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HIGHWAY RESEARCH

Systematic Selection and Evaluation Processes Needed for Research Program

**G A O****Accountability * Integrity * Reliability**

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Abbreviations

DOT	Department of Transportation
FHWA	Federal Highway Administration
RTCC	Research and Technology Coordinating Committee



United States General Accounting Office
Washington, DC 20548

May 24, 2002

The Honorable Harold Rogers
Chairman
The Honorable Martin Sabo
Ranking Minority Member
Subcommittee on Transportation
Committee on Appropriations
House of Representatives

The Honorable Patty Murray
Chairman
The Honorable Richard Shelby
Ranking Minority Member
Subcommittee on Transportation
Committee on Appropriations
United States Senate

Throughout the past decade, the Federal Highway Administration (FHWA) has received hundreds of millions of dollars for its surface transportation research and technology program. For example, in 1998 the Transportation Equity Act for the 21st Century, which authorized the Department of Transportation's (DOT) transportation programs for highways, highway safety, and transit for the 6-year period of 1998 through 2003, included over \$447 million for fiscal year 2002 for FHWA's transportation research and technology efforts. These efforts included programs for surface transportation research, technology deployment, intelligent transportation systems, training and education, university transportation research, and the Bureau of Transportation Statistics. In addition to providing funding, this authorization required DOT to establish a strategic focus for its surface transportation research and technology program. As it considers reauthorizing this program, Congress will be making decisions on the future characteristics of the program and the level of resources it should receive.

As a result of congressional concern about the efficient and effective use of the research funds provided for FHWA, the House Committee on Appropriations report accompanying the Department of Transportation and Related Agencies Appropriations Act for 2002 directed us to review FHWA's surface transportation research and technology program by evaluating program benefits and identifying successful programs and problems. In response, as agreed with your staff, this report discusses

(1) the organization of FHWA's research and technology program and (2) the extent to which FHWA's processes for developing research agendas and evaluating research outcomes align with the best practices for similar federal research programs. We are also providing information on funding for this program since fiscal year 1991 (see app. I). Except where otherwise noted, this report focuses primarily on those activities funded by the surface transportation research and technology deployment categories identified in the Transportation Equity Act for the 21st Century. However, all categories of funding are presented in our discussion of historical funding for the agency's research and technology program.

To address these issues we obtained information from FHWA officials, including representatives of each of its five core business units and three of its eight service business units, on how the research and technology program is organized and on FHWA's processes for developing research agendas and evaluating research outcomes. We reviewed program documents, including budget allocations and department and agency strategic plans, as well as relevant legislation. We analyzed and presented data on agency funding of the program since fiscal year 1991. We also contacted or met with representatives of DOT's Research and Special Programs Administration, the American Association of State Highway and Transportation Officials, and the Transportation Research Board.¹ We also reviewed various publications on best practices in federal research from the Transportation Research Board and the Committee on Science, Engineering, and Public Policy. We selected these publications on best practices because they were most relevant to the program aspects we reviewed and to federal agencies that support scientific and engineering research. We conducted our review from August 2001 through May 2002 in accordance with generally accepted government auditing standards.

Results in Brief

FHWA's research and technology program's organization is complex and decentralized throughout the agency. The program's organization is complex because each of the program offices within the agency (called business units) is responsible for identifying research needs, formulating

¹The Transportation Research Board is a unit of the National Research Council, a private, nonprofit institution that is the principal operating agency of the National Academy of Sciences and the National Academy of Engineering. The board's mission is to promote innovation and progress in transportation by motivating and conducting research, facilitating the dissemination of information, and encouraging the implementation of research results.

strategies to address transportation problems, and setting goals for research and technology activities that support the agency's strategic goals. One business unit that is located at FHWA's research laboratory provides support for administering the overall program and conducts some of the research. The agency's leadership team, consisting of the directors of the business units and other FHWA offices, provides periodic oversight of the overall program. In addition to the research activities within FHWA, the agency collaborates with other DOT agencies to conduct research and technology activities. Other nonfederal research and technology organizations also conduct research funded by FHWA related to highways and bridges. These organizations include state research and technology programs, the National Cooperative Highway Research Program, private-sector activities, and universities.

FHWA's processes for managing the research and technology program, and in particular for developing research agendas and evaluating research outcomes against intended results, do not always align with the best practices for similar federal research and technology programs. Leading research organizations recognize that it is challenging for research and technology programs to set goals and evaluate results in a traditional manner. Nevertheless, best practices used in other federal research programs or recommended by experts include: (1) developing research agendas in consultation with external stakeholders to identify high-value research and (2) using a systematic approach to evaluate ongoing and completed research through such techniques as peer review. FHWA acknowledges that its approach for developing research agendas and involving external stakeholders in determining the direction of the program's research lacks a consistent, transparent, and systematic process. Instead, most external stakeholder involvement is ad hoc through technical committees and professional societies. FHWA officials also told us that their research decisions were affected by funding designations contained in authorizing legislation as well as in reports accompanying annual appropriations acts that reflect congressional interests. Between 44 and 48 percent of authorized surface transportation research and technology deployment funds were designated in fiscal years 2000 through 2002. With regard to evaluating research outcomes, FHWA officials also told us that the agency does not have a systematic process. Instead, the agency primarily uses a "success story" approach to evaluate its research outcomes. While this approach shows that the agency's research produces some benefits, it cannot be used as the primary method to evaluate the outcomes of the research against intended results because these stories represent only a fraction of the program's completed research projects. As a result of its relatively varied processes, it is unclear whether the

organization is selecting research projects that have the highest potential value, or what is the extent to which these projects have achieved their objectives. We are making recommendations to improve the agency's agenda-development processes and its approach to evaluation by incorporating the use of best practices for the research and technology program. FHWA commented on a draft of this report and generally agreed with our findings and recommendations.

Background

FHWA is the DOT agency responsible for federal highway programs—including distributing billions of dollars in federal highway funds to the states—and developing federal policy regarding the nation's highways. The agency provides technical assistance to improve the quality of the transportation network, conducts transportation research, and disseminates research results throughout the country. FHWA's business units conduct these activities through its research and technology program, which includes "research" (conducting research activities), "development" (developing practical applications or prototypes of research findings), and "technology" (communicating research and development knowledge and products to users). FHWA maintains a highway research facility in McLean, Virginia. This facility, known as the Turner-Fairbank Highway Research Center, has over 24 indoor and outdoor laboratories and support facilities. Approximately 300 federal employees, on-site contract employees, and students are currently engaged in transportation research at the center.

According to FHWA officials, the agency's research and technology program is oriented to supporting the agency's and DOT's strategic goals for the nation's transportation system, including

- to promote public health and safety by working toward the elimination of transportation-related deaths and injuries;
- to provide an accessible, affordable, and reliable transportation system for all people, goods, and regions;
- to support a transportation system that sustains the nation's economic growth;
- to protect and enhance communities and the natural environment affected by transportation; and
- to ensure the security of the transportation system for the movement of people and goods, and to support the national security strategy.

The research and technology program is generally a component of broader agency programs directed toward the achievement of these strategic goals.

