The U.S. highway system faces many challenges in the years ahead, challenges that cannot be successfully addressed without new knowledge and innovations of all sorts. For example, how can 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 impact? Can we develop affordable materials that will significantly extend the lives of highway pavements and bridges?

As users of the nation’s highway system and residents of communities affected by highways, most of us can identify with questions like these, or at least their premises. No wonder: The U.S. highway system handles more than 90 percent of all trips to and from work, more than 80 percent of intercity person trips over 100 miles, and about 70 percent of freight traffic, based on billings. 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 this system for decades to come.

Consequently, questions such as those posed at the outset will be relevant for years to come. Answering them requires research 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 lifestyle, 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. Several factors contribute to this situation. First, the field has a low-tech image. The familiarity of the system and its use of materials and technologies whose origins can be traced to antiquity contribute to the thinking that there is nothing left to learn about highway technology and that today’s challenges are no different from ones the industry has faced before. Second, the highway system is highly decentralized. Roughly 35,000 governmental units operate highways, 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. Third, there are few incentives to innovate. The prevalence of highly prescriptive design specifications...
and low-bid procurement practices provides little incentive for private-sector contractors and material suppliers to conduct research on their own and offer innovative products. In addition, in the public sector, there are no market or competitive factors to push innovation. Finally, the benefits of research are hard to measure. Miracle cures for problems such as 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 investment. Moreover, the benefits come in multiple forms, some of which can be measured (for example, out-of-pocket cost savings or reduced fatalities and injuries) whereas others cannot (for example, improved aesthetics).

All of this translates to highway research spending that does not match the investment levels of other industries. Research spending for highways, including technology transfer and other activities that promote innovation, is less than 0.6 percent of total highway expenditures by highway agencies. Emerging industries, such as information and electronics and medical substances and devices, spend 7 percent or more of their net sales to research, and even relatively mature industries, including basic industries such as materials, machinery, and chemicals, devote 1 to 3 percent of their net sales to research.

Research success stories

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 lifecycle 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 highway and transit systems would affect travel. The reality is that virtually every aspect of highway planning, design, operation, and construction has improved during 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. Further, demands on the highway system during the past four decades have significantly outpaced capacity growth. From 1980 to 1997, vehicle-miles of travel on the system increased by 67 percent, while system lane-miles increased by just 4 percent. As 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 mix of loosely connected, relatively independent programs and activities that lack strong overall management. The available resources for highway research, roughly $700 million per year, 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 critical to keeping the program relevant and improving the chances that promising products and techniques will 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 during the past 80 years, and without its involvement and leadership, there would be many fewer success stories to report. The federal government has provided:

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 engage in 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 National Academies’ 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.

Direct support for research. Acting through the Federal Highway Administration (FHWA), the federal government maintains its own research laboratories, provides funding for university research, 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 federally supported highways. With offices in every state and a technically savvy staff, the FHWA is well positioned, indeed uniquely positioned, to fill this role.

Special research programs. With support from state departments of transportation, Congress has occasionally 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.

New directions
Indispensable as it has been, the federal research program faces new 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. TRB and National Research Council committees have been reviewing various aspects of the research program for the past 10 years, with particular emphasis on the research funds directly managed by FHWA. These committees recently completed three reports that address the federal program and where they believe it should be headed: The Federal Role in Highway Research and Technology (2001), Strategic Highway Research: Saving Lives, Reducing Congestion, Improving Quality of Life (2001), and Surface Transportation Environmental Research: A Long-Term Strategy (2002). In brief, their recommendations call 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, because, for example, only research of this type will enable us to understand at the molecular level how the composition of asphalt and concrete affects their performance as highway materials. Also, long-term study is needed to understand better how individuals and households make choices related to travel and how these decisions interact with other lifestyle choices. A refocused program would also include research that fills gaps that other research programs are unable fill, such as pavement experiments or other large-scale data collection efforts that require a sustained commitment of resources. 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, as well as wholly new concerns such as heightened security and counterterrorism needs.

Providing for more substantive stakeholder involvement in setting priorities and allocating...
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 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 (highway agencies, environmental regulatory agencies, or others) has not been clear.

This proposed program would involve 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. The program would incorporate features from existing cooperative research programs such as the Health Effects Institute, the Environmental Protection Agency’s Science to Achieve Results Program, the NCHRP, and the Transit Cooperative Research Program.

Supplementing established programs with a new Strategic Highway Research Program. Modeled after SHRP, this program would be created for only six years. It would sponsor research at an unprecedented scale on four of the most critical problem areas facing motorists and highway agencies.

Accelerating the renewal of U.S. highways. Much of our highway system, particularly interstates and primary arterial highways, must be reconstructed in the coming years, and because we are so dependent on them, they must be reconstructed while remaining open to traffic. Systematic approaches to reconstruction offer opportunities to significantly reduce the construction time and mitigate the disruption to motorists and adjacent communities. These approaches would include new construction methods and materials, new processes that integrate design and construction planning, new strategies for traffic control and safety, and new procurement methods and specifications. At the same time, opportunities exist through better materials, designs, and maintenance planning to rebuild highways that will last longer and require less frequent maintenance. This research would include not only the development of new methods and approaches but also activities aimed at promoting implementation.

