual mobility assessment to give an indication of how well the transportation system is performing (in the view of passengers, operators, shippers), how much it costs, how well industry is doing, and where significant gaps or problems are being experienced.

Among other recommendations, the panel singled out some pressing needs for research and development now being experienced in various modes of transportation: the need to gain an understanding of what is required to achieve significant improvement and growth (perhaps increasing ridership from 4 percent to about 20-30 percent) through a much improved system of urban mass transportation, for example. The panel thought such an effort should receive more attention and research money. Other examples the panel offered include the need for research in highway maintenance, an examination of the feasibility of automating enroute air traffic control of aircraft, and more research to support the government's regulatory functions.

The valuable participation of many individuals during this review is gratefully recognized by the committee. The panel members and participants are listed on pages 240 to 245.

The committee expresses special appreciation for the many contributions during the planning for this workshop by Dr. James R. Nelson before his death April 30, 1980.


Raymond L. Bisplinghoff
Chairman
Committee on Transportation

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WELCOME

COURTLAND D. PERKINS
PRESIDENT
NATIONAL ACADEMY OF ENGINEERING

I certainly do welcome all of you to this workshop, not only for the National Academy of Engineering but for the National Academy of Sciences as well. This workshop is being sponsored by the Committee on Transportation of the National Research Council, the U.S. Department of Transportation, and the Industrial Research Institute and its Research Corporation.

It goes without saying that innovation has become a good word in this area. As a matter of fact, as I was just discussing with Ray Bisplinghoff, every two or three years we get a new group of studies on innovation. The one thing all of them have in common is that after very carefully run studies, and very carefully worded reports and recommendations, nothing ever happens.

That brings me back to one of the speakers today, Bob Charpie, who ran the first innovation study that I remember, when he was with the Commerce Technical Advisory Board. Later, Betsy Ancker-Johnson and Herb Holloman prepared studies, and now Jordan Baruch has conducted one. It is hoped that out of this welter of studies something will actually take place.

In point of fact, in response to the recommendations of several NAE members, the NAE, under the chairmanship of Art Bueche of General Electric, is planning a colloquium in December 1979. It is to be a study of the studies. The intent is to review all studies of innovation, and to see if there is any agreement on what the major factors are and at what point these will become strong recommendations. To whom these would go, I am not quite sure.

I also mentioned to Ray Bisplinghoff that innovation is starting to look something like the Air Force. In my experience with the Air Force, we ran studies of the military uses for space systems about every third year. We would recommend all sorts of good things that way. We also conducted studies of manned bombers. These surfaced about every third year also. Innovation is now a very visible problem in Washington, and many of us are struggling to find out what can really be done, and who will do it.

It is interesting to me that in this workshop you have picked a narrow objective. You are going to talk about innovation in transportation. There is no question that whatever you decide upon will be

extrapolated to other areas as well. Let us take on innovation in transportation then, and see if we can come up with some really important ideas, about which somebody may do something.

Certainly we need innovation in transportation, not only because of the economics of the situation, but also to solve the difficult problems that we are facing, which will be even more difficult to solve in the near future. Therefore I am sure that those of us who are looking at the broad gauge problems of innovation in this city will be looking to this workshop to see if your results will lead us to a technique for some action, for some actual implementation.

Therefore we welcome you. We hope you are successful in this venture. I was delighted when I read the program. It is a very powerful one, and you have excellent speakers. You have very strong leaders for the different panels, and I am positive that if anything can be done, it will be done here.

One of the areas of innovation that I do not see on the program is the one that concerns every one of us. This is the relationship between technical innovation and the educational process. Whether the problem gets fed into the problem of innovation in transportation, I do not know; however, it does appear to many of us that we have difficult problems in the engineering education field. With respect to this particular subject, I hope that somebody, or one of these panels, refers to this problem at least briefly. I have talked about this with our industrial members of the NAE on many occasions, and those connected with innovative industries are deeply concerned. I hope that this aspect of the problem is noted in this particular meeting, at least as a side issue. I think that it is a major issue.

Anyway, we welcome you here. You are dealing with an important and complicated problem. So far we have not proceeded very far in actually getting anything done. We hope that the focus of innovation on transportation will give us the lead on how to get at this.

KEYNOTE ADDRESS:

STIMULATING TRANSPORTATION INNOVATION--THE FEDERAL ROLE

BY

HENRY ESCHWEGE

The General Accounting Office (GAO), under the leadership of the comptroller general, Elmer Staats, is an arm of the Congress that reviews the programs and policies of the federal government and makes recommendations for improvements. In this process, we sometimes step on people's toes. Even helpful criticism is not always welcome. But our intent is positive. We believe that government can be efficient and effective and that constructive oversight and program evaluation by the Congress and its support agencies can help the federal government serve the American people better.

What role does the General Accounting Office have in a debate on innovation? The answer to this question lies in the extensive influence government policies and programs have on innovation--whether or not it is encouraged, suppressed, or ignored. GAO has a unique opportunity to identify impediments to innovation and to recommend improvements.

But before I get involved in suggesting approaches to solutions, let us ask ourselves, what is the problem? We are constantly reminded that the United States is losing its competitive edge in world markets because of declining innovation and productivity, that private investment in long-range research and modernization of capital plant and equipment is decreasing, that we are becoming an increasingly "have not" nation in critical resources such as energy, and that our friends in Western Europe and the Far East have more efficient transportation systems.

What of solutions? I begin on a note of optimism. It is true the U.S. reputation for technological superiority and innovativeness has been somewhat tainted. Yet recent efforts by Jordan Baruch, assistant secretary of commerce, and this workshop attest to our determination to reverse any negative trend.

A sizable portion of GAO's resources, for example, is devoted to reviewing the programs and policies of the federal agencies involved in the U.S. transportation system. These efforts, logically, lead us to an assessment of how state and local governments, industry, and other parts of the private sector are affected by federal actions.

From this vantage point, let us consider the question: What can the federal government do to encourage transportation innovation and productivity? First, let us briefly explore what we mean by transportation innovation and how transportation innovation is related to

productivity and new technology. I suggest that one of the most important meanings of transportation innovation is using existing ideas more effectively.

Second, I will discuss some of the barriers to transportation innovation and productivity within the federal government and in the private sector. My purpose is to describe changes needed to encourage innovation and productivity and to suggest issues for discussion by this workshop.

Finally, I will cite some recent GAO studies that suggest ways that federal transportation programs can be made more productive through needed changes in government organization and enabling legislation, and through improvements in operating methods and procedures.

A dictionary tells us that the word "innovation" means "something newly introduced, a new method, device, et cetera," and also "the act of introducing a change or something new." Obviously, this neutral definition is not really what most of us mean when we use the term "transportation innovation." We usually mean an improvement in our transportation system, a change for the better. In particular, we tend to perceive the kind of improvement that increases economic productivity, that increases the quality or quantity of goods and services produced from a given level of resources.

When we talk about transportation innovation, we also tend to mean new technology--new transportation systems, new devices to improve fuel economy or protect lives, new telecommunications systems that can substitute for physical transportation of passengers and mail. We tend to emphasize scientific and engineering improvements. We lay particular stress on whether something is new.

The connotations influence the way in which we think about transportation innovation. Obviously, new transportation technologies and new ideas in applied science and engineering are important aspects of transportation innovation, but many of our transportation problems are due to our inability to make effective use of the ideas that we already have.

For example, from an engineering point of view, we are now able to make automobiles that are much more fuel efficient than the average automobile produced in the United States in 1979. Our biggest national problems in this area have to do not with the technology but with (1) convincing more American motorists that fuel efficient cars are desirable, (2) the reluctance of American automobile manufacturers to move too far ahead of consumer preferences, and (3) institutional problems within the federal government that prevent the development of a cohesive policy toward the automobile.

Therefore one of the most important meanings of transportation innovation should be, as I said, using existing ideas more effectively. This is perhaps a less glamorous subject than potential scientific breakthroughs, but in the near term it is a more practical objective for federal transportation programs.

Possible issues for this workshop include the following: How can the federal government and the private sector cooperate more productively so as to encourage transportation innovation? What improvements can

be made in the efficiency and effectiveness of the routine operations of our transportation systems so as to increase their economic productivity?

As we consider these issues, we should bear in mind the following maxims: New ideas are not always the most useful ones. Useful ideas must be used to become productive innovations. Productive innovations require changes. Changes involve risks. People and institutions, by and large, prefer to avoid risks. It is just as sure a recipe for failure to have the right idea 50 years too soon as 5 years too late.

An example might be truck weight limitations. GAO's recent study of weight limitations for trucks traveling the nation's highways raised challenging questions about the net benefits of increasing weight limits to conserve fuel. On first consideration, the idea of achieving fuel savings by resorting to heavier truck shipments is impressive. But the price we pay in terms of increased highway maintenance and maintenance of vehicles trying to traverse deteriorated highways may make this idea neither useful nor productive. Also, at a time when we want automobiles to be smaller, the idea of larger, heavier trucks seems to run counter to our efforts to make driving safer.

In GAO reviews of federal transportation programs, we have found a number of formidable barriers to productive changes in the U.S. transportation system. One of the worst barriers to transportation innovation is the lack of trust and the mutual antagonism that frequently undercut productive cooperation between government and the private sector.

There are those in government who tend to assume that the private sector is no better than it has to be, a collection of selfish individuals and profit-obsessed corporations that can only be forced to do the right thing by stringent government controls and regulations. Many in the business community see the government as the enemy pursuing unrealistic and overly moralistic goals at the expense of practicality and common sense. And there are private citizens deeply committed to a particular personal cause or goal who view both government and business as dangerous adversaries to be supported only if they completely agree with one's personal goals and to be harshly condemned if they disagree.

These problems are deeply rooted in our society, and it is clear that simple solutions are unlikely. This workshop ought to consider ways in which mistrust and antagonism between government and the private sector can be reduced so as to improve the climate for transportation innovation.

Possible issues for discussion include the following: Can citizen understanding of government and decision-making in business be improved? Can government give better consideration to the views and needs of private citizens and private industry? Can business give better consideration to the public's views and interests?

A second barrier to transportation innovation is fragmentation within the federal government. Some of you may have seen an article in the New York Times Magazine earlier this month quoting a secretary of commerce who said, "I have found that the brown bears are under the jurisdiction of the secretary of agriculture. The grizzly bears are

are under the care of the secretary of the interior. And the polar bears are under my protection." This was not the present secretary of commerce, Juanita Kreps, but Secretary Herbert Hoover, in 1921.

In the transportation area, one of the most troublesome examples of government fragmentation is found in federal programs and policies involving the automobile. According to a report issued earlier this month by Resources for the Future, the passenger automobile uses 13.1 percent of total U.S. energy consumption or slightly over half of the energy used by the entire transportation sector.

From a technological point of view, there are some very good prospects for energy savings by improving auto fuel economy, by diverting motorists to more efficient modes of transportation, and by making more efficient use of the passenger car itself.

I have already mentioned some of the barriers in the private sector to more efficient use of the automobile. The American motorist has strongly resisted efforts to lure him into mass transit and car pools and only recently has begun to show any real preference for cars that save fuel. Moreover, the American automobile industry has been understandably unenthusiastic about moving too far ahead of consumer preferences. But in the present economic climate of sharply increased gasoline prices and potential unavailability of gasoline, these barriers have been somewhat reduced.

Still with us is the problem of fragmented federal policies and programs for the automobile. Responsibilities for auto fuel economy are divided between the Department of Transportation and the Department of Energy. Automotive air pollution control is the responsibility of the Environmental Protection Agency. Auto safety programs are administered by the Department of Transportation. From a technological viewpoint, fuel economy, pollution control, and safety are closely interrelated. Yet there is no comprehensive federal policy that links and integrates these programs. In practice, this organizational fragmentation has thrust the burden of integrating federal policies for the automobile on the automobile industry itself. Since these policies are diverse and potentially conflicting, the auto industry has felt beleaguered and defensive, and progress toward necessary environmental safety and fuel economy goals has been slower than it might have been.

Issues for discussion by this workshop include the following: How can federal programs for auto fuel economy, safety, and pollution control organizationally be brought closer together? Can a unified federal policy toward the automobile be developed that would improve the cohesiveness and consistency of our auto-related goals and objectives? Can federal automotive policies and programs be coordinated so as to improve cooperation and trust between the government and the auto industry, both in long-range strategic planning and in day-to-day operating relationships? How can we bring together the results of research conducted by government, industry, and the universities in support of innovation without running afoul of antitrust laws and legitimate proprietary interests?

A third barrier to transportation innovation is government regulation, both excessive regulation and inconsistent regulatory policy.

Excessive regulation can be seen in some of the federal paperwork requirements placed on American business. In a recent study for the Joint Economic Committee of the U.S. Congress, GAO found that federal reporting and recordkeeping requirements take up 69 million hours of business time per year and cost over \$1 billion. The Department of Transportation, Interstate Commerce Commission, Civil Aeronautics Board, and Environmental Protection Agency are among the 14 federal agencies with the most burdensome reporting requirements. While many of these requirements are needed to meet legitimate regulatory objectives, it is apparent that some regulatory reporting requirements are excessive and too costly for the benefits they produce.

Excessive regulation has two adverse effects on transportation innovation. First, the direct costs of complying with unnecessary regulations require staff and capital expenditures that otherwise might be used more productively. Second, and even more important, excessive regulation creates an economic climate that discourages risk-taking and places a premium on adjustment to the status quo. The railroad industry is an example. The cumbersome regulatory requirements that govern whether rail lines can be abandoned or freight rates and services modified have discouraged railroad managements from adopting needed improvements in operating methods and procedures.

Inconsistent regulatory policies also discourage transportation innovation. I have referred to the problems created by lack of a cohesive, consistent federal policy toward the automobile. Similar inconsistencies can be seen in the federal government's economic regulatory policies for surface freight transportation. Although the various freight transportation modes are in competition with one another, federal regulatory controls vary from almost total coverage of the railroad industry to partial coverage of the trucking industry to minimal coverage of the barge and pipeline industries.

These inconsistencies often make parts of the surface transportation industry, particularly the railroads, less competitive and less profitable, and handicap them in taking the initiative to make needed investments in modern equipment and facilities. Recent initiatives by the administration and the Congress to overcome regulatory inconsistencies and balance the cost of regulation against perceived benefits have begun to reduce the regulatory burden.

GAO's 1977 study of fare reductions to be achieved from less airline regulation suggested savings of \$1.4 billion to \$1.8 billion annually. The congressional debate that followed resulted in legislation to phase out airline regulation. The positive results from this legislation have encouraged similar efforts in the field of surface freight transportation. GAO has a complex study underway to simulate the impact of freight deregulation that we hope will contribute to the current congressional debate on this important issue.

The maze of federal and state government procurement regulations can be another barrier to maximizing innovation. The prevalent procurement practice favors the lowest bidder who offers products meeting acceptable quality or minimal, but complicated standards. In many cases, the public would be served better by "best-buy" competition based on superior or innovative performance and life cycle costs.

Issues for discussion by this workshop include the following: Can the paperwork burden required to meet legitimate regulatory goals be reduced and made more cost effective? What are the excessive or inconsistent government regulations presenting barriers to transportation innovation and how can they be removed?

Let me mention a few more recent GAO studies that address the problems of making federal transportation policies and programs more effective. For the most part, these studies focus on needed changes in government organization and in enabling legislation, and on ways to improve operating methods and procedures.

I would argue that these are precisely the kind of modest improvements and innovations making effective use of existing ideas that are most needed to make our transportation system more productive.

In a report released earlier this month, we observed that aircraft delays cost U.S. airlines over \$800 million in 1977, detained the traveling public by 60 million hours, and caused the airlines to use an additional 700 million gallons of fuel. Generally, aircraft delays result from excessive air traffic and bad weather. GAO recommended that the Congress authorize the secretary of transportation to decrease air traffic during peak periods and that the secretary use peak surcharges and/or quotas to implement this authority.

In a report about to be issued, GAO discusses efforts by the Department of Transportation to encourage better use of existing urban transportation systems through planning and coordination of local actions affecting autos, taxis, transit, pedestrians, and bicycles. We found that innovative transportation projects were not successfully competing for federal funds with traditional projects such as highway construction and bus replacement.

We will propose changes aimed at encouraging more innovative projects by state and local governments. We also will propose integration of Federal Highway Administration and Urban Mass Transportation Administration planning and review functions in this area, so as to provide better federal guidance to urban areas.

In another study now in progress, GAO is examining the causes of railroad freight car shortages. One of the most important causes appears to be the very poor rail car utilization rate of some railroads. In other words, rail cars are sitting idle for long periods waiting to be loaded and unloaded. This is unproductive time during which they are basically functioning as miniature warehouses. Cutting down this unproductive time would free up a substantial number of rail cars and go a long way toward solving the rail car shortage without requiring costly investment in new cars.

In conclusion, let me express some words of satisfaction coupled with the traditional language of caution you might expect from an auditor. The array of talent you have assembled here today from industry, academia, and government promises to generate the kind of debate and understanding that are sorely needed if we are serious about removing barriers and providing incentives to innovation.

As President Perkins pointed out, however, beyond this workshop there is the need to translate your ideas into actions. Your

suggestions for innovation must be convincing to the different sectors of society. Implementation of your ideas by government must be pursued through the political process so that needed changes in attitudes, policies, and processes can be achieved. We in the General Accounting Office have more than a passing interest in your efforts. We believe we can help each other to bring about transportation innovation.

SPEAKERS

THE TRANSPORTATION COMMUNITY AND
POSSIBILITIES FOR INNOVATION

BY

ROBERT A. CHARPIE

In the previous paper, Henry Eschwege made the point that if you have a problem, you ought to get a good solution for it and not be fascinated either by technology or by innovation in and of itself.

He also commented that in his position in the General Accounting Office he has had the experience many times of being involved in giving helpful criticism that was not accepted. As surely as innovation, if it works, can help solve problems, I would remind the GAO that the giver should not be the one to decide whether the criticism is helpful. That decision should come from the recipient, and as you prescribe innovation and as you prescribe programs that you think are helpful, do not forget that somebody else has to decide whether they really are helpful.

My background is as a scientist and a corporate executive, one by training and the other by experience. I know nothing about transportation. I buy a lot of transportation, but that is about all I know about it.

However, I grasp instantly the idea that we could stand some improvements in transportation. It took me two hours to come to Washington from Boston this morning. It was a perfectly clear day, yet our flight was held on the runway, both at Boston and at Washington. No taxicabs were quickly available in Washington. The planes, both terminals, and taxicabs I used at both ends of the trip were dirty. We can stand improvements in this system that requires the passenger to do so much arranging.

The only way we are going to get improvements in transportation is by pulling ourselves together in an organized way and looking at the problems. Transportation is a very big business, a big activity. It is 20 percent of the gross national product (GNP), and there are very few parts, big pieces, of the GNP that disaggregate into our individual lives as transportation does.

Studies show that over a wide range of incomes, a full factor of 10, the average individual spends about one-fifth of his disposable income on transportation. So not only is it big in the GNP, it is big in the personal disposable product, too. It is one of our nation's largest expenditures.

Over a rather wide range of possibilities, as the unit cost of transportation comes down, people consume more and more of it, roughly in proportion to their income. There is a huge latent demand for transportation.

The automobile is the most pervasive and visible part of the transportation system. When I think about the automobile, I do not think about it in terms of what it is or what it costs but rather in terms of what it does. There are two important aspects: (1) it gives us tremendous personal mobility, and (2) whether we admit it or not, it has a huge psychological impact on the design of our lives.

There has been much talk about the love affair between the American and his car. That phrase dangerously belittles a very important human characteristic as reflected in our relationship with the automobile. One simply can not discuss transportation without talking about the automobile.

The car does a lot of things for us. It expands our activity radius and gives us speed and power; for some people it provides appearance, prestige, image, and more. It is not only the American to whom those factors are important. Every nation, every society, exhibits the same reaction to the automobile. It is part of the human condition, not an American idiosyncrasy.

And so we must be very careful to describe the automobile for what it is and for how it contributes to our personal satisfaction and what problems it creates in the way we use it. Only then can we evaluate proposed innovations in automobile transportation in a reasonable context.

The automobile is a perfect example of a case where the experts have been befuddled for a long time. They have been confused by how rapidly it has been accepted all over the world. They have been dismayed by the inelasticity of auto demand with respect to price. They failed early on, particularly immediately after World War II, to understand the way in which it would interact with deeply cherished desires and generate new problems--suburban sprawl, urban congestion, environmental insults, and so on.

What is worse is the fact that even though we missed this understanding the first time around, we persist in misestimating the effect of the automobile. We tend to prescribe for the problem the automobile creates by saying that what we really need is good urban mass transit or that we ought to rejuvenate the railroad system of the United States and get the automobiles off the road.

The simple fact is that people do not want to ride on trains. They also do not want to ride on subways--not if they can ride in automobiles at not too high a penalty. That is the key point: at not too high a penalty in cost. The mistake that the designers and the experts have made has been to underestimate the price people have been willing to pay, and will be willing to pay in the future, for mobility, for the convenience of going from point to point at a time of their own choosing. Underestimated also has been people's willingness to vote for people who propose projects that make very little economic sense to the transportation experts, but which are brought into being by the mass of public majority opinion. People are willing to pay a high price, a terribly high price--20 percent of GNP and personal product--for transportation, of which a large portion is for automobiles.

If we look at the rest of the transportation system, beyond the automobile, we will find the same effect. It is surprising how high a price people are prepared to pay for what they regard as acceptably good transportation services. Maybe it is the saving of time, maybe it is the reliability of delivery, maybe it is convenience or comfort or other perceived values, but somehow those are the things that cause people to pay the high price.

Unfortunately, when we talk about transportation and economics, we often hear about the parts of the system that are not faring too well, the ones that are in trouble--those that are appealing for or require subsidies, regulatory protection, tax breaks, or outright public ownership to be successful. Such cases are usually not a majority of the transportation systems, but those are the ones on which we tend to focus. We can best learn how to deal with those parts of the system if we pay particular attention to the other parts of the transportation system that do not require special treatment, special pleading, or designation as special problems, in order to understand what it is people want and what they are willing to pay for.

It is clear that people will pay the high price requested for good transportation services. It seems to me, as a businessman, that it ought to be possible to have a transportation service system that, aside from some special case that I have not figured out yet, pays for itself and earns an adequate return for the owners. That is the only sound basis for supplying transportation services.

That kind of thinking necessarily leads me to comment that there already is an excess of government activity in the transportation sector. Some fraction of our present poor performance is attributable to the way we are organized and the interaction between the industry related to transportation and the segments of government related to transportation.

Earlier I mentioned my problems in getting here from Boston this morning. I think that serves as an interesting illustration of an opportunity for new service, which I hope those in transportation will provide. Transportation is now organized by modes. We have railroads, airplanes, highways, and other modes. Typically, each mode has its own constituency, its own lobby, and its own godfather in the form of a regulatory agency, or two or three or four. The components are not always in step with each other. In traveling from my home to a meeting, I do not merely want to buy an airplane ride from Logan Airport to National Airport; I want to leave Weston, Massachusetts, and get to the National Academy of Sciences in Washington. This is a fairly simple idea since the two requirements on the end of a long airplane ride of 59 minutes are fairly simple, straightforward, and short. I can not buy a ticket from Weston to the National Academy.

It is easy to construct much more elegant and difficult case studies involving several modes of transportation, which take into account as you cross the nodes where all the trouble is, that there is baggage involved, there are other people involved, and there is consternation and conflict and confrontation and plenty of cussing involved. Sooner or later, somebody is going to find out how to offer a

service that cuts across at least some of the more troublesome nodes, that simplifies the travel process, and that makes it easier to get from source to destination without handling all the arrangements and hassles at the hard spots by yourself or with the help of a travel coordinator.

Other similar opportunities have been exploited: Federal Express, container services, trailer on flatcars, auto-trains. They have not all been successful, but they are examples of imaginative, if not innovative, attempts to cope with the node problems, with the multimodal problems of going from point to point by using several different kinds of transportation to deliver the goods, whether that is an individual or a case of wine, from source to destination in a coordinated way.

We must increasingly pay attention to that problem, and if we are to do so successfully, the federal and state governments must pay attention to how they should organize themselves so that they do not stand in the way, that is, deal only with a piece of the trip and regulate it in such a way as to make integration and coordination harder or perhaps even impossible.

When we talk about innovation, we must remember that innovation means change, no matter if we mean using old ideas or new ideas. Change in and of itself is harder to accept in the transportation sector than in many other sectors, for the incentives to change are often too small or in fact may not exist at all.

Given that much of the transportation sector is regulated in one way or another, there is an inevitable relationship between the modally oriented industry and the regulatory agency with which it interfaces. Now, if one were to ask that industry to supply new services, to create new products, or to deliver services and products packaged in new ways, then there must be as a minimum concurrence and ideally outright encouragement and support for such changes within the government agencies related to that industry.

But why should such a government agency be innovative? Or, more particularly, why should the individuals within an agency of the government be innovative? The answer is that they should not. To be innovative is not in their best self-interest. Innovation and change are risky; it hardly ever works right on the first try. The failure rate is very high. The process by which we find out which proposals are good ones is to give our ideas a try--to abort the failures and persist with the successes.

So, viewed from a distance looking back, history often seems to suggest we have had a string of innovative successes. There are graveyards full of innovative failures. We can no longer get the facts about these once they have been abandoned.

The motivation for success in the industrial sector is very clear. Everybody associated with the company that has such a success is probably better off personally. The individuals who were the promoters of the success and who took leadership risk positions probably have prospered personally--they may have been promoted, earned more money, gained recognition.

On the government side of the same activity, there is no possibility for personal gain. Given the high percentage of failures in the innovative situation, in fact, the probabilities favor personal loss.

And so in a regulated industry, one of the things that the government has to do if it is serious about promoting innovation is to find a way to reward its own people for promoting and participating in successful innovation, instead of penalizing them for failures. Government people do not now receive any of the direct rewards that those in the industrial sector do. The government should not penalize its employees for failure if the innovations they have been proposing and promoting were soundly conceived but turned out to be unacceptable in the marketplace.

Another point I would make in the interface between industry and government on innovation is that an individual in a government agency must not allow himself to fall in love forever with what seems to him to be a good idea. Even though that idea promotes a concept or a value in which he believes, he can have no assurance that it is the basis of a successful innovation. In the innovation business, timing is everything. It is as bad to be five years early as it is to be five years late with an idea. There is hardly an innovation made that has not been tried in some form earlier, when it was truly too early. So far as timing goes, there is hardly an industry that does not have examples of companies that failed to see the light of day in time, and so "went down the tube" because they were too late in moving on a seminal idea that they understood but misappraised.

Instead of worrying about being early or late, the innovator and the agency alike should worry about whether they can succeed by sheer force at a certain time and whether the market might pull them through even if they bobble the idea somewhat.

Look at the automobile again. We have three automobile companies. What is their condition? It is very clear that Chrysler is in trouble. Despite the fact that everybody could see that small cars were coming, Chrysler could not. At least they could not see it well enough to make a positive decision to capitalize on the very good early small cars they had and bet their company on them. Chrysler inadvertently bet the company by not having little cars in quantity now, and I think they are going to lose out.

Then there is Ford. In the sixties, Ford decided that safety was a good thing. The U.S. government told all of us and Ford that safety was a good thing. The government encouraged Ford and patted them on the head, and Ford was so pleased with being patted on the head that for five years they tried to sell the idea of safety options and lost lots of money at it. That loss of money represented the loss of financial capacity. The loss of capacity represented the inability to do other things as well, and so on the one hand they diverted, and on the other hand they failed to accumulate resources as they might have. Ford has surely not been mortally wounded, but they have been badly scratched. Ford is not as strong today as it would have been had it not persisted in that safety campaign in which they were selling safety as a good thing and as an extra at the time that the public did not want it.

That the public was wrong, we might agree. We would all be better off today if a lot of people had not been killed because they had been driving without those safety extras, but the fact of the matter is that decisions on innovative proposals are made by the public voting with its pocketbook, and with its feet, and even if they are wrong, the way they vote determines how the election comes out.

By contrast, General Motor's sense of timing on the small car was exquisite, and that is being reflected in GM's market share.

Now, the government can not insulate anybody against risks. Sometimes we act as though the government can do so, but it really can not. The government can mandate riskless innovation, but in so doing it must necessarily push the costs off on the consumer or the taxpayer. Amtrak is an example of a riskless innovation. The decision to have seat belts in all cars is a riskless innovation; every manufacturer has got them. The government can also transfer risks to the producer as in the Corporate Average Fuel Economy (CAFE) standards.

The fact of the matter is, however, that the ultimate decision on whether an innovation is truly a sound idea is made by the public in a complicated, unpredictable way. The costs do not always track either the decision to act or the decision to buy.

Another problem we all know about that is particularly important in the transportation sector is that the scale of transportation activity is so large and the infrastructure so complex that it is terribly hard to do small-scale tests to determine if a proposed change is good or even acceptable.

This problem is compounded by the fact that people do not always act in accordance with what they claim to believe. Every transportation survey I have seen on the subject in the last two years shows that an overwhelming majority of the public believes that the 55-mile-per-hour national speed limit is a good thing. I can testify that although more people are staying closer to the 55-mile-per-hour limit now than last year, the average speed is still above 55 on the interstate highways.

The public strongly supports in every opinion poll the proposals for improved mass transit. We have quite a few examples of good mass transit, but practically nobody is riding on them. The members of the public are in favor of urban mass transit for all the public except themselves, and they do not patronize it even though they claim to believe in it and want more of it. One of our difficulties is that we do not know how to translate apparent opinion into reliable predictions of public response.

I am not going to go through the long recitation of problems we have had with apparently good ideas that turned out not to be acceptable for one reason or another, or the glitches we have had in the execution of some of the good ideas that have caused them to arrive on the scene late and therefore not have maximum effectiveness.

What I would like to do in closing is simply to focus on my primary assignment, which is to make a couple of suggestions about the government's role in innovation and to focus on what is possible and what I think is impossible.

It is clear to me that the easiest rallying point for transportation today is the demand for energy efficiency. The fact that we finally are in a position where the president of General Motors can and did recently remark that the American public wants small cars is, I think, a watershed in America. If the public wants them and creates demand for them at the dealerships, the public is going to have small cars because the manufacturers are going to supply them.

It is unfortunately perfectly clear despite that fact that we are not likely to realize in the design of the U.S. automobile all of the possible energy reductions that can be technologically accomplished, even though some of these will be publicly acceptable. I doubt that the Congress can successfully legislate them either, except in the broadest possible sense. I think, however, that government might provide incentives to make some of them happen sooner. The fleet average mileage standards are an example of such an accomplishment.

Ideally, we ought to put a lot of people to work thinking about the automobile efficiency problem. One simple idea might be to have a big contest in which there could be 1,000 prizes of \$50,000 to \$1 million each for the best ideas over a period of time, say a couple of years. That sounds like a lot of money, but it is peanuts in this game, and I have a lot of confidence that the Department of Transportation can manage a contest that rewards innovation somewhat better than it manages innovation directly. So I would be willing to advocate such a contest.

The second thing that I would advocate would be to go back and review the programs of the last 10 years in transportation that might be deemed innovative but have either failed or been killed and systematically inquire for each one whether we would take the same course of action in the light of today's problems.

We have had a lot of big programs come and go, ranging from the glamorous projects like the SST and automated highways to simpler ideas.

I am convinced that there are some very good ideas that have been set aside, and I am convinced that we can learn more about how to manage these ideas better if we review decisions away from the battlefield of circumstance in which they were made.

I also think it would be a useful thing for DOT to think about the question of how well the government--not DOT--has responded in the past in the innovation area in transportation, why it has done what it has done, and how well it did. I have a theory that the government's performance in safety innovation, for example, and innovations related to safety, has not been good and has not been timely, although in the end it has almost always been right.

By way of example, I felt that the government waited too long to react to the data on the DC-10 cargo door. I felt that it took too much time to decide that the highway sign foundation problem was real and that people would continue to be killed until we did something about it. I may be wrong. I may be impatient. But I would like to have a thoughtful review of what the process was that caused so much time to be taken for those important decisions. I think that there is a basic weakness in government that is reflected in its inability to react to

innovation quickly and positively. There is therefore an incommensurability between the government's promoting innovation and the needs of the system for change.

I would hope that government might learn to create policies that would encourage innovation. The first thing, of course, that must be done is for government to say it is in favor of it. Those at this conference say that. Secondly, government has to decide how to be involved. I hope that government decides it is not going to be in the innovation business itself, and I hope it decides that it is possible to create useful incentives and opportunities that will cause innovation to progress through conventional channels--tax incentives, national competitions, and others.

Finally, I would hope that government would continue, and much more vigorously than DOT has in the past, to encourage imaginative research in our universities that might lead to the definition of new innovation opportunities or to the prescription of useful innovations themselves. I think that one of DOT's weaknesses has been a lack of breadth and depth in coverage of basic university technology support in transportation alternatives. If we were limited to a single recommendation for action, I would urge that it be for DOT to take a more active role in the support of transportation technology and planning activities on our university campuses, rooted in the assurance that out of such a program would come a general description of several important innovative, economically sensible transportation opportunities for the United States.

THE EXTERNAL CLIMATE FOR INNOVATION

BY

WARD J. HAAS

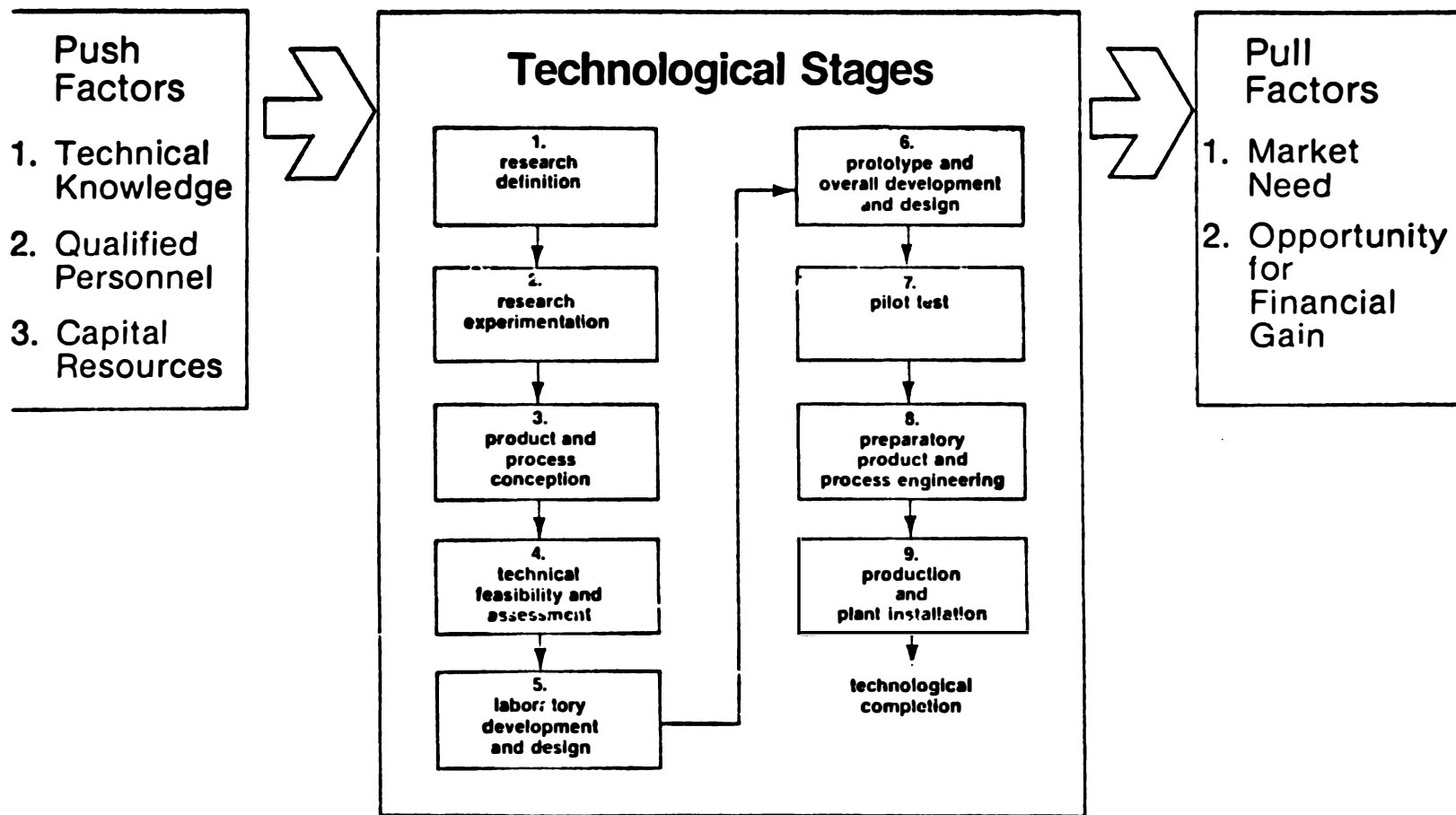
My mission is to discuss Innovation from the viewpoint of the Industrial Research Institute (IRI). The IRI is an association of approximately 250 industrial companies with major R&D operations. Originally organized in 1938, the IRI has as its main purpose the promotion of cooperative endeavors to improve all aspects of industrial research operations. Company representatives in the institute are invariably senior R&D managers, who are all too aware that R&D that does not culminate at some point in successful innovation is of no value to their firm. Hence our major interest in the general topic of your workshop.

About a year and a half ago, the IRI formed several subcommittees to discuss and study various aspects of the innovation process in preparation for a three-day program of papers and extensive discussions at our spring meeting last May.¹ I shall attempt this morning to boil down the three days of this meeting into thirty minutes. Because the IRI, as a voluntary association, is only partway through the process of reviewing and digesting many of the points I will present, please view them as personal opinions of this R&D manager and not as official positions of the institute.

Starting off with a definition of technological innovation as a process that starts with the discovery or compilation of knowledge in one or more technical fields and culminates in the successful introduction of a changed or new product, service or manufacturing process in the economy, we can picture or model it in simplified form as shown in Figure 1. In the middle box are the iterative processes of discovery or invention, or whatever goes on in creative idea sessions, in analysis, hypothesis, evaluation, and testing in the laboratory and in the technological stages outlined years ago in the reports by the Charpie,² the Denver Research Institute,³ and many others.

On the left-hand side of the figure are the so-called Push factors. To make innovation possible, we have to have the technological competence or understanding to do something new; we have to be able to produce it (or deliver it if it is a service); and we have to have the raw materials to make it. These latter requirements further mean that there must be economic resources, capital for investment, available for the innovation process, or nothing will happen.

On the other side of the model are the Pull factors. There has to be a real use, or need, for whatever the new innovation or change is



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FIGURE 1 The innovation process. Adapted from M.D. Robbins et al., "Federal Incentives for Innovation," final report to the NSF by the Denver Research Institute on Contract C-790, November 1973.

going to be. There has to be some way of identifying and locating this need and of getting the new product or service to where the need exists, i.e., to the actual market or market segment. Finally, there has to be a return, or profit to pay back the Push factor requirements in order to motivate and move the whole process forward.

Although it was not obvious initially, and certainly not during the early stages of the post-World War II science and technology boom in the United States, we also now know that the Push and Pull parts of the model are not equal in their effort on the whole process. Numerous examples and historical studies have shown that the Pull factors are much more important than the Push factors in actually making innovation and change take place.

In addition, there is one other extremely important feature of technological innovation. It is especially sensitive to uncertainty or risk. As illustrated in Figure 2, we all know that costs escalate exponentially as an innovation moves out of the laboratory stages toward the marketplace or actual full-scale utilization. And at each point along the cost curve, the probability of final success and reward must be judged by the responsible manager or management group. The greater the risk or uncertainty of return, the more courage it takes to proceed with the process, or, conversely, the less likely it is that the extra costs or resources to continue will be committed.

In summary, your friendly private sector colleagues will tell you that technological innovation:

1. Is more--a great deal more--than invention or discovery.
2. Requires Push factors: capital resources, qualified people, and technical knowledge.
3. Is especially responsive to Pull factors: need or market, and financial gain or reward.
4. Is especially sensitive to uncertainty or risk.

Innovation also has a number of other characteristics that are not explicitly shown in the Figure 1 model, but that are nonetheless very important to its management. For instance, almost all innovation is incremental. So called "core" or basic inventions such as the transistor, xerography, the internal combustion engine, and the discovery of radio are massive in their eventual far-reaching effects, but they are few and far between and take a long while to show up in the marketplace. So most technological, social, and economic change results from a sequence of small steps that are often hardly realized at the time by the participants.

It is a little difficult for me to think of specifics in transportation that illustrate this point because I have been solely a consumer in your area, not a real participant. However, in my own business, the pharmaceutical industry, there are many excellent examples. For instance, a direct progression of modified chemical structures can be seen from the earliest sulfa drug. Prontosil, over about a decade and a half to the oral antidiabetic agents.

Innovation is user directed, pulled toward what users or markets really want and will pay for. It is therefore very sensitive to rates of change in user needs or desires, serendipitous (subject to the

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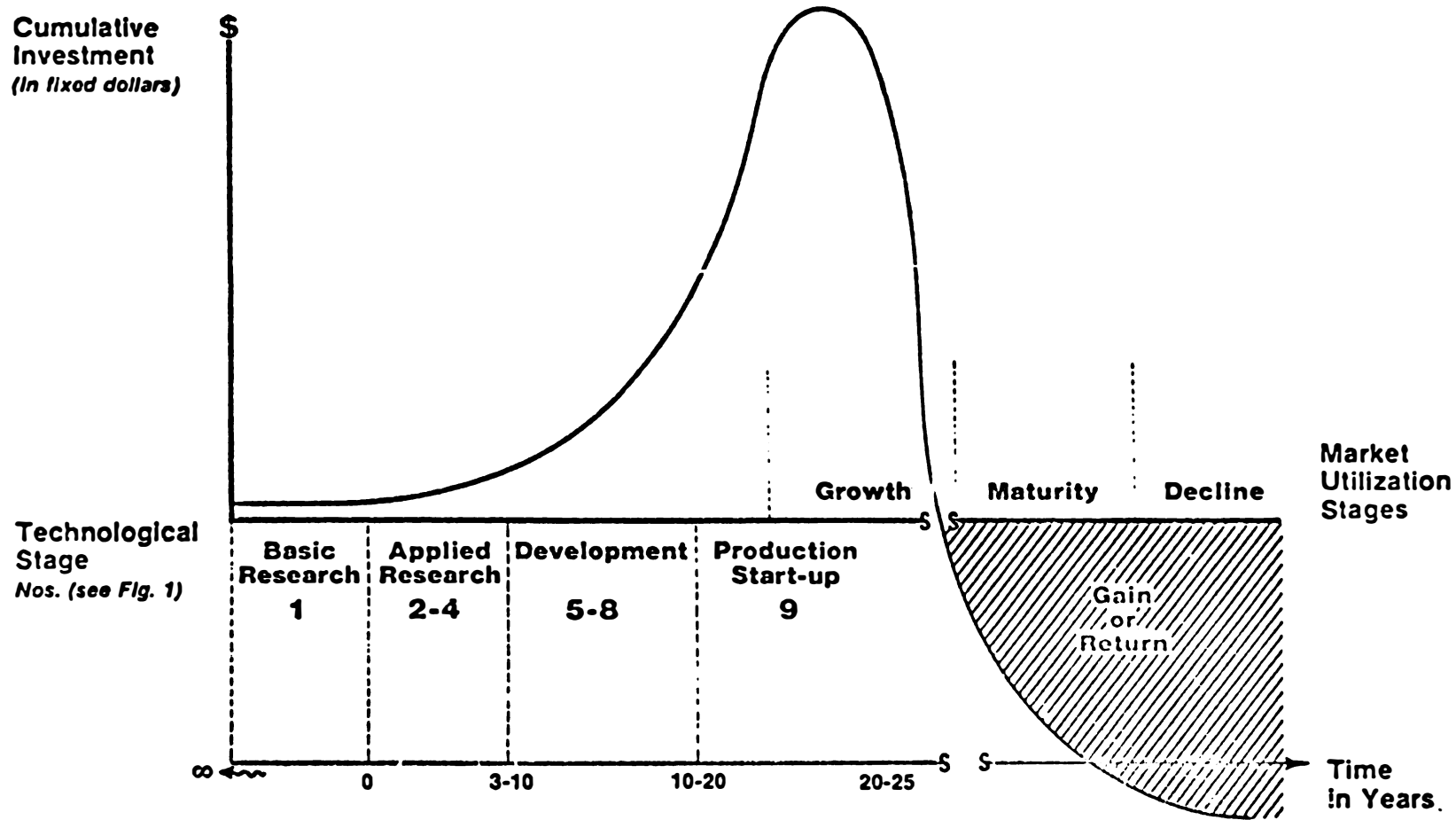


FIGURE 2 The innovation investment curve. Adapted from M.D. Robbins et al., "Federal Incentives for Innovation," final report to the NSF by the Denver Research Institute on Contract C-790, November 1978.

unexpected), and usually, perhaps almost always, bitterly resisted by the very people or constituencies that the experts might think would benefit most from it. The consumer goods industry is very aware of this latter point, but it is again difficult for me to think of illustrative examples in transportation. One example might be the failure of the Ford Motor Company's attempt to introduce seat belts and other safety features as major benefits of a new model year back in the early 1960s.

Part of the inertial resistance to innovation is certainly due to the problems of capital replacement, as we have all heard from the U.S. steel industry. Probably much more important is the all too human "not-invented-here" (NIH) syndrome. One famous historical example of this problem is not in transportation, but is germane to the challenge presented by large systems involving many people in a bureaucratic organization. It concerns the U.S. Navy and has been most entertainingly told by the technology historian, Elting Morison,⁴ in his description of the difficulties in introducing continuous aim firing in naval gunnery. By the turn of the century, rifle barrels and flat trajectories were available in artillery and naval guns, making possible longer-range gunnery. But the guns were still aimed at a fixed elevation from the deck and fired whenever the roll of the vessel brought the muzzle elevation to a point where the gunner judged he was "on target." A U.S. naval officer in the China fleet--a long way from Washington--picked up the idea from a British colleague of putting continuous gearing on his guns so they could be constantly cranked up and down independently of the angle of the deck, thus greatly increasing both the accuracy and the rate of fire. After making the modification and practicing a little, he was soon breaking all the target practice records in the fleet and enthusiastically writing back to the Bureau of Ordnance recommending adoption of the new system to the whole Navy. He got absolutely nowhere.

At first his letters, diagrams, and results were discounted, disbelieved, and ridiculed. When he persisted, they were ignored--for months on end, nobody would even bother to answer "the crank." When that did not work anymore he was quietly threatened, and then he finally got wise (or desperate) and made himself into what (in the lingo of the innovation game) is called "a disposable agent of change" (also known as the human sacrifice). He wrote his story out of channels to the president, Teddy Roosevelt. Reluctantly, but obediently, the Navy finally changed over, but of course even Roosevelt could not save the officer's career.

This anecdote also illustrates a final point about the innovation process that must be kept in mind. It almost never works without an energetic advocate, the new product, process, or service champion, the entrepreneur, within or without the sponsoring organization. And, if such an individual does not exist, somehow, one must create him.

Based on all these characteristics, our IRI groups took a look at what needs to be done internally, within the private sector profit-making organization, to increase innovation. The resulting recommendations fell into four groups:

First, find and nurture innovators. Specifically, search actively in your organization for creativity and creative people. Create an atmosphere for their autonomy and independence by the use of such devices as discretionary funds, project free time, etc. And improve their motivation for invention, discovery, and innovation by adequate recognition and rewards for those responsible.

Second, organize to minimize the internal resistance to innovation. Make sure that needed technology units are at a critical mass (generally more than one, but less than ten professionals); that the R&D management is sufficiently decentralized that it can focus on market or service needs and be adequately user directed; that all possible tools for speedy transfer of technology and knowledge are used (e.g., matrix or team organization and movement of knowledgeable people forward with the innovation project), and finally that the organization allows for the existence of the all-important innovation advocate. If at all possible, make him "indispensable" rather than "disposable."

Third, take great care to insure the adequacy of the coupling, understanding, between the functional areas involved in the innovation process, and, most particularly, of the coupling between your organization and the marketplace it is seeking to serve. Failure to accomplish this all-important linkage can often be fatal even to the most technologically competent firms, as was illustrated by the collapse of Republic Aviation on Long Island some years ago. Although Republic had available all of the NASA technology tapes and everything one can think of in the way of aids to technology transfer, they were simply unable to couple into non-space-related general consumer or civilian market needs in time to avoid financial collapse.

And, finally, emphasize top management's responsibility for the "innovation imperative." If the chief executive officer (CEO) of the corporation really cares about innovating and changing or improving the corporate product or service line, remarkable results will often ensue. In this connection, I can think of an illustration from my own experience. When I worked for Pfizer a number of years ago, the then CEO was never satisfied with the broad spectrum antibiotic innovations that initially made the company into a highly successful multinational enterprise. He was constantly using all of the motivational tools (both positive and negative) at his command to call for new and different products. By contrast, another much older and better established pharmaceutical company was led by a manager who radiated vibrations to the organization that essentially said, "What's the matter, isn't Chloromycetin good enough for you?" This latter firm had a bigger and better basic research organization than Pfizer at the time, but only 10 years later it was quietly acquired by another company while Pfizer continued to grow and expand.

In fact, the IRI study group taking a look at this aspect of innovation management felt that both the business schools, at one end of the management development process, and the corporate boards of directors, at the other, could productively devote more time and attention to training and directing senior management to be innovation conscious.

To move now to the recommendations concerning the external, and especially the governmental, climate for innovation, our study came to

one overriding general conclusion. Federal government actions to stimulate innovation at this point are really not required. What is required are actions to dismantle the barriers and reduce the disincentives to successful innovation that have grown up over the past years as the government, the public, all or us, looked the other way. These actions fall into several groups.

The first of these are economic recommendations, the most important of which is to control inflation. As inflation heats up, not only do high interest rates add appreciably to the investment costs of innovation, but the uncertainty of the true value, in "real" or deflated dollars, of the expected return is greatly increased. Consequently, the time and risk horizons of responsible management at all stages of the innovation process are shortened, and the rate of innovation slows or even stops.

In this connection, it is my opinion that congressional action to reduce federal deficits and monetization of the resulting debt is, in turn, the essential first step in the inflation control process. Attempts, as at present, to manage inflation by countercyclically manipulating the interest rate cost of money not only are obviously inefficient, but add appreciably to the overall uncertainties that depress the innovation process.

Next, as we all know, innovation has an insatiable need for capital, both for new investment and to replace plants and equipment made obsolete by innovation. In transportation, as in the steel and other capital intensive industries, we must all be particularly aware of this latter point.

For this reason, we discussed a number of ways to increase the formation of capital. These include:

1. The study, for possible phased introduction, of alternatives to our present progressive income tax with its numerous inherent biases against the accumulation of savings and wealth. One of these alternatives could be a progressive individual consumption tax with a flat or regressive income tax that is as small as possible. A consumption tax obviously sounds like a far out idea, but it might just be one whose time, after a long hiatus, has come. It was originally developed conceptually by the United Kingdom economist, Nicholas Kaldor, in the 1940s,⁵ and it was also part of a serious study of taxation undertaken by the Treasury Department in the last administration.⁶ I personally think it makes sense; it may or may not be politically possible.

2. Further reductions in the income tax on so-called capital gain income. "So-called" because capital growth is not income, and an individual or nation that spends or treats it as if it were is headed for the miseries so well described by Charles Dickens' Mr. Micawber and recently dramatized by the city of New York. The sensitivity of the innovation process to this kind of change is well illustrated by the rejuvenation of the venture capital markets in the United States since the "capital gains" tax rate was changed back to have some preference over other forms of again "so-called" nonearned income.

3. Further increases in depreciation allowances and investment tax credits, at least for technologically venturesome organizations.

Our study also considered the question of direct federal subsidies of socially important innovation, and we came to the conclusion that they were justifiable for sufficiently important programs, but only as a last resort. Specifically, we believe that subsidies and other government interventions into the marketplace should not be used as an excuse for failing to deal more directly with the economic incentive and capital formation issues discussed above.

Originally, in drafting this position for IRI discussion, I had put in the thought that subsidies might be justified if extremely large amounts of capital were required--a point that is probably of interest to all of us in the field, considering our history of land grants for railroads, federal highway programs, and the development of the air travel industry.

Significantly, our present recommendation does not contain any reference to justification for subsidies other than relative appropriability (I believe that this is the correct economic jargon term) of the benefits of the proposed innovation to society as a whole. As Gilpin⁷ and others have emphasized, capital availability for any project, no matter how large, would not be a problem if financial markets were in adequate shape and if the rate of formation of capital was sufficient to keep its price within reason for the risks involved in the project.

Our final economic recommendation was that the federal government, instead of providing subsidies, should take an active and proper role in the stimulation of socially important innovation by, as Henry Eschwege said in an earlier paper, aggregating markets and setting performance standards through the procurement process. Veterans of the last innovation battle in the early 1970s may recall a discussion I am going to use to illustrate this point simply because it did not happen and will therefore not tread on any toes. Back when solid waste was the problem of the day, the idea was that the government should stop passing laws, rules, and regulations and should simply buy solid waste at whatever price was required to insure that it was delivered to the appropriate handling depots rather than strewn along the highways.

If the price was high enough at any set of performance standards (e.g., for presorted trash) to stimulate supply, some innovator would soon come along offering the housewife a new service between her home and the buyer's depot. Another entrepreneur would then enter with a sorting device, and so on, and the whole socially important innovation would take place remarkably rapidly. Analogies to this hypothetical series of events certainly exist in the transportation area.

Our study then moved on to consider regulation and regulatory uncertainty. Obviously, regulation is a necessary evil. In all modern socioeconomic systems, no other mechanism for meeting and controlling social costs, such as the exploitation of limited natural resources, the pollution of the biosphere, and the exposure of consumers to undetermined safety risks exists since they can not be readily evaluated in the marketplace. And reasonably regulatory administrative requirements have been shown to be important incentives to technological innovation in their own right.

But our IRI group believes that the negative effects of regulation on innovation over the past decade have been overwhelmingly negative because regulations are:

1. Rapidly increasing.
2. Often unpredictable.
3. Sometimes mutually incompatible.

To expand on this point for a moment, I am not aware--although I am sure they exist--of mutually incompatible regulations in transportation. However, William E. Simon mentions some other examples in his book⁸ that would be funny if they were not so symptomatic. For example, the Armour Company was ordered by the Federal Meat Inspection Service to create an aperture in a sausage conveyor line so that samples could be taken out for tests. After the company created the aperture, OSHA came along and demanded that it be closed because it was a safety hazard. In another case, OSHA required employers to provide special lounge facilities for women's restrooms. Then EEO said that if you supply lounges for women, you must supply them for men.

Overdone regulations also sap capital and other resources. Both Murray Weidenbaum's⁹ Center for the Study of Business and, more recently, Chase Manhattan Bank economists¹⁰ have put a price tag of \$100 billion as the overall annual cost of regulations in the United States. I do not know how sound the figure is, but it is illustrative of the growing understanding in all sectors of the economy that the costs of regulation are very, very large--quite probably too big a price to pay for the societal benefits obtained.

Charpie and Eschwege referred in earlier papers to some of the costs that might be contained in this figure. Some others that are a little more difficult to put in dollars smack of just plain harassment. For example, Simon points out that the typical small business in 1976 grossing \$30,000 a year or less had to fill out 53 federal government forms, and the situation certainly has gotten worse since then. George Lockwood¹¹ once gave a talk about an innovative agribusiness venture on the West Coast. Trying to get the operation underway had required reporting to 40 different agencies. Not all of these were federal, of course, but in many cases state, city, and county bureaucrats can be a lot more troublesome than federal inspectors.

Now all of these "costs" are particularly pernicious because they delay innovation by, and therefore effectively deny market entry to, the smaller entrepreneurial new venture which has historically been responsible for much, if not most, of the true technological innovation in the United States.

Against this rather bleak picture, we then come to hopefully appropriate recommendations. Perhaps surprisingly, IRI is not in favor of deregulation.

Why? Because we think deregulation very often fits Herbert Stein's definition, which I would like to read out of a recent New York Times Magazine: "Deregulation: A process of restoring free markets by eliminating the old, small regulations we are used to, as in the case of airline fares, and imposing big, new regulations, as in the case of who can use how much energy for what purpose, with the result that the total number of regulations becomes larger and stranger."

What we favor is adequate administrative review of regulations prior to implementation carried out by a truly nonpartisan group, in other words, by competent individuals other than representatives of the regulatory agencies involved.

As an aside, most R&D managers such as myself who have quality assurance and quality control responsibilities make sure that the quality control managers in our production plants do not report directly to the plant manager. We do not believe in having the cops working for the robbers, as the old phrase puts it. Similarly, we do not believe that a regulation review should be managed by the regulators.

In such a review, the effect of the proposed regulation on innovation should obviously be of prime importance. I would like to see the review carried out (although I do not know whether this is practical), in somewhat the same way that the Office of Management and Budget conducts reviews on the financial aspects of all government programs. In other words, the review ought to have some teeth in it!

In addition to such preimplementation reviews of proposed regulations, the regulatory process needs improvement by such means as:

1. Changing wherever possible from legalistic advisory procedures to minimum cost balance of risk approaches to regulatory rule-making. As Eschwege indicated, our dedication to advisory procedures is the mirror image of the mistrust problem that exists widely in U.S. society. It is also complicated by the fact, as many others have pointed out, that regulations are written by lawyers and often issued without adequate technical review by competent professionals in the field.

2. Utilizing market-adjusting economic incentives as opposed to legal restrictions and penalties, wherever possible to meet regulatory goals. The IRI has noted that at least the EPA has recently started to explore such economic incentives as marketable emission permits, and they strongly believe that all regulatory agencies should be legislatively or otherwise directed to do likewise.

Actually, it is as much a different mode of thinking as it is a set of specific mechanisms that is needed here. In spite of the politics of envy, which we see so well illustrated in the current debates about energy policy, we need to trust market mechanisms more and the bureaucracy--no matter how enlightened--less in attempting to meet social and political objectives.