For example, in a recent report the Transportation Research Board's Research and Technology Coordinating Committee (RTCC) stated that most of FHWA's research and technology program's projects are aimed at incremental improvements to lower highway construction and maintenance costs, improve highway system performance, increase highway capacity, reduce highway fatalities and injuries, reduce adverse environmental impacts, and provide a variety of benefits such as improved travel times and fewer hazards for highway users.²

Concerned about the strategic focus of surface transportation research and technology activities, Congress required DOT to establish a strategic planning process to identify national priorities related to research and technology for surface transportation when it passed the Transportation Equity Act for the 21st Century in 1998. This process was to result in a strategic plan that included, among other things, performance goals, resources needed to achieve those goals, and performance indicators for the succeeding 5 years for each area of research and technology deployment. The plan was also to be developed with comments from external stakeholders. In response to this requirement, FHWA contributed to the development of a research, development, and technology strategic plan for all of DOT. DOT's plan identifies formal research, development, and technology strategies to support each of DOT's strategic goals. The plan is not focused solely on surface transportation research but applies to all modes, including examples of research activities undertaken by FHWA in support of the agency's strategic goals. Congress also required that a group established by the National Research Council review DOT's plan, and this has taken place for several years. Separately, in 1998 FHWA developed a 10-year strategic plan for the agency as a whole, stating that research is a strategy for achieving the plan's objectives. The Research, Development, and Technology business unit has developed performance plans that support some of FHWA's research efforts.

Funding mechanisms for this program's activities have varied in recent years. Prior to fiscal year 1992, they were wholly funded from FHWA's administrative and operating funds. From fiscal years 1992 through 1997, the program was supported by a mix of operating funds and funds made

²Transportation Research Board, *The Federal Role in Highway Research and Technology* (Washington, D.C.: National Academy Press, 2001), p.76. RTCC was convened in 1991 by the Transportation Research Board of the National Academies to provide a continuing, independent assessment of FHWA's research and technology program. FHWA provides funding for the committee.

available for specific types of research. For fiscal years 1998 through 2003, the Transportation Equity Act for the 21st Century authorized funding for the following seven research activities: surface transportation research, technology deployment, training and education, intelligent transportation systems, intelligent transportation systems deployment, university transportation centers, and the Bureau of Transportation Statistics.³ Since 1998, FHWA has generally not used administrative funds for research activities. A portion of the funds for the research and technology program are designated for or directed to particular research programs and recipients, either in the authorization or appropriations legislation or in committee reports. Although FHWA technical staff set priorities for the research and technology program, its activities are carried out through a combination of federal employees, private contractors and grantees, and university researchers. During the past decade, the use of contract employees instead of federal employees to conduct research has increased. Because the program's authorizing legislation is scheduled to expire in fiscal year 2003, to continue it Congress will have to reauthorize the program and determine how it will be funded.

FHWA's Surface Transportation Research and Technology Program's Organization Is Complex and Decentralized

Since 1998, individual business units within FHWA have directed and carried out the activities of FHWA's research and technology program that fall under the surface transportation research and technology deployment areas. (See app. II for agency organization charts.) Under the current organization, directors of these business units (Federal Lands Highway; Infrastructure; Operations; Planning and Environment; Policy; Research, Development, and Technology; and Safety) work collaboratively to provide leadership for the program's activities (see table 1).

³This report focuses primarily on the Surface Transportation Research and Technology Deployment activities.

Table 1: Roles of Business Units in Research and Technology

Unit name	Role in research and technology	Examples of current research and technology projects
Federal Lands Highway	Development of applied research and technology applicable to transportation systems serving federal lands.	Road Surface Analyzer (ROSAN) measurement of pavement smoothness.
Infrastructure	Development of research and technology in the areas of highway construction and physical maintenance, pavements, and structures.	Long-term pavement performance. Concrete research and technology. Innovative bridge technology.
Operations	Development of research and technology program plans for the Intelligent Transportation Systems program, as well as operation of the transportation system and management of freight transportation.	Research into advanced traffic simulation modeling. Prediction tools and research into advanced, adaptive traffic signal control strategies. Analysis of critical intermodal freight corridors and facilities. Work zone best practices guide and program support.
Planning and Environment	Development of research and technology in the areas of planning, environment, and property acquisition.	Workshops, synthesis materials, and case studies of state consultation practices with rural officials. Statewide planning and travel forecasting training. Research on the contribution of transportation to air pollution and on strategies to reduce transportation effects. Highway noise barrier design handbook.
Policy	Development of analytical tools and data systems for policy development and studies; conducting analysis and studies to support the formulation of transportation policy and legislative initiatives; and preparation of major reports to Congress on highway policy issues.	National personal transportation survey. Highway cost allocation study. Production of biennial report, "Status of the Nation's Highways, Bridges, and Transit: Condition and Performance."
Safety	Leading in development of research and technology activities in the areas of Intersections; Pedestrian and Bicyclist Safety; Roadside Safety; Run-Off-Road Safety; and Speed Management.	Interactive highway safety design model for two-lane roads. Pedestrian safety countermeasure selection system. Education and community programs for pedestrian/bicyclist safety. Analysis of intersection safety issues. Red-light running prevention. Speed limit setting and enforcement. Variable speed limits.
Research, Development, and Technology	Support of all other business units in the development and delivery of new technologies.	Research activities to support Infrastructure, Operations, and Safety business units.

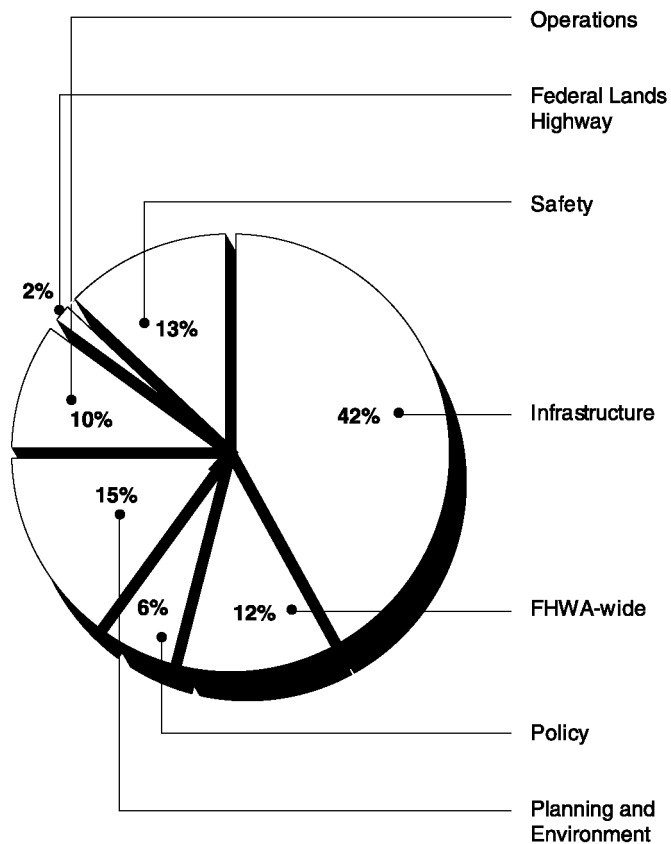
Source: GAO presentation of information provided by FHWA.

The program's management is complex because these business units are individually responsible, among other things, for identifying research needs, developing strategies to address transportation problems, and managing research and technology activities that support the agency's strategic goals. In some cases, the business units conduct their own

research. However, the Research, Development, and Technology business unit, located at the Turner-Fairbank Highway Research Center, conducts research for the Infrastructure, Operations, and Safety business units. The Research, Development, and Technology business unit also works with the other business units to prepare materials to support the program's overall budget, and it serves as FHWA's liaison to other organizations that advise FHWA on research or conduct highway-related research. The agency's leadership team, composed of the business unit directors, field service directors, a division administrator, the FHWA administrator, and the FHWA executive director, meets periodically to advise the business units on research and technology program priorities, budgets, and milestones.

FHWA's leadership team advises the business units on how funds should be distributed by considering designations in statutes and committee reports and the stated needs of individual business units. The Office of the Administrator approves final budgets for the business units. In fiscal year 2002, the business unit responsible for the largest percentage of surface transportation research and technology deployment funds was the Infrastructure business unit (see fig. 1).

