A CBO STUDY

HIGH-TECH HIGHWAYS: INTELLIGENT TRANSPORTATION SYSTEMS AND POLICY

OCTOBER 1995

The Congress of the United States
Congressional Budget Office

NOTES

Rounded numbers in text, tables, and figures throughout this study may produce sums that do not correspond to the totals shown.

Unless otherwise indicated, all years referred to in this study are fiscal years.

Preface

The Intermodal Surface Transportation Efficiency Act of 1991 established the Intelligent Vehicle Highway Systems program for improving transit and highway travel through research, development, testing, and evaluation of advanced computer and communications technologies. Now known as Intelligent Transportation Systems (ITS), the program is authorized through 1997. In response to a request from the Chairman and Ranking Minority Member of the Senate Committee on Environment and Public Works, this study provides a midcourse review of the program and presents options that the Congress may wish to consider in reauthorizing it. In keeping with the Congressional Budget Office's (CBO's) mandate to provide nonpartisan analysis, this study makes no recommendations.

Elizabeth Pinkston of CBO's Natural Resources and Commerce Division wrote the report under the supervision of Jan Paul Acton and Elliot Schwartz. The author wishes to thank Mark Booth, Peter Fontaine, John Patterson, and Rachel Schmidt of CBO for their useful comments and criticism. She also appreciates the thorough reviews by Kevin Dopart, John Fischer, Damian Kulash, Paul Rothberg, and Richard Theroux. She gratefully acknowledges the assistance of many members of the staff of the Department of Transportation who provided data, reports, and valuable insights about the ITS program.

Sherwood D. Kohn edited the manuscript. Chris Spoor provided editorial assistance. Tina Holliday and John McCarty typed numerous drafts of the study. Kathryn Quattrone prepared the report for publication.

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Summary

Over the past four decades, the nation has responded to traffic congestion and other transportation problems by constructing new highways, widening existing roads, and building and improving rail transit systems. Adding new capacity to the nation's surface transportation network is becoming increasingly costly, however, leading transportation officials to seek high-technology substitutes for steel and concrete.

In 1991, the Congress authorized a program exploring the use of advanced computer, communications, and sensor technologies to improve travel on highways and mass transit. Originally established under the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) as the Intelligent Vehicle Highway Systems program, the effort has come to be known as Intelligent Transportation Systems (ITS) to reflect a broader set of concerns. The Department of Transportation manages the program.

In establishing the ITS program, the Congress enunciated a set of diverse objectives--including reducing congestion, making travel safer, increasing productivity, and safeguarding the environment--to be achieved through advanced technologies. To meet those goals, the Department of Transportation is sponsoring several hundred projects to research, develop, test, and deploy new technologies. The projects are mostly small in scale, with average funding of about $1 million, and grouped into several major clusters:

- *Travel and transportation management* is aimed at keeping highway traffic flowing smoothly. It uses such measures as removing accidents and broken-down vehicles from roadways, controlling traffic signals, and providing information enroute to travelers about roads and services.

- *Travel demand management* aims to reduce travel by single-occupancy vehicles. It provides pretrip information about traffic conditions and the availability of transit services and ridesharing opportunities.

- *Public transportation operations* would provide enroute information to transit users, enable transit officials to keep track of the locations of their vehicles and monitor ridership demands, and enhance the safety of transit operations.

- *Electronic payment* would facilitate travel by allowing travelers to pay for parking, transit fares, and tolls through "smart cards."

- *Commercial vehicle operations* would facilitate interstate trucking by substituting electronic clearance for paperwork that is now required to comply with state requirements, weighing trucks at highway speeds instead of requiring them to stop at weigh stations, monitoring operations to enhance safety and improve efficiency, and providing for immediate notification of authorities in case of accidents, especially if hazardous materials are involved.

- *Emergency management* would enable quick notification of authorities and prompt response in emergencies.

- *Advanced vehicle control and safety systems* would employ such devices as collision avoidance warnings, automatic braking controls, and automated highway systems on which vehicles could move without being actively operated by a driver.

In addition to those applications, the ITS program includes several other efforts:

- *Corridor programs*, which would integrate various applications of technology within heavily traveled transportation corridors.

- *Development of a systems architecture*, which provides a blueprint of the way the various pieces of intelligent transportation technologies will fit together over the next five, 10, and 20 years, and beyond.

- *Deployment planning and support*, which involves resolving various legal and institutional issues as well as integrating new technologies into transportation systems.

Funding

Spending authority for the ITS program grew from $20 million in 1991 to $227.5 million in 1995. For the 1991-1995 period, the Congress has voted $827.6 million, and by the end of fiscal year 1994 the Department of Transportation had obligated $544 million for the program (see Summary Table 1).

The ITS budget constitutes less than 1 percent of total federal spending on highways and mass transit. That small percentage belies its strategic importance, however, because decisions made today about research, testing, and deployment of ITS systems could have profound implications for the way people travel to and from work, school, and other activities over the next several decades. ITS research may enable highway and transit authorities to provide better service at lower cost, possibly reducing the need for public subsidies.

Summary Table 1.
Funding for Intelligent Transportation Systems
(In millions of dollars)

Fiscal Year	Funds Provided	Funds Obligated
1991	20.0	19.9
1992	233.8	89.9
1993	143.0	150.9
1994	203.3	283.3
1995	227.5	283.6[a]
Total	827.6	827.6

SOURCE: Federal Highway Administration.

a. Estimated.

Although the Congress had provided some funding for ITS research before 1991, the program gained greater visibility and support when it was formally authorized as part of ISTEA, which reauthorized the federal highway and mass transportation programs.

The Appropriate Role of Government

The primary rationale for the ITS program is the government's role in providing transportation services. Highways and mass transit are generally provided by government, not by the private sector. Although there are some private roads and transit services, they are not common in the United States. Public support of transportation research and development (R&D) can directly improve the government's ability to provide highways and mass transit service.

Apart from its role in financing highways and transit, the government has a potential role to play in sponsoring research and development in general. Government sponsorship of R&D is usually justified on the grounds of market failure. If research produces spillover benefits, the private sector may not conduct enough because it cannot realize sufficient benefits to make research worthwhile. The government can disseminate research findings without having to recoup their costs in the marketplace.

State and local governments may underinvest in research and development for the same reason that private firms may hold back. State and local governments may not be able to reap enough benefits to cover their costs, but if the knowledge gained is shared with other jurisdictions, the total benefits may exceed the costs. In such cases, when the benefits nationwide exceed the costs (and provide a competitive rate of return), federal support may be justified.

Underinvestment in research is a form of market failure, but market failure alone is not sufficient justification for government involvement. In dynamic economies, some amount of market failure is normal. In considering government involvement to "correct" a market failure, one must weigh the potential for governmental failure as well. Even though the market may not produce the optimal amount of research, there is no presumption that the government can identify and conduct a "better" quantity and quality of research.

The benefits of some applications of ITS would increase substantially if the technologies were compatible among jurisdictions. Travelers tend to cross boundary lines and would prefer to encounter compatible technologies so that they would need to learn only one system and purchase one type of equipment, especially in such applications as electronic toll collection. Systems that would allow trucks equipped with electronic tags containing registration and other important information to travel an interstate corridor without stopping to show paper proof of compliance with state requirements could vastly improve productivity. The federal government could facilitate interstate agreements on compatible technologies and procedures, although the existence of interjurisdictional coalitions and compacts may make federal involvement unnecessary.

To be successful, ITS projects must appeal to the needs and pocketbooks of users. State and local governments will make the key decisions about the adoption of most applications. Projects must pass benefit-cost tests in terms of both capital investment and operation and maintenance costs over a useful life. For some types of applications, especially commercial vehicle operations, the private sector can make--and indeed has made--investments on its own, without government participation. But such investments typically are limited to situations in which a company can recoup its investment internally. For investments that have substantial spillover benefits to other highway users, government funding would probably be required.

Evaluation

As the federal ITS program enters its fifth year, many observers are asking to see results. Although the program's managers can point to a number of individual projects that appear successful, little systematic evaluation has been completed. In the early days of the program, attention to evaluation was limited. That situation is changing. The program's managers recognize that they must be able to show both results and a clear justification of their role in order to receive continued funding. Several major efforts are under way to strengthen the evaluation process.

Evaluating ITS projects entails making judgments about a number of factors, such as the degree to which a new technology will be adopted, how it will be used, the behavioral responses of consumers, and the value of such benefits as time saved by alleviating congestion. Evaluation requires weighing whether a new product appeals to users and whether it solves problems more efficiently than existing solutions. Work is under way to develop models that would identify the wide range of potential consequences of ITS activities. Such models will help sort out which parts of ITS further which objectives, and how, and will suggest where meeting those objections will produce trade-offs and mutual benefits.

Criteria for evaluating the ITS program and its component projects include the following:

o Is there a rationale for government involvement, or can the private sector undertake the research, testing, or deployment? Are there external benefits or costs that cause the market to fail? Do the costs of market failure outweigh the risks of governmental failure?

- o What is the federal interest in the program or project? Are there nationwide benefits? Could and would state and local agencies take responsibility?

- o How will the effort contribute to the state of knowledge about the benefits and cost of prospective technological applications? How will it advance the ultimate goals of mobility, efficiency, safety, and environmental quality?

- o How does the project fit in with other projects? Will it help fill gaps in knowledge about technologies or behavioral responses? Is this the best way of gaining that information?

- o Is the project designed in a way that helps evaluation?

The ultimate measure of the ITS program's success will be the adoption of its products and technologies by state and local governments and other transportation providers and users.

Options

The need to constrain federal spending in general affects the ITS program in particular. Assuming that budgets will be tighter in the future, this study suggests three alternatives for reform of the program: eliminating it as a separate program, narrowing its focus, or strengthening it through managerial improvements. Those options would produce somewhat different results in terms of the types of applications emphasized and the nature of federal government involvement.

Eliminating the Program

Eliminating the ITS program as a separate programmatic and budgetary entity would not necessarily mean ending federal support for intelligent transportation technologies; it would only require such efforts to compete more directly for federal funding with other transportation projects. Under this option, the Federal Highway Administration (FHWA), Federal Transit Administration (FTA), and National Highway Traffic Safety Administration (NHTSA) could continue to sponsor ITS projects under their existing research and operational testing programs. State and local governments could also use federal funds for research, testing, and deployment of intelligent systems.

Underlying this option is the premise that the ITS program has largely succeeded in its goals of bringing together parties that have a stake in intelligent transportation and highlighting the benefits of applying advanced technologies to solve transportation problems. The federal government has provided seed money for a variety of projects and has called the attention of state and local officials to smart systems so that those executives can make informed investment decisions about whether to apply new transportation technologies in their communities.

Scaling Back and Refocusing

Another option is to scale back the ITS program and focus on areas where federal intervention would facilitate interstate commerce. Electronic clearance of commercial vehicle operators and electronic payment of tolls would be most likely to meet this criterion. Other project areas could be considered on the basis of the strength of federal interest and the need for federal involvement.

Strengthening Control

A third option is to retain the ITS program in its current form but to improve the process of setting priorities and selecting projects. Funding is divided among several hundred projects, including some that appear to duplicate others and some that have not been designed to produce clear-cut results. The program could be strengthened by judging projects on the basis of their potential contribution to knowledge. Researchers could be required to show what they would learn, what gaps in knowledge the project would fill, and what transportation problems it would help solve, as well as the likely success of doing so. Peer review of proposals and results could strengthen the evaluation process.

Conclusion

As with most new programs, ITS has had problems of start-up and rapid growth. But the establishment of the Intelligent Transportation Systems Joint Program Office within the Department of Transportation has helped bring together a disparate set of projects run by FHWA, FTA, and NHTSA and is providing greater oversight to the process of selecting, overseeing, and evaluating projects. The next two years will be crucial in demonstrating what the program can produce. At this juncture, the jury is still out on the question of whether it is a sound investment of federal dollars. Unless the program can demonstrate that it is helping to meet the overall transportation objectives of mobility, productivity, safety, and environmental quality without increasing costs, it will have difficulty competing with other programs for limited budgetary resources.

In considering legislation to succeed ISTEA, the Congress will debate the future federal role in setting policies and providing financing for highways and mass transit systems. The three options offer ways of modifying the ITS program within the context of the existing federal framework. The criteria presented for federal involvement--a national interest transcending state lines and the existence of spillover benefits and costs--can also be applied more generally to highway and transit programs. If the Congress should decide to scale back or significantly alter the federal role in surface transportation, the role in funding intelligent transportation systems could be modified accordingly.

Chapter One

Introduction

The Intelligent Transportation Systems (ITS) program is a research, development, testing, evaluation, and deployment program to improve travel on mass transit and highways by using advanced computer, communications, and sensor technologies.[1] The program is several years into its first authorization period, making a midcourse review desirable.

The ITS program consists of several hundred projects designed to apply new technologies to solve such transportation problems as traffic congestion, safety, and adverse environmental effects. Some projects address problems through the supply side, attempting to assist highway and transit agencies in reducing costs or making better use of the resources they control. Other projects work through the demand side, attempting to satisfy the needs of users. But the diversity of users, the multiplicity of suppliers, and the variety of objectives complicate efforts to establish comprehensive measures for evaluating the program.

In choosing the most promising research efforts, the federal government must consider which projects most deserve federal dollars. Important criteria include the size of public benefits in relation to costs and whether another level of government or the private sector might pursue the project.

1. The program was originally known as the Intelligent Vehicle Highway Systems (IVHS) program.

The ultimate beneficiaries are highway and transit users: commuters, tourists, trucking companies, and so on. Those commercial and individual users will make the final decisions about installing and using equipment in their vehicles and homes to help plan their travel--what mode to take, when to go, and what route to follow. And those decisions are affected by the types of investments undertaken by state and local governments that own and operate highways and transit systems.

The value of government investments in intelligent transportation systems will depend in large measure on how travelers greet those systems; do they welcome, merely accept, reject, or resist them? Therefore, government research and development (R&D) efforts must include not only whether technologies work but also behavioral responses and how those responses translate into safer, faster, cheaper, more reliable travel.

For several decades, the federal government has played a significant role in funding the construction of major highways and mass transit systems and providing assistance in operating and maintaining those systems. If it continues to provide such assistance, it has a stake in reducing the costs of those systems.

The federal government also plays a role in facilitating the flow of commerce between states. One way is by promoting compatibility of technologies across state lines. That approach could be useful in electronically collecting tolls and clearing trucks that would otherwise have to stop at state checkpoints to demonstrate compliance with registration requirements, weight limits, and other regulations.

Although federal funding is not the sole support for transportation research and development, the federal government's policies are likely to have far-reaching implications for the future of transportation. During the next few years, the success of the ITS program can be measured by the willingness of transportation users and providers to adopt technologies it has sponsored. They will do so if they see that those innovations reduce costs or improve service.

The ITS Program

To meet the diverse goals established by the Congress--mobility, safety, productivity, environmental quality, and improved technology--the ITS program has started work on a variety of applications. Those applications can be grouped into several major categories:

- *Travel and transportation management*, aimed at keeping highway traffic flowing smoothly, using such measures as clearing accident scenes and removing broken-down vehicles from roadways, controlling traffic signals, and providing information to travelers about routes and services.

- *Travel demand management,* to reduce travel by single-occupancy vehicles by providing information in advance about traffic conditions and the availability of transit services and ridesharing opportunities.

- *Public transportation operations*, to give transit users information enroute, enable transit officials to keep track of the locations of their vehicles and monitor ridership demands, and enhance the safety of transit operations.