To further illustrate, let me use again a personal experience example that at least is somewhat related to transportation. For a number of years, I have tried to make a suggestion to help the traffic problem in New York City--admittedly without much success. The suggestion is that, rather than worry about all kinds of rules and regulations to control congestion, vehicle-induced air pollutions, etc., the city simply sell the traffic space on Manhattan Island to those users or private automobiles who want the psychological and other satisfactions of taking their territories onto the "common" by a variation of the present medallion license for taxis. There is obviously some price for a private car medallion that would adjust the demand for automobile traffic space on Manhattan Island to the available supply, which is equally obviously a very limited economic good. This price is probably

on the order of \$1000 or \$2000 per year, or \$25 or \$30 for just a single day's permit, and it really ought to be politically possible, since most of the voting residents of at least the island borough do not own their own automobiles.

3. Finding ways to improve the performance of the personnel working in the regulatory agencies. For example we now have internships from the private sector into the government. How about internships from the government into the private sector? To go a little further out, how about requiring prior private sector experience (obviously in a nonassociated industry as far as a specific regulatory agency is concerned) or perhaps even requiring entrepreneurial or innovation management experience, before an individual can be qualified for a senior position in the federal regulatory apparatus.

Significantly, no mechanisms now seem to exist in this regulatory apparatus for adequately recognizing the time and dollar cost of delay and uncertainty in handling any type of permit or for example a new drug application. And there is certainly no discernible reward system in the agencies for personnel who advance innovative or economically advantageous projects. So the question is, "How can regulatory agency personnel be motivated to make appropriately balanced decisions with respect to risk, cost, and benefits, and to become aids rather than barriers to useful innovation?" At a minimum, how about creating an "ombudsman for innovation" within each regulatory agency? In other words, as I commented earlier about private sector firms, we should create within the agencies the advocates or innovation champions whom we know are necessary for the innovation process.

Finally, our IRI study reviewed actions we felt would be important to increasing the new knowledge or R&D part (the initial Push factor) of the innovation process, with recommendations as follows:

1. Increase federal support for basic and exploratory research at universities and other knowledge centers.

2. Index this support in some way, possibly by relating it in the budgetary process to the nominal GNP, so that it would be reasonably consistent over a span of years.

3. Modify antitrust regulations where and if required to permit private sector R&D consortia for major projects.

4. Modify or eliminate the Treasury Department Regulation 1.861-8. Although it is almost impossible for anybody but a certified public accountant to understand, this little regulation has the net effect of stimulating managers in large companies with any kind of overseas R&D operations to build up the R&D staff and activities in the invention and discovery of new knowledge overseas instead of in this country. Since R&D jobs are jobs like any others, this point is one of the very few on which both private sector management and big labor agree.

5. Develop coherent patent policies across all the government agencies to encourage exclusive licensing of federally owned patents. As many of the points that Charpie and Eschwege made earlier illustrate, this may perhaps be the most important recommendation of all with respect to a quick return on the new knowledge base produced with support of public funds. If exclusive licensing of federal patents is not made

possible, harnessing the Pull factor of financial gain or reward to make them exploitable for innovation is very, very difficult to do.

These last points complete my summary of IRI's discussions of the innovation process. In closing, I am also pleased to report on more official actions that the institute has under way. IRI has already issued a number of official papers, one on patent policy and another on regulation not connected to its economic aspects and is now well into the process of distilling out of the points and recommendations outlined above an additional position paper on the economic aspects of innovation, which should appear sometime this fall.

This paper will start off with the same statement I made earlier that what the country does not need is government actions to stimulate innovation. On the contrary, what is needed is to replace to the maximum extent possible, the dead hand of government with the invisible hand of the free market economy. The paper will then go on to recommend that:

1. We control the basic causes of inflation.
2. We increase capital formation.
3. We utilize market incentives to meet regulatory goals.
4. The government properly exercise its role by aggregating markets and setting performance standards in its procurement operations.

REFERENCES

1. "Stimulation of Technological Innovation." Research Management, XXII, (6), 12-38, November 1979.
2. Charpie, R. "Technological Innovation and Economic Growth--Applied Science and Technological Progress," a report on science and astronautics to the U.S. House of Representatives, June 1967.
3. Robbins, M., C. Burke, and J. Milliken. Industrial Economics Division, Denver Research Institute, University of Denver, Denver, Colo., final report to the National Science Foundation on Contract C-790, November 1973.
4. Morison, E. "A Case Study in Innovation." Engineering and Science, 13, (7), 5-11, April 1950.
5. Kaldor, N. An Expenditure Tax. Westport, Conn.: Greenwood Press, 1977.
6. Ehbar, A. "Manifesto for a Tax Revolution." Fortune, April, 1977.
7. Gilpin, R. "Technology, Economic Growth, and International Competitiveness," a report for the use of the Subcommittee on Economic Growth of the Joint Economic Committee of Congress. Washington, D.C.: Government Printing Office, July 9, 1975.
8. Simon, W. A Time for Truth. New York: McGraw-Hill, 1978.
9. Weidenbaum, M. The Future of Business Regulation. New York: American Management Association, 1979.
10. "If You Like Challenges...Try This!" Chase Manhattan Bank Advertisement, New York Times, Friday, October 26, 1979, p. D-3.
11. Lockwood, G. (Monterey Abalone Farms). "Some Causes and Consequences of Declining Innovation," address at Third Annual Colloquium on Research and Development Policy, American Association for the Advancement of Science, Washington, D.C., June 1978.

LABOR AND PUBLIC INTEREST CONSIDERATIONS

BY

WILLIAM B. SAUNDERS

I do not completely agree with the previous paper by Ward J. Haas. One of the figures suggested that we do not need government stimulation in order to innovate.

That may be true in many industries, but in transportation there is an evident need for government participation. I address the public interest aspects and the labor aspects of innovation in transportation because there is a public dimension as well as a government dimension to the problem of innovation.

There are obvious differences between the normal process in unregulated industries and the process in transportation. In other industries, decisions about innovation and about research and development are made by the producing and consuming industries, jointly or separately. There is at least an interaction between them wherein decisions reflect what Haas talked about: the market criteria. In short, the risk factors are borne by those who make the decisions to spend the money.

When the government is involved, there is a shift in the nature of the decision-making process. Bringing government in permits a re-examination of the time horizon: management decisions must have a shorter time horizon than is needed for R&D decisions by government. With government, we can have a reexamination of the planning criteria and of the risk criteria that individual enterprises are willing to absorb.

That risk and rate of return feature is fundamental to the role of government in providing a different innovation environment. It is the risk feature on which government should concentrate: how to share the risk.

When we talk about sharing the risk, we immediately run into criteria that are not very evident in private decisions: public interest criteria and labor criteria. While they are recognized in every decision, they may not be major or significant factors in deciding whether to go ahead or not in the case of strictly private sector decisions.

Let's talk about the public interest first. Legislation and public understandings about policy in the country lead to a whole series of national goals that any senator or congressman will tell you about. They may include things like the Humphrey-Hawkins full employment criteria, equal employment opportunity, environmental considerations, national defense, and so on.

The question then is when you establish a public interest set of criteria, what do you do with it? When government is involved, it has to face this question. There are two ways of looking at it. One is to say that it is good to have that in the preamble to some legislation so as to set the broad guidelines and to give some assurance that the agencies administering that national policy take into account these various criteria. On the other hand, I would be very concerned if the approach were to take those criteria and apply them in evaluating each individual project. If we go that route, we will be hindering the rate of innovation rather than helping it.

Almost any project can be justified in terms of having some beneficial impact, some national goal. In the same way, almost any project will have some aspect that might be found to have a negative impact. Hence it comes down to a question of weighing the broad public interest of, for example, more employment versus lower cost. Somebody has to decide that. If we let each project be decided by a special interest in a particular aspect of the public interest, I think we will stifle innovation directed toward overall benefits.

How do we decide? If we look at the proposed legislation, S-1250, we get a point of view that I find very alarming. That legislation talks about a technology review panel in which there would be, clearly, experts familiar with research, development, innovation, marketing, and the various other aspects that have to be considered in evaluating a project from a business point of view. But then it goes on to say that it should also have members of the panel who are "affected by technical innovation."

When we talk about including anybody that is "affected by technological innovation," the door is being opened to a vast variety of people who could very readily throw monkey wrenches into the machinery.

The question is then, what do we do about public interest? What is the public interest itself? If we look at the public interest criteria list I mentioned at the beginning, it is clear that a wide range of political judgments is involved in evaluating and deciding what the public interest is. It is a political judgment; it is not a technical judgment.

The engineers and the scientists, then, have to back away and admit that they have no special claim to deciding the public interest. On the other hand, one does not want to have a large number of individual special interests sitting on committees to say, "well, that is a great idea except it has environmental impact" or "that is a great idea except it has labor impact."

Therefore I suggest to you that the stress of those who want to see innovation in transportation should be on the political process. Instead of talking entirely about the technical side of it, we should address the political process. The political process in America is one we should be proud of. It is a very good process. What I am suggesting is that all these negotiations and trade-offs be handled through the Congress rather than in technical committees that are going to review individual projects. If the Congress appropriates money for a program, that will be the best way to see that the various interests

are considered, and then, in the overall, given some relative weight that is consistent with the political judgment of the country. The alternative, I believe, is simply to defeat innovation.

On the other hand, it is fair to say that the political process sometimes gives us funny results. We now have a National Highway Traffic Safety Administration. I am sure it does a lot of good work. But the policy question to be asked is, would we like to have a safety administration for every mode in which we are interested? I think that would make it a nightmare for decision-making, and again, we would have one group with a special interest in safety alone directing the efforts of a group that might be interested in safety as merely one factor to be considered.

One has to ask whether in the political process, proposals can be made to Congress that will be acceptable and workable but that will not result in a proliferation of agencies to tackle the various segments of research.

I am a believer in the systems approach, but we will never have a systems approach to decision-making in transportation if we divide up all the areas of interest with separate administrative groups looking narrowly at each one.

We already have problems between departments: for example, Energy and Transportation may have completely different views about what is right or appropriate for the automobile as one element of transportation.

Let us talk now about the political process for determining the transportation share of the total research or innovation dollar. From an overall industry point of view, there is a movement to have the Department of Commerce to be a kind of clearinghouse or central agency for research. Should that be the vehicle for doing transportation research or fostering transportation research? I think not. I think we have enough expertise in the transportation industry (including its suppliers) to have that industry be responsible for evaluating what it needs. That industry can work with the Department of Transportation and its related agencies to evaluate the needs of the transportation industry.

However, there is a political problem. The problem is that transportation has to compete for its share of the total dollars the government spends and for its share of the administrative or political interest that the government will expend on transportation as against all the other industries that need attention.

Now here we get one step closer to technology. Getting a bill passed is largely political and strategic. The departments perform a partly political function in competing with each other, but they also inject some technical input into the competition.

I am talking about the stage where the Department of Transportation has some technical input. It has panels, it has committees representing people who understand the technical problems, and that department provides input vis à vis the Department of Commerce, the Department of Energy, NASA, the Department of Defense, and so on, in getting a share of the limited research and innovation budget.

I have to admit, however, that the democratic process very often takes a long time to make a decision. Too often the decisions are made only when the problem reaches a crisis stage.

I view this situation with alarm because crisis decisions are not the best way to reach optimum solutions. I remember in 1972 and 1973 going to a briefing on energy by a staff group of one of the joint committees; their studies had shown that within perhaps 10 years, if nothing untoward happened, there would be a serious energy crunch. They were concerned about our dependence on foreign supplies of petroleum.

It was a very impressive demonstration. Afterward they told us they had made presentations to about one hundred congressmen and senators, one or two at a time, and everyone they showed it to had been impressed, but each admitted he was not ready to urge conservation in automobile use or substitution of new energy sources. They feared political reactions even when they knew what was good from a national policy point of view.

So while the process was there, there was not adequate courage on the part of our representatives to stand up and tackle a very tough question. We are now in a real crisis on energy, which we might have avoided had we started earlier to tackle it.

The same point can be made with respect to railways, which are basically in a crisis situation. We have seen it coming for a long time, yet we are paralyzed in our political approach. For example, Congress has not been willing, until very recently, to say that there is a lot of obsolete or unneeded plant that we should let railways abandon.

So while I say that the political process is important and necessary, I am painfully aware of the fact that it takes a long time and we tend, too often, to operate on the crisis theory. We need better ways of reaching out to the public, which in turn reaches Congress.

My own preference would be to see the public interest issue described in terms of productivity. I would like to see everybody who is interested talk about productivity as the main public interest issue. Productivity is something we can all understand and something we can measure, whereas standards involving national defense and social values are very difficult to use in evaluating a government research program.

I was delighted to see the August report of the Joint Economic Committee, which places very heavy stress on productivity. They say it is the linchpin for our economic progress. Our national administration is beginning to get around to addressing productivity. It is a political problem for the administration, but if we are going to try to control inflation, we can get the support of the average person by talking about the power of increased productivity as a way of restricting the inflation rate.

Let us take a look at Canada, because they have faced this problem of the public interest in their research program. First of all, when they set up their R&D effort, they set up an interdepartmental committee, which makes sense. In their case, they put it under the Treasury Board because that is where the money comes from. We have a little different process here, and we do not have to put it under Treasury, but

one admirable effect of their process is that it filters the decisions through the various departments. So there is competition in evaluating where the money goes and what kinds of projects are supported.

The effect of that is that once a department has a chunk of money to spend, it tends to have the most to say about the nature of the project, and that is not unlike the situation in private enterprise.

By looking at Canada, we can see one of the pitfalls that I would be concerned about here. In their case, for a lot of historical and sociological reasons, they place great stress on regional development. We have an Economic Development Administration in the Department of Commerce that also looks at regional matters, but in Canada, regional development is a very important, sensitive issue, and so they have a separate department concerned with regional economic development. That agency has a big chunk of the research budget, and so that agency gets into the decision-making process in transportation. It can decide to encourage research in certain subjects because it wants to expand industry in a given region where a nucleus exists. That decision may not be the best from the standpoint of increasing transport productivity, but it does fit a broad political objective. Looking at that from an American point of view, I would be concerned about letting the Department of Commerce, Economic Development Administration, decide that we ought to be doing research on some kind of a project in transportation that would benefit, say, Appalachia, because that should not be the criterion for optimizing the use of the limited budget that we have to put into transportation.

It is also interesting to note that the Canadian process does not contemplate a role for a Ralph Nader. They have a Consumer Association of Canada that is similar to what we have here. They do have a voice politically through their general impact on Parliament, but they do not evaluate individual innovation projects.

There is one other point to make about the Canadian method. They have a very powerful solution to the issue of risk sharing. In their process, a specific decision is made about what share of the project will be borne by the various interested parties. It is almost a bidding process. If the government has a pet idea that industry does not think is a very good one, then industry says it will not put up money for that project.

On the other hand, if the government still feels strongly about it, it will go ahead and spend only government funds for its own idea. But taking 100 percent of the risk is a sobering idea for the government, and it may be cautious about such projects. Yet again, industry may feel there is some merit in an idea, but not be willing to risk more than X dollars on it. This leaves room for the government to decide whether it wants to spend any extra sums needed--in comparison with the benefits it may derive from investing in other projects. Hence the share of funding is a way of measuring the relative risk.

My own view is that government should look at it in the same way a private entrepreneur looks at it. Say that a normal business decision might have a planning horizon of 3 or 4 years. As a manager, if I can do it in 3 or 4 years, then I am willing to spend the money because I

am able to predict within that range--not with certainty, but with some comfort. On this basis, I would conclude that government funding should be only a small portion of the effort on projects that are, say, of 3-year duration, while a much larger portion would be appropriate on projects that have a potential payoff 10 years out.

I submit that that criterion would enable the dollars to go further and would help the decision makers to look at the real choices in terms of possible impact on the economy and on the income statement of the entrepreneur.

Concerning the labor aspect, it is obvious that labor is directly affected by innovation. Labor can be hurt and hurt badly. It does not help an unemployed or underemployed or downgraded person to know that in another city and in another industry there will be new jobs at a higher salary.

So there is a real difference between the short-run impact and the long-run benefits to society, and we have to be sensitive to that short-run impact. Organized labor has a justified concern about how innovation is handled.

What is the labor response to innovation? It varies tremendously. The United Mine Workers under John L. Lewis made a decision many years ago that no matter how many jobs were lost, everybody left would be a member of the union with a good income and good working conditions. Lewis was content with innovation as long as the people that were left on the job did very well.

The International Ladies Garment Workers Union (ILGWU) faced a declining industry, and it decided to protect its jobs; instead of just waiting, they spent money to find ways of increasing productivity of the factories in which their members worked.

The Airline Pilots Association has shared directly and proportionately in the economies that came from larger, more efficient aircraft, but because their share of the total cost was relatively small, their compensation has not crippled the industry. If the pilots accounted for a large proportion of total cost, that process could not have worked as effectively as it has in aviation.

The longshoremen fought the container movement bitterly. In effect they have set up employment protection systems, but there still remain economies in the container movement that permit that innovation to continue to grow and flourish.

Let us take a look at the difference between the teamsters and the railroad unions. It points up an interesting economic reality. My opinion is that the Teamsters Union over the years did not resist innovation because it said: "Anything we do to stimulate the trucking industry is going to take traffic away from the railways; that is going to mean more jobs for our members, so it is a good thing." In other words, the nature of the market and the employment opportunities in trucking encouraged or at least permitted the leadership of the Teamsters to move in a positive or at least nonnegative direction with respect to innovation. The contrast with the railways, where it has been a continuous battle to get innovation, is clear.

I will mention one other interesting recent development--Eastern Air Lines and its attempt to provide incentives for workers to be concerned about innovation and productivity. Under the plan, 3.5 percent of the pay of the employees and 5 percent of executive pay are put into a reserve fund. If earnings equal 2 percent of revenue, the money is paid back to the employees. If earnings are more than 2 percent, the extra money is shared with the employees. But if the earnings are less than 2 percent, then that fund is available to assure lenders or equity investors that the company will remain solvent.

It has worked so far. How long it will continue to work I do not know. But it is an innovative approach to sharing the cost of survival and progress.

The overall research approach to innovation is important, but we should recognize that efficiency and economy at the work place are also important. Changes in methods do not always require new technology. Simple changes in work methods and rules can be significant for improvement in transportation.

Obviously, that kind of issue permits only a very limited role for government. Education and support for change would help, but retraining would be the major specific role for government. However, innovation at the work place is hard to achieve without aggressive management, without hard work with unions, and without incentives for the workers. Part of the slow progress in change at the work place can be attributed to what I call regulatory malaise. Too many managements can just blame the government for all their problems and therefore simply coast along with things as they are.

The fear of head-on conflict and possible strike acts as a cloud over many management decisions. A weak railroad has great difficulty in facing a strike. The Rock Island, which is certainly among the weaker railroads, is now going through that. But for stronger railroads, that need not be the same kind of limiting factor.

Again, I will use a Canadian example that deals with an institutional or environmental factor from which we could learn. The Canadians were way ahead of us in getting rid of the firemen on the locomotive back in 1957. It was precipitated by a strike, and as a result of the strike, the government set up what they call a Royal Commission. I am a great believer in the Royal Commission process, and I wish we could do it here.

This is how a Royal Commission, of course here we must call it something else, works. When the government has a tough political problem to tackle, it sets up an independent tribunal, very prestigious and composed of well-respected public figures, to evaluate and make findings and recommendations.

The findings are not binding, but when the independent group does its job it is much easier for the government to take the hard political decision and rely on the Commission's findings. We could make more use of such powerful, independent tribunals or commissions. We are all tangled up in administrative agencies that do not necessarily have the political stature of the independent special commission. The findings of an administrative law judge represent a technical decision rather than one of broad public policy.

I would hope that we would find ways of tackling big, broad issues by addressing them with this sort of independent commission. Unfortunately, in America we are not as willing to accept the idea that a commission can be independent and authoritative. Nonetheless, we need to do more to break away from our normal mode of administrative agency decision making.

The Canadians are ahead of us in another work place on the railways. Practically all the switching crews in Canada now have only two workers. We almost always use three. This cost-saving, productivity-improving change did not require the government. No research effort was involved. Rather, it was a matter of negotiating, dealing with supervisors, dealing with workers, seeing their ideas, trying to find ways of taking advantage of it, and not being smug and talking down to people.

One more thing we might learn from the Canadian experience is that having a few strong companies will help to permit savings to be made. It is not just that there should be only a few companies. They have to be strong, because having a hodgepodge of weak properties put together is not going to have the dollars; they are not going to have the economic strength to tackle either their union problems or their public relations problems.

I have come to the following conclusions:

1. If we had intermodal corporations in transportation, we would have a better chance for optimizing the use of our scarce resources. There are intermodal corporations in Canada. Even so, they do not do as much in terms of a systems approach for purposes of resource allocation as they could. They tend to operate on the basis of profit centers, which is, a perfectly normal business practice. It makes sense in most industries. In the case of transportation, where there is a competitive thrust among the components and where there are options for deciding how given goods may be moved between point A and point B, I am not so sure that profit center criteria alone should be used. I can see where a systems approach could be brought in that says on balance it would be better to divert some of this commodity moving from A to B to the truck side or the rail side or the air side for a variety of reasons that, overall, will maximize the benefit to the corporation as a whole.

That is a tough decision, and it is one that has a lot of public interest feedback. Many people will say that this will tend to reduce competition, and antitrust laws ought to be applied to prevent intermodal companies. But on the whole, I believe it offers some potential for improving resource allocation and innovation.

2. Even if there were an intermodal corporation, we would not have any better results in negotiating changes at the work place as long as we have the present structure of unions. There are now a number of competing unions, not only mode to mode but within modes, and it is impossible to visualize a system under which an employee in union A can be laid off and readily given a job in another mode run by the same company. The union in the other mode will not be likely to put that worker into the seniority list at the same place he had in another union. That is simply not consistent with the political realities today.

Hence I do not see any advantage in having intermodal companies to tackle the problem of expanding and contracting segments of transportation, unless it was accompanied by a completely different union structure. That process involves so many political problems and personality problems that I can not see it in the reasonably near future.

3. We need to have a better sharing in the savings of innovation. When I say sharing, I do not mean just that labor should get a bigger share of the savings. I think we have tended to concentrate so much on "labor productivity" that we have lost sight of the very difficult and very real problem of total factor productivity--labor, capital, and materials. Politically, it is important to begin to stress total factor productivity--because only in that way will we be able to see the true advantages and disadvantages of management decisions on innovation. Only in that way will we be able to sell the notion that the labor incentive to innovate should be there, but it can not always take the major share of the total savings.

Total factor productivity is not discussed enough in the government literature or in the political environment. I would hope that one of the benefits of this workshop is that there will be a paper that will go to congressmen stressing the benefit of looking at total factor productivity.

4. We need new incentives, which will take tough bargaining, in order to maximize work place innovation and to reduce jurisdictional problems. The transportation industry is full of those problems. The solutions seem to take a long time to spread from point to point. Again, I will cite the Canadian experience on switching; it was done by negotiating with the appropriate authority to look at individual situations on a local basis. When that was done, it was reviewed and examined location by location, and the result is that in a relatively small number of years, there has been a significant change in the way switching is performed by the railways up there.

5. The government share of any innovation effort should be based on risk. If the project or the idea has great risk, the government share should be greater. If the project has low risk, the government share should be low. There should be bidding on shares by the various parties to determine the relative interest that people have in the potential of each project.

6. If a research effort is to be effective, we need to have the minimum possible lag by government. Now, how are we going to do that? Government, once it sets the process in motion, will inevitably be worried about making mistakes and that concern can be deadly to innovation.

We have to rely on the political process, but I think we can minimize it by not having the political process reflected in the technical boards that look at individual projects.

7. In setting priorities for effort, it would be a mistake to have government make the list. It would be much more effective to put the first responsibility on the industry involved to make the list of priorities and to put in a justification for why each project is on the list, with costs, benefits, and so forth.

When that is done, the government can review it and suggest, perhaps, that not enough attention was paid to safety or environmental

considerations. Those considerations could be included in a project that the industry has offered or could be independent of other projects. If it is accepted that this is not an adversary process, the government still has control. It does not have to be a rubber stamp, but it will be much freer to comment and expand on or delete projects than if it has to create the projects de novo.

8. In evaluating projects, we ought to be asking what the cost consequences are. There are all sorts of projects, and some of them are the pet project of some particular scientist or engineer. If we go into a project, we should ask what the cost saving significance is for this project as opposed to some other project. Will we save 1 percent or 5 percent of operating expenses by successfully solving this problem? The one that saves 5 percent (subject to these other considerations that I call political or public interest considerations) ought to have the higher priority.

9. We need more public education. We have an adversary system that is encouraged by the political process. I think we can do something to educate people about productivity that they can accept. The average citizen can accept the principle of productivity. We need to educate people for that is a way of breaking down the spirit of hostility in the adversary process that results in unsound decisions.

10. The role of government in designing infrastructure differences into the system must be considered. One mode supplies most or practically all of its infrastructure. Another mode has it almost entirely supplied by the government. In one case, say, in the case of trucking, there are fuel taxes that do not involve the same capital commitment that the railway has to have when it provides its own right of way. The airline is provided with a right of way, and it has an argument about what the taxes are. The waterways have another kind of an argument about their responsibility for the provision of the infrastructure.

So when we look at the share to go to each mode in trying to decide what is a rational approach to transportation innovation from the standpoint of the government, we have to consider the fact that the dollars are spent on quite different kinds of projects, because of the different financial responsibilities that managements have.

I would suggest, then, that we look at R&D expenditures, for example, expressed per dollar of total capital investment, not just those of the company but the total committed to the industry; likewise, we ought to be looking at R&D expenditures in relation to the current year's capital outlays.

Why do I make the distinction? I make the distinction because in the case of railways, we have such an old investment that the dollars are obsolete dollars. Much of the plant may not even be relevant. While we ought to look at that to get a comparison of the different modes, it will not tell us enough without looking at the way current dollars are spent. Again, current dollars means the dollars currently spent in each mode including the government contribution.

The practical suggestions that we may come up with should be directed toward the political process that now prevails, rather than toward the theory of innovation or the organization of industry in doing research.

**REMARKS BY CHAIRMEN ON THE SCOPE OF PANEL DELIBERATIONS,
PRESENTATION OF BACKGROUND PAPERS,
AND DISCUSSANTS' COMMENTS**

THE SETTING FOR INNOVATION

REMARKS

BY

FOSTER L. WELDON

My remarks will be rather brief. I plan only to outline a framework within which I think our panel can approach its assignment. In the process, I hope to suggest how we might view the setting for innovation as a starting point for our deliberations.

People look at the term "setting" in different ways. For my own part, I would like to define setting as simply the environment within which a transportation change might take place. What I am hoping we can do is look at transportation needs in terms of performance requirements and explore, then, why our abundant technology has not been applied more effectively, instead of looking at what hardware might have been applied.

In other words, we want to get away from specific hardware ideas in order to explore the larger setting: why technology has not been applied more fruitfully.

I know I will get some arguments on this point, because many people say one cannot really look at the environment for innovation except in a specific problem context. That makes good sense. Certainly an innovative solution to an air-scheduling problem is developed in an environment that is quite different from that in which a productivity improvement in a marine terminal is made.

But I have a rather simple-minded answer to that. If we imagine absolutely the worst environment for transportation innovation and if we suggest ways for improving that setting, then I think we will have some results that are generally applicable.

That is what we will be trying to do, and, of course, the model "worst" environment that was in the back of my mind when I developed this discussion framework is the urban transportation setting. That is where the diffuse trip problems are. That is where most of the political problems are.

Therefore, how does one categorize a worst environment from the point of view of looking at the setting for transportation innovation? I have selected four major headings that I believe cover everything we need to discuss. Number one is the governmental setting. I isolated that one because certainly almost everything that is planned or done in transportation is affected by or impinges on government in one way or another and at one or more levels.

Number two is the industrial-commercial setting. Industrial-commercial entities develop and provide almost all transportation equipment and services, so the environment there needs a clear look.

Number three is the research setting. Why put that in? Well, research certainly is the foundation for long-range planning and development in transportation, and we need to take a good look at that side of the problem.

The fourth heading is the implementation setting, not because it is distinct from the three already listed but because it will permit us to focus on some very refractory problems that are common to the other three categories.

So, we have all these components to look at: governmental, industrial-commercial, research, and the catchall, implementation settings. Our overall objective, in looking at innovation in this framework, is to see if we can identify some recommended changes that will help DOT expedite the innovative process.

The governmental setting necessarily includes the federal government, state governments, and local governments--all those city, county, township, and special purpose districts or authorities that are set up to monitor or to operate transportation.

The federal level appears to be the best source of funding for innovative programs, but unfortunately, the federal government is not the real customer for transportation innovation. Unfortunately again, the local arena, which really is the customer in almost every case, is a hodgepodge of all sorts of different quasi-governmental agencies that all have different ideas about what is good for them. At last count, in our 200-plus standard metropolitan statistical areas, there were more than 18,000 governmental units--a highly fractionated customer indeed to be convinced and compromised into accepting any innovative idea in transportation.

What types of questions will we be asking about this governmental setting? A few examples: Is there any way to stimulate innovation at the local level simply through a judicious choice of initial projects? Demonstration programs have tried time and time again, but too often by the time a project gets approved it has been so compromised to accommodate conflicting viewpoints that it does not represent innovation at all, and by the time the project is in place it contains nothing more than off-the-shelf components and concepts.

Other obvious questions: How can federal resources best be deployed to promote innovation? Not just through funding alone but perhaps through basic research? How about the state's role? What is it now? More or less a pass-through agency for funds? What should it be? We have a lot to look at under this heading.

In the industrial-commercial setting, there are at least four factors we must consider--the equipment suppliers; the transport system operators; the architectural, engineering, and construction firms; and the special interest organizations, that is the professional, occupational, and industrial associations that represent the others. All are important in the innovation scene, and we want to find out what their influences are.

One thing that needs to be pointed out is that the equipment suppliers and the transport system operators certainly represent a rather mature industry that is heavily invested in fixed plant. In other words, they have characteristics that are not particularly conducive to entrepreneurial or agile innovation. We want to examine whether this is indeed a deterrent to innovation and what might be done to change the situation.

The architectural, engineering, and construction firms, (A-E and C companies), though not similarly burdened with fixed plant, may also have a built-in inertia to change that derives from all of the rigid standards under which they must operate. Just building codes, for example, and construction standards may create significant deterrents to innovation.

The special interest organizations and trade associations are generally dedicated to status quo, I believe, to protect the interests of their membership. So there is a lot of inertia in all these areas, and the kind of question we will be asking is, what can DOT do to help overcome this resistance to change?

As to the research setting, at least four types of research facilities enter into the picture. These are the government R&D facilities, the industrial R&D facilities, the academic research centers, and the independent research organizations.

Government R&D certainly houses a great deal of research talent and facilities, but I do not believe that transportation is really getting a fair share of the spinoff from all of these resources. Very little, in my experience, has been brought directly to bear on transportation problems from this source.

Theoretically, the industrial R&D activities are available to DOT through the request for proposal (RFP) process, but here, again, there are some serious problems. Many companies are reluctant to participate in bidding for a number of reasons, e.g., contract restrictions on the direction of effort, allowable costs.

In the academic centers, I detect a considerable decline in innovative transportation activity. There is really no transportation curriculum in most institutions, and transportation centers themselves, in some cases, at least, are suffering from what all universities are going through now, declining enrollment and increasing costs. The first cuts are bound to come in the nondepartmental activities of the university.

So that leaves the independent research organizations that are specially well-organized to handle the RFPs and respond to government proposals. A lot of good work is done in this sector, but that sort of activity does not fulfill the university role of producing young, innovative talent to go into industrial transportation activities.

The fourth category is the setting for implementation; without implementation there is, of course, no innovation. Certain factors here are particularly important. One is the physical system characteristic of transportation. This inhibits any kind of innovation, or so it is said, just by virtue of its size. It is massive; it is complex; and how can one change it significantly in any reasonable time frame? This is one aspect of the implementation setting that I would like to look at very critically.

Labor-management attitudes and objectives also need to be singled out and looked at very carefully. Associated with these are the market characteristics and certain human and organization factors that inhibit innovation.

One final point in regard to the implementation of innovative transportation concepts is the terrible dilemma that faces a transportation innovator in the private sector. He cannot really risk massive company funds to test a system for which he has no measure of the down-the-road payoff. Certainly, it would be possible to construct fancy demand models to predict performance for expanding present transportation systems, but for a really innovative system change there are no hard data to plug into the model short of building and testing the new concept. A prudent manager simply cannot put money into that kind of thing. One cannot afford to put a good idea into action just to get the data one needs to evaluate the risks of the idea as an ongoing commercial venture.

This business of the speculative nature of transportation innovation leads directly into labor-management questions as well. Risking front-end money is only a small part of the picture in proceeding with a transportation innovation. There is the risk of upsetting the established labor-management relationships that are the foundation of the transportation business that one had before the innovation. So, the prospective change could mean risking more than the initial cost of innovation; it could mean risking one's whole business, because a strike could shut down and even ruin it.

Aside from labor problems, there are organizational and human factors. Organizations and people are uncomfortable with change. If things are going well, why rock the boat? And so it is the very companies that can afford innovation that are least likely to try it because they are doing all right anyway and they could put the front-end money back into their existing business at no risk and probably make out just as well.

INNOVATION AND THE STRUCTURE OF TRANSPORTATION ACTIVITIES

BY

WILLIAM L. GARRISON

Our thesis is structural and deterministic--innovation in transportation is constrained by the structures of transportation activities that provide the environments for innovation and its adoption. Innovation and technology supply, in turn, affect industry structure. In addition, transportation activities adhere to development paths that may be described as growth "dynamics," patterns, or cycles; innovation opportunities and impacts differ upon the growth dynamic circumstances.

We begin our analysis of transportation innovation by describing the principal features of transportation activities and characterizing innovation and technology deployment activities. The discussion then narrows to the analysis of the characteristics of the separate modes

and their components; guideways, vehicles, control technologies, and institutions. We will examine characteristics of transportation that affect innovation and are common to all modes, characteristics such as the standardization necessary to link individual modes into networks. This analysis will explain the present status of innovation and provide a basis for recommendations to better orient and accelerate innovation and technology deployment activities.

Although we will use the extensive literature dealing with the many aspects of innovation processes, our organizing focus is that of industry structure, a focus reflected only in bits and pieces in the innovation literature.

We believe that more attention should be given to the structures of activities that provide the environments for innovation. This attention might clarify the diverse findings of empirical studies such as those reviewed by Johnson (1975, chapter 4).¹ It also might explain why innovation differs among industries, the factors that condition the diffusion of innovation knowledge and its disregard or adoption, and the social and economic roles of innovative individuals and organizations.

Concerns about innovation follow from the heavy investment of government and some industries in research; the regulatory, taxation, patent, and other policies of governments that might accelerate or dampen innovation and its adoption; and the role of innovation in economic growth, including its contribution to the comparative advantage of one nation versus others. To respond to these general concerns and our specific interest in transportation, we make three recommendations at the end of this paper: to strengthen the assessment of component technology development, to better define needs for systems, and to better formulate systems alternatives.

Although these recommendations are different from those of studies that have examined the national scene, such as the Charpie (U.S. Department of Commerce, 1967) report,² we believe our recommendations have a broad application. In particular, these suggestions with suitable adaptation might be generalized to public facilities such as water supply systems, communication systems, and the post office. (Elsewhere, we have written about the rather striking similarities between these systems and transportation [1978]).³

TRANSPORTATION

Viewed in a general, simplified manner, transportation is performed when force is applied to displace a mass (soil erosion, the drilling of cavities in teeth, and the flight of an airplane are all transportation). Viewed narrowly, a transportation innovation is the organization of a physical system to perform that work in some purposeful manner. Even before the building of pyramids, innovative groups and individuals had thought of ways to enable and control the displacement of masses. Five major transportation modes--rail, air, highway, water, and pipeline--make up today's systems. In order to adopt and deploy

technologies, institutional structures were necessary and they were created; railroads and airline companies are pieces of the structure.

Some things about transportation industries are not so obvious. Why are there five major modes and not some other number? (Here, we are viewing transit as a variation of rail and highway.) Why do some modes involve both public and private activities and others appear less splintered? Does it matter? Why do innovation and technology activities differ, and what needs to be done to improve those activities? What are innovation opportunities? These are simple questions where simple answers do not give insight.

Growth Dynamics

One useful way to approach these questions is to think of the modes as evolving in a dynamic of physical systems-institutional systems-market systems. The history of the automobile highway system during this century provides an example. The automobile was the triggering innovation, the putting together of the wagon chassis with a steam, electric, or gasoline engine; then came the application of vehicle control protocols to wagons and buggies--the operator guided the vehicle and obeyed the rules of the road. At first, the automobile was truly a rich man's toy; it was expensive and had little use, for the road system did not accommodate travel. But the situation changed drastically in only a decade or two. By the 1920s a paved roadway system suitable for automobile and lightweight trucks was expanding rapidly (Figure 1). A variety of innovations such as lightweight steels, improved testing methods, and assembly line production was improving and reducing the cost of automobiles. The market was also adjusting as suburbanization, new patterns of employment, and a different wholesale and retail distribution pattern emerged.

The dynamic was energized by improvements in accessibility. The decision to purchase a vehicle enabled the user to gain accessibility provided by the road system and offered by changes in patterns of production and consumption. The gasoline tax, a financial mechanism, linked automobile use to road improvements, but it was truly the expansion of accessibility opportunities that shaped the dynamic.

This dynamic involved more than the innovation of a physical system, its deployment, and market adaptations. Institutions were necessary; they too required innovation. The Alfred P. Sloan type manufacturing industry was one such innovation; financial institutions providing installment credit were another. Institutions to provide the highway system evolved, state highway departments were created or modified, and local government and federal institutions and financing arrangements were formed. Vehicle insurance, driver training, and traffic engineering institutions were also established.

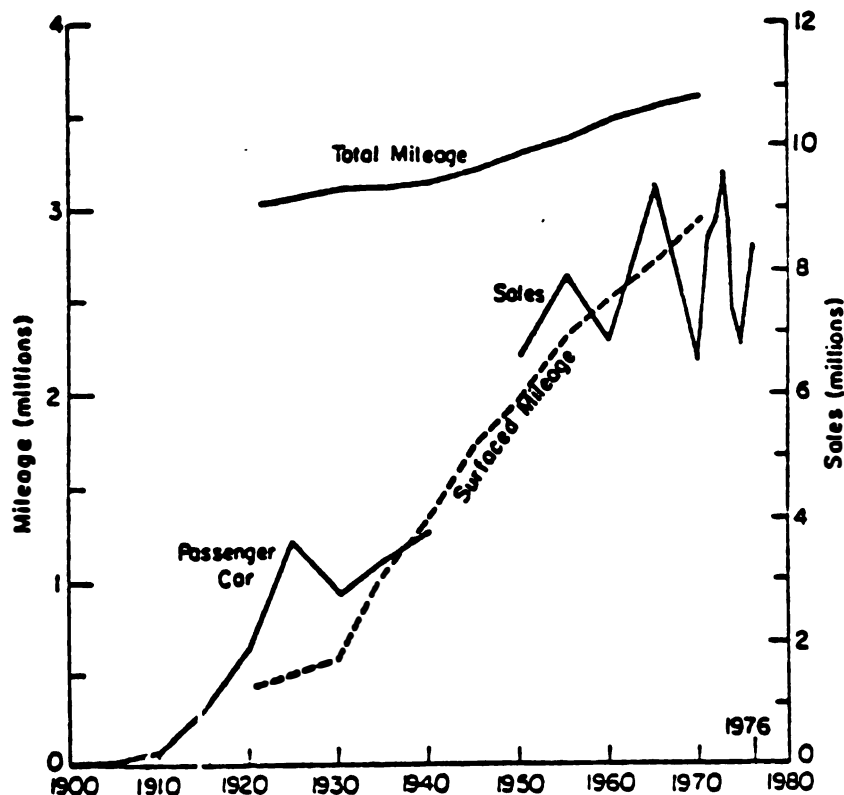


FIGURE 1. Comparison of passenger car sales (sales [Motor Vehicle Manufacturers Association, 1977]⁴ shown every fifth year [1940 to 1945 eliminated] to 1970, annual thereafter to 1976.) with total and surfaced mileage of roads and streets (rural roads and municipal streets [U.S. Bureau of the Census, 1975],⁵ series begins in 1921, ends in 1970).

Each transportation technology form has a growth dynamic. Table 1 characterizes each technology or mode within its dynamic, and the innovation and technology adoption that corresponds to the phase of its dynamic.

Now we will turn to the reasons for variations in innovation and technology activities and lay a basis for recommendations to improve those activities.

The dynamic for a technology has beginning conditions from which it emerges. The highway system provides an example. The King's highways of the fifteenth and sixteenth centuries were swaths along which people could walk and drive animals. Improvements were limited to laying stones for footing over poor ground and the providing of narrow bridges. In the 1700s, wagon and carriage traffic increased rapidly with the extension of maritime and colonial activities; a dynamic

TABLE 1. Characterization of Transportation Innovation and Technology Deployment

Status of Transportation Technologies and Their Institutions	Innovation and Technology Activities
Near the end, at, or past their growth dynamic--mass transit, rail freight, automobile	Frenetic search for technologies to reduce costs and to meet constraints including: political requirements for service in high cost markets, regulatory, labor, capital, and institutional; much government involvement in technology matters; technologies of limited scope (e.g., improved ways to empty fare collection boxes, better rail wheels, lightweight automobile hoods); there are narrow (e.g., technology is needed for filling potholes) and sometimes suboptimal views of technology needs; some interest in new systems when the technology is well past its growth dynamic, e.g., personal rapid transit; interest in technologies to protect traditional markets, e.g., TOFC and COFC.
In rapid growth phase--truck highway, pipelines, inland waterways, air.	Alternative technological and/or institutional forms continue development from early growth dynamic phase, e.g., specialized contract carrier trucks, new aircraft, product and slurry pipelines, and the United Parcel Service; technology responding to safety and environmental regulation, other constraints may be pushed aside by productivity gains, although they affect the technology, e.g., Air Line Pilots Association work and pay requirements; search for technologies for system expansion, e.g., efficient short-range aircraft
Near the beginning of their growth dynamic--slurry pipelines; container, roll-on, roll-off, and large-bulk ships.	Search among the technological and institutional forms for old and new markets; high productivity pushes aside constraints other than environmental and safety; little government involvement; industry factors seek standardization.

responding to demand began. Highways were developed for wagons and carriages, with the assistance of local government and tollway organizations. Plank roads were used in the United States. The macadam road in England is remembered from this period, although McAdam's genius lay more in the organization and financing of highway building and maintenance than in the type of surface ordinarily associated with his name (Webb and Webb, 1913)⁶; there was nothing new about that.

Another example of a dynamic running its course, slowing, and beginning again, starts with the "break of bulk" steamship in the late 1800s. By the 1920s, there was a stagnation of technology (and institution and market) development. Recently, containerization and the use of larger container ships and large bulk ships have set off a new dynamic.

The highway system provides several examples of the reenergizing of a dynamic. The interstate system in the 1960s enabled higher driving speeds that, together with market shifts, continued to improve access until recently. Early in the century the highway-truck system evolved rapidly, serving mainly a local collector-distributor function. Improvements in the regional roads in the 1930s and 1940s and development of the interstate system later set off another truck dynamic which continues running its course.

Conditions at the beginning of a development dynamic include institutions and market conditions, each with its claims on resources. Much of the market is subject to the "tooth and claw" of free enterprise; its evolution with the growth dynamic is relatively unfettered compared with other aspects of the dynamic. But market conditions and the difficulties of changing them are not to be dismissed completely. As we have discussed elsewhere (Garrison, 1978),³ systems users claim a right to transportation service, and much of government regulation of transportation service and subsidy, such as that of mass transit, is to offset changes resulting from growth and the new interplay of technology forms.

Institutional change has a dynamic of its own and usually occurs with the creation of new institutions. Once created, even new institutions reflect the conditions of the times in which they were created and become a brake on change. The railroad organizations of today exhibit conditions from the time of their origins. Their geographical division, for example, reflects communications and logistics conditions that existed over a century ago. The railroads have changed, of course, but the basic organizational frame remains.

The railroads put carriages on steel wheels; routes were laid out primarily for passenger traffic. In the United States the abundance of coal and early adoption of high-pressure steam engines, along with the constraints on labor, including construction management skills, affected the grades and layout of today's routes (Williams, 1976)⁷. The light-weight four-wheel carriage became a 100-ton or more freight car riding on four-wheel trucks, with up to 36-inch wheels and a much higher center of gravity than the carriage transformed to a railroad car. Although physical technology has changed incrementally and is radically different from what it was in the beginning conditions. G. Plowman has identified (to the author in a letter) the increasing of gauge, doing away with

operating railroads on the carriage-wheel spacing of the eighteenth century, as one of the major problems of today's railroads.

Later, we will discuss the components of transportation technology--guideway, vehicle, and control--and how their disjointed character has limited change to building incrementally from conditions existing at the start of a dynamic.

Geographical Networks: Standardization

The highway system and the waterways system reflect in their present development the existence of an initial network (the then existing roadway and waterway networks). Their present dynamics began with the necessity of serving those networks. Much of the mileage of today's highway system was laid by the late nineteenth century. About 50,000 miles of interstate route have been added, and mileage has been added as cities have expanded, but much of the dynamic growth of the twentieth century has occurred on the stage set by the existing road plant. Today's inland waterway and maritime trade started out with existing routes tied to the locations of ports and markets, and modern inland waterway transportation technology takes place on routes where rafts once floated and steamboats hauled cotton and pork.

Railroad, airline, and pipeline networks were new, but even here there is the imprint of preexisting markets and the location of the routes of competing modes from which these new modes hoped to snare traffic.

A preexisting network can restrain or assist the innovation process. It assists because it eases the onus of tying places together by procuring land or terminals. We will return later to the positive side of the right-of-way or network question when stressing innovation opportunities. The sections on transportation system components and incremental decision-making will also deal with the forcing of a technology to operate on an existing guideway.

In order to benefit from accessibility, either people or goods have to get from one place to another; there are rewards from connecting links into networks, system articulation, and standardization. A standardized time system was developed, and a standardized railroad gauge was adopted. Other needs for standardization resulted in the creation of the Association of American Railroads and, by other actors, uniform labor rules. Uniform air and highway traffic rules represent standardization in other systems, as does the evolution of pavement construction standards and the development of the rules-of-the-road in ports on inland waterways. Early, industry seeks standards; the government's role expands later as safety and service standards are demanded. Today, of course, nonindustry-specific government safety and environmental restraints apply early.

Standardization has two chief effects on innovation. First, it almost locks out technological change that is more than incremental; innovations have to fit the standards. It also dampens innovation because of the effort required to meet standards.

Yet, standardization forges a large market if a desirable technique or device can be innovated to fit a standard; a large market can result in economies of scale in production. (This seems to be the motive behind creating standards for buses, wheelchair lifts, and similar things.) The critical matter is the ease with which standards can be bypassed. For example, although there are standards for packaging, innovative techniques seem to work within or push aside those standards by obtaining exceptions (U.S. Department of Transportation, 1978)⁸.

As history shows, standards are pushed aside if a development is highly desired. MoPed advocates were able to sidestep safety standards for motorcycles. The 707 aircraft proved so productive that the standards for runway strength and length were dropped by airport operators who wanted jet service; they lengthened and strengthened their runways. The ascent and descent rate used then in air traffic control suited to DC-3 aircraft and ill-suited for jets was also pushed aside. On the West Coast, the longshoremen constraint gave way to productive container systems. Standards for harbor dredging also gave way rather quickly before the productivity available from large container or bulk ships. Today, the productivity gains to be garnered from increasing truck weights and sizes are clashing with entrenched standards.

Market Impacts

Turning from standards to markets, we note production and consumption shifts as a dynamic evolves. This market response affects the characteristics of innovation during the dynamic. Successful innovations are market-sensitive; attention is given to the manner in which the market is evolving, and more effort is made to fit a technology to new developments or to particular niches in the market. The development in 1837 of packet service out of the Port of New York for the North Atlantic trade was responsive to a market niche. Today's specialized ships hauling assembled automobiles are another maritime example. Unit trains and the specialized trucks of contract carriers are other market niche innovations, and efforts to find technologies suitable for short-haul, collector-distributor air transportation represent a sensitivity to the need for fitting technology to market niches as well as an effort to improve the network of service.

This is the pull of demand. A transportation technology evolves, and production and consumption organizations shift how and where they do things considering the availability of that technology. The continued learning and shifting of the activities or organizations create new opportunities, the growth of organized diversity on the market side.

Innovation

We can describe several relationships between innovation and technology utilization and systems development. Table 1 lists in capsule form the activities resulting from these relationships. Below, we outline a development dynamic as it runs its course.

- There is a vigorous, early competition among forms of the technology--vehicle, guideway, and control combinations and their institutions.
- Also early on, managers seek standardization to provide networks to serve markets and to achieve economies of scale in production.
- As the market evolves, more and more attention is given to process and product innovations suitable for particular markets.
- These technologies for market niches are constrained and limited. As the system develops, existing institutional arrangements and conditions set by the existing physical system limit the scope of technological change.
- Attention shifts from the innovation of competitive technology forms to innovations of a very narrow scope, bits and pieces of hardware or processes. The impacts of particular technology developments are limited, although their aggregate impact may be great.
- While there are restraints on systems from the start, including those common to all activities, transportation-specific system constraints on innovation and technology development and deployment multiply as the dynamic unfolds. These constraints result partly from increasing recognition of system externalities; they are originated by governments. Many are imposed by the increasing complexity of transportation institutions and the inability of complex institutions to overcome stasis. The rights of labor, management, and users are increasingly cemented. Capital restraints tighten.
- The publics interested in the system become less supportive; they are increasingly disenchanted. At first there is support, for the system dynamic multiplies accessibility. Later, gains are not as great and negative externalities more apparent. The systems' bureaucracies become increasingly inflexible. The public demands innovation and technology, often via regulatory mandates, to fix problems.
- In contrast, late in the dynamic there are publics who imagine and value early technology and market conditions. They seek maintenance of technology with no market for innovation (cable cars), or a reincarnation (light [sic] rail transit) using the best available innovation and technology.
- The concerned publics' and the technologists' views of innovation and technology needs shift. Early, they are broadly framed in terms of systems and associated development. Later, they narrow and are addressed to correcting something about a small part of the system perceived to be faulty.
- The systems' growth is never unbiased; conditions at the start of the dynamic strongly influence its course and the opportunities for innovation.
- Yet the path of the dynamic is never certain; the dynamic may be changed fully or partially by market shifts (more need for coal transport) or by technology and institutional development.
- The role of the innovator changes as the dynamic unfolds. Early, the innovators focus on the system; later they address bits and pieces of things. Because of the structure of the industry and societal views of needs, the small is valued more than the large.

• Yet the above does not restrain innovative effort. Systems innovators do not hold the values of their peers and their institutions. As these values become more rigid, more innovators disclaim, but their probability of success declines.

Again, the activities listed in Table 1 are some outcomes of these relationships; more outcomes could be noted. Not all the relationships are fully discussed, but their basis and consequences will be more fully developed as we continue.

Productivity

Before developing further the characteristics of transportation that are behind these relationships, we ask whether these relationships matter. In our opinion they do.

In his book on the automobile industry, Abernathy (1978)⁹ observed: (1) the development of a dominant technology (in this case, the Model T) and (2) the evolution of a mass production, low-profit-margin method of producing it. He argues that the search for productivity is consequently constrained to minor (mass production) process improvements, which are subject to diminishing returns. The future is bleak.

In Chapter 4 of his book, Abernathy refers to supporting studies, and in a 1975 discussion paper with J.M. Utterback¹⁰ (which appears to be the basis for Chapter 4), Abernathy provides examples from the semiconductor industry, the aircraft industry, light bulb manufacturing, the automobile industry, and the processed foods industry. Here and in his later work he offers a conceptual model in which an industry is created by radical product innovations. One dominant innovation sets a pattern for a product; then process innovations dominate as ways are sought to produce that predominant type.

In this perspective of our paper, the restraint on the supplier activities in transportation results from industry structure. Productivity is a question more because of those constraints than because of those of the manufacturing process of particular firms. In contrast to automobiles, railroad cars, barges, and aircraft are produced on a job lot (a run of several) basis, yet they too are productivity limited. Abernathy's view of the firm is too limited; to change productivity requires system change. Such change can be achieved if system technology can be innovated and deployed to change a development dynamic or start a new one.

Technology and Market Gaps

Figures 2 and 3 abstract two performance characteristics from the complexity of the organizations providing transportation. Figure 2 illustrates that the cost of moving a unit decreases as the number of units increases. Figure 3 illustrates that the cost of moving a unit between places, for a given number of units, varies from mode to mode depending

on the distance. Other such figures could be drawn illustrating characteristics of transportation activities. These might display relationship of gross to net weight; horsepower per ton moved; velocity, say distance a commodity may be moved overnight; and weight/volume ratios for the filling of vehicles or containers. Data on relationships of this type are displayed in *National Transportation Trends and Choices* (U.S. Department of Transportation, 1977).¹¹ J. D. Ward et al. (1977)¹² have explored such data fruitfully.

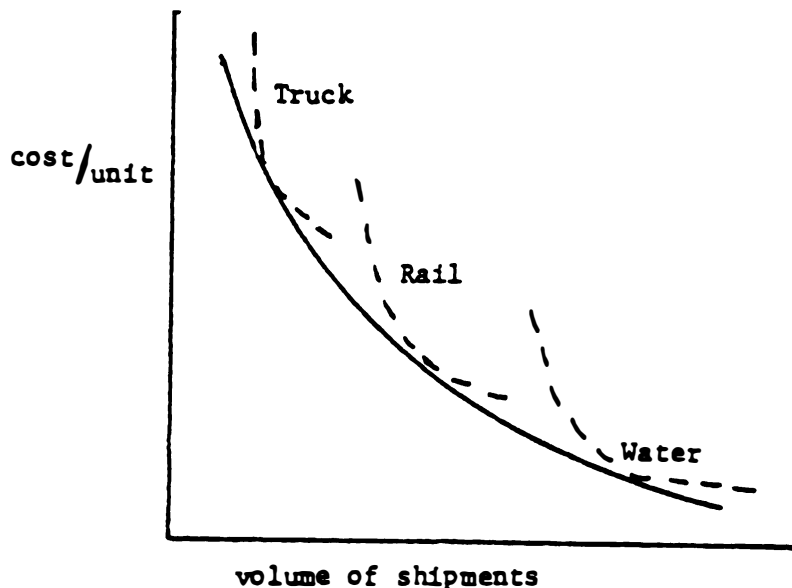


FIGURE 2 Relationship of cost to volume. (The dashed lines suggest where existing modes perform best and the "gaps" between them.)

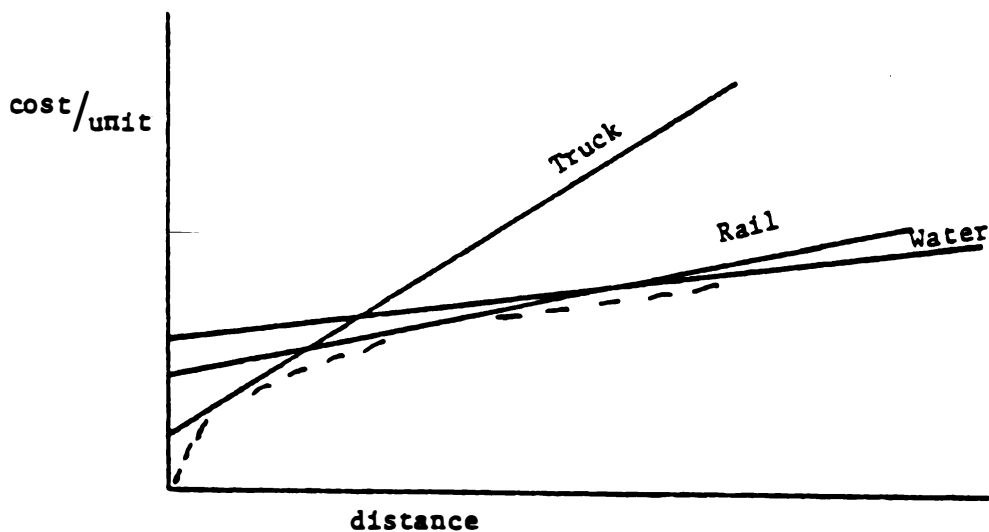


FIGURE 3 Relationship of cost to distance. (The dashed lines suggest gaps.)

One may think of mapping between such performance characteristics of transportation, markets, and the technologies and institutions that provide transportation. Mapping on Figures 2 and 3, we would expect rail and water to provide for high-volume, longer-distance movements. Helicopters are used to move structural steel for the construction of towers in isolated places; airlines get a larger share of long-distance traffic than short.

Gabriel Bouladon (1967)¹³ has developed a concept of gaps to describe the interstices where the existing modes do not serve markets well: the "too far to walk but too close to drive" gap and the "too far to drive but too close to fly" gaps, for example (Figure 4).

TRANSPORT DEMAND

DISTANCE (miles)	0.3	0.6	1	3	6	10	30	60	100	300	600	1000	3000	6000
TIME (minutes)	61	75	88	123	15	17.5	24.5	30	35	49	60	69	96.5	120
SPEED (m.p.h.)	2.9	4.8	6.9	14.7	24	34.2	73	120	172	370	600	870	1865	3000

FIGURE 4 Bouladon's transportation gaps.

Bouladon's development of gaps is a useful introduction, but it greatly oversimplifies the manner in which gaps may occur. In passenger transportation, gaps should be imagined arising out of the performance characteristics of the available modes compared with the functions that passenger transportation serves and not with distance alone. Elsewhere, this author and Clarke (1977)¹⁴ have sketched the concept of a neighborhood car that, although serving in the range of "too far to walk but too close to drive," fills the gap defined by those functions that are performed in neighborhood travel. The camper vehicle fills a certain kind of gap. When sketching gaps for freight transportation, one should also consider functions as well as the comparative advantage of modes, a complex mapping.

Institutions compete with each other and strive to preserve themselves. The interstices between which existing modes have a marked

comparative advantage are competitive battlegrounds. The railroads fight hard to maintain their claim on bulk traffic vis à vis the agricultural-exempt truck and waterways. Some railroads give attention to trailers and containers on freight cars (TOFC and COFC) and "merchandise" traffic in order to preserve their traffic or expand into that gap. Urban bus operators are preoccupied with expanding service in thin markets to compete with the automobile, and much of what is said to be needed in technology development of mass transit is technology to serve those markets, for example, paratransit.