Figure 1: Distribution of Surface Transportation Research and Technology Deployment Funds, Fiscal Year 2002



Note: Business units are responsible for managing these funds but may distribute them to other business units to meet research needs. For example, Infrastructure, Operations, and Safety business units distribute most of their research funds to the Research, Development, and Technology business unit to conduct particular research on their behalf. The FHWA-wide category in this figure includes funds for research projects in which multiple offices within FHWA have responsibility.

Source: GAO analysis of data from FHWA.

Prior to the agencywide restructuring in 1998, research activities were managed throughout the organization, including at the Office of the Associate Administrator for Research and Development and the Office of Technology Applications. Decisions related to developing research and technology projects, budgets, and acquisition plans were made by the Research and Technology Executive Board. Chaired by the executive director, the board's membership included all agency associate administrators, the director of the Intelligent Transportation Systems Joint Program Office, and one regional administrator. The board met

periodically to obtain information from working groups composed of representatives from across the agency, the National Highway Institute, and other DOT agencies.⁴ FHWA has recently assessed the effects of its 1998 agencywide restructuring and has drafted 13 recommendations to address the limitations of the new organization. Two of these recommendations specifically address the agency's research and technology program, identifying the need to raise its stature in FHWA. The agency has created and filled the position of assistant director for Research, Technology, and Innovation Deployment as a response to this recommendation. This new position will also be responsible for implementing recent recommendations made by the RTCC for improving FHWA's program.

FHWA Collaborates with Other DOT Offices for Research Efforts

In addition to its own research projects, FHWA collaborates with other DOT agencies to conduct research. For example, FHWA works with DOT's Research and Special Programs Administration to coordinate efforts to support key research identified in the department's strategic plan.⁵ In fiscal year 2001, FHWA and the Research and Special Programs Administration contributed an estimated \$15.2 million and \$3.5 million, respectively, for these collaborative, "intermodal" research and technology efforts. Examples of FHWA's research with other transportation modes include:

- an ongoing study with DOT's National Highway Traffic Safety Administration, through the Georgia Institute of Technology, to investigate the relationship between vehicle speed and crash risk under various demographic, environmental, and physical conditions. Funds from FHWA were spent to compare the speeds of drivers involved in crashes with the prevailing speeds of other drivers at the time and location of the crashes; and
- a study at the Center for Climate Change and Environmental Forecasting, with the collaboration of several other agencies, including DOT's Maritime

⁴The National Highway Institute is a part of the Professional Development business unit. It provides professional training to federal, state, and local highway officials.

⁵As required by Congress, DOT annually develops the departmentwide "Research, Development, and Technology Plan." This plan, drafted by the Research and Special Programs Administration and funded in part by FHWA, provides program-level detail on the directions that DOT's research will take. This plan is used by the individual operating administrations, such as FHWA and the Research and Special Programs Administration, as a resource document to develop their subsequent program proposals for inclusion in their administration budgets.

Administration, Federal Railroad Administration, and National Highway Traffic Safety Administration. This study examined the potential effects on transportation infrastructure of such climate change phenomena as rising sea levels, increasing frequency of severe weather events, and changing precipitation levels.

Other Organizations Have a Significant Role in Research and Technology Efforts

Several other entities and organizations, detailed below, conduct surface transportation research that can be related to FHWA's research and technology program. FHWA officials told us that the agency has both formal and informal means for coordination with some of these other organizations.

- Each of the 50 states, Washington, D. C., and the Commonwealth of Puerto Rico have an independent highway research program. In general, state programs address technical questions associated with the planning, design, construction, rehabilitation, and maintenance of highways. State highway research projects usually reflect local concerns. According to an official at the Transportation Research Board, 47 states indicated that they spent approximately \$322 million in 1999 on such research.⁶ State research programs are generally funded through federal funds set aside from the federal highway aid apportioned to the states. FHWA division administrators in each state approve the state's annual or biennial research program, funded by a subset of federal funds. The national association that represents state departments of transportation, the American Association of State Highway and Transportation Officials, also plays a key role in highway research. This association has a standing committee on research that develops voluntary standards and guidelines.
- The National Cooperative Highway Research Program conducts research on acute problems related to highway planning, design, construction, operation, and maintenance that are common to most states. Typically, its research projects are problem-oriented and designed to produce results that have an immediate application. As voluntary program members, state departments of transportation approve research projects and agree to provide financial support. Each member state provides an amount equal to 5.5 percent of its state planning and research funds. Program funding for fiscal year 2001 was \$30.6 million. FHWA formally coordinates with members of this program and the American Association of State Highway and Transportation Officials to review proposed projects. FHWA also

⁶These are the most recent available data.

participates in selecting projects that complement the agency's defined program, reducing duplication and leveraging limited funding.

- The private sector conducts or sponsors individual programs. Private organizations include companies that design and construct highways and supply highway-related products, national associations of industry components, and engineering associations active in construction and highway transportation. Funding information for private-sector highway research is generally proprietary in nature, although an official of the Transportation Research Board estimated that the total funding for this research ranged from \$75 million to \$150 million annually.
- Universities receive funding for research on surface transportation from FHWA, the states, and the private sector. For example, since 1988 DOT has awarded grants under its University Transportation Center program to universities throughout the nation to support education, research, and technology deployment.⁷ Each grantee is called a University Transportation Center, whether working alone or as the lead of a consortium of universities. Some have formed centers for research, education, and training in specialty areas related to highway transportation. Thirty-three centers currently exist; they were either selected competitively or specified in legislation. The Office of Innovation, Research, and Education within the department's Research and Special Programs Administration manages the program; funding provided for the 33 centers in fiscal year 2001 from FHWA's research and technology program amounted to \$23.9 million.

FHWA Processes for Developing Research Agendas and Evaluating Research Outcomes Do Not Always Follow Best Practices for Federal Research Programs

Leading organizations that conduct scientific and engineering research, other federal agencies with research programs, and experts in research and technology have identified and use best practices for developing research agendas and evaluating research outcomes. Although the uncertain nature of research outcomes over time makes it difficult to set specific, measurable program goals and evaluate results, the best practices we identified are designed to ensure that the research objectives are related to the areas of greatest interest and concern to research users and that research is evaluated according to these objectives. These practices include:

⁷The University Transportation Centers were created to advance U.S. technology and expertise in many disciplines related to transportation through education, research, and technology transfer programs at university-level centers.

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- *Developing research agendas through the involvement of external stakeholders:* External stakeholder involvement and merit review are particularly important for FHWA because its research is expected to improve the construction, safety, and operation of transportation systems that are primarily managed by others, such as state departments of transportation. According to RTCC, research has to be closely connected to its stakeholders to help ensure relevance and program support, and stakeholders are more likely to promote the use of research results if they are involved in the research process from the start.⁸ The committee also identified merit review of research proposals based on technical criteria by independent technical experts as being necessary to help ensure the most effective use of federal research funds. In 1999, we reported that other federal science agencies—such as the Environmental Protection Agency and the National Science Foundation—used such reviews to varying degrees to assess the merits of competitive and noncompetitive research proposals.⁹
 - *Evaluation of research using expert review of the quality of research outcomes or other best practices:* A form of expert review called peer review is a process that includes an independent assessment of the technical and scientific merit or quality of research by peers with essential subject area expertise and perspective equal to that of the researchers. Peer review does not require that the final impact of the research be known. In 1999, we reported that federal agencies, such as the Department of Agriculture, the National Institutes of Health, and the Department of Energy, use peer review to help them (1) determine whether to continue or renew research projects, (2) evaluate the results of research prior to publication of those results, and (3) evaluate the performance of programs and scientists.¹⁰ In its 1999 report, the Committee on Science, Engineering,

⁸Transportation Research Board, *The Federal Role in Highway Research and Technology* (Washington, D.C.: National Academy Press, 2001), p. 76. For surface transportation research, potential stakeholders include state and local highway agencies that own and operate the nation's highways; highway users; the companies that furnish the products, services, and equipment needed to build, operate, and maintain the highway system; and the people and communities that benefit from and are affected by the system.