- *Electronic payment,* to facilitate travel by allowing travelers to pay for parking, transit fares, and tolls with "smart cards."

- *Commercial vehicle operations*, to facilitate interstate trucking by substituting electronic clearance for paperwork now needed to comply with state requirements, weighing trucks at highway speeds instead of requiring them to stop at weigh stations, monitoring functions to enhance safety and improve efficiency, and providing for immediate notification of authorities in case of traffic accidents, especially if hazardous materials are involved.

- *Emergency management,* to provide for quick notification of authorities and prompt response in emergencies.

- *Advanced vehicle control and safety systems,* such as collision avoidance warnings or automatic braking controls and automated highway systems, on which vehicles could move without drivers.

In addition to those applications, the ITS program includes several other efforts:

- *Corridor programs,* to integrate various applications of technology within heavily traveled transportation corridors.

- *Development of a systems architecture,* to provide a blueprint of the way in which the various intelligent transportation technologies will fit together during the next 20 years and beyond.

- *Deployment planning and support,* to resolve legal and institutional issues as well as to integrate new technologies into the nation’s transportation systems.

Legislative Authority

The Congress authorized the Intelligent Vehicle Highway Systems (IVHS) program in the Intelligent Vehicle-Highway Systems Act of 1991, which was included as title VI, part B of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA).[2] The act set forth eight goals for the program:

2. ISTEA, section 6051 et seq. As noted above, the program has become commonly known as Intelligent Transportation Systems.

- Enhance the capacity, efficiency, and safety of the federal-aid highway system and serve as an alternative to expanding the physical capacity of the highway system;

- Enhance efforts to attain air quality goals established in the Clean Air Act;

- Improve safety on the highways;

- Develop and promote an IVHS industry in the United States;

- Reduce the societal, economic, and environmental costs of traffic congestion;

- Enhance U.S. competitiveness and productivity by improving the free flow of commerce and establish a significant U.S. presence in an emerging field of technology;

- Develop a technology base for IVHS, using the capabilities of national laboratories; and

- Help transfer transportation technology from the national laboratories to the private sector.[3]

Some of the eight objectives are complementary but others compete with each other. Deploying more resources to advance some goals may require spending less for others. The Congress gave the Department of Transportation (DOT) substantial latitude in meeting the objectives, although it also earmarked funding for some projects and directed the department to meet certain deadlines.

Participants in ITS Development

The federal government's primary role in developing the ITS program is to set priorities, provide funding, act as a coordinator, and serve as a catalyst; it will perform relatively little in-house research and development, operational testing, or deployment. In fact, it aims to promote development of ITS by other levels of government and the private sector. The participation of state and local governments is crucial to the ultimate success of the ITS program because they own and operate most of the transportation infrastructure in the United States. Historically, the federal government has provided funding for transportation to lower levels of government, usually with strings attached. In addition, it conducts or sponsors research and shares the results with other levels of government.

To be successful, ITS projects must address the economic and transportation needs of people who would use their services. State and local governments will make the key decisions about adopting most applications. Projects must be economically justifiable in terms of capital investment and operation and maintenance costs over their useful life. For some types of applications, especially commercial vehicle operations, the private sector can make--and indeed has made--investments on its own, without governmental participation. But such investments typically are limited to those for which the company can recoup the investment internally--that is, from which it can reap enough benefits to make the investment worthwhile. For investments that have substantial spillover benefits to other highway users, government funding would help expand R&D to levels that are more beneficial to society.

Many ITS activities are partnerships between government and private parties, and some involve more than one level of government. Among the private entities involved are motor vehicle manufacturers, companies with expertise in communications and electronics, truckers, university research centers, and organizations representing motorists and users of public transit. Many consultants are also involved. In the public sector, federal, state and local highway and transit officials are the key players.

DOT's ITS Joint Program Office

In 1994, the Department of Transportation established the ITS Joint Program Office to coordinate efforts by the Federal Highway Administration (FHWA), the Federal Transit Administration (FTA),

3. ISTEA, section 6052(b)(1) through 6052(b)(8).

and the National Highway Traffic Safety Administration. The Federal Highway Administration continues to play a dominant role, reflecting the amount of funding for roadway projects that are traditionally in its purview. But the establishment of the joint office underscores DOT's broader transportation interests, which include transit and safety in addition to highways. It also reflects the growing size of the ITS program and demands for greater program integration and coordination.

ITS America

One unique participant is the Intelligent Transportation Society of America (ITS America), which was established in 1991 as a federal advisory committee on the ITS program.[4] It draws members from all parts of the surface transportation community: state and local governments, motor vehicle manufacturers, commercial vehicle operators, railroads, telecommunications and computer technology companies, universities and other research organizations, consulting firms, and public interest groups.

ITS America offers advice formally and informally to the Department of Transportation. It sponsors workshops, conferences, and symposiums that bring together researchers, producers, and users of ITS services. These meetings provide the opportunity to exchange ideas about what works and what does not, what is useful and what is not, and which needs remain unfulfilled. ITS America has produced a number of reports, including a strategic plan for ITS, recommendations for federal spending on ITS, proceedings of its conferences, and reviews of the program.

4. ITS America changed its name from the Intelligent Vehicle-Highway Society of America (IVHS America) effective September 13, 1994, to reflect a broader mission. DOT designated IVHS America as a federal advisory committee under section 6053(e) of ISTEA.

Funding

The Congress has provided $827.6 million for the ITS program for the 1991-1995 period.[5] Beginning with $20 million in 1991, the spending authority of the program has grown to $227.5 million in 1995.

Compared with total federal spending on highways of about $20 billion annually, the ITS budget is quite small--roughly 1 percent. But its size belies its strategic importance because decisions made today about research, testing, and deployment of ITS systems could have profound implications for highway travel over the next several decades. Likewise, the approximately $60 million spent through 1994 on projects with public transit applications is small compared with FTA's total budget of around $5 billion a year. But if ITS research results in the ability of transit systems to cut costs or increase ridership, it could reduce the size of public subsidies.

In the 1980s, before the inception of the formal ITS program, FHWA began as part of its research program to fund a number of projects involving the use of computer, communications, and sensor technologies in transportation. Those activities formed the nucleus of the early ITS program.

In its conference report on the 1989 appropriation act for transportation, the Congress recognized the emerging research program and directed DOT to report comprehensively on intelligent vehicle highway systems. ITS first appeared as a line item in the conference report accompanying transportation appropriations for 1991, when it was allocated $20 million within FHWA's research budget. That funding comes under the general operating expenses (GOE) account in FHWA, which receives annual appropriations. The highway bills that the Congress periodically enacts, including ISTEA, include spending authority that can be used without further Congressional action--that is, without the need for appropriations. In most years, however, the appropriation bill for transportation includes obligation ceilings. Those

5. Before 1991, the Congress appropriated funds for IVHS activities, but they were small and are difficult to track because they were part of FHWA's general research funding.

limitations effectively reduce the amount of spending authority, previously granted in a highway bill, that can be used in any one year.

The ITS program gained greater visibility and support when it was formally authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991, which reauthorized the federal highway and mass transportation programs. ISTEA provides funding in the form of contract authority, which is available without requiring annual appropriations (although it is still subject to the limitation on obligations established in appropriation legislation). The Congress has continued to designate portions of FHWA's general operating expense funds for ITS, however, so spending authority comes from both sources: GOE appropriations and contract authority.

Through appropriations and ISTEA, the Congress has provided $827.6 million for the ITS program for the 1991-1995 period. By the end of fiscal year 1994, the Department of Transportation had obligated $544 million for the program (see Table 1).

In ISTEA, the Congress authorized funding for ITS of $94 million in 1992 and $113 million for each successive year through 1997, for a total of $659 million over the six-year period. The Congress appropriated $280.1 million for ITS to FHWA's general operating expenses account for the 1991-1994 period and $114.5 million for 1995. Thus, of the total of $827.6 million provided from 1991 through 1995, 47.7 percent is from GOE, and 52.3 percent is from contract authority in the federal-aid highways program.

Earmarked Funding

The Congress has designated specific projects to be funded under both GOE appropriations and ISTEA. Since 1992, about $396.5 million (49.1 percent of the

Table 1.
Funding and Obligations for the Intelligent Transportation Systems Program (In millions of dollars)

	1991	1992	1993	1994	Total Through 1994	1995[a]	Total Through 1995[a]
Funding							
General Operating Expenses	20.0	139.8	30.0	90.3	280.1	114.5	394.6
ISTEA Contract Authority	0	94.0	113.0	113.0	320.0	113.0	433.0
Total	20.0	233.8	143.0	203.3	600.1	227.5	827.6
Obligations							
General Operating Expenses	19.9	72.4	38.7	127.9	258.9	135.7	394.6
ISTEA Contract Authority	0	17.5	112.2	155.3	285.1	147.9	433.0
Total	19.9	89.9	150.9	283.3	544.0	283.6	827.6

SOURCE: Federal Highway Administration.

NOTE: ISTEA = Intermodal Surface Transportation Efficiency Act of 1991.

a. Estimated.

Table 2.
Spending Obligations for the Intelligent Transportation Systems Program by Type, 1991-1995
(In millions of dollars)

	1991	1992	1993	1994	Total Through 1994	Share Through 1994 (Percent)	1995	Total Through 1995	Share Through 1995 (Percent)
Research and Development	7.9	19.9	34.2	39.6	101.6	18.7	36.6	138.2	16.7
Operational Tests	10.4	3.9	28.9	60.1	103.3	19.0	53.7	157.1	19.0
Commercial Vehicle Operations	0	0	0	13.9	13.9	2.6	11.6	25.5	3.1
Automated Highway Systems	0	0	14.0	0.1	14.1	2.6	13.0	27.1	3.3
Advanced Technology	0	0	0	12.8	12.8	2.4	15.0	27.8	3.4
Corridors	0	57.6	41.4	128.4	227.4	41.8	117.6	345.0	41.7
Deployment Support	0	5.1	7.0	4.7	16.8	3.1	9.3	26.1	3.2
Program Support	1.6	3.4	19.6	14.3	38.9	7.1	13.5	52.4	6.3
Systems Architecture	0	0	5.8	9.4	15.2	2.8	13.2	28.4	3.4
Total	19.9	89.9	150.9	283.3	544.0	100.0	283.6	827.6	100.0

SOURCE: Federal Highway Administration.

total provided) has been earmarked. About $128 million (34.2 percent) of GOE funding has been ear marked, as has about $268.5 million (62 percent) of ISTEA funding.

All of the ISTEA and most of the GOE earmarked funding has been designated for transportation corridors. In the 1992 appropriation conference report, the Congress distributed $119.8 million for "congested corridors." Of that, $109 million was earmarked for specific projects, and $10.8 million was left unallocated.

ISTEA authorized $71 million in 1992 and $86 million a year for the 1993-1997 period for the corridors program. The act required the Secretary of Transportation to designate transportation corridors in which application of ITS would have particular benefit, and it set forth criteria for allocating not less than 50 percent of corridor funding for three to 10 "priority corridors." DOT has designated four priority corridors: the Northeast, Houston, Midwest (Gary-Chicago-Milwaukee), and Southern California.

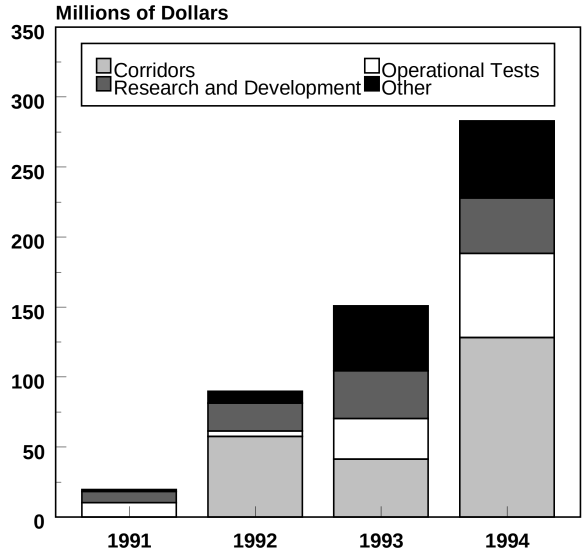
The factors to be considered in designating priority corridors were traffic density; nonattainment of ozone goals under the Clean Air Act; a variety of types of transportation facilities (such as highways, bridges, tunnels, and toll and nontoll facilities); inability to expand significantly the capacity of existing surface transportation facilities; a significant mix of passenger, transit, and commercial motor carrier traffic; complexity of traffic patterns; and potential contribution to carrying out DOT's strategic plan for IVHS.

Funding by Type of Activity

Conference reports accompanying appropriation bills have designated funding by type of activity (see Table 2).[6] The three largest categories--corridors (41.8 percent), operational tests (19 percent), and

6. DOT's categories and amounts differ slightly from those designated in conference reports because DOT has been given the authority to make some shifts in funds within the program.

Figure 1.
Spending Obligations for the Intelligent Transportation Systems Program by Category



SOURCE: Federal Highway Administration.

research and development (18.7 percent)--account for about 80 percent of spending through 1994.[7] Such breakouts are useful to show generally where the money is going, but the categories are difficult to compare because some refer to a type of activity, such as R&D and operational testing, but others refer to applications, such as commercial vehicle operations and automated highway systems. A large part of the spending on corridors could be ascribed to operational testing, as could much of the funding for commercial vehicle operations.

The composition of ITS funding has fluctuated as its size has grown (see Figure 1). Since 1992, the largest component each year has been the corridors program. Obligations for corridors dipped from $57.6 million in 1992 to $41.4 million in 1993 but surged to $128.4 million in 1994. By comparison, funding for operational tests declined from 1991 to 1992 but has exploded since then. Research and development has grown more steadily, rising from $7.9 million in 1991 to $39.6 million in 1994.

7. The categories combine congested and priority corridors.

Program support, the largest of the smaller areas of the ITS program, received a 7.1 percent share of total funding from 1991 to 1994. The others probably should be included in one of the larger categories for purposes of analysis, but available data do not facilitate the task. Most--but not all--spending for commercial vehicle operations (CVO) has gone for operational testing. The Senate's 1995 appropriation report recommended that no CVO funds should go for operational tests; operational testing of CVO applications would have to compete for funding within the operational tests category. The House-Senate conferees allowed CVO funding for one major operational test but agreed that for 1996 and beyond such funding must come from operational tests.

Funding for deployment support has fluctuated. Spending is expected to jump from $4.7 million in 1994 to $9.3 million in 1995. Deployment support may prove to be a key ingredient in the successful application of ITS technologies because it focuses on understanding institutional and legal obstacles.

Systems architecture became a separate line item in 1993, when program officials recognized the importance of establishing an integrated program structure with compatible technologies. DOT funded this area at $5.8 million in 1993 and $9.4 million in 1994.

Advanced technology applications became a separate item within ITS under the GOE appropriations for 1994. Of the $15 million appropriated for 1994 and 1995, DOT obligated $12.8 million in 1994 and expects to obligate $15 million in 1995.

Funding by Type of Application

ITS spending can also be characterized by area of application (see Table 3). These data are more subjective than those presented in the previous section because they are based on judgments about what objectives the various projects may promote. Many projects have more than one objective or application area. For this analysis, funding for projects with multiple purposes was counted as spending for each major purpose. For example, a project intended to enhance public transportation in rural areas was categorized as having both transit and rural applications.