Questions can be asked (but not answered) about the appropriateness of the present number of modes. For example, in terms of existing markets, is Amtrak needed given intercity bus service? The extent of railroad freight service is sometimes questioned given truck service. Is a complex of long-distance highways engineered for automobiles reasonable given the availability of air transportation?

Intermodal arrangements combine the advantages of two or more modes. Technologies to improve intermodal service were stressed years ago in the Eastman Report (Office of the Federal Coordinator of Transportation, 1940),¹⁵ but these are not of interest to the existing modes when one party has something to lose. (It is not surprising that rail dominated services [ICC Plan II] are the more successful TOFC endeavors.) An intermodal service works if one party is not harmed and the other gains, or if both gain. Rail transit institutions will pave parking lots and worry about bus stops adjacent to stations. Maritime container shipping organizations and railroads are jointly concerned about efficient ports and intermodal service; those who carry containers to the port do not have the option of continuing overseas with them.

We will return to this notion of gaps and develop innovation and technology options more fully after discussing some of the characteristics of modal components.

COMPONENT DISJOINTEDNESS AND INCREMENTALISM

Physical work in transportation is performed by applying a force to move something along a guideway. While the guideway may control the direction of movement, there is always additional control activity. The core of the physical technology involves a vehicle and propulsion unit, a guideway, and a control system--the components of transportation technology.

There are technological and institutional supply streams for each component. Highway vehicles, for example, are provided by automobile and truck manufacturers through a system involving dealerships, financing institutions, regulating institutions, fuel suppliers, and so on. The technologies here are mainly those of mechanical engineering for the vehicle (and chemical engineering for fuels). Guideways are supplied by governments drawing on several subspecialties in civil engineering. In the main, control of the vehicle movement is provided by the driver training and licensing systems. Traffic control is provided by traffic engineers, and the driver's fiscal integrity is warranted by insurance arrangements.

This pattern of disjointed technology components appears in each transportation mode. Ships are provided by shipbuilding companies, operated and controlled by shipping companies and by inshore and offshore rules-of-the-road, and operate on guideways partly provided by navigation and by dredging. Aircraft are produced by airframe manufacturers, operated and controlled by airline companies and by air traffic control regulations, and use guideways supplied by governments.

One outcome of this disjointedness is incremental decision making. The technology-supplying institutions see their role as that of meeting needs occasioned by markets and constrained by characteristics of other components. Railroad right-of-way suppliers strive to provide suitable guideways for the types of trains that are operated on routes and their frequency. Automobile manufacturers have an eye to the market. They are constrained by the type of highways on which the vehicles will be used, the standards of driver licensing and the norm and distribution of driving skills, and traffic rules. Highway traffic engineers establish regulations considering vehicle characteristics, drivers, and roadway conditions.

The consequences of incrementalism are constraints on the technology supply stream. Only incremental technology change is permissible, and all technology choices that consider a system--that is, involve control, vehicles, and guideways--have no market. This can be seen by even a cursory examination of current technology activities. The traffic engineering literature is replete with ways to do traffic engineering better; all else is given. The protocol for benefit-cost studies in highway design is to minimize the joint cost of providing highways, given the characteristics of vehicles including their operating cost and the way they are operated. Today, automobile manufacturers are preoccupied with developing technologies to meet emission and fuel consumption standards with everything else taken as given. The automobile engineering literature is as limited to the automobile (and the truck) as traffic engineering literature is limited to traffic.

An interest in transportation systems is mainly a conceptualization of transportation as a network rather than a link and node phenomenon. Systems planning, such as that of the United States Railway Association (USRA), is planning for guideway systems; urban transportation planning since World War II has been planning for highway networks. Symptomatic of the lack of system thinking is the recent change of name of the Institute of Traffic Engineers to the Institute of Transportation Engineers--traffic engineers take what they do to be transportation engineering and do not seem to recognize the system scope of the technology.

Finally, consider studies of highway needs such as the 1977 study published by the Congress (Committee on Public Works and Transportation, 1977).¹⁶ For many years, studies of needs were made by comparing the physical state of existing highways with an ideal expressed by engineering standards. In recent years there has been a modest recognition of markets through considerations of the amount of traffic on facilities. Highway needs studies take other components of the system as given.

In addition to being highly constraining, the disjointedness of components distorts system goals and innovation. Technologies are

sought without institutions to conceptualize transportation and thus formulate broad transportation goals. Goals, such as good roads or safe cars, reflect institutions and components. Transportation is heavily regulated, which also affects goals. Some institutions strive to meet regulations regardless of the cost.

Compared to other modes, railroads appear to have integrated components. Railroad organizations supply their own guideways, make decisions to purchase equipment, and control and operate that equipment. Even so, these components are supplied and operated in a disjointed fashion largely because of the separate technological traditions of components and their supplying institutions. Component managers have differing goals. The equipment manager seeks appropriate equipment, given operations and guideway systems; the guideway manager seeks an appropriate guideway, given equipment and the way it is used; and operations personnel spot cars and move them, working with what is available in the way of equipment and guideways.

The disjointedness of railroad components is illustrated by the aggravation of right-of-way problems through the purchase and use of heavy freight cars. Cars of 100 tons or more created unexpected right-of-way and operation problems, leading John C. German of the Missouri Pacific Railroad to remark, "there has not been enough cooperative discussion between the equipment engineer and the track engineer" (German, 1974).¹⁷

Railroads are heavily regulated--self-regulated through industry-wide standards and regulated by government. Industry standards apply to components, and federal regulations apply mainly to operations dealing with service and rates. Safety regulations are addressed to components.

The other modes are also regulated. Gellman (1971)¹⁸ has stated that regulation has distorted decisions to purchase equipment and has dampened equipment innovation. He concludes that "the innovative performance of the transportation sector can best be improved by gradually eliminating economic regulations." While we accept Gellman's remark about distorted and dampened innovation, we do not agree fully with his conclusion. Even without regulation, decisions to purchase equipment would be constrained; they would be incremental and oriented to component goals.

Innovation and its adoption are often motivated by an opportunity for a specific payoff. A.S. Lang and S.A. Burd, (American Association of Railroads, 1976), in an unpublished paper responding to suggestions by Wyckoff (1974),¹⁹ Wyckoff (1976),²⁰ and Reebie and Robertson (1979),²¹ have addressed the difficulty of forming profit centers in railroad organizations. Profitability is a matter for the chief executive officer because expenditure and cost control are in the hands of equipment and guideway providers and operations staff while revenues are in the hands of persons recruiting traffic. Lang and Burd examine options for aligning cost and revenues on a more decentralized basis, either through suborganizations that recognize specific lines of business or by spatial markets. But equipment and routes may be used for more than one line of business, and spatial markets are not discrete. A particular spatial market, such as the city pair, is entered and egressed by traffic serving other markets. To deal with these complications, Lang and Burd

suggest organizational forms where equipment and operating people function as profit centers selling to marketing people.

Lang and Burd's suggestions offer insight and should be useful. We do not, however, feel that these organizational reforms would deal with the fundamental problems of incrementalism and disjointedness. These problems will remain because component supply streams are entrenched, their goals are internalized, and constraints are imposed by network articulation and standardization. Lang and Burd observe that less-than-a-truckload-lot intercity trucking firms have been able to organize profit centers for a particular market (cities) and contract truck carriers organize to serve specific markets, often using tailored equipment. While this capability contributes to efficiency in the firms organized in this manner, it is very limited, being constrained by component disjointedness. Equipment and operations decisions are made incrementally against the backdrop of conditions of the existing highway system and traffic control with its speed and weight controls.

IMPROVING COMPONENT INNOVATIONS

Useful recommendations for improving innovation, technology development, and deployment within extant component supply arrangements are limited. Institutions, policies, and programs exist in the planning, managing, and expending of resources, but the restructuring of institutions is slow and difficult. Restructuring also is not practicable because component-arranged activities reflect the professional and scientific disciplines and the organization of the trades; relationships are cemented into existing status and behavioral patterns. Transportation organization is a slice of all social and economic organization, and change driven by transportation has little priority and voice.

For this reason, we regard present arrangements as fixed and seek actions consistent with those arrangements. We seek action that will better match component activities to systems needs and opportunities. We seek to lessen the risk that component technology may suboptimize.

Suboptimization

Component-shaped innovation and technology adoption is quite active: improved electronics for aircraft, electronic engine control for automobiles, computer-aided vehicle design, improved insulation for tank cars, improved aggregates for highways, better methods to preserve railroad cross ties, and active or passive sensors for traffic control. This innovation within components is viable because it passes the market test of being useful to the component. Its efficacy for systems is unknown.

We believe that component goals are not consistent with systems goals that are almost never stated. The ability of systems to perform social functions measured against resource use may or may not be improved by a particular component innovation. A possible example is the

procurement in recent years of heavyweight railcars with large wheels by the mechanical departments of railroads. These perhaps have not been cost-effective if their cost is extended to the damage that they do to rail guideways.

Earlier, we commented that the development of the 707 aircraft violated the constraints of incrementalism because it (and the family of jet aircraft emulating the 707) required the strengthening and expansion of runways, changes in aircraft control protocol, and changes in terminals. Then, many thought that the 707 did not fit the system, especially its market interrelations (Bright, 1978).²² Yet, in this case system change occurred because of a major change in a component. To some extent the diesel railroad locomotive and the development of the interstate both have induced system change. While these system changes probably measure positively in social and economic terms, an unanswered question is whether some other technological form might have been created if overall system impacts had been considered in the beginning.

Assessments

There are existing mechanisms addressing the worth of new technology, programs, or projects: technology assessment, environmental impact, and inflation impact analyses. Inflation assessment is concerned primarily with the trade-off between a proposed action and productivity. Regulatory actions are reviewed, actions that may induce hardware innovation or the adoption of the existing innovation.

Technology assessment has been institutionalized in the Congress, in federal agencies, and in some state and local governments. It takes the stance of measuring technology impacts on scales of efficiency, environment, energy, and externality.

The recent study of the automobile by the Office of Technology Assessment of the Congress (1979)²³ was one of the most thorough assessments made of a transportation technology. The study examined where the technology is, how it might evolve, and its associated costs; it treated air pollution and fuel problems. The cost of implementing more fuel-efficient and environmentally benign vehicles was assessed. Market and systems matters were not much recognized. The study was a vehicle assessment and never claimed to be more. It dealt with mobility, accessibility, and related topics of the growth dynamic in only a very slim fashion. It took the way things are going as a given, including the present and future status of the nonautomotive components of the system. Most technology assessments in transportation take a similar stance, although they are generally less broad and thorough.

Environmental impact analyses and statements are mandated for all federal activities with "significant" impacts on the environment; they are also used by a number of state and local governments. While the mandate is broad, the emphasis is on physical environment impacts. Analyses are most often addressed to designs and plans using existing technologies, projects ready to be implemented. Environmental impacts are listed and quantified when practicable; decision makers may thus

incorporate these assessments in decisions about whether a project will go forward and, if it goes forward, about what steps should be taken to mitigate environmental impacts. Because the environmental impact statement is addressed most often to projects--a railroad relocation around the town or a highway alignment and interchange--it considers the triad of components. An airport impact analysis for example, might examine noise alternatives considering the type of aircraft to be used, approach and departure control procedures, and runway and apron alignments.

These regulatory, technology, and environmental assessments have the appearance of being a choke between innovation and subsequent information dispersion and technology adoption. However, the existence of assessment activities affects the way programs are devised and evaluated well before the hurdle of the assessment occurs. This thinking ahead is a feature of technology implementation planning (TIP) suggested by House and Jones (1977).²⁴ In this approach, the problems of implementation are thought through and fed back to the program design, the evaluation of its milestones, and the selection of program options.

A Suggestion

A modest policy suggestion is that all component technologies be assessed in light of transportation systems and market considerations. This could be done as an addition to current technology assessment and environment impact assessment or both.

A strength and weakness of this suggestion is that it is like the requirements of present policies. This is a strength because actors and institutions might be comfortable with the suggestion. But to avoid not doing more than is now being done, it would be necessary to spell out what is meant by components and systems and market evaluation. Present-day market evaluations are static; they will, say, compare rapid transit with the automobile and ask how many riders will be diverted. It is important to state dynamic questions and inquire into market adjustments and development paths for a technological system, its institutions, and its markets.

As discussed, most of present-day "system" analysis is limited. To improve the limited sense of system, programmatic guidelines should spell out interest in how the parts of the technology and their institutions interact with each other, and again, development dynamics should be highlighted.

This modest suggestion should have more than modest results. An example of a response to a call, such as that by Carey (1979),²⁵ for a new round of research, innovation, and technology deployment for extant highway bridge types will make the point.

Many urban and rural bridges have reached the end of their useful life. Many were built in the 1920s as the road system was upgraded. Even newer bridges have had their life shortened by increasing loads and the use of salt to melt snow and ice. Inventories of repair, rebuilding, and reconstruction needs indicate that they are massive. The funds are sought from Congress for a bridge program.

But a consideration of the system and how it is used suggests that innovation of new technology is misguided if it is to support the reconstruction, rebuilding, or replacement of bridges in the places that they are now and with their present traffic loads. "The bridges are falling down, build them back" is an incorrect view of the problem. The rural highway system (except for the interstate) and the older parts of the urban parts of the system were laid out in the horse, buggy, and wagon days. The over-the-road cost of transportation was high, while the cost of the construction at that time was relatively low; except in the downtown of cities, traffic was light. The situation is radically different today. The relationship between variable (vehicle) and fixed (guideway) costs has changed greatly, and increased volumes of traffic offer opportunities for economies from the concentration of traffic on routes. Consequently, a system for today's markets would have many less miles of route. Some routes should be built with higher standards than today's to carry heavy traffic and to gain economies for the vehicles and the routes. There would be more circuitry of travel. Should those bridges be rebuilt in the pattern that was right for the early part of the century, or should innovation and technologies be sought suited to routes where economies of scale are achieved in heavy traffic volumes and in heavy loads?

SYSTEMS INNOVATIONS

Marked improvements in transportation productivity and the creation of options for social and economic development depend on the innovation of transportation systems, though not exclusively. Innovation is needed now for energy shortfalls, and rapid increases in the cost of energy and other resources will affect the evolution of social and economic organizations. As these organizations adjust to new conditions, it would be highly desirable to have a variety of supporting transportation options. Further, the options provided by the present characteristics of transportation will be even more restrictive as higher fuel costs impinge on the performance of transportation, a factor also pressing for major improvements in old systems or for new systems.

Working toward suggestions with respect to recognizing and creating new systems options, we shall return to two matters that have been discussed previously: the potential for using existing guideways and technology gaps. We shall then review some examples of recent proposals for system technology and use these to pinpoint what seems to be needed. Two suggestions follow.

Using Existing Guideways

As noted, a transportation system may be created de novo or developed by revitalization of an old system, but in either case it is tied to preexisting market conditions and route structures. The liabilities of preexisting route structures have been mentioned, but preexisting routes can be an advantage.

The argument is simple. There is excess capacity throughout all systems because of high over-the-road cost relative to guideway cost during the early development of modes. Earlier, dense highway and air networks were used. Ports and maritime routes were everywhere that ships could sail, and railroad routes were more ubiquitous than today. For a variety of reasons including important political ones, much of the excess capacity created by shifts in cost has not been abandoned; it exists and provides spaces for guideway development. Many of the problems of acquiring land and expanding capital are mitigated.

The idea that there is little or no excess capacity is incorrect. There are some urban airports, air space, and urban roads and streets that are congested a few hours every day. This congestion is visible and annoying, but it obscures the fact that these facilities are not busy most of the time and that they are only a small part of the whole. (We do not view this congestion as serious. It would be ridiculous to construct facilities so that they were never to be used at capacity [although most of the guideways for the modes are so constructed], and there are available tools, such as pricing, that could improve congestion management.)

Gaps

Gaps are difficult to identify because of the equilibrium between the transportation available and the organization of social and economic activity. However, social and economic organization responds to many factors other than transportation, so the relationship between it and the availability of transportation is less than perfect. This suggests that "market pull" gaps may be identified by continually monitoring and evaluating social and economic change. The existing modes are continually searching for markets, and market response from new services suggests another way gaps may be identified. Finally, more thorough studies of how the transportation system performs or might perform "technology push" would improve understanding of situations where improvements in performance might provide a market for innovation and technologies.

Examples of Systems Technology

Examples of proposed systems technologies will illustrate proposals and point out what is needed in order to better generate options. (See also Gabor, 1970.)²⁶

- Railroads haul coal on unit trains between points of production and consumption using old technology. Given the quantities involved, available vehicle and control technologies, and the availability of guideways, it might be reasonable to operate vehicles with, say, a 16-foot width, with a self-contained propulsion unit or units, say, electric motors on each wheel, with either offboard pickup of electric power or a generator on the car or in a locomotive. To keep down rolling

resistance yet avoid high pressure where the vehicle touches the ground, large rubber tires might be used on ribbons of pavement. Wire-following control would be practicable. Because of numerous grade crossings and to keep down the forces working on vehicles, relatively low speeds would be in order. Present guideways would be suitable except for earth-work requirements; some bridges may have to be rebuilt. Because these vehicles and guideways would be in special service, they would not have to be standardized to other rail equipment, although equipment suppliers might push standardization. Present tracks could be left in place and the guideway used for conventional trains.

- The Advanced Freight System study undertaken at the Transportation Systems Center (1977)²⁷ proposed and examined a TRAILS technology-- a 120-mile-per-hour, steel wheel on rail vehicle for COFC, which would share guideway with the interstate system and operate under electronic control. The cost effectiveness of this system versus truck transportation was found marginal.

- Automobiles and light trucks came first. Although lane widths, pavement strengths, and bridge strengths have been increased and some grades have been reduced to accommodate trucks, the highway system is mainly for automobiles. Development of truck-only routes, taking advantage of the economies of higher weight as identified by Winfrey et al. (1968),²⁸ might be practicable.

- Proposals have been made for transmission of suspended solids in pipelines, such as coal slurry, capsule in pipeline systems, automated personal (group) rapid transit, and automated highways.

- Several years ago there was interest in (passenger) high-speed ground transportation utilizing magnetic or air levitation and linear induction motors. High-speed ground transportation systems would be used to link major cities in the 50- to 200-mile range.

Observations may be made about our proposals that might be general to all systems proposals. Interest in systems technologies is sustained when their delivery would utilize existing component technology supply streams--automated highways and transmission of suspended solids in pipelines, for example. Most proposals embody technology development external to the transportation system, control technology for example. Some proposals are responsive to increasing magnitudes of freight shipments or passenger travel in existing markets: high-speed ground transportation and the TRAILS system, for example. For the most part, these proposals ignore the energy problem, changing social structure and patterns of work and leisure, and changes in manufacturing and distribution systems.

Two things are missing: (1) an understanding of the universe of all possible technologies and whether these examples are sensible representations of possibilities, and (2) an understanding of the functions of these examples in terms of market dynamics. Our recommendations will respond to these points.

Understanding What is Needed

James Hillman (1979)²⁹ recently published an essay titled, "Psychological Fantasies in Transportation Problems" in which he examines the transportation expert's statement of transportation problems in terms of efficiency and equity. In his analysis, he probes the expert's complaints about car repair bills, potholes, and congestion and concludes that the expert has a personalized view of the city and of spatial organization. Hillman's thesis relates these perceptions of transportation, of the city, and of spatial organization to the expert's statement of transportation problems. Congress and lay people are accused of knee-jerk reactions to transportation experiences and of demanding naive programs to meet needs. Hillman suggests that the expert's views are also based on fantasy.

The initiation of thorough studies of transportation, where needs are embedded in actual and possible directions of social and economic development, would respond to such limited sense of problems and improve recognition of needs for innovation, technology development, and implementation programs. While there are projections of freight traffic and passenger movements based on the way things are now, there is no work viewing transportation as an integral part of social and economic dynamics. (Studies, such as those of the National Transportation Policy Study Commission (1979)³⁰ using national economic models, are rooted in input/output matrices that take technology and the structure of production as given. They ask about changes given a changing mix of outputs and related price changes, a very limited question from social, technology, and industry structure points of view.)

Some properties of the several examples of recent proposals for transportation technologies were noted, including their very limited view of the market for transportation. For example, the TRAILS study compared the cost of TRAILS movements versus truck and rail alternatives. But shipment using TRAILS would double the radii for overnight deliveries and more than double the geographical size of distribution or market areas. This increase could have radical effects on the patterns of manufacturing and distribution; it would extend the market available for daily resupply in a very significant way.

In 1940, Norman Bel Geddes³¹ published Magic Motorways, a simply written and well-illustrated book about transforming the highway system through interstate type facilities, automated car control, and other technologies. There was a chapter on the elimination of graft (that is, institutional improvements), another on opportunities for better fitting transportation into the physical environment, and the book was dedicated to the "generation of our grandchildren to whom all that is written here will be commonplace."

Bel Geddes' work was imaginative about what society could do with technology although he worked during the 1930s, a time beset with problems. Work as imaginative as Bel Geddes' is needed in the 1970s, 1980s, and beyond to outline what transportation can do. A group should be charged to do such work.

A group that would develop understanding of transportation needs and opportunities cannot be located in existing component supply streams or even close to those supply streams. In government, existing modal agencies and their commitments to components would place political constraints on the work of a group attempting to understand transportation needs and opportunities. Congressional advocates aligned with modal agencies would also influence the work; consequently, if the work is done in government, it would have to be done externally to the DOT and other agencies committed to existing transportation activities.

Congress has supported transportation policy studies on a regular but intermittent basis for several decades. If the Congress could be persuaded that a continuing inquiry into the needs for transportation was warranted in order to make those policy studies effective and in order to improve its cognizance of executive branch programs, then a continuing study that was congressionally housed and supported might be workable. The Office of Technology Assessment would not be a proper home for the needs study; it responds to special needs, and its commitment to transportation seems limited. (There have been recent reductions of transportation professionals (Smith, 1979).³²)

The Transportation Systems Center (TSC) in Cambridge might be delegated the mission of performing needs studies, but at this time the TSC is highly beholden to the modal agencies, so independent studies might not be practicable.

Understanding Technology Possibilities

Again, it must be stressed that it is not enough just to study needs. These would have to be continually transformed into an imaginative set of options for social and economic change, and they would have to be continually integrated with a systems technology development program.

This transportation system development activity could be lodged (expanded) in the Research and Special Programs Administration of the DOT. The modal administrations may attempt to restrain systems work to things more closely related to their component technologies. That liability, however, is offset by the asset of their knowledge, which, while applied to components of their interest, might be transferred to new systems. Also, the feedback of systems ideas to component managers might have value.

The systems technology development activity would depend politically on the argument that technologies under development are supporting the options being identified by the continuing needs study, so there would be a powerful extradepartmental force influencing the work of the systems group. Continuing attention to developing understanding of transportation performance and technology gaps would provide directions for the systems development group as would the requirement for information by the component technology assessment activity discussed earlier.

CLOSURE

Our recommendations on improving component technology and systems are addressed to the federal government because of national interests in productivity and development. Others have roles and opportunities--the private sector, the universities, and state and local governments. Robert Fulton invented the steamboat; Robert R. Livingston provided financing; state government helped by granting Fulton a franchise to provide service on the Hudson River. Regardless of the national interest, transportation must respond to locally expressed goals and the availability of resources. Further, there is little reason to believe that the locus of creativity is the federal government. There are roles for all creative actors and institutions, and government should configure their activities to encourage and support these roles.

REFERENCES

1. Johnson, P.S. The Economics of Invention and Innovation. London: Martin Robinson, 1975.
2. U.S. Department of Commerce. Technological Innovation: Its Environment and Management. Washington, D.C., 1967.
3. Garrison, W.L. "Thinking About Public Facility Systems." In The National Research Council in 1978, pp. 244-265. Washington, D.C.: National Academy of Sciences, 1978.
4. Motor Vehicle Manufacturers Association. Motor Vehicle Facts and Figures '77. Detroit, Mich., 1977.
5. U.S. Bureau of the Census. Historical Statistics of the United States. Washington, D.C., 1975.
6. Webb, S. and B. Webb. English Local Government: The Story of the King's Highway. London: Longmans, Green and Co., 1931.
7. Williams, E.W., Jr. "Government Transportation Policy and Technological Progress." Transportation Journal, 16, 86-91, 1976.
8. U.S. Department of Transportation. 8th Annual Report (on) Hazardous Materials Transportation. DOT/RSPA/MTB-78-3. Washington, D.C., 1978.

9. Abernathy, W.J. The Productivity Dilemma. Baltimore: Johns Hopkins University Press, 1978.
10. Abernathy, W.J. and J.M. Utterback. "Innovation and the Evolving Structure of the Firm." Working Paper, HBS 75-18. Harvard University, Graduate School of Business Administration, Cambridge, Mass., 1975.
11. U.S. Department of Transportation. National Transportation Trends and Choices. Office of the Secretary. Washington, D.C., 1977.
12. Ward, J.D., et al. Toward 2000: Opportunities in Transportation Evolution. DOT-TST-77-19. Washington, D.C.: U.S. Department of Transportation, 1977.
13. Bouladon, G. "The Transportation Gaps." Science Journal, 3, 41-46, 1967.
14. Garrison, W.L., and J.F. Clarke, Jr. Prospects for Neighborhood Cars. Berkeley: Institute of Transportation Studies, University of California, 1977.
15. Office of the Federal Coordinator of Transportation. Public Aids to Transportation. 4 vols. Washington, D.C., 1940.
16. U.S. Congress, Committee on Public Works and Transportation. The Status of The Nation's Highways: Conditions and Performance. Washington, D.C., 1977.
17. German, J.G. "A Maintenance Officer's View on the Effects of Freight Car Dynamics." In Proceedings, 11th Annual Railroad Engineering Conference, p. 49. Washington, D.C.: U.S. Department of Transportation, Federal Railroad Administration, 1974.
18. Gellman, A.J. "Surface Freight Transportation." In Technological Change in Regulated Industries, edited by William M. Capron, Washington, D.C.: The Brookings Institution, 1971.
19. Wyckoff, D.D. Organizational Formality and Performance in the Motor-Carrier Industry. Lexington, Mass.: Lexington Books, 1974.
20. Wyckoff, D.D. Railroad Management. Lexington, Mass.: Lexington Books, 1976.
21. Reebie, R.S., and A.C. Robertson. Organization of Needed Programs Within the National Rail Transportation System. FRA-OPPD-79-3. Washington, D.C.: U.S. Department of Transportation, 1979.
22. Bright, C.D. The Jet Makers. Lawrence, Kansas: The Regents Press, 1978.

23. U.S. Congress, Office of Technology Assessment. Technology Assessment of Changes in the Future Use and Characteristics of the Automobile Transportation System. Washington, D.C., 1979.
24. House, P.W., and D.W. Jones, Jr. Getting It off the Shelf. Boulder, Colo.: Westview Press, 1977.
25. Carey, W.N., Jr. "Transportation Engineering." In Workshop to Define Needed Civil Engineering Research in the United States. National Research Council, Washington, D.C.: Transportation Research Board, 1979.
26. Gabor, D. Innovations: Scientific, Technological, and Social. London: Oxford University Press, 1970.
27. U.S. Department of Transportation, Transportation Systems Center. Advanced Freight Systems Study: Phase I. OS 868/R8515. Cambridge, Mass., 1977.
28. Winfrey, R. et al. Economics of the Maximum Limits of Motor Vehicle Dimensions and Weights, vol. I. FHWA-RD-73-69. Washington, D.C.: U.S. Department of Transportation, 1968.
29. Hillman, J. "Psychological Fantasies in Transportation Problems." University of Dallas, Irving, Tex., 1979.
30. National Transportation Policy Study Commission. National Transportation Policies Through the Year 2000. Washington, D.C., 1979.
31. Bel Geddes, N. Magic Motorways. New York: Random House, 1940.
32. Smith, R. "Thermidore at OTA." Science, 205, 570, 1979.

DISCUSSANT'S COMMENTS

BY

DORN C. McGRATH, JR.

A discussant of a paper can do two things. One is to go through the paper point by point, and suggest gaps and highlights and elaborate on points expressed but not emphasized in all perspectives by the author. Another is simply to elaborate on some of the themes and some of the ideas that the paper provides. I have chosen to do both, inasmuch as it seems to me that the paper deals a lot less with what was programmed as the "Setting for Innovation in Transportation," than it does with some of the processes by which transportation technology has evolved.

In the context of the other panels and the other papers, some discussion of the setting qua "setting" is mandatory for us as a panel in any event. In the planning session at Woods Hole in August 1979

during a day's participation by Bill Garrison, author of the paper, we were not able to cover all points so we did later elaborate on some other ideas that seemed important then as part of the setting. I would like to look at parts of the paper, because there is included one important idea that "gaps" and "niches" in the transportation services being performed have been stimuli for the formation of new technologies and some administrative systems. Examples range from the packet boats of the early nineteenth century to the perceived gap in the ability of the U.S. postal system to deliver small parcels and goods of high value quickly to other places. Some other niches emerge as opportunities for specialized trucks for short-haul activity or for intermodal transfer cranes for handling containerized goods. All of these have emerged in response to important symptoms of weakness in the original transport systems, and they reflect the fact of new market opportunities that seem to have inspired technological change and, upon occasion, bona fide innovation.

Not every author would have done this, but Bill Garrison goes on to seek to fill many of these gaps with recommendations and proposals. In effect, he has accepted the challenge of responding to the mandate of most of the other panels, too, and offers some actual suggestions about how applied technology can fill some of these gaps. But there are two basic aspects that the paper seems to present. One is that clear definition of the fruitful opportunities arising because of the gaps and niches in the service, that we think of as transportation, helps to produce technological change--change ranging from the container terminal as a whole to the roll-on, roll-off systems that break down some of the barriers to intermodal transfers and ultimately lead to new kinds of investment in equipment reflecting a new order of magnitude in weight-handling. There is a question as to how far that trend can go before we should slow the investments in response to the new dynamic that the paper suggests--the dynamic set up by the use of large container ships and bulk-cargo ships, which in turn require new kinds of materials-handling equipment, whether for containers or for bulk cargo. These are analogous to some of the new kinds of materials-handling equipment for transcontinental shipment of coal in slurry pipelines, and mechanical conveyors or other systems also developed to fill gaps. The author maintains that thus a new dynamic is set in motion. I would note that a characteristic of the current context of the setting for innovation is that this dynamic is often undisciplined. We see that it may, particularly in the case of the container ship terminal, become a force motivating every local business promotion group to have its own container terminal whenever possible, whether it be in Charleston, Savannah, Norfolk, Baltimore, or Boston and New York, for example. Every port suddenly believes in the necessity to compete in that particular field of cargo handling, whether or not the market realities of their port system and their hinterland would make this reasonable. They feel compelled to invest. There are many who are prepared to help them do that, and to sell them equipment, outside of any organized context of market reality. There are some recently developed pier projects going begging in New York. There is chronically much unused terminal container capacity in Boston and in other places that we will undoubtedly hear more about. These are some of the consequences of the unfettered dynamic.

There is also a note in the paper that the future looks bleak with respect to productivity. I think that requires another whole set of judgments that we may not be able to make adequately in the context of this paper. But nonetheless, I am not sure that it does look bleak. We were reminded in one of the previous papers that times were never more bleak than during colonization, when all kinds of innovations indeed occurred. I will not dwell on that because I do not want it to be taken out of proportion to some of the other comments that the paper contains.

The paper mentions under "Improving Component Innovations" in the section titled, "A Suggestion," that it is important to state dynamic questions and inquire into market adjustments and development paths for a technological system, its institutions, and its markets. One thing that this paper on the "Setting" does not bring out is the institutional context in which innovation occurs. I want to come back to that, because as a theme it suffers in comparison to the dominance of interesting technological issues presented throughout. This leads to some other conclusions that I would offer as elaborations of the basic points made in the author's paper. It seems that the government, as part of the setting, is seeking to provide some form of organized reconciliation of a series of technological and social factors including human well-being and that these factors become combined in any number of issues involving transportation. The institutional setting as we know it is quite chaotic. The federal agencies are most unpredictable about focusing on long-term goals and objectives. I was very encouraged by the suggestion offered by Charpie and Goldmuntz that government ought to stay out of the direct process of innovating and should instead catalyze innovation by others. Both also suggest that perhaps a contest sponsored by government with the objective of producing innovations would bear fruit. There are some serious problems, however, with the contest that the government already runs every year. It is called a Request for Proposal (RFP) contest, wherein people try to get funds to do whatever they may be able to get funds to do--not necessarily what is needed, nor what is necessarily innovative, but funds for whatever the government seems to be prepared to sponsor for a short period of time. The rules of that game change, except that the RFP process, one of the more stultifying modes for conducting the game, lingers on. The system has many faults, but one of the worst is that it tends to prevent the giving of free rein to innovators. It also tends to work against giving new ideas time to be developed and to mature. Such ideas may require more than a single budget year.

Another characteristic of the governmental side of the setting is the clear lack of institutional memory; each time the administration changes, seemingly, all recollection of anything that went before, except the integration of railroads, is eclipsed. Suddenly, new initiatives have to be asserted, even though much of the research that led up to that point might have been quite good, and brand new people bring to bear old techniques in merchandising programs using the progressively imperfect RFP system. Typically, this context of governmental maneuvering in place lasts for about two and a half years and then it becomes

apparent that something else needs to be done. As election time gets closer, the tendency to innovate falls off very rapidly, as does the discipline concerning where the funds will go and for what purpose. This is part of that chaotic institutional setting that I do not believe should be ignored. It is difficult for people who want better service and ideas about possibilities for improvement out of the transportation system to relate to that process.

The kind of contest that the Atlantic Richfield Oil Company offered in 1974 had some interesting dimensions. They thought that for a six-month promotional effort, which they freely admitted was to help sell gasoline, they would promote a little contest on ideas for innovation in mass transportation. Some of you have seen the little booklets that were produced to publish the results. It turned out that two years later they had received 24,000 entries, 5,000 of which were from children. All kinds of people were interested in the idea of getting from here to there in different ways. While helium-filled bicycle tires to ease the effort in going up hills may have sounded capricious to us, to a kid, and to others who see something really fascinating about transportation and mobility, it was creative thinking. It is what we all believe in very much. But some kind of a contest to tap that resource of frustration and creativity in our market-oriented society might make a lot of sense, if it were organized a little differently. The pent-up creativity and frustration about transportation are certainly part of the context in which things ought to be placed. Also part of the context is the reality that we now have a fairly turgid, immobile, and highly organized system of research with an inertia all its own. Also the lack of a sense of what we are actually trying to do is a problem of the institutional setting for innovation. People are filling some interesting gaps in rail transportation by inventing bigger cars, wider rail gauge, and more powerful locomotives. Such approaches are generally for one purpose--to take coal from the mine mouth to the generating station or steel mill. Some interesting additional hardware can be generated that way, but many other more basic problems are ignored in the process. In terms of what transportation does for society, for the city, or for the people, in terms of more than one mode, we have not been very purposeful with our innovations. That is one of the gaps in the present setting. A curious analogy comes to mind. It seems to me that if we were as serious about dealing with the problems of domestic transportation as we are about the transportation of armaments and explosives overseas by means of high-trajectory vehicles, to land with extreme precision almost anywhere in the world, we would be much further along. In the MX mobile missile system that is being installed in one large area, with a highly sophisticated set of transporters and controls in order to locate weapons at various unpredictable stations, we have developed a kind of shell game analogous to trying to find a bus somewhere in the Los Angeles metropolitan area. It would probably be more difficult for the Russians to find a bus anywhere in the freeway or roadway network in the Los Angeles basin than for them to locate one of these missiles in the shell game involving sophisticated military vehicles. But we have never addressed ourselves to that. The dilemma

of the Russian strategic planner is about the same as that faced by the Los Angeles commuter. The commuter cannot find a bus in the system, and does not know where or at what time it might pop up and be available to him. He is thoroughly flummoxed, and we hope the Russian planner is also. Thus we have gotten a very sophisticated \$38-50 billion investment in one kind of system to keep our potential enemies guessing, yet we fail to address the problem of simplifying a domestic transport system that seems equally confusing to our friends. That strikes me as one of the ironies of our current system.

Another matter of concern in the institutional setting, referred to earlier, is the lack of predictability of many forms of research addressed in Garrison's paper that are to be carried out in the universities. Part of the reality at the present time is that the university is declining as a transportation research center. The universities cannot count on very long-term support from UMTA, other parts of DOT, HUD, or other government departments for projects they may feel deserve a long-term exploration. Those in the Washington area have been through this process. At the invitation of DOT, five of the universities in this area set up a transportation center. The DOT felt that since there were five universities involved, it must be five times as effective and therefore could operate with 20 percent of the funds that might be needed by any other single institution as long as we did not charge any overhead. So we wound up as vehicles to distribute the money to students so they could study with pro bono guidance from their faculty mentors on appropriate kinds of research. Many good products resulted, and the program had just begun to build up a suitable momentum--80 or 90 doctoral and master's level papers. Research projects had been carried through, and a number of young people had gone into the transportation industry. Then with about one-hour's warning, DOT told us that such a process would not be followed anymore, and that they were switching to "mission-oriented research." So the whole operation simply stopped, as the basic source of funds switched to some other type of operation. That kind of disinvestment does not build confidence in research management or in the process of stimulation that might be provided. These processes need some rethinking and need to mature. Fortunately, it takes about four years for research management to mature both at the federal level and among the researchers themselves. However, uncertainty tends to frustrate the researchers in both the public and the private sector. The time lag itself is another difficulty in the institutional setting for innovation.

The last, and maybe the most fundamental, comment I would like to make in respect to Garrison's paper, and also to some of the others prepared for this meeting, is that there seems to be a lack of any real sense of the city as a complex with prospect and potential for an identity that people seek. Instead, cities seem to be viewed simply as a cold-blooded aggregated market for indulging this, that, or the other economic analysis for adventure. We tend to see people viewing urban aggregation mainly in terms of market opportunities, but many cities have begun to reassert an identity. San Francisco, San Diego, Baltimore, Boston, and many others have broken the habit of simply regarding trans-

portation as the technological force to which they must adapt. They have grown to the point where they have begun to see the transportation systems as appropriate servants, within the limits for existing facilities they set for themselves, and for the purpose of aiding in the development of strategic locations. So part of the setting right now is a need to recognize that some cities have matured and would no longer build an elevated expressway down Atlantic Avenue, for example, as in Boston. No longer would they build an expressway along the waterfront as a path of least resistance. No longer would they necessarily locate truck terminals in places where relationships with residential areas would be disrupted. There is a certain maturity of expectations, not well articulated but undeniably present, in the minds of people who are getting sick of cities as places where they survive less and less well. We ought to think about that as providing not a niche, but a yawning gap within which much work needs to be done to think through how transportation systems relate one to the other and to the cities they are supposed to serve. But cities unfortunately are all too often seen, even by their nominal federal advocates, such as HUD or DOT or even Commerce, as more or less intractable problems. These problems add up to political liabilities. One does not want to get too close to these problems when elections are approaching. That is hardly the way to deal with the places where 80 percent of the population lives, and will continue to live, and which offer market opportunities and are more and more sophisticated and refined about where transportation and innovation might exist. It has to be recognized as a result of a limited and inadequate approach that the setting has not attracted a breadth of vision about these problems equal to the breadth of some of these expectations that people have. Nor does the approach seem to be a reflection of some of the values in addition to the opportunities for technological experimentation that exist in urban places. That is part of the setting that is not addressed very much in most of the papers that I have seen. But again, I have discussed what is not there, as well as what is there, as a means of adding to the discussion.

INTERACTIONS OF GOVERNMENT, INDUSTRY, AND ACADEMIA

REMARKS

BY

MARTIN GOLAND

The topic assigned us is how to optimize the interactions between government, industry, and universities so as to take full advantage of these resources in advancing innovation in the broad transportation sector. While the various transportation modes do have many technical features in common, each mode is also characterized by unique potentials and problems--unique by virtue of inherent function, historical development, and the nature of the market to be served. All of these factors must enter into our considerations. Our topic is thus a complicated one indeed.

For the purpose of perspective, it may be of some interest to go back to an earlier and more traditional day and to recall briefly the relative roles played by universities, industry, and government in technological innovation. The universities were the fountainhead of research knowledge, producing the new scientific concepts and data that would later become the foundations for advanced industrial products and processes.

Industry (and in this category I am including the individual inventor and entrepreneur whose ideas flowed directly into corporate industry) represented the productive might of our nation: the producer of goods and services to meet market needs. Innovation within industry was a powerful force, because success in the marketplace depended on it, but it is fair to say that until the post-World War II period, industrial innovation depended more on invention and on improved manufacturing technique than on science. Basic research was largely left as a university function, although there were a limited number of corporations who were the exceptions and who built strong scientific teams and research laboratories to meet their product improvement needs.

The government role in those earlier and simpler days was a selective one. In agriculture it is true that the government was the prime mover in a national program of unexcelled innovation and research advance. Government laboratories also conducted research and development in other fields (and even some production in the case of government arsenals), but only in areas where industrial strength was lacking and where the government was essentially the sole customer (e.g., military equipment), or in areas where the nature of the activity was clearly a government responsibility (e.g., the Bureau of Standards).

If we compare the situation as it was some decades ago with that of today, it is clear that whatever order existed then has evolved into a far more complex system. Universities no longer monopolize the fundamental research function. The government is actively supporting and conducting research and development in a host of nongovernmental market-place-oriented fields, using as its mandate a rapidly growing regulatory involvement and the emergence of energy as a critical national issue. Industry, while retaining its production primacy, has become a powerful force across the entire spectrum of technical activities ranging from basic research to societal analysis. The roles of the three performers have become far more overlapping and interrelated. This is one reason why this meeting can prove to be a valuable step toward achieving better understanding for future policy-making.

One of the position papers is by Lawrence Goldmuntz. It is excellent, and it probes the question of what the government role in transportation innovation should be. In the past, there have been notable successes and failures.

Our highway system is the finest in the world. The world fleet of commercial aircraft is still led by the products of U.S. manufacturers, and this preeminence would not have been achieved without the government-conducted program of the old National Advisory Committee for Aeronautics, now the National Aeronautics and Space Administration. On the other hand, despite great financial support by the government, little innovative progress has been made in the field of urban mass transportation, and government entry into the railroad field has produced little in the way of positive results thus far. Insofar as regulatory actions are concerned, the results are mixed--in some instances, the effects have been counterproductive because regulations were promulgated hastily and without the necessary foundations of knowledge and understanding of the problem.

In this connection, incidentally, let me make the observation that in our assessment of the government role in transportation innovation, we should keep in mind that there are two "governments" in the picture, namely, the executive branch and the legislative branch. Whereas in past years the legislative branch has entered into technical affairs only weakly, this is no longer the case. Legislative committees have built up technical expertise as part of a major growth in staff capabilities, and the members of the House and Senate have individually become more deeply involved with technical issues. The legislative branch often takes the initiative in technical decisions, using its budgetary and law-making authority as levers. The executive branch, of course, has the responsibility for implementing legislative actions, and on occasion executive agencies find themselves the scapegoats for unsuccessful programs they did not devise.

The larger government role has also affected both industry and university programs. Because of greatly increased regulatory pressures, industry has often been forced into a defensive posture, with meeting near-term goals a more urgent requirement than seeking longer-term objectives that may in the end be more worthwhile. The effects of such actions on innovation can only be surmised, but it is one area needing discussion.

Universities, for their part, have tended to become more applied in their research, not only because of a laudable desire to help in the solution of important societal problems, but also for the more pragmatic reason that money flows more easily in support of applied vs. fundamental research. Has this been a desirable trend in contributing to transportation innovation? No doubt our panels will have something to say along these lines.

Perhaps in our panel discussions we will look for models from abroad. I think it is proper to say that in other technologically advanced countries, universities are less directly coupled to industrial research than is the case in the United States. Research institutes, jointly supported by government and industry, are established to do research on generic problems that can be dealt with more cost-effectively by industry as a whole rather than by individual companies. The Japanese mode of operation involves an active government role well beyond that of merely financial support--along with industry, planning is done jointly in support of national initiatives and policies. While individual Japanese groups are intensely competitive with each other, their system nevertheless permits a degree of cooperation at the generic problem level that is not normally permitted under U.S. antitrust law.

Finally, we will no doubt want to examine the levels of transportation innovation in the U.S. compared with those abroad. Have other nations been more innovative than we? Railroads are more effective in passenger service in European countries and in Japan. Is this because of a rational response to a market differently constituted than ours, or is it because their approach is indeed more innovative?

In automobile design, foreign manufacturers are frequently praised for being more innovative than those in the United States. Their cars are more energy-conserving, at least according to critics of the U.S. industry; they are better designed and are more serviceable. If one talks to automotive engineers abroad, however, their appraisal usually does not agree with these assertions. Many Japanese automotive engineers I have talked to admit that they have much greater experience in small-car design, certainly an asset in today's environment, by virtue of the fact that the Japanese marketplace has from the start demanded small cars. But they see their design advantage rapidly disappearing as U.S. engineering teams concentrate their efforts in this area and as U.S. production facilities become better adjusted to the needs for small-car manufacture. Their continuing advantage, they contend, will be in the quality and dedication of their work force. The average Japanese production-line worker, in their opinion, is better educated, more interested in the job, and instilled with the philosophy of insuring high quality in the end product. Those, combined with taxation policies that tend to encourage innovation and capital investment on the production line, are the strengths they will look to in the future. They do not foresee that continued Japanese success in automotive sales will be the result of superior Japanese innovation--some will even admit that U.S. pre-eminence will continue for some time.

These, then, are some of the issues our panel might want to look into. I know that our discussions will be provocative and probing, and that we will give a worthwhile report.

INTERACTIONS OF GOVERNMENT, INDUSTRY, AND ACADEMIA

BY

DAVID S. POTTER

PRESENTER: CRAIG MARKS

INTRODUCTION

It is generally agreed that innovation--be it technological, economic, social, or institutional--is one of the necessary ingredients in the pursuit of progress. However, for some years now, innovation has been discouraged in the United States, for reasons that are mostly independent of the technical field or industry.

You have heard the litany of all management people, within government, industry, or academia, concerning the evils of inflation and high interest. Their application to technological matters is sufficiently specific, however, that I would like to address very briefly the particular way that these economic factors affect technology and, through technology as one example, the opportunities for innovation.

In a long-term sense, a good inflation strategy for an industry might well be a heavy early investment in future productivity as the means for transferring inflation-proof benefits into the future, and R&D expenditures offer such a possibility. In the short-term, though, inflation mitigates against such investments. Most manufacturers have found it impossible to recover inflation-caused cost increases totally. A 70 percent price recovery of inflation-induced cost increases is fairly normal. This shortfall results in a real shortage of capital funds for modernization or replacement of existing equipment. In addition to this first-order effect, there is a curious and troublesome second-order effect so that there are even fewer R&D incentives than before. Successful new-product development would only lead to capital requirements for new products and processes that cannot be funded, so the "why bother?" attitude appears.

Inflation-induced high interest rates also have an insidious effect on the willingness to accept entrepreneurial risks. With current high interest rates, the present value of any future benefit must be discounted so deeply that there is less incentive to undertake the higher-risk programs that characterize a dynamic economy. If the expectation value of a high-risk venture is less than the return on a government bond, prudent management does not invest in risk. Again, this situation yields a second-order impact on R&D. Since one is looking either for very high payoff or relatively low risk programs, the number of R&D projects needed to explore the possibilities meeting these requirements is limited. If, however, the return on investment need be only half as much, as it was in the 1940s and 1950s as compared to today, then many more R&D efforts need to be undertaken because the cutoff point for

success has been significantly lowered. Even though high interest rates can be considered largely to be an internal U.S. matter, they ultimately have a profound effect on our ability to compete in international markets for years to come.

A third area of general concern that is expressed most often by the industrial people is in the area of regulation. A certain amount of regulation is necessary, and I do not quarrel with the point of view that says that in our crowded society, central regulatory bodies are essential for the preservation of our environment and for other amenities of life that we have come to require. No matter how good the regulation, however, it results in nonproductive expense, and that is inflationary. It is the thesis of this paper that a great deterrent to innovation in the transportation industry today is government intervention, much of it in the form of regulation.

At the very least, the cost of the regulatory apparatus both within government and within industry must be factored into the price of the product. I will return to this later.

One also must comment that the uncertainties occasioned by regulation are at least as damaging as the regulation itself. The numbers change seemingly without cause; the test protocols change without notice; and the enforcement criteria change so as to, in effect, change the standard. Given these uncertainties, there can be a tendency to slow down and "wait and see." Let someone else be the guinea pig and learn the hard way what government meant by the latest change.

The ultimate problem with innovation in the private sector is that it exists within, and responds to, all of the same stimuli as its sponsor, the business community. The problems of the private sector eventually all depend upon the health and well-being of our nation's economy. No matter how well intentioned government is in the encouragement of innovation through the many mechanisms available in the federal system, those efforts can have little real impact on the citizenry within our presently conceived private enterprise system. At the risk of too much repetition, I want to underscore the fact that the application of science and technology to the well-being of the people is a function of the private sector. Ultimately, the only way to keep private science and technology healthy is to heal the economy.

Therefore the climate for innovation in the transportation industry requires the essential ingredients of favorable economics, an identified need and good ideas. It requires an inventive and aggressive state of mind on the part of the various participants be they business people, inventors, purchasers and users, or government policy-makers. And, importantly, in the advanced and mature state of our society, innovation requires a mutually supportive attitude between and by the participants in the process.

The balance of this paper, then, is directed to developing these points in the context of transportation.

The first section discusses the opportunities for innovation in transportation as a function of the stages of development--the new, developing, and mature stages.

The second section discusses the roles that government has played in the encouragement or discouragement of transportation innovation--

first, as a sponsor, purchaser, and user of the results; second, in the development of specifications for transportation products or processes for use by others; and, finally, as a regulator. With more and more departure from free market behavior and with increasing levels of interference by government, innovation wanes and disappears. Inappropriate government becomes the major constraint to innovation in transportation.

THE STAGES OF DEVELOPMENT IN TRANSPORTATION

The automobile industry can serve as a useful example of the potential differences that exist in opportunities for innovation as a function of the stages of industrial growth and development.

In the new or initial stage, there is the introduction of a new product or service. There are many participants. Entrepreneurs and inventors are prevalent. There is rapid growth in application or sales. There is high opportunity and, particularly for the individual entrepreneur, risk. In the past, government has had little or no role. Basic knowledge growing out of academic studies has potentially high application and utility.

The automobile industry had its beginnings in the late 1800s and early 1900s. The automobile did not spring, full-blown, into existence but evolved from a variety of dreams and ideas for self-propelled vehicles. The development of practical, liquid-fueled engines around 1885 gave impetus to vehicle development so that by 1900 in the United States there were some 8,000 crude automobiles operating over dirt roads and brick and cobblestone city streets with more than 150 active automobile companies. The number of companies grew to over 200 by 1903, with 22,000 vehicles produced in that year. Seventy-seven thousand vehicles were registered in 1905, and almost half a million in 1910.

The people involved at this stage came from an interesting variety of backgrounds--inventors, engineers, blacksmiths, carriage and wagon makers, bankers, businessmen, and motoring enthusiasts. Laissez-faire conditions prevailed. Innovation was widespread. For example, propulsion choices included battery electrics, steam, diesel, and gasoline engines. Steering could be by tiller or by steering wheels, gears, and linkages.

Risk was justified or rationalized by the entrepreneur because of the high potential return.

Newspapers, magazines, and trade and technical journals devoted exclusively to the automobile appeared and multiplied. A few speed limits and traffic regulations specific to the automobile began to appear.

In the earlier developmental stages, the product or service of an industry is improved, expanded, extended, and perfected. Improvements occur both in the development of the original technology or idea and in the replacement of the original technology with a better technology. Standardization commences. Economies of scale appear. Competition

becomes even more intense. Economic risks become even larger. Government interest grows, and initial government controls may be applied.

Needed regulation often was in the form of self-regulation. Thus standardization commenced on a voluntary basis. The Society of Automobile Engineers (which was first formed in 1905 and became the Society of Automotive Engineers in 1917) created a Standardization Committee in 1910 and succeeded in reducing the number, kinds, and sizes of the various parts that went into an assembled automobile. Gradually, and without government intervention, steering wheels were standardized on the left side; gear shift patterns and gas pedal, brake, and clutch positions were standardized; and such items as four-wheel hydraulic brakes and windshield wipers became standard equipment. The dominance of gasoline-engine-equipped, closed-body automobiles was established.

The Federal Aid Road Act, in 1916, was the beginning of a national system of interstate highways. Wartime excise taxes were levied on automobiles in 1918 as dispensable luxuries. Automotive excise taxes and fuel taxes were introduced, extended, and increased over time.

Opportunities for innovation began to shift toward process and productivity improvements (to the advantage of the consumer) although substantial product innovations continued to be introduced. Several examples include four-wheel brakes in 1924, safety glass in 1926, and automatic transmissions and turn signals in 1939.

It should be noted that the evolutionary improvement of the automobile was directly recognized and applauded by the continued enthusiastic response of the consumer. Sales and use of the automobile continued to increase on a long-term basis.

As development continues, the product or service becomes established. Customer or user expectations are extremely high. Product advancements must be complemented by innovations in other areas, e.g., decreased overhead or manufacturing costs. Competition is very keen. Opportunity remains high, but risks are also very high. Product or process standardization may occur. However, government regulation can become a dominant factor in both business operation and product design. This can result in a narrowing of the scope for possible innovation and can encourage focusing more on reducing risks than on venturesome excursions into the unknown.

Automobile industry developments during the period from World War II to the present represent a period of consolidation for some companies and expansion and modernization for others. Despite the tremendous regulatory burden, competitive forces continue to result in innovations. A few examples are plastic dies for steel stampings in 1952, widespread availability of power steering, also in 1952, power brakes in 1953, improved sealed beam headlamps in 1954, standardization of amber lights for front turn signals in 1962, self-adjusting brakes in 1963, and car warranties over several years and the energy-absorbing steering column in 1966.

At the same time, government interaction with the industry also developed. The Interstate Highway System was approved in the Highway Act of 1956. The Highway Trust Fund was established to apply highway user taxes to finance the federal share of the programs. In 1966, the

National Traffic and Motor Vehicle Safety Act and the Highway Safety Act were passed, and the U.S. Department of Transportation was formed. Motor vehicle safety standards were established and enforced. The Clean Air Act was passed in 1970 and amended in 1977. Standards for automotive exhaust emissions have been established. The Energy Policy and Conservation Act was passed in December 1976, and it mandated automobile fuel economy standards for 1978 to 1980 and for 1985.

Other Examples of Opportunities for Transportation Innovation as Functions of the Stages of Development

A brief mention of examples of opportunities for innovation in other segments of the transportation industry is in order.

Rail Locomotives

As railroads have developed in the United States, the cost of labor to operate the trains has been historically high. The introduction of the air brake, improved rail car couplers, improved brake shoes, and importantly, the vast improvement in control of starting tractive effort made possible with the diesel-electric locomotive all permitted railroads to increase the length of freight trains and thereby to minimize operating costs. Through these and other advantages, the diesel-electric locomotive has become the dominant form of motive power for railroads in the United States.

Now, with energy (both cost and availability) considerations becoming of growing importance, rail companies are taking another hard look at electrification and alternative energy sources for powering trains.

But given the magnitude of the needed investment (especially in the light of the financial plight of many of the railroads), competition for available funds by other needed rail projects, an absence of needed information on potential service or reliability advantages of electrification, and environmental questions--not to mention rate of return on investment considerations--make electrification an extremely high risk issue. The Northwest Corridor Amtrak facility is presently scheduled for improvement of the existing electrification between Washington, D.C., and New Rochelle, New York, and new electrification is slated between New Haven, Connecticut, and Boston, Massachusetts. No other major railroads have anything specific in hand in the way of studies or plans.

Transit Buses

During the history of the motor coach business, a number of major improvements have been introduced and made standard by the industry. Included are diesel-engine-powered motor coaches, air suspension, air conditioning, automatic transmissions, integral aluminum bodies,

transverse rear engine mounting, and fluorescent lighting. (We are happy to note that GM led in pioneering these developments.)

In the early 1970s, in response to transit authority demands for new bus equipment, General Motors announced its plans to produce the first all-new bus design since the "new look" bus was introduced by General Motors in 1959.

The new General Motors design, called the Rapid Transit Series (RTS), not only reflected an entirely new modern-day look and design, it was to be built by a completely different advanced manufacturing process. The U.S. Department of Transportation was notified of the availability of the RTS in early 1971. However, DOT refused to alter its procurement policies to permit purchases of this advanced design bus with federal assistance. Instead, the department asked bus manufacturers to participate in a DOT-sponsored effort, announced in mid-1971, to develop a new government-sponsored bus design under the project name "Transbus."

What has happened since is history. The government's Transbus program was conducted, at great expense and at the cost of delaying by several years the introduction of the new design GM had ready to go. There have been changes in transit bus procurement procedures and both Transbus and RTS specifications. There have been changes in administrations and U.S. Department of Transportation personnel. In addition, litigation further delayed introduction of the new bus design.

Deliveries of the GM's new-design coaches finally were allowed to begin in September 1977 but not without continuing difficulties in obtaining satisfactory government procurement procedures. The issue of whether the government will attempt to issue a mandatory bus design to be followed by all producers is just now being resolved. Needless to say, these events will have considerable impact on the opportunities for innovation in transit bus design and manufacture. Furthermore, the availability of new equipment, deemed by transit operators to be needed, has been delayed by six years.

THE ROLES OF GOVERNMENT

That brings us to a discussion of the roles that government has played in the encouragement and discouragement of transportation innovation and to the development of suggestions for improvements in the government role.

Government has several, sometimes conflicting, responsibilities in transportation. On occasion, government agencies are customers for equipment or services. Sometimes they are the developers of specifications for equipment to be purchased and used by others--public agencies and private individuals. Finally, government has the responsibility to protect the public interest in a very broad social context.

In those several responsibilities, government has a key role, to provide a supportive climate for the encouragement of innovation in transportation. One major deterrent to innovation in transportation is the adversary relationships that have developed between government as

the regulator, the transportation industry (carriers and manufacturers) as the regulated, and shippers as the affected customer.

