

NEW DIRECTIONS FOR HIGHWAY RESEARCH IN THE UNITED STATES

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ABSTRACT

Research does not receive the attention or support in the highway field that it does in other sectors. Nonetheless, U.S. highway research—a collection of loosely connected, relatively independent programs—has produced innovations that have improved virtually every aspect of highway transportation. The role of the federal government has been and continues to be crucial, affecting not only federal research but also research undertaken or sponsored by state departments of transportation and many universities. Before federal highway programs were reauthorized by the U.S. Congress in 2005, Transportation Research Board committees recommended a number of changes to federal highway research programs, including greater focus on long-term research, a new strategic highway research program, a new environmental research program, and a reduction in congressional earmarks and designations. With respect to these recommendations the results were mixed. The federal program now has a larger budget and includes several of the recommended initiatives. The scale and operational details of the programs are at variance with the recommendations in some respects, and the levels of congressional earmarks and designations increased.

1. INTRODUCTION

The U.S. highway system faces many challenges--challenges that cannot be successfully addressed without new knowledge and innovations of all sorts. For example, how can state and local highway agencies and their contractors reconstruct heavily used urban freeways while maintaining service and minimizing traveler delays and community disruption? Can the application of “intelligent” information and communication technologies reduce motor vehicle crashes, squeeze additional capacity out of existing highways, and improve the reliability of motor vehicle travel? How do roadways affect the natural environment and what can be done to mitigate their impacts? Can we develop affordable materials that will significantly extend the lives of highway pavements and bridges?

As users of highway systems and residents of communities affected by highways, most of us can identify with questions like these, or at least their premises. No wonder—in the United States, the highway system handles more than 90 percent of all trips to and from work, more than 90 percent of inter-city person trips over 50 miles, and about 70 percent of freight traffic, based on billings [1, 2, 3]. Clearly the United States is heavily dependent—too dependent in the view of many—on its highway system; but like it or not, the nation will continue to depend on its highway system for decades to come.

Consequently, questions such as those posed at the outset are relevant today and will continue to be relevant for years to come. Answering them requires research¹—research

¹ Throughout the paper, “research” includes research, development, and technology transfer activities. This generally conforms to “research, development, and technology” as used by the Federal Highway Administration. Training activities are excluded except when they are linked directly to research. Deployment is also excluded.

that expands our knowledge about highways, their performance, and their impacts. The stakes are significant because highways are closely linked to economic development, public health, environmental quality, and life style, as well as being a substantial public expense.

Unfortunately, research does not receive the attention or support in the highway field that it does in other sectors, at least not in the United States. Several factors contribute to this situation.

- **Low-tech image:** The familiarity of the highway system and its use of materials and technologies whose origins can be traced to antiquity contribute to the image that there is nothing left to learn about highway technology and that today's challenges are no different than ones the industry has faced before.
- **Decentralized enterprise:** Roughly 35,000 governmental units operate highways in the United States, and tens of thousands of private companies provide materials and services. Most of these organizations do not have the wherewithal to support research on their own, and the sheer numbers involved make it difficult to transfer innovations into practice, even when the benefits are proven and substantial.
- **Few incentives to innovate:** The prevalence of highly prescriptive design specifications and low-bid procurement practices throughout the United States provides little incentive for private-sector contractors and material suppliers to conduct research on their own and offer innovative products. On the public side, there are no market or competitive factors to push innovation, even though the agencies and the public they serve would be the beneficiaries.
- **Hard-to-measure benefits:** Miracle cures for problems like traffic congestion and motor vehicle crashes are unlikely. Progress is more often made through a combination of incremental improvements, making it difficult to attribute the benefits to a particular research project or research investment. Moreover, the benefits come in multiple forms, some of which can be measured (e.g., out-of-pocket cost savings, reduced fatalities and injuries) while others cannot (e.g., improved aesthetics).