⁹*Federal Research: Peer Review Practices at Federal Science Agencies Vary* (GAO/RCED-99-99, Mar. 1999), p. 2.

¹⁰GAO/RCED-99-99.

and Public Policy¹¹ also stated that expert review is widely used to evaluate three aspects of the Government Performance and Results Act:¹² (1) the quality of current research as compared with other work being conducted in the field, (2) the relevance of research to the agency's goals and mission, and (3) whether the research is at the "cutting edge."

External Stakeholders' Involvement in Developing the Program's Research Agendas Has Been Limited

Although FHWA engages external stakeholders in elements of its research and technology program, the agency currently does not follow the best practice of engaging external stakeholders on a sustained basis. The agency expects each business unit to determine how or whether to involve external stakeholders in the research process. As a result, this approach is used inconsistently. Prior to its 1998 restructuring, FHWA worked with some external stakeholders to initiate "roadmapping" activities for each of its key research areas that would have resulted in research agendas for these areas.¹³ To prepare individual roadmaps, the agency's working groups collaborated across agency office boundaries and with members of the RTCC. However, before the roadmapping had been completed for all research areas, FHWA changed its approach to managing research because of the agency's reorganization, and RTCC's involvement with roadmapping ceased.

FHWA acknowledges that its approach to preparing research agendas is inconsistent and that the directors of FHWA's business units primarily use input from the agency's business units, resource centers, and division offices. Although agency officials told us that resource center and division office staff provide the business unit directors with input based on their interactions with external stakeholders, external stakeholder input into

¹¹Committee on Science, Engineering, and Public Policy, *Evaluating Federal Research Programs: Research and the Government Performance and Results Act* (Washington, D.C.: Feb. 1999), p. 39. The Committee on Science, Engineering, and Public Policy is a joint committee of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

¹²The 1993 Government Performance and Results Act requires federal agencies to set strategic goals and establish performance measures for management.

¹³The Transportation Research Board's RTCC has recognized roadmapping as an important tool for research and technology priority setting and programming. Roadmapping is a "reverse engineering" process in which specific, desired research and technology outcomes are identified and the means to accomplish these outcomes are determined. This "backward planning" process was designed to enable FHWA to define how funds are used and to better understand its research and technology priorities and responsibilities.

developing research agendas is usually ad hoc, provided through technical committees and professional societies. For example, the agency's agenda for environmental research was developed with input from both internal sources (including DOT's and FHWA's strategic plans and staff) and external sources (including the Transportation Research Board's reports on environmental research needs and clean air, environmental justice leaders, planners, civil rights advocates, and legal experts). Similarly, the agency uses external stakeholders to provide merit review of research projects on an ad hoc basis. For example, to prepare its "Conditions and Performance Report", the Policy business unit used a peer review group to provide input into the Highway Economic Requirements System (an economic model that uses marginal cost-benefit analysis to optimize highway investment).

FHWA acknowledges that the agency lacks a consistent, transparent, and systematic approach for engaging stakeholders in setting research agendas. However, FHWA has recently taken several steps to increase the involvement of external stakeholders in developing research agendas. First, FHWA's work with RTCC has resulted in the agency's obtaining occasional external guidance for its overall program since 1991. The committee points out, however, that it cannot provide broad-based input from stakeholders on the full range of potential highway research topics or specific projects on a continuing basis because its membership is not representative of all the disciplines included in FHWA's research and technology program.¹⁴ In its 2001 report, the committee recommended that decisions about FHWA research topics should balance stakeholders' concerns against experts' external reviews and recommendations as to which research areas hold promise for significant breakthroughs. According to the draft response to the recommendation, FHWA plans to develop such a process by June 30, 2002. In addition, in 1998, FHWA helped organize a National Highway Research and Technology Partnership Forum to identify national highway research and technology needs using input from external stakeholders.¹⁵ Although the forum identified research

¹⁴Transportation Research Board, *The Federal Role in Highway Research and Technology* (Washington, D.C.: National Academy Press, 2001), p. 83.

¹⁵The National Highway Research and Technology Partnership Forum was initiated in 1998 by FHWA, the American Association of State Highway and Transportation Officials, and the Transportation Research Board. Its purpose is to better coordinate investments among highway research and technology programs in a manner that involves the diverse array of highway transportation stakeholders. The forum has no official standing and relies entirely on volunteer participation. Hundreds of individuals and more than 160 organizations have participated in this initiative.

needs and priorities for FHWA's consideration in its draft report of August 2001, its long-term role remains to be seen.

FHWA officials told us that their ability to develop their research agendas using best practices is also affected by funding designations contained in statutes and committee reports. These designations take a variety of forms, including requiring FHWA to initiate or maintain specific research efforts and specifying dollar amounts for particular recipients. According to agency officials, the designations made by the Transportation Equity Act for the 21st Century and conference reports accompanying recent appropriations acts have represented significant proportions of the agency's research budget. Using agency data, we calculated that 44 percent of authorized surface transportation research and technology deployment funds in fiscal year 2000, 48 percent in fiscal year 2001, and 44 percent in fiscal year 2002 were designated (see app. I, tables 4, 5, and 6).¹⁶ Agency officials acknowledged that these funding designations reflect congressional interests and priorities but also stated that without these designations, FHWA would have an enhanced opportunity to consistently plan its research agendas and select researchers for its projects according to accepted best practices.

FHWA Lacks a Systematic Process to Evaluate Research Outcomes

In 1999, the Committee on Science, Engineering, and Public Policy reported that federal agencies that support research in science and engineering have been challenged to find the most useful and effective ways to evaluate the performance and results of the research programs they support. However, the committee found that research programs, no matter what their character and goals, can be evaluated meaningfully on a regular basis and in accordance with the Government Performance and Results Act. The committee emphasized that the evaluation methods must match the type of research and its objectives, and it concluded that expert or peer review is a particularly effective means to evaluate federally funded research. The peer review process includes an independent assessment of the technical and scientific merits of research by those with knowledge and expertise equal to that of the researchers whose work they review.

¹⁶If calculated based upon available funds subject to obligation limitations, the percentages would be significantly higher.

According to FHWA officials, the agency does not have an agencywide systematic process to evaluate whether its research projects are achieving intended results and does not generally use a peer review approach. Although the agency's business units may use such various methods as obtaining feedback from customers and evaluating outputs or outcomes versus milestones, they all use success stories as the primary method to evaluate research outcomes. According to agency officials, success stories are examples of research results adopted or implemented by such stakeholders as state departments of transportation. Although agency officials told us that peer reviews are useful to assess research quality, relevance, and technical breakthroughs, success stories can document the financial returns on investment and nonmonetary benefits of research and technology efforts. FHWA officials provided us with the following examples of success stories:

- Research conducted by the Infrastructure business unit produced a specification guide on how to mitigate earthquake damage to structures. The guide was adopted by the American Association of State Highway Transportation Officials for inclusion in its guidance to state departments of transportation.
- The operations research and technology group developed the *511* traveler telephone number that replaced 300 different traveler information telephone numbers nationwide. This single, three-digit number is currently being used in the states of Utah and Nebraska and in parts of Virginia, Kentucky, and Ohio to provide motorists with timely local travel information to help relieve traffic congestion.
- To respond to one of FHWA's priority safety emphases, the safety research and technology group developed rumble strips to warn drivers who are driving their vehicles off the road.¹⁷ According to agency officials, in the eight states surveyed that have used rumble strips, crash reduction has ranged from 18 to 72 percent, and the cost-benefit ratio has ranged from 30:1 to as high as 60:1.
- Research on long-term pavement performance is significantly improving the pavement-engineering process nationwide. Engineers are using a software tool known as a long-term pavement performance bind to more accurately determine the asphalt binder grade needed for specific environmental conditions. This software tool has helped highway agencies

¹⁷Rumble strips are milled or rolled-in grooves on a road's shoulder that create a noise and slight vibration felt by the driver when a vehicle leaves the roadway.

to save at least \$50 million each year by reducing the application of unnecessary substances that increase the costs of highway construction.