These adversary relationships have been escalated by the prevailing public perceptions of big government and big business. As a result, regulation has become unilateral, with no room for experimentation or innovation.

Some examples are in order.

Government as Customer

One example of government as an encourager and purchaser of innovation has been in the Department of Defense (DOD). Since another panel of the workshop is addressing procurement incentives directly, only a few points will be made here. There are many examples that might be cited, but we will take the example of the Main Battle Tank, in which General Motors played a role. This program, begun in the mid-1960s was for a completely new piece of military equipment with operational characteristics that far exceeded anything available at that time--a real step forward in the state-of-the-art was required. The original Request for Proposals (RFP) from DOD included performance specifications and was written in such a way as to invite innovation. The RFP spurred an active and healthy competition among potential contractors. During the research and development contract preparation period, there were numerous interactions and improvements of the subsequent contract performance specifications.

Importantly, the contracts were written in a way that specifically invited and rewarded the contribution of innovative ideas and products at all stages in the overall design and development process.

Government as a Developer of Specifications for Others

As an example of where government has not performed quite as well, we will continue the transit bus story begun earlier.

The new GM transit bus designs completed in 1971 were designed to be superior public transit equipment, attractive in appearance and economical to operate and maintain. They were designed to respond to the functional demands of the transit marketplace, with many new, advanced design features.

In investing in tooling, GM expected that the transit system operators--whose rider's needs were considered in designing the vehicle--would be allowed to consider cost-effective features in determining the lowest evaluated bid. Only by allowing credit for the increased values of the new design could it be on a competitive basis with existing, unimproved models.

DOT refused to allow full credit for such cost benefits, and the ability to market the advanced design buses has been impaired. Indeed, much of the time, DOT has insisted on contract awards to the lowest bidder regardless of quality.

Requiring bus contracts to be awarded on the basis of initial cost alone is at odds with fundamental, well-established procurement policy. Imposition of such a requirement discourages innovation and tends to push awards in the direction of the apparently "cheapest" (lowest initial cost) equipment.

The inadequacies of a low-initial-cost policy have long been recognized by the federal government in its own procurement regulations. These regulations declare that "the award of a contract to an offeror solely on the basis of the lowest evaluated prices is a disservice to the government if subsequently the contract defaults, is late in deliveries or otherwise performs unsatisfactorily." The same regulations further provide:

"While it is important that purchases be made on the basis of offers which are most advantageous to the government, price and other factors considered, this does not require an award to an offeror solely because he submits the lowest bid or offer."

The Armed Service Procurement Regulations also expressly endorse the best-value, life cycle cost concepts.

The government's Office of Management and Budget has taken steps to assure that federal grant recipients make their own procurement decisions. This general policy is expressed in the Uniform Administrative Requirements for Grants-in-Aid to State and Local Governments (OMB Circular A-102) that stresses reliance on local initiative and declares in favor of a policy of "greater reliance on state and local governments."

Despite this statement of federal policy, which has been in effect since 1972, DOT for the most part has not allowed self-determination by local agencies and has preempted transit operators' procurement policies and practices.

The low-initial-bid requirement finally was replaced by DOT with a policy permitting contract awards to the supplier submitting the lowest evaluated bid, with local transit operators making the comparative evaluations of competing vehicles. This step, taken in 1976, was intended to give state and local grantees the same right to consider life cycle cost benefits as the federal government exercises in making its own purchases.

However, before this new bid procedure could be implemented, the then secretary of transportation, shortly after taking office, issued yet another procurement policy. Under the current procedure, awards are made to the supplier submitting the lowest adjusted bid. Price offset credits are allowed for some (but not all) superior, cost-beneficial features in determining the lowest adjusted price, but with a key difference from the 1976 policy. Under the current system, DOT officials, not the transit authorities, make the evaluations. Under this policy, DOT officials have disallowed price offset credits for features that transit authorities value highly and for which they have proposed to allow credits.

In another of its many reversals of policy, DOT in 1977 directed that initial purchases of the Transbus design that DOT mandated for all manufacturers be made on the low-initial-bid-price basis, returning to

the philosophy that makes no allowances for real value. Subsequently, after extensive review, DOT, confronted with the many design and operational difficulties inherent in the Transbus design, decided to postpone Transbus indefinitely. The findings of a review panel selected by the government completely support the bus manufacturers' decision not to build the Transbus design as sound business judgment based on the problems found in the design.

Bus manufacturers and transit authorities alike hope that the recent endorsement by Congress of the life cycle cost concept in the Surface Transportation Assistance Act of 1978 will be fully implemented by DOT. The related provision states that after September 30, 1979, transit rolling stock procurements can be based on consideration of life cycle costs and factors other than initial cost.

Manufacturers cannot continue to spend time and money on projects that change every two or three years and for which there is no opportunity to recover costs.

In 1968 a National Academy of Engineering report recommended that the role of the federal government in transit equipment purchases should be one primarily of establishing technical criteria. However, as the 1978 Office of Technology Assessment (OTA) report ("An Analysis of Urban Transit Vehicle Development and Demonstration Programs") pointed out, this procedure was never adopted. The OTA report found that DOT has injected itself deeply into the bus design business, almost to the exclusion of the manufacturers and the local transit authorities. The result has been a system that tends to stifle competition and fails to stimulate the equipment development that comes from a free market relationship between manufacturer and customer.

One possible alternative for dealing with this situation is a mechanism by which the users of transit equipment can play a greater role in determining specifications, cost effectiveness and performance of transit equipment. DOT's role should be that of a monitoring, consultative, and administrative agency.

Government as a Participant in Financial Support of Research and Development as Potential Contributors to Innovation

Members of industry usually are reluctant to posit a governmental role in the "free" economy. Let me stipulate at the outset that government has a right and an obligation to examine those facets of science and technology that have a direct impact on the health and well-being of American citizens and institutions and to provide funding where appropriate.

Historically, most support for scientific activities in this country has come from the intellectual interests and philanthropic activities of private citizens. Technological development largely was carried out by the private sector in response to ordinary commercial incentives to create a new or better product or to create an equivalent product at a lower cost. The direct oversight of government in these matters was not so necessary as it seems today, and except for some

early military development, there was little federal funding. Congress did recognize national interests and exhibited great leadership at a time of real need in developing such programs as the national land grant college program in 1862 through the Morrill Act. As evidence of this program's ongoing contribution to science, one can cite the former American Council on Education evaluations of academic excellence. In addition to the program's intended impact on agriculture and mechanical studies, land grant institutions include some of the nation's finest scientific and technical organizations. Congress certainly played a leadership role and accomplished a great deal over the years with this fine program.

Soon thereafter, in 1863, Senator Wilson of Massachusetts drafted the bill that has become the charter of the National Academy of Sciences. To the everlasting glory of Congress, it has seen fit to leave it in its original form, unchanged, to this day.

After World War II, it was necessary to continue federal support and recognition of science. In describing the creation of the National Science Foundation, Vannevar Bush said, "To persuade the Congress of these pragmatically inclined United States to establish a strong organization to support fundamental research would seem to be one of the minor miracles." This minor miracle did occur and in the postwar era the Congress not only accepted the idea of a National Science Foundation and was instrumental in getting it established, but also pressed for the large growth of the National Institutes of Health. Other examples of creative congressional action include the Atomic Energy Commission, the Sea Grant college program, and the National Aeronautics and Space Administration. Opinions differ on the continuing necessity and effectiveness of these activities, but nonetheless, they provided solutions to perceived national problems.

In other areas, the Congress has assumed a more passive role in research and development activities within existing departments and agencies of the federal government.

Let me now address the R&D activities that are directly funded through the federal government and hence offer a direct opportunity for congressional involvement and policymaking.

An important congressional concern should be, and has been, maintaining a healthy scientific establishment in this country. This means maintaining institutions and educational facilities to produce research personnel of sufficient quality and quantity to serve the needs of the nation. In the process, of course, scientific research is generated. In discussing the training necessary for science and technology and also the research results that are generated in the education process, it is difficult to sort out whether trained personnel or research results are the primary product. The National Science Foundation and the National Institutes of Health seem to have achieved a reasonable balance between the two.

The professionals on the scientific side would certainly argue that Congress should have been more generous in its support and one would also guess that the specific allocation of money to the various grantees must be thought to be somewhat less than perfect by those who failed to

receive grants, but such complaints are certainly to be expected and do not detract from my general observation of a well-considered and executed program by these institutions. It also seems, in retrospect, that congressional handling of the budgetary process has given some sense of national need and priorities to these institutions. Although Congress tends to become quite specific in management objectives in some of the larger programs, for instance the Mohole project, or the work in Antarctica, there seems to have been a general appreciation that Congress in its role of "Board of Directors" is better off giving policy guidance, establishing priorities, and insisting on good management than attempting a detailed management of the enterprise.

The excursion of the National Science Foundation into the more applied world via the RANN (Research Applied to National Needs) program was to my mind a mistake. That excursion, however, was one suggested by a past administration and not by Congress, and I am glad to see that the experiment has ended.

As one moves from the support of science for its own sake to the support of science because of the needs of some mission-oriented agency of department, the record becomes more spotty. In addition, the funding procedures become more complex and variable. In a meeting of the American Association for the Advancement of Science last year on R&D in the federal budget, John C. Calhoun of Texas A&M observed that the R&D budget appears to consist of three processes: one at the agency level, one at the executive policy level, and one at the congressional appropriation level. Each appears to have its own ground rules. Although the processes overlap and are intertwined, they appear to be based on separate analyses and different assumptions.

My personal experience with the Department of Defense and the Office of Naval Research only served to reinforce that view. I am a firm believer in competition and have generally approved of the fact that a researcher might well have two or three sources for funding. In dealing with a bureaucracy, which I will define as a group of professional managers who in trying to achieve some overall good result will not personally be affected by a bad result, it is essential that multiple paths be provided. Although I am no longer personally engaged as either a donor or a beneficiary in government research grants or contracts, I am disturbed by an increasing whimsy on the part of some government agencies in making grants. It seems to me that a Mansfield-type amendment, which would restrict the kinds of programs that can be funded by mission-oriented agencies, promotes short-term efficiency at the expense of a long-term loss of vitality.

Across the full spectrum of the science and technology that Congress supports through direct funding programs, I would conclude that, in general, the science program of this country has been shaped by the national priorities and instructions given by Congress through their allocation of resources to various sectors of science and technology. The congressional choice of the priorities and the consequent shape of our scientific community may be judged successful by some and a poor compromise by others, but the accomplishments and the imposition of the "sense of the Congress" on the scientific establishment should not be doubted.

Now I would like to direct the discussion into those large areas of science and technology that do not receive direct government funding; those that are carried out and financed by the private sector. In this area, Congress has a responsibility to create a climate that nurtures research and development efforts within the private sector and to monitor the nation's health in this area from time to time.

It is only through the private sector that goods and services are provided to our people. Government-funded R&D, in and of itself, cannot provide a continued high standard of living of our people and adequate employment opportunities for all. In recent years, we have witnessed a relative decline in the American economy. Although in an absolute sense we have retained a strong economy, we have lost ground to other important economies in the world. But more importantly, our rate of improvement has not kept pace with our own expectations. We have the scientific, technical, and managerial capacities to do better than we have.

That brings us, then, to a summary discussion of actions that might be considered by government, generally, and by the U.S. Department of Transportation, specifically, to regenerate the needed supportive climate for innovation in transportation.

Above all else, government must take the actions necessary to return the national economy to a healthy state--to eliminate inflation and lower interest rates. Economist Milton Friedman stated the case as succinctly as possible when, in commenting on the growing public dissatisfaction with government, he said, "...inflation is produced primarily in Washington."

It makes very little difference what government does to improve the climate for innovation until the national economy improves. But given a healthy economy, there are some specific things that can be done for the transportation industry.

Cooperative Automotive Research Program

One example is the Cooperative Automotive Research Program (CARP) presently being negotiated between government and industry. On May 18, 1979, representatives from the domestic auto industry met with President Carter to discuss a basic research initiative. While the industry agreed to the principles embodied in the initiative, the details remain to be worked out. The initiative closely parallels the program presented by Philip Smith, Associate Director, Office of Science and Technology Policy, in testimony on May 2, with respect to H.R. 4678, "Automotive Research and Technology Development." The seven stated objectives of this legislation are as follows:

- To preserve and enhance personal mobility at reasonable cost
- To reduce dependence on imported oil
- To increase motor vehicle safety
- To reduce motor vehicle environmental effects
- To improve motor vehicle reliability
- To conserve scarce resources
- To enhance the international competitive position of U.S. autos

If we were asked to list the major objectives of our own programs independently, it would be difficult to improve on those listed in this legislation.

However, government involvement in automotive research should be focused on basic research, not component or product development. This is a very important distinction that is crucial to a successful industry-government relationship.

Admittedly, the bounds of basic research are not always clear, but basic research can be roughly defined as an effort to discover new knowledge without specific commercial objectives. Technology development, as defined in Section 502 of the legislation, goes well beyond the discovery of new knowledge and would have the government working on a parallel path with industry by authorizing the government to "devise new component and system concepts, and develop new experimental components, subsystems, and vehicles when necessary to verify such concepts."

This authority is likely to encourage government to enter into areas of product development that would duplicate industry efforts and be wasteful of national resources. The auto industry has demonstrated the capability to produce the hardware necessary to provide economical, safe, socially acceptable transportation within the framework of manufacturing, marketing, and financial constraints. I believe that technology development--the application of the results of basic research--should be left in the hands of industry.

Basic research, on the other hand, is a legitimate area for government involvement, and there is a wide range of automotive subjects that would seem to qualify for basic research under government auspices. The previously discussed initiative prepared by the Office of Science and Technology Policy proposed the following subjects:

- thermodynamics, combustion, and fluid dynamics
- structures
- noise and vibration
- materials science and processing
- control systems
- friction and wear

While there may well be others, each of these are important areas that would benefit by an expanded research effort.

Basic research, which has no specific commercial objective, typically benefits society in general as well as those industries using the resultant fundamental knowledge to improve their products. In the case of the auto industry, the incentives of the marketplace are more than sufficient to encourage application of knowledge from any source to improve our products. It is recommended therefore that the necessary funding for basic research programs be obtained from general revenues, as is the case with government research in other areas.

It is recognized that an effective basic research program, along the lines indicated here, will require an organized structure within which to implement and coordinate the work to be undertaken. It is essential that, whatever existing government agency is selected to undertake an independent basic research program, high standards of leadership be established. The head of the organization should be a

person appointed by the president, subject, of course, to confirmation proceedings. The criteria for appointment should include stature in the scientific community, a record of achievement, and demonstrated competence in the disciplines of basic research. In addition, staffing for the program should include individuals with a demonstrated ability to manage basic research projects effectively.

It is also important that an independent advisory board be included in the organization to assist in the determination of programs to be undertaken. Further, provisions should be made for third-party peer review of research procedures to be certain that parochial interests are minimized and that objectivity is maintained in all respects.

The Department of Transportation should be considered for at least a portion of this basic research program, provided the organization is structured and staffed along the lines described above. This would mean that research would be under the direction of a competent, highly qualified scientist at the assistant secretary level. This would not only serve to upgrade the needed scientific capability within DOT, but also help to assure that any research project that is undertaken would meet rigorous scientific standards and would be in concert with national needs and priorities.

Finally, I have some general thoughts on government support of basic science, research, and development. On an overall basis, I believe that the Congress deserves high marks for much of its performance in its role as overseer of U.S. science and technology. On many occasions, Congress has anticipated the scientific community's needs in our country and has provided farsighted leadership in meeting those needs. The best performances seem to have been in those areas of direct federal funding for science in the abstract and in those situations in which science and technology are funded to support an important field wherein the practitioners are highly fragmented, as in agriculture, fishing, and health care.

As one proceeds from the support of science to the more programmatic endeavors, the record becomes less impressive. Congress seems to operate best when it undertakes the role of policymaker. When government assigns priorities by major budget allocations into various fields of science, when it insists upon good management by the agencies involved, and when it stays out of the detailed management of the business, the enterprise prospers. In this way, our R&D budgets do tend to track the larger needs of the country as perceived by the Congress. This is as it should be.

However, government is ignoring a pressing need for good basic science. Scientific research for regulation, especially health-related regulations such as the Clean Air Act, is woefully inadequate. The Clean Air Act was written in the middle 1960s and was based on health-needs data that were sketchy at best. And yet, more than a decade later, the body of air-quality-related health data is virtually unchanged. Congress has a golden opportunity to serve the public by supporting such work from institutions that are outside the regulatory structure.

The research programs designed to resolve the controversy surrounding the issue of diesel particulates also illustrate the degree to

which regulatory bodies and industry could coordinate their separate operations toward insuring that scientific efforts pursue the true public interest. In the past, regulatory decisions have sometimes been based on incomplete data. The nature of judgment is such that in some situations, reasonable individuals honestly disagree with the ultimate decisions. For example, there is an urgent need for data on the nature and possible impact of diesel particulate emissions well before the regulations are promulgated. Coincident with that is the obvious desire of all involved in the eventual decision-making process to have the meaningful and appropriate data that are necessary for the decision in their own hands. To resolve this type of dilemma, General Motors proposed a simple and yet unique approach. Instead of having each party design and conduct its research program and then wait until the actual rule-making procedure began to tell the other what the results of its research programs had been, GM and EPA have had a series of discussions in which they exchanged their plans for the diesel particulate research they intended to conduct. While neither organization is in any way constrained from duplicating the other's efforts, it is hoped that any planned duplication would be both conscious and purposeful. The ultimate goal of this early exchange of plans is to assure that when the rule-making process reaches the point of decision making, relevant research will have been done by one or another of the participants. This can only result in regulations that are more intellectually sound, that will be less controversial, and that will best serve the overall public interest.

In addition, the National Academy of Sciences and National Academy of Engineering were asked to establish a panel to review the diesel particulate situation in the light of current regulations and available knowledge. Their charge is to make recommendations on courses of action. This independent, third-party review should prove to be constructive.

Government as Regulator

As was stated at the outset, no rational individual would seriously argue with the idea that in our crowded society central regulatory bodies are essential for the preservation of our environment and for the other amenities of life that we have come to require. No matter how good the regulation, however, it results in nonproductive expense, which is inflationary.

Although somewhere, somehow, it is assumed that a benefit will be achieved for some segment of our population, the effect of a Clean Air Act, or any other regulation of this type, is to increase the specific cost to the customer. Since no extra benefit usually is conveyed to the one individual consumer for that particular unit or service, the cost increase is identical with inflation. Somebody must pay for the 10,000 federal employees of the Environmental Protection Agency and for the tens of thousands of people in industry and in government who must correspond and interact with those 10,000. The greater impact, in the context of innovation, is when the commensurate benefit to balance

the cost is not received by anybody. Those regulations that achieve marginal benefits of low value do more than waste money. They also divert resources that could otherwise be available for the innovative entrepreneurial activities that the nation needs. The diversion of human resources is perhaps the greatest cost of all.

A more direct impact on innovation from regulation stems from the complexity and scope of the current regulatory system and the extreme severity of the penalties for noncompliance. The ultrahigh risks to a manufacturer of noncompliance--risks that range from jail terms for executives to huge fines for corporations--tend to stifle innovation by reducing both the range of potential innovations that are extensively developed and the rate at which innovations can seriously be considered for implementation. A potential innovation that promised a potentially high "pay off" in terms of customer acceptance and a reasonably good chance for successful performance in the field would stand a good chance for implementation in an industry where market forces were the sole disciplinarian. However, in a highly regulated industry where severe penalties would be added to the penalties of the marketplace in the event of the innovation's failure, chances are that prudent management would not implement the innovation without a great deal of additional development. Under the best of circumstances, this situation means that the rate of innovation is retarded by the regulatory system. In practice, such a highly punitive system virtually guarantees that product development is more evolutionary than revolutionary. The ultimate result of regulation can easily become a standardization of products and services, rather than a wider variety of consumer options.

One branch of government that sometimes is not generally regarded as a regulator is the judiciary. Over the years, though, the courts have become a significant consideration in the design process of most industries, including transportation, and also in the decision-making process for the introduction of innovative product changes. Under the current conditions, it is possible that in some courts a design improvement in an existing product could be construed as an admission that previous designs were less than optimal and could subject the manufacturer to product liability claims for not having included the newer design on earlier models. Clearly, this is not a climate that is conducive to innovation. The least onerous result of an overly broad concept of product liability is that products cannot be designed to be used by the normally prudent and thinking consumer. Instead, they must be designed to protect the reckless and thoughtless. This usually means a penalty--either in cost or in utility--for the typical customer. (One should note that this mentality is in no way restricted solely to the judiciary. The case can be made that the decision to require passive restraints in automobiles pivots upon the same philosophical point and penalizes the prudent auto occupant who already is utilizing existing restraint systems.)

So far, we have largely dealt with the effects of government actions on innovation within existing industries and technologies. It should be noted that regulations, which usually are enacted to deal with perceived problems within the existing scheme of things, can virtually preclude innovation from directions that were not foreseen at the time

the regulations were conceived or for needs that emerge after regulations are in place.

Regulation also can impede the innovative process by requiring that fledgling innovative technology compete on the same basis as mature technology. In the absence of regulation, the innovator could identify a niche in which the dominant technology was not the optimal approach and innovate to compete within that niche. If the innovation were successful, it had the potential to grow, improve, and expand into other economic niches in a Darwinian fashion. Regulation usually applies universal criteria over such broad areas that many niches no longer exist. While the need for an innovation still is there, broad regulation can preclude innovation for limited application. Obviously, limiting the potential application for innovation also limits the impetus and the likelihood of innovation.

Congress recognized this problem during the creation of the Clean Air Act and its potential impact on the development of diesel engines. It also recognized that the diesel engine, because of its potential contribution toward energy conservation, might require some temporary exemptions from certain provisions of the Clean Air Act--specifically from the NO^x emission requirements--and included provisions for granting a NO^x waiver for diesels. As it turns out, such a waiver probably will be necessary if General Motors is to be able to offer diesel engines beyond the 1980 model year. Although such a waiver is not automatic--it requires the demonstration of good faith efforts and the absence of danger to the public health--it represents a regulatory feature that is missing in most regulations. It allows time for a young innovation, light-duty, clean diesels, to develop into a competitor against a well-developed technology with a long history of evolution, the light-duty gasoline engine. Assuming that the waiver is granted (as of this writing, the waiver has not been granted), Congress will have successfully avoided two common pitfalls of regulation--the inadvertent exclusion of innovation from unexpected directions and also the accommodation of conflicting regulatory goals, namely emission control and fuel economy. But even if things do go smoothly with the diesel, the situation represents a good example of the potential restrictions of the regulatory process and illustrates how the process easily could prevent--or at least discourage--innovation.

There are other examples where the negative effects of regulations were not foreseen and moderated. One potential energy source, shale oil, is becoming increasingly attractive as petroleum prices rise and as the U.S. balance of payments problems are exacerbated by petroleum imports. Yet, it is virtually impossible for a private enterprise to undertake the task of building a pilot plant to develop the technology to produce oil from shale. It is impossible because of environmental regulatory restraints. Under today's regulations, such a pilot plant would have to guarantee that no matter what technical problems were encountered and no matter what problems might occur, the plant would comply with all environmental regulations. Clearly, when one is dealing with the task of literally inventing a technology, compliance cannot be guaranteed with 100 percent certainty. But given the ultrarisks

of noncompliance, a prudent individual or corporation could not reasonably undertake to develop such a technology even with the honest and unreserved intention of making the best possible effort to maintain and protect the environment. Furthermore, if an individual or organization were willing to take such a risk, the regulatory/judicial system simply would not allow ground to be broken without the demonstrated ability to meet all contingencies. In other area, our political system is equipped to handle situations where there is the likelihood that a law is about to be broken. In most cases, under the provisions of the Constitution and/or the Bill of Rights, the government's power for such "prior restraint" is strictly circumscribed. Such limits on the power of government emerged after decades of political, moral, and ethical discussions that drew on the intellectual and political resources and experiences of academicians through the ages. Our current regulatory system includes some of the fine features of our political system--due process, the rights of individuals to petition and to be heard--and any reasonable person would argue that those rights ought not to be denied to anyone. But at the same time, it is apparent to the reasonable individual that much of our regulatory system evolved on an ad hoc basis and that in its totality, the system lacks a cohesive and consistent philosophical and ethical framework. Perhaps the real need is to generate a climate where the academicians from all disciplines and the bureaucrats on all levels can honestly raise philosophical and ethical questions about the regulatory system without being criticized for abandoning their respective charters and develop a system that would allow some of us to teach and all of us to learn how to regulate better. If this were to happen, it would be the best possible innovation of all.

DISCUSSANT'S COMMENTS

BY

JOHN G. TRUXAL

The previous paper summarizes concisely and effectively the basic problem in the development of the role of academic institutions in innovation in transportation.

The paper focuses primarily on the current "state" of this system and the historical background that has led us into the situation in which universities (and nonprofit research institutions) are playing a relatively minor role in the transportation field, in which the conflict between industry and government (especially in the regulatory arena) is aggravated by a deep-seated public distrust of both government and industry.

From these arguments, however, the paper does not offer any constructive approaches on how this situation might be changed. In my brief comments, I would like to try to offer two specific suggestions in the hope that the panel deliberations will emphasize such a look into the future, rather than a lamentation on the past.

First, in the area of research, the paper calls for a strengthening of basic research (and a deemphasis of applied research). I am not sure the distinction is so easy to draw, but my principal reservation is that the author overrates the quality and significance of present university research programs in transportation. I believe this current activity is not a strong element of the total national picture in engineering and science research. There are several reasons for this:

1. The government (i.e., DOT) has not evolved a consistent, steady policy encouraging participation by leading research personnel.

2. There is no long-term, continuing effort, similar to the Joint Services Electronics Program of the Department of Defense--no program that promises stable support as a university group develops competence and experience.

3. There are too many short-term small grants (which tend to attract individuals who are not supported otherwise). While some of the researchers are excellent, others are not, and the transportation industry does not attract its proper share of the gifted young people.

Second, the author makes a strong issue of the public distrust of both government and industry in transportation. He focuses superbly on this situation as the core of the problem, but I would have added that correction of this attitude is clearly an appropriate use of academic institutions.

In the regulatory area, for example, there is practically no public education--no careful, in-depth analysis of the goals of a particular program. As one example, the corporate fleet mileage goal for the 1980s, discussed so widely in the mass media, are mysterious to the educated adult. Are they significant in terms of petroleum consumption? Are they placing irrational demands on the manufacturers in economic or technological terms? Indeed, what are they? Are they measured sensibly, and do they reflect typical driving patterns and driver characteristics? etc.

The Department of Transportation has done very little in public education, perhaps in the fear of being accused of trying to shape public opinion. Even in the very popular courses that engineers offer for liberal arts students at my own institution, we find it very difficult to include transportation issues because there is so little source material available (except in cases such as the Bay Area Rapid Transit history, where we suffer from overdocumentation).

Education of the public to the point at which intelligent decisions are possible is the ideal area for government-industry cooperation with and utilization of the colleges. With an appropriate informational effort on a national scale, we can avoid repeating the problems and "disasters" of the 1970s in the coming decade.

ECONOMIC INCENTIVES TO INNOVATION IN TRANSPORTATION

REMARKS

BY

BRUCE S. OLD

This panel, while it is involved in economic incentives, has one area that is forbidden to us, and that is the area of federal R&D. Whereas it is proper to say that federal R&D invested in a certain field indeed represents an economic incentive, that field happens to be the purview of another panel.

Now, the fact that we do have certain territorial divisions here brings out the importance of the final panel reports, where, the panel chairmen will be forced to bring about some cross-fertilization among the five panels, because there is a fair amount of overlap.

In order that the reader can better visualize the sorts of things we will be discussing, I would just like to mention the skills in the membership of our panel. We include in our membership people who understand the motor vehicle industry, the railroad industry, the airline industry, and the freight service industry. We also have three experts from the Department of the Treasury who understand economics and tax policies. We also have an investment analyst who understands the opinion of the investment community with respect to innovation in the transportation industry.

A background paper has been prepared for our panel by Aaron Gellman. That paper will be presented by Ed Haeefe of the University of Pennsylvania.

Finally, I would like to make two brief remarks about aspects of the conference that particularly interest me at the moment.

First, Court Perkins, the president of the National Academy of Engineering, has said that there had been a dozen studies on innovation, but never any action taken on the recommendations of the studies. It is important that we develop some ideas as to who is on the other end of the telephone, who the different people are we have to be able to contact in the various agencies, departments, and committees of Congress, to assure that actions are taken on our recommendations. Each panel will have different people at the other end of the telephone line. We have to develop a clear idea about who we have to speak to in order to achieve any actions on recommendations.

The second aspect has to do with the reality of any economic incentives that do indeed affect innovation. I have heard for a good many years that it would be nice to change this or that tax policy and

then things would happen. I think, however, that if one talks in the abstract, it is very difficult to get anybody excited.

I recently ran into a real case history that I think is very exciting. On the north shore of Lake Erie, the Steel Company of Canada (STELCO), a steel company operating in Canada, is planning a Greenfield steel plant. On the south shore of Lake Erie, the United States Steel Corporation, which is seven times the size of STELCO, has had a license granted it to build a Greenfield steel plant near Conneaut, Ohio.

The Canadians are moving ahead with their Greenfield steel plant now. It is under construction. On the other hand, the United States Steel Corporation Executive Committee is still studying the problem, and the problem there is twofold. It is not just a matter of capital availability; the primary problem is return on investment in this particular endeavor.

Now, the Canadians are pulling ahead for a very interesting reason, and it is very simple. They have stated it clearly to us. It is the difference in depreciation allowances between Canada and the United States. The Canadians are allowed to depreciate their entire plant in two years, 50 percent the first year, and they are able to set their own schedule for what they will do in terms of the time taken to depreciate the other 50 percent.

Furthermore, the depreciation begins the moment equipment is delivered at the plant site. They do not have to have the equipment in operation. Therefore they are depreciating that plant right now, and the United States Steel Corporation has not yet been able to come to a decision. So here is a real example of how differences in tax policies indeed create an ability to innovate.

INCENTIVES TO INNOVATION IN THE TRANSPORTATION SECTOR

BY

AARON J. GELLMAN
PRESENTER: EDWIN HAEFELE

SCOPE

The present paper considers the process of innovation in the transportation sector over less than the full spectrum of "transportation." Specifically, the paper concerns itself with transport that is actually or potentially produced on a commercial scale; both passenger and freight transportation are considered, with emphasis on intercity transportation even though there will be reference to urban transportation as well.

The initial mandate for the paper called for consideration only of "economic incentives." It soon became obvious that the scope had to be expanded in two significant ways in order to achieve its overall objectives. Specifically, the adjective "economic" had to be dropped, first,

because of the difficulty in distinguishing economic from noneconomic incentives in many cases and, second, because what is clearly an "economic" incentive for one party to a given innovation process may be seen in quite another light by others.

The second change in scope has been to include disincentives to innovation as well as incentives, since the former have equal or even greater importance, especially where a public-interest sector of the economy (such as transportation) is concerned. Disincentives also need to be considered explicitly if discussion of government's role in improving the innovative performance of such sectors of the economy is to be catalyzed.

Both public and private policies and practices that tend either to promote or to thwart innovation will be analyzed in the material to follow. Special emphasis is laid upon those incentives and disincentives that promote net beneficial innovation in the transportation field, but those which (happily) discourage net costly innovation are not ignored.

In terms of the elements of society that will be considered either directly or indirectly, there is very broad scope indeed. This, of course, grows out of the fact that given processes of innovation can involve either a narrow or wide range of institutions and individuals depending on the nature of the former and the markets that they are intended to address. In any event, the paper will variously consider any or all of the following as is appropriate:

- carriers
- suppliers to carriers
- labor
- shippers
- receivers
- travelers
- the public at large
- special interest groups
- government entities at various levels and in various branches

Finally, as to scope, the paper refers not only to organizations and institutions, but to individuals as well. At the outset the process of innovation must be recognized as a "people process." Fundamentally, it is people who promote or thwart innovation processes, in transportation as elsewhere. Indeed, individuals play a far more critical role in the process of innovation than is often recognized. So it is that the role of the individual is given substantial emphasis in this paper, without unduly downplaying institutions and organizations, both public and private.

DEFINITIONS

Some pertinent definitions follow:

Invention--to conceive the idea.

Innovation--to use the process by which an invention or idea is translated into a product or process and brought into the marketplace.

- "Beneficial" innovation--an innovation that generates benefits net of costs when recorded in either private or social terms, or both.
- Public enterprise--industrial or service activity with an identifiable output (product or service) owned by government such as a federal agency, city, or port authority.
- Shop rights-- the right of an employer to use without payment of any royalty his employee's invention developed in the course of his employment. Such use is restricted to the employer's purposes with the employee otherwise free to exploit his idea or invention for his own gain.
- Perks--fringe benefits, especially nonmonetary, that form a part of an employee's compensation package.

INCENTIVES AND DISINCENTIVES IN THE PROCESS OF INNOVATION

The incentives and disincentives that play upon the process of innovation are many and varied. This is true whether the transport sector or some other element of the economy is the subject of study. Still, there is probably no area of the economy with a wider range of incentives and disincentives to innovate than transportation. This is due to the ubiquity, the wide range of technology, the complex institutional arrangements, and the governmental involvement that characterize the transportation field.

Tables 1 through 10 provide a comprehensive listing of the incentives and disincentives that might be present in any given process of innovation, be it technological innovation or otherwise. The tables have been developed not just with transportation in mind. As was previously noted, however, at some point in the development of the transportation system of the United States each one of these incentives and disincentives has been influential.

With regard to Tables 1 through 10, the odd-numbered tables are devoted to incentives to innovation and the even tables to disincentives. Both incentives and disincentives are listed in terms of the "parties" upon which they bear--parties that can be influential in shaping and pacing specific processes of innovation. These parties to the process of innovation include the following:

- individual persons
- individual firms
- public enterprises
- industries
- nations as a whole

It should be noted that the incentives and disincentives on these tables are not mutually exclusive. More than one incentive or disincentive can be effective contemporaneously in the same process of innovation and can bear upon the same individual or enterprise or nation. Not only that, but some of the incentives (and disincentives)

TABLE 1 Incentives to Innovation That Influence the Individual

1. Increased current income
 2. Increased future income
 3. Nonsalary "perks" of value (e.g., stock options, professional travel)
 4. Job promotion or heightened probability of promotion
 5. Increased prestige and/or responsibility
 6. Job offers
 7. Shop rights
 8. Opportunity to participate in the application of one's own ideas or invention
-

TABLE 2 Disincentives to Innovation That Influence the Individual

1. Lack of rewards, even if "successful"
 2. Increased visibility
 3. Increased responsibility
 4. Extra effort required to perfect the "innovation"
 5. Likelihood of job change (e.g., new responsibilities and/or geographical shift)
 6. Frustration (e.g., inability to advance a "good idea")
 7. Risk of failure
 8. Employer attitude toward failure of an innovation process
-

TABLE 3 Incentives to Innovation That Influence the Firm

1. Increased current earnings
 2. Increased future earnings
 3. Achievement of revenue growth objectives
 4. Achievement of profit objectives (e.g., reduce costs, stimulate demand)
 5. Achievement of corporate diversification objectives
 6. Increased market share
 7. Increased multiple on stock
 8. Capital conservation (e.g., promote non-capital-intensive production methods)
 9. Reduced dependence on labor
 10. Availability of IR&D funds
 11. Meet regulatory requirements
 12. Presence of regulation that heightens the probability and/or profitability of successful innovation
 13. Improve recruitment results
 14. Enhanced image
-

TABLE 4 Discentives to Innovation That Influence the Firm

1. Insufficient competitive spur
 2. Risk of capital loss
 3. Capital shortage
 4. Short-term earnings penalty
 5. Insufficient period of "monopoly profits," even if successful
 6. Sufficiently high returns and growth rates without assuming the risk of innovation
 7. Durability of capital equipment on hand
 8. Inelastic demand for current product(s) or service(s)
 9. Rate-of-return regulation employing a deferred rate-base calculation
 10. Technological integration (e.g., "lumpiness" of investment need to fit into technologically complex system)
 11. Regulation--economic or other
 12. Antitrust implication of innovation
 13. Industrial standardization (externally or internally imposed)
 14. Lack of corporate/divisional growth objectives
 15. Risk or fear of "failure"
 16. Inappropriate reward structure to promote innovation
-

TABLE 5 Incentives to Innovation That Influence the Public Enterprise

1. Increased revenues
2. Expanded responsibilities (e.g., functionally, geographically)
3. Increased return on invested capital
4. Improved ratings of debt instruments
5. Amelioration of complaints (from customers, citizens)
6. Meet regulatory requirements
7. Accommodate "customer" innovation
8. Accommodate political pressures (e.g., demand for increased labor intensity in operations)
9. Enhance "owner's" image generally, in the community served and beyond)

TABLE 6 Disincentives to Innovation That Influence the Public Enterprise

1. Lack of competitive spur
2. Capital constraints
3. Durability of capital equipment on hand
4. Inelastic demand function
5. Absence of life cycle costing
6. Absence of explicit growth objectives
7. Absence of conventional profit-and-loss statement and balance sheet
8. Increased operating costs
9. Lower productivity, labor and/or capital
10. Innovation not required by regulation
11. "Customer" resistance to change
12. Labor content "requirements"
13. Inappropriate reward structure to promote innovation
14. Threat to "low-profile" existence

reinforce one another. For example, with regard to the incentives facing an enterprise or an industry, increased current earnings or prospects of increased future earnings would tend to improve the view investors take of their securities and thus, among other things, increase the multiple of earnings applied to their shares, if they are publicly traded.

Not all incentives or disincentives are applicable to every individual or enterprise. For example, by particularizing to transportation Tables 3 and 4, which deal with incentives and disincentives, respectively, with regard to individual private sector firms, it can be observed that some of the incentives and disincentives apply with different force to carriers as compared with suppliers to such carriers of equipment or infrastructural components or services. With reference to Table 4, the application of rate-of-return regulation, which employs a rate base formula including only investments actually in use as contrasted with those represented by construction work in progress, generates significant incentives to innovate for carriers regulated in this way. Suppliers to carriers are not subject to rate-of-return "rate" regulation in the United States, and consequently this disincentive is not applicable to them.

If the more or less comprehensive list of incentives and disincentives to innovation provided in Tables 1 through 10 merely conveys the complexity and wide variety of possible incentive or disincentive structures at work where the process of innovation is concerned, it will have materially contributed to setting the stage for the discussion that follows. Certainly in the course of the remaining portion of this paper, only a limited number of specific incentives and disincentives will be considered from the total presented.

Before considering specific public policies and their relationships to the innovative performance of the transportation sector, it should be noted that the presentation of the incentives and disincentives has employed a "bottoms-up" approach. This is to underscore the primacy of the individual where innovation process and performance are concerned. No matter what the setting for innovation, there must be one or more individuals who stick their necks out and champion the application of the idea of invention that only becomes an innovation when there is market introduction or a product or service through an arms-length transaction. If individuals are not properly motivated to assume the risks associated with innovation--such risks being monetary, professional, and often very personal--there will be little or no innovation.

The reasons it is difficult to separate "economic" incentives from other incentives can be seen by studying Tables 1 through 10. Consider Table 1; obviously, increased current and future income clearly represents economic incentives to spur an individual to participate enthusiastically in an innovation process. On the other hand, increased prestige or visibility for the individual may not result in economic rewards although it is difficult to say one way or the other in advance. But since such increased prestige or visibility may be of "value" to the individual, it is best to consider them under the rubric "economic

TABLE 7 Incentives to Innovation That Influence an Industry

1. Increased current earnings
 2. Increased future earnings
 3. Improve financeability
 4. Increase share of GNP
 5. Thwart foreign competition
 6. Promote favorable government action
 7. Increased tolerance of industry-wide cooperation
 8. Increased visibility (favorable); improved image
 9. Improved recruiting results
 10. Meet regulatory mandate
-

TABLE 8 Disincentives to Innovation That Influence an Industry

1. Lack of sufficient competitive spur (high concentration ratio?)
 2. Capital constraints
 3. Durability of capital equipment
 4. Technological integration
 5. Standardization (externally or internally imposed)
 6. Inelastic demand for industry output
 7. Regulation--economic or other; regulatory process
 8. Rate of return regulation and deferred rate base calculation
 9. Fear of hurting weak competitor (especially in highly concentrated industry)
-

TABLE 9 Incentives to Innovation That Influence the Nation

1. Increased GNP (real)
 2. Enhanced productivity--any and all factors
 3. Increased employment
 4. Improved distribution of income
 5. Increased development of new enterprises
 6. Improved U.S. balance of payments: cut imports/expand exports
 7. Improved "quality of life"
 8. Increased decentralization of industry
 9. Enhanced international prestige
 10. Strengthened military posture
-

TABLE 10 Disincentives to Innovation That Influence the Nation

1. Regulation--economic, safety, environmental; regulatory process
 2. Chronic inflation
 3. Tax level and structure
 4. Egalitarian philosophy (e.g., redistribution of income objectives)
 5. Decreased employment (e.g., from automation)
 6. Natural resource constraints
 7. Import barriers
 8. Export barriers
 9. Golden Fleece-type awards
-

incentive." To be sure, history records myriad cases, in transportation and elsewhere, where individual star performers in the process of innovation have been motivated at least as much by nonmonetary gains as by other factors, but the line between economic and noneconomic is too fine to draw. Besides, doing so would seriously distort the discussion and likely lead to inappropriate conclusions in some cases.

The same point can be made in the context of the public enterprise, as is shown on Table 5. Here some of the incentives are clearly "economic," such as the desire to increase the revenues of the public enterprise (e.g., commercial airport, municipal transit company, port authority), but is it a purely "economic" incentive that successful innovation could lead to the expansion of the responsibilities of a specific public enterprise? First of all, it might be an economic incentive if increased salaries or other rewards were thereby made available to the proprietors of such a public enterprise, but if the only incentive was the enhancement of their political leverage and prestige and if that was sufficient to spur them to sponsor and support innovative activity, it should certainly be considered, since one cannot be sure that each and every vector of each and every incentive or disincentive eventually will not have economic consequences or implications.

PUBLIC POLICIES THAT INFLUENCE TRANSPORT INNOVATION

In part because of the ubiquity of transportation, literally every public policy in some way influences the process of innovation in transport. Nevertheless, there are several specific but broad policy concerns of government that exercise particular and continuing leverage upon transport innovation, and some of these will be the focus of the present discussion. To be considered are selected policies related to the following:

- competition
- the purchasing function
- financing
- public enterprise
- antitrust
- market aggregation
- identification and amelioration of social or external costs

Where appropriate, the opportunity will also be taken to consider various ways in which public and private policy interact to produce incentives and disincentives to innovation in the transportation field.

Competition

Perhaps the most fundamental and long-standing concern of government where transport is concerned relates to the level and character of competition that obtains in various provinces of the transport sector. Each and every legislative mandate handed to a regulatory agency by

the Congress (or by a state legislature) has cited the preservation, control, or partial elimination of competition as an objective of the legislation and of the regulation that it establishes.

From Tables 1 through 10 it can readily be seen that competition, either explicitly or implicitly, represents an important incentive or disincentive to innovation. Not only must government's concern with competition in transportation be related to the innovative performance of those producing and marketing transportation services, but it is necessary to consider the influence of public policies toward competition on enterprises that supply producers of transportation with the inputs they employ.

During much of the time that transport economic regulatory agencies have been operating in the United States, such agencies have reflected a conservative attitude toward those segments of transportation that are of direct concern to them. Specifically, entry/exit and pricing regulations have usually been structured largely to preserve the competitive status quo. That is, entry and exit have both been substantially constrained in the principal means of transportation in the United States and prices (i.e., rates and charges) have also been subject to such constraints that they have been far more rigid than would have been the case without the regulation. Under such conditions, which often include the imposition of price identity among competitors in the same market, it is not surprising that the propensities to innovate of the regulated (and their suppliers) have been dramatically different than would have been observed without such regulation.

One classic illustrative case concerns the U.S. trunk airlines in the period between the end of World War II and 1960. In this period, under the rate regulatory scheme applied, an airline often put great stress on having flight equipment that was technologically different--advertisably different--from that of its competitors. The stress on establishing such a difference was so great that unit production costs (e.g., cost per available passenger mile) were often a secondary consideration in the choice of new aircraft by U.S. scheduled air carriers. The incentives of increased market share and heightened rate of growth caused many airlines ultimately to choose flight equipment that was more expensive to operate on any basis of calculation than was other equipment then available. Both the Lockheed Constellation aircraft powered with turbo-compound engines and the DC-7 owed their existence to this situation.

Fortunately, the regulatory schemes applied in several areas of transportation either have been changed dramatically or are in the process of change. Specific reference can be made to revision of the economic regulation of U.S. commercial air transportation that calls for all but complete abolition of industry-wide price guidelines by the mid-1980s. "Deregulation" is also being discussed in the context of highway and rail transportation, with one of the explicit objectives of such "deregulation" (more accurately termed "regulatory reform") being to place the incentives of cost reduction and demand stimulation in proper perspective as far as firms and industries are concerned. More enlightened (or less) economic regulation would have led to a very

different history with regard to the Douglas DC-7 and the later versions of the Lockheed Constellation. Here the airlines eschewed cost reduction as an incentive to innovation and embraced totally the incentive of demand-stimulation. At least a better balancing of such motives would have resulted under a more enlightened approach to the regulation of competition in air transportation.

The best public policy toward transport (as in other fields) would seem to be one that encourages entrepreneurs to place the proper weight on these most fundamental incentives to innovation, cost reduction and demand stimulation. Where competition is overly constrained by regulation, the power of these incentives are distorted both in absolute terms and in relation to each other. This suggests, of course, that whenever public policy toward competition in transportation is being considered either de novo or on a review basis, there should be explicit analysis of the impact of such regulation or regulatory change upon the several processes of innovation that will be influenced by such competition as may be created or discouraged.

The regulation of competition in the transport sector has usually been such as to preserve substantially the status quo not only intramodally but intermodally. An excellent case in point concerns a substantial railroad technological innovation of the 1960s, the Southern Railway's "Big John" covered hopper grain cars.

As part of a well-thought out program to enhance both its traffic and its profits, primarily at the expense of inland waterway carriers, the Southern embarked upon a program to increase materially its share of the market in grain traffic between the Midwest and the Southeast. A central part of its strategy was the employment of new and highly innovative aluminum-covered hopper cars with a nominal capacity of 100 tons. The incentive to the Southern was clearly to expand markedly its grain traffic by reducing rates--but only where such rate reductions were more than justified by the cost reductions that would be experienced through use of the Big John cars in multiple-car and unit train services. In short, the cost reductions would support rate reductions that in turn would shift the demand from the barge to the rail mode of transportation. (The Southern also expected to gain traffic at the expense of other competitive rail carriers, but this was a relatively small portion of the traffic gain they expected to enjoy in the long run.)

Using its rate-regulatory powers, the Interstate Commerce Commission (ICC) delayed the Southern's introduction of the new and lower rates, and between the ICC and the federal court system, the Southern was years in realizing the full benefits for itself (and for the shippers and receivers of grain) that it had projected and that were substantially proved to be "deliverable" once the railroad became able to use Big John as had been intended from the beginning.

To achieve its objectives with Big John, the costs imposed upon the Southern by the regulatory scheme of the ICC were very high, in terms of both direct expenses and opportunity costs. While there has never been an explicit accounting from the Southern, it is estimated that the costs related to the workings of the regulatory scheme were

in the range of \$20 to \$40 million in the case of Big John. The point, of course, is that a regulatory approach, such as has been imposed traditionally by the ICC, significantly undermines such incentives to innovation as are shown in Table 3 in items 1, 2, 3, 4, 6, 7, 9, and 14. Moreover, with reference to Table 4, which deals with disincentives to innovation that influence the firm, such regulation certainly heightens the disincentives labeled 2, 4, 5, 11, 15, and 16.

But intramodal and intermodal competition in transportation markets is not the only concern of public policies toward competition, which, in turn, work on the incentive structure that is relevant to the innovation performance of the transportation sector. Both the framers and the administrators of economic regulation in transportation more often than not overlook the implications of such regulations on innovation in those industries that supply carriers with the equipment, infrastructure, and services that such carriers organize so as to produce transportation. Returning to the case of the DC-7 and advanced Super Constellations, for example, it has been demonstrated that the system of price-identity regulation in the airline field was as responsible as any other single factor for the competition among manufacturers of aircraft to develop relatively inefficient aircraft that, however, embodied substantial "advertisable" differences when used by regulated air carriers. Thus the propensities and incentives to innovate of both the carriers and their suppliers of airframes and engines were distorted.

The relationship between carriers and suppliers and the innovative performance of each can be seen in other contexts as well. For example, consider the railroad supply field. Little concern has been expressed by regulators--and to the ICC must be added the Antitrust Division of the Justice Department and Federal Trade Commission in this connection--as far as competition in the railroad supply field is concerned. For instance, the concentration ratios in several areas of railroad supply have been high for decades and remain high today. And by "high" is meant 100 percent at the four-firm level, which tends to mask the fact that concentration in some fields approaches 100 percent at the two-firm level. The most dramatic cases in point, perhaps, relate to railway braking equipment and railway signaling equipment. In each case, just two firms dominate the market. Each enjoys approximately 50 percent of the business and supplies technologically nearly identical components and equipment year after year.

Why are the incentives to innovate so weak (or nonexistent) in the railroad braking and signaling equipment fields where both the railroads and the suppliers of such equipment are concerned? First, there has never even been a hint on the part of federal regulators--either ICC or antitrust--that they are concerned with the situation in either market. What makes this malaise especially surprising is that one of the two firms in the braking equipment business, Abex, in the 1960s became a wholly owned subsidiary of a major railroad, the Illinois Central, which acquisition, in fact, required the ICC to look into the propriety of the matter and which certainly gave the Department of Justice and the Federal Trade Commission the opportunity to do so.

Second, the railroads themselves seem to have little interest in changing the technology employed with regard to the braking of railway

trains and the signaling of railway rights-of-way. This can only be inferred by the fact that railroads continue to publish fundamentally the same design specifications for braking and signaling equipment year after year despite the terrible and growing costs they incur as a result of what constitutes a "no-innovations" policy in each of these areas.

Under such circumstances, it is not surprising that the firms involved, Abex and Wabco in braking equipment and Wabco and General Railway Signal (GRS) in the signaling markets, have adopted positions that lead to minimal technological change and then only where production cost reductions inure largely to the benefit of the manufacturers. Perhaps the most important point is that even when a procompetitive position with regard to transportation companies is maintained, at least at certain times and in certain places, the regulators' ignorance of the situation in the "supply trades" with regard to competition suppresses many of the incentives for innovation as far as suppliers are concerned and heightens the disincentives to innovation in other cases. In terms of Table 3, the situation first described thwarts the incentives to innovation designated 1, 3, 4, 6, and 7. In Table 4, the disincentives to innovation that gain emphasis include 1, 4, 6, 8, 10, 13, and 15. This example suggests that the concept of maintaining effective competition as a spur to innovation in the transportation field must encompass both carriers and suppliers. And it is not merely the industry-specific regulatory agencies that are involved, but also the antitrust "watchdogs" such as the Department of Justice and Federal Trade Commission at the federal level.

Government concern with the suppliers of transportation equipment, infrastructure, and services, is not and cannot be confined to government's role as a regulator of competition. The government is itself a major factor in the acquisition of transportation services, and, in some instances, purchases transport equipment and infrastructural components as well. It is reasonable that supplier performance, and public policy towards the purchase of transport equipment, infrastructure, and services be of interest to transportation enterprises and the government.

Purchasing

What is sometimes referred to as the "new golden rule" holds that "he who has the gold makes the rules." There clearly is truth in this, and it is especially relevant in the context of innovation where parties that have a manifest demand for goods or services should have quite a lot to say about the character of the products or services that they require--provided they care about it enough in the first place to exert such influence. It is power from the demand side that is often a major catalyst to innovation, just as, in other instances, there is a greater measure of "supply-push" than "demand-pull." Without doubt, however, the way in which the purchasing function is exercised can have a profound influence on the process of innovation in that it can heighten or suppress both incentives and disincentives to innovation.

Public policy toward purchasing in the transportation field can be expressed most directly through the power for the purse that the federal government can reflect by its promulgation of "rules" under which its money will be spent. The public sector, in the aggregate, remains the largest single purchaser of intercity freight transport services in the United States. Yet, it has not often exercised this power to "force" private entrepreneurs to furnish transportation services that, in turn, require such carriers to exploit technological possibilities beyond those already underlying the transportation "end product" being offered and used. There would appear to be some considerable leverage available to the federal establishment in its role as shipper; judicious application of such power to induce net beneficial technological innovation in the transport sector could not help but to be a laudable exercise of public policy and power.

Public policy translated through the purchasing function is manifest in a number of other ways as well. For example, the federal government often provides enterprises with the major portion of the financing necessary to acquire given pieces of transportation equipment. An especially interesting case in point relates to the procurement of buses for urban transportation systems, where the federal government has, in fact, attempted to exert considerable influence on technological innovation. The program through which this is most clearly demonstrated is called Transbus.

With Transbus, it is important to keep in mind that the federal government was providing funds necessary for the development of the vehicle but also was committed to supply the greatest proportion of the capital needed for its ultimate procurement by transit firms. Moreover, virtually all the transit companies that would ultimately acquire Transbus would themselves be public enterprises, rather than private, and would also be obtaining on a continuing basis a major share of their operating expenses directly from the federal government, from the same agency that was funding Transbus development and that would fund Transbus procurement. In such a setting, one would normally expect the federal government to have considerable leverage on the process of innovation. And, indeed, it did.

As Transbus emerged more clearly in terms of its role in society under its function as an item of transportation hardware, it became apparent that significant technological innovation would need to be incorporated in the vehicle if it were to meet all its objectives. Certainly, the multitude and variety of objectives loaded on the back of Transbus in and of itself represented one of the fundamental influencing factors where innovation was concerned. Moreover, some of the goals sought to be achieved through Transbus were clearly conflicting. For example, the requirement that Transbus readily accommodate elderly and handicapped (E&H) travelers necessarily made the vehicle substantially heavier than it would otherwise have been; at the same time, maximum energy efficiency was also an explicit mandate. In the face of such conflicts, actual and potential manufacturers of Transbus, who had to be innovative if they were to succeed to an order, must have been confused as to which goals took priority since not all of them could be achieved simultaneously.

To make matters worse from the standpoint of the process of innovation, the federal government in its role as midwife to Transbus (a midwifery wholly financed by the federal government), after almost a decade and after direct expenditures in excess of \$25 million, came up with what was very much a design specification and very little a performance one. Since one of the great catalysts to innovation in a market such as that for public transit vehicles is the true performance specification issued to any and all parties interested in participating in the project, the emergence of what was essentially a design specification in and of itself severely thwarted the process of innovation and, ultimately, the Transbus project itself.

Coupled with the reliance upon a specification couched largely in design rather than performance terms is the fact that the attempted first procurement of Transbus, which required the aggregation of demand of three major metropolitan areas in the United States (Miami, Philadelphia, and Los Angeles) absolutely ruled out the competitive responses being judged in terms of life cycle costing for the Transbuses to be procured. In fact, the Request For Quotation (RFQ) went to the other extreme and made initial capital cost the sole basis for determining the winning bidder. Once more, the abject ignorance of the process of technological innovation manifest through such a policy suggests that perhaps one of the great incentives to beneficial technological innovation in transportation would be to assure that those public officials establishing the policies and rules associated with the procurement of innovative products (or services) know a great deal more about the process of innovation, and particularly about the private sector's investment decision-making processes, than is now obviously the case, at least as reflected in the Transbus program from start to finish.

The necessity of relying upon true performance specifications if the process of technological innovation is to be made more effective in the transportation field cannot be overstressed. Not only is this important where transportation equipment is to be procured, but also where infrastructural components are involved. Consider the case of the reconstruction of the Northeast Corridor railroad network. With funding coming almost entirely from the United States Treasury, as administered by DOT, the specification employed to procure the signaling system for the corridor was so much a design specification that, in fact, only two qualified bidders emerged, the railroad industry's old "friends," Wabco and GRS. So it is that a substantial number of potential competitors, some domestic and some foreign, were effectively ruled off the track before the race even began. Also a situation has been produced in which, in the 1980s, a signaling system featuring mechanical relays and vacuum tubes will be installed in the Northeast Corridor. Not only does this adversely affect the future economic and operational performance of the corridor, but it also denies the railroad industry as a whole the benefits of dramatic technological innovations that unquestionably could have been induced through the corridor purchasing power had the right form of specification been employed in the procurement.

It is worth pointing out that in many transportation programs where federal funding is heavily involved, including Transbus and the

resignaling of the Northeast Corridor, the issue of "buy American" inevitably arises. And yet, the effect of the bias on the part of the United States government, not surprisingly, has been to handicap, if not totally thwart, foreign suppliers in such competitions. While the political basis for "buy American" is clear and understandable, its effects on the process of innovation (and especially upon the presence or absence of a competitive spur in the marketplace) are neither as clear nor as defensible. In the case of Transbus, it was only several months before the bid opening date for the first aggregated purchase of Transbus that the secretary of transportation indicated he might permit foreign suppliers to participate. This was one of the elements leading to the situation that when the bids were to be opened there were none--either from domestic or from non-U.S. suppliers. Certainly competition is a tremendous incentive to innovation, as has previously been established, and public policy ought not blindly rule out foreign production possibilities as a source of generating such competition, particularly where innovation is urgently required to achieve various social, political, and economic goals and where the expected U.S. respondents are few, such as in both the urban bus and the railway signaling fields.

Another major point needs to be made with regard to purchasing policy and its influence on innovation in transportation. There are agencies of government that are the primary source of demand--even the only source of demand--for certain hardware and software related to the production of transportation services. An especially good case in point is the Federal Aviation Administration (FAA), which specifies, designs to a great extent, procures, owns, and operates several systems essential to the production and growth of air transportation services in the United States. This is a case, not unprecedented, where an agency is both the judge and the jury with regard to the technology and technique being employed. Under such circumstances, it would seem prudent that the agency bend over backward to induce competition in every possible dimension among the suppliers upon which it must rely to produce the hardware and software that are at the heart of the systems which it operates.