All this translates to highway research spending that does not match the investment levels of other industries. U.S. research spending for highways, including technology transfer and other activities that promote innovation in the field, public and private, amounted to less than 0.7 percent of total highway expenditures by U.S. highway agencies in 2001 [4]. Emerging industries (e.g., information and electronics, medical substances and devices) spend 7 percent or more of their net sales on research, and even relatively mature industries (basic industries and materials, machinery, and chemicals) devote 1-3 percent of their net sales to research.

2. OVERVIEW OF HIGHWAY RESEARCH PROGRAMS

Despite the modest investment in highway research, there have been many research success stories. Examples include: roadside barrier and crash cushion designs that have saved lives and avoided serious injuries, computer-managed traffic signal systems that reduce delays and air pollutant emissions, paving materials that last longer and reduce life-cycle costs, early treatment strategies that mitigate the effects of snow and ice, data that have monitored changes in travel behavior, and models that forecast how changes to the highway and transit systems would affect travel. The reality is that virtually every aspect of

highway planning, design, operation, and construction has improved over the past 40 years as a steady stream of innovations have been introduced. But as noted earlier, these improvements have been largely incremental, with few dramatic innovations that would be obvious to the public. Indeed, during this period demands on the nation's highway system have significantly outpaced capacity growth—between 1980 and 2005, vehicle-miles of travel on the system increased by 96 percent while system lane-mile increased by just six percent [5,6]. As a result, although the system is far safer and more efficient in many respects, the traveling public often experiences more congested roads that do not deliver the service they expect or have had in the past.

To produce innovations, the nation relies on a decentralized highway research “program,” which is really a collection of loosely connected, relatively independent programs and activities that lack strong overall management. The available resources for highway research are spread among many organizations including state and federal laboratories, universities, consultants, and other research organizations. It is tempting to conclude that these resources would be used more effectively if they were much more concentrated and under the direct management of a strong national research entity. That would be a mistake.

Although there is much room for improvement in the way highway research is organized and conducted, a decentralized research program that directly involves operating agencies and other stakeholders is crucial to keeping the program relevant and improving the chances that promising products and techniques move from the laboratory into practice. As long as the ownership, management, and operation of the highway system are decentralized, a compelling case will exist for keeping research relatively decentralized as well.

With that said, the federal government is clearly the most important single participant in highway research in the United States. It has played multiple roles over the past 80 years, and without its involvement and leadership, there would be many fewer success stories to look back upon.

- Support for state research programs—Congress encouraged and later required state departments of transportation to spend a fraction of their highway federal-aid dollars for research. Currently, at least one-half percent must be spent on research. With these funds, states sponsor in-house research and other innovation-related activities, contract research with universities, and cooperative research with other states. In addition, the states voluntarily pool funds for the National Cooperative Highway Research Program (NCHRP), which is administered by the Transportation Research Board (TRB). Typically, state-sponsored research, including NCHRP, is highly applied, addressing specific technical problems that need near-term solutions and often leading to new specifications and design guidelines. Many states also play a leadership role in introducing innovations to local governments, which have little research capability on their own. Without federal support, state departments of transportation would not abandon research, technology transfer, and other innovation activities, but it is likely that a dramatic drop in scale would occur.
- Support for university research—Through the University Transportation Centers program and other activities, agencies of the U.S. Department of Transportation support research, educational, and technology transfer activities at U.S. universities. Generally, the federal programs require that federal funds be matched with funds from other sources, and often state research funds are used to fulfill this matching

requirement, thereby expanding the total resources made available to universities from public sources.

- In-house research and direct research management—Acting through the Federal Highway Administration (FHWA) and other agencies within the U.S. Department of Transportation, the federal government maintains its own research laboratories and manages merit-based contract research.
- Technology transfer— The federal government has promoted innovation through technology transfer programs and training activities and, at times, through regulations governing design and specification requirements for federal-aid highways. With offices in every state and a technically savvy staff, the Federal Highway Administration is well positioned, really uniquely positioned, to fulfill this role.
- Special research programs—On occasion, with support from state departments of transportation, the Congress has authorized special, highly focused research programs to fulfill a specific mission. A large-scale pavement testing program was completed in the early 1960s, and the five-year Strategic Highway Research Program (SHRP), started in 1988, explored several, mostly materials-related topics. Both programs were well funded, addressed a few pressing problems, and led to significant changes in highway design and materials.