Table 3.
Funding for Intelligent Transportation Systems Projects by Type of Application

Application	Federal Funds Obligated Through 1994 (In millions of dollars)	Percentage of Total Federal Funding of Projects[a]
Travel and Traffic Management	304.6	65.3
Safety	60.2	12.9
Public Transit	59.9	12.8
Commercial Vehicle Operations	25.6	5.5
Rural	12.1	2.6
Environment	5.6	1.2

SOURCE: Congressional Budget Office calculations based on data from Department of Transportation, Federal Highway Administration, *Intelligent Transportation Systems Projects* (January 1995).

a. Excludes program oversight and administration costs. Federal funding for projects through 1994 totaled $466.8 million. But the entries in the table do not add up to that total because some projects are counted twice and others are excluded. See the text for explanation.

Conversely, many projects have a clear primary application, even though they also have indirect objectives. For example, many travel management projects are also intended to improve safety. For this analysis, however, if safety did not appear as a primary motivator of these projects, they were not counted as having safety applications. Thus, the assignment of categories was subjective, but it still provides a rough picture of how ITS funding was allocated by application.

Although funding for some projects was counted more than once--making the percentages add up to more than 100--some projects were not included at all. Projects involving systems architecture, legal and institutional factors, and other matters that do not correspond directly to areas of specific application were omitted from the analysis.

The largest application area was travel and traffic management, which received $304.6 million (65.3 percent of federal funding for ITS projects through 1994). Other areas lagged far behind. Projects with safety as a major motivation received $60.2 million (12.9 percent of federal funding), and projects with public transit applications received $59.9 million (12.8 percent). Projects affecting operations of commercial vehicles got $25.6 million in federal funding (5.5 percent). Rural applications received $12.1 million (2.6 percent), and the environment trailed at $5.6 million (1.2 percent).

Chapter Two

Evaluating the ITS Program

Computer, communications, and sensor technologies offer many opportunities to improve highway and mass transit services. Decisions made over the next few years will affect the shape and performance of the nation's transportation system far into the 21st century. Those decisions will be made by federal, state, and local governments and by private firms and consumers. A review of the issues suggests that the roles the federal government could play most effectively are those that improve transportation services and reduce their costs, stimulate research and development, and encourage agreements about technological standards and institutional cooperation that facilitate interstate commerce.

In reviewing any governmental program, it is useful to consider several questions. First, what is the rationale for governmental involvement? Is this an activity the government--and, in particular, the federal government--should be engaged in? Why? What are the benefits to the public? Second, is the program meeting its objectives? Are taxpayers getting their money's worth?

The Rationale for Government Involvement

Economists generally cite two principal rationales for governmental involvement in providing goods and services: market failure and the distribution of wealth.[1] Markets may not function effectively when one person's use of a good or service does not interfere with that of another person (referred to as "nonrival consumption"), or when excluding users who are not willing to pay is impossible or impractical (called "nonexcludability").[2] Both situations give rise to spillovers, or "externalities," in which people who do not pay for the good benefit from it, or people who do not produce the good or impose the cost pay for it. Spillover benefits may lead to too little of the good being produced, and spillover costs may lead to too much. If spillovers result in a serious misallocation of resources, action by the government--such as producing or regulating a good or service--may help correct the market failure.

The Role of Government in Transportation Services

The primary rationale for the Intelligent Transportation Systems program is the government's role in furnishing transportation services. The government, not the private sector, generally provides highways and mass transit. Although some private roads and transit services exist, they are not common in the United

1. See Richard A. Musgrave and Peggy B. Musgrave, *Public Finance in Theory and Practice*, 4th ed. (New York: McGraw-Hill, 1984); and John F. Due and Ann F. Friedlaender, *Government Finance: Economics of the Public Sector*, 7th ed. (Homewood, Ill.: Richard D. Irwin, Inc., 1981).

2. Musgrave and Musgrave, *Public Finance*, pp. 48-50.

States. In the case of highways, it generally has not been feasible to exclude users who do not pay. Some of the earliest roads in this country were turnpikes. As the nation developed and more roads were built, however, it became more difficult to limit access only to those willing to pay a toll. Electronic toll collection--an element of ITS--could make it feasible to charge highway users and thereby could make private investment in roads more attractive.

Government involvement in mass transit is justified in two ways. One is that because highway users in urban areas do not pay the full costs of travel--including those of congestion and pollution--transit users should be subsidized as a way of redressing the imbalance. The other is based on a belief that people with low incomes are more likely to ride mass transit and that transit subsidies therefore help redistribute income from rich to poor. Both arguments have weak components. Instead of subsidizing highway and transit users, a more direct approach would be to charge for congestion and pollution.[3] ITS technologies could advance this approach through electronic toll collection. As for redistributing income, most economists would agree that transit subsidies are a costly way of assisting poor people because they also aid high-income passengers. In fact, in cities like Washington and San Francisco, where rail transit systems serve many relatively high-income users, subways are subsidized by lower-income people who cannot or do not use transit. In addition, in those areas, rail service used by suburban commuters may take funds away from bus service used by inner-city residents.

Government support of research and development in transportation can directly improve the government's ability to provide highways and mass transit service. Decisions to conduct in-house research to improve quality or lower cost can be likened to a private firm's decisions to do product or process research.

In addition to government providers of transportation services, potential direct beneficiaries of ITS research include users of highways and mass transit. Indirect beneficiaries include shippers and consumers of goods transported on highways, who benefit from efficiencies of commercial vehicle operations, and taxpayers, who may find that their transportation tax dollars go farther than before. Government support of efforts that yield benefits in excess of costs (taking into account the value of alternative uses of capital) can be viewed as an appropriate function--especially in cases in which private enterprise has little incentive to risk its own capital because it cannot recoup its costs.

The Role of Government in Research and Development

In addition to funding highways and transit services, the government has played a role in sponsoring research and development.[4] Government sponsorship of R&D is usually justified either on the grounds of market failure or in direct support of a specific government mission. From a social viewpoint, the private sector may not conduct enough research because it cannot reap enough benefit to make doing so worthwhile. The government can disseminate research findings without having to recoup the costs in the marketplace; the investment can be justified so long as the social benefits outweigh the costs (properly discounted and including the value of alternative uses of capital in the private sector).[5]

Many firms in the private sector engage heavily in research and development, suggesting that they have strong incentives to do so. In sorting out who has incentives to do what types of research, economists have traditionally viewed R&D as a continuum --from basic research (pure science to gain knowledge for its own sake) through applied research (research with specific applications) to development of products and processes. Operational testing and support for deployment may also be added to the end of the process.

3. See Congressional Budget Office, *Paying for Highways, Airways, and Waterways: How Can Users Be Charged?* (May 1992).

4. For an overview of the rationale for federal support of research and development, see Congressional Budget Office, *How Federal Spending for Infrastructure and Other Public Investments Affects the Economy* (July 1991), ch. 4.

5. David C. Mowery and Nathan Rosenberg, *Technology and the Pursuit of Economic Growth* (New York: Cambridge University Press, 1989).

The private sector generally has less incentive to invest in basic research because that is where spillover benefits are generally the greatest and a private firm has the least ability to enjoy the full fruits of its labors. The more the outcome of research can be patented, copyrighted, or otherwise protected, the more likely the firm can benefit and the less government involvement can be justified.

Underinvestment in research is a form of market failure, but market failure alone is not sufficient justification for government involvement. In dynamic economies, some amount of market failure is normal. When considering government involvement to "correct" a market failure, one must weigh the potential for government failure as well. Even though the market may not produce an optimal amount of research, one cannot presume that the government can identify and conduct "better" research.

The ITS program covers a range of activities from basic research to operational testing and support for deployment, and much of the spending goes to activities at the testing and deployment end of the spectrum. Thus, there are concerns about balance in the ITS program. In considering appropriations for 1995, Congressional conferees addressed the issue in terms of the commercial vehicle operations part of the program. Although providing funding for one major operational test for 1995, the conferees stated that

> the funds requested for the commercial vehicle operations component of the IVHS [Intelligent Vehicle Highway System] program should be reserved for higher-risk research and development activities that may not yet be ready for larger-scale deployment. Therefore, the conferees agree that funds for operational tests of this nature should be requested under the operational tests component of the program for fiscal year 1996 and beyond.[6]

6. U.S. House of Representatives, *Making Appropriations for the Department of Transportation and Related Agencies, for the Fiscal Year Ending September 30, 1995, and for Other Purposes,* conference report to accompany H.R. 4556, Report 103-752 (September 30, 1994), p. 49.

Although government spending on operational testing and deployment would be difficult to justify for commercial applications, the issue is trickier when the applications are goods and services provided by the government. This consideration brings the analysis back to the first point: that government spending on ITS can be rationalized more readily because it supports a government activity. Transportation is a service traditionally provided by the government, and R&D that results in lower costs or improved service can benefit taxpayers and consumers.

The Federal Role in Relation to That of State and Local Governments

Why should the federal government fund research on “smart” vehicles, highways, and transit when those activities are typically run at the state or local level of government? For the same reason that private firms may underinvest in research and development, state and local governments may also underinvest. They may not be able to reap enough benefits to cover the costs. But if the knowledge gained is shared with other jurisdictions, the total benefits may exceed costs. In such cases, where the benefits nationwide exceed the costs (and provide a competitive rate of return), federal support can be justified.

In addition to spillover benefits from research, similar benefits are possible as a result of deploying intelligent transportation systems. Decisions made by transportation officials in one jurisdiction affect the traffic in neighboring jurisdictions. Moreover, travelers tend to cross boundary lines and would prefer to encounter compatible technologies so that they would need to learn only one system and purchase one type of equipment, especially in such applications as electronic toll collection and traveler information systems. Whether the federal government is needed to facilitate compatibility is another matter, however, since many interjurisdictional coalitions and compacts already exist.

Because the federal government transfers large sums of money to state and local governments for highways and transit, it has an interest in promoting technologies that reduce the need for funds. State and local governments also have incentives to make their transportation dollars go farther, but the federal government may have an advantage based on economies of scale. It is probably more economical to sponsor research at the federal level into problems common to many states than try to run 50 state-level or thousands of local-level programs. Problems that are unique to individual states or regions may more appropriately be solved locally, although the federal government could play a role in advancing and coordinating projects that cross state lines. Whether the current system of federal financing of highways and transit is the most efficient or sensible is beyond the scope of this study.

The Role of the Private Sector

In ITS research, the private sector enters the picture in two ways. Firms in the communications, electronics, computer, motor vehicle, and related industries are suppliers of ITS goods and services. The motor vehicle industry is also a user of ITS, along with commercial vehicle operators, transit operators, and other highway users. But what is the government's role in relation to the private sector?

Different ITS products have different relationships in the public and private sectors. Some aspects of ITS focus on smart highways, and others focus on smart vehicles. In most cases, returns on investments for making vehicles smarter can be obtained privately. For example, cruise control, collision warning and avoidance, and vision enhancement systems are features that are installed on vehicles, and automakers can decide whether to do so or not on the basis of whether they anticipate enough consumer demand for those products to warrant the investment. The features do not rely on any particular highway infrastructure, so decisions about them can be made without government involvement.

Other vehicle-based features, such as navigation, electronic toll collection, and clearance systems for commercial vehicles, require compatibility between vehicle and highway infrastructure. For more futuristic applications of ITS, such as automated highway and advanced vehicle control systems, the automobile industry has an interest in ensuring that the machines it produces are compatible with highway designs and that vehicles manufactured by one company are compatible with those produced by others. In those instances, the private and public sectors complement each other. Investment decisions are interdependent. The government may have to take the lead in announcing its planned investments and specifying the technologies it intends to adopt so that the private sector can make investment decisions with less risk and uncertainty.

Finally, some elements of ITS are linked entirely to infrastructure. Electronic signs, adaptive control systems (such as traffic signals and ramp meters), and other sensing devices can be installed and operated by highway agencies without any private investment. Decisions about those systems lie with government. In considering the merits of such investments, however, governments should consider the availability of substitutes provided by either the public or the private sector. For example, drivers could learn of congestion ahead either by listening to radio stations that carry traffic reports or by viewing variable-message signs managed by officials at traffic control centers using information from sensors in the roadway.

In evaluating the ITS program, it is useful to keep such distinctions in mind. Government involvement is most justifiable in those elements of ITS that are based on infrastructure and in those that require compatibility between infrastructure and vehicle.

The federal government is encouraging partnerships between the public and private sectors in developing intelligent transportation systems. Such partnerships can improve the coordination between public and private entities so as to avoid duplication of effort and ensure compatibility of technologies. In addition, given tight budgets, government officials hope that their funding will leverage more funds from private sources. The principal reason for caution about public/private partnerships is their potential to create government-sponsored monopolies that keep other private firms from competing--and possibly offering better services at lower prices.

Evaluating the ITS Program

As the federal ITS program enters its fifth year, many observers are asking to see results. Although the program's managers can point to a number of individual projects that appear successful, little systematic evaluation has been completed. In the early days of the program, attention to evaluation was limited. That situation is changing. The program's managers recognize that they must be able to show results and a clear justification of their role in order to receive continued funding. Several major efforts are under way to strengthen the evaluation process. For the most part, those efforts are focused on measurable results.

The Office of Management and Budget

The President's Office of Management and Budget (OMB) has selected the ITS program as a pilot project in its performance measurement program, an initiative to carry out the Government Performance and Results Act of 1993. The ITS Joint Program Office is working with OMB to develop measurements of the program's performance. The intent is to specify the ultimate goal of each program element, list intermediate outcomes that reflect progress in attaining the goal, and identify measurable indicators of achievement. Those goals and indicators will be tied to the development of proposals for the program's budget.

OMB is developing and refining this initiative as part of the budget process for fiscal year 1997. It intends full-scale implementation in the fall of 1997.[7] Although the initiative is in its infancy, it is useful in highlighting the links between budgetary resources and results.

Audit by the Inspector General

The Office of Inspector General (OIG) of the Department of Transportation has evaluated the ITS program's systems for selecting, carrying out, overseeing, and evaluating projects.[8] The OIG concluded that the ITS program needed to improve management and oversight controls.

The OIG found weaknesses in the process of selecting projects, stemming in part from the different ways that the separate administrations within DOT operate. The Federal Highway, Federal Transit, and National Highway Traffic Safety Administrations have different procedures for selecting ITS projects, and in some cases those procedures were not followed. The OIG expressed concern that some projects duplicated others, potentially wasting program resources.[9] In response, the ITS Joint Program Office is developing ways of identifying how each new project will contribute to the overall objectives of the program.[10]

The OIG found that the program office was not effectively monitoring and controlling project costs and schedules. In a review of 12 continuing projects, the OIG found that five had already exceeded original estimates of their costs and nine were behind schedule.[11] The OIG also found that evaluation plans were not submitted in a timely manner for any of the six projects within the sample that required such plans.[12] In response, the program office has engaged a contractor to provide technical assistance with evaluations of operational tests.[13] The program office also hired a contractor to review costs and schedules of all active projects and to develop a system to track them.[14]

The contractor's review of costs and schedules found significant differences in the program office's

7. *Budget of the United States Government, Fiscal Year 1996*, pp. 137-138.

8. Department of Transportation, Office of Inspector General, *Audit Report: Intelligent Transportation Systems Program Delivery Process, Federal Highway Administration*, AS-FH-5-017 (May 4, 1995).

9. Ibid., p. 7.

10. Ibid., p. 21.

11. Ibid., pp. 8-9.

12. Ibid., p. 11.

13. Ibid., p. 24.

14. Ibid., pp. 22-24.

potential for control. Most research and development projects are overseen by contracting officer technical representatives at DOT who have substantial control over them. Operational tests afford considerably less opportunity for federal control because they are typically carried out in partnership with government agencies at the state and local level and with private entities. Institutional and procedural barriers associated with such partnerships make federal oversight more difficult.