But this is not what happens. Instead, at the very beginning of the process of innovation, where creativity is at a premium, the Engineering and Development (E&D) elements of the FAA do not systematically employ techniques of procurement or of publicity to induce imaginative external responses to the needs of the agency with regard, for example, to its air traffic control systems. In fact, FAA E&D personnel have often indicated over a considerable period of time that what the FAA requires in the way of equipment and infrastructure and software is not likely to be supplied by small enterprises, and so they justify the concentration of their procurement activities and communications with quite large enterprises that just happen, in most cases, to be the suppliers they have done business with before. Obviously, this flies in the face of myriad analyses that support the hypothesis that it is small enterprise that is most creative and innovative and that a very substantial proportion of the genius of this country for

reaching to the frontiers of technological possibility is lodged in small enterprise rather than in large. Once more, part of the problem can be traced to the overreliance of the FAA on design specifications--such designs having been developed either by FAA personnel in-house or by firms under contract to FAA. Most thwarting for a large segment of the population of innovative enterprises, however, must be the abject ignorance of the nature of the process of innovation on the part of most persons in the FAA, whether they are involved in research and development, procurement, installation, or maintenance.

Finally with regard to purchasing policy, a subtle issue of considerable importance to the innovative performance of the transportation sector has long been overlooked. In the United States, there has sprung up over the years a substantial number of "small R&D firms" that are highly creative and are capable of carrying out research and development for their customers in an efficient and timely manner. A very large proportion of these firms, however, work exclusively for the federal establishment and have long since defined their goal as making a profit through the performance of research and development contracts. These firms have no commitment to carry the results of their R&D further into the marketplace so that the process of innovation can be completed. In contrast, their research and development results are couched in terms that government executives will understand rather than in terms that promote the onward exploitation of their outcomes.

So it is that there are myriad R&D results on the shelf throughout the federal government, including the transportation agencies, that will never be exploited through the process of innovation in the marketplace. There arises a policy issue as to whether the federal government ought to continue relying upon such enterprises in which the sole reason for existence is to produce R&D results, with the "small R&D firm" never itself becoming committed to carrying such results forward to the "real world." There is certainly need for data on the subject, but at this point it would seem that the process of innovation in transportation would be substantially improved if the government, through its purchasing of R&D results related to hardware and software (as opposed to policy research, for example) were to encourage the onward exploitation of "successful" R&D outcomes rather than discourage them by allowing, if not requiring, a break between the completion of the R&D phase of an innovation process and the commencement of the technology delivery phase. One of the ways to do this is to restrict severely the reliance of transportation agencies on contract R&D firms for R&D results.

Financing

The availability of financing is often an incentive to the process of innovation; a lack of available financing is always a disincentive. Consequently, the public sector has substantial leverage it can bring to bear on the process of innovation in transportation in general, as well as on specific innovation processes, through the granting or withholding of financial support as may be consistent with public policy.

Financing is an issue in several stages of the process of innovation. For example, the financing of basic research (and of applied R&D in many cases) presents government (and private industry as well) with issues that are very different from those presented by financing to support the diffusion of the results of technological innovation that have already been demonstrated to be practical. Yet financing from the public sector has an important role to play in each of these cases and in many others besides.

The activities that lie at the "front end" of innovation, i.e., the research and development sort of activities, contrast sharply with those associated with market diffusion (e.g., the purchase of a national fleet of Transbus equipment). In the former, there is much speculation associated with the investment of resources. (And the more "research" rather than "development" the nature of the activity is, the more uncertain the outcome.) It is in the earliest stages of the process of innovation, then, that private sector entrepreneurs tend to be most reluctant to commit their own resources. Consequently, government financial support is most necessary where R&D is concerned. Further along in an innovation process, external financial subsidies required by the private sector or by public enterprises may be materially less, at least in terms of the proportion of resources required from government. This is because the risk is presumably reduced as the innovation process proceeds in the direction of the market (or else the particular innovative activity would have been killed) and because the time between investment and payoff is much reduced in comparison with the situation where the earliest innovation process activities are concerned. Still, in many cases public support is absolutely required if the process of innovation is to be completed and market diffusion of products or services generate social benefits in excess of external costs, which is often the case in the transportation field. Again, the Transbus program represents a case in point, which is especially apt since the potential acquirers of Transbus were anticipated to be public enterprises.

Public financial support for innovation can be introduced in myriad ways. Perhaps the most direct method is through grants for the acquisition of equipment or infrastructural components that are conditioned by the requirement that the funds cannot be used unless some measurable quantum of innovation is reflected in the material acquired with the grant money. This can be effective, when intelligently administered, but it can also produce little but confusion and waste (as in Transbus to date).

As was noted earlier, a large and disproportionate share of innovative activity, especially at the front end of the innovation process, is lodged in smaller enterprises. Consider also that one more or less common thread in the development history of new items of transportation hardware and software relates to the terrible expense of prototyping and testing the results of a "successful" R&D effort. This suggests that federal financial support might well be made available to promote the process of innovation in the transportation field by making it possible for entrepreneurs--especially in small enterprises--to obtain prototyping and testing "services" at a cost they can afford--at a cost

sufficiently low that these unavoidable steps in the process of innovation can be traversed with minimum delay. Providing "in-kind" support in many cases is just as effective in the process of innovation as providing cash, and perhaps even more so. (It is also worth noting that in some instances the prototype and test facilities to support transportation innovation are the same sort of facilities the military establishment requires for similar purposes. In such cases, the joint use of existing public investments might be possible, thus reducing the direct financial burden on the Treasury while improving the innovation performance of the transportation sector in a measurable way.)

To return to the process of innovation occurring in the market rather than beginning in R&D, it is obvious that much innovation is denied because manufacturers of hardware and infrastructural components see a history of feast or famine with regard to demand even where the results of the innovation process are highly beneficial and attractive to those who must make a purchase decision in favor of the innovation. In many cases, a long history of feast or famine on the demand side has been sufficient to discourage the allocation of private resources to the innovation processes through which transport equipment and infrastructure components would be upgraded technologically. There are no data or information to support an intelligent hypothesis about the leverage--the negative leverage--that the not uncommon feast or famine character of demand has exerted on the process of innovation in transportation, but it is a reasonable speculation that it has been considerable. (Still, one must always remain alert to distinguishing between excuses and reasons and not be overly discouraged when supposed barriers to the process of innovation are dismantled only to find that the influence on the process of innovation had been minimal or even nil. At least some excuses will have been removed from the scene.)

In areas where there is a history of feast-or-famine demand, it is entirely possible that one of the most effective ways to employ federal financial resources to improve the process of innovation is to smooth out the demand for hardware and infrastructural components. Perhaps the government can guarantee a certain minimal demand so that the difference between lean years and fat years is not so dramatic as has often been the case, with railway freight cars, for example. If, but only if, such a program were judiciously and rigidly administered, it could generate mutually beneficial results for the transport sector and for the economy; it requires only that the public sector invest capital for various periods of time as would be associated with the stockpiling of output during periods of slack demand and the distribution of such output as had been stockpiled in periods of peak demand. Once demand is stabilized, technologically improved output can be expected whether or not public financial support was coupled with an explicit requirement that manufacturers extend themselves in this direction.

In many cases--though certainly not all--transport "delivers" to society external benefits in excess of external costs. Where this is so, it becomes rational public policy to support processes of innovation that improve transport sector performance. In this connection, suggestions have been advanced periodically over the years that the

federal government ought to establish a "transportation equipment development bank" that would provide present and prospective producers of transportation equipment with a source of low-interest, long-term financing explicitly to support the process of innovation, whether it be at the front end or in the technology delivery phase of the process. This approach reflects the notion that innovation will be more efficient and will be carried out in a more timely manner if federal funding support is reflected on the liability side of the balance sheet of those firms that take advantage of such financing. The "bank" still provides a substantial subsidy given the low-interest and long-term nature of the financing contemplated, but the net financial burden on the public treasury should be tolerably low and more than recompensed by social benefits realized in the long term.

One of the most interesting, and not entirely philosophical, financial issues concerns the extent to which federal financial support should be provided to private enterprise as opposed to public enterprise. Specifically, is it wholly rational (economically) that public funds for the support of the "aviation system" be allocated to public enterprises (such as airlines)? Clearly, there comes a time when the marginal utility of a dollar is less to the former than to the latter even when only the social-benefits-to-social-costs relationships are assessed. Yet there is little clamor when support is initiated or is increased for public enterprises, even nonfederal public enterprises. In contrast, great objections are usually raised when financial support to the process of innovation is suggested for private entrepreneurs in transportation. It would seem appropriate that this issue, and the determination of the appropriate balance, mode by mode, ought to be the subject of continuing analysis on the part of DOT which, in turn, should have the courage of its ultimate convictions as to where such financial resources will do the most good.

Public Enterprise

The public enterprise is becoming increasingly important in the transportation sector. Although a detailed calculation apparently has never been made, it is clear that the share of macroeconomic activity attributable to public enterprises in the United States is growing year by year. Moreover, if such a calculation were particularized to transportation, it would also show a rising trend, especially since the costs (and revenues) associated with intermodal terminal operations where public enterprises especially flourish are clearly growing both in absolute and in relative terms. Also, there is an increasing tendency for government in various guises to become involved in transportation in various ways. (Consider the history of transit enterprise in the United States, for example, as well as the recent and growing acquisition of rail properties by state and local governments.)

Notwithstanding this growing reliance on public enterprise, little attention has been paid to the management of such activities as opposed to the management of private enterprise. Regrettably, even the "better"

graduate schools of management in the United States have all but ignored the special problems and opportunities associated with public enterprise, perhaps because academics themselves have not taken the time to study public enterprise management as a field unto itself.

A comparison of Tables 5 and 6, which relate to public enterprise, with Tables 3 and 4, which refer to private firms, indicates that the incentives and disincentives at work in the two settings are often very different. In part this grows out of the fact that in the private enterprise there is present the discipline of the profit and loss statement and the balance sheet--something substantially lacking in the typical public enterprise. Moreover, the private enterprise will generally be found operating in a competitive setting where to some extent the management can be judged (and can judge itself) through appropriate comparisons with other enterprises operating in the same market. Most often the public enterprise has a relatively strong monopoly position or at least a position that is greatly protected from competition in the marketplace. Consequently, the sorts of performance comparisons available to private entrepreneurs are usually denied the managers of public enterprises. So it is not surprising that the incentives and disincentives are somewhat different and often have different leverage to exert where the process of innovation is concerned.

The lack of competition in markets in which the public enterprise is active, coupled with the highly politicized nature of public enterprise decision-making processes, makes it necessary that external "force" be brought to bear to introduce some surrogate for competition, if only to enable the public to judge the performance of public enterprise managers against a reasonable standard. Therefore one effective incentive to innovation in the public transportation enterprise may well be the devising and application of means for judging (at least in relative terms) the performance of public enterprise managers in one geographical setting compared with the performance of those in another. This may require that, as a condition of federal funding, a uniform system of accounts for all the public enterprises in a given field be used--a concept public enterprise managers will surely resist with all the vigor they possess. Yet this may also be one of the best means of providing the necessary "incentive" to make public enterprises act more rationally and more aggressively where there are socially acceptable opportunities to innovate or to accept innovation.

Of course, one of the major problems with innovation in the public enterprise reflects the reality that the rewards awaiting the successful entrepreneur are usually not nearly sufficient to justify his taking very great career risks through a flirtation with failure, which is always a possibility where significant innovation activities are undertaken. Indeed, the absolute fear of failure may thwart every attempt to upgrade the innovation performance of public enterprise entrepreneurs. While this is a problem not unique to the public enterprises, it is true that in the public enterprise, failures are often overstressed and this cannot but reduce the enthusiasm for assuming risks through the sponsorship of innovation in such enterprises.

J.A. Schumpeter (Harvard) and many other economic theorists have debated the issue of the extent to which enterprises possessing monopoly power will or will not have a high propensity to innovate. It is reasonably clear that if the monopoly position is one that is so greatly protected that challenge is all but doomed to failure no matter what its source, innovation is not likely to be undertaken with enthusiasm because it is risky and usually requires extra exertion--exertion that managers may very well eschew with impunity, especially in public enterprises. In the transportation field, such enterprises are certainly in a protected monopoly position and their managers may not happily undertake activities that generate added risk and responsibility. If innovation is desirable from public policy and economic performance standpoints, it will usually have to be induced by external forces. One of the ways of providing the incentives required therefore is the identification of the external forces that can be effective and the devising of means for these forces to be applied in the appropriate degree and with the correct timing. Once more, the concept of a uniform system of accounts suggests itself, but the power of demand-pull should also not be ignored. With regard to the latter, it should be noted that where there has been successful and beneficial innovation in public enterprises, it has often come about through pressures of demand that cannot politically or otherwise be ignored by the public enterprise manager.

The periodic revisions observed at most airports represent a particular case in point. Airport management would generally like to live a quiet life, as might be expected, but is often unable to do so because the technology and the patterns of service continue to change where their prime customers, the airlines, are concerned. Yet in order to be continuing institutions, airports must respond to the needs of their most powerful customers, the air carriers. Indeed, there are few cases in the history of airport development in which the lead has been taken by airport management where innovation is concerned. And in those few instances, even when the result turned out to be highly favorable for most, if not all, of the parties concerned (such as at Dulles International Airport), the innovative drive of the public enterprise manager was initially resisted by airport users.

In a way, it is fortunate that the federal government supplies a substantial proportion of the resources required for most public enterprises, including airports, and therefore has the ability to impose certain "standards" with regard to the innovation performance of such public enterprises. Unfortunately, the federal government has shown little inclination to condition its grants to public enterprises in such a way as to promote socially and economically beneficial innovations, but this may be because the administrators of such grant programs have themselves too little knowledge and understanding of the form and function and economics of the public enterprises that they are supporting. It should not be difficult to redress this situation, if only the leadership in DOT has the will to do so. Once again, an improvement in public enterprise performance, as measured partially by their activities in support of beneficial innovation, should not be difficult to achieve, and the cost to the public in financial terms should be close to zero at the outset, and actual savings should be realized in the long term.

Certainly, compared with private enterprise the typical public enterprise has distorted propensities to innovate, given the politicalized environment in which the latter operates. For example, it is entirely possible that in the present era there is too much stress on energy conservation and noise reduction. By "too much stress" it is suggested that perhaps the benefits gained in terms of energy and noise may be outweighed by the costs experienced by either the public enterprise itself or those who use it. Operating in a political fishbowl, and with energy and environment concerns rampant, it is difficult to fault the public enterprise manager who is perhaps oversensitive to the times. Still, DOT, in part because of its power of the purse, ought to be in a position to leaven the loaf as necessary.

Again, public enterprises often have the wrong incentives in mind when they are making decisions whether to innovate or support innovation. For example, revenue maximization is often the overriding objective of public enterprise managers, given the nature of their financial structure. Of course, students of management have long known that revenue maximization frequently leads to the wrong decision where investment and operating policies are concerned, and this is no less true in the context of the public enterprise than of the private firm.

Given the highly personal nature of the process of innovation, it is important to recognize the disincentive to innovation that is present through the scarcity of cases in which public enterprise managers who have borne risk intelligently through support of innovative activity have as a result achieved visible professional and personal success, however measured. Certainly, DOT can afford to spend the limited resources required to gain a better understanding of what constitutes "success" in the minds of those who are prepared to devote themselves professionally to the management of public enterprises in transportation and subsequently to condition its support of public enterprises partially on the establishment of the preconditions in those public enterprises that reflect the professional and personal needs of such managers. This may well prove to be the most effective single means of improving the innovative performance of public enterprises over the next decade or more.

Antitrust

It must be recognized that the process of innovation proceeds by fits and starts. It is not a continuous process in any given field, transportation included. There are "breakthroughs" followed by long periods of what appear to be technological stagnation. The discontinuous process that is innovation contrasts sharply with the controlled and evolutionary development of the law. When legal considerations and constraints are imposed upon the discontinuous process of technological innovation, the effect often is to ration technological possibilities to the ultimate marketplace even in times when the latter are being generated at a rapid rate. Consequently, the imposition of antitrust constraints on the process of technological innovation is an especially

important issue that has been little considered even in the "regulated industries."

One of the "reasons" most often cited by would-be sponsors of innovative activity for their lack of enthusiasm for specific innovation projects is fear of antitrust entanglements, especially if successful innovation were to result. In many instances, options are absolutely foreclosed to industrial entrepreneurs simply by the uncertainty of antitrust policy toward a specific institutional arrangement that is necessary to induce innovation. A particularly important case in point relates to the development, production, and marketing of transport aircraft at the present time.

In order to introduce a new commercial aircraft, even enterprises with the size and character of Boeing or McDonnell Douglas or Lockheed, are required to play "bet-your-company." That is, the resources required to do a new transport exceed in most cases the net worth of the firm. Moreover, given the nature of the technology and of the market for such aircraft, the relationship between the "launching cost" of the new aircraft and the net worth of the firm is becoming increasingly less favorable to a proinnovation decision. Facing such a situation, one of the several options open to airframe manufacturers is the joint enterprise approach to new projects. But under present conditions, no prudent management of an airframe manufacturer in the U.S. can be expected to explore seriously with one of its historic domestic competitors the possibility of a joint venture for the next round of competition where transport aircraft are concerned. This is largely because the Antitrust Division of the Justice Department will give no assurances that such a move would not be viewed as "anticompetitive" and therefore as a step that would be intolerable to the Antitrust Division.

Certainly, if one were to define the market for transport aircraft as being the United States alone, this view of the Justice Department might--but only might--have merit. But an increasing proportion of the demand for transport aircraft is found outside the United States. Indeed, over half of the orders for large transport aircraft currently emanate from non-U.S. sources for the first time. If the market for transport aircraft is viewed as a global one, as it properly should be, then an amalgamation or joint venture involving only U.S. firms is not so onerous, especially given the fact that the joint venture is becoming more or less a "standard" means of exploiting technological possibilities in other countries (e.g., Airbus Industries).

Under the circumstances, in the United States it is increasingly clear that the range of technological possibilities that can be exploited in the form of new transport aircraft is severely limited by the recalcitrance of the Antitrust Division, which refuses to recognize rapidly changing conditions of supply (and of demand) in the transport aircraft field. Indeed, summing up (only a little unfairly) the attitude of the Justice Department, their position is that they will react to any proposition that becomes a reality but will not react to a hypothetical proposition such as posed by the question, "if Boeing and Lockheed were to form a joint venture, would you intervene?" Without the answer to the theoretical question, the disincentives to certain

kinds of innovation in the air transportation field are so great as to be totally thwarting. Yet, antitrust officials cannot, or at least will not, understand this situation; this is not entirely surprising given their background and training in a field that is characterized by orderly and measured change in sharp contrast to the real world in which technological possibilities are developed and innovations (sometimes) result. Clearly, the Department of Transportation, among other agencies of government, ought to make a special effort to redress the situation in which the Antitrust Division is standing in the way of technological progress that would benefit, on balance, both the private and the corporate citizens of the nation.

The accompanying tables indicate that antitrust considerations most often appear as disincentives to innovation. This is not surprising, given the nature of antitrust concerns. One of the most unfortunate influences that antitrust considerations impose upon the process of innovation is reflected in the often insufficient market aggregation activity found in the transportation field. That is, much of the hardware required by transportation enterprises is produced under conditions of supply in which there are very significant economies of scale in production, which condition frequently contrasts with the disaggregated nature of the demand for such elements of hardware. Under these circumstances, to make demand sufficiently large at a point in time requires some measure of market aggregation--some measure of cooperation between otherwise competing economic units. While there is explicit market aggregation in certain fields of transport at times, especially where public enterprises are concerned and antitrust considerations are nil, for the most part there is far less market aggregation in the transport sector than is warranted both by the nature of the supply function for much of what is produced in support of transportation production and by virtue of the benefits of reduced cost that accrue as a result of successful, efficient, and timely innovation in transportation.

There can be no doubt that the antitrust "excuse" has been used on many occasions to thwart private sector cooperative or joint activities that would have been beneficial both to private entrepreneurs and to the public at large. On the other hand, the antitrust officials of government, both at the Justice Department and at the Federal Trade Commission, have on occasion been sufficiently sensitive to certain problems that beset specific industries and companies (usually unrelated to innovation in any direct way) to relax their otherwise rigid positions. A case in point is the several areas of cooperation between General Motors and American Motors and between Ford and American Motors, obviously designed to keep American Motors from throwing in the towel in the automobile business.

The limited history of such flexibility on the part of antitrust officials suggests, however, that an enterprise of industry must be in extremis before there is such relaxation of age-old "principles." It is anything but clear that the traditionally great rigidity in antitrust regulation serves the public interest, and it certainly does not promote the generation of timely and beneficial innovations in many industries, such as transportation. For example, the sharing of test

or maintenance facilities by competitors is often thwarted in the transport field by antitrust considerations, either imagined or real. In part, the tragedy is that there is so much that is imagined and so little that is real, a situation that ought to be corrected to some considerable extent given the nature of technology in the real world and its contrast with the type of legal system being imposed upon its development and diffusion.

Even while the Justice Department is so clearly and properly dedicated to the preservation, and even enhancement, of competition in various markets, it is often blind to developments within the transportation field that have the opposite effect. A classic case in point, of course, relates to the railway braking equipment field, discussed previously, in which in the 1960s approximately half of the production capability for braking equipment came under the control of a major railroad, which, in turn, sits in the councils of the American Railway Engineering Association and the Association of American Railroads, where the technology that is allowed to be applied to equipment in railway interchange service is determined. This acquisition was permitted without any concern being expressed by the Justice Department or the Federal Trade Commission (or the ICC, for that matter).

Of special interest to the antitrust watchdogs should be the growing and unchecked monopoly power of many public enterprises in the United States. But there is no evidence that either the Justice Department or the Federal Trade Commission recognizes the problem or is concerned by it. If they were, they certainly should have recommended some legislation to the Congress by now to enable them to add public enterprises to their own purview.

As was noted earlier, one of the most effective ways to thwart technological innovation is to rely upon design specifications rather than performance specifications when purchasing hardware and software. Surely those concerned with preserving and enhancing competition in the name of antitrust should acquire an understanding of the power of performance specifications to assist them in achieving their stated objectives. In addition, they can work with other elements of government and with the private sector to see that such power is, in fact, exercised to the maximum feasible extent. Certainly, several incentives to innovation would be made more effective even while some disincentives were removed. Once more, DOT can play a triggering and catalyzing role in this regard.

It should be understood from the outset, however, that the use of the performance specifications cannot be a one-shot procedure; what is required is a continuing review of performance specifications to make sure that they are revised at appropriate intervals--certainly no less often than every 10 years. In this way, competitive suppliers can be induced to reach the frontiers of technological possibility, which are themselves expanding with time.

It is true that reliance on performance specifications, and the award of contracts for hardware and software based upon responses to such performance specifications, will often result in dramatic shifts of patronage from one or several enterprises to perhaps only one

enterprise that has distinguished itself in responding to a performance specification. Such a temporary "grant" of monopoly power lies at the heart of the process of innovation and represents one of the most powerful of all the incentives to innovation. Where concentration temporarily results from the application of purchasing techniques that are pro-innovation, the antitrust guardians should recognize this as a reflection of enhanced competition in the long run and not as evidence of the conveyance of permanent monopoly power, which is and ought to be offensive to antitrust policy and law.

The whole concept of standardization should be viewed in the same general way as the application of performance specifications. That is, physical standards must be set in many instances, but they also should be reviewed periodically to insure that competition is not being thwarted and that, indeed, innovation is being promoted. In this connection the recent Hydrolevel antitrust decision is encouraging, especially because of its focus upon the process by which standards are often set. As this case demonstrates, the process can sometimes be subverted and employed explicitly to slow, if not totally discourage, beneficial innovation.

Market Aggregation

Market aggregation has been experienced in many areas of transportation but has not been the subject of the attention it deserves, especially in the context of the process of technological innovation. In part, market aggregation is a difficult concept with which to deal because of the constant fear of antitrust entanglement on the part of private sector entrepreneurs who either attempt to aggregate the market or respond as suppliers to the demands of aggregated markets. Yet, as was previously noted, many items of supply in the transportation field are produced under conditions of great economies of scale, and given the typical fragmentation of the market for transport hardware and software, some aggregation of the various elements of demand is necessary if timely and efficient innovation is to result.

The most dramatic instances of market aggregation in the U.S. transportation sector have occurred under one of two conditions. First, there are those cases in which the federal government has intervened to become the market-aggregating agent for dispersed enterprises with individual demands that were, to some extent, compatible. An early case in point is the President's Conference Committee (PCC) streetcar experience of the 1930s, in which the White House itself was involved in creating a set of more or less uniform specifications, which led to the "mass production" of a large number of PCC streetcars that were distributed throughout the United States and ultimately throughout much of the world. A more recent instance is the Transbus, in which, in the first attempt at procurement, the demands for new urban buses of three major metropolitan areas were combined in a request for quotations in 1979.

The second set of circumstances leads to market aggregation on a quite routine basis and relates to standardization activities most often

associated with the need to maintain interchangeability of equipment. Railroad freight cars are perhaps the best example. Here, the equipment must have a number of common physical attributes if it is to be capable of moving freely throughout the railroad network of North America. Consequently, specifications have been developed--many of them 50 or more years ago--that are almost always totally design specifications in character but that nonetheless tend to serve as a market-aggregating agent where freight car components are concerned. Perhaps because this form of market aggregation has been present for so many years, it is allowed to continue with little or no interference either from anti-trust or railroad officials.

It is clear, however, that market aggregation in the freight car context has been carried too far in the sense that it has thwarted a number of opportunities for technological innovation that could only have been exploited if there were a departure from established specifications to permit the introduction of new technology even if only on a limited scale initially. (Examples include railway braking and coupling systems.) Obviously, it cannot be held that market aggregation is always catalytic in its effect on the process of innovation. Still, on balance, market aggregation that employs performance specifications that are reviewed and republished periodically must promote innovation, though care still has to be exercised to assure that the result will be net beneficial innovation.

As was previously noted, innovation is most often associated with the assumption of risk, both on the part of the sponsors of innovation and on the part of those who accept it. Consequently, one of the most powerful incentives associated with market aggregation is the sharing of the risks of innovation among the various parties to the aggregation process. This cannot be overestimated as a catalyst or incentive to innovation and, indeed, the power of risk sharing is so great that the Department of Transportation would be well advised to catalog all the market aggregation possibilities in the various modes of transportation so as to be able to assess the net cost and net benefits to society that might flow from judicious market aggregation activities sponsored or supported by DOT.

Identification and Amelioration of Social Costs

Social costs and social benefits have become increasing concerns in the United States as the nation has matured, diversified, and experienced threats to its social and economic development from new quarters, such as the environmentalists. One of the great incentives to innovation in many fields, certainly transportation among them, relates to the improvement of what is often referred to as the "way of life" or "life-style." While there is a firm basis for holding that the private sector sometimes makes investment decisions and operating decisions based on the amelioration of social costs, in the final analysis it is a function of government to guide the investment decision-making processes in both the private and the public sectors in such a way that social costs are

minimized on a net basis. Yet it is clear that the U.S. economy is, by and large, still "flying blind" where social cost and social benefit calculations are concerned.

Without adequate and accurate information about social costs and benefits (and the relationships between them), much transport innovation will be wrongheaded, at least where the public interest is concerned. Moreover, several potentially powerful incentives and disincentives to innovate will go unexploited in the absence of an appropriately detailed social cost identification and quantification scheme. Without such "guidance," the innovation propensities for both private sector and public sector executives are being distorted in the transportation field. In part, this is because what may in reality be short-term societal concerns can be magnified far beyond what is rational or beneficial, either to the entrepreneur or to the public.

There are myriad reasons why government should increase its efforts to identify, quantify, and devise schemes for ameliorating social costs. Improvement of the innovative performance of the transportation sector is but one of these reasons. Standing alone, however, it is sufficient to induce DOT to exert new and strenuous efforts in this direction. Meanwhile, DOT might also consider various means of countering the strong negative effects on certain desirable processes of innovation in transportation that exist because of the growing emphasis on "social costs" and "social benefits," even while society remains largely incapable of identifying and quantifying such costs and benefits with a degree of precision that justifies their use in this way. DOT might well now attempt to devise schemes that, for the present at least, reduce to manageable proportions the disincentive effects of the possible existence of external costs associated with a prospective innovation so that process can move forward on a broader front in the transportation field.

DOT can proceed in this regard in a number of ways. One of them relates to the creation of insurance schemes that reduce, if not eliminate, losses experienced by suppliers and their customers should a transportation technique be found to be socially undesirable at some point after its adoption and diffusion. While the careful drawing of performance specifications and goals to include externalities-producing criteria is a promising means of reducing the risks of both society and entrepreneurs engaged in transportation innovation, and it is quite clear that this can actually be accomplished without discouraging the "golden geese" innovations, the better course is to promote innovation actively but also to develop mechanisms that permit subsequent "recalls" if an innovation turns out to be socially offensive based on actual experience.

DISCUSSANT'S COMMENTS

BY

HARVEY E. BRAZER

The Gellman paper is highly informative and should serve as a useful stimulus to constructive thinking about ways in which public policy can be effective in encouraging innovation in the transportation sector of the U.S. economy. I was especially impressed by the author's demonstration of the folly of government procurement policy that focuses on specification of design details rather than on performance specifications.

I should like to have seen more attention devoted to the role of organized labor in influencing the pace of innovative activity. We are all too familiar with the case of "firemen" riding diesel-powered locomotives and what some would consider "excess" personnel carried in the control compartments of commercial aircraft. But what is much less obvious is the appropriate set of incentives that would serve to remove such barriers to innovation. Much the same may be said of management incentives with respect to innovative activities--and Gellman does deal with this problem more fully--and the relative rewards of risk avoidance as opposed to risk taking. Perhaps innovation is strongly discouraged because rewards tend to focus on outcomes to the exclusion of inventiveness in attempts to improve outcomes, irrespective of results. In other words, we may be strongly in need of a means of providing a payoff for innovation as such, in a way that would drastically reduce the costs, and therefore the risk, of failure.

In discussion of innovation in the United States, it should be recognized that, through outlays on research and development that currently run at about 2.5 percent of GNP and by other means, the post-World War II years have witnessed an enormous outpouring of new products, new production and distribution techniques, and so forth. The problem confronting the committee stems largely from the fact that innovation in the transportation industries has not kept pace with that in other sectors.

Clearly, innovation need not involve capital outlay requirements, but wherever new technology is the means to innovation and that technology is embodied in capital assets, capital outlays associated with innovations may be enormous. U.S. government policy in the field of taxation has been cognizant of this for at least 25 years, and several major steps have been taken to improve the profitability of investment in depreciable assets other than structures and to increase business cash flow. In 1954 the Congress permitted the use of such accelerated methods of depreciation as double declining balance and sum of the year's digits; in 1962 the investment tax credit was introduced, at a rate of 7 percent, increased to 10 percent in 1976; and new shorter

lives for depreciation were introduced in 1962 and further liberalized in 1971 with the adoption of the "asset depreciation range" approach to depreciation. Taken together, these changes in the tax treatment of business capital assets now provide some \$50 billion a year in additional cash flow to American enterprises, approximately equivalent to a drop of 40 percent in the federal corporate income tax. And this is exclusive of recent reductions in the tax rate itself.

There is now much discussion, in Congress, in the administration, and in business and academic circles of the need for further tax help for the supply of investable funds. A strong candidate for enactment is the "3-5-10" bill. It would permit vehicles to be depreciated in three years, machinery and equipment in five, and structures in 10 years. That such a measure would encourage and facilitate innovation is undoubtedly true. But what is not clear is whether or not it would be efficient public policy.

With respect to transportation, the current picture for much of that sector is such as to suggest that tax concessions are not the answer. Few railroads now pay appreciable amounts of federal income tax, so that additional depreciation allowances, if made available and if taken, would serve only to increase accounting losses. Two of the big three auto firms will report huge losses for domestic operations in 1979, and the outlook for all three for 1980 is bleak. Thus, depreciation that is too liberalized is certainly not likely to be helpful here in the near-term future. On the other hand, other segments of the transportation sector continue to be profitable, including airlines, trucking, pipelines, and their suppliers of equipment and other capital goods. And for these, of course, liberalized depreciation would be helpful.

More important, in general, however, is the question of whether the tax route is the most appropriate, most effective means of achieving the goal of stimulating innovative activity in transportation. For the reason just suggested it is quite obviously not useful to some of the major parts of this sector, and it may not be the most desirable approach for any part of it. This follows, in part, from the fact that accelerated depreciation, the investment credit, and across-the-board tax cuts are not and cannot readily be designed to be directly related to innovation. That is to say that the same tax break is afforded to the firm that acquires more of the same old machinery to produce, using the same methods, the same old products, as is afforded to the firm that acquires machinery that embodies a revolutionary new technological breakthrough. Thus one may expect that for each dollar of tax concession that facilitates innovation there may be several that do not. Apart even from innovation, it is not clear that tax policy of the kind now widely advocated is very effective in stimulating investment. A number of surveys and econometric studies conducted in recent years suggest that each dollar of revenue foregone through the investment credit and accelerated depreciation tends to be associated with anywhere from something less than a dollar to a little more than a dollar of new investment. At this rate the Treasury would seem to be getting a rather poor bargain--certainly if the revenue cost were to be compared with the volume of new investment representing innovative change.

It seems to me that we have gone to the same old well to often with too little to show for our efforts. Surely the fact that virtually no one concedes that either our investment or our innovation needs have been met through tax policy measures of the past must suggest that some innovative thinking is needed at least as much in this area as in any other. The answer may be found in the form of grants tailored to provide the needed reward system for innovation of all kinds, whether or not they involve capital formation. But before new public funds are committed to this endeavor, in any form, we should be reasonably sure that we have made a strong, intelligent effort to remove the immeasurable institutional barriers to innovation that Gellman and others have pointed up so well.

PROCUREMENT AND INDEPENDENT RESEARCH AND DEVELOPMENT

REMARKS

BY

ALLEN E. PUCKETT

Our panel is concerned with independent research and development (IR&D) and procurement. I take that to mean government procurement. I am not sure about all the connections between that topic and the field of transportation, but we will explore that in our panel meeting.

IR&D generally, in the industrial world, means that element of research and development that is conducted entirely at the initiative of the company. It may be conducted without respect to any particular contract support or orders from the government, from other companies, or from other customers, and it is a research and development component determined by management to provide for the future of the company. In plain English, the purpose of independent research and development is to improve old products, or to develop new products, and services, as the case may be. It is not directed or controlled by customers at all, in the direct sense. Nevertheless, properly managed IR&D has a primary purpose, and that is to be responsive to customers: to be responsive to perceived customer needs and, in many cases, to anticipate customer needs or perhaps even in the most important cases to create new customer needs. I do not need to go through the long list of things in that category that you all know as well as I do.

Some of the most important real innovations in the country came about before a customer need existed. In fact, an important part of the innovation process was to create, eventually, that demand in the customer world. So that is the IR&D role.

How is it paid for? In the end, it has to be paid for by our customers, if one speaks from the industrial point of view. In other words, this follows the old first law of economics: there is no such thing as a free lunch. Sooner or later, one way or another, the price of all the IR&D that we do must appear in the price tag of the customer.

But now, as a practical matter, the mechanics of how this is done is a matter of accounting procedure. I will let you in on another secret that may be known to many of you. Accounting is not an exact science. When I was a much younger engineer, I suppose I had some illusion that accounting was a matter of arithmetic, that the rules were quite clear, and that everyone, when they had read the book, knew how to do their accounting. It turns out that that is not true.

In fact, we have a little story at our place about a very short form method of interviewing applicants for various categories of jobs.

Three very important professions, of course, are engineering, law and accounting. When the engineering applicant shows up, we ask him, "What is the sum of one plus one?" If he says "two," he is a pretty good engineer, and we hire him. When a lawyer shows up, we ask him, "What is the sum of one plus one?" If he says, "Well, it all depends," he is a pretty good lawyer, and we hire him. Then when the accountant shows up, we ask him, "What is one plus one?" and if he says, "What would you like it to be?" then he is a good accountant.

So the many techniques by which the costs of IR&D are handled in the accounting procedure are various and wonderful. But essentially, IR&D in any corporation eventually shows up in an account called overhead.

Overhead is sometimes regarded by governmental authorities as a kind of pejorative term. There is the view that overhead is something that we should not have and further, that a measure of your management capability is the size of your overhead, and the lower the overhead, the better you are.

As a side comment, I have to point out that that is not true. My idea of the perfect manufacturing plant is one with about 10,000 percent overhead, because there could be one man in there on direct labor and everything else could be automated, and that is overhead. But that is a different topic.

But the point is that sooner or later all IR&D charges go into overhead. The cost, the overhead account, in some way is allocated against cost of sales. That is the way the customer pays, eventually.

Put another way, IR&D in any segment of American industry is a normal cost of doing business. It is an essential part of maintaining the health of the company and of providing for the future of the company. It is included as a necessary element in the cost of sales. It is in the price of the product.

However, the price of the product may not necessarily be directly related to its cost. That is another matter. But in any event, if we do our accounting properly, the element of IR&D is included in the cost of sales.

I will now switch to the special area of government procurement. Currently, we have some extra rules. In the case we are considering, in these complex relationships between industry and government in the government procurement process, for good reasons the government negotiates with us generally on our overhead rates. That is not necessarily true if they are buying shoes, buying a catalog item, or buying many commercially available items. However, in the more complex endeavors that we are talking about here, the government does negotiate overhead rates. In fact, they find it desirable to negotiate, in particular, this little segment known as IR&D.

One of the topics, then, of great interest to all of us who are involved in government procurement concerns the rules, the policies, and the practices that accompany the negotiation of that segment of our IR&D that may be legally, legitimately included in this overhead rate. A segment that represents part of the cost of sales, which in turn we are going to allocate to the price of our product.

The end result is that the IR&D dollars a company spends as a normal cost of doing business may not be allowed completely in the price of its

products to the government. The government is still going to pay in one way or other, but it simply does not come out as a fixed, finite part of the allowable cost.

Some interesting questions of policy are involved in this matter of government treatment of IR&D. It has been a controversial topic for many years, and I really do not want to try to give the conclusions of the panel because I do not know what they are going to be. I do think, though, that this is an appropriate time to bring together some experts in this field, on both the government and the industry side, and to review what it is we have been doing and whether we think it still makes sense.

To return to the relationship of all this to transportation, I said at the outset that I am not sure whether there really is a connection. I am not an expert in transportation at all, so I come here with no preconceived ideas. I did think, though, that I should get some feeling, some perspective, on this vast area that we are talking about--the national transportation picture. The things I learned in scanning the 1977 DOT report on Trends and Choices in transportation--a fascinating document--are probably well known to you. Some of them were certainly a bit surprising to me.

One of the speakers mentioned that the transportation industry, or enterprise, the services, the manufacturing, and the public users, takes up about 20 percent of our gross national product. That is a remarkably large number, around \$600 billion in current terms. I learned that about half of the GNP fraction is related to passenger transportation, and about half of it to freight. That was interesting.

The next thing I learned, and this may be very well known to all of you but it was a little bit of a surprise to me, was that in the passenger area, over 90 percent of all passenger miles are provided by private automobiles! It may be over 90 percent depending on how one does the calculations.

So the remaining 10 percent or less of passenger miles is supplied by airplanes, buses, railroads, and boats, I suppose. To the extent that we are interested in passenger transportation, the inescapable fact is that the automobile totally dominates the scene. We could double urban mass transportation patronage, and it would hardly affect the nature of automobile transportation at all. At least, that is the preliminary feeling I get.

Transportation is a big business. There is a great amount of leverage in automotive transportation; an enormous industry is involved.

I then took a look at the Department of Transportation to see what our leverage and the interconnection are there. The Department of Transportation's budget is about \$17 billion a year. Of that, something around \$12 billion is dispensed in the form of grants. A large part of that is in highways, and another part of it is in urban mass transportation. So, in that sense the DOT is really just a pipeline, a pass-through arrangement, for this money that flows out in some fashion, but apparently is not involved at that level, in government procurement.

Finally, I saw the item for R&D. Now, there may be some other elements of R&D hidden in the budget that I could not find in a short

study, but I will give the item that I noticed, in billions because we started with billions. We started with \$600 billion for the whole of transportation. I got down to \$17 billion for the Department of Transportation. The R&D segment is about \$0.38 billion. That is not a very big number.

Just by comparison, the DOD budget component in R&D is about \$12 billion this year, or something on that order. That is out of a total budget of about \$120 billion. It may not be fair to draw those comparisons, but I will draw them anyway.

Once again, that raises in my mind the real questions regarding the role of IR&D, of government procurements, and of government R&D generally with respect to transportation. From the few things I have said, it would be very tempting to draw the conclusion that the relationship is somewhere between small and zero, but that is probably not right. I want to take a more positive approach to encourage the panel.

The one thing that is overwhelmingly true about IR&D anywhere, in any industry in the United States, is the enormous leverage that it has on the future of the company, of the country, of the economy, and of the state of the industry. The leverage is tremendous, and therefore, even attention to small numbers and faint connections may have real value.

It may be that innovation, and, of course, here I am thinking particularly of the technical aspect of it, may depend much more on factors in the private sector, but the stimulus of the government's interest in IR&D--interest or the lack of it, as the case may be--does in turn have an effect on industry, generally. That is particularly true in the high-technology industries, where very often the most difficult problems that we attack, the impossible jobs that we attempt to do, really provide the stimulus or the pressure to create. I am distinguishing here from innovation. I mean the stimulus to create, to invent, and to conceive the new solutions that open the door to many applications that were not initially in mind.

So the leverage is there, and the connection is there, and I think we have an interesting opportunity to explore it in this panel.

A VIEW OF U.S. GOVERNMENT CONTRACTING POLICIES AS THEY RELATE TO THE SUPPORT OF INNOVATION

BY

WILLIAM L. RODENBAUGH AND
W.B. GIST

INTRODUCTION

The dictionary tells us that an innovation is the making of a change in something established. The change is usually understood to be the bringing in of new ideas, methods, or devices. Innovations in commercial

and industrial establishments are mostly analogous to the biological process of evolutionary change through mutation, though less frequent revolutionary changes do occur. Market pressures are normally adequate to motivate, develop, and insure the survival of the fittest innovations provided that they are initially seen as sufficiently advantageous to outweigh the risks and inconveniences of change by both the supplier and the user. Our concern here is with those exceptional situations in the transportation industries in which these market pressures are inadequate or inappropriate to provide innovative improvements at a pace perceived to be required by the public interest.

The National Transportation System is a classically mature establishment with formidable "risks and inconveniences" to both the supplier and the user of any change. Consider the railroads. There is little potential for market growth or penetration by outsiders. Well-developed and inflexible systems are established with an entrenched industrial base. Restrictive regulations and equipment standards abound. The labor force has the demonstrated power to negate the benefits of labor-saving innovations. Regulated tariffs and costs not entirely under the control of management have kept profits too low to support an adequate R&D base. The cost and risk of any change in this system discourage the adoption of any but the most modest evolutionary innovations and provides little incentive for innovative effort on the part of equipment suppliers or users.

The level of maturity and stagnation attained by the nation's railroads is unique, but most of the industries affected by the Department of Transportation have some of the innovation-stifling characteristics of the railroads. The air transportation system is at the other end of the spectrum among revenue carriers, but even here, the signs of encroaching maturity are evident.

The government has several vital roles to play if innovation in these systems is to be encouraged:

1. Providing directions or goals for innovators based on a long-range overview of societal/economic needs.
2. Augmenting the commercial incentives for innovative effort (and eliminating disincentives).
3. Overcoming or eliminating regulatory and institutional roadblocks.
4. Aiding in the capitalization of innovative experiments and systems.

Inventiveness and genius for innovation can be discovered almost anywhere; it is assumed that the likelihood that it will be discovered is proportional to the number of potential sources attracted and enlisted in the effort to solve any particular problem. The likelihood that any given innovation will be able to fulfill the purpose for which it is intended is probably enhanced if the innovator has appropriate skills and knowledge and facilities to apply to the problem solution.

Procurement policies are conceived not only for the purpose of establishing orderliness and consistency in the administrative procedures for managing the purchase of commodities from vendors with prudence and wisdom (as is suggested by the dictionary's definition of the word policy). They also serve as instruments for accomplishing social,

environmental, and economic goals of the Congress and the administration that are not necessarily related to the quality of the end product. Inevitably, they are a factor influencing the responsiveness of commercial firms and universities, which could be leading sources of innovations sought by the government for the purposes of improving national transportation systems.

This paper will reflect on the existing procurement policies of the government and how they might be viewed by potential suppliers of innovative concepts, studies, developments, and products as providing either incentives or disincentives for applying their talents and resources to government-contracted programs.

HOW FEDERAL PROCUREMENT POLICIES ARE VIEWED BY POTENTIAL INNOVATIVE CONTRACTORS

One of the ways in which the government can give directions to and provide incentives for innovative efforts is through improvement of federal procurement policies and practices, especially in regard to research and development efforts undertaken by industry in support of government objectives. These policies are continually being changed to meet newly perceived needs of the government as a customer and as a guardian of the rights and a dispenser of the benefits for every segment of the population and of the economy. It sometimes happens that the policies adopted turn out to be counterproductive with respect to obtaining the best that industry could provide in the way of innovative contributions. The very immensity of federal expenditures and the correspondingly heavy stewardship responsibilities of both the executive and the legislative bodies dictate that procedures designed to protect the public treasury be extremely complex with provisions that are sometimes onerous to contractors.

Some of the disincentives in government procurement policies stem from the government's laudable objective of maintaining multiple competitive sources for a particular service or product. When this objective is sought by applying such devices as a conflict of interest clause to minimize the competitive advantage gained by a particular contractor from work performed on a prior government study contract, the result tends to discourage early competitive participation and thus inhibit innovative effort.

Other problems stem from the government's legitimate desire to get full value from government contracts: services and products that meet the government's quality expectations and currently perceived needs (which frequently change during the performance of long-term government contracts), with on-time delivery and no cost overrun. These objectives have led to intrusion into the contractor's customary managerial functions and prerogatives by government inspectors, auditors, and reviewers. This adds significantly to administrative and clerical costs incurred by a firm and limits the ability of company management to control specifications and costs within the originally contracted values.¹

¹ Council of Defense and Space Industry Associations (CODSIA), "Study Costs Unique to Government Contracting," December 8, 1971.

These practices, plus the need to minimize procurement costs when effective competition is lacking or when a unique product or service is single-sourced, cause most government procurements to be negotiated with a cost-based price. This invokes a fundamental issue of how much margin to allow for profit and reinvestment by the company. Company reinvestments of margin into company-selected and company-managed research and development for the purpose of maintaining or enhancing the future competitiveness of the company are thus subjected to separate identification and audit as cost elements by the government. This element of cost has been labeled independent research and development (IR&D) by some government agencies, and its allowance has become a political issue.

The remainder of this paper will enlarge upon the relationship of these procurement policies to the interests of potential contractors in government-sponsored programs, leading to recommendations that would stimulate participation by university and industry innovators.

Setting Goals

In providing a direction for innovative research and development, the government must be careful to identify the problem precisely (and not attempt to specify the solution) in order to obtain most effective application of the independent inventive genius of industry and academia. Good problem solutions are not always apparent without some exploratory research and evaluation. Contracted studies to aid in the process of winnowing the good ideas from the rest should be obtained from qualified researchers with applicable knowledge, skills, and technology. The Department of Energy has recently imposed a policy that excludes the best-qualified firms from participation in technical evaluation and consulting services on the basis of a conflict of interests. This organizational conflict of interest policy is being considered by other government agencies. Most firms in industry engage in R&D activities only as a means of obtaining a competitive advantage in their future products or technical capabilities. This conflict of interest policy can be a strong deterrent to their participation in a process where they have much to offer and where the most significant decisions on potential innovative opportunities are frequently made. The government believes that participants in early studies leading to a product development or procurement will obtain a competitive advantage over nonparticipants. Why else would a firm of innovators risk the disclosure of its good ideas to potential competitors during the course of such preliminary evaluations?

The government also seeks to avoid biased assessments of alternative approaches by this proposed policy, but biases can be discerned and allowed far more readily than incompetence and lack of realism. Parallel competitive studies by firms with a vital interest in the results may be a better means of providing balance.

Providing Incentives (and Eliminating Disincentives) for Innovation Participation

It is in augmenting the commercial incentives for innovative effort that the government's procurement policies have the most impact. DOD has successfully encouraged dramatic innovations in military systems through farsighted policies on R&D procurement, including directly funded industrial R&D, and NASA has had similar success with similar policies in both space and aeronautics. Commercial spin-offs from the DOD and the NASA-sponsored innovations have provided benefits to the nation far beyond the original objectives of these agencies and far beyond the level that would have resulted from commercial incentives alone.

The complexity of the federal procurement policies is such that the sheer volume and the administrative costs associated with keeping abreast will deter some commercial entrepreneurs from becoming involved with government business.

Some of the major differences between commercial business and business under government contracts are as follows:

1. In the government marketplace, there are no permanent commitments--the government order that a business receives is incrementally funded and, if performance is to be carried out over several years, is subject to annual congressional program review as well as continuous reviews by several layers of "yes/no" decision makers who can decide to scrap a program or alter its direction after it has started. The company new to government business will find such potential program vagaries accommodated in its contract with special terms and conditions, e.g., termination for convenience, limitation of government obligation, and changes. In the commercial marketplace, the usual pattern is for the seller to carry out performance and delivery as ordered by the customer with a reasonable certainty of contract continuity as agreed by the parties at contract signing.

2. After selection of a supplier through examination of his product and his specifications for a potential product, the commercial purchaser places an order and expects the supplier to manage his own business to assure contract performance. Except for specific and agreed-to contract provisions, the Uniform Commercial Code governs the transaction or its outcome in the event of dispute. The government purchaser instead will impose his own standards for such fundamental business activities as quality control, production control, and sub-contract purchase routing, in "courts" (Board of Contract Appeals) using federal law/regulations--Armed Services Procurement Regulations, Federal Procurement Regulations, NASA Procurement Regulations (ASPR/FPR/NASAPR). If the government contract is negotiated, the supplier is also subject to the rigid cost control/financial system disciplines encompassed in the cost accounting standards and the cost (dis)allowance criteria in section 15 of the ASPR. To compete for a negotiated contract with the government, the potential supplier must furnish cost projections in extensive detail and provide government auditors with access to the supporting documentation for all direct

and indirect cost.² After completion of the financial audit and several surveys of the business, e.g., purchasing, production, and technical, the give and take of the negotiation process is initiated, in which the government's objective seems to be to obtain the lowest possible (not probable) cost to which a statutory or regulatory (low) profit rate is applied. These regulations are imposed as well on the winner of the contract and affect each subsequent change negotiation. At frequent intervals during performance, business reviewers are sent to the supplier's plant, or for larger, longer-term contracts, they will be resident in the place of business of the supplier as a permanent staff of auditors, inspectors, and reviewers.

3. In addition to the aforementioned imposition of government controls on the "business" aspects of the enterprise, the would-be government supplier must be aware of the difference he may expect from commercial practices due to the impact of the technical and product acceptance criteria used in most government procurements. Commercial customers expect to receive and will inspect and accept a product in accordance with agreed-upon practical specifications-performance criteria. Express warranties define the supplier's after-delivery responsibilities. Because the government accepts greater after-delivery responsibility for the product, the supplier to the government usually finds that his contract not only defines what he is to deliver and how it will be inspected and accepted, but also will control many of his technical and manufacturing activities: the sources for certain materials and component parts, the in-process inspection techniques, the ability to change the physical configuration of internal parts, the drafting practices, and more. If disagreements arise, the supplier's recourse is first through one of the government's administrative Boards of Contract Appeals and not through the courts suppliers use in most commercial disputes.

4. Another difference between commercial and government business is in the area of rights in technical data. Commercial purchasers of goods and services rarely expect any form of data rights as a condition of purchase; in the special cases in which such rights are sought commercially, license arrangements providing for special compensation are the usual approach. Contrary to the commercial approach, the government usually seeks to obtain the rights to make or have made for its own use any product (or its parts needed for repairs) developed or modified under a government contract. Before entering into a contract, which may jeopardize any patent protection, know-how, or unique process the business may have developed on its own prior to a government contract, the prudent commercial businessman will obtain counsel from a competent legal authority specializing in government contracting as to those precontract technical rights that may flow to the government as a result of the contract.

² CODSIA identified 17 different types of audits and reviews for which there are no comparable commercial work costs or which exceed similar types of costs on commercial business in their "Study of Costs Unique to Government Contracting," December 8, 1971.

On the other hand, government contracts have a number of advantages over normal commercial contracts that make them very attractive. Government contracts may provide for special financing arrangements, i.e., progress payments, without cost or price concessions from the supplier. This is especially helpful when a research and development program requires many years or imposes large costs. Also, while government contractors may be concerned about abrupt contract terminations, they need not be concerned about the purchaser's bankruptcy. Most importantly, the results of technical efforts supported by government development funds may be introduced into the commercial products of the business to enhance their competitive value or lower their costs. The additional volume of a government contract may also improve the utilization of fixed investment through lowering the costs on a continuing commercial business.

Perhaps the most widely debated issue of federal procurement policy is the propriety of compensating contractors for the independent research and development that they conduct in order to retain or enhance their future competitive capability. In dynamic and competitively innovative industries, research and development is essential to continued survival. In these industries a company must consider reinvestment of margin into research leading to the development of future products or new markets as part of the cost of doing business. Margins must be maintained high enough to provide for this reinvestment, but at the same time prices must remain competitive on current products. Thus the managements of these firms are forced to use great care in deciding how much effort to apply and in selecting research activities with a potential payoff. Such decisions are "the most difficult, and in the long term, most significant decisions of management in any enterprise, because in no other way does a company put its future on the line to the degree that it does in making such determinations."³

This internal discipline for assuring reasonableness and appropriateness of R&D based on long-term competitiveness of products as well as short-term competitiveness of prices works very well under most circumstances.

But when effective competition is lacking or when a sole-source procurement is necessary owing to uniqueness of a product or service, prices of government purchases are negotiated on the basis of actual cost plus a "reasonable" profit. In negotiated government procurements the amount of profit must not exceed specified statutory limits, and contract negotiators usually settle for profits significantly below the statutory limits and below commercial profit levels achieved after reinvestment in independent research and development. Thus, if allowed at all, the IR&D reinvestment must be treated as a negotiable and auditable cost along with all other costs, and as such the government must be satisfied as to the reasonableness of the level of this cost and the appropriateness or relevance of the activity in relation to the

³ AIAA, "Recommendations to the Domestic Policy Review of Industrial Innovation," AIAA, February 2, 1979.

government's interests. (Independent Research and Development, or IR&D, is a term devised by the Department of Defense and used by federal agencies to identify a contractor's basic and applied research, development, and concept formulation studies performed under circumstances other than a government-sponsored arrangement such as a contract or grant.)

The Department of Defense has evolved an elaborate procedure for controlling IR&D costs recoverable on their contracts.⁴ The procedure involves prenegotiation of allowable dollar ceilings (if the contractor's prior-year "payments" for IR&D plus bid and proposal (B&P) exceeded \$2 million⁵ on both IR&D and B&P. In establishing the ceiling the government takes into consideration a technical evaluation of the proposed IR&D projects and the potential military relationship of the projects. The ceiling almost always is below the actual IR&D and B&P expenditures of the company. Subject to progress reviews and reports and audits of all projects included under the ceiling, the government allows only a share proportional to the ratio of DOD sales to the total sales of the company to be recovered in the price of products sold to DOD during the year covered by the agreement.

These policies on IR&D reimbursement have apparently been an outstanding bargain for the DOD. In 1975, Director of Defense Research and Engineering Malcolm R. Currie stated in congressional testimony that, "In 1974, on the average, 92 percent of all IR&D projects were directly relevant to DOD interests while, on the average, DOD paid for only 39 percent of the IR&D effort incurred. For this discounted payment, the government is able to maintain the most advanced technology and innovative systems in the world."

Industry regrets that the government has elected to put many restraints on IR&D. The Aerospace Industries Association of America (AIAA) has stated to the Domestic Policy Review of Industrial Innovation that:

It is to government's advantage to preserve the independent nature of a contractor's research and development effort. Independence permits a firm to apply its resources to those technologies and programs in which its capabilities are highest and which, therefore, will provide greatest benefits to both firm and customer.

Government control that inhibits the flexibility of industry to respond to the changing market environment is clearly an adverse influence. It makes government partly responsible for the success or failure of industry and presumes that government possesses some sort of omniscience that has never been demonstrated.

⁴ Defense Procurement Circular (DPC) 90, effective, January 1, 1972.

⁵ For companies not required to negotiate advance agreements, allowable IR&D and B&P costs are determined by using a formula based on previous years' costs and sales.

The present governmental method of recognizing IR&D costs may restrict the amount of IR&D costs which can be recovered under a company's government contracts. Under Public Law 91-441, only those projects considered by DOD to have potential military relationship are considered for cost recovery--and then only within a ceiling established by negotiation or formula, depending upon the company's previous recovery of IR&D costs.

While industry has learned how to comply with these restrictions, there are serious drawbacks in the present method. The basic concern is that the method really does not recognize IR&D as a legitimate cost of doing business; it implies that IR&D is dispensable when it is not.

The price of every company's products should properly include the company's proper cost of doing business and each customer should pay its fair share of that cost. As a customer, the government is neither buying IR&D as a commodity, nor is it supporting or subsidizing IR&D; instead, it is buying goods or services, the prices of which should contain a proportionate allocable share of all indirect costs. Legislation under which the government enjoys a preferred position, free of the obligation to pay a pro-rata share, unfairly discriminates against other customers. It is particularly unfair when the government is in a position to influence legislation to its own advantage.

To the extent that government refuses to recognize such costs in its prices, government receives an unwarranted discount on its purchase. To the extent that government does not pay, the burden is shifted to the stockholder in terms of reduced return on investments; or where the company also produces for the commercial market, the extra burden may result in higher prices for the consuming public, thereby weakening the company's competitive position in the market. The company is thus persuaded, often even forced, to shift away from government business, because the return on investment is not comparable with the return from other markets.

