SPECIAL REPORT 292

Safety Research on Highway Infrastructure and Operations

Improving Priorities, Coordination, and Quality

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

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Committee on Research Priorities and Coordination in Highway Infrastructure and Operations Safety

TRANSPORTATION RESEARCH BOARD
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This report has been reviewed by a group other than the authors according to the procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Preface

Following the 1998 passage of the Transportation Equity Act for the 21st Century, the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials, and the Transportation Research Board (TRB) convened the National Highway Research and Technology Partnership, an ad hoc group that sought to engage the highway transportation community in the identification of research and technology needs. The partnership's Safety Working Group identified eight research themes, one of which—highway infrastructure and operations safety—represents the largest categories of fatal and injury crashes on the nation's roads. Follow-on activities engaged safety program administrators, researchers, and research program managers in further exploration of strategies aimed at identifying and prioritizing research topics under the highway infrastructure and operations safety theme; coordinating research efforts among the members of the diverse and decentralized highway safety research community; and improving the quality of highway safety research.

In 2005, FHWA and the state departments of transportation, through the National Cooperative Highway Research Program (NCHRP), asked TRB to convene an expert committee to provide an independent review and assessment of the process used to establish research priorities and coordination in the area of highway infrastructure and operations safety. This choice of focus area allowed the committee to leverage the aforementioned activities of the National Highway Research and Technology Partnership's Safety Working Group and others. The project was also viewed as a potential model for priority setting and coordination in other areas of highway research. Thus, the committee was asked to recommend an efficient and effective process for setting research priorities and

coordinating research in the area of highway infrastructure and operations safety and to comment on the potential for applying this process to other highway research areas. The committee was also tasked with commenting on strategies to improve research quality.

In accordance with the usual procedures of the National Research Council (NRC), TRB assembled a study committee of nine members under the leadership of Forrest M. Council, a senior research scientist at the University of North Carolina's Highway Safety Research Center and at BMI-SG, a transportation engineering firm in Vienna, Virginia. Committee members have expertise in highway safety research, the use of highway safety research, research management and coordination, and research methodologies.

The committee held three meetings in Washington, D.C., between September 2005 and April 2006. The final meeting included a workshop on research in highway infrastructure and operations safety attended by representatives of organizations that currently fund research in this area. The committee then developed its report by correspondence.

ACKNOWLEDGMENTS

The committee thanks all who participated in the information-gathering sessions of its meetings, including representatives of the study's sponsors, FHWA and NCHRP. Special thanks go to Michael Trentacoste and Michael Griffith of FHWA[1] and Charles Niessner of NCHRP for participating in all the meetings, engaging in group discussions, and responding to the committee's questions and requests for information. Thanks go also to Richard Pain of TRB's Technical Activities Division for his participation in committee meetings and assistance in clarifying various aspects of activities undertaken by the National Highway Research and Technology Partnership's Safety Working Group.

The committee also thanks those individuals from organizations sponsoring research on highway infrastructure and operations safety who provided information about current research processes: Michael Trentacoste and Michael Griffith of FHWA; Martin Walker of the

[1] Michael Griffith is now with the Federal Motor Carrier Safety Administration.

Federal Motor Carrier Safety Administration; Richard Compton of the National Highway Traffic Safety Administration; Thomas Welch of the Iowa Department of Transportation; Gary Modi of the Pennsylvania Department of Transportation; Peter Kissinger and Scott Osberg of the AAA Foundation for Traffic Safety; and Susan Ferguson and Allan Williams of the Insurance Institute for Highway Safety.

The contributions of all who participated in the committee's April 2006 workshop on research in highway infrastructure and operations safety are gratefully acknowledged. (Participants are listed in Appendix C of this report.) Their input proved particularly valuable in informing the committee's development of a recommended research agenda-setting and coordination process.

Jill Wilson managed the study and drafted sections of the report under the guidance of the committee and the supervision of Stephen R. Godwin, Director of TRB's Studies and Special Programs Division.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the Report Review Committee of NRC. The purpose of this review is to provide candid and critical comments that will assist the institution in making the report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process.

NRC thanks the following individuals for their review of this report: Dean Carlson, Carlson Associates, Topeka, Kansas; Paul Jovanis, Pennsylvania State University, University Park; Peter Kissinger, AAA Foundation for Traffic Safety, Washington, D.C.; George Ostensen, FHWA (retired), Brooksville, Florida; and Thomas Welch, Iowa Department of Transportation, Ames. Although the reviewers provided many constructive comments and suggestions, they were not asked to endorse the committee's findings, conclusions, or recommendations, nor did they see the final draft before its release. The review of this report was overseen by C. Michael Walton, University of Texas at Austin. Appointed by NRC, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional

procedures and that all review comments were carefully considered. Responsibility for the final content of the report rests solely with the committee and the institution.

Suzanne Schneider, Associate Executive Director of TRB, managed the report review process. The report was edited by Gail Baker. In the TRB Publications Office, Jennifer J. Weeks prepared the final manuscript for posting on the web and Norman Solomon provided final editorial guidance, under the supervision of Javy Awan, Director of Publications.

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Summary

Fatalities and injuries resulting from road traffic crashes remain a major public health concern in the United States, with more than 42,000 people killed and 2.5 million injured in 2006. Research on road traffic safety over the past five decades has led to important reductions in death and injury rates. An important question going forward is how best to use the limited available research funding to achieve further reductions, particularly now that some of the most obvious and effective strategies, such as seat belt legislation, already have been widely implemented. As understanding of road safety moves toward a scientific basis, as opposed to conventional wisdom and observation of practice, numerous research opportunities have been identified, some of which could yield cost-effective safety improvements. The challenge for those who fund research is threefold. It requires (*a*) devising a sensible process for identifying and prioritizing the best research opportunities, (*b*) ensuring that the high-priority research is funded and conducted without unnecessary duplication of effort, and (*c*) ensuring that the research conducted produces reliable and useful results.

In response to a request from the Federal Highway Administration (FHWA) and the state departments of transportation (DOTs), through the National Cooperative Highway Research Program (NCHRP), the Transportation Research Board (TRB) convened an expert committee to provide an independent review and assessment of the processes currently used to establish research priorities and to coordinate research activities in the area of highway infrastructure and operations safety. The committee was also charged with recommending an efficient and effective research priority-setting and coordination process and with commenting on strategies to improve research quality. The committee's work built

on the results of earlier initiatives by the National Highway Research and Technology Partnership, FHWA, and others aimed at bringing together the members of the diverse and decentralized highway safety research community.

The committee proposes the creation of an independent scientific advisory committee (SAC) composed primarily of experienced safety program managers and knowledgeable researchers. The SAC would be charged with (*a*) developing a transparent process for identifying and prioritizing research needs and opportunities in highway safety, with emphasis on infrastructure and operations, and (*b*) using the process developed to recommend a national research agenda focused on highway infrastructure and operations safety. To assist in conducting these tasks, the SAC would enlist the help of outside experts as needed.

One of the most challenging aspects of the SAC's work would be the development of a methodology for assigning research priorities. A quantitative analytical approach that examines clearly defined criteria to determine the value of a research project or topic is recommended, and two possibilities—one "traditional" and one based on decision analysis methods—are suggested for further consideration by the SAC. The approach chosen should take into account the needs of safety program managers, the state of current knowledge, and the potential for research to solve the problem. Hence, the SAC's national research agenda should be based on in-depth knowledge of current research, include some quantifiable measure of the value or benefit of a proposed research effort for greater road safety, include an assessment of the likely ability of research to address the problem, and reflect expert judgment about possible implementation of research outputs.

The committee's examination of factors affecting research quality led it to conclude that having a well-conceived national agenda, developed as suggested, would be a primary strategy for improving research quality. Such an agenda also could help ensure that high-priority research issues are identified and funded on a continuing basis.

A further strategy for improving research quality is to award research funding competitively on the basis of the judgment of scientific peers. This proven strategy is likely to have increasingly important benefits as highway safety research transitions to a science-based approach. In addi-

tion, the trained and independent researcher needs to be a more influential partner throughout the entire knowledge development process, working with the experienced safety program manager not only to formulate research programs and projects, shape proposals, and select researchers to perform the work, but also to monitor ongoing research and assess final results before publication. Finally, there may be benefits to setting aside a portion of available funding for investigator-initiated fundamental research aimed at developing better research methods and exploring innovative solutions to road safety problems.

The main purpose of research coordination is to ensure the effective use of research funds by eliminating unnecessary duplication and making sure high-priority research gets funded. In addition, experience within the NCHRP safety programs has shown that higher-quality research can result when individual state DOTs coordinate their research efforts through a large-scale pooled fund program rather than undertake their own separate research programs with limited funding. Nonetheless, any new coordination mechanism requiring a cumbersome, costly, and rigid administrative structure appears destined to fail because of both resource limitations and the inability to accommodate existing goals of and constraints on research funding organizations. Both the committee's knowledge of the field and inputs from representatives of key research funding agencies who attended the committee's workshop supported this observation. Thus, the committee proposes an informal approach to research coordination with the SAC's national research agenda as a unifying focal point. The SAC would host a 1-day meeting each year at which research funding organizations and other interested parties, including congressional staff, would discuss the national research agenda among themselves and with SAC members. Such a meeting would provide an opportunity to explore the potential benefits of coordinating research in the priority areas and topics identified by the SAC.

The committee was unable to obtain reliable estimates of the total amount of funding currently spent on research in highway infrastructure and operations safety. Therefore, an approximate estimate was generated by using data from TRB's Research-in-Progress Database. The result—about $24 million a year, excluding periodic efforts such as the ongoing Strategic Highway Research Program 2—indicates that the total cost of

developing a national research agenda and hosting the first informal coordination meeting would be less than 3 percent of total annual research expenditures on highway infrastructure and operations safety. The annual cost of a follow-on informal research coordination meeting held every year would be approximately one-tenth of 1 percent of annual research expenditures.

Getting the SAC activity started would require not only funding but also an effective organizational strategy. In the committee's view, having an influential champion with the necessary knowledge and expertise step forward to lead the effort could go a long way toward garnering support for the initiative from a broad range of constituencies. Of those capable of championing the SAC effort, the American Association of State Highway and Transportation Officials and FHWA appear to be strong candidates.

1

Setting the Context

In 2006, 42,642 people were killed and 2,575,000 were injured in the United States as a result of road traffic crashes (NHTSA 2007). These crash statistics equate to 1.42 fatalities and 86 injured persons per 100 million vehicle miles traveled, and while they represent a considerable improvement over the corresponding values of 10 years ago, they give no cause for complacency.[1] Experts estimate that if current trends continue, one of every 90 children born today will die violently in a motor vehicle crash, and 70 of every 100 will be injured in a highway crash (AASHTO 2005). Despite numerous programs over the past five decades aimed at reducing the toll, motor vehicle crashes still remain the leading cause of death in the United States for persons aged 3 to 34, the leading cause of spinal cord injuries for persons under 65, and the leading cause of traumatic brain injury for persons under 75 (NHTSA 2005; NCIPC n.d. a; NCIPC n.d. b; NCIPC n.d. c).

Organizations involved in highway safety have set targets as part of their efforts to reduce the numbers of fatalities and injuries resulting from road traffic crashes. The Federal Highway Administration's (FHWA's) 1998 *National Strategic Plan* (FHWA 1998) established a strategic objective of reducing the number of highway-related fatalities and serious injuries by 20 percent in 10 years, and in 2003, the American Association of State Highway and Transportation Officials (AASHTO) Board of Directors, the Governors' Highway Safety Association, the American Association of Motor Vehicle Administrators, and the U.S. Department of Transportation set as a goal the reduction of the nation's highway

[1] Fatality and injury rates per 100 million vehicle miles traveled in 1996 were 1.7 and 141, respectively (NHTSA 1997).

fatality rate by 2008 to not more than 1.0 deaths per 100 million vehicle miles traveled (AASHTO 2005).

ROLE OF RESEARCH IN IMPROVING ROAD SAFETY

The field of safety improvement is moving toward a scientific basis, with knowledge based on sound research studies rather than on conventional wisdom and observation of practice. Recent high-caliber research continues to demonstrate that, in some cases, conventional safety wisdom is incorrect. For example, efforts to provide the driver with a better view of the road in bad weather by providing permanent raised pavement markers were intuitively expected to reduce crash rates, whereas research has shown that this is not necessarily the case for all roadway types (Persaud et al. 2004). Certain safety treatments need to be targeted to specific situations to have a positive effect and may have a negative effect on safety if not appropriately targeted.

Crashes are complex events resulting from a combination of factors affecting the driver, the vehicle, and the roadway. Hence, understanding the key factors resulting in a crash and developing effective countermeasures require a rigorous science-based approach that seeks to identify and isolate many contributing and often interrelated effects. The National Cooperative Highway Research Program (NCHRP) Series 500 guides illustrate the limitations of current understanding of countermeasures (TRB 2003–2008). These guides are intended to assist state and local agencies in reducing injuries and fatalities in targeted areas (run-off-road collisions, collisions at signalized and unsignalized intersections, and so on) by identifying appropriate strategies or countermeasures. While some of the strategies have been subjected to well-designed evaluations to prove their effectiveness, many, including some that are widely used, have not been adequately evaluated. Consequently, users of the guides are advised to exercise caution before adopting such strategies for implementation. Examination of all the Series 500 guides reveals that good measures of effectiveness are not available for the overwhelming majority of treatments described. In other words, many of the treatments are based on traditional judgment and observation of practice rather than on a robust science base, and questions remain about their effect on

safety in various situations. Hence, research is needed to create additional knowledge and better understanding. If appropriately applied, the results of this research have the potential to reduce the number of motor vehicle crashes, mitigate their consequences, and result in more cost-effective road safety management.[2]

In a time of declining research budgets and emphasis on "doing more with less," organizations that fund and conduct road safety research are under increasing pressure to demonstrate their return on investment for research dollars. Given the inherently unpredictable nature of research, the many years that may elapse between completing a research program and seeing the practical effects of implementing its results, and the nonlinear nature of the implementation process, demonstrating the value of research is often difficult, particularly within the time frame of a few years considered by many decision makers. Furthermore, in the view of many experts, many of the most obvious and effective strategies for improving road safety, such as seat belt legislation, already have been widely implemented. Thus, additional beneficial treatments or countermeasures to meet current and anticipated road safety problems are likely to be more difficult to identify and may well lead to smaller incremental improvements than in the past. The identification and quantification of these smaller treatment effects will require improved research data and methods.

Research outcomes can, nonetheless, be extremely valuable in improving road safety. For example, an assessment of the research program of the Texas Department of Transportation (TxDOT) indicated that 245 lives will be saved, more than 24,000 accidents will not occur, and more than $322 million in costs will be saved during the next 10 years as a result of 21 technologies and methods produced by TxDOT's research programs (Krugler 2003). A further example of research payoff is provided by the Missouri Department of Transportation's research in the 1980s aimed at improving safety by preventing cross-median crashes

[2] Participants in a 2006 workshop aimed at developing a long-term traffic safety research agenda suggested that real progress in traffic safety "depends far more on changing [the] culture of indifference than on developing or implementing any specific countermeasure" (Hedlund 2007, 2). Issues relating to the traffic safety culture in the United States are beyond the scope of this report but are examined in a recent series of papers commissioned by the AAA Foundation for Traffic Safety (2007).

(Chandler 2007). Studies by other states and an internal study led the agency to consider median cable barriers as a solution to the problem. Installation of these barriers on Missouri Interstates with the highest traffic volumes and the highest number of cross-median severe crashes led to important safety improvements. The cable was found to catch 95 percent of vehicles entering the median, keeping them from entering the opposing lanes. On Interstate 70, the installation of 179 miles of median cable barrier on the freeway resulted in a decrease in cross-median roadway fatalities to two in 2006, down from a peak of 24 in 2002.

Although the value of road safety research is widely recognized, many organizations face a dilemma in deciding how best to invest their scarce research dollars to yield maximum safety improvements. The choice of what road safety research to fund is more critical today than ever because of the following factors:

- Road safety remains a major public health concern in the United States. Despite many good ongoing safety programs, improved approaches and strategies are needed to reduce the number of crash-related fatalities and injuries.
- Vehicle and driver populations are changing rapidly. Increasing numbers of large pickups, SUVs, and elderly drivers give cause for concern about safety.
- Safety research budgets are not growing as rapidly as safety knowledge needs. A greater understanding of the science underlying crashes has revealed an array of topics for which research has the potential to result in safety improvements, but available funds are insufficient to research all these topics. Moreover, the budgets of some major funders are shrinking. For example, FHWA's budget that can be targeted to high-priority research issues has been greatly reduced by congressional designations and earmarks.
- Funding organizations are under increasing pressure to demonstrate the return on investment for their research spending. Hence, the focus tends to be on research areas likely to yield relatively near-term benefits rather than on higher-risk, longer-term research aimed at enhancing fundamental understanding of safety issues—an understanding that could lead to major breakthroughs rather than smaller, incremental improvements in safety treatments.

- Safety organizations are under pressure to find quick solutions to safety problems. Products promising "quick fixes" are available but may not have been adequately evaluated and may themselves be targets for additional research.

SAFETY RESEARCH AND THE NATIONAL HIGHWAY RESEARCH AND TECHNOLOGY PARTNERSHIP

The 1998 passage of the Transportation Equity Act for the 21st Century resulted in a significant downturn in federal support for research and technology (R&T) transfer. Since then, informal stakeholder groups and interested individuals have aligned themselves according to interest and expertise in a collective effort to focus on research priorities and to share limited resources. In particular, the National Highway Research and Technology Partnership, an ad hoc group convened in late 1998 by FHWA, AASHTO, and the Transportation Research Board (TRB), sought to engage the highway transportation community in the identification of R&T needs and to address the benefits to be realized by forming partnerships to fulfill those needs (National Highway Research and Technology Partnership 2002). Acting in a volunteer capacity under the auspices of the partnership, members of the highway research community—federal agencies, state departments of transportation (DOTs), associations, institutes, industry, consultants, universities, and others—worked together through an informal process to develop a highway R&T agenda. One of the five major R&T areas selected by the partnership was safety.[3]

The partnership's safety working group held a series of meetings during 2000 to obtain input from interested parties and to draft its report, which identified eight safety research themes.[4, 5] The group's vision was "to bring about a profound reduction in deaths, injuries and crashes generated from the successful development and implementation of an

[3] The other major R&T areas were infrastructure renewal; operations and mobility; policy analysis, planning, and systems monitoring; and planning and environment.

[4] Tom Bryer of the Pennsylvania Department of Transportation, now retired, and Leanna Depue of the Missouri Safety Center, now with the Missouri Department of Transportation, chaired the group.

[5] The eight safety research themes were safety management and data systems, driver competency, high-risk drivers, light-duty vehicle safety, highway infrastructure and operations, vulnerable road users, truck and bus safety, and postcrash management.

integrated, cost-effective strategic highway safety research agenda." This vision would be realized by "identifying the most promising short, mid, and long-term research, development and implementation activities that result in precipitous reductions in deaths, injuries and crashes" (National Highway Research and Technology Partnership Safety Working Group 2001, 1).

Following from the partnership activity, an ad hoc working group made up of safety program administrators, researchers, and research program managers continued to develop and refine a common research agenda that would address highway infrastructure and operations safety. This theme, in addition to being one of the research themes identified by the partnership's Safety Working Group, represents the largest categories of fatal and injury crashes. The ad hoc group met in September 2002 to begin a priority-setting process and to recommend how the research programs and activities of FHWA, the DOTs, university transportation centers, and private organizations such as the AAA Foundation for Traffic Safety could be better focused and coordinated in carrying out the highway safety research agenda.

After its September 2002 meeting, the ad hoc group recommended to FHWA that it commission expert white papers in selected areas of highway infrastructure and operations safety research. Responding to this recommendation, FHWA commissioned five expert, peer-reviewed working papers, each of which analyzes and rates individual research projects in one of the five selected areas. The group also recommended to FHWA and the states that they fund the creation of a National Research Council (NRC) committee that would narrow the list of potential research projects and make recommendations about priority projects to research funding organizations. A continuing area for discussion by the group was the need for approaches that would strengthen the scientific rigor of highway safety research generally. Part of the rationale for recommending the creation of an NRC committee was to heighten attention to the need for improved research quality.

CHARGE TO THE COMMITTEE

In April 2005, FHWA and the state DOTs, through NCHRP, asked TRB to convene an expert committee to examine issues raised by the National

Highway Research and Technology Partnership's Safety Working Group and the subsequent ad hoc group with regard to research priorities, coordination, and quality. In particular, the expert committee was to provide an independent review and assessment not only of the expert white papers but also of the process used to establish research priorities and coordination in the area of highway infrastructure and operations safety.

The committee was charged with

1. Reviewing the applied and fundamental research projects proposed in the expert working papers on run-off-road research needs, intersection safety, human factors, work zone crashes, and fundamental advanced research and providing guidance with regard to the inclusion of these projects in a national research agenda;
2. Holding a meeting of highway safety research funding organizations to discuss research priority areas, priority setting, and coordination;
3. Recommending an efficient and effective research priority-setting and coordination process that could be used in other highway research areas; and
4. Commenting on strategies to improve research quality.

The FHWA and NCHRP sponsors viewed the project as a potential model for priority setting and coordination that might be applied to other areas of highway research. For this reason, the committee was asked to comment on the potential of applying a similar process to other areas. Focusing on one of the eight theme areas identified by the partnership's Safety Working Group was deemed more feasible for this exploratory effort than trying to address highway safety research in its entirety.

COMMITTEE'S APPROACH

For the purposes of the present project, research on highway infrastructure and operations safety was interpreted by the committee as comprising all safety-related research that is directed to the roadway component of safety and is not specific to either driver or vehicle safety research programs. Hence, research on highway infrastructure and operations safety includes all of FHWA's research and most of the safety research traditionally funded by NCHRP but not research areas traditionally funded by the National Highway Traffic Safety Administration. It does, however,

include an "operator/user" component of human factors research that addresses the way in which people interface with the roadway and with traffic operations.

The committee held three meetings in Washington, D.C., between September 2005 and April 2006 (Appendix A). The first and second meetings were devoted largely to two areas of investigation:

- Identifying the lessons learned from recent efforts to set research agendas, including the expert working papers (white papers) commissioned by FHWA, *The Concrete Pavement Road Map* (FHWA-HRT-05-074) describing a long-term plan for concrete pavement R&T, and the AAA Foundation for Traffic Safety's Futures Workshop; and
- Reviewing research processes used by organizations that fund highway safety research (to inform the committee's discussion of this topic, funding organizations were contacted before the second meeting and asked to provide summaries of their research processes, with emphasis on ways of identifying priority research areas and selecting projects to fund).

The committee used the information gathered on agenda-setting efforts and research processes, together with the outcomes of its initial deliberations, to outline a possible process for developing a national research agenda in highway infrastructure and operations safety. It also discussed the possibility of using such an agenda as a focal point for coordination among research funding organizations.

On the first day of its third and final meeting, the committee hosted a workshop on research in highway infrastructure and operations safety, which was attended by representatives of organizations that currently fund research in this area. The purpose of the workshop was to provide the committee with feedback on its proposed process for developing a national research agenda and to explore with funding organizations possible mechanisms for coordinating their research efforts so that the most critical research gets funded. The committee used the comments and suggestions from workshop participants to develop and refine its recommendations for an efficient and effective research priority-setting and coordination process.

At the beginning of the project, there was a perception among some observers that the committee itself might be able to develop a prioritized

national research agenda in highway infrastructure and operations safety by building on the earlier work of the National Highway Research and Technology Partnership's Safety Working Group and the subsequent ad hoc group, and on the white papers commissioned by FHWA. The process used and the lessons learned by the committee in developing such an agenda would then form the basis for an improved research agenda-setting and prioritization process applicable to other highway research areas. After examining the outputs from the precursor efforts, however, the committee rapidly concluded that developing a prioritized national research agenda would not be possible with the resources available for the present project. The lessons learned from the precursor efforts were valuable in informing the committee's work. Nonetheless, these precursor efforts alone did not provide a sufficiently substantive and robust foundation to allow a volunteer group, with no support from expert consultants, to develop and reach consensus on a prioritized national research agenda in highway infrastructure and operations safety over the course of three 2-day meetings. Consequently, the committee has recommended a process for research priority setting and coordination, as requested, but has not defined a specific methodology for developing a national research agenda and setting research priorities. It has, however, defined important attributes of such an agenda and identified key features of the prioritization process.