Evaluations of Operational Tests

The FHWA has contracted with the consulting firm of Booz-Allen & Hamilton to provide support in evaluating operational test projects. The contract, which will last up to five years, should help FHWA and the state highway departments design projects with evaluation criteria in mind. Those criteria should lead to improvements in evaluation--including greater confidence in the results--over the current situation, in which evaluations have often been tacked on almost as an afterthought rather than being incorporated into the design of the test. Nevertheless, coordinating among all the partners in operational tests--state and local agencies and private-sector firms--presents a substantial challenge to designers and evaluators alike.

Development of a Systems Architecture

Another avenue of pursuit for program evaluation is the effort to develop a systems architecture. The systems architecture is a blueprint showing how the various pieces of intelligent transportation technology fit together to form a general framework. It is the grand conceptual design of an intelligent transportation system in 5, 10, and 20 years and beyond. Part of the process of developing an architecture is evaluating the benefits and costs of alternative design scenarios.

Four teams competed in the first phase of developing a systems architecture. As part of that effort, the teams simulated the way technologies would be applied in a model city called "Urbansville," which resembled Detroit in terms of demographics, transportation facilities, and other characteristics. Although the teams estimated benefits and costs under the Urbansville scenario, they did not tie together the benefit and cost estimates in an easily comparable fashion. Moreover, they made many speculative assumptions in their simulations. The results, therefore, do not shed much light on the benefits and costs of intelligent transportation systems.

One of the difficulties facing simulators is the uncertainty about the kinds of intelligent products and services the public values. The simulators had to make assumptions about which technologies state and local officials, as well as private companies and individuals, would adopt. They also had to use FHWA's models and assumptions about traffic and other variables. Unfortunately, FHWA's models did not produce enough congestion to allow certain ITS technologies to demonstrate their effectiveness in relieving the problem. Such difficulties add another layer of uncertainty to the process of interpreting the results of the simulations.

Reports of the Volpe Center

DOT's research arm, the Volpe National Transportation Systems Center, has issued several reports summarizing analyses of intelligent transportation systems.[15] They catalogue efforts to evaluate projects and indicate gaps in knowledge. The researchers at Volpe did not verify or evaluate the studies; their contribution was to provide an inventory of research efforts.

Many of the analyses summarized by Volpe researchers examined only benefits, not costs. Often the analyses gave the results of relatively small tests, raising questions about whether the results could be generalized on a large scale. In many cases, the project being evaluated had not run long enough to ascertain long-term effects, such as changes in travel patterns; only initial impacts were measured.

15. Department of Transportation, Volpe National Transportation Systems Center, *Analysis of IVHS Benefits/Costs Studies* (September 1993), *Quick Overview of Recent Studies and Modeling Results* (January 1995), and *Intelligent Transportation System Benefit Inventory* (June 1995).

National ITS Program Plan

In March 1995, the program office and ITS America (the federal advisory committee established to advise the ITS program) jointly issued the National ITS Program Plan, which contains a chapter outlining issues related to program assessment.[16] The report discusses methods for assessing the program, identifies parameters for evaluation, and describes a number of efforts under way. If those efforts proceed as planned, they will provide over the next few years a substantial amount of information about which types of projects produce the greatest benefits. Combined with the Office of Management and Budget's initiative to measure performance and link budgets to results, those efforts could help guide decisions about deploying intelligent transportation systems.

Issues to Address in Evaluating the Program

One issue that recurs in reviewing evaluations is the question of what exactly is being evaluated. In research and operational testing, the chief concern tends to be whether the technology works: does it produce the anticipated physical results? How reliable is it? Does it function effectively most of the time? Evaluations of the ITS program must go further if they are to be useful to policymakers in making decisions about funding priorities. Thus, it is desirable to estimate the value of the benefit provided, such as the value of time saved by alleviating congestion. Such estimating requires projecting the degree to which a new technology will be adopted, how it will be used, and the behavioral responses of consumers. Does the technology offer a new capability that cannot currently be offered or produced? If so, is the product something that users need or desire? Or does it do more efficiently something that is already being done?

Those questions are not always easy to answer. There are many different users of transportation systems, and a given user may have different needs at different times. People commuting to work by automobile typically want to know about traffic congestion. More specifically, they want to know whether there is any *unusual* congestion on their standard route, in which case they might alter their route, time of departure, or mode of travel. Those commuters already know which routes are typically congested at their time of travel, and they are familiar enough with their area to know of alternative routes. Most of all, they need up-to-the-minute information about the location of incidents and extent of backups; other information such as route guidance or information about traveler services is far less important.

When they take a vacation trip, however, those same travelers have entirely different needs. Route navigation and information about services for travelers and tourist attractions become important. If they are traveling to or through a metropolitan area, they may want information about congestion--including information about the predictable kind that results from inadequate roads as well as the unpredictable kind that results from traffic accidents.

If consumers place a higher value on their work-related time than on their leisure time, they will probably value systems that reduce commuting time more highly than systems that reduce travel time during a vacation.

Vacation and business travelers often rent cars in unfamiliar surroundings. Those travelers generally want information about routes and services. Business travelers may also need information about congestion. Rental car companies could respond to those demands by equipping their vehicles with intelligent systems. Consumers might not think it worthwhile to equip their own vehicles with systems to provide traveler information because most of the time they drive their vehicles in familiar territory and do not need it. But rental car companies could find such equipment a competitive marketing tool to attract more customers. This activity could be done without government involvement.

Commercial users of highways may have quite different needs. At the local level, taxi and delivery-truck drivers could most productively use information that would help them save time, such as live in-

16. Gary W. Euler and H. Douglas Robertson, eds., *National ITS Program Plan*, vol. I (ITS Joint Program Office and ITS America, March 1995), ch. 8.

formation about traffic incidents. They typically need this information at off-peak times as well as rush hours. Because commercial users are expected to be familiar with their region's roads, they generally should not need navigation or traveler-service information. Private delivery companies, however, might find it advantageous to install computer systems that map out the most efficient routes for picking up and delivering packages within a metropolitan region. Some companies already employ such systems, which suggests that private enterprise has the incentive to adopt this new technology without government involvement.

Long-distance trucking companies have a variety of needs that could be satisfied through intelligent computer and communications technologies. Many ITS applications in commercial vehicle operations that do not require government involvement are well developed. The evaluation of CVO projects should entail considering whether private firms have incentives to apply technologies on their own or whether government involvement is desirable.

Determining Users' Needs

In assessing ITS projects, therefore, one needs to think about the nature of demand for various applications of technologies, recognizing that different sets of users have different needs and that different needs may be met by different providers.

Assessing users' demands entails estimating what users are willing and able to pay for new products. Although an innovation may be a technological success, it may not be a commercial success. In air transportation, for example, the supersonic transport aircraft has been successful in reducing travel time across the Atlantic but financially has not been able to break even. Most passengers have not been willing or able to pay the extra cost to save a few hours. Similar considerations apply in evaluating ITS technologies; many offer benefits, but whether users are willing to pay for the benefits is an open question. ITS technologies will have to compete with a variety of existing alternatives--cellular telephones, traffic reports broadcast on commercial radio and television stations, road maps and atlases, tourist services offered by groups such as the American Automobile Association, and so on.

Many ITS technologies appear to offer more and better services to travelers than do existing systems. Weighing those additional benefits against the additional costs of ITS systems can help guide decisions about which technologies offer the greatest net benefits to society.

Keeping track of direct and indirect benefits of ITS systems is complicated. Nevertheless, there are some indications of strengths and weaknesses of alternative approaches to meeting the various objectives. Work is under way to develop models that would identify the wide range of potential consequences of ITS activities. Those models will help sort out which parts of ITS further which objectives and how. They will also suggest where the trade-offs and mutual benefits lie in trying to meet the various objectives.

Setting Criteria for Evaluating the ITS Program

The issues discussed in this chapter suggest a number of criteria for evaluating the ITS program and its component projects:

- o Is there a rationale for government involvement, or can the private sector undertake the research, testing, or deployment? Are there external benefits or costs that cause the market to fail? Do the costs of market failure outweigh the risks of governmental failure?

- o What is the federal interest in the program or project? Are there nationwide benefits? Could and would state and local agencies take responsibility?

- o How will the effort contribute to the state of knowledge about the benefits and costs of prospective technological applications? How will it advance the ultimate goals of mobility, efficiency, safety, and environmental quality?

- o How does a project fit in with other projects? Will it help fill the gaps in knowledge about technologies or behavioral responses? Is a given approach the best way of gaining that information?

- o Is the project designed in a way that facilitates evaluation?

The answers to those questions can help guide the Congress in deciding on the future of the ITS program.

There is a distinction between evaluating individual ITS projects or clusters of projects and evaluating the program as a whole. The nature of a research program is that the outcomes of experiments are unknown. Some will succeed, and some will fail. A certain amount of failure is not only acceptable but also, in retrospect, desirable because success in all projects suggests that other promising opportunities might not have been explored. Therefore, evaluations of the program and its projects may require somewhat different criteria.

The objectives of the ITS program include enhancing mobility, improving efficiency, increasing safety, and protecting environmental quality. Some types of ITS projects may promote several objectives. For example, an effort that enhances safety will result in fewer accidents. Reducing accidents on busy highways decreases the resulting traffic tie-ups. That outcome in turn may improve productivity by cutting time lost to congestion, and it may abate pollution associated with stop-and-go traffic around an accident scene.

Public transit projects may wind up benefiting not only transit providers and users but also motorists, taxpayers, and other citizens. For example, "smart bus" projects may result in more efficient transit operations, thereby reducing the need for public subsidies and offering passengers safer and more reliable service. Improved service may induce some motorists to switch to transit, resulting in less congestion for the remaining motorists. Such a result could have beneficial consequences for productivity and air quality.

Projects must compete for resources, however, within the constraints of the program's budget. Policymakers will have to decide on a balance among projects of different types that will best satisfy the multiple objectives of the program. Trade-offs must be made--between vehicle and infrastructure, highway and transit, urban and rural, commercial and private vehicles, and other applications.

Chapter Three

Applications of Intelligent Transportation Systems

The Intelligent Transportation Systems program seeks ways of applying advanced technologies to meet a variety of transportation objectives. ITS has started several hundred projects to explore the effectiveness of various technical applications in advancing those objectives. The program office has classified the projects according to their principal applications: travel and transportation management, travel demand management, public transportation operations, electronic payment, commercial vehicle operations, emergency management, advanced vehicle control and safety systems, and priority corridors. (For a list of the ITS projects that received the most federal funding through 1994, see Table 4.)

Travel and Transportation Management

One of the major transportation problems that gives impetus to ITS is traffic congestion, which is a growing problem in the nation's urban areas. The Department of Transportation estimates that congestion costs the country about $100 billion a year in lost productivity.[1] Combined with an increase in the number of cars on the road--which derives from increases in population, numbers of households, and numbers of workers--is an increasing difficulty in expanding existing highway capacity. In many urban areas, land for building new highways or widening existing highways is available only at a very high cost. Citizens often value vacant land more highly for its use as a park, wetland, or open area than as another roadway. Concern about air pollution constrains additions to highway capacity that will result in more cars on the road emitting more pollutants into the air.

Many ITS projects have as their primary goal enhancing highway capacity--enabling more vehicles to use existing highway lanes without pouring more concrete. The Federal Highway Administration estimates that equipping one mile of freeway with electronic traffic surveillance costs about $1 million, but constructing one mile of urban freeway costs about $40 million.[2] Thus, using advanced technologies to accommodate more vehicles on existing highways can save a lot of money.

Projects in the travel and transportation management category account for about half of ITS funding. Two major subcategories are traffic management and traveler information systems.

1. Gary W. Euler and H. Douglas Robertson, eds., *National ITS Program Plan*, vol. I (ITS Joint Program Office and ITS America, March 1995), p. 1.

2. Department of Transportation, ITS Joint Program Office, briefing chart (May 1995).

Table 4.
Major Intelligent Transportation Systems Projects (In millions of dollars)

Projects and Participants	Estimated Total Project Cost	Anticipated Total Federal Funding	Federal Funds Obligated Through 1994	Federal Share of Total Cost (In percent)
Travel and Transportation Management				
FAST-TRAC (Oakland County, Michigan) FHWA, Michigan DOT, County of Oakland, University of Michigan, Road Commission for Oakland County, several automobile companies	70.0	55.5	40.5	79.3
Electronic Toll and Traffic Management (New Jersey) FHWA, NJDOT, N.J. Highway Authority, South Jersey Transportation Authority	40.0	32.0	32.0	80.0
Detroit, Michigan, Areawide Development of ATMS/ATIS FHWA, Michigan DOT	33.0	28.5	28.5	86.4
ADVANCE (Northwest suburbs of Chicago, Illinois) DOT, Motorola Inc., Illinois Universities Transportation Research Consortium, American Automobile Association, and FHWA	52.0	35.0	21.0	67.3
TRANSCOM Congestion Management Program (Metro New York City area) FHWA, New York Department of Transportation, New Jersey Department of Transportation, TRANSCOM, and other member agencies	To be determined	To be determined	15.1	To be determined
New York Thruway Electronic Toll Collection and Traffic Management Partners to be determined	40.0	11.6	11.6	29.1
Southern State Parkway (Long Island, New York) New York State DOT, FHWA	To be determined	To be determined	6.3	To be determined
Integrated Corridor Management (New Jersey/Philadelphia, Pennsylvania) FHWA, New Jersey DOT	6.0	6.0	6.0	100.0

(Continued)

Table 4.
Continued

Projects and Participants	Estimated Total Project Cost	Anticipated Total Federal Funding	Federal Funds Obligated Through 1994	Federal Share of Total Cost (In percent)
Travel and Transportation Management (Continued)				
New Jersey Signal Computerization FHWA, New Jersey Department of Transportation	10.2	6.0	6.0	58.8
“Capital”--Washington, D.C., Area Operational Test FHWA, Virginia Department of Transportation, Maryland State Highway Administration, Engineering Research Associates, Bell Atlantic Mobile, and Farradyne Systems Inc.	7.2	5.5	5.5	76.9
Human Factors in Advanced Traveler Information Systems and Commercial Vehicle Operations Design Evolution (National) FHWA, Battelle Human Affairs Research Center	5.3	5.3	5.3	100.0
Human Factors in Advanced Traffic Management Systems FHWA, Georgia Tech Research Institute, Georgia Institute of Technology	4.8	4.8	4.8	100.0
Traffic Surveillance and Detection Technology Development Jet Propulsion Laboratory	4.0	4.0	4.0	100.0
Travel Demand Management and Public Transportation Operations				
Denver Smart Vehicle FTA, Regional Transportation District Denver	10.5	8.4	8.3	80.2
Suburban Mobility Authority for Regional Transportation (SMART) Project (Detroit, Michigan) FHWA, SMART	11.6	9.5	4.5	81.7

(Continued)