3. RESHAPING THE FEDERAL ROLE

The federal role in highway research evolved over time as federal aid programs were revised by the U.S. Congress. Typically, the Congress must reauthorize highway programs every six years, and it is through the reauthorization legislation that major changes are made to the research program.

Indispensable as it has been, the federal research program faces new challenges--challenges that could ultimately threaten the effectiveness and perhaps viability of the program. And as with any research program, periodic adjustments in direction and organization are required in any case.

After the passage of the 1998 highway legislation, which was part of the Transportation Equity Act for the 21st Century, TRB committees that had been reviewing various aspects of the research program completed three reports that address the federal program and where they believe it should be headed--*The Federal Role in Highway Research and Technology* [7], *Strategic Highway Research, Saving Lives, Reducing Congestion, Improving Quality of Life* [8], and *Surface Transportation Environmental Research: A Long-Term Strategy* [9].

In brief, their recommendations called for the following actions:

Refocusing the federal research program on topics that reflect a long-term, national perspective. Such a focus would complement the state- and private-sector-funded programs that emphasize shorter-term, highly applied research.

It would include fundamental, long-term research. Only research of this type will enable us to understand how the composition of asphalt and concrete at the molecular level affects their performance as highway materials; or to understand better how individuals and households make choices related to travel, how these decisions interact with other lifestyle choices.

It would include research that fills gaps that other research programs are unable fill—for example, pavement experiments or other large-scale data collection efforts that require a sustained commitment of resources.

And finally, it would include research on emerging issues with national implications. A variety of topics related to federal policy and regulatory responsibilities fit this category (e.g., energy consumption), as well as wholly new concerns such as heightened security and counter-terrorism needs.

Reemphasizing competition and merit-based evaluation in awarding research contracts. Congressional actions that “ earmark” funds for specific institutions or designate funds for relatively narrow purposes have increased significantly over the past 15 years. Earmarks bypass technical competition and merit review, which are the best ways to ensure the maximum return on investment in research funding and to guarantee that the door is open for talent and creativity. Unnecessarily narrow topic designations limit agency discretion and the ability to respond to unforeseen challenges.

Supplementing established programs with a new continuing program that would address the growing list of important topics at the nexus of highways and the environment. Different perspectives and mistrust between highway organizations and environmental organizations often prevent practical solutions to problems as diverse as storm-water runoff and environmental justice. For example, there are competing “facts” and views about the impact of highways on the human and natural environment, the public response to alternative transportation services, the role of highways in creating or enabling low-density development, and the economic impact of highway expansion. Many issues of this sort routinely arise in required environmental impact statements. Available resources for research have not been commensurate with the significance of these problems, and responsibility for finding the resources (e.g., highway agencies, environmental regulatory agencies, other) has not been clear.

As proposed, this program would involve both highway and environmental groups in the oversight of a new, independently managed research program seeking solutions to problems that ultimately require acceptance by both groups for widespread implementation.

Supplementing established programs with a new Strategic Highway Research Program. Modeled after the Strategic Highway Research Program, this program would sunset after six years and would be funded at \$75 million per year. It would sponsor research at an unprecedented scale on four of the most critical challenges facing motorists and highway agencies.

- Renewal: Accelerating the Renewal of America’s Highways
- Safety: Making a Significant Improvement in Highway Safety
- Reliability: Providing a Highway System with Reliable Travel Times
- Capacity: Providing Highway Capacity in Support of the Nation’s Economic, Environmental, and Social Goals.

Research in all of these problem areas is under way today, but the scale of effort is too low to promise near-term research results that could substantially change practice.

4. FEDERAL RESEARCH TODAY

Most of these recommended actions required congressional consent and action. Indeed, the committees developed the recommendations with hopes that the Congress would incorporate them in the next reauthorization legislation for federal highway programs. That legislation, which ultimately became law in 2005, was part of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users.

How did the recommendations of the TRB committees fare in the new legislation? The results are mixed.