At its first and second meetings, the committee spent considerable time discussing the white papers commissioned by FHWA as an outgrowth of the research agenda-setting efforts under the National Highway Research and Technology Partnership. The committee learned some useful lessons about agenda setting from its review of these papers and the process used to commission them. However, responding to the first item of its charge (review the projects proposed in the white papers and provide guidance about their inclusion in a national research agenda) proved problematic. As a relatively small group of experts, only a few of whom are knowledgeable in some of the detailed subject areas addressed by the proposed projects, the committee was uncomfortable with providing consensus guidance about the inclusion of these projects in a national research agenda. In particular, it was mindful of one of its own findings about the white papers process, namely, that relying on the advice of one or a small number of experts requires caution, particularly

if a topic is controversial or not well understood. Consequently, the committee has included in Appendix B a summary of comments from individual members on projects proposed in the white papers. For each project, comments were provided by only those members (usually two or three individuals) with the necessary knowledge and expertise. Thus, the comments contained in Appendix B do not represent the consensus of the committee, and the guidance offered should be used with that caution in mind.

ORGANIZATION OF THE REPORT

The next chapter outlines current approaches to research priority setting and coordination in the area of highway infrastructure and operations safety. Chapter 3 addresses research quality, with emphasis on opportunities for improvement through the processes used to develop and select research projects for funding. Chapter 4 discusses the lessons learned from the FHWA-commissioned white papers about developing a research agenda, and Chapter 5 describes the committee's workshop with research funding organizations. The report concludes with the committee's recommendations for a research priority-setting and coordination process. The focus throughout the report is on highway infrastructure and operations safety, but much of the discussion is also relevant to other areas of highway safety research.

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Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
FHWA	Federal Highway Administration
NCIPC	National Center for Injury Prevention and Control
NHTSA	National Highway Traffic Safety Administration
TRB	Transportation Research Board

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2

Highway Safety Research: Current Approaches to Priority Setting and Coordination

Highway research in the United States is notable for its diversity and decentralization, with funding coming from as many as 100 entities. In addition to the federal program, each state department of transportation (DOT) has a research program, and there are periodic efforts such as the Strategic Highway Research Programs (SHRP and SHRP 2) authorized by Congress, as well as privately funded programs of individual companies and industry consortia. Some universities also sponsor highway research.[1] Research focused on highway safety is similarly characterized by diverse public and private research funding organizations, each with its own mission and related priorities.

This chapter identifies the major organizations with highway safety research programs and provides an estimate of total annual funding for research on the focus area of this report, namely, highway infrastructure and operations safety. The approaches that organizations use to identify and prioritize research topics and select projects for funding are then summarized. The chapter concludes with an overview of current efforts to coordinate highway safety research, including an approach proposed by the National Highway Research and Technology Partnership's Safety Working Group.

[1] Highway research and technology (R&T) programs are discussed in a report from the Research and Technology Coordinating Committee (TRB 1994). While some of the details have changed in the years since the report was published, the discussion provides an informative overview of the diverse and decentralized highway R&T enterprise in the United States.

ORGANIZATIONS WITH HIGHWAY SAFETY RESEARCH PROGRAMS

Federal

The research program of the Federal Highway Administration (FHWA) is the nation's largest single highway research program. It has two major components: (*a*) research in structures, pavements, operations, safety, environment and planning, and policy; and (*b*) the intelligent transportation systems (ITS) program, which has significant safety components.[2] In addition to FHWA, other federal agencies—notably, the National Highway Traffic Safety Administration (NHTSA), the Federal Motor Carrier Safety Administration (FMCSA), and the Centers for Disease Control and Prevention (CDC)—fund research in highway safety. NHTSA's research primarily focuses on vehicles, but the agency also funds research on motor vehicle operators, school transportation safety, and other topics. FMCSA's research focuses on commercial motor vehicle–related crashes, while CDC's National Center for Injury Prevention and Control (NCIPC) conducts public health research aimed at preventing injuries associated with motor vehicle use. The National Institute for Occupational Safety and Health conducts a small amount of highway safety research focused on workplace injury prevention, including work zone crashes. Alcohol and driving safety research is supported from time to time by the National Institute on Alcohol Abuse and Alcoholism, and the National Institute on Drug Abuse may fund research on drugged driving.

State

State DOTs fund and conduct research on highway safety through a variety of mechanisms, notably, state planning and research (SP&R) programs, individual state programs, the National Cooperative Highway Research Program (NCHRP), and FHWA's Transportation Pooled Fund (TPF) Program.

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[2] The ITS program was managed by FHWA from its inception in 1991 until it was transferred to the U.S. Department of Transportation's Research and Innovative Technology Administration in 2006. The ITS Joint Program Office managed research projects addressing highway, transit, and motor carrier applications.

The American Association of State Highway and Transportation Officials (AASHTO) plays a major role in state DOT research through the involvement of its Standing Committee on Research (SCOR) in NCHRP activities (see below). Of particular interest in the present context is the AASHTO *Strategic Highway Safety Plan* (AASHTO 2005), which provides guidance and direction for national deployment of effective countermeasures in areas in which they can have the greatest impact in reducing vehicle-related fatalities and injuries on the nation's highways.

SP&R Programs

As part of the federal aid highway program, Congress currently authorizes 2 percent of certain categories of state federal aid to be spent on SP&R programs, of which one-fourth must be spent on research. State DOTs organize their programs in a wide variety of ways. SP&R studies tend to focus on the development of practical solutions for quick application to current problems, and highway safety is only one of a variety of topics addressed.

Individual State Programs

States also may have their own research staffs and facilities that support highway research fully funded by the state. Virginia, for example, conducts such research through the Virginia Transportation Research Council. Other states, such as Florida, support sizable research programs, but all their research is performed by subcontractors rather than in-house. States may also support research centers affiliated with universities. Examples of such centers include the Texas Transportation Institute, the University of North Carolina's Highway Safety Research Center, and the Center for Transportation Research and Education at Iowa State University.

NCHRP

In addition to supporting programs focusing on local issues, the states pool their resources to support research on large national or regional problems affecting many states. In particular, NCHRP, administered by the Transportation Research Board (TRB), addresses problems on a wide range of topics. Traffic safety is one of 25 research fields NCHRP addresses.

In most cases, projects are problem oriented and designed to produce results for immediate application.[3]

TPF Program

FHWA's TPF program was established in the early 1980s to enable states to pool funds with each other and with FHWA to address research and technology projects of mutual interest. The program was reengineered in 2000, and current participants include federal, state, and local governments, as well as Canadian provinces and private industry. Projects cover a wide range of topics, from aviation and freight transportation through public transit and transportation law. At the end of FY 2006, there were 187 active pooled fund projects listed on the TPF website,[4] of which 24 (13 percent) were listed under the highway safety and human performance category, which focuses primarily on safety.

University Transportation Centers

The University Transportation Centers (UTC) program, initiated in 1987 under the Surface Transportation and Uniform Relocation Assistance Act, authorized the establishment and operation of transportation centers in each of the 10 standard federal regions. The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) reauthorized the UTCs for 6 more years and added four national centers and six University Research Institutes (URIs). The mission of the 14 UTCs was to advance U.S. expertise and technology transfer. The six URIs each had a specific transportation research and development mandate. The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), enacted on August 10, 2005, authorized up to $76.7 million per year from FY 2005 to FY 2009 funds for grants to establish and operate up to 60 UTCs throughout the United States. Twenty of these centers were competitively selected during 2006, and 40 centers are located at institutions named in the legislation.

[3] Further information is available on the NCHRP website (www.trb.org/CRP/NCHRP/NCHRP.asp).
[4] www.pooledfund.org.

Most of the federal aid for UTCs must be matched dollar for dollar with funds from nonfederal sources, such as state and local governments, industry, and nonprofit organizations.[5] While all UTCs are required to support transportation education, research, and technology transfer activities, individual organizations may differ greatly in their approaches. Some UTCs have been functioning for many years and have well-defined procedures for conducting their research programs, whereas some of the newer institutions are still getting established.

The U.S. Department of Transportation's (USDOT's) Research and Innovative Technology Administration (RITA) requires that each UTC it funds select a unique theme as part of its strategic planning process. Of the 68 such UTCs, 13 (19 percent) include safety in some form in their theme topics, although this observation does not by any means imply that the activities of these centers are dedicated to highway safety research. At the time of writing, just over 20 percent of UTC research projects listed in TRB's Research in Progress (RiP) Database are categorized by the UTCs themselves as relating to highway safety and human factors. In addition, more than 60 transportation centers at universities are affiliated through consortia with the 68 RITA-funded UTCs. The extent to which these additional centers are involved in highway safety research is difficult to determine. Limited research in highway safety is also conducted by university-based researchers funded by grants or by their own universities.

Other Organizations

Nonprofit and private organizations also fund highway safety research. The AAA Foundation for Traffic Safety funds research on topics such as distracted driving, pavement markings, older driver safety, and teen safety. The Insurance Institute for Highway Safety (IIHS) funds research on a variety of highway safety topics including signal phasing and safety, red light running cameras, vehicles, speed, speed cameras, and large trucks. Private insurance companies also fund some research in highway safety. Automobile manufacturers conduct highway safety research

[5] The eight Title III UTCs have no matching requirement.

relating to their products, although information on the scope and extent of these activities is not widely available.

Strategic Highway Research Program 2

The organizations previously identified fund highway safety research on a continuing basis, albeit at a modest level in some instances. In contrast, periodic efforts such as SHRP and SHRP 2 provide concentrated resources over a short time. SHRP 2 is authorized in SAFETEA-LU through FY 2009. The 4-year program has been authorized at a funding level of $205 million but expects to receive a maximum of $150 million over this period. Of the four focus areas—safety, renewal, reliability, and capacity—safety is expected to receive the largest share of funding for research contracts (approximately $43 million). The safety research focuses on two high-priority highway issues—road departure and intersection collisions—and is exploring opportunities to prevent or reduce the severity of such crashes by understanding driver behavior, that is, how drivers interact with the roadway, vehicle, and environment.

Not all the safety research outlined above falls under the rubric of highway infrastructure and operations safety that is the focus of the present study, but research in some areas, such as human factors, spans all dimensions of highway safety research.

FUNDING LEVELS

The committee was unable to obtain any reliable estimates of the total amount of funding currently being spent on research in the area of highway infrastructure and operations safety, possibly because of the diverse and decentralized nature of this activity. Therefore, an approximate estimate was generated on the basis of ongoing research listed in the TRB RiP Database (see Box 2-1).

The average U.S. annual research and development (R&D) expenditure on highway infrastructure and operations safety was estimated to be about $24 million. While clearly approximate for the reasons stated in Box 2-1, this estimate provides some indication of current funding levels, excluding SHRP 2.

BOX 2-1

Estimate of Annual U.S. Research Funding for Highway Infrastructure and Operations Safety

TRB's RiP Database includes approximately 137 records of active U.S. research projects related to highway infrastructure and operations safety. These records come from state DOTs, FHWA, NCHRP, universities, and the AAA Foundation for Traffic Safety and therefore include input from the broad spectrum of organizations involved in research on highway infrastructure and operations safety. The 137 records do not include research devoted primarily to other safety areas, such as vehicle crash avoidance capabilities, drivers' education, seat belt use, or impaired driving, nor do they include research conducted as part of SHRP 2, which is a one-time effort with a scope dictated largely by congressional mandate.

On the basis of the 137 RiP records, annual U.S. funding for research on highway infrastructure and operations safety was estimated at $24 million, as discussed below. This approximate value should be treated with caution because of three possible sources of error.

First, it is likely that the 137 records underestimate the total amount of research on highway infrastructure and operations safety because of incomplete reporting. Approximately 80 percent of states updated their RiP records in 2007. While this percentage is higher than in previous years, it suggests that some research on highway infrastructure and operations safety funded by state DOTs may not be captured in the RiP Database. In addition, RITA's requirement that all UTCs and earmarked universities enter RiP records was implemented for the first time in 2007. While anecdotal evidence indicates that most universities are complying, the newness of the requirement suggests that RiP coverage of research by UTCs and earmarked universities may not yet be complete.

Second, approximately a quarter of the 137 records do not include information on the cost of the research. (There is no requirement to provide budget information when entering projects into the RiP Database.) For these records, which are primarily from state DOTs, a value was imputed on the basis of the average cost of a research project ($230,000), excluding approximately 10 projects, mostly funded by FHWA, with budgets in excess of $1 million.

Third, the crosscutting nature of much highway safety research leads to ambiguities about how best to categorize some of the projects.[a] In addition, a relatively small number of records contain only brief project descriptions (or no project description at all), making it difficult to ascertain with confidence that the research is focused primarily on highway infrastructure and operations safety.

The total research cost for the 137 projects was estimated at approximately $72 million. The average duration of the more modest projects (less than $1 million) was approximately 2¼ years and that of the large projects (greater than $1 million) was approximately 4 years.[b] On the basis of these estimates of project duration, the annualized funding for research on highway infrastructure and operations safety was estimated to be approximately $24 million.

[a]Frequent reference was made to the safety R&T themes and emphasis areas identified by the National Highway Research and Technology Partnership for guidance on how best to categorize projects listed in the RiP Database (National Highway Research and Technology Partnership 2002, 35).

[b]Information on project duration was not provided for approximately one-fifth of the 137 records. Average project durations were calculated by using the available data; no attempt was made to impute the missing values.

CURRENT APPROACHES TO RESEARCH AGENDA SETTING

To inform its development of an effective and efficient research priority-setting process, the committee gathered information about current processes from a range of organizations that fund highway safety research. Although the list of organizations that provided information is by no means exhaustive, it includes examples of the three major categories of organizations that fund research on highway infrastructure and operations safety, namely, federal and state governments and the private sector. The information provided by these organizations is summarized in Tables 2-1, 2-2, and 2-3 as responses to three questions:

1. How are the organization's mission and research priorities established (Table 2-1)?
2. Who or what is usually the source of research topics (Table 2-2)?
3. How and by whom are projects selected for funding (Table 2-3)?

The most striking feature of these tables is the lack of uniformity among the processes that organizations use to identify and prioritize research needs and opportunities and to select projects for funding. Some accept suggestions for research topics from a wide spectrum of organizations and individuals, while others limit the submission of suggestions to specific groups. Many take a "top-down" approach to identifying research opportunities consistent with an established mission or strategic plan, while others rely on a "bottom-up" approach to identify problems requiring research. And some make use of outside experts to help make decisions about what research to conduct, while others rely almost exclusively on in-house expertise.

This diversity of approaches indicates that any effort to develop a national research agenda, as suggested by the National Highway Research and Technology Partnership's Safety Working Group, would need to take account of the wide range of current processes. Funding organizations are unlikely to abandon their established processes in favor of a unified, national approach to research agenda setting, in part because of the constraints imposed by each organization's individual mission as defined by its stakeholders or, in the case of federal agencies, by administration policy and congressional mandates. The committee noted, however, that research funding organizations could perhaps be encouraged to "buy in"

TABLE 2-1 Research Agenda Setting: Mission and Priorities

Organization	How Are the Organization's Mission and Research Priorities Established?
Federal	
CDC/NCIPC	Preventing and controlling transportation injuries is one of seven major emphasis areas. NCIPC's broad-based research agenda, published in 2002, was developed with participation by researchers, practitioners, and policy makers from partner organizations and agencies. Research priorities are based on the institution's mission, the public health burden, and research opportunities.
FHWA	At the highest level, FHWA's applied research priorities (including safety research priorities) are driven by policy direction from the administration. Safety objectives are articulated in FHWA's Strategic Plan, and specific research elements to meet performance goals are identified in research road maps prepared jointly by the Safety Office and the Office of Safety Research. Stakeholders provide informal input during development of the road maps; a more systematic stakeholder involvement process is being implemented.
FMCSA	FMCSA's mission requires it to have a research and technology program that leads to the reduction of commercial motor vehicle–related crashes, fatalities, injuries, and losses and that enhances operational efficiency. The agency's strategic plan, based on stakeholder input, outlines the kinds of research FMCSA will conduct.
NHTSA	NHTSA's priorities in behavioral research are based on problem identification from data analysis, agency priorities, the 5-year behavioral and evaluation strategic plan (developed in consultation with stakeholders), and research results.
State	
NCHRP	State DOTs submit problem statements to address particular problems that are shared by multiple states. SCOR tends to allocate problem statements across areas of topical concern (structures, pavements, operations, safety, etc.) and may introduce strategic focus by developing a multiyear program of research in a specific area or setting aside funds for a specific purpose (e.g., NCHRP Project 17-18 to develop a series of implementation guides in support of AASHTO's *Strategic Highway Safety Plan*).
Iowa DOT	Strategic direction for the Iowa DOT Safety Research Program (one of Iowa DOT's three independent research programs) is provided by a focus group that meets biannually. This group comprises FHWA; Iowa state, county, and city traffic/safety professionals; and traffic/safety staff from the three state universities.
PennDOT	PennDOT's research program is based on operational needs identified by employees and is strictly applied research. Senior PennDOT staff members establish priorities within six major areas, of which safety administration is one.
Private Sector	
AAA Foundation	Overall direction is provided by the Board of Directors. The R&D Advisory Committee, whose members are almost exclusively senior officials of AAA clubs, provides input on the research agenda.
IIHS	Senior staff members meet biannually to review the organization's research portfolio and decide on new initiatives.

TABLE 2-2 Research Agenda Setting: Sources of Research Topics

Organization	Who or What Is Usually the Source of Research Topics?
Federal	
CDC/NCIPC	NCIPC divisions develop annual solicitations for extramural research on the basis of NCIPC's research agenda and divisional priorities.
FHWA	The Safety Program Leadership Team, made up of senior managers from the Office of Safety and the Office of Safety Research, identifies research topics. Leadership team professionals interact informally with stakeholders in identifying the topics.
FMCSA	Input on research topics is solicited from external and internal stakeholders. Topics are developed in consultation with stakeholders, following data analysis and examination of root causes and the potential impact of research on these causes. (Research staff rates each topic by using a standard rating procedure.) The FMCSA Research Executive Board, which comprises representatives of FMCSA headquarters and field offices and possibly representatives of other USDOT agencies, reviews the research topics and their ratings and sets priorities.
NHTSA	Suggestions are received from regional offices, safety organizations, researchers, and other agencies.
State	
NCHRP	Submission of problem statements is limited to state and provincial DOTs (AASHTO members), AASHTO committees, CEOs of member organizations, and FHWA.
Iowa DOT	Members of the Safety Research Program's focus group submit research ideas. Any state, city, county, or university staff person can also submit an informal research idea. In 2006, the focus group became a regional safety research focus group, with participants from Missouri, Kansas, and Nebraska invited to participate.
PennDOT	In general, only PennDOT employees may submit research ideas for consideration. However, an outside party can submit an idea if an internal sponsor supports the project.
Private Sector	
AAA Foundation	Preproposals and ideas for research can be submitted by anyone through the foundation's website. Preproposals are welcomed from traffic safety experts and educators, AAA and Canadian AAA clubs, and so on.
IIHS	Research topics are identified by staff members, who keep abreast of research conducted by other organizations.

TABLE 2-3 Research Agenda Setting: Project Selection and Funding

Organization	How and by Whom Are Projects Selected for Funding?
Federal	
CDC/NCIPC	Requests for proposals (RFPs) are issued each November. Successful proposals must pass three levels of scrutiny. Following initial staff screening for responsiveness to the RFP, a three-person panel of external experts conducts a review for scientific merit. An advisory group of 16 public members, who are selected by the CDC director and have expertise in injury prevention and control, then screens for relevance and duplication. The final selection of projects is made by NCIPC senior management in consultation with the advisory group.
FHWA	Projects are selected by the FHWA R&T Leadership Team, which is made up of associate administrators, directors of field services, and Division Administrators' Council members. The RD&T Office decides whether research will be conducted internally at the Turner–Fairbank Highway Research Center or extramurally. For the most part, there is no formal merit review involving external experts, although external assistance in scoping projects and in merit reviews has been recommended.
FMCSA	The Research Executive Board (REB) approves annual proposals and ensures that they meet agency and departmental goals. Projects selected by the REB are competitively awarded by the Office of R&T. Some are competed openly, others are limited to competition among contractors approved by the General Services Administration, and others are added to existing competitively awarded contracts. FMCSA internal experts select proposals for funding; there is no involvement of external experts in merit review.
NHTSA	A budget execution plan is developed on the basis of congressional appropriations and earmarks. The projects included in the plan are drawn from the list used to develop a budget estimate and are selected by senior management.
State	
NCHRP	Projects are rated by AASHTO's Research Advisory Committee and SCOR and then selected by SCOR. For each project selected, NCHRP forms a panel of state DOT representatives and other experts. The panel prepares an RFP, which is posted on the web. The panel reviews the proposals received and selects one for funding.
Iowa DOT	Following the ranking of research ideas by the focus group, staff from one of the three state universities writes the problem statements for the highest-ranked ideas. The university with expertise in a given research area writes the problem statement. The Advisory Committee (made up of DOT traffic and safety staff, city traffic engineers, and county engineers) then reviews and selects the safety projects to be funded. Iowa DOT has an umbrella contract with each of the three Iowa state universities, which are the only entities that conduct the state traffic operations/infrastructure safety research.

(continued on next page)

TABLE 2-3 *(continued)* **Research Agenda Setting: Project Selection and Funding**

Organization	How and by Whom Are Projects Selected for Funding?
PennDOT	Research ideas approved by bureau directors and district executives are forwarded to Research Division staff members, who review the submissions and perform a Transportation Research Information Services search to ensure that there is no duplication of effort. Submissions are then reviewed by deputy secretaries and, if approved, are sent to Research Division staff, who develop a draft research program. This draft program is then submitted to the Program Management Committee (secretary, deputy secretaries, and a few selected employees) for approval. Once the program plan is approved, a project oversight panel is established, and interested vendors (including colleges and universities and consultants) are invited to qualify. Requests for quote are issued to qualified vendors. Vendors are then selected by the panel, and contracts are awarded.
Private Sector	
AAA Foundation	The R&D Advisory Committee considers preproposals selected or developed by foundation staff, with occasional assistance from staff of AAA clubs and other experts. The committee selects topics for full proposals and RFPs. Foundation staff are primarily responsible for making the final selection of projects and researchers to be funded. External experts may assist in assessing scientific merit of research methodologies.
IIHS	Staff select projects and decide on any outside contract research. Most research is conducted in-house by a small staff.

to a national research agenda if it added value to current efforts by filling gaps and remedying deficiencies. A national agenda with the potential to increase the likelihood of research expenditures leading to useful and usable outcomes could be attractive to funding organizations, particularly if it could be readily incorporated into current agenda-setting processes. Such an agenda could also influence the direction of safety research conducted by universities in the UTC program, particularly if referenced by Congress.

In reviewing the information summarized in Tables 2-1, 2-2, and 2-3, the committee identified two areas of particular concern. First, advice from experts, including knowledgeable researchers, about the current state of knowledge, the effectiveness of research to date in solving the problem, and the availability of appropriate research methods and data, does not appear to be routinely taken into account in identifying priority research areas and deciding which projects to fund. Second, the commit-

tee observed a bias in favor of short-term research aimed at solving problems of immediate concern, with relatively little attention given to longer-term fundamental research aimed at developing a foundation for further knowledge. Both these concerns are discussed in the next chapter.

RESEARCH COORDINATION

In the committee's view, the main purpose of coordinating research efforts is to ensure effective use of funds by eliminating unnecessary duplication and ensuring that high-priority research is funded. Ensuring that research is of high quality is also key to effective use of funds, and this topic is discussed in the next chapter. With respect to duplication, the committee notes that planned duplication of research—building on past research as a starting point for further investigation—is a key component of knowledge growth. In contrast, unplanned duplication that fails to take account of prior research can be wasteful of funds. Organizations funding highway safety research generally take measures to try to avoid such unplanned duplication. For example, NCHRP strongly encourages those submitting research proposals to conduct a literature search to make sure a problem has not already been solved or is not already under study, and FHWA requires state DOTs to check the RiP Database before embarking on a project. The availability and quality of databases such as RiP and their use by both funders and researchers are critical in helping to avoid unnecessary research duplication.