IR&D controls, similar to those used by DOD, are employed by NASA, DOE, EPA, and some DOT agencies, but some other agencies allow no recovery of IR&D expenses. At the very least, the government should standardize IR&D recovery regulation for all agencies and allow government-wide relevancy tests. For instance, IR&D relevant to DOT interests should be allowed under ceilings established by DOD and all other government agencies, and it should be recoverable on all government contracts performed by the company.

CONCLUSION AND SUMMARY OF RECOMMENDATIONS

The government has important roles to play in fostering innovation in the nation's transportation systems due to the limited incentives and

disproportionate risks that stifle commercially motivated innovative efforts, particularly in the federally regulated transportation systems. In providing guidance and direction for innovators and in augmenting commercial incentives to attract innovative entrepreneurs, the government's procurement policies can be either a positive or a negative factor. It is in the government's interest to obtain the active application of the country's best industrial and academic knowledge, skills, and ideas to the nation's perceived transportation problems. Toward this end, implementation of the following recommendations could make a significant contribution. They are operable within the confines of the need to use cost-based price contracting.

RECOMMENDATIONS

The government should do as follows:

1. Provide directions or goals for innovators based on a long-range overview of societal and economic needs.
2. Rely on parallel exploratory and feasibility evaluations and assessments in establishing innovative goals and potential problem solutions. The organizations contracted for this effort should include firms with applicable skills and knowledge in the field. These firms should not be prohibited from any follow-on development or production opportunities.
3. Strive to simplify and standardize the procurement regulations used by various government agencies with the goal of minimizing non-productive management/administrative burdens upon the contractor and unwarranted cost to the government.
4. Fully compensate contractors for all overhead expenses incurred due to government-imposed contract management requirements.
5. Fully compensate contractors for intellectual property acquired by the government, and only those properties necessary to protect the legitimate needs of the government should be acquired.
6. Recognize that IR&D is a legitimate cost of doing business and that its cost should be recovered in the prices of the company's goods and services.⁶
7. Provide that IR&D be truly independent as regards the performer's choice and execution.

⁶ Recommendations 6 and 7 are selected from those made by the AIAA to the Domestic Policy Review of Industrial Innovation.

DISCUSSANT'S COMMENTS¹

BY

JAMES E. CARPENTER

I can offer no specific criticism of the paper. I certainly agree that such issues as conflict of interest, the recognition of differences between commercial and government business, rights to technical data and intellectual property, and the treatment of Independent Research and Development/Budgets and Programs (IR&D/B&P) are significant and should be addressed by the panel. Particular emphasis should be given to IR&D; if any procurement issue needs clarification and needs to be placed in the proper perspective, that is the one. Such indirect costs must be recognized as a legitimate cost of doing business, the existing DOD relevancy requirement needs reexamination, and the critics should recognize that such activities have averaged only 3 1/2 to 4 percent of costs over the past several years. Several elements of overhead are much larger and, in many cases, less productive. Some criticism of IR&D/B&P might be valid and merit discussion by the panel. First, there is some concern that the present procedures discriminate against small firms in particular and any firm attempting to enter the government marketplace for the first time. Second, some data indicate that R&D activities concentrate on the downstream, heavy development end of the spectrum rather than on the early-research, concept formulation phases. Is this good or bad? One final point regarding the paper: The suggested recommendations sound very much like OMB Circular A-109, and this should be acknowledged. It should also be made clear that the Office of Federal Procurement Policy (OFPP) in OMB (responsible for the development and implementation of A-109) has ongoing activities directed toward the resolution of many of the issues highlighted in the paper. The present status of these OFPP initiatives should be made available to the panel.

The panel's charter is to examine and make recommendations on issues that relate to the package of and interrelationships among procurement, IR&D, innovation, and transportation. To place these four elements in a context suitable for a meaningful discussion, I would suggest the following approach.

The federal government support of R&D and innovation usually falls within one of three main categories of rationale: (1) support of the nation's technology base (basic research, special facilities, etc.); (2) the development of new products or services to be used by the supporting agency (DOD, NASA); or (3) the development of new products or services for public consumption (DOE, DOT, etc.). By the inclusion of

¹ The views expressed in this discussion paper are those of the author and do not necessarily reflect the official position of the National Science Foundation.

transportation as a specific in the panel's charter, our focus should be on item (3), which is the issue of commercialization to meet civil agency missions.

If this premise is accepted, the following agenda items seem appropriate for panel discussion, analysis, and resolution:

1. The general problem of commercialization is a very recent and growing issue in the science and technology policy area. Some studies have been completed, and many are now in progress. It is becoming apparent that the innovation process supported by civil agencies is much different from that successfully experienced by those agencies concerned only with obtaining products and services for their own use. One of the reasons for this difficulty is cited in Larry Goldmuntz's paper prepared for another workshop panel.

The user is not the buyer, the buyer doesn't pay for it, the payer usually doesn't buy it or use it, the operator is a professional who doesn't use it, pay for it, or buy it.

A second problem area was addressed by the Charpie Task Force Report to the Department of Energy, February 1978.

If DOE's objective is commercialization, it should be heavily staffed with entrepreneurs rather than technocrats, R&D managers and their economic advisors. An analysis of DOE's roster of several hundred R&D executives revealed that only eleven had commercialization experience. As an example, the Task Force observed that most DOE contracts were overmanaged, and were therefore much more expensive to the public than they need have been.

The panel should be cognizant of the fact that many of the experiences learned in the DOD/NASA-type marketplace may not be useful for transportation commercialization. Notwithstanding the above, there may be elements of procurement practices, if properly applied, that could be helpful. Included might be OMB Circular A-109, treatment of IR&D/B&P, patents, background data rights, unsolicited proposals, and others. As long as the marketplace differences are recognized, the panel could conceivably develop worthwhile recommendations in the commercialization area.

2. The implementation of "The Federal Grant and Cooperative Agreement Act of 1977" (PL 95-224) could have a major impact on commercialization by civil agencies. A major mechanism for dispensing DOT funds is by grants to state and local governments. They, in turn, contract with the private sector for goods and services. A second mode is by contracting directly with the private sector, usually for demonstration-type projects. According to PL 95-224, some changes may be required in the mechanism for fund transfer. For example, if the cooperative agreement is utilized for demonstration programs, there may be changes in such procurement-related issues as patents, IR&D, cost sharing, profits, background data rights, etc. The panel should recognize the difference between acquisition and assistance and the impact of the assistance mode on innovation in transportation.

3. Much of the direct commercialization activities of the civil agencies has been via demonstration programs. Overall, the results have

been poor. The DOT experience should be reviewed by the panel to determine reasons for failure and to assess possibly the merits of the demonstration approach and perhaps changes in procurement procedures that might result in improving the chances of program success.

4. The Department of Commerce has recently completed a Domestic Policy Review (DPR) on industrial innovation. The final report of this study is now being reviewed at the highest levels within the administration. It is not known at this time which of the DPR recommendations, if any, will be supported by the president for implementation. However, a panel review of the industry inputs to the study may be worthwhile, since many of these inputs relate to procurement, IR&D, and innovation.

5. Several of the papers submitted to the workshop panels highlighted the possibility that a major cause of DOT difficulties may be organization. For example, and again I quote from Larry Goldmuntz's paper:

There is no political stability in DOT. There have been five secretaries of transportation in 10 years, as well as five UMTA administrators. Not one of these rose through the ranks, a sign of a badly managed enterprise. Each secretary tended to reverse the policies of his predecessor. Volpe wanted to mandate air bags, Brinegar felt the decision should be left to the private sector, Coleman wanted to test air bags, Adams mandated air bags, and now we have Goldschmidt. Volpe wanted to mandate Transbus, Brinegar wanted to leave it to the transit operators, Coleman selected Transbus parameters acceptable to operators and manufacturers, Adams mandated more stringent parameters, and operators and manufacturers "got off the bus."

Another organization concern, probably more appropriate for panel consideration, is the fact that there is no single office at the assistant secretary level, or above, responsible for the department's technology program. This may or may not be a problem, but the existing organizational structure of the department should be reviewed by the panel to determine if organizational changes might be helpful in improving the DOT procurement process as it related to technological innovation.

The above five agenda items are certainly not all-inclusive and do contain some coupling between items. Hopefully, if considered by the panel, they can serve as a springboard for meaningful panel discussion resulting in recommendations to improve the DOT technological innovation process.

TECHNOLOGY AND R&D POLICIES
TO STIMULATE INNOVATION

REMARKS

BY

HERBERT D. BENINGTON

The scope of our panel includes consideration of the overall federal research and development program in transportation and also the federal policies that can affect research and development done in transportation elsewhere. It is not a part of our job to look at the individual industrial R&D programs and to judge what they should do in the way of technology and R&D.

I think I realized what the general tone about federal R&D was going to be when I noticed that this is the first time in a meeting such as this on innovation that federal R&D shows up as the last, rather than the first, panel. This is an innovation by the academy in its organization of the workshop. I suspect it is a harbinger of the fact that many of our panels, including my own, may urge Uncle Sam to stay out of R&D.

At the summer planning workshop, I saw this writing on the wall when the discussion kept returning to Robert A. Charpie's report--the one that he did almost 10 years ago. Several who were present there kept emphasizing how well it hit the mark. That report, you know, emphasized that the way the federal government could help most was to decrease or improve regulation, to improve taxation, to get better financial and accounting structures and not to do federally selected and sponsored research and development.

Then our keynote speaker started out on that theme. He suggested that we should use current ideas, which I suppose means that we do not need to develop new ones with federal R&D. Charpie followed right through, saying, "The government itself should not be in the innovation business." Our industrial speaker said that specific government action is not needed. Bill Saunders gave me some hope when he said government action was needed; but then, later on, he said: "It is not a research effort at all that I am talking about." I began to think we would have a fairly demoralized panel, and I thank Allen Puckett very much for saying \$0.38 billion for DOT research is not very much at all.

But there are, in fact, many very important questions that are being raised about how much is the right amount of federal involvement in R&D in transportation and where it should be spent.

Court Perkins said in his welcome that he thought we were clever to narrow down the problem and to avoid generalizing too much about innovation. Instead he suggested that we really go ahead and look at it

in the transportation setting. As I have thought about this job, it seems to me that, in fact, we may not be narrowing down enough. I see at least five different sectors of government transportation in which we could have very different research and development policies and very different research and development activities. These differences relate to something that has been mentioned here several times, and that is the widely varying federal involvement in the different aspects of the transportation business.

In this regard, it seems to me that there is a spectrum. At one end of the spectrum there are organizations like the DOD and the Coast Guard, and I think that is the full set, where all of the regulation, marketplace, and use decisions are made for the most part within those organizations. Coordinated efforts are not needed. So there is a real sense of accountability. If you do research and development and it goes no place, then you can start to figure out why. In these departments you can find out much more easily what the operators want, although even then it is tough sometimes.

At the other end of the spectrum, in areas like pipelines and barges, so far there has been very little, almost no, federal involvement. We have three sectors in between. One sector involves organizations like NASA and the FAA, who in many ways are their own users; on the other hand, when they are part of a larger system, they have to interact with that system. Certainly, the FAA traffic control system has to work with pilots, airplanes, and the air transportation companies.

Then in the middle of the spectrum there are causes such as mass transit and rail where the government has a great deal of economic and legal leverage. Allen Puckett mentioned the grants, and, of course, this implies that there must be some sense of accountability.

Finally, there is the automobile, where the government makes virtually no marketplace decisions regarding who buys and sells what vehicles. On the other hand, they do have a tremendous impact and a growing impact through regulation.

These are the five areas of interest to us. As our panel considers research and development programs and policies, we recognize that this is quite a broad spectrum, and a sound policy in one of these areas could be an anathema to another.

I have analyzed the two papers that were commissioned for our panel, added some of my own thoughts, and put down what I think are ten issues that we should be considering. I will go over these very quickly and give you briefly some of the related recommendations contained in our two papers, as well as some of the issues that I thought were left out.

The first issue involved the question of what can be done to improve our understanding of national transportation as a system, both currently and in the future. If we could get a good understanding of the national transportation system and the possibilities for the future, what impact would that have on our technological contributions to innovation, recognizing that technology is only a part of--maybe even a small part of--innovation?

Along these lines, Edward Morlok feels very strongly that we need something that he calls a mobility assessment. In support of this, he

said, "We know so little about how the whole system works, and how the different parts come together." He proposes that an important function of DOT, which would not necessarily be very expensive in terms of dollars, but certainly would be in terms of intellectual horsepower, would be to have what he calls a basic research program in transportation. One could also describe his proposed activity as a very deep market analysis that would look at questions such as the role and the need for transportation in society, alternative technologies to meet those needs, alternative organizational arrangement at all levels for transportation, and the impact of transportation on society.

The second issue is, "Generally, what is the appropriate federal role in research and development as contrasted to that of the local government, universities, private industry, and others?" As I suggested earlier, it may be that there are five different federal roles, depending on which transportation area is served. Larry Goldmuntz implies this in his paper as he concludes that we ought to put our federal R&D assets where they are appropriate for federal involvement. He stresses air traffic control and surface transportation for a variety of reasons, and he says we ought to get the federal government out of automotive R&D.

The Morlok paper, among its recommendations, talks about a catalytic role that the federal government could play. He proposes that we should establish institutes that would help integrate, that is, orchestrate, the efforts of universities, private industry, and other government programs.

The third issue then involves the questions, "Are there, in fact, promising areas for federal funding of research and development in transportation?" It seems to me that most people agree that there should be some federal role in some of the basic technologies supporting transportation. That has been mentioned several times today. Some of us feel that in air traffic control and surface transportation, an important role could be played. And, of course, there are some very contentious areas such as aircraft R&D. For a while there was a proposal that the government should get involved in developing new wide-body jets. Of course, there is the SST issue. I have already mentioned the role of the automobile.

The fourth issue is, "Do we adequately follow the foreign competition or foreign markets in transportation?" In Goldmuntz's paper, there are some observations about German, French, and Japanese technologies, and he concludes that they may be ahead of us in some important areas. If they are, that could hurt us in transportation, in our own transportation industry, and in our balance of payments.

"Can we improve the means for funding of R&D?" is the next issue. Morlok proposes a set-aside tax that would be relatively quite small and would guarantee continued funding. There have been proposals made that we could jointly fund with industry. Another idea is that, with grants, we could combine R&D funding with some of the capital money and get better results.

If there is to be federal involvement, another very important issue is, "What steps will improve the communication between developers, buyers, operators, and users in order that the developments may be more relevant and acceptable?" We have talked about the many people who are

involved. The best statement that I have seen of this subject was in Goldmuntz' paper. He says of one large transportation sector: "The user is not the buyer, the buyer doesn't pay for it, the payer usually doesn't buy or use it, and the operator is a professional who doesn't use, pay for it, or buy it."

In that kind of a situation, it is very tough to try to discover what technology or innovation will prove successful, operational, and economical in the end. In fact, in Goldmuntz' paper, he cites many specific programs in which those kinds of disconnects and lacks of accountability have been at the heart of some major programmatic problems.

There have been successful solutions. He mentions a recent study of the FAA in which the FAA has retained an independent group to get together representatives of all the various players in this game and to look at some of the major mission thrusts that could be made.

It seems to me that many of Morlok's ideas on the institute, on the mobility assessment, and on the Department of Transportation market research program could be a very important vehicle for getting more and better communication between these different groups.

A seventh issue is, "How can we improve the collaboration between government and industry where each is sponsoring research and development in the same or closely related areas?" Our previous speakers have talked about some of the hostile behavior that some government people seem to show toward industry; and, on the other side of the coin, consider the low confidence that industry generally has in the technical ability of individuals and groups in the government to make technical and economic decisions.

If, in fact, we are going to continue and strengthen our R&D programs--for example, those in basic research and technology underlying transportation--I know from my own experience in DOD that it is very difficult to make sure that those kinds of programs are relevant to the later system choices. This is going to be a very difficult thing to do.

An eighth issue involves the question, "How can DOT's management be improved in the area of research and development?" When I heard Ward Haas say earlier that good innovation in technology means that the organization has to do such things as decentralize, make something as small as possible, short-circuit, and consistently fund, I began to get pessimistic about whether, if the federal government is involved, we can, in fact, get a good management of innovation.

In fact, two of Goldmuntz' three major recommendations address the management question in DOT. In one, he emphasizes the need to streamline the technological approval process and gives an example of some problems we have had there, and, in another recommendation, he would depoliticize DOT. He points out that we have had five secretaries of transportation and five UMTA administrators in the last 10 years and that in successive years we have found a real discontinuity, a reversal of decisions that makes any kind of progress in economic-technical development very difficult.

We have to, under this organization question, consider the impact of the various modal administrations on technology development. You

may recall that when Bob Charpie looked at commercialization in the Department of Energy, his recommendation was that the department should be organized the way industry is, not by mode but by function; he felt that if this did not happen, if we did not have the organization structured from the development, to planning, to marketing, and to production, that we would find that much less commercialization of the government-developed technology was taking place.

Therefore we will have to look into that question of the modal administrations, the strengths they have, and some of the barriers they present to innovation.

The ninth issue is, "Does the somewhat fragmented organization of the federal government act as a barrier to transportation technology?" I think we are commissioned here by DOT, but it is important to recognize that three other organizations are heavily in the transportation development operation business--NASA, DOT, DOE, in areas such as energy conservation, and EPA, in the environmental business. And, if we are going to talk about more basic programs, there is always the role of the National Science Foundation.

Whereas we may need consistency in regulation, we fortunately do not need consistency, or not as much, in R&D. On the other hand, it is important to see that there is adequate communication between these various programs, that the right agencies are used in the right way; this raises the question, for example, about NASA. Is it possible that we want a national transportation R&D plan? I, myself, would be very pessimistic about the ability of the federal government to put one together.

Then the last issue is, "Would changes in federal regulation, funding arrangement, taxation, or others of the Charpie-like rules help to stimulate transportation technology in industry?" One of the finest parts of Morlok's paper addresses this question. He points out that because of this encrustation of rules very little change takes place, and that change is certainly not necessarily innovation, but that when there is very little change taking place, then it is an almost impossible climate for any new technology to come in or for people involved to feel that they want it. And so he has made a recommendation, and I quote, "...it is imperative that a policy of the Department of Transportation be to take an active role in insuring that laws and regulations of the federal as well as other levels of government be written in a manner that is conducive to socially desirable forms of innovation."

That is our agenda. I will repeat what the other panel chairmen have said, and that is, the final report may be organized in a completely different way.

Also, I like Bruce Old's comment that we need to find out who is on the other end of the telephone. One of the advantages that our panel will have is that we know pretty well who is on the other end of our telephone.

TECHNOLOGY RESEARCH AND DEVELOPMENT POLICIES OF THE
FEDERAL GOVERNMENT AND TRANSPORTATION INNOVATION

BY

EDWARD K. MORLOK

This paper is intended to provide background information and ideas for the panel session entitled, "Technology and R&D Policies to Stimulate Innovation." It deliberately takes a rather broad view of the subject. This is primarily because a wide variety of policies affect innovation, research and development, and the deployment of transport technology. Furthermore, we contend that some fundamental changes in federal policies are necessary to stimulate innovation in transportation that is socially desirable. Many of the ideas and proposals contained herein will prove quite controversial; it is hoped that they will stimulate discussion and provide a basis for specific recommendations to DOT regarding policy changes and areas requiring more detailed investigation.

SOME CONCEPTS

Before we begin the discussion, it is necessary to define a few important terms and concepts with respect to both innovation and transportation. First, by innovation we mean the creation of a new product or service, or creation of a new process by which to produce that product or service, or a combination of the two (4). Innovation is differentiated from invention by virtue of the application or use of that new product, service or process. Without the application, the new ideas do not constitute an innovation, but rather simply an invention. Or to state the distinction more simply, "the difference between the processes of invention and innovation is the difference between the verbs "to conceive and to use." (11, p. 2).

Thus, the term "innovation" is certainly not synonymous with technological research and development. Innovation refers to a process. This process typically consists of four steps (this being taken from some unpublished writings of Herbert Holloman):

1. Creation of the new idea (product or process).
2. The research and development necessary to make that idea reasonably practical or applicable.
3. The refinement of that idea into a practical one, based upon initial application and testing.
4. General adoption and dissemination of the idea,

This description of the process in four steps is really one that reflects the view of the innovator, but there is a broader view that encompasses the assimilation of the idea into society and the further impacts of that assimilation. The process of innovation is really part of society's general process of adaption to change, whether that change be in resource

availability, in the needs or desires of people, or in other external conditions. As stated in the Department of Commerce report on innovation (11, p. 2),

...invention and innovation encompass the totality of processes by which new ideas are conceived, nurtured, developed, and finally introduced into the economy as new products and processes; or into an organization to change its internal and external relationships; or into a society to provide for its social needs and to adapt itself to the world or the world to itself.

These terms need some elaboration with respect to transportation. In the context of transportation, the product can be conceived of as a combination of the price and other characteristics of the transportation service that are important from the standpoint of the customer--a traveller or shipper of freight. These other characteristics include such items as travel time, comfort, likelihood of damage to goods, etc., and the collection of these is usually termed "level of service." Thus from the standpoint of a user (or buyer) of transportation, the product is described by its price and level of service. Since we usually speak of transportation as a service rather than as a product, for the remainder of this paper we shall use the phrase "transportation service."

An innovation could thus be the creation of a transportation service that is new in the sense that it has a combination of price and level of service that is different from preexisting forms of transportation. Thus high-speed rail service (once implemented) represents an innovation, since it is higher in speed and perhaps different in other characteristics from prior rail service. Similarly, the introduction of very rapid package or mail delivery services, such as Federal Express or the U.S. Postal Service Express Mail, also represents an innovation in the sense of a new transportation product or service.

A useful way to think about a transportation service innovation is by means of a figure, such as Figure 1, in which level of service is on one axis and price is on the other (7). Existing forms of transportation are indicated there, along with a new or innovative form of transportation, which is indicated by a new point in this level of service-price domain.

The second aspect of innovation relates to creation of a new process for producing an existing or new transportation service (in the level of service-price sense). An example of a process innovation would be the automation of rail rapid transit trains, which did not create a new service (since it did not alter in any significant way the quality of service or price of an existing transportation mode) but rather simply provided an alternative way to produce that service, using a higher degree of automation and less labor input. This change in the process of producing transportation represents an innovation. Of course, if there are substantial cost savings resulting from the application of such automation, then it might also change the transportation service in the sense of lowering its price.

Many innovations in transportation consist of either one of the other of the two types of changes, as indicated by the example above,

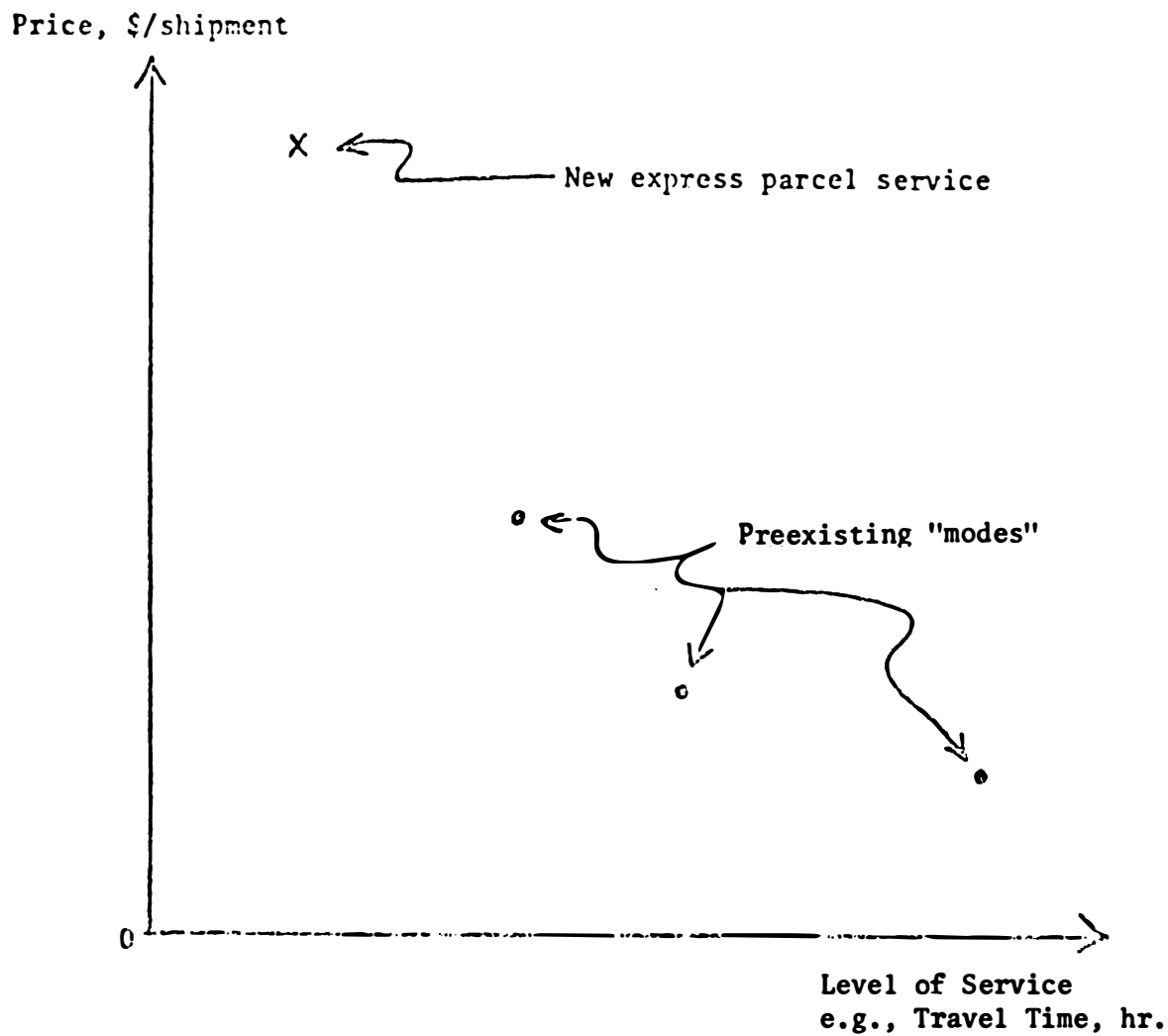


FIGURE 1 Description of innovations in transportation products or services in terms of price and level of service. Hypothetical example of a new transportation service or mode option for the shipment of parcels between a specific pair of cities. The new service has a price and service qualities that differ from previously available options.

while other innovations represent both new transportation services and new processes. For example, the introduction of air travel would represent an innovation consisting of both a new process, that of powered flight, and a new service in the sense of a new level of service and price combination.

An important question that remains is exactly how technology relates to these concepts of service and process and thereby to innovation. Technology refers to the process by which resources can be transformed into products (or services) that are of value to mankind. Our technological capabilities in carrying out this transformation can be described by the range of products (or services) it is possible to produce and the resources used or costs (in its broadest sense, including environmental costs, for example) associated with producing them. One portrayal of this might appear as in Figure 2. Here, for simplicity, only one measure of cost is used, and the product is homogeneous, so only the quantity produced is variable. At any point in time, the available technology might permit producing this product at the cost given by the line CD. As a result of development of new technology, it may be possible to reduce cost per unit to the line FG.

Turning from technology in general to transportation technology in particular, the capability to produce transportation can similarly be described in terms of costs and the nature and quantity of the product (or transportation service). The product characteristics are described by what was defined earlier as the level of service. The cost in general will depend on the amount of usage of the transportation system (because the amount of usage affects the amount of fuel consumed and because of congestion phenomena affecting the level of service, to mention two reasons), and hence there is an added dimension of usage. Thus the technology of transportation can be described by the relationship between cost, level of service, and usage, as shown in Figure 3. (This scheme for describing transport technology is developed and discussed more fully in reference 8, chapter 1.)

This conceptualization of transportation technology provides a framework for considering the effect of technological innovations. The set of points in this level of service-usage-cost space that corresponds to the known processes for providing transport describes the current state of transport technology. These might appear as the surface A in Figure 4. This would encompass all the known variations in hardware and operations of the existing means of transport and would include all the different "modes."

A technological innovation could result from two types of change. First, technological developments may enable the provision of a level of services that was heretofore unavailable. This extends the range of possible transportation service qualities as indicated by area B. The corresponding cost is given by the extension of the cost surface labeled B'. The second type of change is a reduction in the cost, as indicated by the shift of part of surface A to A'.

Such changes could result from technological developments embodying new hardware, or new ways of operating that hardware (operations plans), or both. The previously mentioned example of the innovation of express,

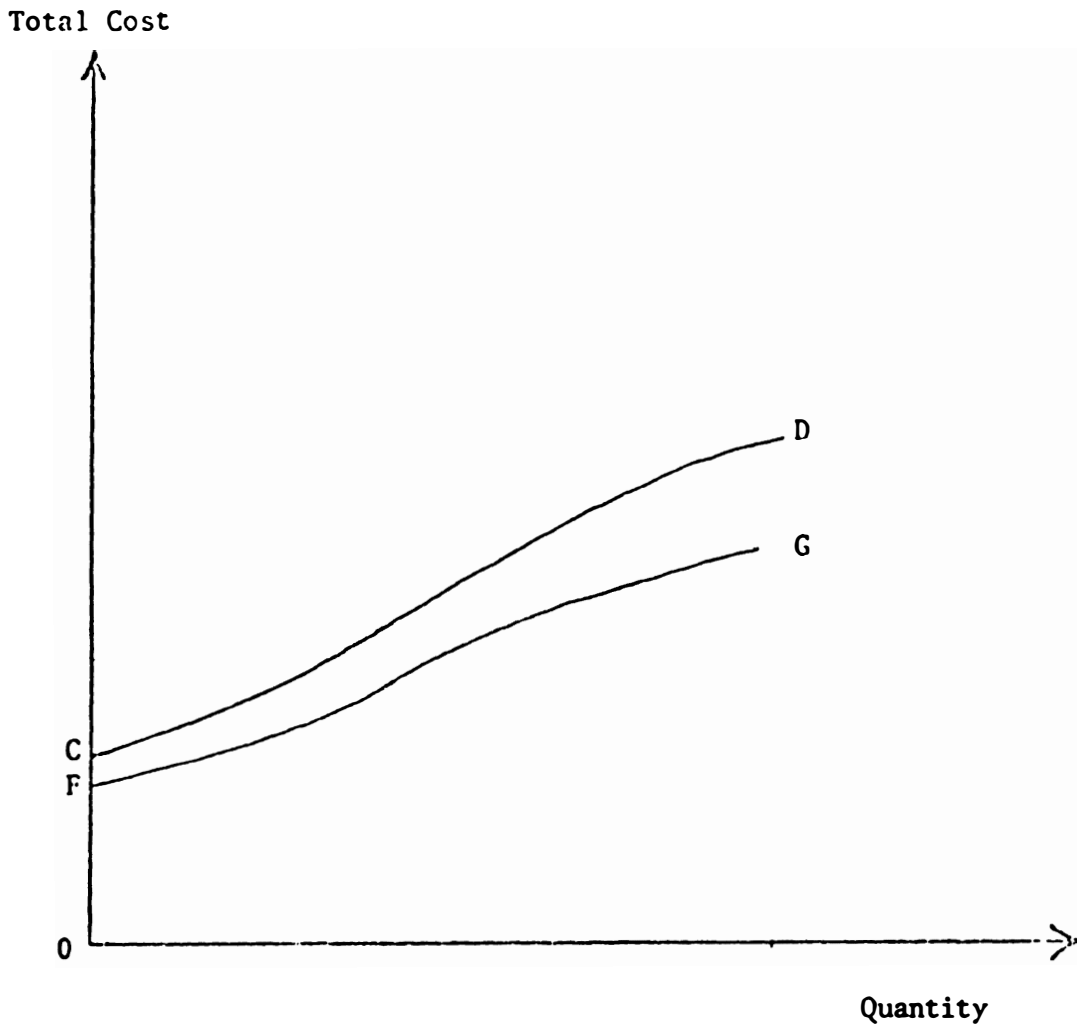


FIGURE 2 Technology described by the relationship between cost and quantity of a particular product.

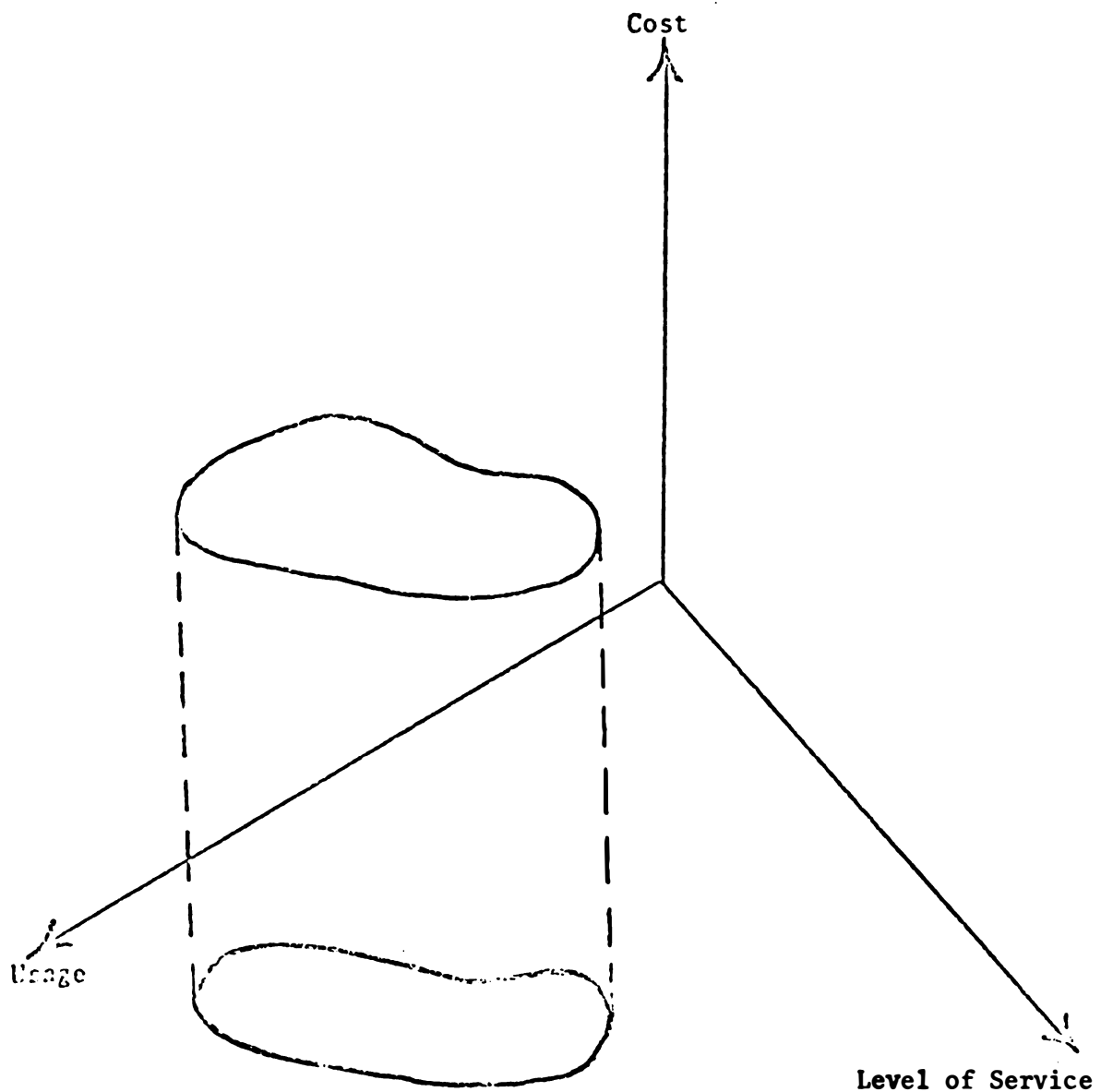


FIGURE 3 Characterization of transport technology as the relationship between cost, level of service, and usage.

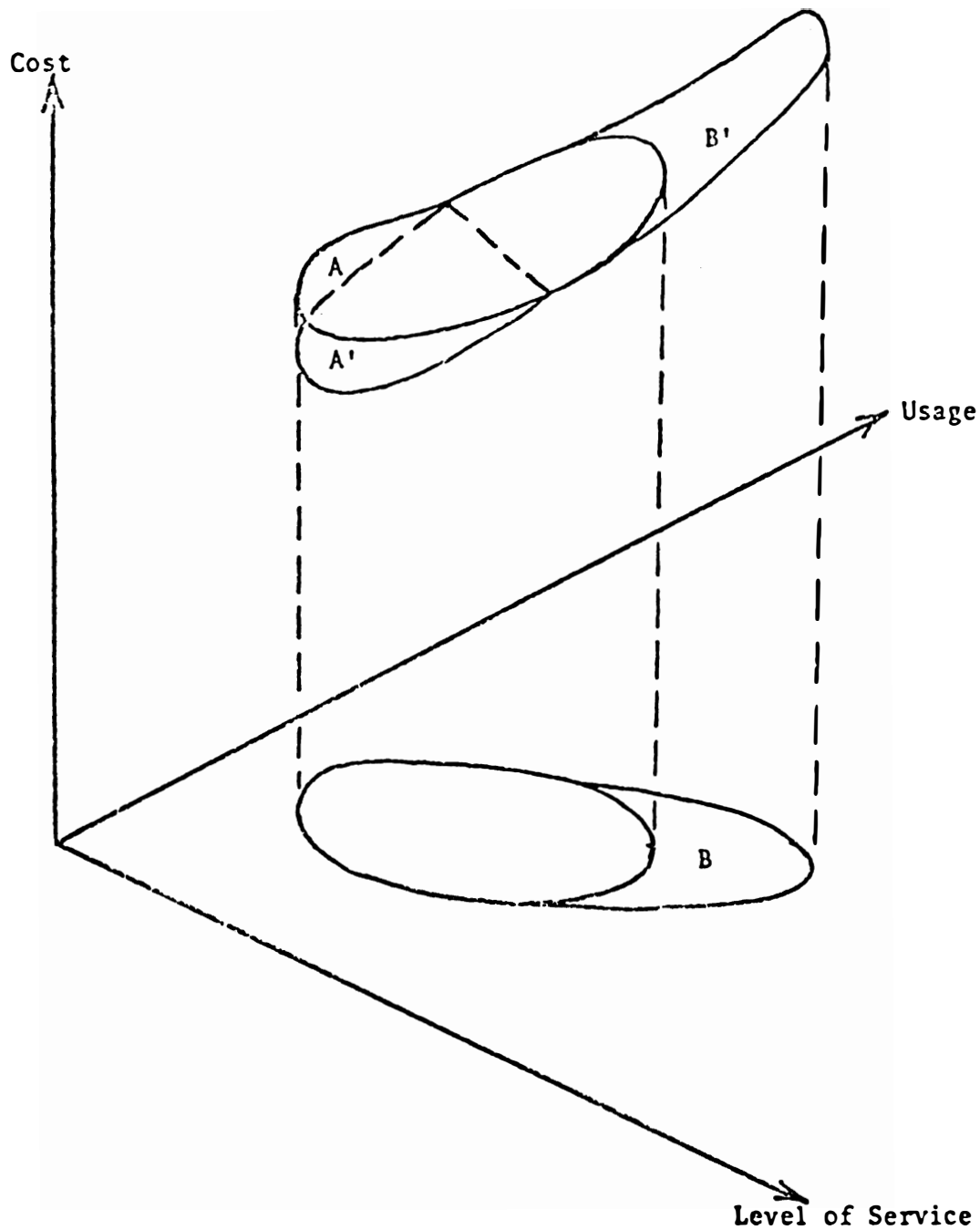


FIGURE 4 Technological innovations characterized by changes in the cost-usage-level of service relationship.

guaranteed delivery parcel service resulted primarily from operating available hardware in a new way. On the other hand, a new high-speed rail passenger service typically would involve primarily hardware changes from more conventional rail passenger service.

In this discussion of technology, price has not been mentioned. The reason is that the price charged a user does not necessarily bear any particular relationship to cost or other characteristics of the technology. It is determined primarily by institutional considerations. Of course, in our society most institutions are required to generate total revenue from users at least equal to total cost, although many transportation organizations are heavily subsidized so that prices can be set far below monetary cost.

What then are the roles of technology research and development in transportation? Clearly, these are (1) to expand the range of level of service that can be provided, and (2) to reduce the resource costs. These bear a brief discussion.

Expansion of the level of service options can occur in many ways. One is to develop what might be considered an entirely new type of transport technology, such as the aircraft. Some such new technologies do expand the range in ways that appear to have been useful and beneficial, as in the case of aircraft. Others, though, while new and different, meet with little acceptance and hence are not so beneficial, an example being the monorail (at least up to the present). On the other hand, many technological innovations in transportation that embody a new level of service require only modest or incremental extensions of existing technology. The express package services are one example, and the dial-a-bus concept in urban transit is another.

It is important to note that all service innovations in transportation do not require any underlying technological innovation. A service innovation may be simply a change in price. Special reduced fare plans represent one example, and the lowering of air fares in some markets as a result of increased competition and altered regulations represents another.

The reduction of costs also has many aspects. It is usually discussed in terms of reducing the monetary cost of production, but this is only one aspect. Cost is used here to mean all resources used in the broadest sense, and therefore cost refers also to resources used for which there may be no monetary payment, such as air pollution and noise (where the resource "used" is clean air or quiet).

SOME OBSERVATIONS

Although the preceding presentation of definitions was somewhat tedious, it will prove useful immediately because it provides the basis for a number of points related to innovation and R&D in transportation.

An extremely important point--and one that is often missed--is that there has been and probably continues to be a very substantial amount of innovation in transportation, despite all the rhetoric to the contrary. One need not look far to see this. Since World War II we have

witnessed innovations such as the introduction of jet aircraft, the rapid expansion of long-distance pipelines, the emergence of long-distance trucking in its many forms (private, contract, common, etc.), and the introduction of rapid, guaranteed-delivery parcel services--all of which represent both new transportation services and new processes. Also very recently, we have seen considerable innovation in urban transport, some involving new services and processes, such as dial-a-bus and Personal Rapid Transit (PRT), others providing innovative services but not involving a very substantial process innovation, such as transit services targeted to the needs of particular groups (e.g., for elderly and handicapped, high-quality commuter service, commuter clubs), and still others consisting of process changes that affect only resources used (e.g., automated rail rapid transit, rubber-tired rail transit).

Furthermore, the R&D underlying new inventions, and hence potential innovations, continues. Much of this is process oriented and often designed to reduce costs, such as work on improving fuel efficiency found in every mode. Other efforts portend changes in service, too, such as the railroad industry's efforts in car routing and control and the computerized methods for real-time monitoring and control of urban street networks (already implemented with respect to a few control variables on a small scale in a handful of cities).

Not all efforts are directed at refining what might be thought of as existing forms of transportation; some research on what might be termed entirely new systems is also underway. In particular, there is some work on the movement of merchandise freight in capsules in liquid or gas pipelines. Interestingly, to the best of my knowledge, the only R&D work on this in the United States is being undertaken by private firms, except for one small, preliminary study of economic feasibility of the so-called "solids pipeline" sponsored by DOT (12). Private R&D work has reached the stage of a short demonstration line to test the equipment. Prospects for this technology are difficult to judge, but even a former administrator of the Federal Railroad Administration has referred to solids pipelines as the "'sleeper' in freight transport technology" (6, pp. 54-55). Perhaps DOT has done so little in connection with solids pipelines because there is no home for such work; there is no modal pipeline administration, and of course such technology would be viewed as a threat in the context of other modal administrations.

It has also been argued that organizations currently engaged in transportation will concentrate their R&D efforts only on innovations that represent evolutionary changes in the technologies with which they are concerned. An implication of this, some argue, is that an entirely new form of transport would never emerge from such an evolutionary process. This is then taken as evidence of a need for government-sponsored R&D in new forms of transport, if such new forms are ever to develop. It is not at all clear that new forms of transportation, representing very significantly improved transportation services (in the level of service-price sense presented previously) or reductions in resource needs, would not occur. One reason is that what might be viewed initially as an evolutionary step in an existing form of transport may become

the basis for a major improvement in service and costs. An example is the replacement of propellers by the jet aircraft engine. Another reason is that one form of transport may emerge gradually from a previous one that continues on its own development path. An example is the railroad, which today is radically different from road transport but which evolved from horse-drawn wagons on gravel roads in the eighteenth century, the first railroads being simply road wagons operating on plank paths or "tracks." Thus, given the freedom to alter technology, a new form of transport can emerge in an evolutionary way to become what is then thought of as a form distinct from its origins.

Given the level of research, development, and implementation of innovations in transportation, care must be exercised so that changes in federal R&D policies do not damage desirable features of current efforts. In particular, care must be taken lest any increased federal efforts simply drive out private efforts and efforts at other levels of government.

ROLE OF GOVERNMENT

It has sometimes been argued that national governments really have relatively little influence on the pattern of innovation in society. For example, a 1971 Organization for Economic Cooperation and Development report concludes (10, p. 138):

The available information also shows that the main agents for the creation and application of scientific and technological innovations are the universities and industry. Uncertainty, change, the need for competition, flexible structures, rapid decision making, and being close to technological and market developments, all imply that technological innovation is more likely to flourish in a decentralized and pluristic environment. Thus, government roles in the innovative process, although important, are not determinant.

This statement is perhaps a bit misleading, for it really refers primarily to the direct influence of government actions on the amount and character of innovations. Clearly, the influence of government extends far beyond its direct actions, because governments create the framework within which other organizations act, and therefore will influence the direction and amount of innovative activity of other organizations. The federal government could influence innovative activity of others through a variety of channels, including but not limited to direct involvement in steps of the innovative process, incentives to innovation through taxation policies, regulations, and policies regarding the creation and dissemination of new knowledge.

The role of the federal government in transportation innovation is somewhat unique in comparison with other sectors of the economy, because of the direct involvement of government in the provision of transportation facilities and services. Most transportation facilities are provided by various levels of government, usually with considerable federal involvement in financing such facilities, sometimes from user charges

and sometimes from general taxes. Along with such funding there is considerable influence over planning and design, pricing, level of service, and other aspects of such facilities. Also, most of the transportation system that is not directly financed by the federal government--mainly privately owned carriers--is subject to regulation that is in addition to the general regulation of business enterprises. Such regulation is mainly by federal and state agencies and includes control over entry and exit from service, prices to be charged, and in some cases the level of the service. This involvement of federal government creates many ways in which it can influence the speed and direction of technological innovation in addition to policies related to R&D in general.

The ensuing discussion of possible federal policies toward research and development in transportation emphasizes the relatively unique involvement of the government in transportation. Thus the discussion touches only slightly on general policies toward R&D and innovation in general, such as in the areas of taxation or patent law. These areas are covered very well in existing literature(2,5,9) and an attempt to include the essence of such studies would be an injustice to such reports and make this paper overly long. Hence we shall focus rather specifically on "transportation" technology and R&D policies. This will be in the form of a discussion of major areas of policy, each of which will contain one or more specific policy recommendations.

Where Innovation is Needed

One of the most critical requirements is for information on where innovations are needed in transportation, or where innovation will produce benefits--to users of the transportation system or to others impacted by it. Such knowledge is of central importance as a guide to governmental policies related to technology R&D directly and to other policies that influence the adaptation of the transportation system in general. Innovations can be beneficial because they provide a new type of transportation service in the level of service-price sense discussed earlier or because they employ new technology that reduces the societal costs or negative impacts associated with that transportation. Identifying where innovations will be beneficial requires attention to both of the possibilities.

Turning first to "new" kinds of transportation services that might be offered, there would seem to be two primary means of identifying what types of innovations are likely to be beneficial. The first of these involves surveying users and potential users of the transportation system to ascertain the degree to which they are satisfied with the range of services (or "modes") now available and their current needs or expectations regarding the desirability of alternative types of service (again, in the sense of level of service and price combinations). Such a survey would in effect provide an assessment of the adequacy of the transportation system from the standpoint of performing its primary function, that of providing mobility. Hence this survey can be termed a mobility assessment.

It is perhaps amazing that while transportation (and other activities) is monitored from the standpoint of impacts other than that of its function, particularly environmental impacts, it is not now monitored with respect to how well it performs its primary function. Yet how well the transportation system meets the mobility needs of the nation is surely equal in importance to its potential negative environmental impacts. What is needed is a continuing assessment of mobility. Such a survey will be difficult to construct, but should provide substantial benefits in terms of indicating where problems exist in the transportation system. It is important to recognize that this assessment should address the adequacy of the system from the standpoint of the user and should not be an assessment against arbitrary engineering or other criteria, a type of assessment that is often made but that is not truly indicative of the degree to which the system is performing its function adequately. In addition to providing guidance for technology R&D, this assessment would also provide guidance for other policies and programs.

The emphasis in the preceding paragraph on evaluation of the adequacy of the transportation system from the standpoint of mobility is not to imply that other viewpoints such as that of the environment are unimportant. Along with the mobility assessment should continue assessments of environmental impacts, and in some cases these should be expanded. This presumably would be accomplished in cooperating with agencies already concerned with environmental matters. As was pointed out earlier, to some extent this type of assessment is already commonplace, as in the case of air pollution in metropolitan areas.

Closely related to this survey of transportation system users would be an attempt to identify mobility and other problems that are likely to occur in the future. The basic purpose of this would be to anticipate problems far enough in advance that corrective action, whether it would involve technological innovation or other changes to the transportation system, could be taken before the problem becomes damaging to society. It would attempt to assess future requirements for movement and then to determine the extent to which the system will accommodate those needs through its normal processes of adaptation and change. If that adaptation is insufficient, then this indicates a problem that requires corrective action. The corrective action could involve an attempt to develop new technologies or could be of another type, such as changes in regulations or funding. Some efforts are already being made along these lines, such as the National Transportation Needs Study, although existing efforts do not focus on anticipating future problems and attempting to design solutions.

Another important source of information on types of innovations that would be beneficial consists of the many governmental organizations that are already involved in planning and providing transportation facilities and services. Primarily as a result of federal requirements, there are agencies at various levels of government concerned with the planning of particular portions of the transportation system. These include metropolitan planning organizations at the local level, which are concerned with both passenger and freight transportation via all

modes within metropolitan areas; statewide transportation planning organizations, which have traditionally focused primarily on highways, air, and to some extent, water transport facilities, although now they are extending their purview to rail transport and to other carrier services; and various federal planning activities, such as those related to the overall air transportation system and water transport. As part of the planning function of these organizations, future needs for transport are assessed, and attempts are made to develop plans for system expansion to meet those needs.

At the present time, except for air transport, almost no consideration is being given to innovation within such planning agencies. Yet it is within these organizations that the need for and benefits of innovation could readily be assessed. Each planning unit presumably has developed some understanding of the need for transportation in its area of concern, and would be particularly aware of present and emerging problems, such as cost escalation or a lack of mobility among particular groups. A natural requirement or role for these organizations would be to provide information on the types of innovations, both service and process, that would be beneficial to the areas with which they are concerned. Since so many of them operate under federal guidelines at the present time, the mechanism already exists whereby these agencies could be required to produce statements of innovation needs and priorities on a regular basis.

This leads to the first set of recommendations for DOT policy related to R&D programs:

The federal government, in cooperation with state and local governments as appropriate, should assess the performance of the transportation system at regular intervals.

They should consider:

- adequacy in meeting the needs of users.
- viability of the organizations providing transportation facilities and services.
- impacts on development, resource use, pollution, etc.

A similar effort should be undertaken with respect to anticipating future problems--both near term and long term--considering the likely natural adaptation of the transportation system to changing conditions. Such a survey and studies would provide the basis for identifying and prioritizing problems in terms of severity and time frame.

This emphasis on understanding what types of innovations are needed, or might produce substantial benefits, is intended to create what might be termed a benefit orientation to innovation, whether that innovation will be developed essentially through government programs, or by the private sector, or by a combination of the two. Unfortunately, many government programs concerned with technology research and development, especially in surface transportation, seem to have been motivated primarily by the realization that a particular form of transportation could be developed to the point where it is technologically feasible, but with little or no regard for whether that technology would in fact create net benefits greater than those associated with the existing

technology that it was designed to replace. Examples of this include many of the efforts to develop new types of urban transit technology and much of the R&D effort in high-speed, intermodal intercity freight systems. This is of course not to imply that innovation in these two areas might not be beneficial, but simply to point out that much of the current research and development does not seem to have been directed in ways that would produce substantial gains. To correct this, it is recommended that:

Priorities for federal research and development efforts be based on consideration of (1) the role that innovations resulting from such R&D would play in alleviating current and anticipated future problems, and (2) the enhancement of the transportation system and its effect on the quality of life resulting from such R&D-associated innovations.

The R&D Program

Another important issue is what type of R&D program the government should have. A general conclusion that runs through much of the innovation literature is that the proper role of government in R&D is to extend the frontier of knowledge that is generic to a particular area, but to leave to the private sector the selection of specific technological innovations to be developed and brought into the market. This conclusion rests on a number of characteristics of the innovation process, in particular, the uncertainty of success, the need for firsthand knowledge of the potential markets as well as the feasibility of producing a particular new product, and the need for entrepreneurial skill, which are unlikely in governmental bureaucracies. Also, an important consideration is the fact that not much general or basic research would be undertaken by anyone, or not on a very large scale at least, without government support. This conclusion that the most effective role of government is in basic research seems to be so widely accepted that it would seem to be one of the most important policy guidelines for government R&D programs in transportation.

However, again on this matter it is important to recognize that there are unique features of transportation that can modify these conclusions about the roles of government and other organizations. Agencies of various levels of government are the buyers of many transportation system components, especially in the highway, transit, and air modes. As a result there are many impediments to R&D by suppliers of these components. R&D generally is not an allowable cost for which the government will pay. Also, some supplier industries may be so fragmented that no one firm could undertake any significant amount of R&D, as in some areas of construction. As a result, it may be necessary and appropriate for the government itself to undertake R&D that pushes much closer to readiness for application, or to directly fund applied R&D in the private sector.

Recognizing this caveat, though, the general policy guidelines would seem to be:

R&D sponsored by the federal government should be directed toward providing the knowledge and results that are necessary for private firms or publicly owned transportation agencies (e.g., state road departments) to refine and develop the new concepts to the point where implementation is possible. In general, every effort should be made to provide the bases for alternative technologies, rather than focusing on one approach, allowing the market to decide which approaches will ultimately be used.

Also widely accepted is the critical role played by basic research in technological innovation. For example, in a study of "five economically and socially important civilian innovations," it was found that of 341 key events that led to these innovations, approximately 70 percent were the result of "nonmission research," essentially equivalent to what we normally think of as fundamental or basic research, 20 percent were "mission-oriented research," and 10 percent were the result of specific development and application work (1, p. 84). While the fraction of key events behind any innovation that results from basic research will of course vary considerably among innovations, the importance of fundamental knowledge seems quite clear.

One of the basic problems in innovation in the transportation field is that the state of fundamental, generalizable knowledge is very limited and fragmentary at best. Most of the knowledge that has been generated is the result of rather specific application-oriented efforts. These are dominated by attempts to refine existing technologies (e.g., better materials, improved design guidelines) and by attempts to better project future travel as a guide to investment using conventional technologies. There is a continuing emphasis on research on specific missions and immediate application, with only a tiny fraction of the Department of Transportation budget being devoted to basic research in transportation.

If innovation in transportation is to be fostered, a program of basic research in transportation must be undertaken. Responsibility for this rests clearly with the Department of Transportation, for it is the only organization with the broad, long-term view and the financial resources to undertake such a program. Thus a recommendation is as follows:

The U.S. Department of Transportation should undertake a program of basic research in transportation, which would complement and support its mission responsibilities and provide the knowledge base on which future innovations in transportation can be developed. This program should include research on (1) the role of and need for transportation in society, (2) alternative technologies for meeting those needs, (3) alternative organizational arrangements for supplying transportation, and (4) the impacts of transportation on society.

Probably the most appropriate mechanism for undertaking such a research program would be a program of support to key universities and organizations concerned with basic research in this field. To be effective, such support must give wide latitude to the nature of problems

studied, must be sufficient to support units of substantial size and diversity of talents at each institution, and must provide continuing funding over an extended period. Such a program would be comparable to the support for basic research in many areas of physical science and mathematics by the military in the two decades after World War II, a period in which there was tremendous advance and innovation in those areas. It has been observed that with the reduction in emphasis on military matters and the increase in attention paid to civilian problems, one of our society's major problems is to reorient basic research toward the more important civilian problems and away from areas that have application primarily in the military. (This is discussed at length in reference 5.) Transportation is clearly one such area.

Such a program of basic research in transportation would be in addition to the current research programs of the Department of Transportation, which are primarily within the several modal administrations. Current programs include technology research and development within the sphere of each mode, and for the most part this research seems quite adequate. The major exception is, of course, pipelines, since that mode is not represented in the department by an administration, nor is it covered by a separate agency (as in maritime transportation).

Technical Institutes

Related to these considerations is the coupling of the results of R&D with potential users. A common suggestion is for this to be the function of research institutes, which would be capable of conducting some of their own research and development (falling between the basic research typically conducted at universities and the applied R&D work typically undertaken in private industries). These institutes would be charged with the responsibility for working closely not only with governmental organizations involved in transportation but also with private sector organizations such as carriers, vehicle manufacturers, and construction firms. Another function of these organizations could be to assist entrepreneurs who are developing new products or services. Such assistance could range from technical advice to helping to identify potential users, financiers, etc.

Organizations that perform some of the functions of such institutes already exist. These are in the research units that were formed at the state universities to assist state road departments in the construction, design, maintenance, and operation of highways. Some of these have expanded to encompass other areas of transportation, but rarely with the close coupling to the various external organizations evident in the highway transportation areas. The tremendous strides made in highway design and operations attest to the value of such coupling, although of course it required substantial, continuing funding. But there are significant differences between the organizations involved in the provision of highways and those in other areas of transportation, so the same form may not be applicable elsewhere. However, the potential benefits are so high that:

The DOT should explore the appropriateness of creating technical institutes where the primary function would be cooperative research and development involving various levels of government and private industry.