Table 4.
Continued

Projects and Participants	Estimated Total Project Cost	Anticipated Total Federal Funding	Federal Funds Obligated Through 1994	Federal Share of Total Cost (In percent)
Travel Demand Management and Public Transportation Operations (Continued)				
Seattle Wide-Area Information for Travelers (SWIFT) FHWA, Washington State Department of Transportation, Seiko Communications System, IBM Corporation, Delco, Etak Metro Traffic, King County (Washington) Metro Transit, University of Washington	7.2	4.4	4.4	61.1
Commercial Vehicle Operations				
HELP/Crescent (British Columbia, Washington State, Oregon, California, Arizona, New Mexico, Texas) Arizona DOT, California DOT (Caltrans), Colorado DOT, Idaho DOT, Iowa DOT, Minnesota DOT, Nevada DOT, New Mexico SHTD, Oregon DOT, Pennsylvania DOT, Texas SDHPT, Utah DOT, Virginia DOT, Washington State DOT, motor carrier industry, Transport Canada, FHWA	22.0	5.9	5.9	26.6
Advantage I-75 (I-75 in Florida, Georgia, Tennessee, Kentucky, Ohio, Michigan, and Ontario, Canada) FHWA, Florida, Georgia Tennessee, Kentucky, Ohio, Michigan, Ontario, motor carrier industry	11.0	7.7	4.0	70.3
Advanced Vehicle Control and Safety Systems				
Automated Highway Systems--Precursor System Analyses (Nationwide) FHWA, Battelle, BDM International, Calspan, Delco, Honeywell, Martin Marietta, Northrop Grumman, PATH, Raytheon, Rockwell International, SAIC, TASC, TRW Inc., University of California at Davis	14.1	14.1	14.1	100.0

(Continued)

Table 4.
Continued

Projects and Participants	Estimated Total Project Cost	Anticipated Total Federal Funding	Federal Funds Obligated Through 1994	Federal Share of Total Cost (In percent)
Advanced Vehicle Control and Safety Systems (Continued)				
National Automated Highway Systems Consortium (Nationwide) FHWA, General Motors, Delco Electronics, Hughes Aircraft, Caltrans, Bechtel, Parsons-Brinkerhoff, Martin Marietta, PATH, and Carnegie Mellon University Robotic Institute	210.0	160.0	12.0	76.2
Human Factors Design of Automated Highway Systems FHWA, Honeywell	5.1	5.1	5.1	100.0
Other				
System Architecture Development (Nationwide) FHWA, Hughes Aircraft, Loral/IBM, Rockwell International, Westinghouse Electric	20.0	20.0	10.4	100.0
ITS Research Centers of Excellence (Michigan, Texas, Virginia) FHWA, University of Michigan, Texas A&M University, and Virginia Polytechnic Institute	18.4	15.4	6.1	83.7
System Architecture Manager (National) FHWA, National Aeronautics and Space Administration, Jet Propulsion Laboratory	6.3	6.3	5.7	100.0
ITS IDEA Program (Nationwide) FHWA, NHTSA, Transportation Research Board	5.5	5.5	5.5	100.0

SOURCE: Department of Transportation, Federal Highway Administration, *Intelligent Transportation Systems Projects* (January 1995).

NOTES: FHWA = Federal Highway Administration; DOT = Department of Transportation; ATMS = Advanced Traffic Management Systems; ATIS = Advanced Traveler Information Systems; FTA = Federal Transit Administration; SHTD = State Highway and Transportation Department; SDHPT = State Department of Highways and Public Transportation; PATH = Program for Advanced Transit and Highway; SAIC = Science Applications International Corporation; TASC = The Analytic Sciences Corporation; NHTSA = National Highway Traffic Safety Administration.

Traffic Management

Central features of traffic management include monitoring the flow, identifying and interpreting disruptions, and attempting to change traffic patterns. To keep track of traffic, electronic sensors embedded in roadways or cameras allowing visual monitoring are often employed. Communicating information about traffic flow can be automated in varying degrees. Trained personnel watching video monitors at traffic management centers can interpret problems taking place at remote highway sites and respond. For example, if staff personnel see an accident or breakdown, they can alert emergency response teams and provide information to motorists through electronic signs, radio, or other means. More highly automated systems, however, can detect slowing in the flow of traffic and can automatically alter signs and traffic control signals at freeway entry ramps to divert or smooth the stream of vehicles.

The TRANSCOM and TRANSMIT Projects. New York City's metropolitan area suffers traffic congestion at virtually every hour of the day and night. Large numbers of vehicles clog the roads leading to the relatively few bridges and tunnels crossing the Hudson River, and any event such as an accident or disabled vehicle that closes highway lanes can have an enormous effect on traffic, not only on the road where it occurs but also on feeder and substitute highways. A consortium of 15 transportation and public safety agencies in New Jersey, New York, and Connecticut--the Transportation Operations Coordinating Committee, known as TRANSCOM--has been formed to improve response to traffic incidents. (An incident is an accident, vehicle breakdown, or other event that impedes the flow of traffic.)

The TRANSCOM Operations Information Center receives and disseminates information about major incidents so that member agencies can alert drivers who are still some distance away from the problem and divert them to alternative routes while they still have that option.[3] Variable-message signs and highway advisory radio are used to alert drivers.

TRANSCOM is conducting an operational test known as TRANSMIT (for TRANSCOM's System for Managing Incidents and Traffic). TRANSMIT will equip vehicles with electronic tags that can serve as traffic probes and can be used for electronic toll collection.[4] Computers tracking the tags can detect when the actual travel time between tag readers is greater than predicted and thus locate traffic incidents. The faster an incident is detected and cleared from the roadway, the less congestion will result.

In addition to helping manage traffic congestion in general, the TRANSCOM project will aid public transit through its Alternate Bus Routing System (ABRS). It will provide real-time information to some 400 New Jersey Transit buses by means of roadside cameras and a vehicle-to-roadside communications network that will enable drivers to choose between the Garden State Parkway and Route 9 approaches to the New Jersey Turnpike at Interchange 11 in Woodbridge.[5]

The federal government obligated $15.1 million for TRANSCOM through fiscal year 1994. The total project cost and federal contribution have yet to be determined. For TRANSMIT, the federal government has obligated $2 million; for ABRS, $500,000.[6]

The ADVANCE Project. The ADVANCE (an acronym for Advanced Driver and Vehicle Advisory Navigation Concept) project, based in the northwestern suburbs of Chicago, will use vehicles as probes to transmit real-time information about traffic to a traffic information center. The center will then process the information and send the vehicles instructions on modifying their routes in order to avoid congestion. Initially the plan was to use 3,000 vehicles as probes, but the number has been scaled back to 75. That will allow the technology, but not the benefits to traffic management, to be tested. The estimated cost of the project as initially planned was $52 million, and the

3. Testimony of Matthew Edelman, General Manager, TRANSCOM, in U.S. House of Representatives, *Intelligent Vehicle-Highway Systems*, hearings before the Subcommittee on Investigations and Oversight of the Committee on Public Works and Transportation, Committee Print 103-66 (June 29 and July 21, 1994), pp. 97-98.

4. Ibid., p. 99.

5. Ibid., p. 101.

6. Department of Transportation, Federal Highway Administration, *Intelligent Transportation Systems Projects* (January 1995), pp. 94, 96, and 138.

federal government was to provide $35 million.[7] Through the end of fiscal year 1994, the federal government had obligated $21 million for ADVANCE.[8]

The Role of Government in Traffic Management

Government has traditionally handled traffic management. If advanced technologies can help the government provide better service at lower costs, the rationale for government involvement in developing them is clear. The federal government can play an especially important role in traffic management projects that cross state lines, such as the TRANSCOM project.

To be successful, ITS technologies must be attractive to local and state transportation agencies. Local and state governments own and maintain the roadways, even roads built primarily with funding from the federal government. But the greater the coordination required among transportation agencies for an ITS application, the more difficult it is to adopt and carry out.

The general manager of TRANSCOM has noted that the success of coordination among high-tech systems depends on success in coordinating and cooperating on ordinary low-tech matters:

> It took a number of years to establish the kind of trust and credibility necessary, for example, to get a construction manager to be willing to modify a project schedule in the name of supporting another agency. However, through the effective working relationships developed through these low tech activities, we actually created an organizational infrastructure which could then be applied to multi-agency implementation of ITS systems.[9]

7. Department of Transportation, *ITS Projects*, p. 57.

8. Ibid.

9. Testimony of Matthew Edelman in *Intelligent Vehicle-Highway Systems*, pp. 98-99.

One of the major challenges for ITS projects that involve multiple jurisdictions is to find the right mix among facilitating, promoting, and making sure that equipment is universally compatible on the one hand, and recognizing local concerns and unique circumstances on the other. Many ITS technologies are well developed; the problem is not the lack of technological know-how but rather the difficulty of getting multiple public agencies to agree on compatible standards.

The federal government may be able to facilitate adoption of traffic management technologies by providing a forum where local officials can come together, discuss their concerns, and compare alternative ways of dealing with traffic problems that cross jurisdictional lines. The federal government may be in the best position to serve as a clearinghouse of information about how technologies have worked in other areas, and how governmental bodies in other areas have resolved differences among themselves in order to cooperate on uniform technologies. Attempting to impose federal standards can be counterproductive, however, if the imposition leads to less efficient results than those that are tailored to individual situations.

Nevertheless, the federal government has a constitutional role in ensuring the free flow of interstate commerce and helping to resolve conflicts among jurisdictions that substantially affect interstate transportation. If there are spillover effects that one jurisdiction may not take into account in carrying out its policies, the state or federal government might appropriately step in. For example, an advanced traffic management system might yield benefits not only to the jurisdiction that adopts it but also to neighboring jurisdictions. Such a project might fail a benefit-cost test when only one jurisdiction's benefits are considered, even though the total benefits (including spillovers in other jurisdictions) exceed the costs. In principle, such an investment should be undertaken (assuming that the cost estimates include the opportunity cost of capital). The federal (or state) government could facilitate such an investment, perhaps by finding a mechanism for compensation.

In summary, when evaluating the appropriate role of government in traffic management projects, it is useful to take into consideration the extent to which the projects help transportation agencies manage resources, such as crowded highways, more efficiently; the effects of time wasted in congested traffic; and the spillover benefits and costs among jurisdictions.

Traveler Information Systems

Providing information to travelers can help them avoid congested roads and keep them from adding to congestion. Several ITS projects are testing ways of providing useful information in a timely and understandable fashion about routes, traffic congestion, transit availability, and so on. Sophisticated traveler information systems are closely tied to traffic management systems, which collect, integrate, and provide information to travelers and even use information collected from vehicles equipped with transponders that can indicate their speed and alert traffic managers to roadway congestion.

TravTek. One of the earliest ITS projects, TravTek, involved advanced traveler information systems. In this project, begun in 1990, General Motors equipped 100 rental cars in Orlando with on-board navigation systems to help tourists find their way around the area. The systems provided not only route directions but also information about traffic congestion, which was sent by digital data radio to the vehicles from a traffic management center. On-board computers advised motorists by video display or voice guidance about the best routes to take.

Participating in this project were the Federal Highway Administration, the Florida Department of Transportation, the City of Orlando, General Motors, and the American Automobile Association. Operational testing has been completed and the results are being analyzed. The estimated total project cost is $12 million, of which the federal government contributed $2.7 million.[10]

FAST-TRAC. Oakland County, Michigan, has launched a large-scale program called FAST-TRAC (for Faster and Safer Travel through Traffic Routing and Advanced Controls). The program combines advanced traffic management and traveler information technologies in an attempt to provide real-time information that will enable drivers to adapt instantly to changes in traffic conditions. The project will use video technology to detect traffic conditions. Vehicles will be equipped with route navigation systems to feed drivers information on how to modify their routes to avoid delays. The project is expected to cost $70 million, with the federal government paying $55.5 million.[11]

TransCal. Although the focus of travel and transportation management is on urban areas, reflecting the motivation to reduce congestion, the Federal Highway Administration has selected a few projects with rural applications. TransCal is an operational test project along the mostly rural stretch of Interstate 80 and U.S. 50 between San Francisco and Lake Tahoe and Reno. It will provide information to suitably equipped travelers about road conditions, traffic, weather, and services along the route, using telephones, digital communication devices, in-vehicle navigation and display systems, and interactive kiosks. The project will also include a satellite-based system for emergency assistance on the highway (a "Mayday" system).

In addition to testing the use of land-line and cellular telephone and wireless FM subcarrier networks to transport information to travelers, TransCal will test a system's ability to integrate information about congestion and traffic incidents from multiple regions and to provide coordinated responses to assist drivers and transit passengers. The estimated project cost is $7.2 million, with the federal government paying $3.2 million.[12]

The Role of Government in Providing Information to Travelers

Government can contribute effectively to providing information to travelers because it can take advantage of economies of scale in collecting and disseminating information. The federal government's Global Positioning System (GPS) is a key element in naviga-

10. Department of Transportation, *ITS Projects*, p. 100.

11. Ibid., p. 67.

12. Ibid., p. 92.

tion systems for travelers. But the private sector has also played a substantial role in providing information, including real-time bulletins about traffic congestion.

Traffic information broadcast on commercial radio often seems superior to government-operated traffic advisory radio. Travelers complain that government advisories, which are usually broadcast at the ends of the AM radio spectrum, are faint or garbled. Government-provided radio reports and variable-message signs sometimes seem out of touch with existing traffic conditions. It is not clear whether the primary problem is with collecting the information about traffic conditions, analyzing it, or disseminating it. Variable-message signs are limited by space constraints--usually only three or four short lines that motorists must be able to read and comprehend while traveling on busy roads at highway speeds. Similarly, announcements about delays in rail transit systems sometimes lack credibility, especially if passengers' observations about train arrivals differ from the information conveyed in the announcement. Intelligent technologies can improve the quality and timeliness of information but will be beneficial only if users are able to receive and interpret the information in an accurate and understandable way.

Many information systems for travelers do not require a link with traffic management systems; they could consist, for example, of just a computer in the vehicle containing detailed maps and programmed information linked to the GPS. The driver could state (via keyboard or voice) a desired destination and receive detailed instructions via monitor or voice telling where to turn and when. The computer could also provide such information as the location of rest stops, service stations, restaurants, and motels.

For many traveler-information projects, federal support appears to be predicated more on the basis of a perceived market failure in the supply of research and development than on the desire to achieve greater efficiency in the supply of publicly provided services. But there is no strong indication that the market would fail: private developers of these technologies should be able to sell their products to consumers and reap the rewards. For example, the success of TravTek suggests that rental car companies and automobile makers have incentives to adopt onboard navigation systems.

Travel Demand Management

Managing the demand for travel is another approach to reducing congestion and pollution. About 10 ITS projects are primarily focused on managing travel demand. Those projects are intended to reduce the number of vehicles on the road, especially at rush hour, by making transit and carpooling more attractive to commuters. They provide up-to-the-minute, reliable information about the availability of transit and make possible instant matching of riders and drivers to allow use of high-occupancy-vehicle (HOV) lanes. They also include information about conditions that affect travel times. Unlike the enroute information systems for travelers, management programs focus on pretrip information that could lead travelers to alter their choice of mode, destination, or time of trip, depending on what they learn about conditions and the availability of alternatives. In addition to providing pretrip information, ITS applications in managing travel demand include multipurpose "smart cards" that can be used for bus and rail fares, parking fees, telephone calls, and toll roads.

Informing Travelers

Between 1980 and 1990, the number of commuters driving to work alone rose from 62.2 million (64.4 percent of commuters) to 84.2 million (73.2 percent). Over the same period, the number of workers carpooling dropped from 19.1 million to 15.4 million, and the number using public transit fell from 6.2 million to 6.1 million.[13] Several projects seek to reverse those trends by providing travelers with better information about the availability of transit and carpools.

13. Department of Transportation, Federal Highway Administration, Office of Highway Information Management, *New Perspectives in Commuting* (July 1992), p. 8.