Coordinating research not only can eliminate unnecessary duplication but also can lead to the funding of high-priority research at a level needed to ensure a scientifically robust outcome. For example, individual state DOTs rarely have the necessary resources to conduct the scientifically sound evaluations needed to define credible accident modification factors (AMFs).[6] Because of this resource limitation, considerable national effort is aimed at establishing sound AMFs. Much of this work is funded by NCHRP [for example, NCHRP projects on crash reduction factors for traffic engineering and ITS improvements (17-25), on methodology to predict the safety performance of urban and suburban arterials (17-26)

[6] AMFs were formerly referred to as crash reduction factors.

and of rural multilane highways (17-29), and on the development of the *Highway Safety Manual*] or by FHWA through pooled fund evaluations of low-cost treatments. In the committee's judgment, these relatively well-funded national efforts, which use state-of-the-art evaluation methods, are likely to produce more credible AMFs than efforts by individual state DOTs with limited funding.

FHWA's Role

FHWA historically has played a major role in coordinating its own highway research and that funded by state DOTs with other funders, as discussed in Box 2-2. The agency's current coordination role, however, is more modest, focusing primarily on coordinating its own research with efforts within NCHRP, the Long-Term Pavement Performance (LTPP) program, and the TPF program. In response to a recommendation from the Research and Technology Coordinating Committee, FHWA is also hosting a series of workshops to provide opportunities for interaction and coordination among researchers and organizations conducting highway research (see the section Coordination of UTC Research Activities in this chapter).[7]

NCHRP

Since 1962, FHWA has assisted states in funding NCHRP, a large-scale and continuing pooled fund program. All states share in the development of the annual work program and participate in the panels that oversee individual projects. FHWA also suggests projects to be funded through NCHRP, reviews and rates projects as part of the annual program, and provides staff to serve on NCHRP panels. On occasion, the agency also supplements funding of individual projects.

LTPP Program

A different coordination model exists in the LTPP program, which is the nation's largest single highway research project in terms of total funding

[7] These coordination activities address the broad spectrum of highway research, rather than simply research on highway safety.

BOX 2-2

FHWA's Role in Coordinating Highway Safety Research

Starting in about 1973, FHWA began actively coordinating its own highway research and that sponsored by the state DOTs through the Federally Coordinated Program (FCP) of Highway Research and Development (USDOT 1976, 1). From 1973 to about 1986, FHWA oversaw the research projects proposed by the states in their SP&R programs to coordinate work in priority areas, specifically including safety, and to avoid duplication. Priority areas included improved highway design and operation for safety, reduction of congestion and improved operational efficiency, and improved materials utilization and durability. Coordination was carried out by FHWA staff identifying priority areas, hosting biannual meetings of FHWA and state DOT R&D staff working in an area to develop and coordinate multiyear programs of research, and assigning roles to participants. When states subsequently proposed work in an identified area of national interest, FHWA worked with them to develop projects that would fit within the existing program plan.

Beginning in 1987, and consistent with the general devolution of the federal aid highway program during this era, the FCP was replaced with the Nationally Coordinated Program (NCP) of Highway Research, Development, and Technology. Under the NCP, FHWA's goals focused on concentrating resources on the most urgent problems, avoiding duplication, and identifying and highlighting gaps (USDOT 1987). With the NCP, FHWA apparently withdrew from active coordination of state research programs, at least in part as a result of resource constraints (Brach 2002). FHWA's R&D office no longer approved individual SP&R projects; instead, FHWA division offices began reviewing and approving state research programs as a whole (TRB 1994, 58).[a]

(continued on next page)

BOX 2-2 *(continued)*
FHWA's Role in Coordinating Highway Safety Research

With the passage of ISTEA in 1991, which gave states more flexibility across the board in the use of federal aid, FHWA modified the regulations pertaining to the conduct and use of SP&R funds to give states greater discretion (58 FR 67510). Coordination became limited to requiring states to establish procedures to avoid investing in duplicate research and strongly encouraging states to combine resources to fund research projects of common interest. To avoid duplication, FHWA specifically required states to enter all new research projects in TRB's Transportation Research Information Services Database and to check the database before initiating projects.[b] FHWA's changed posture with regard to highway research by the states was entirely consistent with its changed posture with regard to control of federal highway aid to the states, but the changes created something of a vacuum in coordination of the entire SP&R program, a role that FHWA had formerly filled.

[a]Requirements that pertain to SP&R funds are summarized at www.tfhrc.gov/sprguide.os.htm.
[b]At the time of this rule making, the database included the RiP Database as a subfile. RiP was subsequently established as a separate database freely available on the web.

over the multiple years of the program. In this model, FHWA and the states have shared in funding various components of the program under FHWA's leadership.

TPF Program

As noted, FHWA also encourages and supports a pooled fund mechanism whereby groups of states, together with other research funding organizations, can combine resources to study a particular topic. FHWA manages

a website, provides administrative support to ad hoc pooled fund efforts, and initiates and collaborates in such projects.

AASHTO's Role

As noted, AASHTO's SCOR plays a major role in research supported by state DOTs. As such, SCOR is well positioned to coordinate such research efforts, ensuring that topics of major importance to state DOTs are funded and helping to avoid unnecessary duplication. SCOR's responsibilities include encouraging the effective use of research funding, serving as a forum and coordinating committee for highway and other transportation research, and fostering coordination of the various national programs of highway and other transportation research.[8] AASHTO's Standing Committee on Highway Traffic Safety cooperates closely with SCOR in promoting research on significant highway safety issues.

Coordination Across Federal Agencies

Coordination of highway safety research across federal agencies has been irregular and ad hoc in the past, but it has become more common over the last dozen years or so as USDOT leaders have attempted to overcome strictly modal perspectives of the administrations that make up the department. Although their highway safety responsibilities are fairly distinct, FHWA and NHTSA have begun to work collaboratively with each other, as well as with FMCSA, on topics of common interest, such as speed management. Moreover, all agencies in USDOT participate in a human factors research committee that shares information and coordinates research in this area of common interest. Some reorganizations within USDOT may not have facilitated coordination. Until 1999, for example, FHWA managed truck safety research. With the creation of FMCSA in 2000, FHWA's motor carrier research activities were moved to FMCSA. FHWA, however, has continued to fund limited research concerning infrastructure effects on truck safety.

[8] Further information on SCOR's roles and responsibilities is available at research.transportation.org/?siteid=55&pageid=853.

Coordination of UTC Research Activities

The extent of research coordination across the UTC program is difficult to assess because of the program's many components. Twenty centers at the regional and Tier 1 levels are selected competitively. All centers, whether selected competitively or named in legislation, are required by RITA to develop unique theme areas to discourage duplication. In practice, however, the centers are heavily dependent on finding matching funding; thus, the sponsor providing the match effectively dictates the research agenda. Some UTCs are themselves consortia with similar interests, suggesting that there may be coordination among individual UTCs within a consortium. With the relatively new, noncompetitive UTCs created under SAFETEA-LU, however, it is too soon to know to what extent research will be coordinated to avoid duplication with efforts elsewhere. FHWA recently initiated efforts to increase coordination between the federal and university highway research programs and hosted three workshops with UTCs in 2006—one on congestion, one on highway safety, and one on infrastructure. Approximately 20 UTCs attended the highway safety workshop.

Proposed New Safety Research Process

The National Highway Research and Technology Partnership's Safety Working Group identified a number of current and emerging issues with highway safety research, including overlap and fragmentation, variable research quality leading to concerns about the implementation of research results, and changes in the quantities and types of data available for research as event data recorders, other vehicle-mounted sensors, and ITS technologies come online. In an effort to address these and other issues, the group examined the research processes used by organizations outside of the traditional highway research arena, such as the National Institutes of Health, to determine whether useful lessons could be learned from experience in other research fields. The group's resulting white paper, Proposed Safety Research Process for Carrying out the National Highway R&T Partnership, presents a process that starts with the development of a national research agenda and ends with the implementation of research findings.[9] Two expert groups, the Safety Research Advisory

[9] The unpublished paper was made available to the study committee to inform its discussions and deliberations.

Committee and the Highway Safety Scientific Review Group, play major roles in the various steps of the proposed process, from formulating and prioritizing research needs through reviewing research proposals to performing research. A key feature is the focus on eliminating current stovepipes, whereby organizations conduct research largely independently of each other. Thus, the process envisages all research funding organizations—states, USDOT, universities, private-sector organizations, and others—coordinating all their research needs and activities through the Safety Research Advisory Committee and Highway Safety Scientific Review Group.

The purpose of the Safety Working Group's white paper was to stimulate discussion and refinement of the proposed process, and it was examined by the current committee in this light. The committee's comments on the proposed process are presented in Chapter 6 in the broader context of its overall findings and conclusions about research priority setting and coordination.

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Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
TRB	Transportation Research Board
USDOT	U.S. Department of Transportation

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3

Improving Research Quality

The National Highway Research and Technology Partnership's Safety Working Group joined other organizations and individuals in expressing concern about the quality of highway safety research and proposed an initiative to improve various aspects of the research process, including research quality (see Chapter 2). At the group's Safety Research Agenda Planning Conference in Irvine, California, in September 2002, a representative from the Federal Highway Administration (FHWA) observed that practitioners need to have confidence that research results are going to work. If research is not done the way it should be, state and local organizations with responsibility for road safety do not have the necessary confidence that proposed countermeasures, if implemented, will be effective (Hanscom 2002). In a recent paper about the future of road safety management, Hauer observes that the main purpose of research on road safety is to help answer the question, How is Action X likely to affect crash frequency or severity? He goes on to note that readers who have attempted a critical review of the literature on a subject such as the safety effect of lane and shoulder width on two-lane rural roads "will attest to the fact that many of the research reports found will be quickly discarded" because they are "too deficient in method, too small to draw conclusions from, inconclusive, obsolete, of obscure message, biased, or otherwise seriously flawed" (Hauer 2005, 337).

In light of the concerns expressed by the partnership's Safety Working Group and others, the committee was asked to comment on strategies to improve research quality. The members noted that if research funding is to be well spent, it is necessary not only to select the "right" topics, but also to ensure that research on these topics is of high quality. They also observed that the transition toward science-based road safety management

is creating a growing demand for information produced by competent researchers with good data and methods.

This chapter discusses factors that may hinder the conduct of high-quality road safety research, namely, the challenging nature of the research, the need for multidisciplinary research teams, and the shortage of trained researchers. It then explores opportunities for improvement during the various steps of the research process—identification of research needs and development of problem statements; identification of qualified researchers and award of funds; and monitoring of ongoing research and assessment of final outputs. The focus throughout is on efforts that could help ensure more effective use of limited research funds as the road safety community transitions toward science-based road safety management.

FACTORS AFFECTING RESEARCH QUALITY

A Challenging Research Area

The problems confronting road safety researchers are generally not easy to tackle. Not only do they involve elements of many disciplines, ranging from civil and mechanical engineering through statistics and psychology to public health, but also data are frequently limited in quantity and of variable quality. Furthermore, the conduct of controlled experiments is seldom possible, and methodologies may be lacking. Two examples illustrate some of these difficulties.

In a discussion of the harm done by tests of significance, Hauer relates the experience of researchers investigating the impact of allowing right turn on red (RTOR) at signalized intersections (Hauer 2004). A number of studies had shown increases in accidents following RTOR signing, although these increases were not statistically significant for the relatively small data sets used in each study. It was only after RTOR had been nearly universally adopted in North America that several large data sets became available and the adverse effect of RTOR on safety was established. This example illustrates the difficulty encountered by researchers when data are limited and sometimes of questionable quality. Because none of the individual data sets showed a statistically significant effect, each study taken in isolation led to the conclusion that

the researchers could not be sure the safety effect of RTOR was not zero, even though the results taken together all pointed toward an adverse impact on safety.

The impossibility in most road safety research of conducting experiments in which causal factors are either held constant or randomized leads to further difficulties. Hauer observes that "all we know about the safety effect of horizontal curvature, lane width, grade, sight distance, traffic control devices, etc., comes from . . . uncontrolled comparisons [in which] there is always a multitude of causal factors to be accounted for" (Hauer 2002a, 8). Many studies of these safety effects are cross-sectional in nature, comparing sites with the differing characteristics of interest (e.g., different median widths). But these sites also differ in other characteristics, some measurable and some not. Inferring cause from such studies is much more difficult than when a well-designed and scientifically sound "before–after" study is possible, that is, a study in which some characteristic actually changed at a given site. Hauer goes on to discuss the example of research on the relationship between accident frequency and lane width on rural two-lane roads. A body of empirical evidence suggested that accident frequency on such roads is at a minimum for lane widths between 11 and 12 feet. However, the choice of a functional form that cannot have a minimum for modeling purposes led to the conclusion that, in general, the wider the lanes (up to 13 feet or so), the fewer the accidents. Reanalyses of data for two-lane rural roads show this conclusion to be true for lanes up to 11 feet in width, but lanes wider than 12 feet may increase crashes. The original model results, however, have had a considerable influence on highway safety design, illustrating that a lack of research quality control can have undesirable practical consequences.

Need for Multidisciplinary Research Teams

Crashes are complex events resulting from a combination of factors affecting the driver, the vehicle, and the roadway. Thus, highway safety research frequently requires multidisciplinary teams with knowledge of engineering, psychology, human factors, economics, statistics, education, law enforcement, systems analysis, marketing, biomechanics, and public health. Unfortunately, such teams are formed rarely.

During the 2002 Safety Research Agenda Planning Conference, participants noted that the requirement for multidisciplinary teams is of particular concern in the field of highway safety, in which research efforts are fragmented, generally uncoordinated, and geographically dispersed (Hanscom 2002). In particular, the requirement raises concern about the opportunities afforded researchers working alone or in small groups to interact as needed with their peers. The number of road safety professionals working in any one organization may not be large enough to cover the range of disciplines required. State departments of transportation (DOTs), for example, may not have the critical mass of expertise needed to ensure that their research is based on sound methodologies (Council 2006). In this context, the committee was encouraged to learn that the Iowa Department of Transportation has expanded its Safety Research Program's focus group to become a regional group, with participants from Missouri, Kansas, and Nebraska invited to attend (see Table 2-2).

Participants in the Safety Research Agenda Planning Conference suggested that establishing centers of excellence on selected topics could overcome some of the difficulties associated with the decentralized nature of the highway safety research enterprise, although sources of funding for such centers were not explored.

Shortage of Trained Researchers

The preceding discussion of the challenges and multidisciplinary nature of highway safety research illustrates clearly the need for specialized training of researchers in this field. Although highway safety research was for many years treated as an adjunct to other disciplines, notably civil engineering, it has now emerged as a discipline in its own right requiring appropriate education and training of professionals (TRB 2007b). According to Hauer, several conditions combine to produce reliable research results, and paramount among these conditions is that "the researcher be well trained both in road safety knowledge and in methods of road safety research" (Hauer 2005, 337). The committee notes that this is particularly true since there is no single "research protocol" that describes the best methodology for all safety research efforts. The most scientifically sound methodology possible should be used, but the choice

of methodology will depend on a number of factors, including the nature of the research question and the nature of the data available for use. Thus, the needed training should cover multiple methods, multiple data types and qualities, and how the choice of "best method" can be made. Hauer goes on to note that civil engineers typically do not receive any training in the kind of research method needed in road safety. The personal experience of individual committee members in reviewing manuscripts of technical papers on road safety research indicates that without appropriate education and training and mentoring, research of questionable quality is often produced.

Several groups have echoed Hauer's statements, expressing concern that the highway safety community is unprepared for recruiting and developing the next generation of professionals, including researchers. The Transportation Research Board (TRB) Joint Subcommittee for Highway Safety Workforce Development was formed in 2003 to raise awareness of the lack of education and training opportunities available for highway safety professionals. The subcommittee initiated and guided a study, based on a scan of U.S. universities, to reveal the extent to which core competencies for highway safety professionals are incorporated into existing safety curricula and suggest strategies to expand application of these core competencies to a broader audience (TRB 2006). The study authors surveyed 151 university programs, 117 in engineering and 34 in public health. The 36 responses received revealed significant gaps in coverage in all competency areas, further substantiating observations about deficiencies in road safety training.

A recent TRB policy study addresses the current and future supply of and demand for highway safety professionals in the public sector and recommends approaches to building the pool of trained individuals to meet the rising demand (TRB 2007b). Hence, this topic will not be addressed further here, except to note that the committee endorses the report's observations about the need for more well-trained highway safety professionals, including researchers.

One outcome of the shortage of trained highway safety researchers is that the technical literature is all too often characterized by poor-quality research leading to unreliable conclusions. [See Hauer (2002a) for examples.] In most research fields, peer review is effective in restricting the

number of unsatisfactory research investigations appearing in the professional literature. In the road safety field, however, a shortage of qualified reviewers has sometimes led to low barriers to publication. As illustrated by the previous examples, the publication of poor-quality research can have a lasting and deleterious effect on efforts to improve road safety.

OPPORTUNITIES FOR IMPROVEMENT

As discussed in Chapter 2, the organizations that fund research in highway infrastructure and operations safety use a variety of approaches to identify topics for research and select projects for funding (see Tables 2-2 and 2-3). These initial steps are critical in determining whether a quality product will ultimately result, although a good start alone is not sufficient to ensure a valuable final outcome. Additional quality control measures are needed during the conduct of research and before the distribution and publication of results. Table 3-1 summarizes information on the quality control measures currently applied by the aforementioned funding organizations.

The personal experience of individual committee members suggests that consideration of the following questions is helpful in assessing whether quality research is likely to result from a program or project:

- Who is involved in identifying research needs and developing problem statements?
- How are qualified researchers identified and on what basis are funds awarded?
- What quality control measures are used during the conduct of research and before the distribution and publication of results?

The following sections discuss these three questions and identify possible changes to current practices that could help improve research quality.

Identifying Research Needs and Developing Problem Statements

In the committee's view, detailed knowledge of research findings, methods, and data is critical in identifying research needs and developing the resulting individual problem statements, as discussed in the following paragraphs.

TABLE 3-1 Conduct of Research: Ensuring Quality

Organization	Quality Control Measures Used During the Conduct of Research and Before Distribution and Publication of Results
Federal	
CDC/NCIPC	NCIPC staff reviews research progress while a project is under way. Once the research is completed, authors are expected to publish their work in peer-reviewed journals. Journal peer review does not involve NCIPC staff and thus provides an independent external assessment of the research.
FHWA	Research contractors are required to report regularly on their progress, and FHWA staff provides ongoing oversight and feedback. For some projects, a technical working group comprising representatives of state and local agencies also provides oversight and feedback about the potential usability of the project results in the field. For reasons of cost, FHWA does not require independent peer review before accepting a research report. FHWA reports are routinely turned into papers submitted to peer-reviewed journals. In accordance with new Office of Management and Budget regulations, some research products now require peer review by experts within the U.S. Department of Transportation.
FMCSA	FMCSA staff exercises oversight (monthly reports, quarterly briefings, and so on) during the course of a project. There is no requirement for external peer review of final reports, although new Office of Management and Budget regulations now require peer review involving experts in other parts of the U.S. Department of Transportation.
NHTSA	NHTSA staff provides oversight through initial and interim meetings and briefings and monthly progress reports. A final report is submitted to NHTSA, and authors are required to submit a paper to a peer-reviewed journal.
State	
NCHRP	Project panels typically meet with the contractor to review an interim report and gauge progress. Once a project is completed, the panel members also serve as reviewers of the final report. NCHRP will not publish research reports that do not gain the panel's approval.
Iowa DOT	A state DOT staff person is usually designated as the contract manager for a project, but for some projects a technical panel provides oversight. On completion of the work, researchers are not expected by the state to publish their work, but many attempt to do so.
PennDOT	Each project has an oversight panel that monitors the time line, budget, and deliverables. This panel comprises technical experts and a representative of PennDOT's Research Division, who provides contractual expertise. Final reports must be reviewed and approved by all project panel members before being accepted and published as PennDOT research reports.
Private Sector	
AAA Foundation for Traffic Safety	Final research reports are subject to independent external peer review. Foundation staff selects reviewers and evaluates whether the authors' responses to the reviewers' comments are adequate. Staff may on occasion ask reviewers to assess the adequacy of the responses. The reviewers are compensated for their reviews. Contrary to widespread practice, the review is not blind; the authors and reviewers know one another's names during the review process.
IIHS	At IIHS, research is conducted and monitored in-house.

NOTE: CDC = Centers for Disease Control and Prevention; NCIPC = National Center for Injury Prevention and Control; FMCSA = Federal Motor Carrier Safety Administration; NHTSA = National Highway Traffic Safety Administration; NCHRP = National Cooperative Highway Research Program; IIHS = Insurance Institute for Highway Safety.

Multidisciplinary Approach to Identifying Research Needs

Examination of Table 2-2 indicates that some organizations currently take minimal advantage of the knowledge and expertise of the broad research community in identifying topics for research, preferring instead to rely on in-house expertise. While this expertise may be strong in certain areas, it is not clear that all research funding organizations possess in-house the necessary breadth and depth of knowledge, particularly given the aforementioned importance of multidisciplinary teams in highway safety research. Thus, the observation that few organizations currently include outside research expertise in setting their research agendas is cause for concern. Bringing external experts, including knowledgeable researchers, into the agenda-setting process could help ensure that the necessary multidisciplinary knowledge is brought to bear in identifying research needs.

Potential of Research to Meet the Needs of Safety Program Managers

A related concern is that some organizations apparently limit the group responsible for identifying research needs to those charged with implementing road safety measures. Selecting research topics exclusively on the basis of user needs has drawbacks. Although experienced safety program managers are likely to be well versed in safety needs, some, through no fault of their own, may lack the research knowledge and experience necessary to make an informed judgment about the potential of research to meet these needs. Thus, they may perceive research as able to solve highway safety problems without realizing that the necessary data or methods to answer the questions being posed are neither available nor readily obtainable. In such cases, funding may be better spent on research topics deemed to be of lower priority but for which data and methods are available. Given the aforementioned technical challenges of highway safety research, advice from knowledgeable researchers is generally needed to assess whether a proposed project is feasible.

Research proposals developed by researchers without the benefit of input from experienced safety program managers, however, run the risk of being impractical because of a lack of awareness of the real-world environment. Thus, input from both experienced safety program managers

and knowledgeable researchers is desirable in identifying research needs and developing problem statements.

Balancing Short- and Long-Term Research Activities

Experienced safety program managers often direct research toward the symptoms of a road safety problem, focusing on short-term efforts to find a solution. In contrast, knowledgeable researchers may be more inclined to direct research toward the cause of a problem and toward longer-term and more fundamental efforts aimed at identifying and understanding this cause. Both perspectives have merit. Safety program managers may argue, with justification, that their primary focus must be to address urgent safety issues. Nonetheless, the full benefits of science-based road safety management will not be achieved without fundamental research, the aims of which include developing methods to produce more trustworthy results and theories to guide productive research, as well as building better research databases. As a number of the projects discussed in Appendix B illustrate, better methods, models, and data are critical if research is to lead to the desired safety enhancements.

Concerned that many major funders of highway safety research—FHWA, the National Cooperative Highway Research Program (NCHRP), and state DOTs—have traditionally focused on applied research with narrowly defined objectives and near-term implementation as a goal, participants in the 2002 Safety Research Agenda Planning Conference discussed the need for a broader highway safety research program covering a spectrum of activities, ranging from short-term applied research to long-term fundamental research of a more exploratory nature (Hanscom 2002). The Research and Technology Coordinating Committee (RTCC), a committee established under the auspices of the National Research Council to provide advice to FHWA on its research program, addressed this same point in the overall context of highway research, recommending in a 2001 report that FHWA's research and technology (R&T) program "should focus on fundamental, long-term research aimed at achieving breakthroughs in the understanding of transportation-related phenomena" (TRB 2001, 6). The report also recommended that at least one-quarter of FHWA's R&T research expenditure should be invested in such fundamental, long-term research.

FHWA's new Exploratory Advanced Research Program (EARP), established in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (Public Law 109-59, Aug. 10, 2005), is a step toward establishing a broader research portfolio encompassing both short- and long-term activities. Approximately $20 million is available for funding projects over the first 3 years of the program. The federal share of the cost of a project is limited to 50 percent. The broad agency announcement (BAA) soliciting proposals under the EARP highlights the importance of projects that could lead to "transformational changes and truly revolutionary advances in highway engineering and intermodal surface transportation" (FHWA 2007).