Making a significant improvement in highway safety. Seat belt laws, occupant restraint devices, tougher limits on alcohol consumption, and a host of other vehicle and roadway safety improvements have significantly reduced fatal crash rates on a per-mile-driven basis. But with more than 40,000 lives lost each year...
and 3 million injured, highway crashes remain nothing less than a public health crisis. With the “easier” safety measures already largely implemented, further improvements in crash rates will be tougher to achieve. Indeed, the growth in travel is already starting to outstrip accident rate reductions and produce net increases in total fatalities annually.

There are many promising new safety measures, such as in-vehicle warning systems or systems that combine detection with automated response. But these technology-based measures raise many questions that are currently unanswerable. What sorts of information will be of greatest value to drivers, and how should it be presented to them so that it can be readily understood and appropriately acted upon? Under what circumstances should vehicle control be relinquished to automated systems? If the vehicles become safer, will drivers adapt and drive faster or in worse conditions, thereby reducing or even eliminating the expected improvement in overall safety?

For the longer term, safety experts agree that more-effective countermeasures cannot be developed without much better information about driver behavior and the specific causes of crashes. Technologies such as in-vehicle event data recorders offer new opportunities to collect this information. The task is great and likelihood of success uncertain, but the door is now open as never before to pursue this research.

Congress should reemphasize competition and merit-based evaluation in awarding research contracts.

Providing a highway system with reliable travel times. Nonrecurring incidents, such as crashes, disabled vehicles, hazardous material spills, major athletic events, and other special events, account for much of the unpredictability in highway performance. Systematic approaches are needed to identify such incidents quickly, alert drivers who still have an opportunity to avoid the incidents, and then swiftly clear them and/or mitigate their consequences. A combination of new strategies, new technologies, and new relationships between the emergency responders and other public agencies involved is needed. Research in this area would pursue all three and would also include implementation strategies.

Providing highway capacity in support of the nation’s economic, environmental, and social goals. The United States will never again build new highways at the pace of the interstate era. Nonetheless, new roads are being constructed and existing roads are being reconstructed with added lanes. This research would examine new approaches to highway development that better balance environmental, aesthetic, and social considerations with engineering and economic considerations. More specifically, it would develop new tools for designing facilities, assessing impacts, and working with affected users and communities.

Research in all of these problem areas is under way today, but the scale of effort is too small to promise near-term research results that could substantially change practice. FHWA can act on some of these recommendations on its own, but most will require congressional consent and action. In the coming year, Congress will be working on legislation to reauthorize the federal surface transportation programs that expire at the end of fiscal year 2003. As always, research will not be at the top of the agenda. Funding levels, formulas that allocate funds among states, and various program specifics will attract most of the attention and energy of legislators, their staffs, and the various interest groups. But when the smoke clears, it may be that what is done, or not done, to support research will have greater long-term consequences.
Future highways
In "Highway Research for the 21st Century" (Issues, Winter 2002-03), Robert E. Skinner, Jr. does a very good job of highlighting the importance of research in the highway field and explaining the unique role that the Federal Highway Administration (FHWA) plays in a decentralized highway research community. The FHWA is committed to providing leadership to a nationally coordinated research and technology (R&T) program, championing the advancement of highway technological innovation, and advancing knowledge through research, development, training, and education.

The FHWA’s leadership role in conducting research to address national problems and advancing new technologies to serve the public is directly related to its stewardship role in using national resources wisely. Stewardship requires that we continue to find ways to meet our highway responsibilities to the public by efficiently delivering the very best in safe, secure, operationally efficient, and technically advanced highway facilities, while meeting our environmental responsibilities. Since FHWA does not own or operate this country’s highway system, providing leadership and working through partnerships are key to our success.

In response to our own agency assessment of our R&T business practices and the recommendations of Transportation Research Board (TRB) Special Report 261, The Federal Role in Highway Research and Technology, the FHWA currently has a major corporate initiative underway to raise the bar for research and deployment of technology and innovation. This effort includes increased stakeholder involvement in our R&T programs and achieving even greater collaboration with other members of the R&T community.

Throughout its history, the FHWA has supported fundamental long-term research aimed at achieving breakthroughs, identified and undertook research to fill highway research gaps, pursued emerging issues with national implications, and shared knowledge. This important work will continue. It is essential that we support and manage our R&T programs so that they continue to produce the innovative materials, tools, and techniques to improve our transportation system.

As part of the reauthorization process, the U.S. Department of Transportation is proposing resources to invest in R&T in order to further innovation and improvements that are critical in meeting our highway responsibilities to the nation in vital areas such as safety, congestion mitigation, and environmental stewardship. As a point of clarification and amplification on Skinner’s article, those proposing the Future Strategic Highway Research Program (F-SHRP) are not intending it to be a prescription for the FHWA’s future R&T program. Rather, F-SHRP is a special purpose time-constrained research program that is intended to complement the FHWA’s R&T program and other national highway R&T programs. If approved by Congress, F-SHRP would concentrate additional research resources on a few strategic areas to accelerate solutions to critical problems.
Delivering transportation improvements that are environmentally sound and provide Americans with the mobility and safety that they have come to expect in a timely manner is no small task. The key to success for our national highway R&T program is a solid partnership among federal, state, and local government, the private sector, and universities. We look forward to working with TRB and all of our partners in carrying out a national R&T program to achieve these goals.

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