Houston Smart Commuter. The Houston Smart Commuter project aims at increasing the use of buses, carpools, and vanpools by giving commuters easy access to timely and accurate information about commuting conditions and the availability of alternatives to driving.

For suburb-to-downtown commuting, the project will attempt to lure commuters out of single-occupancy vehicles and onto buses. Workers who live in the area of the Kuykendahl park-and-ride lot along I-45 North and travel to major downtown businesses will be offered traffic and transit information at home and work. The technologies under consideration for providing this information are touch-tone and cellular telephones, cable television, videotex (television monitors), and pocket receivers.

For suburb-to-suburb commuting, the Houston Smart Commuter project will try to match drivers and riders electronically to form instant carpools for commuters living along the western end of the Katy Freeway Corridor (I-10 West) and working in the Post Oak/Galleria area, a suburban office center.[14] The federal government is paying half of the total project cost of $5 million.[15]

California Projects. Several "Smart Traveler" projects are under way in California. In the Los Angeles area, the California Smart Traveler project will equip travelers with smart cards for parking and transit services and provide real-time information about transit arrival and travel times.[16] The Los Angeles Smart Traveler project features kiosks using videotex and audiotex to provide information about transit, paratransit, and ridesharing options.[17] The kiosks are located at shopping malls and public buildings throughout the Los Angeles area. The Sacramento Rideshare project will give drivers and prospective riders real-time ridesharing information. The project will seek ways of designing incentives for drivers to provide rides. Altogether, these projects will cost about $7.4 million, with the federal government paying $3.2 million.[18]

Seattle Smart Traveler. This project seeks to reduce single-occupancy-vehicle commuting by providing information about alternative means of transportation and by helping to form instant carpools immediately before a trip. It will use cellular phones and information kiosks to provide up-to-the-minute information that will help match drivers and riders. In the first phase of the test, a study found that 42 percent of "drive-alone" commuters would consider instant ridesharing.[19] The second phase of the test examined whether travelers would use a computer-based commuter information center in a downtown office building that offered interactive communications and information on ridesharing, traffic congestion, and bus operations. The third phase, which will make use of an FM communications system and a pager to provide information about traffic, public transit, and ridesharing opportunities, has been selected for a wider-scale test called Seattle Wide-Area Information for Travelers (SWIFT).

Phases I and II of the Seattle Smart Traveler project are estimated to cost $545,000, with the federal government paying $244,000.[20] SWIFT is estimated to cost $7.2 million, of which the federal government will contribute $4.4 million.[21]

TravLink. The TravLink project in the Minneapolis/St. Paul metropolitan area is a smart intermodal system integrating public transit with other ITS applications, especially traffic management.[22] TravLink will integrate automatic vehicle location and advanced information systems for travelers along the Interstate 394 corridor. It will distribute up-to-the-

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14. Department of Transportation, Federal Transit Administration, Office of Technical Assistance and Safety, *Advanced Public Transportation Systems, Technical Assistance Brief 6* (June 1994).

15. Department of Transportation, *ITS Projects*, p. 116.

16. Department of Transportation, Federal Transit Administration, *Advanced Public Transportation Systems Project Summaries* (August 1995), p. 2.

17. Ibid., p. 4.

18. Department of Transportation, *ITS Projects*, pp. 117, 120, and 163.

19. Department of Transportation, *Advanced Public Transportation Systems Project Summaries*, p. 1.

20. Department of Transportation, *ITS Projects*, p. 122.

21. Ibid., p. 123.

22. Department of Transportation, Federal Transit Administration, Office of Technical Assistance and Safety, *Advanced Public Transportation Systems, Technical Assistance Brief 3* (January 1994).

minute information to commuters to help them decide whether to drive, carpool, or take the bus to work. The test will attempt to determine the kind of information most useful to commuters. Types of information devices include interactive kiosks, personal computers with modems, display monitors at transit transfer stations, and electronic signs at park-and-ride lots.

Eighty buses will be outfitted with automatic vehicle location (AVL) equipment, which will enable dispatchers to track them and detect when they are running behind schedule. Dispatchers will be able to send instructions to the drivers to help them get back on schedule. The federal government is contributing $3.6 million of the total estimated project cost of $5.8 million.[23]

Efforts to Manage Travel Demand

Matching drivers and riders is not a new activity; transportation agencies and large companies have offered or supported ridesharing services for many years. The newer ITS projects are more ambitious, however; they attempt to form instant carpools on a real-time basis. How drivers and riders will respond to instant carpooling remains to be seen. It may be more attractive for long commutes, when the time to form the carpool is a smaller fraction of total travel (or travel plus setup) time than for short trips. If travel times are less than half an hour, as little as 10 minutes to form an "instant" carpool and pick up a rider would increase travel time by one-third. By comparison, a study of the Seattle Smart Traveler project reported average trip times of 26.2 minutes for single-occupancy-vehicle drivers and 30.6 minutes for carpoolers.[24] Nationwide, the average commuting time for all modes was 19.7 minutes in 1990.[25] It is likely that the greater the baseline commuting time, the higher the payoff from instant ridesharing. The benefit would also be greater if the carpool could save time between the last pickup and first dropoff by using HOV lanes.

Instant carpools may work best when public transportation is readily available as a backup. For example, in northern Virginia, queues (popularly known as "slug lines") of commuters seeking rides form at commuter parking lots near entrances to HOV lanes on Interstate 95/395. Metrobuses also stop there, serving as a backup if no ride materializes. These instant carpools do not require the use of high-tech equipment, and they probably save time in forming carpools and starting the commute. Comparing the advantages and disadvantages of this low-tech option with high-tech carpool formation could indicate whether additional ITS funds could be used productively in such ridesharing research.

Ridesharing may have unintended consequences that should be considered in evaluating the activity. Getting more riders into carpools will probably reduce congestion (at least in the short run), but it may divert potential transit passengers. That is, are carpoolers drawn from the ranks of single-occupant vehicles (SOVs) or those of transit users? If transit ridership declines, additional subsidies may be required to maintain existing levels of service, and if the decline is sharp, transit service might need to be reduced, dropped, or tailored to meet the remaining demands.

Ridesharing may have another unintended consequence because carpools generally are not as free to alter their travel patterns as are SOV commuters. A study of the Seattle project found that SOV commuters were more likely than carpoolers to adjust their travel patterns on the basis of real-time traffic information.[26] That finding may imply that one of the trade-offs involved in convincing more people to carpool (and therefore reducing the number of cars on the road) is that drivers who are already on the road have less flexibility in avoiding traffic tie-ups. That is, carpooling may reduce regular congestion caused by volume at the expense of creating even more congestion when traffic incidents do occur.

23. Department of Transportation, *ITS Projects*, p. 124.

24. Department of Transportation, Federal Transit Administration, Office of Technical Assistance and Safety, *Bellevue Smart Traveler and Cellular Telecommunications*, DOT-T-93-36 (May 1993), p. 25.

25. Department of Transportation, Federal Highway Administration, Office of Highway Information Management, *1990 Nationwide Personal Transportation Survey, Summary of Travel Trends*, FHWA-PL-92-027 (March 1992), p. 24.

26. Department of Transportation, *Bellevue Smart Traveler*, p. 1.

That effect may be smaller for instant carpools, however, than for established ones.

Environment is another factor to consider in evaluating carpooling options. Because a disproportionate amount of automobile emissions occurs within the first few minutes of driving, carpools in which members drive to central staging areas produce more pollution than carpools that pick up riders at their homes.

Finally, personal safety and comfort must be considered. Although there have been no reports of violence resulting from instant carpools formed by the Virginia slug lines, there always is a risk when picking up strangers or getting into a car with them.[27] It is not clear whether or by how much the risk is diminished when instant carpools are formed electronically. That probably depends in part on whether specific security-enhancing measures are taken, such as requiring that all participants be registered or that they be sponsored by employers. As for comfort, electronic matching could take into account the preferences of drivers and riders on such matters as smoking, radio station or other audio entertainment, type of vehicle, and so on.

The results of the smart-traveler projects that aim to attract more passengers to transit will be most useful if they provide information about what kinds of services encourage travelers to get out of their automobiles and onto mass transit buses or trains. Transit use has declined as automobile ownership and use have increased. The movement of jobs from central business districts to lower-density suburban industrial and business parks has favored automobile use over transit for commuting. To attract more riders, then, transit systems will have to overcome the obstacles of low density, slower travel compared with automobiles, flexible work schedules, and the need of commuters to combine work trips with other trips (taking children to day care, shopping, and so on). Those factors should be considered in assessing the potential effectiveness of ITS technologies in attracting more commuters to transit.

27. Recently, a commuter on the I-95/I-395 corridor was chagrined to learn (after the fact) that he had picked up an escaped convict that morning. His commute to the Pentagon had been uneventful.

Under some circumstances, smart technologies might be able to expand the passenger base. For example, they might make public transit more attractive for unconventional travelers--such as children who need to get to and from activities after school and elderly people who no longer drive. In addition to not driving, children and elderly people may have greater flexibility in their schedules than commuters and may be able to tolerate longer trip times. Smart technologies could enable transit vehicles to tailor service to meet locational and security needs. If ITS technologies can make such forms of transit more efficient, they could help transit agencies comply with provisions of the Americans with Disabilities Act.

Some advanced technologies have been available for many years but have not been widely adopted. For example, transit systems have long had the ability to monitor vehicles and count passengers. When considering new technologies, then, it is desirable to understand why earlier technologies have not been adopted (are they too costly, burdensome, ineffective, cumbersome?) so that new systems do not repeat mistakes.

Another question that arises is why transit officials have not used lower-technology methods of providing information to passengers and taking other actions designed to encourage transit use. For example, in some areas it is difficult to obtain information about transit service. Bus stops often lack information about routes, timetables, frequency of service, and time of service (that is, rush hours, weekdays only, and so on). Perhaps those measures are more costly for transit officials to apply and maintain than computerized information and telecommunications systems, but they may be less costly and more accessible to prospective transit passengers and thereby encourage greater use.

Public Transportation Operations

ITS projects in the area of public transportation operations (PTO) help transit managers use resources more efficiently. Those efforts have strong links to the demand management projects that are targeted at travelers. Together they attempt to make transit more attractive to commuters. Several ITS projects in the category of travel and transportation management also have public transit applications. For example, the TRANSCOM project will help New Jersey Transit officials direct their buses to alternative routes when traffic is heavy on the primary route. Such projects typically make use of AVL technology, using the Global Positioning System.

Smart Vehicles

Many PTO projects involve making vehicles "smarter" by equipping them with communications devices. Information about the location of their vehicles and traffic conditions can help public transit systems provide better service and keep costs under control. Smart-vehicle projects are under way in Baltimore, Dallas, Denver, Milwaukee, and Santa Clara and Orange counties, California.

Denver Smart Vehicle. Denver Smart Vehicle is the largest of the smart bus projects. In conjunction with the Federal Transit Administration, the Regional Transportation District Denver has installed communications and AVL equipment on its fleet of 788 buses and 28 supervisor vehicles.[28] Navigation satellites of the GPS determine the location of each bus, and that information is transmitted to a central dispatch center. Dispatchers can reroute buses to keep them on schedule. Buses also have silent alarms that the driver can activate in case of an emergency, alerting dispatchers to summon assistance. The anticipated federal share of this $10.5 million project is $8.4 million.[29]

Baltimore Smart Vehicle. Like the Denver project, the Baltimore Smart Vehicle project is outfitting buses with AVL equipment to enable a central dispatcher to reroute them. Buses will also be equipped to count passengers, an activity that will help the Mass Transit Administration analyze its ridership and perhaps respond better to the needs of passengers. The communications system is to become operational on a limited number of vehicles in December 1995.[30] Future plans include providing information to passengers using interactive systems in homes and offices. The federal government has obligated $2 million of the $2.5 million cost of the research and development phase of the project and anticipates paying $6.4 million of the estimated $8 million in deployment cost.[31]

Suburban and Rural Transit

Public transportation faces severe challenges in suburban and rural areas where low population densities make it difficult to design routes that would serve enough travelers to pay the cost. Intelligent systems offer a potential solution if they can identify when and where the demand for transportation service exists and find ways to tailor service efficiently. Such service is most likely to be paratransit, using vans or automobiles instead of expensive buses and operating over variable rather than fixed routes.

Suburban Mobility Authority for Regional Transportation (SMART) Project. SMART, a public transportation agency in the Detroit area, is working with the Federal Highway Administration on a paratransit project that would use a dispatch system employing automated reservations and scheduling and an AVL system to track the fleet of vehicles.[32] That project, which will interact with FAST-TRAC and other ITS initiatives in the Detroit area, will cost $11.6 million, with a federal share of $9.5 million. Through fiscal year 1994, the federal government had obligated $4.5 million.[33]

Rogue Valley Mobility Management. The Rogue Valley Mobility Management project, based in Medford, Oregon, has both urban and rural applications. Initially, the program will focus on transportation for elderly and disabled people who cannot use

28. Department of Transportation, *Advanced Public Transportation Systems Project Summaries*, p. 10.

29. Department of Transportation, *ITS Projects*, p. 146.

30. Department of Transportation, *Advanced Public Transportation Systems Project Summaries*, p. 8.

31. Department of Transportation, *ITS Projects*, p. 140.

32. Ibid., p. 151.

33. Ibid.

fixed-route transit service. A second phase of the program may extend service to people with low incomes in the Medford area. The project has a wide variety of participants: the Federal Transit Administration, the Oregon Department of Transportation, the local metropolitan planning organization, human service agencies, and transportation providers, including taxicab companies. The total cost is estimated to be $935,000, of which the federal government will provide $460,000.[34]

The Role of Government in Intelligent Public Transportation Operations

Since the 1960s, public transit systems have typically been operated by governmental entities, often municipal or regional transportation authorities. In recent years, the federal government has provided about $4 billion annually in grants to transit systems, but subsidies are diminishing.[35] If applying intelligent technologies to transit can reduce operating costs or increase revenues by attracting more passengers, the result could lessen demands for subsidies from the federal government.

Deciding whether to adopt smart transit technologies involves comparing the expected costs with the expected benefits. Evaluating projects that aim to reduce costs may be somewhat easier than evaluating projects intended to increase the number of passengers or passenger revenues because the former tend to require mostly financial information, whereas the latter depend on hard-to-model behavioral responses. The public transportation projects should provide useful data about cost savings and, along with the travel demand management projects, shed light on whether passenger revenues are likely to increase. Even with smart technologies, public transit operations are likely to need subsidies from local, state, or federal sources. If the Congress decides to eliminate or limit the role of the federal government in providing transit subsidies, the rationale for federal support of intelligent transit systems will be weakened.

34. Ibid., p. 150.

35. As this study went to press, the Congress had not passed transportation appropriations for 1996, but both the Senate and House bills had reduced transit subsidies from their 1995 levels.

Electronic Payment

Electronic payment of tolls and fares is another important element of intelligent transportation systems and is included in several transportation and traffic management projects. The Federal Transit Administration also has several projects under way to encourage the use of smart cards in public transit systems.

There are several ways of collecting tolls electronically. The process requires vehicles to carry some kind of tag that can be read electronically. In early systems, the tags were "read-only," meaning that a roadside monitor could read a tag and debit an account but could not "write" information on the tag. Because that kind of system requires that users have an account, critics have expressed concerns that toll collection agencies can monitor the comings and goings of individuals, thus invading their privacy. More advanced systems have "read-write" capabilities, which allow for greater anonymity. In those systems, the motorist can purchase a tag good for a certain amount in tolls. Roadside monitors can then send signals debiting the amount of the toll from the tag. When the value remaining on the tag drops below some predetermined level, the driver is notified and can replenish the account.