Highway safety is one of six focus areas identified in the BAA, and proposers are invited to address research that would supplement and complement existing safety research programs, including short-term safety improvement initiatives, longer-term research on intelligent transportation systems, and the SHRP 2 research on understanding crashes. Four safety areas are identified as being of particular interest: enhanced understanding of the importance of the visibility of the roadway, innovative technologies to detect the presence of pedestrians and other vulnerable road users, parameters for a long-term ground traffic control system, and enhanced understanding of the relationship between the vehicle and the roadway (road surface) with a view to improving vehicle control. One of the other focus areas listed in the BAA—crosscutting exploratory advanced research—also invites proposals for longer-term, high-risk research that could bring about dramatic breakthroughs for improving various aspects of highway and intermodal transportation systems, including safety. Bicycle and pedestrian safety is highlighted as being of particular interest.

The committee views the EARP as a potentially important first step toward a more balanced FHWA research portfolio encompassing both short-term applied and longer-term advanced/exploratory research. The dedicated funding for advanced/exploratory research and the move to crosscutting higher-risk research are welcome features, as is the designation of high-priority topics aimed at fundamental, long-range issues rather than specific current problems.

Like RTCC, however, the committee questions whether a 50–50 match is appropriate for advanced research (TRB 2007a). For any sizable research

project, the primary source of matching funds would appear to be state DOT research funds; most researchers have little access to other funds that could provide a match at the required level. Experience indicates, however, that state DOTs are likely to want to direct their research funding to topics of immediate need. Thus, if flexible cost-sharing approaches to meeting the 50–50 match requirement are not found, the EARP could lose its fundamental/advanced focus. It remains to be seen whether the EARP will fulfill its initial promise and become a model for broadening the highway research portfolio to include longer-term advanced research in addition to traditional short-term applied research funded outside of the EARP.

Researcher Input to Problem Statements

Once critical research needs have been identified, input from knowledgeable researchers is needed to develop problem statements. NCHRP, which funds research on highway safety and a variety of other topics, routinely includes researchers on panels charged with developing detailed problem statements. This practice is to be commended. In general, however, only a relatively small number of panel members (normally one or two individuals) are researchers. In the case of highly applied engineering topics, the relative paucity of expert researchers on the panel may be entirely appropriate, given the focus on short-term implementation of research results. In the case of highway safety research, however, the complexity and multidisciplinary nature of the topic suggest that the limited participation of researchers on project panels could fruitfully be increased on occasion. For example, expert knowledge about the availability and quality of research databases may be key in determining whether a project is feasible, as illustrated by several projects discussed in Appendix B.

Investigator-Initiated Research

Traditional road safety research funding organizations, such as the American Association of State Highway and Transportation Officials (AASHTO) and FHWA, generally define both research areas and project descriptions (or projects) more tightly than do federal agencies that fund

safety or health research, such as the Centers for Disease Control and Prevention's (CDC's) National Center for Injury Prevention and Control (NCIPC) and the National Institute on Alcohol Abuse and Alcoholism (Council 2006). The latter two agencies are more likely to define a wider research program area and allow researchers to propose both the most important subtopics and the best research methods. FHWA's new EARP, however, provides an important opportunity for encouraging investigator-initiated highway research.

The committee notes that, as written, the EARP appears to suggest strongly that research address certain fairly focused areas. For example, within the topic of enhanced understanding of the importance of the visibility of the roadway, the subtopics of lighting and pavement marking are explicitly highlighted. Even in the crosscutting exploratory advanced research area—the area most open to investigator ideas—the BAA suggests that bicycle and pedestrian safety is of interest, thereby implying that ideas in other areas may be considered less favorably. In practice, it may transpire that the EARP is in fact open to all investigator ideas, with the onus on the researcher to justify his or her research topic as offering greater promise than the topics or subtopics proposed by FHWA. In the committee's view, however, the wording of such BAAs is critical in determining the research proposed. Even if an open field was FHWA's intent, the current wording could be construed as limiting topics that will receive favorable consideration for funding. FHWA has the opportunity in subsequent years to make sure that the broad exploratory nature of the EARP is clear to those considering submitting proposals.

A related concern is the lack of transparency surrounding the selection of the topics and subtopics designated in the BAA. While the areas identified (visibility, pavement surface effects on safety, pedestrian and bicycle detection, etc.) may well be worthy of investigation, it is not clear how these areas were chosen. Those wishing to propose and justify other areas of investigation could benefit from knowing what criteria FHWA used in selecting its research topics and subtopics.

Investigator-initiated research may not meet all the needs of the highway safety community. Nonetheless, by providing broad research opportunities and giving considerable flexibility to the researcher, this approach

may result in valuable knowledge, particularly in the case of fundamental research aimed at finding innovative, rather than incremental, solutions to safety problems. As discussed in the next section, ensuring that quality products result from a broad research portfolio of short- and long-term activities is likely to require a variety of approaches not only to identifying research topics and developing problem statements but also to identifying qualified researchers and awarding funds.

Identifying Qualified Researchers and Awarding Funds

In a discussion of the benefits of competition and peer review, Brach and Wachs state a principle, long held in scientific circles, that "the competitive award of research funding based on the judgment of scientific peers is the best way to ensure high quality research" (Brach and Wachs 2005, 503). These authors also note that research requires a high degree of expertise and that high-quality research "is not easily discerned by a standard test or a predetermined procedure." For these reasons, the tradition of open competition and peer (merit) review "has been considered the best way to arrive at research funding decisions."

Importance of Open Competition

The research programs of both major highway safety research funding organizations—NCHRP and FHWA—have traditionally been based on open competition. While the NCHRP program remains open, the amount of national research funding for highway safety awarded through such open competition has decreased significantly in recent years, in large part because of the increased proportion of FHWA research funding being earmarked by Congress. (In the present context, earmarking refers to the practice of designating a research area or project, a funding amount, and a recipient.) Brach and Wachs note that in FY 1997, the last year before the implementation of the Transportation Equity Act for the 21st Century (TEA-21), approximately 12 percent of FHWA's research and technology deployment program was earmarked. Most of the remaining 88 percent of FHWA's R&T funding was expended in the form of competitively awarded contracts and other types of agreements with private firms and universities to perform agency-directed research (Brach and Wachs 2005).

Following the passage of TEA-21, earmarking increased significantly, averaging 29 percent of FHWA's R&T program over the TEA-21 years.[1]

Congressional earmarking of research funds is a cause for concern in the present context because of its adverse impact on research quality (Brach and Wachs 2005). As noted by RTCC, "designation of specific projects or research institutions without open competition occurs at the expense of missing creative proposals prepared by the most qualified individuals and organizations throughout the nation and does not reflect the consensus of national highway stakeholders on research needs" (TRB 2001, 8). Thus, earmarking not only bypasses established mechanisms (open competition and merit review) for ensuring the maximum return on investment of research funding but also diverts funds away from priority research areas.

Efforts to improve the quality of highway safety research in general are likely to be hampered by the difficulty of influencing safety research earmarks to ensure that the funds are well spent by good researchers working on worthwhile topics. For example, if funds are awarded to organizations with little knowledge and experience in highway safety, the absence of formal quality control mechanisms involving experienced researchers in the field limits opportunities to ensure that research efforts build on existing knowledge by using robust methods and data.

Value of Merit Review

Examination of Table 2-3 reveals that CDC's NCIPC is the only one among the organizations listed that routinely uses a formal review by external research experts to assess the scientific merit of research proposals, although the AAA Foundation for Traffic Safety uses such reviews on occasion. NCHRP includes researchers on its project panels, as previously noted, and panel responsibilities include reviewing research proposals. However, a greater degree of researcher involvement could be beneficial when safety research proposals are evaluated.

The reasons for the limited use of expert review of research proposals by organizations funding highway infrastructure and operations safety

[1] The figure of 29 percent represents the final level of earmarking after the application of obligation and administrative limitations (Brach and Wachs 2005).

are not clear, although the focus on short-term applied research may partially explain current practice. Organizations with a strong tradition of long-term fundamental research, possibly investigator initiated, also tend to be those that make extensive use of review of research proposals by independent experts in the field. The resulting "revise and resubmit" process is one of the mechanisms by which the quality of scientific inquiry is gradually improved (Brach and Wachs 2005). There is, however, no reason why the benefits of this process should be limited to fundamental research. More expert (researcher) review of requests for proposals, research proposals, and work plans in general could yield benefits in improved research quality (Council 2006).

FHWA's *Corporate Master Plan for Research and Deployment of Technology and Innovation* (FHWA 2003) notes the agency's commitment to including stakeholders in merit review during various phases of the R&T process. Assuming that "stakeholders" in this context includes researchers, the committee is encouraged by FHWA's commitment and looks forward to its implementation. The EARP would appear to provide just such an opportunity—for example, through the appointment of an external scientific review group to provide input to FHWA on the scientific merit of the proposals.

Alternatives to Requests for Proposals

Participants in the Safety Research Agenda Planning Conference suggested that a broader highway safety research portfolio may necessitate a broader array of methods for identifying research topics and qualified researchers and for awarding funds (Hanscom 2002). Thus, BAAs, requests for inquiries, requests for applications, and unsolicited researcher-originated proposals may be needed to supplement the more traditional requests for proposals. Council explores this same theme, highlighting the importance of broad research opportunities that give researchers flexibility to explore knowledge gaps—for example, ways of reducing "total harm" at high-volume intersections (Council 2006). The BAA for FHWA's EARP is a recent example of such alternative approaches for initiating research. As Council also noted, because these new approaches will likely produce proposals on far-reaching topics rather than on only one topic, more expert (researcher) input in assessing the scientific merit of the research proposals will be critical.

Using Quality Control Measures During Research and Before Publication of Results

Monitoring Research Progress

Grant research, as funded by CDC, the National Institute on Alcohol Abuse and Alcoholism, and others in the health area, generally includes relatively few formal "controls" during the conduct of research. Once the research proposal has been vetted and approved by the external expert panel and the agency, the researcher is left to conduct the research with limited oversight. Some highway safety researchers argue strongly that such a path allows for more innovation during the conduct of research and results in a higher probability of knowledge breakthroughs. [See, for example, "An (Old) Researcher's Tale" (Hauer 2002b).] Some research funders and users, however, would argue strongly that there must be oversight during the conduct of research to increase the chance of reaching the project goal. The perceived need for more control is likely the result of a number of factors, including the nature of most roadway and infrastructure research (i.e., topics of limited scope related to current problems) and the long-standing tradition of managerial control over research in this area.

Revising the Approach

While bringing together such divergent viewpoints is difficult, a middle ground that could lead to both high-quality research regardless of topic and an acceleration of science-based safety knowledge could include the following features:

1. A dedicated proportion of available funding being set aside for advanced or fundamental research with less "funder control" of topics and more flexibility to accommodate research direction changes during a project, and
2. More researchers serving as external reviewers during the conduct of research.

The first feature would require that the major funding organizations set aside some proportion of research funds for advanced or fundamental research that is open to researcher-initiated ideas, following the proven model of CDC and other agencies in the health arena. As discussed by

RTCC (TRB 2001), this would require a fundamental change in the way research is conducted but is clearly feasible, as illustrated by FHWA's EARP. While the amount of funding for this program falls short of the 25 percent of FHWA's R&T expenditure recommended by RTCC, the program is nonetheless an encouraging step.

The second feature would require increased researcher input during the conduct of research projects. For NCHRP, this could be readily achieved by increasing the number of researchers on project panels. For FHWA, which usually monitors research by using only its internal staff, a bigger change would be required. Once a contract has been awarded, FHWA could convene a panel of research experts to review the contractor's proposed work plan before implementation. FHWA then could use this same panel to assess and advise on methodology and data issues arising during the conduct of research. As noted earlier, the agency's *Corporate Master Plan for Research and Deployment of Technology and Innovation* (FHWA 2003) commits to including stakeholders in merit review during various phases of the R&T process, as well as in research project and program evaluations and reviews, suggesting that changes will be forthcoming. The EARP provides an opportunity to put this commitment into practice.

Assessing Research Output

Reviewing the findings before publication or distribution is as important as monitoring quality during the conduct of research. Current practices among organizations that fund research on highway infrastructure and operations safety are summarized in Table 3-1. The major funding organizations, FHWA and NCHRP, encourage but do not require significant independent peer review of project findings. FHWA's Office of Research and Technology has instituted a policy of strongly encouraging or requiring submission of research papers to TRB for publication in the *Transportation Research Record: Journal of the Transportation Research Board.* NCHRP allows such publication of its project findings. While the aforementioned shortage of qualified researchers has sometimes made it difficult for TRB to ensure a sound scientific review of all papers submitted, the committee has observed a great improvement in the quality of *Record* papers during the past decade. Part of this improvement is due to better research methods and more qualified reviewers and part is due to the fact

that TRB has instituted a ceiling on the number of papers published annually, thereby raising the publication standard.

One outstanding concern relates to the project reports required by NCHRP and often by FHWA. The review process for *Record* papers often occurs after submission of the final project report. Thus, there may be little chance to modify this report because the project has been completed and no funding remains. As illustrated by the earlier example of the effect of lane width on accident frequency on rural two-lane roads, unsatisfactory research reports can have a lasting and detrimental effect on highway safety design practices if not corrected promptly. Some changes to existing procedures could help ensure that the benefits of the *Record* peer review are captured in NCHRP and FHWA reports. Both agencies could hold open a research contract until after *Record* review is completed, thereby allowing for changes in response to the peer review comments to be reflected in the final report. Alternatively, both agencies could retain additional researchers during the final report review process.

CONCLUDING REMARKS

In summary, the committee concluded that quality research products are most likely to result if the needs of safety program managers, the state of current knowledge, and the potential for research to solve the problem under consideration are taken into account in identifying research needs and developing problem statements. Although mechanisms for ensuring quality need to be an integral part of the research process, from initiation through publication of the final results, a good product is unlikely to result without an informed assessment of research needs and a robust problem statement. Expert review of research proposals helps ensure that the proposed methodologies are valid and appropriate and the project objectives realistic.

The competitive award of research funding on the basis of the judgment of scientific peers is widely recognized as an effective means of greatly increasing the likelihood that research will be of high quality and is likely to have increasingly important benefits as the field of highway safety research transitions to a science-based approach. Competition should be open to all if the maximum return on investment of research funds is to ensue. The increasingly common practice of congressional

earmarking of federal research budgets is hampering efforts to improve research quality because it bypasses the established quality control mechanisms of open competition and merit review.

The transition to science-based road safety management will require changes to current practices to ensure research quality and the effective use of research funds. Most important, the trained and independent researcher needs to be a more influential partner, working with the experienced safety program manager to formulate research programs and projects, shape proposals, select researchers to perform the work, monitor ongoing research, and assess final results before publication. In addition, there may be benefits to setting aside a portion of available funding for investigator-initiated fundamental research aimed at developing better research methods and exploring innovative, rather than incremental, solutions to road safety problems. FHWA's EARP is a potentially important first step in encouraging such investigator-initiated research.

The committee sees the EARP as providing opportunities for FHWA to strengthen its advanced research program in the future through the involvement of outside experts in selecting research areas; increased merit review of research proposals and outputs by outside experts; and greater flexibility in cost sharing to ensure that more advanced and fundamental research is undertaken. Although changing features of the EARP that are written into legislation may not be easy, such changes are worth pursuing, given that the EARP is likely to be the only advanced/fundamental research program in the highway safety field. Thus, the committee views future expansion of this effort, both in increased funding and in implementation of the aforementioned opportunities, as crucial in supporting the transition to science-based road safety management.

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Abbreviations

FHWA	Federal Highway Administration
TRB	Transportation Research Board

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4

White Papers Commissioned by the Federal Highway Administration: An Exercise in Setting Research Priorities

In April 2002, the National Highway Research and Technology Partnership published its report, *Highway Research and Technology: The Need for Greater Investment* (National Highway Research and Technology Partnership 2002). This document is a first step in helping organizations that sponsor highway research identify research and technology (R&T) needs. Within the broad area of highway safety, the report lists eight R&T themes and emphasis areas within each theme. These emphasis areas, while useful in indicating areas in which research may be needed, do not provide the detailed guidance sought by sponsoring organizations in developing their R&T programs. For example, the emphasis areas under the theme of highway infrastructure and operations safety include human factor safety guidelines, consequences of leaving the road, and intersection safety. While widely acknowledged as potentially important for improving road safety, each of these areas comprises a multitude of more detailed topics that are candidates for further research. The National Cooperative Highway Research Program (NCHRP) 500 Series reports on run-off-road and intersection collisions, for example, describe a variety of experimental strategies that could be the subjects of further research (Antonucci et al. 2004; Neuman et al. 2003a; Neuman et al. 2003b).

This chapter describes follow-on efforts aimed at developing the partnership's list of research emphasis areas to a more detailed level for the specific R&T theme of highway infrastructure and operations safety. These follow-on efforts comprised

1. A research agenda planning conference hosted by the partnership's Safety Working Group, and

2. The subsequent commissioning by the Federal Highway Administration (FHWA) of a series of white papers that would build on the lists of critical research needs generated at the planning conference.

The committee was charged with reviewing the research projects proposed in the FHWA-commissioned white papers (see Appendix B). Given the inseparable nature of process and product, the committee also examined the process by which the papers were developed as part of its review. The lessons learned about research priority setting from this examination and from a retrospective evaluation of the research agenda planning conference are presented in the concluding section of this chapter.

RESEARCH AGENDA PLANNING CONFERENCE[1]

In September 2002, the partnership's Safety Working Group hosted a Safety Research Agenda Planning Conference in Irvine, California. The 60 conference participants included state highway agency researchers and traffic engineers, university researchers and research administrators, private-sector researchers, and representatives from the American Association of State Highway and Transportation Officials (AASHTO), FHWA, and the Transportation Research Board (TRB). A major objective of the conference was to start identifying and prioritizing critical highway safety research needs and information gaps in five of the emphasis areas highlighted by the partnership: run-off-road accidents, intersection safety, intelligent infrastructure initiative, human factors applications, and work zone safety.[2]

Following a plenary session comprising presentations on background topics, including TRB's Transportation Research Information Services Database, pooled research funds, research protocols, and infrastructure safety research needs, conference participants divided into five breakout groups, one for each of the five research areas of interest. Each group was tasked with identifying candidate projects needed in its research area

[1] Information on this conference was obtained from the proceedings (Hanscom 2002) and from individual conference participants, several of whom are committee members.

[2] Conference participants also worked on formulating a research program process (see Chapter 2) and discussed the need to improve research quality (see Chapter 3).

over the next 5 years. The projects selected would be those with the greatest potential to yield valuable knowledge that could ultimately lead to substantial improvements in highway safety.

The members of each group, not all of whom were experts in the research area under discussion, were provided with data on the size and nature of the safety problem and asked to address a series of questions. For example, the group dealing with run-off-road accidents considered the following questions:

- Why do drivers run off the road, and what do we know about it? What do we need to know?
- What do drivers and vehicles do when they run off the road, and what do we know about it? What do we need to know?
- What do we know about countermeasures (driver, vehicle, highway)?
- What do we know about the effectiveness of these countermeasures?

Following its discussions, each breakout group used a balloting process to generate a tentative list of critical research needs in its assigned area. By way of example, the highest-ranked research topics identified by the run-off-road breakout group are listed in Box 4-1.

As noted by one of the Safety Working Group cochairs, the process used by the breakout groups was not intended to generate a final list of research gaps but rather to identify some preliminary ideas by having "8–10 people working for about three hours to give [their] best thoughts" (Hanscom 2002, 41). An unresolved question at the conclusion of the conference was how to develop the preliminary lists of research gaps and issues generated during the breakout sessions into a national research agenda supported by and useful for those in the transportation community with an interest in highway infrastructure and operations safety.

FHWA-COMMISSIONED WHITE PAPERS

To continue the research agenda-setting process and provide additional baseline information for future efforts, FHWA commissioned a series of expert papers to expand on the research gaps and issues suggested by participants in the agenda planning conference. These papers, which

BOX 4-1

Highest-Ranked Run-off-Road Research Topics

- Use of one-pass van to inventory roadside features—digitize roads for vehicle–roadway interactions
- Methods for choosing run-off-road sites, corridors, treatment programs
- Rumble strips on narrow paved shoulders
- Intelligent infrastructure warning systems—field test of driver response
- Relationship of simulation and crash test results to real-world crash injuries
- Safer ditch design for rural two-lane roads
- Tree removal trade-off research
- Vehicle–roadside interaction (rollover, tripping effects, etc., by vehicle type)

SOURCE: Hanscom 2002, 8.

were published in May 2004 (Kantowitz et al. 2004), addressed the following five areas:

- Run-off-road research needs,
- Intersection safety,
- Human factors,
- Work zones, and
- Fundamental advanced research.[3]

In commissioning the papers, FHWA aimed to build on the momentum generated by the agenda planning conference and keep the agenda-setting process moving forward, despite budgetary constraints. To minimize

[3] The original intent was to commission a white paper on each of the five topic areas discussed at the conference, together with a sixth crosscutting paper on fundamental advanced research. However, the paper on the intelligent infrastructure initiative was canceled because of competing priorities within FHWA.

contracting delays, the papers were developed under an existing FHWA indefinite delivery/indefinite quantity support contract and were assigned to the prime and existing subcontractors, contingent on staff availability. No attempt was made to add new subcontractors with specialized expertise and experience relevant to the task at hand. Because of the modest budget—$100,000 for the five papers—the authors had limited hours in which to complete their assignments.

Each white paper author was instructed to address statistical evidence from national databases, knowledge strongholds and gaps, and critical future highway issues and to generate a list of research topics and projects. Each research topic was to be classified as either applied or advanced. For each project, authors were asked to estimate cost and duration, as well as likelihood of success rated on a scale from 1 (low likelihood) to 5 (high likelihood). Success was defined as completing the project on time and within budget and either generating useful countermeasures (applied topics) or building a firm foundation for useful countermeasures (advanced topics) (Kantowitz et al. 2004). The tables summarizing the projects identified in each white paper are reproduced in Appendix B.

Initial versions of the white papers were sent to three reviewers selected by FHWA. Each white paper author then "made a serious effort to address most of the issues raised [by the reviewers] despite an extremely limited number of hours remaining in the project for revision" (Kantowitz et al. 2004, 6). The final papers show comments from the reviewers[4] and the responses from the white paper authors, although it is not always possible for the reader to identify the specific modifications made to the papers in response to the reviewers' comments.

In May 2005, the white papers were posted on the TRB website for a 20-day public comment period. Interested individuals were invited to submit their comments on all or part of the white papers report. A handful of comments were received, most of which identified additional research gaps and opportunities. One comment noted that a study similar to one described in the white papers was already under way.

[4] The comments shown in the papers are not those of the individual reviewers. Rather, they appear to be syntheses of comments from all the reviewers.

LESSONS LEARNED

To help identify key features of an efficient and effective research priority-setting process, the committee conducted a critical review of the outputs from the research agenda planning conference and of the FHWA-commissioned white papers and examined the processes used to generate these products. The primary objective of these efforts was to identify problems and issues encountered, research gaps missing from the discussions, and ways in which the processes could be improved in developing a national research agenda.

Overall Assessment of White Papers

In assessing the white papers, the committee attached major importance to the scientific credibility of the proposed research topics and projects, including the extent to which they take account of current knowledge and understanding, whether they propose the use of robust methodologies, and whether they address problems that are tractable in research terms. For example, projects were viewed with skepticism if they depend on new data that are difficult to obtain by using proven methods.

The committee found the white papers to be of variable quality. While some authors were clearly familiar with the subject matter, others appeared less so. This observation probably reflects FHWA's desire to expedite the white paper development by assigning the papers to existing contractors on the basis of staff availability. The proposed projects were of similarly variable quality, as discussed in Appendix B. Some may well be worth considering as components of a national research agenda, but others are of questionable value.

A balanced portfolio of research focused on highway infrastructure and operations safety is likely to include the two research categories addressed in the white papers, namely, crash types (run-off-road, intersections, work zones) and crosscutting areas (human factors, fundamental advanced research). However, different approaches may be needed to identify specific research projects within a broad area with a relatively long-term focus, such as human factors or fundamental advanced research, and a more specific area, such as run-off-road or intersection crashes, in which much of the emphasis is on relatively short-term development of countermeasures. Fundamental advanced research, for

example, encompasses a broad range of topics and addresses future problems as well as the advanced methods and technologies discussed in the white paper. In this case, a preliminary paper on future problems could have been a useful starting point, rather than proceeding directly to the identification of high-priority research. A recent planning workshop on national long-term traffic safety research recognized the importance of setting the context for research needs and commenced with an overview of broad forces and trends likely to affect transportation and traffic safety during the coming decades (AAA Foundation for Traffic Safety 2006).