In 2001, RTCC also concluded that peer or expert review is an appropriate way to evaluate FHWA's surface transportation research and technology program.¹⁸ Therefore, the committee recommended a variety of actions, including a systematic evaluation of outcomes by panels of external stakeholders and technical experts to help ensure the maximum return on investment in research. Agency officials told us that increased stakeholder involvement and peer review will require significant additional expenditures for the program. However, a Transportation Research Board official told us that the cost of obtaining expert assistance could be relatively low because the time needed to provide input would be minimal and could be provided by such inexpensive methods as electronic mail. As a partial response to RTCC's recommendation, FHWA has established a laboratory assessment process that will be used to conduct regular reviews of the Turner-Fairbank Highway Research Center. These reviews will be conducted by panels of external technical experts and will include such issues as technical excellence and quality of lab activities. FHWA's draft response to this recommendation indicates that it plans to initiate an evaluation process by June 30, 2002.

Conclusions

With millions of dollars for its research, FHWA's research and technology program has the potential to significantly improve the nation's highway system. FHWA has described several success stories to us but, because its decisions about selecting research and identifying priorities are uneven in the extent to which they use best practices such as seeking external input, it is unclear whether the agency is selecting the most important and relevant research. In addition, because FHWA does not systematically evaluate its research and technology program, it is unclear whether the research is having the intended results or whether some refocusing of the research would be justified. Therefore, we agree with several of the recent recommendations from the Transportation Research Board's Research and Technology Coordinating Committee, which were designed to remedy these limitations of FHWA's program. In its draft response to these recommendations, FHWA has indicated that it will take action on most of them. The cost of making such improvements in FHWA's research and

¹⁸Transportation Research Board, *The Federal Role in Highway Research and Technology*, p. 88.

technology program is unknown and will influence the extent to which FHWA can adopt certain best practices. Because Congress has been concerned about the strategic focus of FHWA's research and technology program and will soon have to make decisions about the nature of the program and the level of resources to devote to it, information generated by FHWA's potentially improved processes for developing research agendas and evaluating research outcomes, as well as information about the cost of such changes, will also be useful to Congress.

Recommendations for Executive Action

To help ensure that FHWA's research agenda and approach to evaluation are identifying research with the highest value to the surface transportation community and monitoring the outcomes of that research, we are recommending that the secretary of transportation direct the FHWA administrator to

- develop a systematic approach for obtaining input from external stakeholders in determining the research and technology program's agendas;
- develop a systematic process for evaluating significant ongoing and completed research that incorporates peer review or other best practices in use at federal agencies that conduct research; and
- develop specific plans for implementing these recommendations, including time frames and estimates of their cost.

Agency Comments and Our Evaluation

We obtained oral comments on a draft of this report from FHWA officials, including the director of Research, Development, and Technology and the director of the Office of Program Development and Evaluation. These officials indicated that they were pleased that the draft report had recognized some of the FHWA research and technology program's accomplishments to date, along with its potential to significantly improve the nation's highway system. They also indicated general agreement with the draft report's overall assessment of the program and the draft report's recommendations.

The FHWA officials told us that they have been working with both internal and external groups to assess the processes used to plan the research and technology program and to evaluate its results. These officials maintain that the program is essentially sound and pursues worthy research in an effective manner with key program stakeholders. Nonetheless, the agency officials agreed that improvements are possible in the methods used to select research and technology projects and to evaluate program results.

They told us that FHWA had recently taken steps to make research a higher priority for the agency by investing in research to meet stakeholders' needs, improving delivery of innovations to potential users, and improving business processes in the research and technology program. As a result of a major restructuring assessment, FHWA officials told us that the agency has also committed to making research and technology more prominent as a strategy for achieving FHWA's mission. With regard to project planning and selection, FHWA officials explained that they are examining ways to improve existing methods for incorporating stakeholder input and seeking means to further ensure that stakeholder perspectives are fully and effectively considered. Finally, with regard to evaluating program results, FHWA officials told us that although there are merits to current methods, more extensive and consistent use of best practices such as peer review could benefit the program.

We acknowledge that FHWA recently has planned or put into place several initiatives designed to improve its research and technology program, and we describe these actions in this report. Nevertheless, we continue to believe that additional actions in response to our recommendations are warranted to improve FHWA's processes for setting research agendas and evaluating research efforts.

We are sending copies of this report to congressional committees and subcommittees with responsibilities for transportation, the secretary of transportation, the Federal Highway Administration administrator, and the director of the Office of Management and Budget. We will make copies available to others upon request.

If you or your staff have any questions about this report, please call me at (202) 512-2834. Key contributors to this report were Sharon Dyer, Sally Gilley, Octavia Parks, Deena Richart, and Kate Siggerud.

A handwritten signature in black ink, reading "JayEtta Z. Hecker". The signature is fluid and cursive, with the first name "JayEtta" and last name "Hecker" clearly legible, and a middle initial "Z." in between.

JayEtta Z. Hecker
Director, Physical Infrastructure Team

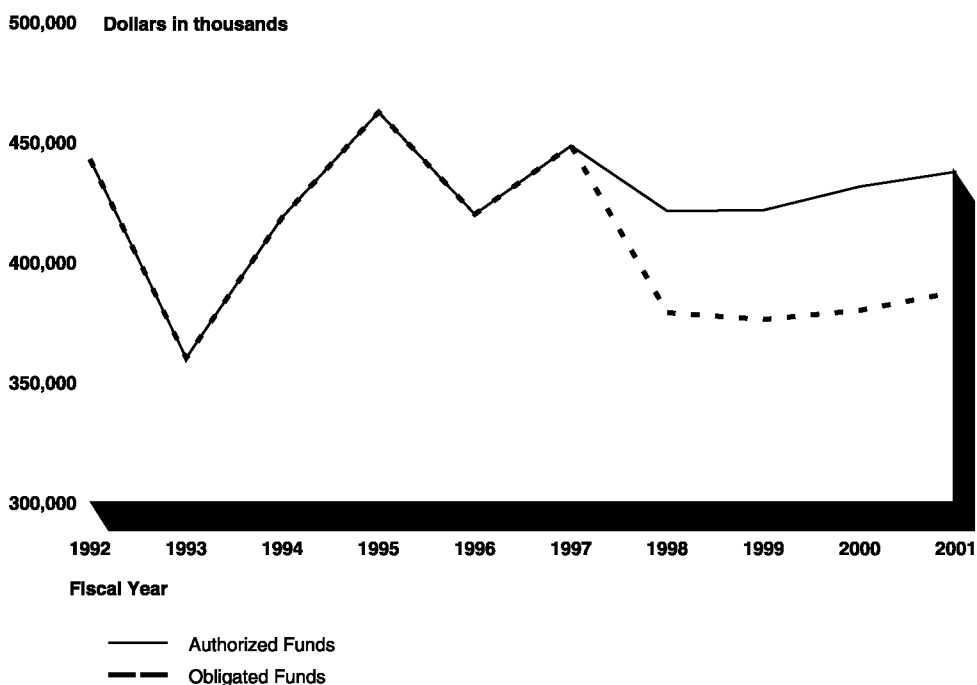
Appendix I: Funding Information for FHWA's Research and Technology Program

In fiscal year 1992 (the first year in which FHWA's research and technology program was authorized under the Intermodal Surface Transportation Efficiency Act of 1991), authorized funding for the entire program increased almost fivefold, from approximately \$88.6 million in fiscal year 1991 to \$442.4 million.¹⁹ Since that time, authorized funding for FHWA's research and technology program has remained relatively flat; from fiscal year 1992 through fiscal year 2001, authorized funding for the program went from \$442.4 million to \$437.3 million. However, since fiscal year 1998 these authorized funds have been subject to an obligation limitation that has reduced amounts available for research purposes an average of about 11 percent a year below authorized funding levels (see fig. 2).²⁰

¹⁹The dollar amounts in this section, unless otherwise noted, are adjusted to 2001 dollars.