Collecting tolls electronically can reduce congestion at toll barriers by making it unnecessary for tag-equipped vehicles to stop, and it can help in levying tolls that vary by time of day in order to charge peak-period users more and thus reduce their numbers.

Electronic Toll Collection Predating the ITS Program

In the United States, at least 10 agencies have installed electronic toll collection systems.[36] Systems are currently operating in Texas, Louisiana, California, and Oklahoma. Kansas, Massachusetts, New

36. Testimony of Allan V. Johnson on behalf of the International Bridge, Tunnel & Turnpike Association, in U.S. House of Representatives, *Intelligent Vehicle-Highway Systems*, hearings before the Subcommittee on Investigations and Oversight of the Committee on Public Works and Transportation, Committee Print 103-66 (June 29 and July 21, 1994), p. 134.

York, New Jersey, and Pennsylvania are moving toward such systems.[37]

The Oklahoma Turnpike was an early user. Its Pikepass system enables participating motorists to travel past toll collection facilities at highway speeds, while nonparticipants must pull off the main roadway and stop at a toll plaza. The 222,000 participating motorists account for about 35 percent of all transactions.[38]

The Texas Turnpike Authority is another pioneer in electronic toll collection; it has operated such a system on the Dallas North Tollway since 1989. The authority has issued more than 71,000 tags and processes more than 31 million transactions annually, reportedly with virtually no error.[39] About 40 percent of peak-hour motorists use the electronic system, which roughly doubles the toll-processing capacity at rush hour.[40]

E-ZPass

The proliferation of technologies and tags is a potential problem for electronic toll collection. From the standpoint of convenience to motorists, the ideal solution is to use a common tag that works at toll plazas throughout the country. That approach would require the various toll authorities to work together, not only in adopting a single technology but also in settling accounts among jurisdictions.

Seven transportation agencies in New York, New Jersey, and Pennsylvania are cooperating in an effort to develop an electronic toll collection system that would be compatible throughout their jurisdictions. The "E-ZPass" agencies include the New Jersey Highway Authority, New Jersey Turnpike Authority, New York State Thruway Authority, South Jersey Transportation Authority, Pennsylvania Turnpike Commission, Port Authority of New York and New Jersey, and Metropolitan Transportation Authority Bridges and Tunnels. The International Bridge, Tunnel & Turnpike Association estimates that those agencies' tollways account for nearly 40 percent of all toll transactions and 67 percent of all toll revenue in the United States.[41] Eventually, toll agency officials expect E-ZPass transactions to number more than 1 million daily in several hundred toll plaza lanes.[42] Nearly 50,000 vehicles are already equipped with E-ZPass transponders for use at two of the New York State Thruway Authority's toll plazas.[43]

The Role of Government in Electronic Toll Collection

The experience with electronic toll collection indicates some of the institutional obstacles to adopting new technologies. The fact that the Oklahoma Turnpike is a self-contained system and does not need to coordinate with other states undoubtedly helped in its early adoption of electronic toll collection. If the turnpike authority had needed to coordinate with other toll authorities, implementation could easily have been delayed by the approval process. Achieving agreement among numerous agencies--as contemplated in the E-ZPass plan--may take time. Officials will have to work out mechanisms for accounting for and distributing the proceeds of tolls used on the individual toll roads. That process involves answering such questions as who will set up, maintain, and pay for the administrative functions and how each agency will ensure that it gets its fair share of the toll revenues.

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37. Testimony of Michael Zimmerman on behalf of the E-ZPass Interagency Group Policy Committee, in U.S. House of Representatives, *Intelligent Vehicle-Highway Systems,* hearings before the Subcommittee on Investigations and Oversight of the Committee on Public Works and Transportation, Committee Print 103-66 (June 29 and July 21, 1994), pp. 164-165.

38. Testimony of Allan V. Johnson in *Intelligent Vehicle-Highway Systems*, p. 134.

39. Ibid., p. 134.

40. Youngbin Yim, "Consumer Responses to Advanced Automotive Electronics: User Survey on Electronic Toll Collection Systems," *Transportation Research Record*, no. 1359 (Transportation Research Board, National Research Council, Washington, D.C., 1992), p. 3.

41. Testimony of Allan V. Johnson in *Intelligent Vehicle-Highway Systems*, p. 136.

42. Ibid.

43. Testimony of Matthew Edelman in *Intelligent Vehicle-Highway Systems*, p. 103.

Notwithstanding, adoption of a unified system that would enable users of several toll facilities--such as the turnpikes, bridges, and tunnels in the New York-New Jersey-Connecticut region--to buy a single tag that would automatically pay tolls on all the facilities would be especially beneficial to users. They would not only avoid lengthy lines at each toll plaza but would be spared the need to buy and install several different electronic tags. Electronic toll collection has been popular among tollway users in Oklahoma and elsewhere. The public appears willing to accept this mechanism for paying tolls because of the benefits of speed and convenience, despite drawbacks. Some of those, such as concerns about invasion of privacy, can be easily solved. Toll roads using electronic collection methods are also equipped to collect cash tolls. Cash can be used by people who want to protect their privacy as well as by infrequent users who find buying electronic tags inconvenient or inefficient.

The federal government can encourage interstate cooperation in electronic toll collection. It can provide a forum for bringing state agencies together to work out agreements that ease electronic toll collection. The federal government has an interest in compatible systems across state lines that will aid interstate commerce.

Commercial Vehicle Operations

The ITS projects with the greatest potential effects on productivity--or at least those in which productivity effects are most directly identifiable--are ones that have applications in the area of commercial vehicle operations. Trucking companies began to adopt communications and computer technologies to aid their operations long before the ITS program was instituted. Their early efforts were aimed at improving the productivity of their fleets and drivers and at providing better service to shippers. They have used the Global Positioning System to monitor the location and speed of vehicles and the number and length of stops. Carriers have found the ability to tell shippers exactly where their shipments are and when they will arrive to be an effective marketing tool. In addition, commercial vehicle operators have used advanced technologies to monitor drivers' hours on duty, keep track of tax payments, and comply with paperwork requirements and other federal and state regulations.

The technologies that commercial vehicle operators have adopted--such as vehicle locators and electronic billing--clearly meet the market test of improving profitability. The ITS program expands on those efforts by exploring additional applications of computer, communications, and sensor technologies that would broaden benefits for the public as well as for commercial vehicle operators and shippers. Those applications include substituting electronic filing for paperwork that is required to show compliance with federal and state laws, weighing trucks in motion so that they do not have to stop at weigh stations, keeping track of roadside safety inspections, monitoring emissions, and notifying authorities of incidents involving trucks carrying hazardous materials.

The HELP/Crescent Project

One of the first major CVO efforts of intelligent transportation systems, begun in 1991, was the Heavy Vehicle Electronic License Plate (HELP)/ Crescent project. It covers a crescent from British Columbia to Texas that runs south along Interstate 5 through Washington, Oregon, and California, then east along Interstate 10 through Arizona, New Mexico, and Texas, and then branches onto Interstate 20 in Texas. The project involved the motor carrier industry, federal highway officials, and officials from state and provincial transportation agencies.

The goal of HELP/Crescent is a system in which a truck can drive through participating jurisdictions without having to stop at weigh stations or ports of entry. The system involves gathering the information needed to comply with all laws and regulations--size and weight, certification of safety inspections, payment of state fuel and other taxes and fees, registration certificates, and so on--and recording it on a smart card in the vehicle and entering it into a database on a central computer. As the truck traverses its route, the card can be read electronically and matched with information in the computer. Any discrepancies--for example, if data from a checkpoint where vehicles are weighed in motion differed from the stated weight--could cause a truck to be stopped and checked.

During the test period, which ended in 1994, approximately 2,000 trucks were equipped with transponders to communicate with vehicle identification, vehicle classification, and weigh-in-motion equipment installed along the crescent. The test results are now being evaluated, and many of the participants are optimistic about the feasibility and desirability of the CVO applications being tested. Indeed, the project has been hailed as such a success that it has been spun off to a new private organization, HELP, Inc.

The cost of the HELP/Crescent project is estimated to be $22 million, of which the federal government contributed $5.9 million.[44]

Advantage I-75

Advantage I-75 is another large CVO project, which is estimated to cost nearly $11 million, including a federal share of $7.7 million.[45] Advantage I-75 runs along the Interstate 75 corridor from Ontario to Florida through Michigan, Ohio, Kentucky, Tennessee, and Georgia. Like HELP/Crescent, it contemplates electronic clearance of transponder-equipped vehicles to minimize the need for stopping in transit. Begun in 1991, the project is expected to continue into 1997. Equipment that will link electronically all weigh stations along I-75 is being installed. One study has concluded that if all weigh-station stops on I-75 could be eliminated, savings would total $260 million a year.[46]

44. Department of Transportation, *ITS Projects*, p. 142.

45. Ibid., p. 178.

46. Study by the Center for Urban Transportation Research at the University of South Florida, reported in the testimony of Don C. Kelly, Secretary of Transportation, Commonwealth of Kentucky, and Chairman of the Advantage I-75 Policy Committee, in U.S. House of Representatives, *Intelligent Vehicle-Highway Systems*, hearings before the Subcommittee on Investigations and Oversight of the Committee on Public Works and Transportation, Committee Print 103-66 (June 29 and July 21, 1994), p. 262.

Factors Affecting Adoption of Advanced Technologies

Using advanced technologies to ensure compliance with state regulations could substantially benefit commercial vehicle operators. Requiring fewer stops could reduce travel time, increase productivity, save fuel, and reduce emissions.

Commercial vehicle operators have been skeptical, however, that ITS would be a net benefit. One of the foremost concerns appears to be that advanced technologies for weighing vehicles in motion and identifying vehicles electronically could ease imposing highway user fees based on the weight of the vehicle and distance driven. Weight-distance charges are popular among policy analysts and some highway officials who note that damage to pavement depends on the weight of trucks--or, more precisely, the weight supported by each axle.[47] Thus, charging vehicles according to their weight and the distance they travel could promote efficient use of highways by causing truckers to recognize the damage they inflict and inducing them to spread their cargo over more axles. A few states have imposed charges or taxes associated with weight and distance. Most notably, Oregon has levied a weight-mile tax for many years. But the availability of advanced technologies enhances the feasibility of such charges because it makes them easier to administer, monitor, and enforce.

How favorably state highway officials would view such technologies is not clear. On the positive side, advanced technologies could help them monitor trucking operations, collect fees and taxes, and enforce weight restrictions and other laws. Such technologies also could make working conditions safer for people staffing roadside monitoring stations. But achieving those savings might require state highway officials to relinquish some degree of control and autonomy. They might have to alter some of their business practices--such as reporting forms and requirements, and auditing and inspection schedules--

47. See Department of Transportation, Federal Highway Administration, Highway Revenue Analysis Branch, *The Feasibility of a National Weight-Distance Tax*, report of the Secretary of Transportation to the U.S. Congress pursuant to section 933 of the Deficit Reduction Act of 1984 (December 1988).

to attain compatibility with neighboring states. Decisions about whether to participate in multistate programs involving advanced technologies will entail weighing both political and economic factors.

The amount of risk involved also contributes to the decision process of state highway officials. They may be reluctant to tinker with something that appears to be working perfectly well. Adopting computerized monitoring of commercial vehicle operations might be more efficient than paper-based systems, but the risk, familiar to many who deal with computer networks, is that they can crash. To provide for such a system failure, state highway departments might have to maintain costly backup systems, which could diminish the savings achieved by computerization.

As for effects on the general public, systems that enhance the productivity of commercial vehicle operations are likely to result in lower shipping costs, since the trucking industry is highly competitive. That decrease could reduce the cost of consumer goods, nearly all of which are carried by truck at least some of the way from plant or port to retail outlet.

Under certain conditions, electronic monitoring could enhance safety. If new technologies enable highway officials to identify unsafe vehicles--such as vehicles with defective brakes--accidents could be prevented. In addition, fewer stops at weigh stations would generate fewer opportunities for collisions between slow-moving trucks pulling out of weigh stations and fast-moving automobiles. If stopping at weigh stations provides a rest for truck drivers, however, eliminating the need to stop could diminish safety, although officials have other ways of enforcing the rules concerning rest breaks. Eliminating the deceleration and acceleration associated with stopping at weigh stations would also reduce emissions.

In evaluating ITS projects affecting commercial vehicle operations, all of these considerations--effects on trucking productivity, costs and benefits to state and local governments, and effects on safety and the environment--should be weighed.

Emergency Management

Advanced communications technologies can be employed to assist in alerting authorities of the need for police, fire, and rescue services and to reduce the time it takes them to respond. Two operational tests are under way.

In north-central Colorado, the Colorado State Patrol is working with communications firms to evaluate using the GPS to locate vehicles and cellular phones to assist travelers. The Colorado Mayday project will help evaluate both the technology and the organizational structure for providing timely assistance in emergencies. The total estimated project cost is $3.8 million, of which the federal government's share is $2.4 million.[48]

In northwest Washington, the Federal Highway Administration is working with the Washington State Department of Transportation, the Washington State Patrol, the University of Washington, and several communications and consulting firms to develop a regional system of emergency notification and response. The primary objective of the Puget Sound Help Me (PUSHME) Mayday System is to assess the operational, institutional, and technology requirements for such a system. The federal government has obligated $1.4 million of the total $2.5 million project cost.[49]

Traditionally, state and local governments have had primary responsibility for emergency management. Justification for federal involvement through the ITS program would rest on the concept that research and development is a public good; that is, that the knowledge gained from research in one jurisdiction can be used in others, but since no single jurisdiction can obtain all the benefits, none may want to undertake the costs unless it receives financial assistance from an external source.

48. Department of Transportation, *ITS Projects*, p. 202.

49. Ibid., p. 203.

Advanced Vehicle Control and Safety Systems

Many of the ITS projects described above have safety as one objective, although it is not generally the principal objective. Accident prevention is a way of reducing congestion related to traffic incidents, making safety at least auxiliary to the traffic management objective, and emergency management is integrally related to safety. But safety is the central focus of two other ITS efforts: automated highway systems (AHS) and advanced vehicle control systems.

Automated Highway Systems

Section 6054(b) of the Intermodal Surface Transportation Efficiency Act of 1991 required the Secretary of Transportation to

> develop an automated highway and vehicle prototype from which future fully automated intelligent vehicle-highway systems can be developed. Such development shall include research in human factors to ensure the success of the man-machine relationship. The goal of this program is to have the first fully automated roadway or an automated test track in operation by 1997.[50]

In the long term, automated highways are envisioned as roads on which drivers do not have to operate their vehicles. Vehicles would be automatically guided along such roads and kept a safe distance apart.

The Department of Transportation has started several AHS projects. The largest consists of a consortium of several companies, transportation agencies, and a university, led by General Motors. The total cost of this project is estimated to be $210 million, with the federal government paying $160 million.[51] The long-term goal of the project is to improve the safety and efficiency of the nation's surface transportation network through an automated highway system.

Other AHS projects address special concerns that must be resolved in the early planning stages of an automated highway system. For example, the $5.1 million project called Human Factors Design of Automated Highway Systems studies how drivers will handle such tasks as entering and exiting the AHS, how they will react to manual driving after automated operation, and how they will react to different spacing between vehicles on the automated highway.[52] Another project, Precursor Systems Analyses, is intended to support the systems development stage of AHS. It involves 15 prime contractors, with federal funding of $14.1 million.[53]

Advanced Vehicle Control Systems

In addition to work on automated highway systems, DOT has funded several projects for research into the closely related matter of advanced vehicle control systems. Advanced vehicle controls include such measures as sensing systems that sound an alarm or take control of the vehicle if the sensors detect an imminent accident. For example, sensors can detect whether a vehicle is moving too rapidly in relation to the vehicle in front of it and can tell drivers to slow down or automatically apply the brakes. Sensors can detect whether another vehicle is in an adjoining lane, perhaps in the driver's blind spot, and can sound a warning against changing lanes.