Selection and Prioritization of Research Areas and Topics

The challenge inherent in selecting areas for research is widely recognized. The National Highway Research and Technology Partnership noted that the first step in conducting a comprehensive program within a decentralized community is to "involve the broad community in the initial determination of needs" (National Highway Research and Technology Partnership 2002, 31). Taking such a step gave the partnership confidence that its lists of R&T themes and emphasis areas are relevant to the current challenges faced by safety program managers.

Taking the next step and prioritizing a comprehensive list of research areas and topics is arguably more challenging than compiling the list initially, and widespread consensus on all the priority areas and topics is extremely unlikely. For example, the partnership's Safety Working Group identified work zone safety as an emphasis area, and one of the FHWA-commissioned white papers was subsequently devoted to this area. All three paper reviewers, however, questioned the inclusion of work zone crashes as a major research area, arguing that crash data do not justify the focus on work zones and noting that research in other areas is more likely to lead to important improvements in road safety. The committee itself was unable to reach agreement on the importance of work zone crashes for a national research agenda. Some members endorsed the view of the white paper reviewers, while others identified work zones as an area of growing importance, given the current focus on renewal of existing highway infrastructure as opposed to new con-

struction. Thus, although run-off-road and intersection crashes, which capture the majority of fatalities and serious injuries, are included in many highway safety research agendas such as AASHTO's *Strategic Highway Safety Plan* (AASHTO 2005) and the AAA foundation's *Traffic Safety Issues for the Future* (AAA Foundation for Traffic Safety 2006), the differing perspectives and responsibilities of various organizations and individuals may well lead them to prioritize other research needs differently.

Importance of Transparency

The credibility of the lists of research topics developed at the agenda planning conference was undermined by a lack of transparency in the lists' development. Some conference participants expressed concern about their own lack of familiarity with the existing body of research in the areas under discussion, leading one to question what criteria these (and other) participants used in voting on research priorities. In the case of the white papers, the degree of transparency varies from paper to paper. Some authors articulated clearly the basis for their proposed projects (crash data, expert knowledge) and referenced relevant publications, whereas others left the reader to speculate about the rationale underlying their choice of priorities.

In light of the divergence of views about research priorities, as illustrated by the example of work zones, the committee noted the importance of articulating clearly the basis for choices and decisions made in arriving at those priorities. While people may disagree with the priorities included in a national research agenda, they may be more willing to recognize the value of such an agenda—and adopt some parts of it, perhaps in modified form—if the rationale for the assignment of priorities is clear.

Value of Expert Input

Some participants in the 2002 Safety Research Agenda Planning Conference commented on the absence of experts with an in-depth understanding of the state of the art and associated knowledge gaps (Hanscom 2002). Thus, FHWA's decision to remedy this deficiency by commissioning a series of expert papers to follow up on the conference appears sensible,

although, as already noted, time and resource constraints may have precluded the recruitment of established experts to write some of the papers.

As noted earlier, FHWA asked three experts to review drafts of the white papers. These reviewers, in turn, requested input on the proposed human factors projects from five international experts on human factors in road safety. These human factors experts were chosen because of their knowledge of the subject matter and their independence. None had been closely involved in the white papers initiative or precursor activities, and none would be expected to benefit directly from a decision by FHWA to fund research in this area. By drawing on additional independent expertise in specific research areas, the reviewers were able to obtain unbiased assessments of the value of the proposed research, thereby determining that some of the projects proposed would be impossible to conduct and would not yield the expected information.

Other agenda-setting exercises have used experts in different ways. For example, the AAA Foundation for Traffic Safety hosted a planning workshop in Washington, D.C., in October 2005 to identify and prioritize national long-term traffic safety research needs (AAA Foundation for Traffic Safety 2006). To stimulate participants' thinking about potential research areas, three experts were invited to summarize their views of research needs and gaps in their areas of expertise. The workshop attendees (some of whom were also subject-matter experts) then added other needs and gaps and used the expanded list as a basis for developing prioritized lists of potential research areas.

As the previous examples illustrate, there are various ways of involving experts in research planning efforts. Whatever ways are chosen, obtaining expert advice from experienced and knowledgeable researchers needs to be an important and integral part of research agenda setting because, as discussed in Chapter 3, it draws on knowledge that supplements that of the safety program manager. It also subjects proposed research to informed discussion, analysis, and criticism, thereby increasing the likelihood that potential problems will be identified before major expenditures are incurred. Nonetheless, relying on the advice of one expert or a small number of experts requires caution, particularly if a topic is controversial or not well understood. In such cases, the independence of expert advice is particularly important.

SUMMARY

In summary, the committee observed that efforts to develop research projects under the theme of highway infrastructure and operations safety illustrate the major challenges inherent in setting research priorities for a diverse and decentralized community of interested parties. There is no single ideal approach, particularly for a research portfolio comprising both short-term applied research and longer-term exploratory research. Furthermore, unanimous agreement on research priorities among all interested parties is unlikely. Each organization uses its own set of criteria, based on its mission and the needs of its stakeholders, to judge the relative importance of various research activities. Meanwhile, individual researchers and other experts may well adopt a different set of criteria, based on their knowledge of the state of the art and their assessment of the ability of research to solve a given problem. Priority setting needs to take account of these different perspectives, combining the knowledge and judgment of researchers about knowledge gaps and the ability to fill them through research with advice from safety program managers on the importance of the knowledge for real-life applications. Transparency—clearly stating the details of the process used and the participants involved in this process—enhances the credibility of the priority-setting process, even if consensus on the priorities is not achievable.

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Abbreviation

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5

Workshop with Highway Safety Research Funding Organizations

The committee was tasked with holding a meeting of highway safety research funding organizations to discuss research priority areas, priority setting, and coordination. In preparation for this meeting, members discussed the challenges of identifying research priority areas and priority setting and began exploring whether the development of a national research agenda would be a useful first step. Such an agenda would describe promising research opportunities in enough detail to provide guidance to funding organizations and researchers and would indicate relative priorities. The committee also explored possible approaches to research coordination, including use of a national agenda as a focal point for coordination efforts. Preliminary estimates of the likely costs of the various options for priority setting and coordination were then prepared. Armed with these preliminary ideas and information, the committee hosted a workshop on research in highway infrastructure and operations safety in Washington, D.C., on April 10, 2006, to test the merits of a national research agenda and various approaches to coordination.

The following section of this chapter provides information about the workshop logistics. The committee's preliminary ideas and the feedback from workshop participants on a national research agenda and on research coordination are then presented. The chapter concludes with the committee's findings from the workshop.

WORKSHOP LOGISTICS

The main organizations and groups that currently fund, and will likely continue to fund, safety research related to highway infrastructure and operations were invited to send representatives to the workshop. Invitees

were advised that the main purpose of the meeting was to determine whether research funding organizations see any potential value in a national research agenda and, if so, how coordination of research activities in support of such an agenda might be achieved. As shown in Box 5-1, the attendees represented federal agencies, state departments of transportation (DOTs), universities, and private-sector organizations, as well as ongoing research programs with important highway safety com-

BOX 5-1

Organizations Attending the Workshop

U.S. Department of Transportation
Federal Highway Administration
Federal Motor Carrier Safety Administration
National Highway Traffic Safety Administration

State Agencies and Organizations
American Association of State Highway and Transportation Officials
California DOT
Florida DOT
Michigan DOT
Ohio DOT
Washington State DOT

Transportation Research Board
NCHRP
SHRP 2

Universities
Calspan–University of Buffalo Research Center
University of Minnesota
Virginia Tech Transportation Institute

Private Organizations
American Transportation Research Institute
AAA Foundation for Traffic Safety

ponents, namely, the National Cooperative Highway Research Program (NCHRP) and the Strategic Highway Research Program 2 (SHRP 2). Names of the 20 attendees are given in Appendix C.

The format of the workshop was designed to encourage discussion among small groups of guests and committee members. Following presentations introducing the morning and afternoon sessions, participants divided into breakout groups to discuss a series of questions and then reconvened to share and discuss their ideas (see the workshop agenda in Appendix C).

For the discussion of questions relating to the national research agenda, participants were assigned to breakout groups according to the type of organization they represented. Thus, one breakout group was composed of federal agency representatives, one of state DOT representatives, one of private-sector representatives, and one of university representatives. The rationale behind this assignment to breakout groups was that each type of organization is likely to experience its own particular constraints in using a national agenda to guide its research activities. For example, federal agencies are often subject to congressional mandates and administration policy directives in deciding what research to conduct, while private-sector organizations are likely to undertake research in response to commercial pressures to develop a better product or a more cost-effective service.

For the discussion of questions relating to research coordination, each breakout group comprised at least one representative from each type of organization (federal, state DOT, private-sector, university) in an effort to stimulate exchange of ideas among those with different perspectives. The rationale for this approach was that research coordination is unlikely to be successful unless all those participating are engaged in the process and have been involved in developing the coordination strategy.

NATIONAL RESEARCH AGENDA

In preparation for the workshop, the committee investigated various approaches to developing an efficient and effective research priority-setting and coordination process. In particular, it

- Mapped and compared the research processes used by organizations involved in research on highway infrastructure and operations safety (see Chapter 2);

- Considered a recent example of a national research agenda, namely, *The Concrete Pavement Road Map: A Long Term Plan for Concrete Pavement Research and Technology* (FHWA 2005);
- Examined the safety research process proposed by the National Highway Research and Technology Partnership's Safety Working Group (see Chapter 2);[1] and
- Identified lessons learned from the effort sponsored by the Federal Highway Administration (FHWA) to develop priority research programs in highway infrastructure and operations safety (see Chapter 4).

With the information and insights gained from these activities, the committee developed its preliminary ideas about the nature of and a process for developing a national research agenda and identified possible approaches to research coordination.

Proposed Model

Nature of the Agenda

According to the committee's preliminary ideas, a national research agenda for highway infrastructure and operations safety would identify and describe the most promising opportunities for reducing the number of crashes and mitigating crash outcomes through research. The agenda would contain both short-term applied and longer-term advanced/fundamental research topics. The level of detail provided in the agenda for the two types of issues would likely differ, with more specificity being provided for the applied issues. For example, an applied issue could be "effectiveness of different geometric changes and traffic control devices (TCDs) in reducing crashes on curves on two-lane rural roads." A fundamental issue could be "reducing crash harm on two-lane rural curves," which would open opportunities to investigate not only geometric and TCD changes but also changes in vehicle-based warning or speed-control systems, driver perception of and reaction to different curve "looks," and other possible paths to reducing crash harm.

[1] *Proposed Safety Research Process for Carrying Out the National Highway R&T Partnership.* Undated white paper prepared by the Safety Working Group of the National Highway Research and Technology Partnership.

In the case of fundamental research, the committee considers it important that topics not be overly prescriptive, thus giving researchers the flexibility to explore promising avenues of investigation. But if the opportunities identified in the agenda are too generic (e.g., high-risk driving, vulnerable road users), almost any research project would fit and the agenda would serve no purpose.

Agenda-Setting Process

The national agenda would provide data-driven indicators of research opportunities rather than prescribing research that funding organizations should support. The information provided would assist decision makers in developing their own portfolios of research projects and discussing research needs with other organizations and individuals. The research opportunities and their relative priorities would be based on a range of strategic and practical factors, most notably

- The size of the problem, including the number and severity of crashes, and the associated economic burden;
- Future trends that could affect the size of the problem, such as changing demographics and increasing congestion;
- In-depth knowledge of current research and understanding in the proposed subject area, including gaps and uncertainties;
- The effectiveness of research to date in addressing the problem;
- Expert judgment about the likelihood of future research leading to effective and implementable solutions; and
- Estimates of research cost, including indications of areas in which research is likely to be particularly costly and could consume a disproportionate share of funding, to the detriment of other areas.

Setting a national research agenda would be a challenging task because of the inherent unpredictability of research outcomes and the difficulty of quantifying benefits, some of which may not result until many years after the research is completed. In recent years, there have been several attempts to develop a national research agenda in highway safety, including those by the National Highway Research and Technology Partnership (2002) and the AAA Foundation for Traffic Safety (2006). These efforts have generally used a well-versed group

of stakeholders—including researchers and other technical experts, research users, and managers from research funding organizations—to generate and develop ideas that are then prioritized through some sort of voting process. Because different organizations have different mandates and respond to different constituencies, a voting system inevitably results in some disagreement over topics and priorities, with the outcome of the final vote a function of the meeting participants; that is, another group of participants would likely set somewhat different priorities.

In the committee's view, the process for developing a national research agenda should (*a*) be as transparent as possible; (*b*) seek to minimize subjective judgments about priorities; and (*c*) reflect the best available data, expert knowledge, and practical experience. There may be a role for decision analysis as a tool for structuring discussions and capturing expert judgment in a consistent fashion during the agenda-setting process, as well as for assessing the prospective benefits of research (costs and potential value) to inform priority setting.

Role of an Expert Panel

A variety of experts would need to be involved in the agenda-setting process. For example, individuals with knowledge of the state of the art would identify critical knowledge gaps. Researchers would determine whether these gaps can, in principle, be filled and whether the necessary data and research methodologies are available to do so. And safety program managers would judge whether the knowledge is important and usable for real-life applications.

The committee discussed the possibility of using an independent scientific advisory panel first to establish and document a consistent and transparent process for developing and prioritizing research opportunities and then use this process to set an initial agenda for research in highway infrastructure and operations safety. Ideally, sufficient resources would be available to update the agenda periodically. A number of organizations could host the scientific advisory panel. In the committee's view, the likelihood of a successful outcome would be enhanced if the hosting organization (*a*) operated independently of the major research

funding organizations, (*b*) were able to provide the necessary staff to support the panel's work, and (*c*) were held in high regard by members of the diverse highway safety research community.

Funding for the Panel

Financial support for the panel's activities would be provided by the major users of the resulting agenda, namely, the organizations that fund research in this area. In a different research field, the U.S. Environmental Protection Agency used a similar model to support an effort to develop research priorities for airborne particulate matter in response to the 1997 National Ambient Air Quality Standards (NRC 1998). A committee of experts in a range of relevant research areas identified high-priority research topics, described recommended research, commented on the potential value of this research from a scientific perspective and for decision making, and provided approximate estimates of research costs.

Feedback from Workshop Participants

Workshop participants were asked to respond to four questions relating to the committee's proposed model for a national research agenda:

1. Do you see a need for a national research agenda in highway infrastructure and operations safety? Why or why not?
2. Would you use the national agenda in setting your own research portfolio? Why or why not? Qualifications?
3. Do you agree with the committee's idea for how the agenda would be developed (i.e., by an independent scientific advisory group)? Why or why not? Would you suggest any modifications to the agenda development process?
4. If you agree that a national agenda is needed and would be used, would your organization be willing to help fund such an ongoing effort?

The following synthesis of participants' responses to the four questions addresses four main themes—the need for a national research agenda, its use, its development, and funding.

Need

Research funding organizations, notably those in the public sector, see the development of a national research agenda for highway safety as a worthwhile endeavor that could help in developing their own research portfolios and identifying research partnership opportunities. The national research agenda could also bring valuable perspective to efforts to improve highway safety by interpreting crash and other data and then linking these interpretations to research aimed at finding solutions. Information on the scientific rationale for undertaking a particular research effort would be useful for funding organizations in communicating with a variety of stakeholders, some of whom may not be familiar with research as a tool for solving highway safety problems. The agenda would be most useful for a broad range of constituencies if it identified opportunities and priorities for both short-term applied research and longer-term fundamental research, thereby helping organizations to focus on research consistent with their mission and expertise.

Despite its anticipated benefits, some see a national research agenda for highway infrastructure and operations safety as possibly creating "silos" and thus missing opportunities for crosscutting research. It is generally recognized, however, that developing a comprehensive highway safety research agenda could be an overwhelming task. Focusing on highway infrastructure and operations safety is likely to be more tractable as a prototype effort but would have added value if interfaces with other research areas, such as human factors, could be identified as part of the agenda. Thus, workshop participants suggested that an attempt should be made in any prototype effort to broaden the agenda to include crosscutting research on topics such as driver behavior and adaptation and vehicle design.

Use

Workshop participants envisaged using a national research agenda in a variety of ways. State DOTs could use it as a first filter in reviewing possible research projects and as a tool in identifying opportunities for research partnerships and leveraging of funds. In addition, the American Association of State Highway and Transportation Officials (AASHTO) Standing Committee on Research (SCOR) could use the agenda in evaluating and

selecting research topics. Universities would find the agenda particularly useful if funding followed the agenda priorities. Researchers then would be able to target their proposals to areas that not only are important but also have accompanying resources. Federal and private-sector organizations anticipated using the agenda to guide their own research portfolios, although both noted that responding to their key stakeholders (Congress and the administration, and member organizations, respectively) would determine the extent to which they could follow the advice contained in the agenda.

Development

Three aspects of the process used to develop a national research agenda were identified as critical in determining the extent to which the agenda would have credibility and be used by funding organizations in developing their research portfolios.

First, the group developing the agenda should command the respect of the highway safety community through its depth and breadth of experience and the proven technical expertise of its members. Various suggestions were made concerning the membership of the group, but it was generally agreed that an expert panel could bring a particularly valuable perspective in interpreting crash and other data and connecting these data to possible solutions. Any perceptions of bias in the agenda would be minimized by (*a*) ensuring that the individual members of the group were independent and perceived as such and (*b*) focusing on a data-driven approach to identification of research opportunities.

Second, interactions between the group developing the agenda and other interested parties, including research users and policy makers, would be needed to ensure that the financial and political difficulties of implementing research outputs and outcomes were factored into the research prioritization process. Broad opportunities for input and review with a variety of mechanisms would help ensure extensive buy-in and subsequent implementation of the agenda. Possible mechanisms could include presentations and discussions during a Transportation Research Board (TRB) annual meeting, a website with response capabilities, and presentations to meetings of key stakeholder groups such as AASHTO's SCOR and Standing Committee on Highway Traffic Safety.

Finally, the process for developing the agenda should be transparent, with a clearly articulated rationale for selecting and prioritizing research opportunities. A systematic approach, possibly driven by an established national highway safety goal and quantitative procedures, was highlighted as an important consideration by some participants.

Workshop participants were undecided about whether a national research agenda should be strategic or comprehensive and about the level of detail it should provide in describing research opportunities. For example, a strategic agenda might identify the need for research aimed at lessening the crash harm of roadway departure crashes, whereas a comprehensive agenda would enumerate specific projects to study departure crash treatments. A higher-level strategic agenda could be easier to link to existing priorities but under some circumstances might be less useful than a comprehensive description of prioritized research opportunities. Concerns were expressed about possible confusion if the agenda were to mix high-level strategic and more detailed research areas.

Funding

FHWA representatives indicated that their organization would be willing to help fund the development of a national research agenda. Other workshop participants were less sure in their responses to the question about funding, indicating that financial support from their organizations would depend on the details of the funding arrangements, including prorating of contributions and opportunities to contribute "in kind," as well as on who else joined the effort. Concerns were expressed that an agenda for highway infrastructure and operations safety could be the "tip of the iceberg," with funding organizations later being asked to contribute to the development of national research agendas in other highway safety areas. Infrastructure and operations is but one of the eight safety research themes identified by the National Highway Research and Technology Partnership (2002).

Estimates of the costs of developing a national research agenda in highway infrastructure and operations safety and coordinating research activities are given in the following section.

RESEARCH COORDINATION

Possible Approaches

Before the workshop, the committee identified four possible approaches to research coordination and priority setting and made preliminary estimates of the associated resource requirements. The four options were presented to the workshop participants for discussion. Information on the four options, including updated cost estimates, is summarized in Table 5-1 and discussed below.

For Options 1, 2, and 3, the estimates assume that committees of volunteers would provide the technical expertise for the various activities and indicate the number of days of pro bono expert time needed.[2] For Options 1A and 2, additional expertise would be provided by paid consultants who, under the committee's direction, would undertake specific tasks related to the development of a prioritized research agenda. For Option 1B, the reviewers of research proposals and of completed research would receive honoraria.

Also for Options 1, 2, and 3, the estimates assume that the expert committees would operate under the auspices of the National Research Council (NRC) and would provide formal advice (written recommendations) to the federal government and others on research priorities. The committee used the NRC model to generate the cost estimates because it had access to the necessary financial data. The financial information needed to generate cost estimates for alternative non-NRC models was not available, although such models certainly should not be excluded from further consideration. Expert groups have been convened by organizations outside of the NRC to develop highway safety research agendas. For example, the AAA Foundation for Traffic Safety, with additional support from FHWA and the National Highway Traffic Safety Administration, sponsored a planning workshop for traffic safety researchers

[2] In the following discussion, the estimates of pro bono expert time cover the time spent by volunteer committee members on a variety of activities, notably traveling to and from and attending committee meetings; preparing for meetings; undertaking assignments in support of the committee's work, including data and information gathering, analyses, and drafting report materials; and reviewing and commenting on report drafts.

TABLE 5-1 Estimated Costs of Prioritizing and Coordinating Research

Option	Key Features	Comments	Duration and Approximate Cost
1	Process proposed by National Highway Research and Technology Partnership's Safety Working Group	Most comprehensive option, involving two phases (Options 1A and 1B) Option 1A: One-time effort by an expert committee, assisted by consultants, to develop a prioritized research agenda Option 1B: Ongoing review of research proposals, peer review of research, and evaluation of outputs conducted under auspices of an expert committee	Option 1A: 20-month effort. Total cost of $675,000 (including consultants' fees) plus 240 days of pro bono expert time Option 1B: Ongoing effort. Annual cost of $400,000 (including honoraria for reviewers) plus 120 days of pro bono expert time
2	Recommended research agenda, with priorities	One-time effort by an expert committee, assisted by consultants, to develop research priorities; very limited informal coordination activities	20-month effort. Total cost of $700,000 (including consultants' fees) plus 270 days of pro bono expert time
3	Coordination of funding organizations, with expert advice about priorities	Annual gathering of funding organizations to coordinate ongoing and proposed research, with advice on priorities from an expert committee	Ongoing effort. Annual cost of $200,000 plus 60 days of pro bono expert time
4	Informal coordination of funding organizations	Annual gathering of funding organizations to coordinate research efforts; no expert advice	Ongoing effort. Annual cost of $25,000 to $50,000 and a few days of pro bono expert time

and practitioners to identify and prioritize long-term safety research needs, with emphasis on identifying gaps in existing research plans (AAA Foundation for Traffic Safety 2006).

The annualized costs of the four options outlined in Table 5-1 range from 0.1 percent to 1.8 percent of the approximate estimated annual U.S. research expenditures in highway infrastructure and operations safety, excluding SHRP 2 ($24 million). (See Chapter 2, Box 2-1.)

Option 1: Safety Working Group's Recommended Process

The model for priority setting and collaboration developed by the National Highway Research and Technology Partnership's Safety Working Group envisions a four-stage, multiyear process. In the first stage, the stakeholders would come together through an NRC-appointed Safety Research Advisory Committee that would develop a prioritized national safety research agenda. In the second stage, a Highway Safety Scientific Review Group (HSSRG) would review and prioritize research proposals intended to further the research agenda and would make recommendations to funding agencies. In the third stage, HSSRG would provide peer review of the completed research and make recommendations to implementing organizations. In the fourth stage, HSSRG would review the results of the implementation and make recommendations back to the Safety Research Advisory Committee about potential modifications to the national safety research agenda.

The first-stage development of a national safety research agenda (designated Option 1A in Table 5-1) would be a significant one-time effort. An NRC committee process that included substantial stakeholder input, committee analysis supported by expert consultants, and deliberation to reach consensus would cost $675,000 and require approximately 20 months of effort. Pro bono days by experts involved in such a process could be on the order of 240, including time spent attending committee meetings and reviewing materials.

The second-stage review of research proposals, even if done by an NRC-appointed committee, would not necessarily result in consensus advice about which proposals to fund. Instead, the committee could select reviewers, and the reviewers could advise the funding agencies directly about the proposals reviewed. The cost estimate assumes that the expert reviewers selected by the committee would receive modest honoraria. The

committee would likely meet at the beginning of the process to identify suitable reviewers and meet again after the reviews were completed to identify lessons learned and opportunities to improve the process. These lessons and opportunities would be captured in a letter report. The third-stage review of completed research might follow a process similar to that of the second stage and have a similar cost. The fourth-stage review of research implementations would be at a much smaller scale than the second and third stages; it would be expected that relatively few research projects would be implemented and that even fewer would be formally evaluated.