²⁰A limitation on obligations acts as a ceiling on the obligations of authorized funds that can be made within a specified time period, usually a fiscal year. Congress relies on limitations on obligations to control program spending and to make it more responsive to prevailing budget and economic policy. Limitations on obligations are included in the annual appropriations act for DOT.

Figure 2: Federal Highway Administration's Funding for Research and Technology Program, Fiscal Years 1992–2001



Notes:

Research funds were not subject to a specific obligation limitation from fiscal years 1992 through 1997. Funds were then subjected to the following obligation limitations: 89.1 percent in fiscal year 1998; 88.3 percent in fiscal year 1999; 87.1 percent in fiscal year 2000; and 87.9 percent in fiscal year 2001. Fiscal year 2001 funds were also reduced by a 0.22 percent rescission required by P.L. 106-554. Dollar amounts are adjusted to 2001 dollars.

This figure includes all categories of funding under research and technology provided to FHWA.

Source: GAO presentation of data from FHWA.

The areas of research funded from fiscal years 1992 through 2001 have varied based on authorizing legislation. From fiscal year 1992 through fiscal year 1997, the majority of FHWA's entire surface transportation research and technology funding went to support the Intelligent Vehicle

Highway Systems program.²¹ The remainder of funds primarily supported the agency's highway research, development, and technology program and applied research and technology program. Since fiscal year 1998, the majority of the agency's research and technology program funds have continued to support the intelligent transportation systems program as well as the surface transportation research program. (See tables 2 and 3 for funding allocations by program area for fiscal years 1992 through 2001.)

Table 2: Research and Technology Program Allocations by Program Area, Fiscal Years 1992–1997

(Dollars in thousands)						
Program area	1992	1993	1994	1995	1996	1997
Highway research development and technology						
Safety	\$6,492	\$8,862	\$5,738	\$7,768	\$8,335	\$8,650
Materials	3,375	5,923	3,685	5,451	0	0
Pavements	4,186	7,278	7,259	7,476	8,791	9,731
Structure	4,187	6,203	4,860	6,311	12,558	14,362
Environment	2,654	4,873	4,080	5,593	5,317	5,443
Right-of-way	487	487	320	429	408	322
Policy	6,072	7,797	6,689	6,681	5,401	5,328
Planning	1,047	2,437	4,369	6,069	5,769	5,889
Motor Carrier	0	4,183	5,345	7,774	7,390	7,399
Long Term Pavement Performance	0	0	0	0	0	10,000
Subtotal	\$28,500	\$48,043	\$42,525	\$53,552	\$53,969	\$67,124
Intelligent Vehicle Highway Systems						
Research and development	\$0	\$17,500	\$28,000	\$35,000	\$49,916	\$28,605
IVHS operational tests	0	0	15,000	22,500	31,052	54,992
Commercial vehicle operations	1,550	0	10,000	10,700	0	0
Automated highway system	0	0	10,000	10,000	0	0
Advance technology applications	0	0	15,000	15,000	0	0
IVHS program & system support	5,750	12,500	12,300	11,300	10,034	7,761
Institutional issues program	1,500	0	0	0	0	0
Deployment program	2,700	0	0	0	0	0
Advanced traffic management system and advanced traveler information system	16,025	0	0	0	0	0

²¹The Intermodal Surface Transportation Efficiency Act of 1991 established the Intelligent Vehicle Highway Systems Program—later renamed the Intelligent Transportation Systems Program—prescribing the “widespread implementation of intelligent transportation systems to enhance the capacity, efficiency, and safety of the federal-aid highway system and to serve as an alternative to additional physical capacity of the federal-aid highway system.”

**Appendix I: Funding Information for FHWA's
Research and Technology Program**

(Dollars in thousands)						
Program area	1992	1993	1994	1995	1996	1997
Advanced vehicle control system	2,275	0	0	0	0	0
Priority corridors	0	0	0	10,000	0	0
AHS/Advanced crash avoidance	0	0	0	0	14,000	22,000
Evaluations	0	0	0	0	0	2,000
Architecture and standards	0	0	0	0	0	5,000
Other IVHS activities	110,000	0	0	0	0	0
Subtotal	\$139,800	\$30,000	\$90,300	\$114,500	\$105,002	\$120,358
Long-term pavement performance	\$10,000	\$6,000	\$7,000	\$8,739	\$8,308	\$0
Technology assessment & deployment	8,000	8,000	12,000	12,622	12,499	13,811
Local rural technology assistance	3,750	4,000	500	3,015	2,866	2,827
National Highway Institute	3,000	4,500	4,500	4,369	4,327	4,269
Multimodal studies	4,000	3,000	0	0	0	0
Minority/disadvantaged business enterprise	8,000	8,000	10,000	10,000	9,506	9,378
Highway inventory and user cost	0	750	0	0	0	0
Highway use tax evasion project	1,000	0	0	0	0	0
International transportation	100	250	400	500	475	475
Feasibility, design, environmental studies	650	0	0	0	0	0
On-the-job training, skill training	0	0	0	5,000	0	0
Russia technical assistance	0	0	0	400	380	200
Truck dynamic test facility	0	0	0	0	713	0
Cost allocation study	0	0	0	0	1,901	300
Transportation investment analysis	0	0	0	0	0	250
Federal lands contamination site cleanup	0	0	0	0	0	2,466
Rehabilitation of Turner-Fairbank	0	1,940	1,250	3,000	0	500
Subtotal all programs	\$206,800	\$114,483	\$168,475	\$215,697	\$199,946	\$221,958
Direct contract authority programs^a						
Intelligent transportation systems	\$94,000	\$113,000	\$113,000	\$113,000	\$97,910	\$113,000
Local technical assistance program	6,000	6,000	6,000	6,000	6,000	6,000
University transportation centers	5,000	6,000	6,000	6,000	6,000	6,000
University research institute	6,250	6,250	6,250	6,250	6,250	6,250
Strategic highway research program implementation	12,000	16,000	20,000	20,000	20,000	20,000
Eisenhower transportation fellowship program	2,000	2,000	2,000	2,000	2,000	2,000
Applied research and technology	35,000	41,000	41,000	41,000	41,000	41,000
Seismic research and development program	2,000	2,000	2,000	2,000	2,000	2,000
Fundamental properties of asphalts	3,000	3,000	3,000	3,000	3,000	N/A
Subtotal direct contract authority	\$165,250	\$195,250	\$199,250	\$199,250	\$184,160	\$196,250
Total	\$372,050	\$309,733	\$367,725	\$414,947	\$384,106	\$418,208

^aFunding consisted of direct contract authority provided in authorizing legislation. All other funding in this table was provided from amounts available for FHWA's general operating expenses. Funds were obligated at 100 percent.

Note: All dollar amounts in this table represent nominal dollars and have not been adjusted for inflation.