R&D Funding

Programs such as those sketched above will not be inexpensive, and it will not be easy to obtain necessary funding in this period of fiscal restraint. A separately budgeted research program would elicit considerable opposition, and scrutiny of each element would undoubtedly lead to elimination of many promising lines of inquiry. For these reasons, it would seem prudent to associate the research with major DOT program areas rather than have it appear as a separate, very vulnerable, item. An approach that has been used quite successfully in the past in highway programs is to allocate a small fraction of program expenditures to research. Even though the fraction was quite small, 1 1/2 percent, the results in that field were very significant and beneficial, as was pointed out previously. A major difference between that highway research program and a general transportation research program would be that the general program should encompass all forms of transportation and should reflect the needs of users, other impacted groups, and transport technology and organizations in general instead of focusing on research that would necessarily fit into the purview of one or more modes. Therefore, on funding it is recommended that:

To insure adequate funding of R&D, it should be DOT policy to set aside a small fraction of all expenditures for research and development. This set-aside should be distributed between (1) R&D directed toward evolutionary improvement in that area of transportation (mode, organization, etc.), and (2) R&D directed toward providing the basis for major innovations and improvements in the transportation system in general.

Barriers to Innovation

A final important area for fostering technological innovation in transportation is the elimination of many barriers to innovation that exist as a direct result of the present form of federal (and other) government involvement in transportation. As was mentioned previously, transportation is somewhat unusual in that the government is heavily involved in regulating many transportation activities and also because the government is involved in funding many such activities.

With respect to regulation, it seems clear that virtually no cognizance is taken of the effect of current economic regulation of transportation on the pattern or degree of innovation in the regulated industries (3). It is also clear that regulation is in no sense neutral with respect to technological innovation. In some cases, such as the airline industry, the rate of technological innovation may have

increased as a result of regulation in comparison to what it would have been without that regulation. In contrast, in the railroad industry it is equally clear that the current pattern of regulation has impeded many innovations that the carriers would have liked to have undertaken and undoubtedly has created a climate so difficult for much innovation that many are not even considered. Some change in this climate will undoubtedly occur as a result of current efforts at regulatory reform, but the reforms seem to be based primarily on considerations other than innovation, and therefore the result may still be a regulatory process not in consonance with innovation.

Regulatory agencies must begin to consider the effect of their rulings on the propensity and ability of the regulated carriers to innovate and adapt to changing conditions. Changing habits or regulatory agencies will undoubtedly take many years to bring about, but certainly the change can be accelerated by specific requirements for such agencies to consider the effect of their decisions on innovation, in effect requiring them to produce innovation impact statements as part of their decision process.

Another type of regulatory change that would drastically improve the climate for innovation would be to give providers of transportation services much greater latitude for experimentation with new types of services and processes for delivering them. Clearly, there would have to be some limit on the amount of service that could be involved in an experiment or the entire regulatory process would cease to exercise control over the system and would become meaningless. But at the present time the regulation seems to be so rigid as to preclude trying many promising ideas, and unless they can be tried, they will never become innovations. This freedom to experiment on a limited scale would ideally apply not only to carriers already performing a service but also to new entrants into the field, so that new forms of service, new institutional arrangements, etc., could all be tried.

The second important area of government involvement is that of funding many transportation facilities. Highway facilities are largely funded through a hierarchy of charges or taxes collected from highway users by the federal, state, and local governments, most of which is spent by state and local agencies to construct and maintain the highway system. Other services such as urban public transportation and Amtrak are financed by federal and local monies collected from general taxes and revenues from users, while others such as the waterway system are funded primarily from general taxes only. These mechanisms often are quite rational from the standpoint of raising money and then providing that money to those who need it, but such mechanisms often are deficient from the standpoint of encouraging efficiency and innovation in socially desirable ways. Perhaps one of the most notorious examples of this is in connection with the funding of the Interstate System, in which each state is permitted to build up to a certain number of miles of interstate highway. As the Interstate System is nearing completion, states are realizing that it is in their selfish interest to make the remaining few miles as expensive as possible, in order to maximize the influx of "federal" monies into their states. This creates a disincentive to innovation that would reduce the cost of such programs.

Less dramatic, but perhaps of more significance given the amounts of money involved, are the consequences of federal funding mechanisms for other parts of the transportation system. For example, in the case of more typical urban transit or highway projects in which the federal government pays 80 percent of the capital costs (the state and metropolitan area paying the remainder), there is the temptation to maximize expenditures so as to maximize the amount of federal money flowing into the area. After all, \$4.00 or more of "federal" money is attracted to the region for every \$1.00 of local money. Furthermore, there is a natural hesitancy of those in the political process to experiment with any innovation, for these have a higher risk of failure than traditional approaches. Few persons are criticized for taking the safe course of traditional technology even if an innovative approach might prove more beneficial, but criticism will be loud and clear if one initiates a failure.

Also creating disincentives for innovation is the form of federal funding of operating losses on urban transit. Current laws provide for the matching of local funds, with little or no regard for the efficiency with which funds are expended. This, in conjunction with the politicization of key managerial functions (fares, areas to be served, routes, levels of service, and management posture in labor negotiations), and the monopoly position of most public transit organizations, creates a climate that discourages much innovation. Added to this are federal requirements for capital project funding that protect labor to the point of perpetuating outdated staffing practices. This is a dismal setting for innovation indeed.

Thus substantial disincentives to innovation are built into existing federal programs in transportation. This has a direct bearing on technology R&D, for if there is little likelihood for implementation of new or improved technology, there is little point to developing it. It is analogous to pushing on a rope; unless there is a pull at the other end, nothing will happen.

Overcoming these disincentives will not be an easy task. One solution is to increase the possible gains to the local area resulting from innovation. The disincentives inherent in current funding might be eliminated by substitution of some type of grant funding for matching funding. In the grant funding there would be a ceiling on the amount of money that might flow into an area for transportation projects. Such funding would create an incentive to maximize the benefits to the region from the expenditures, and innovations that promise particularly large potential increases in those benefits presumably would be more likely to be tried. If an innovation were successful in one location, then the uncertainty or risk in other situations is reduced and it is more likely to be applied elsewhere.

This type of funding change in conjunction with increasing sensitization of state and local transportation agencies to the prospective benefits of innovation (through such means as requiring innovation priority statements, as mentioned above) should go a long way toward improving the climate for innovation. If federal efforts at innovation are shaped by local priorities for innovation, then the innovations

that are developed should be more in keeping with local needs, and the likelihood of implementation should increase correspondingly.

Much of the foregoing has related to innovation in general rather than technology R&D in particular, but there is a direct connection. If there are substantial disincentives or barriers to innovation, then there is little likelihood of even very promising ideas being implemented. In this case, research and development of improved technology is a futile exercise, for it is unlikely to be used. Moreover, efforts to develop an R&D program are likely to be opposed, for many will see it as a waste of government energies and resources, and justifiably so. Thus the climate for innovation has a direct bearing on the development of an R&D program. It is recommended that:

Just as transportation R&D must ultimately be responsive to the needs and priorities of society, so must the private and public organizations that control the transportation system be receptive to innovations. Therefore it is imperative that a policy of the Department of Transportation be to take an active role in insuring that laws and regulations of the federal as well as other levels of government be written in a manner that is conducive to socially desirable forms of innovation.

EPILOGUE

This paper has approached the question of federal policies on technology R&D and to stimulate innovation in transportation from a rather broad perspective. It has focused on questions of the proper purpose and scope of the DOT R&D effort, its relationship to other organizations involved in the provision of transportation equipment, facilities, and services, and its relationship to other governmental policies in transportation, such as economic regulations. It has suggested some policy guidelines in these areas, but in the spirit of the charge "to develop suggestions for more detailed analyses and evaluation" it has not attempted to carry suggestions to the level of specific actions or programs. The panel sessions will provide an opportunity to attempt to develop more specific recommendations to DOT regarding policy changes and questions that require further attention.

REFERENCES

1. Abernathy, W.J., and V.S. Chakravarthy. Technological Change in U.S. Automobile Industry: Assessing Past Federal Initiatives. DOT-TSC-NHTSA-79-13, Transportation Systems Center, report to the National Highway Traffic Safety Administration, by Lexington Technology Associates, Lexington, Mass. Washington, D.C.: U.S. Department of Transportation, 1979.
2. Advisory Committee on Industrial Innovation, of the Domestic Policy Review on Industrial Innovation. Review and Recommendations of the Policy Alternatives of the Public Interest Advisory Subcommittee, draft report. Washington, D.C.: U.S. Department of Commerce, 1979.
3. Boyd, H. Inducing the Development and Adoption of Socially Efficient Automotive Technology. DOT-TSC-RSPD-78-4, Research and Special Programs Directorate. Washington, D.C.: U.S. Department of Transportation, February 1978.
4. Gellman Research Associates, Inc. Economic Regulation and Technological Innovation: A Cross-National Literature Survey and Analysis. 3 vols. A report to the National Science Foundation, Jenkintown, Penn., 1974.
5. Gilpin, R. Technology, Economic Growth, and International Competitiveness. A report prepared for the use of the Subcommittee on Economic Growth of the Joint Economic Committee, Congress of the United States. Washington, D.C.: U.S. Government Printing Office, July 1975.
6. Lang, A.S. "Demand and Supply: The Technology of Transportation." In The Future of American Transportation, edited by Ernest W. Williams, pp. 41-57. Englewood Cliffs, N.J.: Prentice-Hall, 1971.
7. Morlok, E.K. Introduction to Transportation Engineering and Planning. New York: McGraw-Hill, 1978.
8. Morlok, E.K. An Analysis of Transportation Technology and Network Structure, Evanston, Ill.: Northwestern University Press, 1969.
9. National Academy of Sciences. Technological Innovation and the U.S. Economy. An Academy Forum held in Washington, D.C., November 14, 1973.
10. Organization for Economic Cooperation and Development. The Conditions for Success in Technological Innovation. Paris, 1971.

11. U.S. Department of Commerce. Technological Innovation: Its Environment and Management. Washington, D.C.: U.S. Government Printing Office, 1967.
12. Zandi, I. et al. Transport of Solid Commodities via Freight Pipeline. 4 vols. A report prepared for the Office of University Research. Washington, D.C.: U.S. Department of Transportation, July 1976.

TECHNOLOGIES AND R&D POLICIES TO STIMULATE INNOVATION

BY

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INTRODUCTION

The practice at the federal level of stimulating innovation in transportation is faulty, lags behind that of our international competitors, and has diverged from theory. This results in serious consequences for the consumer, industry, and the competitive position of U.S. commerce.

The stimulus for innovation is frequently discussed in terms of demand-pull or technology-push. In demand-pull, the usual strategy is to depend on involvement of the users of the innovation or their surrogates, market-research personnel, to determine market needs. Under this strategy, the role of government is to remove obstacles to the free expression of market forces so that development of technologies will be appropriate and will satisfy operators and users. In the technology-push approach to innovation, one relies on the market intuition of technologists as to what users or operators, that is, the market need or want. The demand-pull strategy has been exemplified, at least historically, by the automotive industry. Technology-push is exemplified by NASA's programs. While the distinction between demand-pull or technology-push may be useful to analyze technological innovation, both are frequently necessary to introduce innovation into the marketplace. Successful innovation depends on knowing when each approach should be emphasized and when one might make a transition from one approach to another and which institutions to go to to make sure that each approach has a reasonable chance to make its contribution to the introduction of innovation into transportation.

While there has been innovation in transportation, it has not been in general due to a thoughtful federal initiative. At times the federal role seems perverse: demand-pull has been used where technology-push would probably have been more effective and vice versa; the ability to respond to markets has been inhibited when the government itself if the customer; and, in some cases, modes have been pressured to accept inappropriate technologies and these actions have usually been publicized with elaborate performances by public affairs officials.

If these comments seem harsh, consider the following:

1. The Metro cars for the Washington-New York corridor were specified and designed in 1967 to operate at 175 miles per hour although the roadbed, catenary, and trains on parallel track would be destroyed at these speeds. The justification was to outperform projected Japanese trains, which were in fact not built.

A high-speed air cushion vehicle from McLean to Dulles airport was proposed by a secretary of transportation to be constructed within 18 months, in time for Transpo 1972 as a demonstration project. Technologists questioned the schedule, economists questioned the market, OMB observed that it went from no place to nowhere. It was cancelled.

3. The Morgantown Project was to be completed in time for the President's daughter to make a campaign-oriented inaugural ride. Trouble-free service occurred much later.

4. Passive automotive restraints were mandated before there were field data on the performance of passive belts. A program to obtain adequate field data on air bag restraints proposed by one secretary of transportation, who then decided to reinvent the automobile, and then resigned, but for other reasons.

5. The Downtown People Movers demonstration was inaugurated by DOT, but an adequate technological base to provide options for city planners was lacking. The technological options made available to German city planners by their Ministry of Research and Technology are considerably more extensive and have been developed in a shorter time and with less funding than comparable U.S. programs.

6. Transbus specifications were changed by four successive secretaries of transportation. The last change--made despite warnings of problems perceived by both operators and manufacturers and contained in an Office of Technology Assessment report--resulted in no manufacturer responding to the bid request.

7. A microwave landing system was first demonstrated in 1946. A more refined microwave landing system was approved by the International Civil Aviation Organization (ICAO) in 1977. Implementation is not yet in sight. Yet 50 percent of fatalities are associated with the approach and landing phase of flight. A constant concern of users of the air traffic control system relates to the length of time taken to complete and implement engineering and development programs.

While all these programs are complex, and while capsule criticisms are sometimes glib, the thrust of this small sampling is correct: DOT has not stimulated innovation successfully.

DOT STIMULATION OF INNOVATION IN AUTOMOTIVE TRANSPORTATION--WHERE IT IS NEITHER CUSTOMER NOR USER

The proper federal role in transportation innovation should vary significantly from mode to mode. In automotive transportation the government's role over the last 10-15 years has been to promulgate certain health and safety standards and, more recently, certain performance standards with respect to fuel economy. Prior to these 10-15 years, the

government had essentially no role with respect to the automobile itself, although it did have a significant role with respect to arranging the financing for highways and highway maintenance. Consideration is now being given to an expanded federal role in research as it applies to the automotive industry.

There have been some minor and mostly unsuccessful federal research and development efforts in support of the automotive environmental and safety regulatory programs. For example, DOT's Research Safety Vehicle program and EPA's, then ERDA's, and now DOE's support of automotive power systems that might satisfy the requirements of the Clean Air Act and be fuel efficient have not successfully achieved their objectives.

The Automotive Power Systems Program had expanded more than \$50 million by 1977 and has since been budgeted for much higher expenditures. The initial purpose of the program was to demonstrate automotive engine technologies that would meet the 1975 emission standards established in the Clean Air Act of 1970. The program in fact had little impact on any of the technological approaches that the automotive companies selected to meet the emission standards. The program concentrated on external combustion technologies rather than exhaust treatment. All the external combustion technologies turned out--in accordance with the automotive industries' predictions--to be significantly less efficient than internal combustion technologies. The Office of Management and Budget directed that program efforts should not be duplicative of automotive industry efforts. This seems quite reasonable. But this forced the program to look at precisely those technologies that the automotive industry found unattractive. This is not a recipe for efficient use of federal funds.

There have been claims that this program could have been more successful if its designers had recognized that automotive technology was mature and federal support has to be at a more basic level in the R&D hierarchy in order to make a contribution and that basic support of catalyst phenomenon or combustion theory research would lead to a successful federal intervention. However, catalyst experts today make a good deal of money protecting their proprietary position, the experts are likely to be wary of the constraints associated with federal money, and the government should not support the inexpert. Furthermore, those technologies that might lead to low pollution levels and high efficiencies--the Stirling and Stratified Charge engine--are probably more limited by cost and manufacturing technology than by basic combustion theory. There is thus some question as to the effectiveness of federal support of automobile engine manufacturing technology--a subject more familiar to industry than government.

Some say that EPA's Automotive Power Systems Program was initiated to forestall an even more expansive program that Congress was intent on legislating. Perhaps the Automotive Power Systems Program exemplifies a damage-limiting justification for R&D investment, which is a novel wrinkle in economic theory. However, as serendipity would have it, evidently some burner technology--developed under this program for turbines--may be useful in boilers, and ceramic turbine blade developments, also supported by this program, may yet be developed and find applications.

Some claim that federal automotive R&D support is needed for those companies in the industry that are marginally viable. Automotive companies are marginally viable because of management problems and federal regulatory excesses, and it is hard to conceive how federal R&D support corrects these deficiencies.

However, there is an economic rationale for some federal support of basic R&D that might aid automotive and other technologies. Companies cannot fully capture the benefits of long-range R&D, and therefore long-range R&D is insufficiently funded by the private sector. The criteria for additional federal support, however, should include joint private/public sector funding, project selection and supervision, as well as full disclosure and public ownership of results. Perhaps an automotive equivalent to Electric Power Research Institute (EPRI) is needed, but it must be structured with the recognition of the fact that the automobile companies do maintain large laboratories accomplishing long-range R&D that might lead to proprietary technologies in a competitive industry, whereas utilities have not supported such facilities and proprietary technologies are not as relevant in a regulated industry.

The result of the Research Safety Vehicle (RSV) program also raises some disturbing questions. DOT displayed its RSV vehicle with great fanfare only to have the president of General Motors confront a secretary of transportation on public television with the fact that GM's X-body car had equivalent safety characteristics, better fuel economy, and more occupant space than the RSV car. Thousands of X-body vehicles were being produced per day at the very time the RSV was unveiled. DOT personnel have confirmed the observations of GM's president. Thus the RSV program does not seem to have been a good use of federal funds.

In summary, the federal government can probably do little that is helpful by direct R&D support of automotive technology. However, a great deal could be done to promote cost-effective innovation by much better federal performance in evaluating and setting automotive emission and safety standards. A few specific suggestions are in order:

1. The mandatory use of seat belts is an innovation that has resulted in more than 75 percent of utilization of harnesses in approximately 20 countries. No U.S. secretary of transportation has attempted such a program despite innumerable studies demonstrating that this is the single most beneficial safety innovation available. No foreign country has adopted the U.S. approach of passive restraints. Why is there a barrier to this innovation in the United States?

2. Carbon monoxide is the one pollutant that can be personally monitored. This can be done by measuring the carboxyhemoglobin (COHb) content of blood. The current ambient monitor of CO is a poor indicator--its measurement varying by factors of at least two depending on trivial changes in location. EPA has not accepted this innovative and more accurate approach to measurement. This in turn increases the stringency of emission standards because of uncertainties, and this then limits the range of automotive innovation.

3. Reducing hydrocarbon emissions in the Los Angeles basin reduces oxidant levels. Reducing hydrocarbon emissions in the Northeast has no impact on oxidant levels. EPA has refused to contemplate the

innovation of a regional approach to automotive emission control, even though the California standards have always differed from federal standards. This barrier to innovation ripples through the system causing needless expenditures.

DOT STIMULATION OF INNOVATION IN AIR TRAFFIC CONTROL--WHERE IT IS A CUSTOMER BUT NOT A USER

Government involvement in air traffic control, where the government is its own customer, is and should be different from federal involvement with automotive innovation. While the users of airways are mostly in the private sector, they utilize a federally operated air traffic control system and must comply with its procedures and safety and equipage regulations. Their economic fate and their physical safety depend on the safety and efficiency of the air traffic control system over which these users have little control, except by appealing to Congress or the FAA. However, the FAA has been sensitive to this problem and has instituted formal user consultative conferences and interchanges to assure user input to FAA engineering and development (E&D) initiatives. Some user comments resulting from this process illustrate the value of a formal user consultation.¹

The user community did develop some general conclusions concerning operational restraints on E&D objectives. For example, all users recognize the need for evolutionary development of the ATC system--not as an excuse for slow development--but as a recognition of the limits to change in a system that operates in real time with many lives at stake and with massive investments in the training and proficiency of hundreds of thousands of people and measured in the tens of billions of dollars of equipment. This evolutionary requirement is certain to cause complications, expense and delays in upgrading center and terminal automation.

The FAA must obtain whatever manpower and money is required to accomplish this vital program.

A constant concern of the user community relates to the length of time taken to complete and implement certain vital E&D programs. For example, M&S has been under development for a decade and still has many remaining uncertainties so that an eventual implementation date is simply not in sight. The rate of development of the Vortex Avoidance System (VAS) is of equal concern. Meanwhile the airport capacity issue becomes ever more serious.

The user community is also concerned about the need for improved integration of E&D programs within the E&D structure of FAA, with other relevant organizations in FAA and with users and manufacturers. The troubled introduction of autoland is an example of the problem. Pilots first attempt automatic landings under better visibility conditions than the minimum certification of their equipment. This provides

¹ Quotes are from "New Engineering and Development Initiatives--Policy and Technology Choices," DOT-FA77WA-4001, vol. 1, March 1, 1979.

early familiarity with the equipment in a forgiving environment. However, the ILS signal quality is less satisfactory in this environment than under poor visibility conditions, such as CAT II, when aircraft must avoid areas that adversely affect the ILS signal quality. The autoland system follows the ILS vagaries faithfully, but the pilot is sure he can accomplish a better landing manually, so the pilot decouples, his familiarity suffers and his reluctance to use autoland increases. Unfortunately there are other inconsistencies between some ATC procedures and autoland capabilities. Furthermore, the reliability specification is unrealistically high. Therefore its complexity is great and maintenance expensive. When aircraft operators realize autoland is not used frequently by pilots, they are less fastidious about its maintenance. This discourages pilots even more. Obviously, coordination between pilots, manufacturers, operators, FAA flight standards and MLS advocates is needed if autoland is to become a reality as NTSB suggests. Could an organization or process within FAA coordinate all the participants in an effort to achieve utilization of autoland?

Another example has to do with airport capacity. Exquisite integration is needed between runway, exit and taxiway design, terminal automation, M&S, wake vortex avoidance, MLS and surveillance of the surface and the terminal airspace, in order to squeeze capacity into airports safely. Could an organization or process within FAA--perhaps as an extension of the present Airport Task Forces--integrate the various components needed to improve airport capacity on a site specific basis?

One last example deals with upgrading the air traffic control process in centers and terminals. This is a huge and necessary undertaking. The development of the desired ATC capabilities requires significant effort in two areas: first, the establishment of new automation concepts, the related operational procedures and the corresponding computer algorithms; second, the procurement and implementation of the necessary hardware and software to support the automation requirements. The first of these two tasks may well be the most time consuming and difficult since it involves exploration of some fundamental changes to the ATC process itself.

The removal of rotating beacons from airport terminals and compass locators from outer markers has caused pilots unnecessary difficulties measured against the trivial cost of maintaining these facilities. In some cases, pilots will not accept a visual clearance to an airport on a clear night because they cannot identify the terminal against a background of urban lighting in the absence of a rotating beacon. This decreases airport capacity and increases controller work load. While this issue is not as significant as most E&D policies discussed previously, it is included here to illustrate the value of formal user consultation.

These quotations indicate the value of formal consultation with private sector users of the government-operated ATC system to be sure that federal programs respond to perceived needs. The users know they fund E&D products through the trust fund and were not reckless with their suggestions. As one can see from this abstract of user comments, FAA has had difficulty completing programs in a timely way owing to money limitations and the long and burdensome process of obtaining approvals for technological developments through FAA, DOT, OMB, and the Congress.

DOT STIMULATION OF RAILROAD INNOVATION--WHERE IT IS NEITHER CUSTOMER NOR USER

The Federal Railroad Administration (FRA) also has a problem making sure that its R&D is consistent with the needs of the railroads. As was indicated previously, some early programs were driven by technology rather than market needs, and the results were unfortunate. In recent years, FRA and the Association of American Railroads (AAR) have developed a way of jointly funding R&D programs. An evaluation of this process for AAR concluded²:

...The AAR's policy of bringing 'funds to the table,' negotiating joint programs and maintaining a high level of R&D competence within AAR to orchestrate the effort is an excellent approach to public/private sector management of R&D. Neither the Air Transport Association (ATA) nor the American Public Transit Association (APTA) has done as well as AAR in recent years in modulating federal R&D programs to meet user needs. This is the case despite the fact that APTA represents local governments--public bodies--while AAR represents mostly private sector interests. AAR's better record seems to be due to at least two factors; neither APTA nor ATA invests money in R&D and neither organization has a strong R&D capability. As a result, members of ATA have had to install safety equipment of dubious value developed and mandated by the FAA; and APTA has had to endure various bus and train demonstration programs that they felt were inappropriate and badly executed and that have led to mandated equipment they do not wish to operate.

DOT STIMULATION OF TRANSIT INNOVATION--WHERE IT IS AN INDIRECT CUSTOMER BUT NOT A USER

The Urban Mass Transportation Administration (UMTA) funds R&D that it hopes will be useful to the transit properties, most of whom are supported by

² "Joint Public/Private Sector Management of Railroad R&D," Economics and Science Planning, Inc., May 24, 1977.

capital and operating grants from UMTA. Many issues face:

...federally supported R&D when (1) the ultimate customer is not the federal government but local transit properties; (2) the ultimate user is the public with many diverse interests; (3) the manufacturers' investment in development and tooling is predicated not only on market forces but also on federal and local regulations and procurement policies and most particularly their steadiness; and (4) there are government concerns about anticompetitive concentration.

Some observers have described transit system development under these circumstances as follows:

The user is not the buyer, the buyer doesn't pay for it, the payer usually doesn't buy it or use it, the operator is a professional who doesn't use it, pay for it, or buy it.³

UMTA An Office of Technology Assessment report⁴ evaluated some early efforts as follows:

The Transbus program focused on a product rather than development of the key components that would make that product practical in revenue service. Fearing increased maintenance and reliability costs and service penalties because of the uncertain status of key components, such as cantilevered tires, brakes and axles, the transit operators withdrew their support. Transbus as initially proposed and conducted was overly ambitious, expensive for what was accomplished and delayed an interim or advanced bus. Future financial support for Transbus could be used more effectively if directed at component development and evaluation.

The transit operators view the SOAC (State-of-the-Art-Car) demonstration with mixed feelings. To some it was useful, to others it was not. Urban Mass Transportation Administration (UMTA) during the period 1968-1972 took the approach that aerospace technology and management techniques could offer substantial benefits to the transit industry. In this spirit, UMTA determined that a SOAC demonstration would be useful even though it incorporated no new technology.

The ACT (Advanced Concept Train) program was overly ambitious, troubled with unrealistic cost estimates, late deliveries and management problems. ACT incorporated in its subsystems several important technological innovations which, when proven, are likely to be adopted by transit properties. An ACT program aimed at subsystem development and evaluation rather than construction of an integrated vehicle might well have been more effective at less cost. Present UMTA management has recognized this situation and has instituted an Advanced Subsystem Development Program with these objectives.

³ "Transit Vehicle R&D--Transbus, SOAC and ACT," United States Congress, Office of Technology Assessment, March 8, 1977.

⁴ Ibid.

UMTA should support research, development and demonstrations of train and bus advanced technologies, particularly at the subsystem level, that would lead to improved transit vehicles. It is not an effective use of federal money to develop conventional transit vehicles as final products, since transit manufacturers can more effectively do this based on specifications developed by the transit operators. These specifications will incorporate new subsystems appropriate to each local transit property when they are shown to be effective by UMTA or industry.

Standardization at the subsystem level is frequently achieved through a procurement process that permits transit properties some discretion. Most of the drive trains and engines on current buses are standard without federal regulation other than the consent decree of 1965. UMTA's heavy rail car standardization efforts at the subsystem performance and interface level promise to be beneficial. Standardization of the total vehicle design is likely to be unproductive.

The ability to deliver R&D to the transit properties is dependent on federal policies relating to procurements, grants, regulations and standards as much as on the R&D process itself. These interactions and some alternatives are discussed in the report. This assessment has focused on conventional transit vehicles. Other policies may be appropriate to high risk advanced transit system development.

There has also been concern with advanced transit system development. One expression of this was the formation in 1976 of the Advanced Transit Association (ATRA)--a group of urban planners, transit technologists, and transit operators who felt that APTA represented transit system operators but not necessarily individuals who used transit systems or urban planners. Its purpose is, "(1) To improve the quality of urban life through the judicious application of advanced technology and planning concepts to transit services; (2) To disseminate information on advanced transit to the members, to the interested professions, to the public, and to representatives of all levels of government; and (3) To improve the quality of transit-system analysis, planning, design and implementation."

Another expression of concern has resulted from a recent review of European, particularly German, progress in advanced technology transit, occasioned by the International Transportation Exposition in Hamburg in June 1979. The consensus of congressional, DOT, and private sector individuals is that the United States is substantially behind demonstrated German technology whether it be M-Bahn (magnetic levitation), C-Bahn (GRT or PRT), S-Bahn (commuter rail), U-Bahn (rail rapid transit), or Strassen-Bahn (street rail). One irony in this situation is that the two outstanding texts on high-technology transit were published recently (1978) by two Americans--Transit Systems Theory by J. Edward Anderson and Fundamentals of Personal Rapid Transit by Jack H. Irving. There is nothing wrong with the U.S. ability to conceptualize and analyze, but

evidently the United States does not produce prototype hardware. A U.S. urban planner has to travel to Germany today to view the full range of transit options. DOT lack of support for developing and testing transit options has led to this debacle. Some quotations from the trip reports of several federal U.S. observers make the point:

Volkswagen, BMW, Mercedes, Siemens, MBB, and many others had exhibits featuring new technology in electronic controls and safety systems. The most disappointing exhibit was the U.S. exhibit put on by DOT. It featured the minicars RSV, the UMTA paratransit vehicle, an air bag display, and photographs of President Carter and Brock Adams.

On Sunday I flew to Hamburg to attend and participate in the IVA. A great deal of money and effort went into the exhibits themselves with representation primarily from European countries. The European supply industry displays of equipment and new technology developments were impressive. To the contrary, the U.S. exhibit was somewhat embarrassing for its lack of any significant equipment or technology offerings.

I diagnosed with some chagrin and envy that...it is now a virtual certainty that at least two Japanese systems (more ambitious than ours), one French system, and one German system will become operational before we open our first DPM.... To me, it seems that other industrialized nations can move much faster in making decisions and implementing them than the United States....We have a long way to go to obtain this kind of commitment by transit to consider new technologies.

...a feeling of a truly cooperative joint effort between government, transit operators, and the equipment suppliers in developing new transit technologies and techniques, is needed as well as more cooperation than I believe exists in the United States today, although it is possible that the harmony was more a promotion for the visiting delegation than in reality exists. Still, it is difficult to imagine an experience such as the Transbus controversy taking place in Germany.... Thus UMTA has evidently failed to stimulate innovation where other countries have succeeded.

CONCLUSIONS AND RECOMMENDATIONS

It is clear that transportation innovation has not prospered under DOT management. During the first half decade of DOT's history (1967-1972), technological developments supported by DOT too frequently lacked a market. Evidently, there has now been an overcorrection--at least in certain modes--and technological possibilities and even requirements are not being developed at the needed pace or in some cases at all.

The modal administrations within DOT seem to have learned to work with users in recent years so that technological developments tend to satisfy user needs. But the technologists within the modal administrations have not been able to push through the thicket of bureaucratic stifling of innovation within their own modes, within the DOT supervisory structure, within OMB, and within the Congress. Maybe no mortal could. Perhaps the bureaucratic maze should be unravelled. One example should suffice: In Germany, the Ministry of Research and Technology has a staff of two devoted to urban transit development. UMTA has a staff of 65, many of whom are evidently consumed in modal, DOT, OMB, and congressional justifications and contractual procedures. Recall that with this staff of two, Germany is outperforming the United States.

Recommendation: Streamline the technological approval process in DOT and the federal government.

There is no political stability in DOT. There have been five secretaries of transportation in 10 years, as well as five UMTA administrators. Not one of these rose through the ranks, a sign of a badly managed enterprise. Each secretary tended to reverse the policies of his predecessor. Volpe wanted to mandate air bags, Brinegar felt the decision should be left to the private sector, Coleman wanted to test air bags, Adams mandated air bags, and now we have Goldschmidt. Volpe wanted to mandate Transbus, Brinegar wanted to leave it to the transit operators, Coleman selected Transbus parameters acceptable to operators and manufacturers, Adams mandated more stringent parameters, and operators and manufacturers "got off the bus." Innovation cannot prosper in such a highly politicized department.

Recommendation: Depoliticize DOT, at the very least depoliticize the technological components of DOT. Consider whether modal administrators could be bipartisan, appointed for six-year terms, preferably from the ranks. A change in administration in the United States involves a change in 4,000 top government professionals, usually within six months. This is an impossible task to do well. Germany, England, France, and Japan change only 40-70 top jobs with a change in administration. They seem to maintain political control.

Innovation seems to do better with federal stimulus where the federal government is the customer--air traffic control--and least well where the government is neither the user nor the customer--the automotive industry.

Recommendation: Deploy R&D assets where it is more appropriate for federal involvement in technological development, that is from the automotive industry to air traffic control, for example. Railroad and transit R&D are also more appropriate recipients of federal technological development aid, since the long history of federal regulation in railroad transportation stifled innovation and adaptability and since the federal government funds most transit capital gains.

DISCUSSANT'S COMMENTS

BY

HOWARD K. NASON

There has been general agreement at this meeting that technological innovation comprises the successful introduction and diffusion of new products, processes, or services, using new technologies or new combinations of technologies that distinguish the innovation from its predecessors.

There also has been a consensus that, in the United States at least, the creation and introduction of such innovations is a function of the industrial sector. But the essential final step of the innovation process, commercial acceptance, is controlled by the public. Innovation has not been accomplished until the user makes the critical decision to buy it.

Morlok and Goldmuntz, of this panel, and Garrison, of the Panel on the Setting for Innovation, examine in their position papers many of the complexities of the innovation process. They specifically probe the many factors involved in innovation in transportation. From their contributions and from the views of other participants in the workshop, we can see a number of areas of common concern.

THE ROLE OF TECHNOLOGY

R&D and the technology it generates are essential elements of innovation. Standing as they do at the beginning of the process, they have been taken by many to be the most important element in the chain. Speakers at this meeting separately have emphasized that every link in the chain is essential and that if any one is defective the entire process fails. Capital to carry the technology into production; marketing skills to insure a match of user needs and wants with ability to manufacture and to secure consumer acceptance; and overall management to insure integration of each step in the process, to make sure that social as well as economic and market requirements are served by the innovation, and to secure a return sufficient to repay the costs of the innovation and to help support development of successive ones, are all required.

Thus a climate supportive of all steps in the innovation process is essential. It is the role of management, whether in industry, government, academia, or other institutions to insure the perpetuation of such a climate.

Technology thus is a concern of all elements of our society. There seems to be agreement that technology per se is in good health in America, with support in all sectors. Specifically, there seems to be no lack of innovative components and processes for application in

transportation. There does seem to be a shortfall in the understanding of total systems, into which components and processes must be integrated if they are to be useful. Also, knowledge of valid user needs and wants, as they relate to various modes or combinations of modes, and to the opportunities for innovation in these, seems to be in need of improvement. Both private and public sectors need to develop better capabilities in these areas. Charpie cautions that user needs are not always what users say they want.

PUBLIC ATTITUDES

Public opinion is important to innovation, not only with respect to acceptance but also with respect to the support of R&D, to the generation of investment capital, and to the maintenance of a favorable climate for constructive change. Several speakers expressed concern over the pejorative antipathy between public and private sectors that is evident today, intensified by misguided utterances that seem to receive more attention from the media than is warranted by validity or merit.

Public ignorance of elementary economic realities is especially damaging to innovation. Lack of understanding of investment, profit, savings, and of who ultimately must pay the costs, leads to political pressures resulting in actions very damaging to savings, creation of capital, investment, and modernization, which are essential to innovation, productivity, international competitiveness, and the maintenance of quality of life.

It is felt that government should take a positive, rather than an adversary, approach to such problems.

ROLE OF GOVERNMENT

On a number of issues there seems to be a consensus, both in the prepared papers and in the discussions. Such issues include the following:

1. Support of basic knowledge. While industry and universities will continue to make substantial contributions to the support of basic research, the majority of the funding should continue to come from the federal government. (This holds true for most other industrial nations also.) Most of the actual performance of basic research should continue to be done in the universities.

2. Support of generic technology. Where the development of basic knowledge into technology that is generic to an entire industry or to several industries, and where the cost of such development is too great for any company or group of companies to bear, support by government is appropriate, subject to reservations discussed below. Such support is most effective when industry and academe participate in planning, funding, and execution.

3. Establishment of objectives. Government could make a major contribution by catalyzing the establishment of overall, long-range objectives for innovation in a technology or in an area of social need.

Nowhere is this more evident than in transportation where national needs should be evaluated from the standpoint of total systems, of their interactions, and of their relationships to other national goals. Definition of needs for innovative technologies would flow from such efforts.

4. Climate. Government plays a critical role in determining the climate for innovation and productivity. It should make sure that its actions contribute to a climate favoring initiative in the creation and application of technology to the total innovation process, and particularly should emphasize the avoidance or the removal of disincentives that its other activities may create. Control of inflation is an essential step. Elimination of confiscatory tax policies, and the adoption of policies favoring savings and investment are needed to fuel vital steps of the innovation process. Regulation and direct control of technical and economic matters must be handled so that innovation is encouraged rather than inhibited.

And management processes in government must be depoliticized if they are to be effective.

5. Direct intervention. Government should intervene directly in the latter stages of innovation only where market forces clearly are incapable of meeting a national need. Examples include streets and highways, waterways, public health, area sanitation, etc. Public acceptance, as evidenced by willingness to buy a new product or service, remains the most potent decision-making element. Government should avoid intervening in product or process decisions and should guard against attempts to impose new technologies, however otherwise attractive they may appear to be.

ROLE OF THE PRIVATE SECTOR

The private sector has responsibilities to insure diversity in the creation and delivery of goods and services that meet society's needs. The public is the ultimate judge of success; it buys or it does not. Not every innovation--not even most innovations--will win such acceptance. An industry's overall track record in winning such acceptance will determine its survival. Not every innovator will survive. Many will not deserve to survive. That some deserving ones will not survive is unfortunate, but survival of the fittest is the determinate of fitness. Artificial props to prevent failure of unacceptable innovations never succeed in the long run.

Industry thus has fundamental responsibilities, to the public and the consumer, to its employees, and to its investors. Failure to meet any of these responsibilities fully constitutes failure of the whole.

INSTITUTIONALIZATION

Transportation is highly institutionalized between transport companies themselves (railways, airlines, shipping companies, bus and truck companies, etc.), regional operators (e.g., transport authorities, Amtrak, Conrail, etc.), suppliers (component and equipment manufacturers),

associations, and a variety of governmental bodies involved in every phase of the process.

This affords an opportunity as well as a challenge. Opportunity for an intermodal engineering systems approach, in which all sectors, public and private, could participate constructively, from earliest conceptual and planning phases to final delivery and operational phases.

How can we integrate (compromise) public and private roles in decision making?

We have historic models that provide clues as to how or how not to do it. One of the best of these is the example of the former National Advisory Committee on Aeronautics. NACA never designed airplanes. But it provided basic technology of great sophistication, which the industry then incorporated into advanced designs, which led to aeronautical pre-dominance for America. Industry, academia, and government working together produced superior basic technology, and through its application, innovation. NASA, which absorbed NACA, on the other hand, has lost the touch for this kind of collaboration, and innovation has suffered.

Examples from the Department of Defense as contrasted to those from the AEC/ERDA/DOE provide the same kind of lesson. Bob Charpie drew stimulating conclusions.

In sum, those in attendance came through strongly for a participating systems approach for innovation in transportation, with appropriate inputs by government, industry, and the academic community, not dominated by one sector, but guided by the fundamental principles that have been shown as controlling for the process of innovation. A readjustment of the role of government, and of its image of that role, clearly is indicated.

PANEL REPORTS

THE SETTING FOR INNOVATION

BY

FOSTER L. WELDON

Our panel members agreed on a couple of things rather quickly. First, that the setting for innovation was a "lousy" one, and, second, that it was going to be tough to try to improve it. We had little trouble identifying barriers throughout the session, but we had real difficulties arriving at recommendations for improvements. This is simply because of the complexity of the thing; a whole potpourri of public and private organizations is interacting within a framework that is really a very dynamic marketplace, but at the same time it is constrained by static laws and static regulations.

At a highly aggregated level of all of these components we finally were able to agree on several suggestions for improvement. But attempts to dig into the detailed interactions were not very productive.

In what follows I will try first to outline the consensus reached concerning the barriers to innovation, and then I will get to the recommendations for lowering the barriers.

First, the barriers that were identified in the executive branch of the government are as follows:

1. Fragmentation of authority and responsibility for transportation programs, both across and among the major modes of transportation.
2. Inconsistent and erratic leadership in pursuit of transportation goals and objectives.
3. Lack of systematic approaches to encourage transportation innovation.
4. Lack of long-term plans and policy commitments to pursue specific transportation goals and objectives.
5. Faulty coordination among agencies in the management of inter-related transportation activities.

In the state and local governments, the major barrier to innovation is simply the great number and diversity of these entities. The primary customer of transportation at the local level is a hodgepodge of city, county, and regional governments, districts, and authorities with ambivalent perceptions of the needs and mechanisms for, and the desirability and efficacy of, transportation improvement.

We then looked at the congressional level of government and identified barriers to innovation that are somewhat similar to those in the executive agencies: inconsistent leadership and lack of long-term plans and policy commitments in pursuit of transportation goals:

In addition, two other specific barriers at the congressional level were identified:

(1) Too many oversight committees with conflicting objectives and overlapping authority.

(2) Uncoordinated transportation-related activities undertaken in response to a variety of constituencies.

In the industrial/commercial setting, barriers to innovation are as follows:

(1) Size, maturity, and massive infrastructure of the component companies, characteristics that are not generally conducive to agile innovation.

(2) The low rate-of-return characteristics of operating companies in the transportation business.

(3) The inherent difficulties in predicting market response and economic impact of significant changes in transportation system operation.

(4) The high-cost/high-risk nature of necessary full-scale, real-world proof testing.

(5) The natural resistance to change that characterizes many individuals and organizations until threatened.

In the research setting, academic institutions were singled out for special consideration. This is because of their value as a source of new, innovative talent for the transportation industry. Lack of a steady supply of technically superior talent is certainly a barrier to innovation, and yet it seems that this supply is threatened by scarcity and lack of continuity of funds needed to support academic research activities.

Request for proposal grantsmanship for unrelated agency or mission-oriented projects does not solve this problem and may even compound it by absorbing talent and resources that could better be used in more basic research and teaching.

Other barriers were identified that are related to legal, societal, and general technological matters. I will just note these quickly.

The patterns of laws having some bearing on transportation matters has been established for several decades, and certainly, at least in the areas of patent policies and antitrust legislation, there should be some critical reviews to ascertain the deleterious effects this fact may be exerting on innovation.

The general uncertainties in our society, created by such things as inflation and energy worries, certainly also affect innovation by skewing new developments toward small, short-term, low-risk projects.

In the general technological area, it was felt that we are not getting nearly enough spin-off from foreign and nontransport R&D activities.

These remarks have summarized the barriers. Now I will outline what we think might be done about them.

Part A. To provide potential innovators with a sound knowledge of federal priorities, resources, commitments, and philosophy pertaining to meeting transportation needs, DOT should take the following steps:

1. Prepare and issue an annual long-range national transportation plan. This plan should spell out policy initiatives, capital assistance priorities, and R&D priorities. Management of the program for meeting these initiatives should be included.

2. Include the interrelationships between DOT and other regulatory agencies in the plan, and, importantly, show a rationale for the evolution of nonoverlapping regulations.

3. Develop program criteria for innovative content, and use them to test the department's initiatives and programs.

4. Define priorities and resource allocations for at least the next 10 years. These definitions should be included in the plan and should relate to DOT's role in sharing information, providing leadership to state and local governments, aggregating markets, pursuing high-risk R&D and defining needs and specifications.

Part B. Changes in the current process affecting program acceptance and definition and coordination should be made to foster transportation innovation. Therefore DOT should:

1. Request the legislative branch to consolidate its authorizing, appropriating, and oversight committees for all modes of transportation, combining the functions in a single committee in each branch of the legislature.

2. Emphasize the sharing of assistance and information with state and local agencies, stressing innovative management approaches rather than technological approaches.

3. Involve operators of transportation systems in the cooperative generation of programs and functional specifications that foster innovative products and services.

Part C. The panel believes that the government executive and legislative programs, processes, and leadership lack the stability needed to induce innovators to take entrepreneurial risks. To ameliorate this problem, DOT should:

1. Define and implement actions to assure continuity of management and funding for these programs.

2. Relate DOT program structure to mission areas and priorities defined in its annual plan.

3. Create within the office of the secretary an authoritative mechanism responsible for overseeing the roles, functions, and missions of the operating administrations from an innovational point of view.

4. Develop a continuing educational and research program with the academic community.

Part D. In view of the fact that transportation contributes a whopping 20 percent of the GNP, the panel believes that Congress should establish a special financial mechanism, analogous to the export/import bank. The bank would be empowered to produce variable-interest loans and/or assistance funds and loan guarantees to communities and to private enterprise to develop and test, over appropriate periods of time, innovative transportation systems and services. Criteria for the selection and evaluation of these projects would be based on national goals with regard to energy, natural resources, environmental quality, society, the economy, and so forth.

Such projects would serve to consolidate disparate local interests and objectives and would provide a powerful stimulus to innovative transportation and community development.

DISCUSSION

BISPLINGHOFF: Now, is there anything anyone would like to say?

LIST: I am a little concerned about one thread I see running through what you say. It is that the government created the problem, and somehow in all of its wisdom it will solve it, and that if we could just get a little less government, the prospect for solutions appearing would probably be much greater.

WELDON: I did not mean to imply that the government necessarily caused the problems.

LIST: Well, I do.

WELDON: However, since we are directing this to DOT, clearly, we should be trying to help DOT solve the problems wherever they were created. As I said when I started, it is a very difficult thing to try to improve.

BISPLINGHOFF: That is a good comment. Let's have some more like that.

PIKARSKY: Along the same line, you started by identifying some of the barriers. You indicated that one barrier was the large number of state and local governments that are diverse in form and that is a key barrier. You indicated that DOT should establish priorities in transportation funding. My reaction to that point was that we have substantial regional differences and that, desirably, we should have a little less government. We should have the performance requirements of our goals and objectives identified at the federal level, but allow regional areas to resolve their local differences. At the end of your remarks you touched on that by talking about a variation of the import/export-type bank facilities, which indicated we should encourage local initiatives and innovation. I think that there is a contradiction in that espousal in comparison with federal transportation requirements.

WELDON: Well, the two definitely tie together. The barrier statement was that there is a great diversity of local opinion within a regional area, and that is an inhibitor to innovation because the customer cannot agree on what is needed. Now, at the end, the intended cure for that is this analogy to the export/import bank, a way through funding to try to get these local objectives together.

PIKARSKY: Let me suggest that, perhaps, one of the difficulties at the regional and local level is the specific requirement for agency cooperation and coordination that the federal DOT establishment requires. Let me give a specific example. In the case of coordinated comprehensive planning in an agency, DOT and other agencies have tried to define a specific regional entity; one entity for a region. In the Chicago metropolitan area, for example, where we have had at least some political influence to modify that, we have a series of about 8 or 10 agencies, some ad hoc, some legislatively created, that contribute to

that overall coordination. Through that informal activity there has been, generally, consensus among all the agencies in coming up with the unified plans for the area. But this arrangement has come about through a political interaction that is not politically attainable in many other regional areas of the country. So again, it may be that the federal establishment is trying to identify specific forms of structures of agencies, instead of setting performance requirements for coordination, and that, perhaps, creates the problem.

WELDON: I am sure that is correct, yes.

BISPLINGHOFF: Are there other questions or comments?

SHIPLEY: I would like to comment on the diversity question, too. Generally, I think we should not condemn diversity, because very often it is that sort of thing that leads to innovative approaches, or different approaches that stimulate new things. And so, I think you need to say what you are alarmed about in connection with diversity.

And one other point was a recommendation to reduce risk. Well, as we become more and more imbued with a philosophy of a riskless society, it seems to me that that is a dead hand that squelches most willingness to change. I think what you are concerned about are the uncertainties because of short-term programs, put up on the part of Congress and others, which make it very difficult to foresee more than two or three years. Most innovation in transport will require longer than that. So, I think it is not the risk, per se, which would be involved in any kind of innovative development for external reasons, but it is the uncertainty owing to the shortness of certain kinds of programs.

WELDON: I have to agree with you. It is a matter of degree, though, I think. It is a question of reducing risk to the point where the industry will put their own money into innovative, real-world experiments, and, on the other hand, we certainly think that our recommendations about the longer-term stability will help in that direction as well.

BISPLINGHOFF: Dr. Chesebrough.

CHESEBROUGH: In your statement about the customers, I do not think I heard reference to people. You got down to local governments and local operating units, but they are not the customers. It is people who are the customers. Now, admittedly, the local governmental units and operating entities might be the agents of and the spokesmen for the people, but we have plenty of examples in this country in which, because of our political process, they do not always accurately enough reflect the real desires, willingness, and interest of the people. It seems to me that this point deserves a little more mention.

WELDON: I agree with you completely. I did not mention people, but I was not leaving them out intentionally. We just did not know what to say about them. You are right. These local government units do not always represent the people, and sometimes that results in a rude awakening in the marketplace later.

DEAVER: I just want to double-check what you said, Foster, although it may be somewhat repetitious of things that have been said already. In perceiving the problem of innovation in transportation, the kinds of solutions you come up with--part of it is simply reorganizing what you have, doing a little better planning and coordinating--

sound suspicious to me, in terms of adding additional resources. You talk about a bank. This would take resources and, in effect, subsidize a particular aspect of the economy. It sounds as if there would be additional bureaucracy involved in some of these planning and coordinating functions. I am not sure it would have to be, but it sounds to me as though we are talking about a bigger governmental role, and a subsidy to a particular area. I wonder if that is the direction that this group really wants us to take?

WELDON: I do not agree with part of your statement. The analogy to the export/import bank; I would certainly not call that a subsidy. The export/import bank has been very successful and at practically zero cost. Another analogy is the so-called "MIKI" arrangement in Japan, where the consortium of banks, operating with industry and government with federal goals in mind, has been enormously successful in pulling Japanese industry up from really nothing, to a world leader. So, these schemes have been tried and proved productive, and I would not call that a subsidy.

I cannot argue with the other parts of your comment. We do not think we are recommending a significant addition to bureaucracy, although we cannot really control that. It depends on how it is done. Hopefully, we are adding very little, and perhaps, with better planning, there will be an opportunity for savings along with it.

GREEHAN: I want to make a comment about one point where you indicated that the size, maturity, and massive infrastructure were barriers to innovation. That is not necessarily true, although it is frequently true. We have some large industries that are innovative, and they have size, maturity, and a large infrastructure to go with them. I think our airlines are doing pretty well. The telephone industry and the communications industry are both large, and have maturity and large infrastructures.

WELDON: I agree with you completely. I did not mean to wrap all components of the transportation industry into that statement. Many equipment suppliers are very innovative. They have to be to keep up with the competition. The reference to infrastructure was the old stuff, 250,000 miles of rail track in place, 42,000 miles of interstate highway. That is pretty heavy infrastructure. Now, I want to add one more thing to that. In my view, if we are innovative enough, the right of way represented by that infrastructure is invaluable for innovation. How in the world could you get that much right of way for guideways and things, if they did not already exist?

BISPLINGHOFF: Foster, one of the things that we have struggled with in the committee are the questions of what is different about a desirable setting for environment in transportation vis à vis other fields and how does it differ, perhaps, between the modes. We heard Ward Haas tell us that for consumer goods, the main job of government is to create a good economic environment and control inflation and then get out of the way. The private sector will then do everything that is required. Now, that obviously cannot be said about many of the fields of transportation. As you pointed out a moment ago, the highway system depended on a big government intervention in that

business. What do you have to say about that question? It seems to me that it is a pretty fundamental one that we ultimately need to talk to.

WELDON: I have puzzled with that one, and there are all kinds of ways you can slice it. I have not come up with a very satisfying answer. I think one difference is that in our society there is a feeling of almost a right, a constitutional right, to mobility. And because the government is involved in transportation operations, there are always pressures to keep costs down to preserve this right of mobility. I do not know if that is an important factor, but it certainly is part of the reason why transportation operating companies operate at very low return on investment and many are subsidized, which again, brings in the government and creates a situation that is quite different from free operation of the marketplace. I am no economist, but those are a couple of things that I would mention.

BISPLINGHOFF: Does anybody in the audience have any comments on that point?

PINNES: I have just a little variation on what Ray was saying. When you lump all of transportation together, I think it is still worth recognizing that we have the best air system in the world. We have the best highway system in the world, and we probably have the worst rail system in the world; yet they all operate under the same general rules. Now, what makes one good and one bad?

WELDON: I cannot answer that question. I agree with you.

LIST: I would like to make one comment. For one, we do not have the worst rail system in the world.

PINNES: The second best?

LIST: No, it is probably the best rail system in the world as far as the freight shipper is concerned. The impression that the rail system is not good comes mostly from the passenger end of the business. It is fair to say that the passenger transportation in Europe is head and shoulders over anything we offer here on the railroad. But the freight transportation is exactly the other way around. We do not want to forget that.

WELDON: May I put in a comment there? I have to agree that the freight part of the rail operations must be pretty efficient or the trip-end problem in pickup and delivery of goods is pretty lousy because I discovered some remarkable statistics the other day. Forty percent of the huge contribution to GNP that freight shipping makes is from local trucking, that is, the pickup and delivery of goods in metropolitan areas. Now, contrasted to that, the total cost of line-haul trucking nationally is 10 percent less than the cost of local trucking, and, lo and behold, all railroad freight, despite its enormous tonnages, is only about one-third as costly as local trucking. So, it would appear that rail is operating very efficiently in the freight area.

BISPLINGHOFF: Foster, one of your points is that there is a lack of long-term plans in the DOT. I wonder if a long-term plan of a federal agency ever has any meaning. I have seen a lot of long-range planning done mainly for the benefit of public relations in the Congress, but when it comes right down to it, it had little relationship to what actually happens. Is that very important?

WELDON: Maybe you are too close to it, Ray. I think the way I should have stated it is that a perception of stability needs to be sent out there into the world. Innovators, as I mentioned, in these uncertain times are inclined to go for short-term, small, low-risk innovations. If they could just perceive some higher degree of stability in government programs, I think it would help. It does not necessarily have to be so, if the innovators perceive it in that way.

CHESEBROUGH: It just occurs to me that perhaps the decline of the passenger rail system in this country is a perfect example of the workings of innovation in transportation by private industry. Industry developed different ways of transporting individuals that have more appeal to the individuals, and therefore people are using those innovative methods instead of continuing with one that existed originally. I would also echo what the gentleman said about the freight system. I managed a relatively large enterprise in France for a few years. There was a saying over there that if you really wanted to lose something, ship it someplace on the railroad.

BISPLINGHOFF: Foster, I wonder if you would be able to tell us what your most important recommendation is?

WELDON: I am an innovator, so I like the export/import bank analogy and I do not think it would cost much. That would be my favorite, but you ought to call on the other members of my panel. They might not agree.

BISPLINGHOFF: Are there other members of the panel here? I see Ed Gray. What is your most important recommendation, Ed?

GRAY: Well, as we looked at the situation for the transportation activities of DOT, I was struck by the remarkably small amount of money they spend on research and development in comparison with the part that transportation plays in their total R&D. It is a very minuscule part, and I believe that one of the things that would help stir innovation across the board would be more vigorous and aggressive programs--a better stated program with longer-range objectives of what needs to be accomplished in the whole field of transportation. They should put some money behind an assistance-type program without major strings attached to it and allow for the innovative abilities of the private sector to come up with ideas, and put some seed money behind this in order to get some ideas sponsored and carried to the point where we could see what their contribution to the transportation field might be.

BISPLINGHOFF: Good point.

INTERACTIONS OF GOVERNMENT, INDUSTRY, AND ACADEMIA

BY

MARTIN GOLAND

Our panel was requested to concentrate on the interactions between government agencies, industry, and universities and how these inter-relationships can be optimized in DOT policies and program planning to further innovation in the transportation areas. As a framework for our discussions, we chose to appraise the role of each of the three participants in turn, with the expectation--as indeed did happen--that the desirable functions of each would be clarified as the exchange of ideas progressed. Our panel was an exemplary one, including persons with long experience in transportation research, development, and utilization, and a wide variety of past program experiences were brought up to illustrate how university-government-industry collaboration could be made truly effective, as well as instances where the results were less than desirable.

It is, of course, impossible to condense in a few minutes the many points raised during a full day of deliberation. I shall try, however, to summarize the principal conclusions we reached, noting that much material recorded in the full transcript is worthy of detailed study.

Considering the role of universities, it was unanimously agreed that university engineers and scientists must play a strong role in DOT's formulation of an innovative transportation research program. In addition to the advancement of knowledge and understanding, the universities are also the source of trained personnel who are essential for the future health and well-being of all transportation activities spanning the spectrum from theory to practice. It was also agreed by the panel members that DOT has thus far not been particularly successful in building sound relationships with the university community.

What is needed above all is the establishment of a long-range pattern of DOT-university collaborations based on two essential features--stable programmatic policies and relatively stable funding levels. It was pointed out that DOD has recognized the importance of basic research as a necessary element in achieving its mission objectives and has taken direct action to insure that relationships with university staffs are maintained at a mutually supportive level. A similar situation prevails within the NASA program. DOT, on the other hand, has not given this area sufficient attention and in fact--as was noted by a university member of the panel--transportation research and education, with the

exception of aerospace technology and a few other special-interest sectors, are not particularly visible commodities on the campus scene.

In building bridges to the university, the panel felt that the primary roles of the university must be kept in mind. These are the conduct of basic research and education. Too often, university staffs have become occupied with applied research and development activities for which they are not well equipped in terms of either environment or talent, and for this reason their project performance has proved to be inadequate. The terms "intellectual capital" and "intellectual capacity" were used during the discussion to portray the proper roles of the university. The former refers to the university responsibility to enlarge basic knowledge and achieve deeper understanding; the latter signifies the university responsibility to train and develop innovative students who will not only serve future university needs, but also flow outward to industry and government to develop and operate the transportation systems of the future.

It was noted that support for university research and education is not solely a government responsibility. The transportation industry must also play its legitimate role in providing financial support as well as a continuing dialogue with faculty and students to highlight research potentials and a better understanding of industry affairs.

University research, even though basic in nature, should not disregard the innovative areas that sometimes lead to inventions. A panel member remarked on the lack of prestige in university circles often accorded the issuance of a patent as compared with the prestige of a peer review publication.