For the purposes of cost estimation, Stages 2, 3, and 4 were combined into Option 1B. The second stage (review of research proposals) would follow within a year or two of the completion of the research agenda, but the third and fourth stages probably would not occur for several more years because of the time needed to complete research and implement the results. Once established, however, Option 1B would be an ongoing effort with an estimated annual cost of $400,000, plus 120 days of pro bono expert time.

Option 2: Recommended Research Agenda

An alternative to the two-phase Option 1 would be to limit the effort to a single, one-time project to develop a prioritized national research agenda. This would be the same as Option 1A, except that at the conclusion of the effort the committee would host an additional meeting of funding organizations to brief them on its recommendations for future research as articulated in the agenda. This meeting would provide an opportunity for informal coordination by bringing funding organizations together for focused discussion of recommended research topics and priorities. Subsequent peer review of proposals and project findings would be the responsibility of the individual funding organizations.

Option 3: Coordination of Funding Organizations, with Expert Advice About Priorities

In Option 3, an expert committee would convene a meeting of stakeholders each year to discuss research plans and progress and provide for informal collaboration. No formal national research agenda would be established before this meeting. Funding organizations and researchers would report on plans for research and discuss results and issues encoun-

tered. Following the meeting, the committee would issue a brief report containing its consensus advice about priorities for research in highway infrastructure and operations safety. These recommended priorities would be based on information from the meeting and the knowledge of individual committee members, rather than being primarily driven by data. The process would cost about $200,000 annually and require about 60 days of pro bono expert time.

Option 3 has some of the coordination elements of Option 2 and ongoing expert opinion about priorities. But it does not include either the initial development of a research agenda as a focal point for coordination efforts or peer review of proposals and completed research. Nonetheless, it would provide for information sharing, informal coordination, and advice from experts about priorities.

Option 4: Coordination of Funding Organizations

A less-expensive alternative to Option 3 would be to hold an annual forum for organizations that fund highway safety research and experts in the field. The forum would involve sharing of research plans and results and discussions among the participants about priorities and opportunities for coordination. While this process would not result in consensus advice from experts, it could, nonetheless, result in informal coordination and a growing appreciation among sponsors of the highest research priorities requiring attention. If conducted as an adjunct to the TRB annual meeting and the associated SCOR meeting, the cost could be modest. If staged by TRB at a different time—for example, to coincide with the annual meeting of AASHTO's Highway Safety Committee—there would be additional administrative and travel costs. In either case, the total cost probably would be between $25,000 and $50,000 per year.

Feedback from Workshop Participants

Following an overview of the coordination models associated with Options 1 through 4, workshop participants were asked to respond to three questions relating to research coordination:

1. Is coordination among funding agencies needed? Advantages or disadvantages?

2. Will coordination happen, given the political realities? Who is likely to get "in" and who "out"?
3. If coordination is needed, what mechanisms or processes would be needed to cause this coordination to occur?

The following synthesis of participants' responses to these questions addresses three areas—the need for research coordination, the likelihood of coordination, and possible coordination mechanisms.

Need for Coordination

Workshop participants reported difficulties in obtaining timely information about ongoing research efforts outside their own organizations and noted that unnecessary duplication of research may result. The current lack of coordination among research funding organizations was identified as one of the contributors to this lack of timely information. Thus, research coordination would be worthwhile if it resulted in better information that could help provide "more bang for the research buck." In particular, coordination should facilitate the identification of research that builds on the most up-to-date knowledge and understanding and exploits synergies among research activities.

Some recent modifications to TRB's Research in Progress (RiP) Database may assist in providing the timely information sought by workshop participants. Thus, the 60 University Transportation Centers (UTCs) funded in the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) are now entering information about their research activities into the database, as required by the Research and Innovative Technology Administration. In addition, RiP's scope has been extended to include research needs statements developed by TRB standing committees.

Likelihood

An inverse relationship is anticipated between the willingness of research funding organizations to coordinate their activities and the degree of control associated with coordination mechanisms. Thus, coordination achieved through the provision of information and advice about research opportunities and priorities is likely to attract greater participation than "prescriptive" coordination, which seeks to control who

does what research and is perceived by some as stifling creativity and innovation.

Some research funding organizations, particularly those in the public sector, are potentially willing to participate in informal coordination efforts, such as an established schedule of meetings to discuss a national research agenda. With some exceptions, private-sector organizations may be reluctant to participate because the overriding commercial demands governing their research portfolios leave few opportunities to align with a national agenda.

The participation of university researchers in coordination efforts could be greatly influenced by the extent to which research budgets are aligned with a national research agenda. For example, if state DOTs were to use the agenda in selecting areas in which to make matching funds available for university research, a degree of coordination focused on the agenda would result. In addition, SAFETEA-LU requires UTCs to conduct research linked to the national strategy for surface transportation research as articulated in strategic plans from FHWA and the Federal Transit Administration, as well as in the report *Highway Research and Technology: The Need for Greater Investment* (National Highway Research and Technology Partnership 2002). Thus, if FHWA's strategic research plan (and associated funding) were to reflect the needs and priorities identified in a national research agenda for highway safety, some alignment of university research with the agenda could be anticipated.

Mechanisms

Meeting participants agreed that the menu of research opportunities described in a national research agenda could facilitate the coordination of research efforts. If research funding organizations were to select items from the menu when developing their research portfolios and associated budgets, a degree of informal coordination could result.

At a minimum, this coordination initiative would require a meeting of research funding organizations at which the agenda would be presented and discussed. Making information about the agenda available in a user-friendly format, for example as an adjunct to the RiP Database, would also be helpful. These informal coordination mechanisms would

require a "champion" (agency or group) that would take responsibility for organizing and implementing them.

COMMITTEE FINDINGS

1. Research funding organizations see a national research agenda in highway infrastructure and operations safety, with interfaces to other areas, as a potentially useful tool in informing the development of their research portfolios, identifying opportunities for research partnerships, and forming a basis for informal coordination of research efforts across organizations.
2. If a national research agenda is to achieve widespread acceptance and lead to a degree of informal research coordination, it needs to be developed by an independent expert group using a transparent process that provides broad opportunities for input from and review by diverse stakeholders.
3. Research coordination efforts are most likely to succeed if they focus on providing information and advice about research opportunities and priorities and facilitating informal interactions among funding organizations. The organization and implementation of these research efforts would require a "champion" (organization or group).
4. On the basis of Findings 1, 2, and 3, the setting of a national agenda and the subsequent coordination will need to be based on a combination of some of the options discussed at the workshop.
5. While the annualized costs of research agenda-setting and coordination efforts are estimated to be less than 2 percent of annual U.S. research spending on highway infrastructure and operations safety, the financial support from funding organizations needed for a prototype effort may not be immediately forthcoming, particularly in the absence of proven benefits. However, FHWA has indicated interest in funding the development of a national research agenda in highway infrastructure and operations safety.

REFERENCES

Abbreviations

FHWA	Federal Highway Administration
NRC	National Research Council

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6

Proposed Research Priority-Setting and Coordination Process

As noted in the opening chapter of this report, the field of highway safety improvement is moving toward a scientific basis, with knowledge based on research studies rather than on conventional wisdom and observation of practice. The transition toward science-based road safety management raises critical questions concerning the future of highway safety research. Decisions will need to be made concerning the appropriate mix of research efforts (e.g., near-term applied versus longer-term exploratory/advanced), how high-priority research issues can be best identified and who will identify them, how a high level of research quality can be ensured in the research funded, and whether increased coordination of research funding is needed and if so, how it can be accomplished. Without answers to these questions, the highway safety community will not be able to take full advantage of the potential benefits offered by science-based road safety management. Furthermore, without these benefits, it is questionable whether the ambitious road safety goals set by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and others can be achieved. As a first step, therefore, the committee agreed that its efforts to develop an effective and efficient research priority-setting and coordination process for highway safety research should be guided by the following vision statement:

> Deaths and injuries on the nation's highways will be substantially reduced as a result of the transition to science-based road safety management. Research will be the foundation for transitioning from the current intuition-based approach to a science-based approach.

Against this backdrop, the committee examined current approaches to research agenda setting and coordination within the highway safety research community (Chapter 2), as well as initiatives aimed at identifying and prioritizing research needs (Chapter 4). It also hosted a workshop for research funding organizations to obtain their views on research priority setting and coordination (Chapter 5). The committee explored opportunities to improve research quality, and its findings are discussed in Chapter 3. Some of the themes identified in the context of quality improvement recur throughout the report—notably the need for greater involvement of experts throughout the research process. Hence, the development of an effective and efficient priority-setting and coordination process, as specified in the committee's task statement, may be viewed as part of a larger effort to improve research quality.

This chapter presents the committee's conclusions, based on its findings from the above activities. It then discusses the committee's recommended approach to developing a national research agenda, which would incorporate research priorities and constitute a basis for informal research coordination. Establishing priorities for highway safety research has proved problematic in previous agenda-setting efforts, so strategies to enhance the process are offered for future consideration. The chapter concludes with estimates of the likely costs of the recommended agenda-setting and coordination activities.

The committee was charged with recommending an efficient and effective research priority-setting and coordination process that could be used in other highway research areas, in addition to infrastructure and operations safety. At the beginning of the project, there was a perception among some observers that the committee itself might be able to develop a prioritized national research agenda in highway infrastructure and operations safety by building on the earlier work of the National Highway Research and Technology Partnership's Safety Working Group and the subsequent ad hoc group, and on the white papers commissioned by FHWA. The process used and the lessons learned by the committee in setting such an agenda would then form the basis for an improved research agenda-setting and prioritization process applicable to other highway research areas. However, the committee's examination of the outputs from the precursor efforts rapidly led it to conclude that developing a prioritized national research agenda for highway infrastructure

and operations safety would not be possible with the resources available for the present project. For example, as discussed in Chapter 1, the committee of nine members, albeit all highway safety experts, was uncomfortable about providing consensus guidance about the inclusion of individual research projects in a national research agenda because of its limited knowledge of some detailed subject areas. Furthermore, it quickly became apparent during the committee's discussions that a volunteer group with no support from expert consultants does not have the resources needed to establish robust priorities for a national research agenda in highway infrastructure and operations safety. Thus, while this chapter presents a recommended process for research priority setting and coordination, as required by the committee's task statement, it does not define a specific methodology to be followed in developing a national research agenda and setting research priorities. It does, however, define important attributes of such an agenda and identify key features of the prioritization process.

CONCLUSIONS

The following paragraphs present the committee's conclusions in areas that it deemed important for the development of a workable, effective, and efficient process for setting priorities for highway safety research and coordinating research efforts. Such a process needs to reflect the requirements of the diverse and decentralized highway safety research community, incorporate knowledge and advice from experienced safety program managers and knowledgeable researchers, lead to a balanced research portfolio comprising both long- and short-term efforts, use an analytical approach to assign research priorities, and be both objective and transparent.

Diverse and Decentralized Research Community

An understanding of the diverse and decentralized nature of the highway safety research community is key to developing workable processes aimed at ensuring that research funds are put to the best use. As discussed in Chapter 2, research on highway infrastructure and operations safety is funded primarily by federal and state organizations, with limited

additional research conducted by university-based researchers funded by grants or by their own universities. The various research funding organizations take different approaches to developing their own research agendas responsive to their individual missions and stakeholders, while individual university-based researchers set their own agendas on the basis of personal interests. Thus, ensuring that the funds available for highway safety research are devoted to the highest-priority topics without unnecessary duplication of effort is a challenge. Different organizations (and different individual researchers) may well have different priorities and may not, therefore, agree about which research should be accorded the highest priority. Furthermore, the mission of an individual organization may require it to undertake research on a particular topic, regardless of what research is being undertaken by others.

The National Highway Research and Technology Partnership's Safety Working Group recognized the difficulties of optimizing overall research expenditures on highway safety when organizations select topics and conduct research largely independently of one another. The group suggested overcoming current "stovepipes" through a research process in which two expert committees would coordinate all aspects of the highway safety research "enterprise." While the intent behind this proposed research process is commendable, the present committee is concerned that the process could be overly constraining and may not give research funding organizations the flexibility necessary to fulfill their individual missions and meet the demands of their stakeholders. In the committee's view, it is unrealistic to expect that the organizations funding highway safety research would, or even could, abandon their established processes in favor of a new centralized process that sets research priorities and coordinates research efforts. Nor would one expect that individuals conducting research on highway safety without support from the aforementioned funding agencies could be easily convinced to modify their research agendas. Participants in the committee's workshop confirmed this view, noting that there is likely to be an inverse relationship between the willingness of research funding organizations (and individual researchers) to coordinate their activities and the degree of control associated with the coordination mechanisms. A mechanism that encourages coordination through the provision of information and guidance is far more likely to succeed than a prescriptive approach that seeks to control who does what research.

Thus, the committee concluded that any new research priority-setting and coordination process needs to complement current processes rather than replace them. Efforts such as the National Cooperative Highway Research Program (NCHRP) and FHWA's Transportation Pooled Fund Program show that there are benefits in encouraging organizations to work together without requiring them to relinquish their ability to fund other research pertinent to their particular needs. An approach that provides guidance about research opportunities and priorities and gives organizations the opportunity to incorporate this information into their own agenda-setting processes as they see fit appears to offer potential benefits—including a possible basis for informal research coordination—without the disadvantages of an overly restrictive and bureaucratic approach. If, over time, the guidance were found useful in leading to valuable, cost-effective research outcomes, funding organizations might become increasingly willing to coordinate their research activities around high-priority topics.

Experienced Safety Program Managers and Knowledgeable Researchers

A consistent message emerging from the committee's various activities was that two types of road safety expert should be partners in identifying and exploring research needs and opportunities—experienced safety program managers and knowledgeable researchers. The National Highway Research and Technology Partnership was effective in bringing together the diverse organizations making up the broad highway safety community in an initial effort to identify research needs. However, subsequent efforts to develop the partnership's research and technology (R&T) themes and emphasis areas into more specific research topics, or even projects, were less successful, at least in the area of highway infrastructure and operations safety. Although the white papers commissioned by FHWA resulted in some useful suggestions for research investigations, some of the proposed projects—particularly those addressing longer-term advanced research—are unsatisfactory in scope or methodology and unlikely to yield the expected information (see Appendix B). Important causes of these deficiencies included a lack of input from a group of experts with specific research experience and expertise in each area, as well as time and budget constraints during the white paper development.

Given the complexity and multidisciplinary nature of highway safety research, advice from experts in road safety research is often needed to assess both the current state of knowledge and the likelihood that further research will solve outstanding problems. As illustrated by some of the examples cited in the NCHRP Series 500 guides, conventional safety wisdom about strategies and countermeasures may not be a reliable guide for future investigations. As a science-based understanding of road safety continues to supersede conventional wisdom and observation of practice, numerous research opportunities are being identified with the potential to yield cost-effective safety improvements. Research budgets, however, are generally constant or may even be decreasing in real terms. Given that fatalities and injuries from road traffic crashes remain a major public health concern in the United States, it is more important than ever to use research funds effectively as part of the effort to improve highway safety. The effective use of funds requires building on the knowledge base established through earlier research, avoiding unnecessary duplication of earlier research efforts, and making informed judgments about the likelihood of further research leading to useful outcomes—all activities that require expert input.

The committee concluded that the formulation of an effective research agenda for the future requires familiarity with the current state of knowledge in both its basic and applied components, an awareness of research gaps and needs and of the challenges of implementing research outputs, an understanding of what can be done by research and how, and up-to-date knowledge of ongoing research. Therefore, only by combining the knowledge of experienced safety program managers with that of experts on road safety research can the full potential of research be realized.

Balanced Portfolio of Short- and Long-Term Research

The transition to science-based road safety management is resulting not only in more research opportunities but also in a change in the nature of the research needed to investigate and take advantage of these opportunities. Thus, in addition to traditional applied research projects focused on specific problems and near-term solutions, there is a need for exploratory, advanced research that develops a foundation for further knowledge. This exploratory research could be aimed at developing methods to produce

more trustworthy results and theories to guide productive research, as well as building better research databases. It could also address research into the human factors aspects of infrastructure design and operation, as the white papers commissioned by FHWA recognized (see Appendix B).

Longer-term, relatively high-risk research is widely viewed as an appropriate recipient of federal funding, and the Research and Technology Coordinating Committee has recommended that FHWA invest at least one-quarter of its R&T research expenditure in fundamental, long-term research (TRB 2001). On the same theme, the National Highway Research and Technology Partnership's Safety Working Group identified a need for a continuum of research activities in support of national highway safety goals. The group suggested that opportunities for investigator-initiated research be included in a gamut of approaches to soliciting research aimed at improving highway safety. FHWA's Exploratory Advanced Research Program, which solicits suggestions for investigator-initiated research in selected areas through a broad agency announcement, is an important but modest first step toward this goal.

The committee concluded that further changes are needed to expand the scope of the highway safety research portfolio to incorporate more longer-term exploratory research, including investigator-initiated research. Exploratory research is essential if the potential benefits offered by science-based road safety management are to be realized in practice.

Prioritizing Research Needs

Establishing priorities for highway safety research has proved problematic, at least at a level of detail that helps funding organizations decide what research topics and projects to support. For example, while there is widespread consensus that run-off-road and intersection crashes in rural areas are important research topics, other areas identified by the National Highway Research and Technology Partnership's Safety Working Group, notably work zone crashes, are more controversial (see Chapter 4). Even within the consensus areas, challenges remain in establishing priorities among the numerous possible projects, as illustrated by the outcomes of the Safety Working Group's agenda-setting conference (Hanscom 2002), FHWA's white papers on priority research areas in highway infrastructure and operations safety (Kantowitz et al. 2004), and

the AAA Foundation's workshop on long-term traffic safety research needs (AAA Foundation for Traffic Safety 2006).

Other research agenda-setting initiatives have avoided the controversial issue of priorities altogether. The National Research Council Committee for Pavement Technology Review and Evaluation criticized the absence of priorities in FHWA's Pavement Technology Road Map (TRB 2007). Also in the pavements area, the Concrete Pavement Road Map, developed with FHWA funding through the Center for Transportation Research and Education of Iowa State University, grouped problem statements identified by a wide range of stakeholders under major research tracks and subtracks (FHWA 2005). No effort was made, however, to prioritize either the tracks or subtracks. Thus, while the outreach process used to engage stakeholders in developing problem statements was effective, the road map lacks the relative priorities and approximate cost estimates that, in the committee's view, should be an integral part of any research agenda.

The National Highway Research and Technology Partnership was also effective in reaching out to diverse stakeholders and identifying research topics deemed important by these stakeholders. Again, however, no attempt was made to prioritize these topics, although annual research costs over a 5-year period were estimated for each of the safety R&T themes (National Highway Research and Technology Partnership 2002).

At its second meeting, the committee discussed a possible approach to assessing the comprehensive economic cost of road traffic crashes by crash type as an aid to prioritizing research efforts. Economic information is only one component of the research prioritization process. Other components include assessments of the likelihood of success in developing a treatment and of its potential effectiveness and an estimate of the extent to which the treatment will be implemented. The committee views quantitative analytical approaches to priority setting, based on items such as economic cost, as more informative and helpful than approaches involving voting by a "representative group" on the basis of criteria that are often poorly defined.

The committee concluded that priorities should be an integral part of any research agenda or road map, despite the challenges in their development. It also concluded that quantitative analytical approaches to priority setting could provide valuable information for those responsible for

allocating research funds, even though consensus on priorities among the diverse members of the highway safety research community is unlikely.

Objectivity and Transparency

An important finding from the committee's workshop with research funding organizations was that guidance on research needs and priorities (in the form of a research agenda or road map) will not achieve widespread acceptance within the highway safety research community unless it is developed by an independent expert group of experienced safety program managers and knowledgeable researchers using a transparent process.

The importance of independent expertise was also highlighted during the committee's examination of the process used to develop the FHWA-commissioned white papers. International experts on human factors in road safety, who had not been closely involved in the white papers initiative or precursor activities and who were not receiving or likely to receive research funding from FHWA in areas directly related to the white papers, were able to provide informed and unbiased assessments of the proposed research.

The need for a transparent process became increasingly clear to the committee as it examined various agenda-setting initiatives. Efforts that involved voting on research topics and priorities by a representative group from the highway safety research community produced variable results, as did papers written by a single expert. While some of the proposed research projects are well conceived and expected to yield useful results, others are of questionable scientific merit. The knowledge and experience of the individuals voting on priority research issues or writing a paper proposing research projects are clearly critical in determining the robustness of the product. Indeed, some of the participants in the Safety Working Group's agenda-setting conference questioned their own competence to make informed recommendations about research opportunities at the level of detail required. In addition, a lack of clear voting criteria appears to have hampered group efforts to establish robust priorities.

Thus, the committee concluded that, to achieve the necessary transparency, a research priority-setting process should be based on clearly defined criteria and involve independent experts with the necessary knowledge whose judgment is free of possible conflicts of interest.

SETTING A NATIONAL RESEARCH AGENDA

The committee concluded that the key features of a workable, effective, and efficient research priority-setting and coordination process could be provided by a national research agenda in highway infrastructure and operations safety, developed by an independent scientific advisory committee (SAC). This agenda, which would describe promising research opportunities and indicate relative priorities, could be a useful tool for research funding organizations in establishing their individual research portfolios, identifying opportunities for research partnerships, and communicating with a variety of stakeholders. It could also contribute to the more effective use of limited research funds by helping to ensure that new research efforts take full advantage of existing knowledge and understanding. And, as discussed later, it could form a basis for informal coordination among the organizations that fund research on highway infrastructure and operations safety.

The committee's recommended approach to setting a national research agenda differs from previous agenda-setting efforts in three important ways: (*a*) the use of a transparent process to identify and prioritize research opportunities, (*b*) the independence and stature of SAC, and (*c*) the expertise of SAC itself and its ability to call on additional external expertise in informing its decisions.

SAC would use a transparent process to identify and prioritize research opportunities, and these opportunities would be clearly linked to the underlying science. Suggestions from the extended safety community would form an essential input to the agenda development process. The rationale for the assigned priorities would be clearly articulated. Thus, voting systems with undefined or ill-defined criteria would be avoided, as would apparently arbitrary assignments of priority. The committee recognizes that different organizations and individuals may well disagree about the relative priorities of various research areas. It considers, nonetheless, that the guidance on priorities provided by a national research agenda may be useful to and usable by individual organizations during their own agenda setting—provided that the underlying rationale is clear.

The committee envisages that SAC would be established within an organization that is widely perceived as providing independent, science-based advice. In addition, candidates for SAC membership would be screened

for conflicts of interest before being invited to serve on the committee, and members would be subject to similar scrutiny during the period of their committee service. Because the independence and stature of SAC would be paramount in determining its credibility, candidates for membership would likely be independent technical experts drawn from pools of experienced safety program managers, including knowledgeable researchers and representatives of state departments of transportation (DOTs) and highway departments. The committee as a whole would be capable of undertaking the following tasks, with some outside advice:

- Identifying potential research issues, both near-term applied and longer-term exploratory;
- Understanding a given safety problem and deciding whether research has the potential to find a solution;
- Assessing the status of the data and methodologies required to conduct the research;
- Providing general estimates of the associated costs and time frames; and
- Assessing the likely ultimate benefits of the research for greater road safety.

Finally, SAC membership would be large enough to cover relevant major areas of expertise with some redundancy, so that decisions relating to a given research area would not be perceived as representing the views of a single individual. In addition, SAC would have at its disposal the resources necessary to enlist the help of other experts as needed. For example, it might wish to have outside experts conduct literature reviews, prepare white papers on specific highway safety issues, or comment in detail on proposed research opportunities.

RECOMMENDATION: An independent SAC should be established and charged with (*a*) developing a transparent process for identifying and prioritizing research needs and opportunities in highway safety, with emphasis on infrastructure and operations, and (*b*) using the process developed to recommend a national research agenda focused on highway infrastructure and operations safety.