Source: GAO presentation of data from FHWA.

**Appendix I: Funding Information for FHWA's
Research and Technology Program**

Table 3: Research and Technology Program Allocations by Program Area, Fiscal Years 1998–2001

(Dollars in thousands)

Program area	1998	1999	2000	2001
Surface transportation research				
Safety	\$6,861	\$11,068	\$12,368	\$13,156
Pavements	9,243	11,611	11,367	13,156
Structure	8,447	14,216	13,065	13,156
Environment	2,971	4,680	5,400	5,438
Policy	4,123	4,768	3,484	4,034
Planning and real estate services	5,856	3,854	3,484	3,596
Motor carrier	5,572	5,651	5,574	0
Technical assessment and deployment	10,163	12,362	12,194	12,279
Research & technology technical support	8,711	6,623	6,533	6,578
Long-term pavement performance	10,000	8,830	8,710	8,771
Advanced research	0	883	784	789
International outreach	889	442	436	438
National advanced driver simulator	11,806	0	0	0
Highway operations/asset management	894	0	0	4,561
Highway operations	0	662	653	0
Freight research and development	0	0	436	0
Revenue-aligned budget authority	0	0	0	0
Subtotal	\$85,536	\$65,650	\$84,488	\$85,952
Technology deployment program				
Tech. deployment program	\$31,182	\$30,905	\$34,840	\$39,468
Revenue aligned budget authority	0	0	0	0
Subtotal	\$31,182	\$30,905	\$34,840	\$39,468
Intelligent transportation systems				
Research and development	\$40,429	\$33,554	\$41,329	\$40,784
Operational tests	6,580	15,011	5,792	10,367
Evaluation/program assessment	6,000	5,740	6,097	6,797
Architecture and standards	10,662	15,894	14,284	12,060
Integration	10,837	5,298	10,191	9,718
Program support	8,654	8,389	7,839	7,981
Deployment incentives	1,483	0	0	0
ITS deployment	89,991	92,715	98,423	103,494
Revenue-aligned budget authority-ITS research	0	0	0	0
Revenue-aligned budget authority-ITS deployment	0	0	0	0
Subtotal	\$174,636	\$176,601	\$183,955	\$191,201
Training and education				
Local rural technology assistance	\$6,237	\$6,181	\$6,968	\$7,894
National Highway Institute	4,455	5,298	5,226	6,139
Eisenhower fellowship program	1,782	1,766	1,742	1,754
Revenue-aligned budget authority	0	0	0	0
Subtotal	\$12,474	\$13,245	\$13,936	\$15,787

**Appendix I: Funding Information for FHWA's
Research and Technology Program**

(Dollars in thousands)				
Program area	1998	1999	2000	2001
Bureau of Transportation Statistics				
Bureau of Transportation Statistics	\$31,000	\$31,000	\$31,000	\$30,932
Revenue-aligned budget authority	0	0	0	0
Subtotal	\$31,000	\$31,000	\$31,000	\$30,932
University transportation centers				
University transportation centers	\$22,854	\$22,649	\$23,735	\$23,900
Revenue-aligned budget authority	0	0	0	0
Subtotal	\$22,854	\$22,649	\$23,735	\$23,900
Total	\$357,685	\$360,050	\$371,954	\$387,240

Notes: Funds were subjected to the following obligation limitations: 89.1 percent in fiscal year 1998; 88.3 percent in fiscal year 1999; 87.1 percent in fiscal year 2000; and 87.9 percent in fiscal year 2001. Fiscal year 2001 funds were also reduced by a 0.22 percent rescission required by P.L. 106-554.

All dollar amounts in this table represent nominal dollars and have not been adjusted for inflation.

Source: GAO presentation of data from FHWA.

These funds were subject to designations in statutes and committee reports, with the Infrastructure business unit being the most affected (see tables 4, 5, and 6 for designations by business unit for fiscal years 2000 through 2002). In fiscal year 2002, approximately 80 percent of the surface transportation research and technology deployment funds provided to the Infrastructure business unit were designated.

**Appendix I: Funding Information for FHWA's
Research and Technology Program**

Table 4: Surface Transportation Research and Technology Deployment Funds, Designations in Statutes and Committee Reports, Fiscal Year 2000

(Dollars in thousands)

Business unit	Surface Transportation Research funds designated in authorizing legislation^a	Technology Deployment funds designated in authorizing legislation^a	Technology Deployment funds designated in appropriations act conference report	Surface Transportation Research funds designated in appropriations act conference report	Total designations	Designations as percentage of available Surface Transportation Research and Technology Deployment funds
Infrastructure	\$20,251	\$17,420	\$500	\$4,425	\$42,596	81.3%
Planning and Environment	975	5,575	0	2,475	9,025	59.5
Operations	0	2,932	1,000	0	3,932	42.2
Safety	0	4,050	0	50	4,100	26.6
Agencywide	436	0	0	0	436	3.0

^aTransportation Equity Act for the 21st Century.

Notes: Obligation limitation of 87.1 percent applied to amounts designated in authorizing legislation; designations of "up to" amounts in reports funded at 50 percent.

All dollar amounts in this table represent nominal dollars and have not been adjusted for inflation.

Source: GAO presentation of data from FHWA.

Table 5: Surface Transportation Research and Technology Deployment Funds, Designations in Statutes and Committee Reports, Fiscal Year 2001

(Dollars in thousands)

Business unit	Surface Transportation Research funds designated in authorizing legislation^a	Technology Deployment funds designated in authorizing legislation^a	Surface Transportation Research funds designated in appropriations act conference report	Technology Deployment funds designated in appropriations act conference report	Total	Designations as percentage of available Surface Transportation Research and Technology Deployment funds
Infrastructure	\$19,778	\$19,778	\$10,100	\$0	\$49,656	85.1%
Planning and Environment	176	5,626	1,500	0	7,302	42.7
Operations	0	2,959	720	800	4,479	44.4
Safety	0	3,472	2,720	0	6,192	34.5
Agencywide	440	0	0	0	440	3.2

^aTransportation Equity Act for the 21st Century.

Notes: Obligation limitation of 87.9 percent applied to amounts designated in authorizing legislation; designations of "up to" amounts in reports funded at 40 percent.

All dollar amounts in this table represent nominal dollars and have not been adjusted for inflation.

Source: GAO presentation of data from FHWA.

**Appendix I: Funding Information for FHWA's
Research and Technology Program**

Table 6: Surface Transportation Research and Technology Deployment Funds, Designations in Statutes and Committee Reports, Fiscal Year 2002

(Dollars in thousands)

Business unit	Surface Transportation Research funds designated in authorizing legislation^a	Technology Deployment funds designated in authorizing legislation^a	Appropriations act conference action	Total	Designations as percentage of available Surface Transportation Research and Technology Deployment funds
Infrastructure	\$20,340	\$19,436	\$5,108	\$44,884	80.4%
Planning and Environment	181	5,786	2,034	8,001	39.7
Operations	0	3,044	904	3,948	31.0
Safety	0	3,571	1,175	4,746	27.5
Policy	0	0	1,808	1,808	24.0
Agencywide	452	0	542	994	6.3

^aTransportation Equity Act for the 21st Century.