The Role of Government in Vehicle Control and Safety Systems

Although automated highways will require vehicles that have advanced controls, such vehicles could operate independently of automated highways. Over the past quarter century, manufacturers have incorporated increasing numbers of safety-related features in vehicles. Some of those features have been required

50. Section 6054(b) of the Intermodal Surface Transportation Efficiency Act of 1991, 23 U.S.C. 307, 105 Stat. 291.

51. Department of Transportation, *ITS Projects*, p. 231.

52. Ibid., pp. 226-227.

53. Ibid., pp. 212-213.

by federal government regulation, and others have come in response to customers' demands. Many types of advanced vehicle controls could most likely be adopted without government involvement; the market can respond to consumers' preferences.

But some government involvement could probably be rationalized. Owners of vehicles equipped with safety features are not the only ones who benefit from them; all drivers gain from their use. For example, a vehicle equipped with a lateral collision warning system may help drivers in adjacent lanes. In addition, if it is cheaper to mass-produce vehicles with advanced controls, some government involvement may increase the demand for them and thus save buyers enough money to make the government's cost worthwhile.

One unintended consequence of advanced controls could be that drivers whose vehicles have such control devices might drive less carefully than they would without them. Some economists have suggested that drivers may in effect seek a given level of safety and "compensate" for improved safety features in vehicles by driving faster or more recklessly.[54] If that fear is real, the effect diminishes the net benefits from advanced vehicle control systems.

If advanced vehicle controls are evolutionary, automated highway systems could produce a revolutionary change in the relationship between vehicle operators and the operators and maintainers of roadways. Government operation of an automated highway system in which vehicles were owned and controlled by individuals would require fundamental changes in the relationship between them. Liability issues present a major concern. A highway system failure could have catastrophic results. To guarantee that an automated highway worked safely, managers would have to ensure that vehicles operating on it were safe and in good repair. A system that automatically applied brakes, for example, would be effective only if all vehicles' brakes were in good working condition. A flat tire or other breakdown could cause massive disruption in an automated highway system.

54. Sam Peltzman, "The Effects of Automobile Safety Regulation," *Journal of Political Economy*, vol. 83, no. 4 (August 1975), p. 717.

Priority Corridors

In the legislation authorizing the ITS program, the Congress established a special category for applications of technology to transportation corridors. Section 6056 of ISTEA required the Secretary of Transportation to designate transportation corridors in which application of ITS would be particularly beneficial, and it set forth criteria for allocating not less than 50 percent of corridor funding for three to ten "priority corridors."

The factors to be considered in designating priority corridors were traffic density; nonattainment of ozone goals under the Clean Air Act; a variety of types of transportation facilities (such as highways, bridges, tunnels, and toll and nontoll facilities); inability to expand the capacity of existing surface transportation facilities substantially; a significant mix of passenger, transit, and commercial motor carrier traffic; complexity of traffic patterns; and potential contribution to carrying out DOT's strategic plan for intelligent vehicle and highway systems.

In addition, in the conference reports to appropriation bills following passage of ISTEA, the Congress has designated funding from the federal-aid highway (ISTEA) account for specific corridors.

In March 1993, DOT designated four priority corridors: the Northeast (I-95 northeast from Maryland to Connecticut), Midwest (I-80/I-90/I-94, from Gary through Chicago to Milwaukee), Houston (I-10 and I-45), and Southern California (I-5/I-10, Los Angeles to San Diego).[55] Those corridors encompass metropolitan areas that have grown so large that they have blended together. Traffic congestion is common not only during rush hours between a central city and its suburbs but also along entire urbanized corridors linking central cities and their suburbs. Traffic spills over from one jurisdiction to the next, making coordination among transportation agencies desirable.

55. Department of Transportation, *ITS Projects*, p. 391.

SMART Corridor (Los Angeles)

The Southern California corridor includes parts of Ventura, Los Angeles, San Bernardino, Riverside, San Diego, and Orange counties. Within the corridor are several ITS projects, including the "SMART Corridor." The SMART Corridor, a joint project of the Los Angeles County Transportation Commission, the City of Los Angeles, and the Federal Highway Administration, runs along 12.3 miles of the Santa Monica Freeway in Los Angeles. The system will use highway advisory radio and changeable message signs to advise motorists of traffic conditions and alternative routes. It will also improve emergency response. Those actions are expected to relieve congestion, enhance safety, reduce fuel consumption, and improve air quality. DOT expects the project to be fully operational in the summer of 1995.[56]

56. Ibid., p. 109.

The Role of Government in Priority Corridors

The priority corridor programs generally encompass a number of ITS projects. Some are relatively limited in scope and can be undertaken by a small number of jurisdictions. But the projects that probably warrant the greatest emphasis by the federal government are those that have the greatest amount of jurisdictional overlap, and which a single jurisdiction is least likely to carry out. They are also the most complex in terms of gaining cooperation among jurisdictions. Thus, they probably make the strongest case for federal assistance. Of course, such projects should still be examined to make sure they meet benefit-cost criteria.

Chapter Four

Options for Reform

The Intelligent Transportation Systems program is about midway through its first authorization period. Critics are pressing it to show results. In addition, the need to constrain federal spending has made the program a candidate for budget cuts or elimination. There are three options for reform: eliminating ITS as a separate program, retaining it as a program with a narrow focus, or strengthening the existing program.

All of the options are based on the assumption that budgets will be tighter in the future. ITS projects will have to compete with many others for fewer federal dollars. The options would produce somewhat different results based on the types of applications emphasized and the nature of the federal government's involvement.

The options are predicated on the existing role of the federal government in financing highways and transit systems. If the Congress reexamines and radically changes that role, fundamentally different options arise. If, for example, the federal government halted subsidies for mass transit, the justification for federal support of transit research and development would fade (although a small role might remain, based on the reasoning that research and development is a public good). Such policy changes lie beyond the scope of this study.

Eliminating the Program

The option of eliminating the ITS program as a separate programmatic and budgetary entity would not necessarily mean ending federal support for intelligent transportation technologies; it would merely require such efforts to compete more directly for federal funding with other transportation projects. Under this option, the Federal Highway, Federal Transit, and National Highway Traffic Safety Administrations could continue to sponsor ITS projects under their existing research and operational testing programs. State and local governments could also use federal funds for research, testing, and deployment of intelligent systems. State and local governments have incentives to continue seeking technological solutions to traffic and travel problems, and the private sector would most likely continue to do research in areas where it could reap enough benefits to make those efforts worthwhile.

Underlying this option is the premise that the ITS program has largely succeeded in its original mission. It has brought together parties with a stake in intelligent transportation: state and local governments; universities and other research centers; automobile, electronics, communications, and other firms that supply technologies; and commercial vehicle operators and other users of the highway system. The Department of Transportation and ITS America, the federal advisory committee on intelligent transportation systems, have provided leadership in stimulating new ideas and developing ways of using new technologies to improve travel by highway and mass transit. The federal government has provided seed money for a variety of projects and has brought smart systems to the attention of state and local officials who can make informed investment decisions about whether to use the new transportation technologies in their communities.

The efforts to develop a systems architecture have stimulated new ways of thinking about solving transportation problems. Those efforts have also identified potential stumbling blocks to success, such as incompatible technologies. And they have brought together various private standard-setting organizations to work out procedures for deciding on and adopting compatible systems.

Having supported research and testing that demonstrate ways of improving transportation through advanced computer, communications, and sensor technologies, the ITS program has accomplished much of its initial purpose. According to that line of reasoning, the rationale for the program as a separate entity has diminished--although additional R&D may still be desirable.

Terminating the program as a separate entity--either when its initial authorization expires in 1997 or earlier, as part of a deficit reduction plan--has disadvantages as well as merits. Many projects are still under way and may need additional federal funding or technical assistance to accomplish their objectives. Without a central program office to disseminate the results of research and operational tests, state and local transportation officials may find it more difficult to learn about them and to get assistance in applying them in their jurisdictions. To some extent, this problem is mitigated by the existence of other organizations and forums for sharing research results, such as the Transportation Research Board, the National Cooperative Highway Research Program, and the American Association of State Highway and Transportation Officials. ITS America could also serve a useful role as the central clearinghouse for coordinating research efforts. Still, without the focus of a federal ITS program, the impetus for additional research and development of smart transportation systems might diminish.

Limiting the Scope of the ITS Program

Another option is to scale back the ITS program and focus on areas where federal intervention is desirable because it will facilitate interstate commerce. Two major areas of application are most likely to meet the criterion of facilitating interstate commerce: electronic clearance of commercial vehicle operators and electronic payment of tolls. Other project areas could be considered on the basis of the strength of the federal interest and the need for involvement by the federal government.

ITS efforts in the areas of travel and transportation management, travel demand management, public transportation operations, and emergency management are less likely to meet the criteria of this option. Projects in those areas could continue to seek federal funding support from existing programs authorized by the Intermodal Surface Transportation Efficiency Act of 1991 or through annual appropriations, but they would no longer enjoy special treatment under a separate program. They would have to compete on an equal basis with other funding proposals. Most of the promising ITS projects would be able to do so. The main exception would probably be traveler information systems that are vehicle-based, such as route guidance and navigation. But the success of TravTek suggests that those projects would be attractive to the private sector. Automobile manufacturers and rental car companies, in particular, would continue to pursue traveler information systems because they have discovered that consumers are willing and able to pay for them.

This option would also drop most of the projects concerned with advanced vehicle control and safety systems because vehicle-based projects could be left to the private sector. Although the automated highway system is based on infrastructure and is therefore a stronger candidate for governmental support than a system based on vehicles, it might not meet the criterion of interstate interest and would be more likely to fail a benefit-cost test.

Efforts in the commercial vehicle and electronic payment areas would not have to be conducted as a separate ITS program. The Federal Highway Administration's Office of Motor Carriers has taken the lead on projects developing electronic clearance of commercial vehicles, and it will probably continue to lead in assisting states in cooperating with one another. Because trucking companies believe that electronic clearance will save them time and money, they, too, will be a force for continuing work in this area. Since trucking companies have adopted various smart technologies on their own, continued efforts in this area seem likely. In addition, FHWA has other initiatives, including the Motor Carrier Safety Assistance Program, that could augment ITS efforts.

Efforts toward electronic payment of tolls might abate. The principal beneficiaries of electronic toll collection, in contrast to those who benefit from electronic clearance of commercial vehicles, are individual motorists who are not organized enough to lobby against long lines at toll facilities. Although organizations such as the American Automobile Association might be expected to express the interests of members, they might not wish to improve electronic toll collection. First, AAA has traditionally opposed tolls and probably would not want to make them more attractive as a means of financing highways and bridges. Second, the benefits from interstate cooperation in electronic toll collection are primarily limited to the Northeastern states, where both tolls and interstate travel are common.

Strengthening the ITS Program

A third option is to retain the Intelligent Transportation Systems program in its general form but to continue managers' efforts to improve it. The process of selecting projects could be strengthened by imposing stricter criteria and procedures.

One area for improvement is in setting priorities for the program. The strategy so far has been essentially to let a thousand flowers bloom. Several hundred projects share in the funding, making support for the average venture about $1 million a year. Of course, the size of projects varies widely.

The largest share of ITS funding--41.8 percent through 1994--has been used for the corridors programs as specified by the Congress. Those programs are aimed primarily at alleviating traffic congestion; their secondary objectives are improving safety and emergency response. Their focus is on the application of technologies to solve such problems, not on basic research.

The rest of the funding is divided among about 200 projects. A review of each one is beyond the scope of this study, but the broad picture that emerges from the summary descriptions is something of a patchwork quilt. That state of affairs is not necessarily undesirable, especially in the early stages of a research program. By sponsoring a diverse set of projects, the program can reduce the risk of prematurely closing off a promising line of research. Once funding is cut off from a research effort, an entire set of opportunities may be lost. Thus, it is not unreasonable to sponsor a diverse set of projects early in a research program, recognizing that some will be more successful than others but that even unsuccessful attempts will contribute to the state of knowledge because they provide lessons about what to avoid in future research.

At some point, however, a research program should become more focused. It might be strengthened by judging projects on the basis of more demanding criteria. Proposals can be scrutinized for their potential contribution to the state of knowledge. Researchers can be required to show what they would learn, what gaps in knowledge the project would fill, and what transportation problems it would help solve, as well as the likely success of doing so. Peer review of proposals and results can strengthen the evaluation process.

The costs of projects should be weighed against their benefits. The benefit-cost approach is somewhat complicated in a program like ITS, in which benefits may be separated into two broad categories--namely, those associated with the knowledge gained from the research, and those that help the users and providers of transportation services. The latter occur in the multitude of ITS projects that use the real world for a laboratory--the projects that aim to reduce congestion, transit waiting time, and costs of managing highway and transit systems; enhance mobility; and so on.

One note of concern in the ITS program is that many projects appear to have essentially the same objective and approach. Although some similarities may be useful in helping researchers identify specific factors that are vital to the success or failure of a given technological application, too much duplication is wasteful and risks turning a research program into a pork barrel. Additional funding would be more productive if it was designed to fill in gaps in knowledge.

Several other factors should enter into consideration of new projects. Projects having the greatest potential public benefits in relation to costs might be better projects for the federal government to sponsor because they are generally less attractive to private entities. Similarly, those that might benefit many jurisdictions may be better targets than those that address unique local problems. Private firms would be less likely to undertake riskier projects. To get a sense of the value of potential projects to state and local officials, selection criteria could include the extent to which those officials were willing to provide matching funds. Participation by the private sector could also be weighed.

Among the objectives set forth by the Congress, the one that seems to have received the least attention is the environment. Although some of the travel management projects could benefit the environment, how they might do so is not entirely clear because short-term reductions in traffic and congestion could lead to greater numbers of vehicles on the road, resulting in even greater pollution.

Conclusion

Establishing the ITS Joint Program Office has alleviated many of the organizational problems that are common to start-up and rapid growth. The office has helped bring together a disparate set of projects run by FHWA, FTA, and NHTSA and is providing greater oversight in the process of selecting, supervising, and evaluating projects. Future projects will probably be subjected to greater scrutiny than were earlier ones. The next two years will be crucial in demonstrating what the program can produce. At this juncture, the jury is still out on the question of whether the program is a sound investment of federal dollars. Some projects appear to be yielding useful results; others are floundering. Unless the program can demonstrate that it is producing useful knowledge and communicating that knowledge effectively to those who make decisions about using new transportation technologies, it will have difficulty competing with other programs for limited budgetary resources.

The ITS program is authorized through fiscal year 1997 under the Intermodal Surface Transportation Efficiency Act. When it considers legislation to succeed ISTEA, the Congress will debate the future federal role in setting policies and providing financing for highways and mass transit systems. The three options set forth in this chapter offer ways of reforming the ITS program within the context of the existing federal framework. The criteria presented for federal involvement--a national interest transcending state lines and spillover costs or benefits--can also be applied more generally to highway and transit programs. If the Congress should decide to scale back or significantly alter the federal role in surface transportation, the role in funding intelligent transportation systems could be modified accordingly.