RECOMMENDATION: The national research agenda developed by SAC should

- **Be based on in-depth knowledge of current research in a proposed area, including gaps and uncertainties;**
- **Include some quantifiable measure of the value or benefit of a proposed research effort in terms of greater road safety (a number of factors would be inherent in this quantification, including the size of the problem, perhaps in terms of its economic cost to society, and future trends likely to affect problem size);**
- **Include an assessment of the likely ability of research to address the problem;**
- **Reflect expert judgment about possible implementation of research outputs; and**
- **Include general estimates of research cost.**

The committee deliberately has not defined how SAC would identify potential research areas and issues. Indeed, development of the process to be used would be one of SAC's initial tasks. The committee does, however, envisage the process including multiple sources of input and being open to suggestions from the broad highway safety community. Inputs to past efforts aimed at developing a listing of potential research areas have included knowledge gaps identified in and reviews of past research (e.g., the *Highway Safety Manual*), knowledge gaps identified by review of research problem statements from standing committees of the Transportation Research Board, examination of data related to highway harm "causes" without solutions, unfunded high-priority research from NCHRP and other major funding sources, and inputs from users (e.g., safety engineers, safety program managers, researchers, the public) concerning issues deemed important on the basis of the size of the current (or anticipated) problem.

During the course of its discussions, the committee identified two further items that SAC may wish to consider during the course of its work.

Opportunities for research can be categorized in many ways—themes, specific areas of concern, and topics, for example. The committee considered briefly various approaches to categorization but did not develop a satisfactory approach in the time available. While a consistent system of categorization could help in the agenda-setting process, it is, in the committee's judgment, far less important than developing a strategy

that guides the search for research opportunities without prematurely restricting this search.

The research agenda developed by SAC is likely to describe research opportunities in varying levels of detail, depending on the nature of the problem, the extent of current knowledge and understanding, and the type of research needed (applied or advanced/exploratory). To avoid confusion, the reasons behind the varying levels of detail may need to be explained to users of the agenda.

ESTABLISHING RESEARCH PRIORITIES

In the committee's view, the most challenging aspect of SAC's work is likely to be the development of a methodology for assigning research priorities. However, this development, which forms a major part of SAC's initial effort, is critical. The following discussion explores approaches that SAC may wish to consider, together with other techniques, as it develops a process for prioritizing research.

As already noted, research prioritization is not a simple task. The committee discussed approaches to prioritization at some length, and the discussion led to guiding principles and examples of processes rather than to a single recommended approach. The members agreed, however, that the critical step of establishing research priorities should use a process that is (*a*) transparent, so that those who use the resulting research agenda are fully aware of how it was developed, and (*b*) as analytical and quantitative as possible, while recognizing that it would likely include expert opinion and judgment.

Research has both value and cost. The role of highway safety research is to establish knowledge that, if used, would allow safety to be managed more cost-effectively. It follows that the value of a piece of research derives from and is to be judged by the extent to which its results improve safety decisions that lead to effective safety management. Effective management would thus deliver improvements and would do so cost-effectively. In prioritizing research, therefore, the optimum methodology appears to be to rank research projects on the basis of value of research per unit of research cost. The highest-priority research would have the highest value per dollar spent. Estimating the value of research is difficult. The following sections provide ideas on how this estimation might be achieved.

Options

The committee observed that processes used to rank research projects, and thus to estimate research value (whether knowingly or not), range from what might be considered a "low option" to a more analytical "high option." The low option is often characterized by convening a group of individuals, developing through discussion a list of potential research projects, voicing the merits of certain projects, and using some form of voting to converge on a set of research priorities. While such a process could produce a well-conceived research agenda, two important components are often missing—the premeeting preparations needed to facilitate informed voting and measures to ensure participation by an appropriate mix of "voting experts." For the process to be successful, one would need to do the following:

- Prepare for the meeting by providing participants with written information on each research project or topic describing, at a minimum, the decision or action to be enhanced by the research result (i.e., what part of safety management would be affected), the number of target accidents potentially affected by the decision or action, the degree of present uncertainty about the effect of the decision or action (i.e., the quality of knowledge from past research studies), the data and method needed to reduce the uncertainty, and the degree to which a successful result would be implemented; and
- Invite to the meeting a mix of researchers, safety program managers, and other research users who jointly can make use of the information provided and are relatively free of prejudicial interest.

The high option for prioritizing research (the option favored by the committee) would include a quantitative analytical process for examining the items listed above (part of safety management that would be affected, number of target accidents, etc.) and others in determining the value of a research project or topic. This process would involve (*a*) accumulating the information noted above for each project or issue under consideration and (*b*) combining this information in a consistent and logical quantitative process. Clearly, information on some treatments or issues will not always be sufficient to allow a numerically based process, so some degree of flexibility must be built into the process.

Analytical Approaches

The committee identified two analytical approaches to research prioritization that it deemed worthy of consideration—among others—by SAC. The first is more traditional and involves basing priorities on criteria such as the size of the problem that the research examines, the probability of success, and the probability that the research will be implemented. The second, an approach used in other fields but less known in the highway safety arena, involves calculating a "value of research" on the basis of decision theory methods. These decision analyses are based on the "value of information" and involve assigning a numerical value to the new information potentially developed by the research.

Traditional Approach

An example of the first approach was used to prioritize research to develop new accident modification factors (AMFs)—measures of crash-harm reduction expected from the implementation of each of a series of safety treatments aimed at reducing intersection crashes or run-off-road crashes (Harkey et al. in press). The prioritization process took account of the following factors:

- *User priority level:* The results from a survey of state DOTs were used to assign high, medium, or low ratings to more than 100 possible treatments in terms of their use of the treatment and need for a good AMF. These ratings were assumed to capture the probability of implementation of the treatment, given successful research.
- *Level of predictive certainty:* A detailed literature review had produced a ranking of the level of predictive certainty for each of the possible treatments' AMFs—high, medium-high, medium-low, low, nonexistent. These rankings provided a measure of "current research knowledge."
- *Ongoing and future research:* Review of several research-in-progress databases, discussions with other highway safety researchers, and conversations with research sponsors such as FHWA and the Insurance Institute for Highway Safety were used to determine whether there was ongoing or planned research that might improve the AMF.
- *Availability of needed research data:* For each treatment being considered, an assessment was made of the adequacy of data on the treat-

ment, as well as associated crash and related data. Because the study goal was to conduct scientifically sound evaluations with state-of-practice research methods, among the data needed were not only detailed historical data concerning treatment descriptions and treatment dates from the implementing agencies but also linkable historical crash, roadway inventory, and traffic flow data for both treated and comparison/reference sites.

- *Estimate of crash-related harm possibly affected by the treatment:* This factor provided a measure of economic value of crash harm associated with the crash problem being affected by the treatment being studied.

The uniqueness of this approach lies in the final factor—the estimate of crash harm. In other attempts to include problem size in a rating, simple crash frequencies by crash type have been used (e.g., the frequency of intersection angle and broadside crashes for treatments related to signalization of an intersection). In this case, a more sophisticated technique was used to assign a high, medium-high, medium-low, or low crash-harm rating to each treatment (and thus each evaluation) being considered. This was done by assigning a primary, or target, crash type (the crash type or types that would be most affected) to the treatment and defining the appropriate rating on the basis of the economic level of national crash harm associated with that crash type. The use of an economic measure of crash harm allows the appropriate combination of both crash frequency and crash severity in the same measure, an important consideration due to differing average severities of critical crash types (e.g., angle and rear-end crashes). The national annual economic estimates for each of 31 crash types were based on work by Miller, and a more detailed discussion of the methodology is presented in Appendix A of that report (Miller et al. 1995).

A rating for each of these five factors was then considered in developing a combined rating for each treatment evaluation under consideration. These ratings were then used to prioritize the AMFs to be developed (i.e., the treatments to be evaluated).

One factor not considered in this priority-setting process is the probability of the research effort being successful. If different potential research efforts have a higher or lower risk for success, it appears that this probability would have to be estimated. While partially accounted for in the

exploration of potential databases noted above, this probability also would be a function of whether an appropriate research design could be implemented. If the probability is essentially the same for all research efforts being prioritized, it could be omitted.

Decision Analysis Approach

A second high-option analytical approach, the use of decision theory methods, has been applied in other health-related fields to prioritize research. This approach might also be used in prioritizing highway safety research. In general, action (or the failure to act) to prevent crashes can be based either on sound knowledge or on unsound or nonexistent knowledge. The less known about an issue, the more likely that any action taken (including inaction) will be incorrect. Research creates new knowledge if none exists (a gap in knowledge) or makes existing knowledge better. Thus, high-priority research is defined not only by instances when no knowledge exists but also by instances when existing knowledge can be improved. It could be argued that the highest priority should be given to research when there is little or no sound knowledge about an issue and when the consequences of incorrect action are large compared with incorrect action on other issues. Thus, setting priorities for highway safety research is not simply a question of identifying gaps in knowledge or of establishing the size of the safety problem. It requires taking many factors into account, including the current level of knowledge and the consequences of incorrect action based on that knowledge.

A decision analysis approach takes these multiple factors into consideration in a quantitative process. For example, Claxton et al. (2004) reported on the experimental use of decision analysis and value of information methods in decisions concerning choices among medical research projects. The method involves developing statistical models to examine the probability of making a wrong decision about the use of a specific medicine or procedure and the effect of added information in reducing the odds of making that wrong decision (e.g., reducing the odds of deciding not to use a beneficial drug). Each alternative treatment is considered in a case study format. Each case study requires accumulating detailed information from existing research about the risk of the disease, the size of the potential patient population, and the quality of information avail-

able on the treatment being studied. Then, by using sophisticated simulation modeling, estimates are made of the reduction in the probability of a wrong decision, given all the uncertainties of the inputs. These efforts are labor-intensive but, in the case cited, were judged to be extremely helpful in making decisions on proposed research efforts.

Decision analysis methodology has also been used to measure the relative benefits expected from the U.S. Department of Energy's applied energy research and development, with a view to informing decisions about what programs should be continued, expanded, scaled back, or eliminated (NRC 2005). Simple decision trees ensure that the role of government support and the important technology and market uncertainties are considered in the benefits calculation, which relies on expert opinion and analytic approximations. The extent to which the methodology will find widespread acceptance remains to be seen.

The above discussion is intended to inform SAC's consideration of approaches to setting research priorities but is by no means comprehensive. An important consideration is whether either the traditional approach or the decision analysis approach would allow the prioritization of both basic and applied research efforts. As noted earlier, a national research agenda should include a balanced mix of basic (or fundamental) and applied research efforts, and the priority-setting process needs to take account of this requirement. Thus, SAC will need to develop strategies for prioritizing research not only within the basic and applied categories but also across these categories.

RECOMMENDATION: The process developed by SAC for prioritizing research should incorporate the following features:

- **A quantitative analytical approach that examines clearly defined criteria to determine the value of a research project or topic. In the absence of data needed for quantitative analysis, expert assessment of the available information could be used in examining the relevant criterion or criteria.**
- **The involvement of a mix of experts, some of whom are familiar with research methods and data and some of whom bring knowledge about highway safety practice. The experts should be qualified to assimilate the prepared information and be**

likely to make judgments that are not colored by organizational or personal interests. While SAC's membership is expected to include much of the needed expertise, it may at times be necessary to involve additional experts in the development of the needed inputs on specific research issues or projects.

BASIS FOR COORDINATING RESEARCH

Efforts to coordinate highway safety research need to take account of the constraints on funding organizations in both the public and the private sectors. For example, federal agencies must be responsive to their missions and to congressional mandates, while state DOTs and private-sector organizations must respond to the needs of their stakeholders. Thus, any coordination mechanism requiring a cumbersome, costly, and rigid administrative structure is destined to fail not only because of lack of resources but also because of its inability to accommodate existing constraints on funding organizations. If efforts to coordinate research are to succeed, they should be voluntary; easy to understand, communicate, and implement; and sufficiently flexible to accommodate the different needs and approaches of the diverse funding organizations.

In the committee's view, a national research agenda developed by SAC could facilitate informal coordination of research activities—provided that it is developed in a transparent fashion with input from interested parties and is perceived by stakeholders as being credible and objective. Building on existing work widely judged to be of high quality and pertinent to improving highway safety, such as the *Highway Safety Manual* and the NCHRP 500 series of reports, could enhance the agenda's credibility. Similarly, an agenda that recognizes the needs of participants in the National Highway Research and Technology Partnership initiative likely would be viewed favorably by many stakeholders.

The committee envisages that SAC would host a 1-day meeting for research funding organizations and other interested parties to discuss its completed national research agenda. Meeting guests would discuss the recommended research topics and priorities with SAC and each other. Engaging congressional staff in these discussions of research needs and priorities could help inform the development of federal research budgets. In addition, funding organizations would have an opportunity to

review the recommended topics together and identify those of mutual interest. Follow-up activities to explore opportunities for coordination of research efforts (and possible research partnerships) would be the responsibility of individual funding organizations but would build on the foundation provided by SAC's agenda.

In the committee's view, there could be value in SAC hosting a meeting for research funding organizations every year, rather than on a one-time basis. The first meeting would be as already described. Subsequent meetings would include discussion of research undertaken in response to SAC's recommended agenda and could also consider intervening events affecting priorities and funding, such as new congressional initiatives. These discussions could lead to further opportunities for informal coordination of research efforts. If the necessary resources were available, it would also be desirable for SAC to update the national research agenda periodically on a schedule that is timely in informing decisions about highway research funding.[1] These updates would then be discussed at the annual meeting with research funding organizations.

The agenda could also help strengthen existing coordination mechanisms. For example, it could be used by AASHTO's Standing Committee on Research in ranking NCHRP proposals and could stimulate the formation of research partnerships within FHWA's Transportation Pooled Fund Program.

If state DOTs and other nonfederal research funding organizations were to buy in to the agenda, it could also be useful in helping University Transportation Centers (UTCs) identify important research topics for which matching funds are likely to be available. Thus, there could be an increased likelihood of high-priority research being funded, although the extent to which UTCs would or could coordinate their efforts remains uncertain.

The committee notes that the informal coordination mechanism described would not preclude organizations from pursuing research topics of their choice that are not part of SAC's national research agenda.

[1] Updating could include evaluation of the process developed and used by SAC. For example, it could assess whether the process had developed reasonable priorities, fostered sound research aimed at the higher-priority issues, and resulted in better safety program decisions.

However, if the major funding organizations (FHWA, NCHRP, state DOTs) were to participate in the proposed coordination process, the resulting benefits could encourage others to join the process over time and to align at least some of their research with the national agenda.

RECOMMENDATION: Once it has developed a national research agenda, SAC should host a 1-day meeting each year at which research funding organizations and other interested parties, including congressional staff, would have the opportunity to discuss the agenda with SAC and each other. This informal and relatively low-cost approach would provide an opportunity to explore the potential benefits of research coordination, with the national research agenda as a unifying focal point.

ESTIMATED COSTS

As discussed in Chapter 5, the committee identified several mechanisms for research coordination varying in cost and degree of formality (see Table 5-1, reproduced here as Table 6-1).

As already discussed, the committee judged Option 1—the process proposed by the National Highway Research and Technology Partnership's Safety Working Group—to be too constraining and unlikely to work in practice. Over the period of some years necessary for the process to be effective, this option would also be the most expensive of the four considered.

Options 3 and 4 are the least expensive, with annual requirements of $200,000 plus 60 days of pro bono expert time for Option 3 and $25,000 to $50,000 and a few days of pro bono expert time for Option 4. Both options could facilitate informal coordination of research activities among funding organizations, but neither offers the advantage of a predetermined science-based research agenda, including priorities, as a focal point for meeting discussion and subsequent follow-on activities. Without the direction provided by a research agenda, there is a greater risk that the initiative will not lead to enhanced research coordination.

Thus, the committee identified Option 2—a one-time effort by an expert committee (SAC) to develop research priorities, with limited informal coordination activities—as the most promising approach, as

TABLE 6-1 Estimated Costs of Prioritizing and Coordinating Research

Option	Key Features	Comments	Duration and Approximate Cost
1	Process proposed by National Highway Research and Technology Partnership's Safety Working Group	Most comprehensive option, involving two phases (Options 1A and 1B) Option 1A: One-time effort by an expert committee, assisted by consultants, to develop a prioritized research agenda Option 1B: Ongoing review of research proposals, peer review of research, and evaluation of outputs conducted under auspices of an expert committee	Option 1A: 20-month effort. Total cost of $675,000 (including consultants' fees) plus 240 days of pro bono expert time Option 1B: Ongoing effort. Annual cost of $400,000 (including honoraria for reviewers) plus 120 days of pro bono expert time
2	Recommended research agenda, with priorities	One-time effort by an expert committee, assisted by consultants, to develop research priorities; very limited informal coordination activities	20-month effort. Total cost of $700,000 (including consultants' fees) plus 270 days of pro bono expert time
3	Coordination of funding organizations, with expert advice about priorities	Annual gathering of funding organizations to coordinate ongoing and proposed research, with advice on priorities from an expert committee	Ongoing effort. Annual cost of $200,000 plus 60 days of pro bono expert time
4	Informal coordination of funding organizations	Annual gathering of funding organizations to coordinate research efforts; no expert advice	Ongoing effort. Annual cost of $25,000 to $50,000 and a few days of pro bono expert time

discussed earlier. The effort is estimated to require $700,000 plus 270 days of pro bono expert time over a 20-month period. This estimate includes a final meeting of the expert committee (SAC) with research funding organizations to discuss the proposed research agenda. If these meetings were held annually, an additional $25,000 per year would be needed, together with several days of pro bono time. Periodic updating of the agenda by SAC every several years would require additional funds and pro bono time.

To put these estimates in a meaningful context, an approximate estimate of annual U.S. funding for research on highway infrastructure and operations safety was made by using data from the Transportation Research Board's Research-in-Progress Database (see Box 2-1). The result was approximately $24 million per year, excluding periodic efforts such as the ongoing Strategic Highway Research Program 2. Thus, the total cost of developing a national research agenda over a 20-month period and holding an informal coordination meeting of funding organizations to discuss this agenda (Option 2) would be less than 3 percent of total annual research expenditures.[2] The annual cost of a follow-on informal research coordination meeting held every year would be approximately 0.1 percent of annual research expenditures on highway infrastructure and operations safety.

The committee recognizes that getting the SAC activity started would require both funding and an effective organizational strategy. As noted in Chapter 5, workshop participants identified the need for a "champion" (an agency or group) to take responsibility for organizing and implementing informal research coordination mechanisms. In the committee's view, having a champion to lead the entire SAC effort, including both the agenda-setting and coordination components, would greatly increase the likelihood of success. Both AASHTO and FHWA appear to be strong candidates for this leadership position, given their current roles within the highway safety research community and their technical knowledge and expertise. The ability to influence the development of federal research budgets could put the champion in a strong position to help ensure the success of the SAC initiative.

[2] The annualized cost of Option 2 would be less than 2 percent of total annual research expenditures.

Consistent with the committee's charge, the emphasis throughout its activities was on highway infrastructure and operations safety—that is, on the roadway component of safety as opposed to the driver or vehicle components. However, the recommended process of using an expert committee (SAC) to establish a prioritized national research agenda emphasizing highway infrastructure and operations safety could, if successful, be a model for other highway safety research areas, including research on drivers and vehicles. The expertise of the committee members would be different from that required to address research on highway infrastructure and operations safety, and the major federal government stakeholder would in all likelihood be the National Highway Traffic Safety Administration, as opposed to FHWA. Nonetheless, as noted in Chapter 2, highway research in general is characterized by its diversity and decentralization, and the resulting need for research coordination is not specific to the area of infrastructure and operations safety examined by the committee. Thus, a national research agenda on the driver or vehicle components of safety could be used as a unifying focal point for research coordination, albeit with different players. In the committee's view, the fundamentals of a transparent, analysis-driven process based on the value of research and involving detailed inputs from experts would remain the same.

CLOSING REMARKS

Road safety management in the infrastructure and operations area is moving toward a scientific basis, paralleling similar movements in the past in other public health and safety areas. As in those areas, this movement is expected to result in important benefits—in this case, a reduction in crash injuries and deaths on the nation's roads. Recent crash statistics show that in 2006 there were 1.42 fatalities per 100 million vehicle miles traveled (NHTSA 2007). While this figure is the lowest rate recorded by the U.S. Department of Transportation, it is still considerably higher than the target for 2008 of 1.0 fatalities per 100 million vehicle miles traveled set by AASHTO and others in 2005 (AASHTO 2005). Moreover, U.S. highway fatality rates on a population basis are among the highest for the world's industrialized nations [see, for example, statistics from the Organisation

for Economic Co-operation and Development's International Transport Forum (International Transport Forum 2007)].

Critical to the movement toward science-based road safety management are changes in the manner in which research issues are identified, prioritized for funding, coordinated among potential funders, and investigated. On the basis of its review of research processes and agenda-setting initiatives, its workshop with research funding organizations, and its deliberations, the committee concluded that the establishment of an independent scientific advisory committee, composed of experts and tasked with developing a national research agenda, could result in important progress toward achieving these necessary changes. The development and implementation of a transparent, analytical process for prioritizing research efforts is seen as crucial to the overall success of the effort. The associated cost would represent a very small percentage of the national annual research budget for highway infrastructure and operations safety, while the potential benefits of the recommended approach are, in the committee's judgment, considerable.

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Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
FHWA	Federal Highway Administration
NHTSA	National Highway Traffic Safety Administration
NRC	National Research Council
TRB	Transportation Research Board

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APPENDIX A

Committee Meetings and Other Activities

FIRST COMMITTEE MEETING

September 12–13, 2005, Washington, D.C.

The following presentations were made to the committee by invited speakers and individual committee members:

Overview of Activities of the National Highway Research and Technology Partnership Safety Working Group
Leanna Depue, *committee member*

White Papers: Development of Critical Knowledge Gaps and Research Efforts
Michael Griffith, *Federal Highway Administration*

FHWA Approach to Identifying High-Priority Research Areas
Michael Trentacoste, *Federal Highway Administration*

Approach Taken by National Center for Injury Prevention and Control to Identifying High-Priority Research Areas
Ann Dellinger, *committee member*

Safety Research Process Proposed by National Highway Research and Technology Partnership Safety Working Group
Daniel Turner, *committee member*

The Transportation Pooled Fund Program: A Model for Leveraging Resources to Achieve Common Research Goals
William Zaccagnino, *Federal Highway Administration*

Long-Term Plan for Concrete Pavement Research and Technology: A Research Program with Multiple Owners and Funding Sources
Ted Ferragut, *TDC Partners*

SECOND COMMITTEE MEETING

December 19–20, 2005, Washington, D.C.

The following presentation was made to the committee:

Using Highway Safety Information System (HSIS) Data to Assess the Burden of Different Crash Types
Forrest Council, *committee chair*

THIRD COMMITTEE MEETING AND WORKSHOP

April 10–11, 2006, Washington, D.C.

On April 10, 2006, the committee hosted a workshop for highway safety research funding organizations to discuss the development of a national research agenda and opportunities for research coordination (see Chapter 5 and Appendix C).

APPENDIX B

Comments on Individual Projects Described in White Papers Commissioned by the Federal Highway Administration

The committee was asked to review the applied and fundamental research projects proposed in the expert working papers commissioned by the Federal Highway Administration (FHWA) on run-off-road (ROR) research needs, intersection safety, human factors, work zone crashes, and fundamental advanced research (Kantowitz et al. 2004) and to provide guidance concerning the inclusion of these projects in a national research agenda. Responding to the first item of the charge proved problematic, however, as discussed in Chapter 1.

As a relatively small group of experts with only a few individuals knowledgeable in some of the detailed subject areas addressed by the proposed projects, the committee was uncomfortable about providing consensus guidance with regard to the inclusion of these projects in a national research agenda. In particular, it was mindful of one of its own findings about the white papers process: that relying on the advice of one expert or a small number of experts requires caution, particularly if a topic is controversial or not well understood. Consequently, the committee has provided in this appendix a summary of comments *from individual members* on projects proposed in the white papers. For each project, comments were provided only by those members (usually two or three individuals) with the necessary knowledge and expertise. Thus, the following comments do not represent the consensus view of the committee except where indicated, and the guidance offered should be used with that caution in mind.

The comments in this appendix address the potential value of including the research projects, possibly in modified form, in a national research

agenda. In some instances, the research topic was judged worthy of inclusion in a national agenda, but the proposed methodology was deemed unsuitable. As discussed in Chapter 4, the committee as a whole has reservations about the process used to identify research priority areas as subjects for white papers. As a result, it cautions that the projects identified as worthwhile cover a limited selection of research topic areas and are not necessarily the highest-priority projects for inclusion in a national research agenda in highway infrastructure and operations safety.

The following sections discuss the white papers on

- ROR research needs,
- Intersection safety,
- Human factors,
- Work zones, and
- Fundamental advanced research.