On the positive side, the overall level of funding for highway research, development, and technology programs increased, by about 20 percent, if one compares a year near the end of the 1998 highway legislation—fiscal year 2003—with a year at the beginning of the 2005 legislation—fiscal year 2006 (Table 1). Adding spending by state departments of transportation, the total public-sector spending for highway research is nearly \$750 million, still below where many think it should be but moving in the right direction.

The legislation established a number of new research programs. An “exploratory advanced” research program will help shift the focus to longer term research. A new Strategic Highway Research Program (SHRP 2) will address the topic areas recommended by the TRB committee, but its authorized duration and funding are less than what was recommended (\$51 million per year over 4 years).

An environment and planning research program will tackle environmental issues such as those identified by the TRB committee, but as implemented, it does not feature independent oversight and project selection.

More troublesome, the legislation increased the overall level of congressional earmarks and designations, as illustrated by Table 2. The earmarks generally lessened competition and merit review for research funds. Designated funding for particular, often quite narrowly defined, purposes greatly reduced discretion on the part of U.S. DOT. In fact, reductions in discretionary research funds have in turn led U.S. DOT to cut back or eliminate funding for such things as highway policy research and a variety of technology transfer activities. Indeed the research designations in some categories were so extensive that they exceeded the overall funds authorized, necessitating further reductions in all programs. For instance, SHRP 2 received just \$36 million or about 70 percent of its authorized funds in 2006. Even with the newly authorized environment and planning research program, overall funding for environmental and planning research declined.

5. CONCLUDING COMMENT

In the United States, the highway research program is quite decentralized, but the federal government still plays a crucial role. That role has evolved over time, with the 2005 highway legislation bringing a number of changes. Many of those changes are clearly positive; some are not. Some of the consequences of the legislation were clearly unintended, and may be corrected in subsequent legislation.

Research will never be at the top of the agenda when the Congress considers highway programs. Funding levels, formulas that allocate funds among the states, and user fees will always attract more attention. In the long run, however, it may be that what is done, or not done, to support research will have the greater long-term consequences.

Table 1 - U.S. Public-Sector Spending on Highway Research (thousands of dollars)

	FY 2003	FY 2006
U.S. DOT		
FHWA ²	137,000	169,000
ITS ³	98,000	95,000
University Research ⁴	24,000	60,000
NHTSA ⁵	85,000	92,000
FMCSA ⁶	7,000	7,000
Total, U.S. DOT	351,000	423,000
State DOTs ⁷		
Federal-Aid minimum ⁸	125,000	149,000
Total, State DOTs	NA	326,000 ⁹

² Federal Highway Administration's Surface Transportation Research, Development, and Deployment Program.

³ Intelligent Transportation Systems program; excludes deployment funds

⁴ University Transportation Centers Program—not exclusively highway research

⁵ National Highway Traffic Safety Administration

⁶ Federal Motor Carrier Safety Administration

⁷ Research funds administered by state departments of transportation

⁸ Amount of federal-aid for highways that must be spent on research. Not included in U.S. DOT total.

⁹ Total from 2006 AASHTO Research Advisory Committee survey adjusted to account for missing states using the ratio of total state research spending to SP&R minimum.

Table 2 - Congressional Designations¹⁰ and Earmarks¹¹ within Selected U.S. DOT Highway Research Activities

	FY 2003	FY 2006
FHWA ¹²		
% designated	26	58
% earmarked	21	42
ITS ¹³		
% designated	0	5
% earmarked	0	6
University Research ¹⁴		
% earmarked	69	100

¹⁰ Congressional “designations” specify topic areas on which authorized funds must be spent.

¹¹ Congressional “earmarks” specify particular universities and other research organizations that must receive the authorized funds. Additional earmarks may have been added by the Congress through the annual appropriation process.

¹² Federal Highway Administration’s Surface Transportation Research, Development, and Deployment Program

¹³ Intelligent Transportation Systems Program; excludes deployment.

¹⁴ University Transportation Centers Program—not exclusively highway research. Note that some of the earmarked universities in FY 2006 had originally competed for the program and are scheduled to compete again in the future.

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