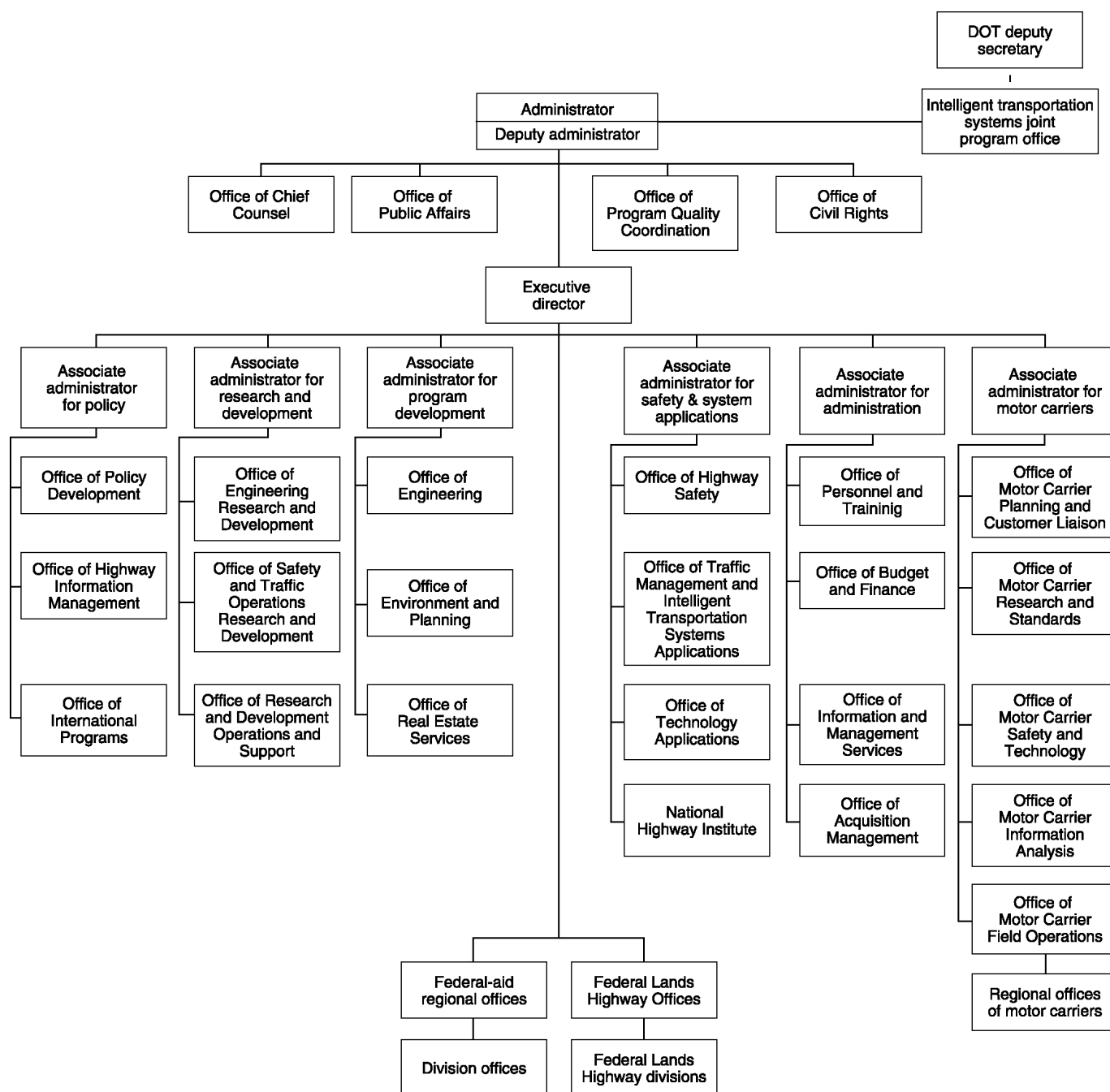
Notes: Obligation limitation of 90.4 percent applied to all designations.

All dollar amounts in this table represent nominal dollars and have not been adjusted for inflation.

Source: GAO presentation of data from FHWA.

Appendix II: Federal Highway Administration Organization Charts

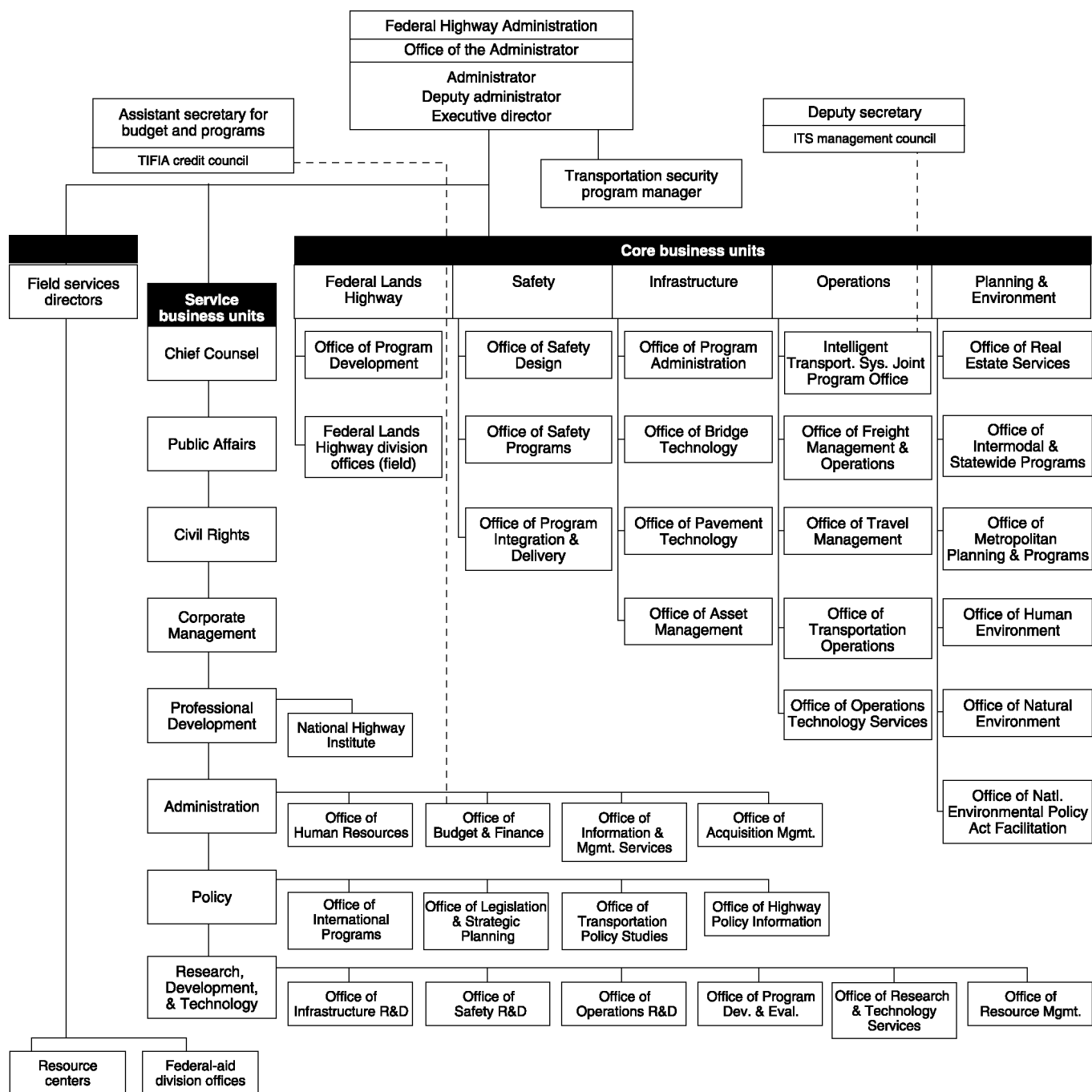
Figure 3: FHWA's Organization Chart before 1998 Restructuring



Source: GAO presentation of information from FHWA.

Appendix II: Federal Highway Administration
Organization Charts

Figure 4: FHWA's Organization Chart after 1998 Restructuring



Source: GAO presentation of information from FHWA.

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