As an extension of the university discussion, the panel considered the need for establishing "centers of excellence" in selected transportation areas. These are visualized as R&D organizations established outside the traditional university structure (although they may in some cases be university-affiliated). Their charter would be to conduct applied research on generic (nonproprietary) problems that, for a variety of reasons, are not adequately dealt with by private industrial laboratories. They can also serve as the focal point for establishing the feasibility of innovative transportation concepts by carrying them through the advanced development stage. There are numerous examples of such organizations that have made significant contributions to the advancement of their fields of specialization, and the panel believes that a study is in order to determine whether they are needed to accelerate progress in selected transportation disciplines.

Turning next to the government role, we first appraised the degree of success achieved by federal government sponsorship in various areas of transportation research and development. Why, for example, is the federal highway program generally accepted as successful and cost-effective, in comparison to such efforts as Morgantown and Transbus?

In the case of the highway program, the general consensus of the panel was that its relative success arises from two factors. First, the government effort is supported by competent technical staffs at the state and municipal levels. Equally important, the basic funding for the highway program involves cost-sharing by the local agencies. The

local agencies (rather than the federal government) are, in effect, the purchasers of highway construction and are responsible for their long-term serviceability as well, and they are directly providing a portion of the total cost with their own dollars.

Insofar as Morgantown and Transbus are concerned, the federal government was the funding source, but in neither case was the government to be in the role of purchaser and operator. Divorced from operational experience, and subject to a variety of political constraints and pressures that distorted original program objectives, the government attempted to dictate the details of vehicle and system designs, which proved to be unacceptable in the marketplace.

In a wider concept, the question arises as to the extent the federal government should become involved in large applied research and development programs in transportation areas where they will be neither the direct purchaser nor the user. Should not the federal government be largely restricted to fundamental research, and to advanced development of innovative concepts only to the extent of demonstrating feasibility? With feasibility established, implementation of a new concept should be transferred to those who must ultimately be responsible for its public acceptance and marketplace success.

Another clear example of positive federal government involvement in transportation is in aircraft design and air traffic control. In the former case, NASA (formerly NACA) restricted its role to providing the fundamental information needed to support advanced aircraft concepts, leaving it to industry to design commercial transports and to DOD to purchase military aircraft for its own use. In the air traffic control instance, the government is both the purchaser and the user of the system, with direct accountability for its effectiveness.

The conclusion must be drawn therefore that when the federal government plays a controlling role in market-oriented development programs in areas where it will be neither the direct purchaser nor the end-user, the results tend to be less than satisfactory. This is not intended as a criticism of the individuals who represent the government, who are usually highly motivated and conscientious. It appears to be a consequence of the political process itself--of government agencies making decisions in unfamiliar arenas, without the discipline of market forces to insure accountability and determine the level of success.

The panel made note of one important function in which the government is, in effect, a "user," namely, that of regulations. The government has mandated a multitude of environmental, safety, and other kinds of regulations that are intended to protect the public interest and welfare. The government must therefore take the responsibility for insuring that regulatory specifications are indeed in the overall public interest and as socially cost-effective as circumstances permit. Yet, many regulations have been instituted on the basis of incomplete information and, in some instances, in an almost arbitrary fashion based on congressional pressures. Even granting that some action is better than inaction in the beginning, the panel noted that government research and fact finding to support regulatory decisions and modifications have been weak efforts, underfunded, and given inadequate attention. Although

other examples could have been quoted, railroad safety legislation was raised as a case in point.

Another observation made by members of the panel related to the lack, within the Department of Transportation, of an individual at the assistant secretary level or its equivalent who has the responsibility for coordinating and overseeing the technical affairs of the department. The need for a competent technical person with these functions has been apparent on past occasions. It was also noted that external advisory committees are used sparingly by DOT, whereas most other agencies have found it desirable to utilize such groups at both the senior policy and the specialist levels.

Finally, the panel turned its attention to the industrial sector. As expected, the earlier discussion had already touched on many of the issues relating to university-government-industry interaction.

It was emphasized that the primary role of industry is to produce and operate the transportation systems that people use. The marketplace is an unforgiving taskmaster; the private company that produces a theoretically and socially ideal transportation system or product but that does not attract buyers and users will quickly find itself in deep trouble. The free market is still the most sensitive barometer of public acceptance, and it is for this reason that industrial talents, experience, and attitudes should be enlisted to support innovative transportation concepts at the earliest practicable stage. We have, of course, already emphasized this point earlier in the discussion.

DISCUSSION

BENINGTON: Let me ask a question about the role of the government in applied research. We agree with you in the air traffic control area. We also agree with you in the automotive area where the government has almost no direct hand in the marketplace decisions except for the automobiles it procures itself. In three areas, the rail, the construction of highways, and the urban mass transportation, the government is certainly not the user or the operator. On the other hand, in the case of mass transportation on the highway, the government is involved in the financing. In the rail, there is some financing because of subsidy, and there is certainly a great deal of regulation. But we concluded that if there were no government research and development, no government active initiative for innovation, then the level of research and development in those three areas would be virtually nil and that the operators, the buyers, and the suppliers are, for a variety of institutional and financial reasons, just not able, motivated, or capable at this stage of conducting any kind of noticeable research and development program. Therefore I wonder how your stricture against the government applied research would apply to any of those modes?

GOLAND: Well, I am not going to say that this question is one that should be couched in black and white terms, but I am not going to depart very far from our stand. There are other members of the panel here who I hope will contribute to this discussion. In terms of mass

transportation, first of all, we certainly cannot look at past experience and decide that the government has contributed very much to putting better buses on the road. In the area of high-speed ground transportation I would say there is a legitimate role for the government in exploring in a preliminary way new possible modes; magnetic levitation and air cushion vehicles are examples from the past. But let's look at that history. The government had sound plans to start with, but once it became quite apparent that these were uneconomic and undesirable directions, the government programs could not be easily shut off. The inertia of government programming in these areas expended many millions after, early in the game, it became apparent these were not promising directions.

I think it would be very desirable if Shef Lang would say a word about the railroad situation.

LANG: I do not think we want to get into a long debate on this question. There obviously are people in the audience who, for good reason, have some different opinions on why things are happening the way they are in the railroad industry. But I do not think there is anything in our experience in applied railroad research that would lead to any conclusions that are different from that general one that the panel reached, namely, that the government, where it is neither the user nor the buyer, can be expected to do a bad job of applied research. The experience in the urban transportation program is very clear and very discouraging. The experience in the railroad area, where there has been a good deal of government applied research in recent years, is almost as bad as the urban transportation applied research experience.

The experience in the highway area has to be differentiated from the experience in rail and urban transportation. Perhaps, in view of the comments and questions that have come up, a word or two on highway research is appropriate here. A large share of the applied research in highway design, construction, maintenance, etc., that has been done over the years (most of which I think people would count as having been pretty successful in the use of research dollars and research resources) has been done by or at the direction of those agencies that were actually building the highways or maintaining them; that is, by the state and local highway departments--not by the Bureau of Public Roads (now the Federal Highway Administration) here in Washington. You could get an argument, and if anybody is here from FHWA I would expect to get such an argument. But I think that on the whole those applied research programs that the Federal Highway Administration has run directly here in Washington have been less successful in terms of their use of resources and the value of their results than those programs that have been managed directly (albeit using federal dollars) by the actual customers or users of the technology in question.

John Young, for one, could speak to how this has worked in other areas that have involved government applied research--but just in transportation we have a rich experience of total, or at best, partial failure of applied research programs managed by government agencies that are not and have not been either customers or users of the resulting technology.

To go back to the rail case, which you asked me to speak to directly, that has very clearly been our experience. The notion that the railroad companies, individually and collectively, are both unwilling and not competent to manage their own program of applied research is on the face of it nonsensical. The industry is, by any measure, large enough to support its own research program. It has not seen fit to support a large program of applied research, but the kind of incentives that are going to produce an effective program of applied research in rail transportation can come only from the railroad companies, their customers, and their suppliers. There is every evidence that where they have seen fit to research their problems, they have done vastly better than the government in research in precisely the same areas. We have many detailed examples of that.

I, personally, cannot find anything in the transportation area to argue against the general conclusions that our panel reached that government ought to get out of the applied research business where it is not its own customer. It was a conclusion on which I think there was complete agreement in a panel that was made up of industry, government, and the academic community.

There is one further comment that I think fits in with what you had to say, Martin (Goland). There was also general agreement that the Department of Transportation, which has a legitimate responsibility for innovation in the transportation sector, could, where it has direct financial involvement in programs such as the Urban Mass Transportation Assistance Program, stimulate more innovative activity. It could do so by making its grant money contingent on a certain commitment by the operators and users of transportation and the purchasers of transportation equipment (e.g., the local transit agencies who receive grants from UMTA) to expend some share of that money for something that could be legitimately called innovation. This is, in effect, the procedure that has been so successful in the highway program. I think it was the Highway Act of 1962 that explicitly set aside up to 1 1/2 percent of the federal grant money given to the state for planning and research purposes. It was not a requirement that the state spend that 1 1/2 percent, but they were allowed to do so. Most of the states have spent that share of their federal grants or something approaching it. It has not all gone for research. A good deal of it has gone for planning, but the relatively successful highway research program that we have had in this country is in no small part the result of this feature in our federal grant program. There is no question but what the United States is still way out in front in most areas of highway technology. This can be traced back to that financial stimulus and encouragement that was provided explicitly in the federal highway grant program.

What our panel was discussing yesterday was the possibility that that principle could be extended to other DOT grant programs, most importantly, the Urban Mass Transportation program. Thus federal money could be used as both a carrot and, to some extent, a stick to get the local governmental units in urban transportation to start thinking in more innovative terms and to start working on their own new technology, instead of sitting back and waiting for the federal government to do it.

BISPLINGHOFF: Mr. Rogers, you had something you wanted to say?

ROGERS: I would like to see if I can assist the past discussion by making the following observation: We are really talking about two different things: one is the proper role of the federal government in a given area (such as applied research or technological development) and the second, a related but separate subject, is how well that role is being discharged. They are two quite different things. For instance, I would point out that in the most recent war that the country has had, the United States did not win. Whatever other conclusions we may have drawn from that result, we did not conclude that therefore there was no role for the military forces in the defense of national objectives. Another instance relates to agriculture. Government does not purchase, to any great extent, agricultural products, but the basic and applied research that the country has done over the past century in the agricultural area is probably one of the outstanding examples of all time of how government can assist such an area. If we are concerned about the present arrangements of organization, or scope, or staffing, or even about the way that the funds are provided, to transportation-related research and development activities, then these matters should be examined. But I do not think at this point that, because of what is described as poor performance, it necessarily follows that there is no role for government in this area.

The second observation I would make goes back to a different subject, and I should preface my comments by saying that I love everybody, particularly my friends and colleagues in the universities. I heard said that the research-related funds that had been given to universities in the past, and accepted by them, were not used in a satisfactory fashion--that is to say, so as to increase the universities' capacity and to increase basic transportation knowledge--and that those funds were therefore misspent. I have held positions in the federal establishment where I have had the responsibility for passing out funds to universities for the conduct of research. I can assure you it would have been a very short meeting if any senior university person had come back to my office, after having taken the federal taxpayer's money and having spent it, and told me I should not have given it to him; it would have been a very short meeting, indeed. If the universities are convinced--and I do not look to the past, I look to the future--that the things that they are being asked to do by the Department of Transportation, or others in the transportation area, are not what they should be asked to do, then I would suggest that these senior university people should be exerting their efforts (1) at home to see that their colleagues do not take such funds and therefore misspend them and (2) in Washington, with the Department of Transportation and other offices, to see that the funds are spent under more appropriate and, from the universities' and the country's point of view, more productive circumstances.

GOLAND: I think I can answer rather briefly a couple of points you have made. First of all, there is not any question that the agricultural extension service has been an enormously successful program. But, for historical reasons--and history is important in its own right--it does not constitute a model of the kinds of problems we have today. Witness

the attempts in several analogous government programs to institute a similar type of service to meet the technological needs of small industry; the State Technical Services Act is one example. You may have your own opinions as to how successful they have been in attempting to follow the agricultural model. My opinion is that they have not been very successful at all.

Now, in another transportation field, let's take an outstanding example on the positive side. The old NACA used to have as one of its strictures that NACA does not build airplanes, although later in their program they did contract with industry to construct a series of experimental aircraft to clarify certain full-scale effects. But the imprint of NACA (now NASA) is on every airplane that flies anywhere in the world. They developed the information that the industry itself used for new designs and for product improvement. I will carry the philosophic argument further. Remember all the dire predictions that United States industry could never develop another transport airplane because government consortia abroad, with government money, would overwhelm our private company capabilities? Yet, who is today laying down a series of excellent new-generation transports? Boeing and other members of private industry.

In terms of this university support question, I do not think we were being critical of any of the parties--at least I hope not. We were making an observation of trends to which all parties have contributed and that go beyond DOT policies alone. It is that we believe universities have gradually moved away to some extent from what their central role should be. I would rather that be an observation than a criticism. It is simply an issue we think needs reconsideration.

BISPLINGHOFF: Very good. Dr. Goldie, you had a comment?

GOLDIE: I would like to take just one narrow area and attack it in specific. The suggestion that the urban mass transit funding use the same 1 1/2 percent idea that the Federal Highway Administration has used. We did discuss that in our panel, but let's take a specific case. Let's take the case of a city that has not now or ever had any mass transit, other than buses. It would like to enter into the construction of a subway system or, perhaps, a people-mover system--whatever. And let's say that the scale is \$300 million, just for a number; 1 1/2 percent of that is \$4.5 million, if I have calculated correctly. Now, are they going to take that \$4.5 million and develop a new and innovative concept for mass transit. No way! It is going to cost \$150 to \$200 million to develop a new and innovative concept. This is one problem.

The second problem is who, in that city, is technically capable of leading that kind of an activity? The city engineer? Have you ever met any of them? I have. They are not. Is the political structure capable of managing this kind of activity? The only contracting mode they know is fixed price. You do not develop new innovations on that basis.

Although I agree with your fundamental principle, we have to bend our principles to face facts. There is no way of inspiring development in mass transit, other than through UMTA.

BISPLINGHOFF: Martin (Goland), do you want to comment?

GOLAND: Well, I would rather have the audience comment on that. I think I have made my point. The record of UMTA has scarcely borne out your conclusions. Sorry!

LIST: As a mass transit innovator, I may not be readily reconized, but I am working in the area and my inclination is to agree with the panel 100 percent.

BISPLINGHOFF: Dr. Herwald.

HERWALD: My comment is, I believe, related at least to the last discussions on mass transit R&D. One of the problems is the turf that you are operating on. Innovators do very well when they can operate on virgin turf, that is, in an area not yet developed. They can always scramble and get enough money to proceed. If the innovators succeed, the payoffs are generally good because the development can be replicated on virgin turf in other places. One of the big differences between innovation in the transportation system and that in some other areas, is that no single innovator anywhere can make anything but a minor dent in the existing transportation system. He cannot revolutionize it by himself. He cannot gamble by himself. He cannot do what Colonel Sanders did, start out on a different approach, a new idea, that did not directly replace something else, and replicate it over and over again. In that kind of circumstance, it is a little hard to see how government intervention is either needed or will help. However, I happen to agree with the conclusions you have come to about how the government ought to intervene; in the transportation case it cannot be done everywhere. In the current transportation modes the infrastructure is basically in place. There is no way it can be replaced quickly, but it might be done over a 25- or 30-year period if you had that brilliant innovative idea. Therefore the idea of planting a transportation innovation as a demonstration--and this comes back to the subject we are on--in order to see if it might work if replicated, is one that makes sense. While I can think of arguments on either side of the last debate, I believe that in certain cases, such demonstrations should be attempted, but I must add that I think they could be done better in the future than has been the case in the past.

LIST: I was interested in your comment about the importance of developing intellectual capital, which I will interpret broadly. I think one of the reasons, in addition to what Shef Lang mentioned, why the highway program went well in the period in which it was important for it to develop was another early requirement in the federal aid highway legislation. Provisions in the legislation required that to be eligible for federal aid, the states must develop competent highway departments. This, along with the Highway Planning and Research 1 1/2 percent funds, very often on the planning side directed in quite some degree by the Bureau of Public Roads with a hands-off but cooperative attitude, was I think responsible for the advances that were made. And, on the planning side, to distinguish that from the technological or physical research, the Bureau of Public Roads, with the states--because of the states' participation as users and therefore their willingness to adopt these things and try them--made enormous advances in the methodology in transportation planning. In fact, they laid the basis for the

whole field of transportation planning we have today. I think it was the combination of these two things, the stick and the carrot, that required a competent user, and at the same time helped the user to develop what was necessary.

PIKARSKY: As someone who has been in the urban mass transit industry for many years and is considered within the industry to be an innovator, I think there is a fundamental defect in this panel's comment about new technologies of the future. I believe that most marketing studies indicate that the greatest factors influencing the use of transit are convenience, time, and dollars. There is the perception within the industry that we have to be spending time to increase the reliability of components, the attractiveness of the system, and on-time performance, and that the perfection of these will increase ridership. This is not true. There is resistance in the industry to complementary, non-fixed-route, service. There is a perception that there are ways of increasing the performance and accessibility of the existing systems through automatic vehicle monitoring and control, schedule changes, and many other actions that are, perhaps, underfunded at the present time. We should be using the states of the art as they exist and pressing to improve them, rather than trying to be in an exploratory mode in most of the technology that we have not used. It is not a wise investment to press to develop new states of the art when we have not really managed adequately to develop the technology we have now. I know that in this particular instance, one of the major industrial giants, IBM, had made a commitment to go into an automated personal rapid transit development, but after evaluating the market they backed out completely. They did so on the basis that the direction for transit should be in improving many of the state of the art mechanisms that we now have.

ECONOMIC INCENTIVES TO INNOVATION
IN THE TRANSPORTATION SECTOR

BY

BRUCE S. OLD

The subject of economic incentives to transportation largely involves regulatory policy, tax policy, and antitrust policy matters. Therefore, this panel decided to concentrate on these three subjects. Since there are very complex questions that have been studied by successive federal administrations for many years--in fact, the tax business has been studied by Treasury since 1789--we do not presume to provide definitive answers as a result of this short workshop. Rather, we would hope to illuminate, based on our extensive multidisciplinary discussions, some important areas for further consideration by qualified groups of experts

The transportation sector is different from most other sectors of industry in that it includes the public and the government as well as industry. Both the government and the public sector tend to bring pressure on the limited capital available to the industry sector by forcing it to spend a disproportionate amount on mandated capital expenditures, rather than elective capital expenditures, which include innovation.

Another difference faced by the transportation sector is that it has been surrounded over many years by numerous restrictive regulatory actions and agencies. These have had the effect of preventing change and discouraging innovative management.

The findings of our panel I will now summarize; first in the area of regulation. In transportation, the regulatory activities include the following: safety standards, environmental standards, mileage standards, and rate and route restrictions. Over the past three decades, prices in transportation have seldom, if ever, reflected true costs. Now, rather suddenly, we find ourselves faced with rising fuel costs and safety and environmental standards, which require many changes in the automotive field, our major mode of transportation.

Due to bureaucratic procedural complexities; frequently unrealistic and rapidly changing or escalating standards, the cost of developing regulated new products and processes has increased alarmingly, without necessarily bringing commensurate benefits to society.

The large mandated capital investments required by the automotive companies have overburdened the limited internally generated capital to the extent that the corporate life of some of the industry is in danger. Because of the uncertainties introduced and the unavailability of capital, only limited investment has been devoted to self-determined innovation to improve productivity in products.

The administration has now recognized this major problem and the president has issued Executive Order 12044. In essence, this order requires that the public must be made aware of the risks, costs, and benefits of regulations before they are enacted; that priorities should be established; that alternative choices should be made clear; and that regulations should be systematically reevaluated. Our panel unanimously endorsed these aims and also pointed out that the government should further endorse innovation by utilizing performance rather than design standards in procurement.

The rate and route regulatory entanglement has affected other portions of the transportation sector in a different manner. For example, it has so stifled and nullified management initiatives that management capable of inserting new and innovative developments is just not attracted to the railroad industry. Motivation to change this situation will be mentioned briefly under the antitrust section. It was noted that advances by the Canadian National Railroad are, indeed, occurring and have followed the deregulation of railroads in Canada.

Now, as to tax policies, the Department of the Treasury is considering changes in depreciation rules in order to increase badly needed cash flow in the transportation and other sectors. This problem has been compounded by the recent increase in inflation. There is a bill before Congress called the Jones-Conable bill, which is currently being debated. The DOT appears to be taking the attitude that it should tilt depreciation liberalization toward equipment and machinery, rather than toward structures. By this tilting, I mean that the current discussions consider that depreciation periods as short as about five years should be assigned to equipment and machinery. It may even be that the link between depreciation and life of assets will be broken. DOT is not inclined, at this time, to change the current tax rules with regard to expensing research and development.

Our panel concurred with the policy of retaining current R&D tax rules and urged early moves toward liberalization of depreciation rules on equipment and machinery. This should increase the capital funds available, but it should be pointed out that this would not guarantee that such funds would be earmarked for expenditure on innovation.

It was recognized this would not favorably affect the railroads, except in rare cases, as they now pay few taxes.

On the matter of antitrust policies--two regulatory agencies with which the transportation sector has had to contend for many years may, indeed, disappear. The Civil Aeronautics Board has been placed on a termination schedule, and it appears that the Interstate Commerce Commission may follow about five years later. A possible problem is that the residual responsibilities of these agencies may be assumed by the Department of Justice. Our panel endorsed the demise of the regulatory agencies just mentioned, although not all railroad or trucking groups agree. However, we urge the study of policies that Justice should adopt. Justice should spur development of the transportation sector rather than attempt to restrict productive growth. For example, we believe some integrated, intermodal transportation companies might be organized that would excite and stimulate efficiency in service and

attract key management personnel to an otherwise unnecessarily restricted and unchallenging industry.

Finally, a miscellaneous point: we began to compose a list of those agencies and congressional committees with which we might have to confer, if indeed any of our findings are to be translated into positive action.

DISCUSSION

PIASECKI: I think that money is the basis of most of our problems, and I think that taxation is perhaps the mechanism for redistributing our money. I sincerely feel that money is perhaps the very foundation for innovation. We must provide the capital that is urgently required for the higher-risk and longer-term investments in innovation by individuals, by small business, and by large businesses. Personal surplus wealth has been the source of capital in this country for new technological enterprises. But that has been taxed away. The government can stimulate such capital development by methods that have been tried, and have been proved. A fundamental step is to reduce personal income taxes. That would include reduction of various taxes on income from personal savings and other investments. We all want that. I do not know of anyone against it.

The second fundamental involves mechanisms to provide special means of financing, such as we had in the Reconstruction Finance Corporation. The law reconstructing the country after financial bankruptcy in the 1920s and 1930s was enacted and continued through World War II. It provided loans where banks could not provide them. If you have a small business like mine, you will find that no matter how good the innovative idea is, the banks will not lend that money on such a risk.

Another way to raise innovative capital would be to call upon the large foundations such as the Ford Foundation or the Rockefeller Foundation whose wealth came from innovation and have them lend funds or guarantee loans to new, independent, private, not-for-profit, and other types of corporations. Such an approach might take the form of loan guarantees to the local banks that might, in turn, lend to companies in the high-risk area of innovation. That approach might require congressional authorization, as you pointed out. Another possibility might be to restructure government tax and regulatory laws to provide equal opportunity for small business. I am sure we are going to hear from the next panel about IR&D. I would like to point out that the IR&D, which is independent research and development provided as part of overhead under government contracts with the Department of Defense and some other departments, only occurs if you have production contracts. God bless them! I am on that side of the fence. That is good. But the little guy, the innovative guy, who does not have production contracts, is therefore up against a stacked deck.

Perhaps graduated taxes should be eliminated for the individual, and maybe for the lower levels of small corporate earnings, to make more capital available to the individual entrepreneur and to small business.

We certainly concur with what you have just said about the change of the federal tax laws to permit accelerated depreciation over two years as an example--I do not see any reason why it should be as many as five--to allow small business owners to defer taxation. In particular, we need changes in the law that IRS and the accounting standards groups have promulgated and applied to industry in our country, the law requiring write-off of research and development funds in the year in which they were incurred. I think we need capital for innovation, and these are some ideas for obtaining it.

PROCUREMENT AND
INDEPENDENT RESEARCH AND DEVELOPMENT

BY

ALLEN E. PUCKETT

One of the first ideas that occurred to the panel in talking about the field of procurement and independent research and development (IR&D) was the fact that it is very difficult to generalize with respect to transportation--either the U.S. transportation system as a whole or just the activities of the Department of Transportation. The Department of Transportation, in its present form, has not existed for very long. Although all of its elements deal with some aspect of transportation, they are all quite different.

For example, the functions and the responsibilities of the Federal Aviation Administration fit into a very special category. The functions of the Coast Guard are in quite a different category, although it certainly deals with an aspect of transportation. The functions of the Federal Highway Administration are in still another category, as are the functions of the National Highway Traffic Safety Administration. And the Federal Railroad Administration is, again, quite different.

Each of these elements has its own problems and its own different interaction with the marketplace and with the industry. I believe our panel agreed that attempts to generalize across the board can be very tricky.

Having said that, I will go ahead and generalize. The first comment has to do with IR&D, which is one of our specific topics. I think we can dispose of this fairly quickly.

Our conclusion comes out something like this: In any of the procurements that DOT may make in any of its administrations, whether they are procurements for hardware or for R&D, there may or may not be an element of IR&D present in the cost accounting or in the program of the contractor. We recommend that the Department of Transportation take an interest in this element of the contractor's program. And I say, "take an interest," see if it is there, recognize it, and identify it as an important part of the contractor's independent activity. In particular, recognize that IR&D is an allowable element of his overhead costs and encourage him to direct some portion of his IR&D into activities of interest to the Department of Transportation. In fact, what we are really saying here is no more or less than to follow the lead of the Office of Federal Procurement Policy (OFPP) in their proposed new

federal acquisition regulation. It has been out for public comment. We hope and expect it will be issued before too long, and will recognize IR&D as a proper element of overhead. In fact, the actions of the Cost Accounting Standards Board and the OFPP have, to some extent, overtaken some of the studies and recommendations that have been made by others in the past.

The last comment on this IR&D subject would be, again, from the standpoint of DOT or of any federal agency, to maintain a respect for the importance of the "I" in IR&D. The independent aspect of IR&D is critical. The important fact is that its real value lies in its management and control by the company, the corporation, and the industry involved, and that it really is a key opportunity for new ideas and for sources of new concepts that may really lead to innovation.

The second topic may be a little bit outside of our charter. However, we chose to be a little elastic. It turns out that this particular topic was also mentioned by one of the previous speakers, and it has to do with the way in which grants are made and controlled or not controlled by DOT. This would be especially pertinent to the Federal Highway Administration, the Federal Railroad Administration, and the Urban Mass Transportation Administration. Each of these makes large grants.

You may remember the total expenditures for the Department of Transportation. Out of their budget of \$17 billion, I think about \$12 billion, a major portion of that budget, simply flows through in the form of grants. So this is far in excess of any of the procurement dollars that are managed through a normal contractual arrangement. Therefore to the extent that dollars are a tool of DOT, the grant process is certainly an important tool. In sheer volume and leverage, it is far larger than the procurement process, itself.

We therefore chose to view grants as a sort of adjunct to the procurement process.

It occurred to us that the funding of large programs through grants to, say, state and local governments, may present an opportunity for DOT, in some way, to encourage innovative activities on the part of the grant recipients, and on the part of the contractors and industries, in turn, with whom they work. We will have to be a little vague about how to do this because we do not really know. We can see an opportunity, and we want to propose a concept. We would suggest that DOT give some attention to the possibility of implementing this approach.

One of the ideas we had was to put "strings" on grants. An example in use right now, as we understand it, is that in certain cases, before a grantee is awarded his grant, he may be asked to submit a study of some alternative approaches to the resolution of his problem, whether it is in the mass transit area, the highway area, or the railroad area. A presentation of his study of alternatives is a nice place to start. It is possible, perhaps, that the process of continuing the grant might include some additional phases in which further effort is expended in what I will call prototype analysis and design (and when I say "prototype," I do not know whether I am talking about a new type of highway bridge, or a highway control system, or a bus system, or a new railway car, or whatever). This follow-on phase of the grant could be managed

under some kind of control with some kind of "strings" attached. It could provide more incentive to the recipient to engage in that kind of innovative analysis activity, rather than making some preconceived, routine, or blind assumptions at the start about the direction in which that activity eventually is going to go.

So the use of grants as an additional tool in encouraging innovation may possibly be something of interest.

To return specifically to the procurement area, to the extent that the department does engage in contracting for R&D, or for prototypes, or for hardware, there are a few particular recommendations we would make. We learned that in some cases--I do not know whether this is frequent or not--the contracts written by DOT may include a clause requiring recoupment of R&D costs or of the costs of that contract in the event that the products resulting from the contract end up in the commercial market.

So, in effect, there is an override, a royalty, or a return of investment to the DOT required under such a clause.

We suggest that this may be a deterrent to contractors with innovative ideas, as well as a deterrent to their contracting with DOT. That kind of a provision decreases the contractor's chances of a competitive position in the commercial market and makes it less attractive for them to go that route. We suggest that DOT follow again the new proposed Federal Acquisition Regulations (FAR), which specifically forbid cost-sharing on goods or services for government use--I am paraphrasing this a little bit--and then also provide for the possible recoupment of R&D costs if it is clearly in the national interest. But the general thrust of the regulation is that the decision on such a provision should be made very judiciously, and, I guess I could say, rarely, if ever imposed.

Another recommendation has to do with patent and data right clauses in DOT contracts. Most of you know that the practices in government concerning patents vary considerably from agency to agency. For example, the Department of Defense, the Department of Energy, and NASA have, in each case, a different kind of patent policy.

As we understand it, DOT does not have a specific policy. It is better to refer to it as a collection of practices.

In this particular area, it may turn out again that events have overtaken us a little bit. There is a bill in the Congress right now, the Schmitt bill (S1250), which does propose a uniform policy and a uniform practice for the treatment of patent and data right clauses in all government procurements. The general pattern proposed in this bill follows pretty much the lead of the Department of Defense. The essence of that, as most of you know, is that the ownership of patents and data rights remains with the contractor. The government gets a royalty-free license for its own use, but at least the contractor has the incentive to apply his best ideas with the possibility of other applications.

So if the Schmitt bill comes along in time to give the department the guidance it needs in this area, that is fine. Otherwise, we suggest that the department take a good look at the DOD practice and policy to see if that might not be a practical uniform basis for their own use.

Our next recommendation has to do with unsolicited proposals that may or may not lead to a procurement from DOT. We learned that the

present DOT practice--I do not know whether this is uniformly true, or generally true, or often true--is that upon receipt of an unsolicited proposal, there is a tendency to convert that proposal into a request for proposal (RFP), which is then put out for competitive procurement. I suppose this is in response to some kind of feeling for the overriding necessity to have competition in everything.

Of course, the net result is that nobody with a really interesting new idea that may include some proprietary aspects, or that is expected somehow by virtue of the innovation to give the innovator a little edge on the rest of the market, is going to bring an unsolicited proposal to the Department of Transportation. It is a very effective "stopper."

It does seem to us that this particular practice is not necessary, and that there is a place for the consideration of unsolicited proposals. There could be thoughtful evaluation, and where desirable and appropriate, the DOT could enter into contracts based on those unsolicited proposals without the necessity of going out with an RFP.

In fact, what we really propose here is nothing more or less than the adoption of another proposed new federal acquisition regulation, which again is in draft form. It is out for comment. It does encourage, in the case of government procurement generally, the receipt and consideration of these unsolicited proposals without the necessity for subsequent competitive RFPs and procurement.

Unlike a lot of federal policies, this one is so short and it is so neat that I am going to read it to you. There is a preamble to define things, but the proposed policy in this FAR reads as follows: "Agencies shall encourage the submission of unsolicited proposals and avoid organizational or regulatory constraints that may inhibit generation and acceptance of innovative ideas from prospective contractors."

So somebody has already done the homework, and we just suggest that this acquisition regulation be anticipated and that DOT practices be changed accordingly.

The next area for consideration, I have called "guidance for innovation." This topic also was touched on by one of the previous speakers. Early in our panel meeting, it occurred to us that, whereas we were asked to examine the processes of innovation in the transportation system and to find ways to encourage innovation and remove the barriers to innovation, nobody was really able to tell us what it is that needs innovating. I asked what might be the particular areas where some great need was felt and what the urgent pressures are to do something different. What are the areas in which we would really like to do something different?

I suppose we all feel instinctively that there must be many such areas. None of us would be willing to say that we are completely satisfied with the transportation system across the board as it is, although I do not feel completely dissatisfied with it, unless I lose my bag at the airport or something like that.

We really could not get a clear picture of the goals and objectives, as seen at least by the Department of Transportation. Now, the Department of Transportation happens to be the one agency in the government that might have a responsibility to try to identify those goals. In

the end, it is going to be the public that does. The public has really got to tell us what they think their goals are. Maybe we have to help them make up their minds.

In any case, our recommendation came out something like this: Give industry better insight into national goals in the transportation scene by assembling and publishing on some periodic basis a list or a statement of goals and objectives and also deficiencies (another way of putting it; a deficiency might suggest a goal) as related to the Department of Transportation missions.

Earlier, a similar recommendation was made. I think it was called a long-range plan. A statement of goals and objectives is not necessarily a long-range plan, although the two have some relation.

A long-range plan has no value, in my opinion, unless it is changed on a periodic basis. Maybe it should be changed every six months or maybe only once a year or even less often. A long-range plan is really nothing more than the instantaneous direction of a vector that is going to keep changing all over the place from year to year. At least one ought to know the direction of that vector momentarily. The goals and objectives that I might see today in the Department of Transportation are very likely not going to be the same next year and the year after. But perhaps it is not unreasonable to ask the department, as best it can--trying to see the world through its own eyes, through the eyes of the public, through their understanding of technology--to give us a list like that. It might be only a page or two; I do not mean a 100-page document.

I have a related comment. We spent quite a lot of time on this, and I think it does relate to the problem of developing this statement. Find ways to improve communication between industry, the public users, state and local governments, and, in turn, the federal government.

We did not really know how to tackle this one at all. We did perceive it as a problem, and we used the word "disconnect." There is a little disconnection at any given moment between what the public thinks it wants, what the federal government thinks the public ought to want, and what the local government may, in its wisdom, believe is good for the city or the public. The communication is just not good enough.

I cannot suggest how to improve it. We suggest that DOT take a look at it.

The next issue is in the congressional area. It is a fact that, for historical reasons, each of the agencies in the present Department of Transportation has to work with different committees in the Congress, both in the Senate and in the House, on their authorization and appropriation bills. So from the standpoint of the administration of the Department of Transportation as a whole, or from the standpoint of looking at transportation as a system, this obviously creates a very awkward situation in the management and budgeting for the DOT program.

We recommend that DOT work with the Office of Management and Budget and with the Congress to regroup these fragmented budgets and congressional authorization and appropriation committees in the transportation areas to focus more specifically on programs in support of DOT's missions.

I do not have any illusions about how easy that may or may not be, or even whether it is practical. In fact, if this were a debating society, I think I could make an argument on the other side. The present committees have developed some continuity and expertise, each in its own area. The committees that deal with the FAA know quite a lot about the FAA, but they sure do not know anything about the railroads, and so on. I do not know how one puts these together.

From DOT's standpoint, it would clearly be very nice if these committees were all together. Whether it is feasible to do that in a way that would create a useful, effective, and competent collection of congressmen and senators, and an effective interface, I do not really know. But it is something to take a look at.

Another recommendation that we offer relates to some of the present procurement procedures in DOT. We have the impression that even though procurement in DOT may be for R&D, or hardware (prototype, and so on), the procurement procedure is a bit ponderous, and there is a long elapsed time between the consideration of proposals, and all the things that go on in the process, and the final signing of the contract. That ponderous process, that lapse of time, and the uncertainties in between, and the slowness of that process may be a deterrent to attracting the interest of contractors in participating in DOT work.

Therefore we suggest that as an administrative procedure, the department take a look at ways of streamlining that procurement procedure, and that they try to simplify the mechanics so that the process can take place in a shorter time. Perhaps that change might result in attracting more innovative potential contractors to the field.

The next recommendation has to do with urban mass transit. Somehow we kept coming back to this, both from considerations of failures and from the consideration of other projects with opportunities to do something innovative. This is an area where there is perhaps the most debate about various ways of solving the problems. One way is good for Los Angeles; another way is going to be good for Detroit, or Chicago, or New York.

I am sure this could be a very controversial topic. We were trying to think of ways of avoiding the Transbus debacle that was mentioned earlier. That resulted from a procurement based on a highly detailed government-prepared design specification, without really adequate consideration of all the problems, the interests, the public, the cost, etc. Consequently, nobody bid on the program.

We are trying to find a way that will allow the Department of Transportation to provide some kind of a useful centralized function, but that still leaves the ultimate decision-making control at the level of the local governments. It may be that there is room for DOT to undertake the procurement of prototypes of some competing vehicles, to procure two or three different prototypes to functional specifications and to qualify these. By qualify, I mean to put them into service tests in some communities, not necessarily on an Aberdeen Proving Ground kind of test track (a "Munson" course test). Rather, they should qualify them in terms of local service, and also in accordance with some criteria that might have general applicability such as reliability and functional

acceptability. Once having qualified these prototypes, DOT could provide to the local governments a kind of a generalized functional specification, a sample specification, that could then be used in the local procurements. In other words, the DOT in this model tries to be helpful to the local governments, without preempting the local functions or decision-making responsibilities by providing qualified products for consideration.

I am sure we can get a lot of argument on that, but we throw it out as a suggestion to consider. If an opportunity seems to present itself, that kind of an approach perhaps may make more sense than the kind used for Transbus.

Our next suggestion has to do with organization. It is an interesting fact that today the Department of Transportation office of the secretary has no senior official with a technical responsibility or a technical title. We could recommend very specific things, such as appoint an assistant secretary for science and technology or for systems development and technology. The title has been changed a couple of times. We chose a rather more general form of this recommendation, suggesting that somebody smarter than we are in DOT or in the administration should figure out how to play the titles game.

We recommend that DOT have a senior technical official, for example, maybe a deputy secretary who has some authority. Specifically, we were thinking of authority to review and approve R&D budgets and programs and to oversee the technical activities of the various administrations.

Our final suggestion is not really a recommendation, but is something to think about. It occurred to us again and again that no matter what our interests may be in airplanes, trucks, railroads, and so forth, the automobile still dominates the personal transportation scene. There is a real question as to what the role of the DOT, or of any part of the federal government, with respect to the automobile may be. We see the regulatory function, obviously. We have talked about that. We see the Department of Energy taking a big interest in the possibility of improving fuel consumption, in new types of engines, in electric cars, and in many things like that.

It is a fact that the involvement of the government in the future of the automobile is somewhat scattered, to say the least. It appears in all these various agencies. Perhaps someone should consider, at least, as an alternative, whether or not all of the various federal interests in the automobile should be collected in a more centralized way into a single agency. Again, I would not be prepared to argue the merits of that idea, pro or con. But the fact that a given situation exists and we see an alternative does suggest to me that someone wiser and more skillful should take a look at whether there is any value in the alternative.

That completes our list of recommendations, unless I left some of them out. If I did, I am sure one of our panel is going to stand up and remind me.

The only other thing I will add is just a little comment on Martin Goland's report. He referred to the centers of excellence. That

somehow popped up on our little list of questions to look at: whether centers of excellence are a good idea and how they relate to federal procurement.

Perhaps we do not even understand the problem, or perhaps we did not understand what centers of excellence are. But there was a view, or a conception, that a center of excellence meant a new organization, a quasi-federal sort of thing. It might be partly run by industry, and partly run by the government, and it might be a "set-aside" center of excellence doing its thing all by itself.

Our panel seemed to have a fairly strong consensus that this was not a very good idea. Of course, there are notable exceptions we could mention. I think our fear here is that we have seen at least some examples of how a federal laboratory, or a quasi-federal laboratory, set up for a particular purpose, has tended to become more of an end in itself than a means to an end. One of its chief aims in life, one of its chief objectives, becomes that of self-perpetuation, rather than serving a purpose. It is a thing of which we should be fearful.

DISCUSSION

ROGERS: I have one comment. I would like to encourage, and indeed urge, the Department of Transportation to pay careful and responsive attention to the innovative suggestion of this panel (and I think another panel as well) that the federal grant programs in transportation be looked at as a source of support of transportation RDT&E activities. It should be appreciated that there are important precedents for so doing. The highway trust fund is one example: 1 1/2 percent of the highway trust fund may be used for research, development, test, and evaluation. And the HUD 701(b) clause, contained within the Comprehensive Metropolitan Planning Act, allows up to 5 percent of the funds authorized and appropriated under 701--it was about \$50 million a year, a few years back--to be used for RDT&E. This is a way of, in principle, perhaps doubling the amount of RDT&E funds to be made available to improve the efficiency and the effectiveness with which those federal grant monies are being spent. And, with these funds, universities, local professional groups, and local commercial and not-for-profit groups could be called upon, and supported, to study transportation problems.

It would also free up, thereby, much of the federally contracted RDT&E dollars from support of smaller, more local studies, and allow their focus upon the larger national problems that might warrant especially large-scale central study.

The second element of such a strategy would come into play downstream. Once having conducted sound RDT&E programs, from which, as a result, improved program efficiency and effectiveness can be demonstrably achieved, the secretary of transportation, working with the administrators, can do a very simple thing. In communicating with those who are asking for large federal transportation equipment, construction, and operating grants, he simply points out that he had perhaps 10 times

as many requests for such funds as he has appropriations to fulfill them. Now, he would not suggest to those state and local bodies who would use such grant funds to develop, construct, install, and operate their transportation systems how to do so, but he would point out that DOT has developed analyses, components, subsystems, whatever, that improve the efficiency and the effectiveness of those transportation systems if sensibly employed. And, naturally, those who evidence a willingness to achieve such increased efficiencies and effectiveness could expect to have their requests put on the top of the pile, for in this fashion, the taxpayer would be getting more for his money. This could be a very powerful strategy.

TECHNOLOGY AND R&D POLICIES
TO STIMULATE INNOVATION

BY

HERBERT D. BENINGTON

I would like first to comment on the constitution of the panel. Since I am very skeptical about the role that the federal government can play in research and development unless it is, in fact, the user of its development products as is the Department of Defense, I was delighted that there were on the panel a large number of others who were also skeptics. It tended to be a panel of entrepreneurs, of people who wanted to be cautious about the government role and who recognized how easily bureaucratic mistakes are made, people who are very wary about technocratic solutions in complicated areas, and people who are concerned about good management and accountability. So, from my point of view, it was a responsible and cautious group.

The panel wanted me to make some observations. We noted that the Department of Transportation research and development budget is only 2.3 percent of its budget, and that compares with something like 11 percent for DOD and almost 50 percent for the Department of Energy. We recognize that one should be cautious about such overarching statements. But we noticed that the DOT R&D budget is also declining at a rate of about 8 percent a year. And we noticed, too, that the position of the Assistant Secretary for Systems Development and Technology was abolished.

We also sensed in talking to some of the individuals in the Office of the Secretary of Transportation (OST) from the department, and from our own experience, that all of this has led to a very poor climate and a poor attitude within the highest levels of OST toward technology and technologists. There appears to be relatively little confidence in and little use of people with scientific and technical backgrounds in some major decisions. Further, procurement practices have evolved--Allen Puckett gave excellent examples--in ways that we think are quite rigid. The process may be good for buying boots, but it is not good for helping the innovative climate. There is often weak support of the R&D programs at OMB and on the Hill.

As I said earlier, in my remarks during discussion of a previous paper, we recognize very well that there were some real difficulties when one of our objectives was to use aerospace technology to help solve transportation problems, particularly surface transportation, including rail and urban mass transit. There were many technologically naive people in the government, and in industry, who thought that we could use this talent and make great progress in transportation R&D. Many unsuccessful programs resulted.

However, it seems to us that if that represented one end of the swing of a pendulum, the pendulum has gone about as far in the other direction as it can go. Given some of the very major national problems that we have now in energy, in the environment, in the urban areas, in balance of payments, and in the health of U.S. industry, a judicious strengthening of the technological arm at OST in DOT is urgently needed.

So, we talked about an assistant secretary for R&D. We would emphasize that this should not be an office that does detailed management of the modal R&D programs. We have seen examples in which this just does not help. It slows things down. We would emphasize that it is very important that the leaders in that office not be thoughtless supporters of technology. There is a history of such support on occasion. There is still a lot of skepticism concerning such an organizational arrangement within the government, on the Hill, and within the OST. So considerable prudence and statesmanship are required in making changes.

We do believe that this office could play a major role in shaping plans and policies that are conducive to innovation, and that extends beyond R&D. It gets into such things as procurement practices, or ways of shaping the grants process. Probably the most important aspect of this idea is the need to apply research and analysis to the whole business of regulation, to make that business more coherent, economically justifiable, accountable, and successful in achieving sensible goals.

We think that this science and technology office could take the lead in discovering intermodal opportunities and in seeing that these get proper emphasis and it could also identify what we call the no-modal opportunity, for example, pipelines. There is no regular DOT mode representing pipelines. Is it possible that some activity could be spurred there by the federal government?

We would establish a full-time scientific advisory group, analogous to the Defense Science Board (DSB), and make sure that that group had people as highly qualified as those in the DSB and the President's Scientific Advisory Committee (PSAC) have been in the past. We would make sure that that group is given access to the problems and given freedom to criticize and to suggest ideas.

Finally, we would change the procurement practices. Puckett touched on one of the most important aspects, the case of unsolicited proposals. We would lower the threshold of authority in awarding sole source grants or contracts. We would increase the use of the performance requirements specifications in procurements. Rather than determining a solution and attendant design specifications, the government should state the objective and the performance requirements being sought. We would also stimulate joint ventures.

We believe that the entire policy and planning function in OST needs very much to be strengthened. Implicitly, we were supporting the notion of the national transportation plan. I second Puckett's comment that plans are made to be changed. On the other hand, they also provide a visibility and a comprehensiveness of thought that can be very useful.

We thought that there should be something called an annual mobility assessment. This mobility assessment would tell us annually how well

we think the system is doing: in terms of the users of the various modes, the services, the costs; in terms of the operators, how well they are doing; in terms of the suppliers, how viable the industry is, and what is happening to it.

This mobility assessment would obviously have to be put together by many elements outside of DOT, in the federal government, in state and local governments, and in private industry. There was some discussion within the panel on how to achieve it. I think a majority felt that it would be done independently, as in a continuing commission, if you will, producing this annual report, independent of the DOT. My own inclination is that it is important that it have an adequate staff and a strong connection to DOT. I would like to see a more regularized role for DOT in mobility assessment.

Let me now turn to the issue of the R&D programs of the various modes. This discussion relates to Martin Goland's earlier remarks, and those of others, concerning the differences in the ways in which the modes operate and the resulting differences one sees for handling R&D. We, too, made the distinction that air traffic control and the Coast Guard are cases in which DOT is the user/operator and needs to take the lead in doing the research and development. In the case of the auto and aircraft, we were very skeptical about any active R&D role. In our discussions of rail, urban mass transit, and highway, we thought there was certainly one case where there was a very important opportunity for a strong federal program, not large in terms of many of the programs that the country has undertaken, but nonetheless a large one. This program would have the aim over the next four or five years of really increasing our system understanding of a much improved urban mass transit technology. Let me give the background to our thinking there.

In looking at the use of urban mass transportation, it seems to us that modest incremental improvements in performance, service, or cost are not going to increase the ridership significantly. Ridership--use of urban mass transport versus other means--is something like 4 or 5 percent of the total, and we think it will stay there, from the way the program is going, over the next 10 to 20 years. At the same time we see, within the city, very major problems. This is certainly one of our major national problem areas and involves congestion, environment, economics, crime, and other factors. We also sense a political commitment to urban mass transportation and that does not gainsay Charpie's comment that everybody is in favor of it and nobody wants to ride it. The fact is that there are political forces behind it.

On the other hand, we do not deny the dismal record of some of DOT's attempts to apply aerospace technology to improving transportation. There is much fundamental agreement on that aspect.

However, let us now make a technical, engineering, and economic observation. It seems to us that if we are to increase ridership from 4 percent to 20 or 30 percent in our large and congested cities, we must do it by making the transportation much more accessible. One must be able to get to his destination much more quickly, and stations are going to have to be closer to where you are and where you are going. We cannot

have the long access times and transit times and waiting times that we have today.

In looking at the bus option it seems to us that buses, anyway you go, are going to be manpower intensive, both in terms of operation and probably in terms of maintenance. Therefore a lot of good work could be done in that area.

We ask the question, "Is it possible to get a capital intensive system for cities that would make the transportation much more accessible to the rider and that would increase the ridership significantly by an order of magnitude, 3, 5, or 10?" I want to emphasize here we are not talking about improving the component state of the art. We are talking about improving the system state of the art. It seems to us that there are technologies coming along whereby if we use some of the state-of-the-art mechanical technologies and the rapidly advancing electronic technologies, we could get systems that would provide automatic-group-rapid-transport or personal-rapid-transit, or a combination of these. The cost of development of these systems would be--if one wanted to have a program in the next five years--much more than the \$50 million or so that is currently programmed by DOT. It might cost as much as \$500 million in the next five to eight years to develop such a program. That is about a third of the cost of one fleet ballistic missile submarine. We do not guarantee that if we undertook this large program we would definitely get something that would succeed. One of the expectations we talked about, for example, was that we should, for the cost of a metro system, be able to increase the ridership by a factor of, say, 5.

It appears possible that a well-managed program that showed concern about the market and that brought along the right technology could produce this kind of quantum step forward. And it seems to us--notwithstanding the failures in technology in the past and the management problems in the past--that this country has done some large R&D projects that have turned out to be extremely successful and this option should be recognized and should be deliberately considered by the Department of Transportation and other people in the government.

We also felt that some progress has been made in the highway technology area. We had some experts who identified many areas in which considerably more could be done and result in a large payoff. We talked about the materials problem, asphalt and concrete, where there has been a lot of progress in the last 10 years, but now we know a lot more things that we would like to look into further--questions such as lighting of roads and access and questions of maintenance technology and standards. It seemed to us that much more progress could be made in these areas. Certainly, the maintenance of the highways is one of the major challenges we are now finding.

In the case of FAA, we felt that the automation of the en route control function should be given very high priority. As you probably know, today the surveillance function is heavily automated, including the processing of flight plans. But the control function itself is virtually completely manual. It seemed to us that the technology is in hand to have a much higher degree of automation of this control

function and that by doing this one would be able to get from New York to Washington flying on instruments in bad weather as fast as it can be done by flying visually. This would really help the airlines and the passengers. Automation would lower the number of controllers needed, even though there is increasing air traffic, particularly in general aviation. If the machine is properly programmed, and we are convinced that can be done, then it is going to be more attentive through the hours than the air traffic controllers can be.

We think that this is an area that requires a high priority for development. In fact, in a mechanism that I will mention in a minute, all the user/operator/supplier elements of the industry seem to feel that this should be pushed ahead.

I have mentioned already the great importance of a stronger technical input into the regulation process. There are many cases in which we have not had good analysis. There has not been good economic analysis, data have been faulty, and experiments have been needed. I think one of the big advantages of having a much stronger technical arm in the OST would be to point out those cases, point out that the decisions are being made on the basis of fluff and prejudice and that they just cannot be justified. Hopefully, this will force people to do more rigorous homework.

I think also that something like Transbus, which has been mentioned several times, might not have happened as easily if there had been a strong technical, acquisition-oriented voice that could have pointed out some of the problems in that procurement.

Finally, we make three recommendations that are independent of modes. First, we support the general involvement of the federal government in basic research in those technologies that underpin the transportation business across the board. Many agencies could play a role here: NASA, DOE, EPA, DOD, and NSF included. We believe that it is DOT's responsibility to make an assessment of the funding that is taking place in those various agencies, find out where the gaps and the opportunities are, and then recommend to them or undertake the right basic research programs. In this connection, it seems to us that the kind of program that is being talked about for automobile research, about \$50 million a year, makes a lot of sense.

Second, we think that DOT must place much greater emphasis on test and evaluation. One of our panelists told of the case where we raped the cities by giving them devices that were developed in part or in full by government funding that did not work adequately. Such cases give the whole approach a black eye. We would stress that where the department has been responsible for the development of an element, it also make sure that that element does undergo rigorous test and evaluation before it gets deployed. We also see a role where the department could provide some test facilities, such as it is now doing in the rail area, and somewhat in urban transit, that would facilitate the industry itself in undertaking better development and evaluation.

The final recommendation of my report has been noted by other panels, and we also think it is very important. We believe that in order for R&D and technical decision making to be more relevant, there

must be much better communication among the DOT, the operators, the suppliers, the users, and some of the other interest groups. We think that the work that has been done, for example between the Association of American Railroads and the Federal Railroad Administration, is an excellent example of good communication. Another recent case has been the Federal Aviation Administration. Under pressure from the Hill to seek broad inputs on the future of air traffic control, the FAA established a committee that looked into different aspects of the air traffic control business. The committee came up with a surprising degree of consensus after very good communication, and now we know much better how to make progress in that area.

DISCUSSION

THOMPSON: I think everybody in this discussion is assuming that innovation is a good thing. I would like to put in a counterview. I listed six innovations in the transport field. One is the transverse engine with front wheel drive on cars. Another is the jet engine. The third is a hovercraft. The fourth is the high-speed train. The fifth is the linear induction motor for dragging anything along a rail. And the sixth is carbon fibers.

I think it would be worthwhile for somebody to study why it is that the original innovator in all of these so far has not made any money on them. You could argue a good case that the way to success is to be second, not to be first.

BENINGTON: I think one could also give some cases where companies themselves seem to have succeeded by being second.

NEJAKO: I hope most people in the room recognize that the Urban Mass Transportation Administration spent some \$30 million developing a test and evaluation capability that is part of the Transportation Test Center in Pueblo, Colorado. It is open to use by the rail transit supply industry. I think they are recognizing its availability much more frequently now. But I want it generally understood that that is a recommendation we began to implement back in about 1972.

CHESEBROUGH: I may sound like a cracked record, but I would like to speak as a self-appointed chairman of panel 6, representing the people. This country developed and became great by respecting people's freedoms, including freedom of choice. I hope we stay that way.

I would like to remind the people that innovation in transportation will proceed only as fast as the emotional interests and pressures of people either demand or accept these innovations. We can create all kinds of sophisticated, technically sound, scientifically logical systems. But if the individual people do not recognize that these fall within their concept of what they want, such systems will become monuments similar to many of the marble buildings we have in this town.

I want to reiterate that this is a facet that must continually be kept in mind. It is extremely difficult to determine in advance what people will accept, emotionally. They, themselves, cannot tell us. If questions are asked of consumer or buyer preference research groups,

one does not, very many times, get the right answers. That has been proved time and again when carefully researched marketing plans, product development plans, collapse upon hitting the market. So do not forget this element.

I have been prompted to say this by a comment that was made, I know in good faith, that we must somehow or other find a way to get urban mass transit ridership up to the 20 percent level. I agree with that. But we had better make sure that 20 percent of the people feel the same way about it.

LIST: As a second member of panel 6, I also hope that people's views are not neglected. DOT may be in many fields where they have no business, but assessing mobility, one of the recommendations of the panel on technology and R&D policies to stimulate innovation, panel 5, would be a very good logical function for DOT to perform. But assessing mobility is right in the middle of their mandate, and this is where the public comes into the picture. In other words, the ultimate criterion is whether it is useful. We have not paid enough attention to that.

GORHAM: I want strongly to endorse the recommendations of at least two panels for the restoration of a center of responsibility for science and technology in DOT. There were many reasons for its abolition. One was the primary desire to reduce the head count in the Office of the Secretary. But we lost a great deal when that was done. One of the recommendations of the panel on economic incentives, panel 3, in which I participated, may not have come through clearly. It was that now we are getting to a point where the rate of development of innovation in individual transit modes in some cases may be running out of steam. The big opportunity for development in innovation at the present moment is in the intermodal field. This can only be accomplished if we have some center within the Department of Transportation that looks across modes and considers the transportation functions of all of them.

BISPLINGHOFF: Ladies and gentlemen: I want to thank all of you for your participation: the speakers, discussants, chairmen, and especially those who stayed with us to the finish. No one knows for sure what results will come from a conference of this kind, but I think we all agree that this kind of examination must be carried out if there is to be progress.

The proceedings of the conference, we hope, will be published early next year. There also will be a committee report later in 1980. It will include the ideas developed in this workshop, as well as information derived through other activities of the committee.

We will do our very best to bring all of the suggestions brought forth in this workshop to the attention of people who are in a position to implement the ideas. We will do everything we can to bring these views to the attention of officials of DOT. In the past we have been able to do that at the highest levels of the department. Although there have been many changes in DOT in the past few weeks, we will present what you have told us to as many of the appropriate people as we can in the Department of Transportation. We plan to go to the leadership in the Congress in the transportation area, and to bring these recommendations and ideas to their attention.

We will certainly make this effort, and hope the net effect will be positive.

Again, I express my gratitude to all of you for taking the time from your very busy schedules, and from the many other important duties you have, to be with us. We appreciate your attendance and your contributions.

WORKSHOP CHAIRMAN'S CLOSING REMARKS

First and foremost, I would like to thank each of you for your dedicated participation.

No one really knows what good can come from a conference of this nature, but I think we all agree that this kind of examination of innovation in transportation has to be carried out if anything at all is going to take place.

We will publish the proceedings of this workshop, and, in addition, there will be a Committee on Transportation report on the process of innovation in transportation later in 1980, which takes account of this workshop, as well as other activities of the committee. We will do our best to bring these to the attention of officials in the Department of Transportation. We are going to try to do the same thing with the appropriate leadership in Congress.

PANEL MEMBERS, PARTICIPANTS, AND OTHER ATTENDEES

PANEL 1:
THE SETTING FOR INNOVATION

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PANEL 2:
INTERACTIONS OF GOVERNMENT, INDUSTRY, AND ACADEMIA

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*U.S. GOVERNMENT PRINTING OFFICE: 1980-0-720-752/20

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