The tables in these sections are taken from the white papers (Kantowitz et al. 2004). Thus, the assignments of research type (applied or advanced) and the estimates of likelihood of success, duration, and cost are those of the paper authors and not of the committee or of the three paper reviewers selected by FHWA (see Chapter 4). All the authors rated likelihood of success on a scale from 1 to 5, with higher numbers representing a greater likelihood of success. Some authors also made qualitative assignments of the likelihood of success (moderate, moderate to high, etc.), although not all used the same scheme. Thus, a ranking of 5 may represent a "high" or a "very high" likelihood of success, depending on the author. While most authors used integers in the range 1 to 5 to rank likelihood of success, one author used a finer scale with intermediate ratings (2.5, 3.0, 3.5, etc.).

ROR RESEARCH NEEDS

General Comments

The committee reviewers note that no set of three or four projects will solve the problem of ROR crashes. Given the numbers of fatalities and serious injuries associated with such crashes, there is a strong need for an

effective process to select projects that will result in progress toward the desired objective of crash reduction. Many possible ROR-related areas were omitted from the proposed set of projects—for example, median barrier effectiveness for different median widths, curve design on multilane roads, effects of speed-reduction treatments, and rollover reduction. Rollovers result in very high "total harm," as measured by economic cost to society, compared with other crash types. Thus, the omission of rollover reduction from the list of priority projects lends additional support to the argument that a better way of choosing ROR research topics is needed.

The geographically dispersed nature of ROR crashes reduces the ability to improve the situation cost-effectively and may contribute to the difficulty of identifying effective research in this area. Also, an improved method of prioritizing ROR research is needed that incorporates some measure of implementation cost.

Human factors contributions to ROR crashes may be important. For example, if rumble strips work, distraction and inattention are likely to be important factors in crashes.

Comments on Specific Projects

(See Table B-1 on page 117.)

ROR 1: Use of Rumble Strips on Nonfreeways

The use of rumble strips for preventing ROR crashes has been accepted by the user community and applied on a larger scale since the 2002 Safety Research Agenda Planning Conference in Irvine, California, as indicated by the number of projects and the variants of rumble strips (shoulder versus edge strip, profiled edge strip, etc.) in use. Committee reviewers agree that the proposed evaluation of nonfreeway shoulder rumble strips is a research topic of national importance. (As noted by the paper author, research on centerline rumble strips is of less importance due to recently completed evaluations.)

Recently completed FHWA-sponsored research within the Highway Safety Information System project aimed to evaluate shoulder rumble strips on two-lane rural roads (Patel et al. 2007). The project also attempted to study the effects on (nonfreeway) multilane rural roads but was unable

TABLE B-1 Summary of ROR Research Projects

Category	Project Title	Type of Research	Likelihood of Success (1–5 scale)	Duration (months)	Cost ($ millions)
Run-off-road	ROR 1: Use of rumble strips on nonfreeways	Applied	5	36	1
Run-off-road	ROR 2: Development of a system of countermeasures to reduce ROR crashes on curves	Applied	4	18	1
Run-off-road	ROR 3: Optimizing the net benefits of delineation	Applied	4	36	1
Run-off-road	ROR 4: Development and application of a roadside inventory database	Advanced	3	24+	1.5

SOURCE: Kantowitz et al. 2004.

to do so. Research targeted to other types of strips (e.g., edge line rumble strips or strips on narrow paved shoulders) is also needed.

The white paper suggests that the choice of rumble strip designs for study be based on driver reaction to alternative designs from a test-track study. Committee reviewers suggest that significant weight be given to the designs that are being used by roadway agencies now or are likely to be used in the future—that is, designs indicated by state standards or national current practice.

Finally, while the methodology suggests driver responses and public acceptance as evaluation criteria, along with crash data, committee reviewers consider crash data to be the most important criterion. In addition, the best possible study methods are needed. Randomly assigning the treatments to sections of public roadway is not likely to be possible, so an empirical Bayes before-and-after study may well be needed. In this case, the planning for the reference group is critical in terms of site choice (e.g., which state databases will contain sufficient historical inventory and average daily traffic data).

ROR 2: Development of a System of Countermeasures to Reduce ROR Crashes on Curves

Committee reviewers agree that this project is of considerable importance for inclusion in a national agenda for ROR research. They fully support the expansion of the original project description, which included only traffic control devices (TCDs), to a project investigating combinations of strategies, including existing and innovative passive and active TCDs, along with curve modification (e.g., wider shoulders or lanes). They suggest that the project duration (3 years) is likely an underestimate if a crash-based before-and-after study is included after the tasks aimed at defining high-priority strategies. They would, however, strongly recommend that such a crash-based analysis be included.

ROR 3: Optimizing the Net Benefits of Delineation

Committee reviewers agree that determining the effects of different delineation treatments on ROR crashes is of national interest, particularly given that delineation is present on virtually all roadways, is relatively inexpensive, and can be "enhanced" rather easily—although enhanced delineation may lead to increased speeds and associated negative safety effects. Increased speeds have been shown to occur at night, likely because drivers are able to see farther and therefore are more comfortable traveling at a higher speed. On low-standard roads, the use of raised pavement markers and post-mounted delineators has been shown to lead to increased crashes, likely for the same reason.

The project recognizes that driver behavior may change according to the "safety appearance" of the roadway. Its subject is the behavioral adaptation to various delineation devices, and it asks to what extent better delineation is converted into increased confidence, reduced alertness, higher speed, and so on. In the view of committee reviewers, this project would be better classified as fundamental research since its objective is to provide the now-missing understanding of adaptation. Retaining it in the ROR section may, however, target it to the crash type most likely affected.

The proposed methodology is not as well defined as in other projects, and some suggestions are questionable. Task 1 suggests laboratory-type and test-track studies, but it appears that there are also opportunities to examine driver behaviors on different delineation schemes in real-

world settings (e.g., driver behaviors before and after restriping without repaving). Committee reviewers also note that if laboratory studies are considered, it is critical that the selected laboratory measures be *validated* surrogates of crashes. Task 2 suggests that data related to driver behaviors can produce a model that "should predict driver behavior and resultant effects on crash frequency and severity." Committee reviewers do not consider the latter to be possible based on such driver-behavior data alone. Further, they note that if the "safety measures" in Task 3 are "crashes" (as they should be), then huge samples will be required, since the expected effect would be small. In short, committee reviewers suggest that a new Task 1 be included that would define a detailed study plan.

ROR 4: Development and Application of a Roadside Inventory Database

Committee reviewers agree strongly that the development of roadside databases should be part of the national research agenda. This project begins to develop the supporting rationale and approach for developing and using the necessary data collection technologies. However, advances since the white paper was prepared will affect how the project goal is accomplished.

First, while the white paper notes that there are commercial devices that collect some roadway and (perhaps) roadside data, some recent research indicates problems with the accuracy of such devices when collecting "on-road" data particularly relevant to ROR crashes, namely, curvature and grade (Harkey et al. 2004). Second, FHWA has continued to develop its digital highway measurement van, which offers advantages over current commercial devices. In particular, the accuracy for all data items collected appears far superior and the array of roadside data collected is much wider. In addition, FHWA is now initiating a national pooled fund study to expand this development further by adding new collection capabilities and to field-test its use. Third, Washington State Department of Transportation has initiated a roadside data-collection effort using its own technology. Fourth, there is increased emphasis by state departments of transportation (DOTs) on asset management programs that may require and produce inventories of roadside hardware.

Thus, in general, the efforts envisioned by this project have been initiated. However, all these current efforts need to be coordinated and integrated to meet the overall goal of the white paper project—the

development of roadside databases. Committee reviewers strongly support these efforts and hope that FHWA's pooled fund study will serve as the coordinator of all current efforts.

INTERSECTION SAFETY

General Comments

Committee reviewers consider that, in general, the projects in this group represent needed research. As with all the other areas addressed in the white papers, however, they question whether these projects are the highest-priority intersection research needs. For example, while Appendix A of the white paper contains a robust list of intersection safety research needs and the paper itself provides some information about how priorities were decided (i.e., primarily author judgment based on review of other "needs" papers), a different prioritization method could produce a different "highest-priority" list. A reexamination of the priorities should include a review of emerging research not available when this white paper was prepared. Examples include the intersection-related needs identified in the Knowledge section of the *Highway Safety Manual* (in draft form at the time of writing) and in the National Cooperative Highway Research Program's (NCHRP's) Project 17-25 final report, *Crash Reduction Factors for Traffic Engineering and ITS Improvements* (Harkey et al. in press).

Other general concerns raised by committee reviewers were as follows:

- *No projects related to pedestrian safety at intersections:* The author assumed that pedestrian safety research needs were being addressed elsewhere, but committee reviewers were unable to verify the accuracy of this assumption. They note that pedestrians are an integral part of intersection safety.
- *No mention of light condition (day, night, dusk) in the projects:* Light conditions affect driver response and thus could influence treatment effectiveness. Such influences would be revealed by data analyses.
- *No mention of the often-seen trade-off between operational efficiency and safety:* For example, a long red light period may be desirable from an operational perspective but may encourage red light running. In view of increasing congestion and emphasis on better operations to increase

the capacity of the roadway network, traffic engineers may well favor designs and treatments that enhance efficiency, particularly if they lack the tools needed to make safety trade-offs. Thus, there is a need for improved methods to combine safety and nonsafety (e.g., efficiency) effects in evaluations. In addition, treatments that enhance operational efficiency could be high-priority targets for safety evaluations.

- *No discussion of possible research concerning neighborhood or transportation system planning tools:* Efforts are under way by FHWA and the American Association of State Highway and Transportation Officials to incorporate safety into the transportation system planning process. Limited analysis indicates that there may be a safety benefit to reducing the number of intersections, even though higher traffic volumes at the remaining intersections would result. However, sound advice to planners is lacking in this area.
- *No project related to building better intersection research databases:* While most state and local databases include information on intersection crashes, few include the related information on intersection inventories and traffic flows, particularly flows on the minor approaches and on unsignalized intersections. Indeed, most jurisdictions cannot even provide location data for all intersections in their systems. Intersection safety research is and will continue to be hampered by the lack of such data, since each research project must build its own database. There is a need for research on better methods to collect and maintain these data for both research and operations purposes. Data acquisition remains an important goal for state DOTs.
- *No project investigating definition of intersection accidents:* Typically, this definition involves the physical location of the crash (within the bounds of the crossing roads, or within 250 feet of the intersection) and the types of maneuvers being executed (an angle or rear-end crash seems appropriate, while an ROR crash does not). Crashes within the bounds of the intersection are likely to be much different from those occurring 250 feet away (queues at major arterials in major cities can extend even farther). Initial investigations into the accuracy of intersection crash data have revealed that as many as 20 to 33 percent of those crashes probably should not be included in the data set. Removal of these crashes could significantly improve crash analysis and modeling of crashes.

- *Arterial models experience difficulty in handling driveways:* Additional research could be directed toward defining the characteristics of driveways that influence crashes and the point at which a driveway should be considered an intersection.

Comments on Specific Projects

(See Table B-2 on page 123.)

IS 1a: Magnitude, Characteristics, and Causation of Intersection Accidents, and IS 1b: Establish Root Causes of Driver Error

Committee reviewers agree that a variety of factors contribute to the frequency and severity of intersection crashes, that many of these factors are driver related, and that increased knowledge of these factors could increase the ability to develop improved intersection designs and treatments. How far back to go into the causal chain of driver error is, however, debatable, since knowledge of why an error was made (e.g., inattention resulting from cell phone usage or eating) may not lead to realistic safety treatments and may not be necessary to change the error. For example, inattention could be remedied with gap-closure warning systems, regardless of its root cause. Better basic knowledge of driver behaviors and how they are affected by intersection design is expected to lead to designs and treatments that increase safety. However, committee reviewers are not sure that a crash-based analysis, even a detailed on-scene one, would be sufficient because the behaviors at the time of a crash would still be hypothesized rather than measured. The need for better behavior measurements should be filled by the ongoing Strategic Highway Research Program (SHRP) 2 safety research (see gulliver.trb.org/shrp2/SHRPII_Safety.asp). A primary focus of this work is driver behavior at intersections. Committee reviewers suggest that FHWA continue to support this work and monitor it to determine whether supplementary research is needed.

IS 2a-1: Safety Impacts of Alternative Intersection Controls

Committee reviewers agree that more knowledge is needed concerning trade-offs of different intersection control systems, such as no control, yield, stop, signal, and roundabout. Conducting well-controlled research

TABLE B-2 Summary of Intersection Safety Research Projects

Category	Project Title	Type of Research	Likelihood of Success (1–5 scale)	Duration (months)	Cost ($ millions)
Accident causation	IS 1a: Magnitude, characteristics, and causation of intersection accidents	Advanced	Moderate to high 4	36	1.5–2
	IS 1b: Establish root causes of driver error	Advanced	Moderate 3	24	0.5–0.75
Relationship of safety to					
a. Traffic and operational features	IS 2a-1: Safety impacts of alternative intersection controls	Advanced	Moderate 3	36–60	1.0–1.5
	IS 2a-2: Safety effects of alternative left-turn phasing	Applied	Moderate 3	24	0.3
b. Traffic control devices	IS 2b: Safety effects of alternative signal layouts	Applied	Moderate to high 3	36	0.3
c. Design features	IS 2c: Intersection sight distance	Advanced	Low to moderate 2	24–36	0.5
Effectiveness of countermeasures	IS 3: Effectiveness of various countermeasures for reducing accidents	Applied	Moderate to high 4	84 for all phases	2.0
Advanced technology	IS 4: Effectiveness of and driver response to automatic all-red signal extension system	Applied	High 5	6	0.05–0.1

SOURCE: Kantowitz et al. 2004.

will be difficult, since different systems cannot be assigned randomly to the same site. Thus, the cross-sectional research that will be done—comparisons of different control types at different locations—will require considerable care in controlling for the effects of other factors that may differ along with control type (e.g., driver population, vehicle population, annual average daily traffic, pedestrian use, and approach speed).

IS 2a-2: Safety Effects of Alternative Left-Turn Phasing

Committee reviewers agree that left-turn crashes are an important focus for research at signalized intersections. The white paper identifies two approaches: a before-and-after approach in which phasing is changed and a cross-sectional approach in which different phasing types are studied at different intersections. After the development of the white paper, at least two before-and-after studies of phasing changes at urban/suburban locations have been completed, and these should be reviewed to determine what additional research is necessary (see Harkey et al. in press). As noted in the discussion of IS 2a-1, the cross-sectional studies will require considerable care in controlling for the effects of other factors that may differ, along with phasing type. Finally, if crash surrogates for turning crashes can be developed in the SHRP 2 safety research program, the methodology involving site-mounted cameras should be applicable to this phasing question, since it may be possible to change phasing at the same location numerous times.

IS 2b: Safety Effects of Alternative Signal Layouts

This study will examine the issue of alternative signal layouts that all meet national standards but that may or may not all be equal in the resulting intersection safety. The study raises the issues of vision obstructions and of inconsistency among jurisdictions, and even among intersections within the same jurisdiction. Committee reviewers are unsure whether these issues should be accorded high priority but agree that, in the absence of data on the size of the problem caused, the issues should be explored. The proposed study method is cross-sectional in nature, again raising the need both for large samples (since the effect may be small) and for care in controlling for other confounding variables. For some of the configuration changes that may be relatively easy to make, the SHRP 2 site-camera method noted in the discussion of IS 2a-2 may be feasible.

IS 2c: Intersection Sight Distance

Committee reviewers agree that intersection sight distance is a critical safety component at yield and stop-controlled intersections and that knowledge of its effects is limited. The white paper proposes a large-sample cross-sectional study approach and rightfully notes the need to control for the many possible confounding factors. The paper appears to imply that, because a large-sample cross-sectional study may be too costly due to the need to measure sight distance at a large sample of locations, a forensic crash-reconstruction study would be an alternative or at least a first step. In the judgment of committee reviewers, the latter study method would also face some of the same issues, notably the need for a large sample to control for other confounding factors while measuring sight distance in each case. In addition, since a crash-reconstruction study would have no "successes" (no noncrash instances), it could be difficult to tease out the effect of sight distance. If such a study is to be conducted, FHWA should consider a case-control design in which both crashes and a set of "matched" noncrash locations would be included.

IS 3: Effectiveness of Various Countermeasures for Reducing Accidents

This project addresses the development of a prioritized list of intersection treatments for which measures of effectiveness are needed, the development of detailed study plans for each (including identification of databases for use), and the conduct of the evaluations. Committee reviewers and the full committee agree strongly with this approach. FHWA is currently conducting a pooled fund study of before-and-after evaluations of low-cost intersection improvements. This study has completed or is completing evaluations of "Stop Ahead" pavement markings, flashing beacons, and stop signs with increased retroreflectivity at unsignalized intersections; and of positive offset left-turn lanes and advanced street-name signs at signalized intersections. NCHRP Project 17-35, Evaluation of Safety Strategies at Signalized Intersections (www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=461), will evaluate as-yet-undetermined treatments at signalized intersections. The previously noted NCHRP Project 17-25 report documents additional accident modification factors for intersections and suggests high-priority needs on the basis of a multi-criteria rating system (Harkey et al. in press). Committee reviewers suggest that FHWA review these efforts, together with the *Highway Safety Manual,* in identifying needed evaluations.

The critical need for scientifically sound evaluations of safety treatments continues. Committee reviewers commend both FHWA and NCHRP for their current efforts and encourage FHWA to consider implementing a continuing long-term program of such evaluations.

IS 4: Effectiveness of and Driver Response to Automatic All-Red Signal Extension System

This project concerns the evaluation of automatic extension of an all-red phase based on detection of possible intersection encroachment by a vehicle approaching the red signal [e.g., the detection of a possible red light runner (RLR)]. Suggested methods include before-and-after evaluations of both RLR crashes and violations. Committee reviewers agree that angle crashes at signalized intersections continue to require treatment. Whether this specific treatment would be the highest priority for study is questionable.

Committee reviewers agree with the proposed methodology but note that, like other intersection treatments described above, the SHRP 2 site-based camera methodology should be considered here, since it would provide a quicker and less expensive evaluation if validated crash-surrogate measures could be developed in the SHRP 2 study.

Human factors considerations may be important for this project, because those working with red light cameras often suspect that drivers "learn" that they can take advantage of extended all-red phasing.

HUMAN FACTORS

Comments on Specific Projects

(See Table B-3 on page 127.)

HF 1: Computational Driver Model: (a) Whole Enchilada and (b) Light

The original reviewers of the white papers requested input on the proposed human factors projects, particularly the driver model, from five international experts on human factors in road safety. Most of these experts agreed that some limited driver modeling might be possible and could be pursued, but they were of the opinion that the comprehensive model is of questionable feasibility. On the basis of these expert

TABLE B-3 Summary of Human Factors Research Projects

Category	Project Title	Type of Research	Likelihood of Success (1–5 scale)	Duration (months)	Cost ($ millions)
Human factors cognitive models	HF 1a: Computational driver model—WE (whole enchilada)	Advanced	3.5	144	12
	HF 1b: Computational driver model—light	Advanced	4.0	60	5
Human factors information overload	HF 2: Processing multiple sources of information	Advanced	4.0	60	10
Human factors speed control	HF 3: Understanding speed selection	Applied	3.0	48	8
Human factors perception/attention	HF 4: Look but not see	Applied	2.5	36	4
Human factors basis for design standards	HF 5: Design driver	Applied	4.5	18	0.3
Human factors decision rationality	HF 6: Risk homeostasis	Applied	2.5	28	1
Human factors simulator generalization	HF 7: Driving simulator validity	Applied methodology	4.5	42	4.5

SOURCE: Kantowitz et al. 2004.

judgments, the original reviewers' comments, and their own expert judgment, committee reviewers consider inclusion of the comprehensive model projects in a national agenda to be questionable at this point. A more realistic scope for a project on driver modeling would be as follows:

- Compile existing models highlighting the state of the art in modeling;
- Identify aspects of driver behavior about which little is known;

- Identify aspects of behavior that could most usefully be developed to assist with analyzing highway design related to high crash potential (e.g., driver workload and visual requirements in weaving sections and how they affect safe and comfortable interchange spacing, driver speed, and path selection relative to different short-term expectancies about upcoming curve radii); and
- Model development incrementally through a long-term research program.

HF 2: Processing Multiple Sources of Information

A study of processing multiple sources of information could be useful as long as it starts from where the Driver Workload Metrics Project ends. This project to develop practical, repeatable driver workload metrics and procedures for both visual and cognitive demand is being conducted under the auspices of the Crash Avoidance Metrics Partnership between Ford and General Motors. As part of this project, workload metrics have been developed on the basis of laboratory and simulator testing (Angell et al. 2006). Following completion of the project, related work is being conducted at the National Highway Traffic Safety Administration's Vehicle Research and Test Center. The purpose of this work is to determine which workload metrics can be used or adapted to evaluate systems in production vehicles with respect to best practices concerning attention demands of different designs for similar functions or features.

HF 3: Understanding Speed Selection

The cues drivers use to select speeds are still not well understood, especially on arterials and on tangents. Convincing (or forcing) drivers to choose safe speeds through police enforcement can be less than totally effective unless the enforcement is sustained at the same location for long periods. Such enforcement is costly, and the necessary funding is often not available. Thus, more knowledge of how to affect speed selection through road design and perceptual countermeasures (novel lane-marking schemes, landscaping near the road edge, etc.) is important and should be pursued. Such road design leads to distinctly different-looking roads for different purposes and speeds, as in the European development of "self-explaining roads."

HF 4: Look but Not See

The complete road user task at intersections needs further study. Not only drivers but also pedestrians and bicyclists are involved in "looked but did not see" crashes. The naturalistic driver project could provide useful data on visual search in relation to familiarity with the intersection and in relation to intersection design. Specific experimental studies involving selected intersection designs should be included. The recent FHWA project on driver errors at intersections could be a starting point.

HF 5: Design Driver

The design driver should be updated. However, the anthropometric aspects are of interest principally to vehicle manufacturers. If perceptual and cognitive aspects were included (e.g., seeing distance with low-beam headlights to low-contrast objects, perception–reaction time to simple daytime hazard in the road situation, time per major word to read message on changeable message sign), this would be useful information for highway designers and traffic engineers. Any measures should include both means and standard deviations, as well as assumptions about conditions in which the measures are valid.

HF 6: Risk Homeostasis

Driver adaptation can have a huge impact on the effectiveness of a safety countermeasure. For example, studies of both raised pavement markers and post-mounted delineators indicate that increases in speed occur when drivers can see farther and that, on low-standard roads, the number of crashes increases after installation of these devices. In the opinion of committee reviewers, this project definitely should be funded if the emphasis is changed to adaptation rather than risk homeostasis.

HF 7: Driving Simulator Validity

This project may be useful for identifying specific simulator characteristics (e.g., surround screen, motion base, high-resolution road scene) necessary to adequately simulate specific driving tasks (e.g., exiting a freeway ramp, turning left at an intersection).

WORK ZONES

General Comments

In general, the review of this proposed research area resulted in the highest level of disagreement among committee reviewers. While reviewers tentatively agreed that some work zone research may be of high priority, they disagreed among themselves about ranking the overall issue of work zone crashes among the top five infrastructure research areas addressed in the five white papers. One underlying source of this disagreement may be the poor characterization of the size of the work zone crash problem. Some past estimates have included all crashes occurring in the zone, thereby resulting in an overestimate because the overwhelming majority of those crashes (perhaps 80 percent or greater) would have occurred on those highway segments even in the absence of a work zone.

Given that maintenance of roadways is expected to increase in the future, targeted research in work zone safety is deemed to be warranted. The committee reviewers suggest that a review of the results of NCHRP Project 17-30, Traffic Safety Evaluation of Nighttime and Daytime Work Zones (www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=456), and of other recent work zone research be undertaken to help identify specific research projects. In addition, they suggest that increased research is needed on how best to reduce work zones—the "get in, get out, stay out" concept. The SHRP 2 research effort on renewal is aimed at this goal, and review of studies conducted there should provide guidance on other research needs.

Comments on Specific Projects

(See Table B-4 on page 131.)

WZ 1a: Exposure Data: Estimate Work Zone Exposure Characteristics from Financial Management Information System

The objectives of this project are to understand the relationship between key characteristics available in the Financial Management Information System (FMIS) that accurately capture work zone exposure and to develop appropriate unit values for estimating national and regional work zone exposure. The proposed method involves use of existing

TABLE B-4 Summary of Work Zones Research Projects

Category	Project Title	Type of Research	Likelihood of Success (1–5 scale)	Duration (months)	Cost ($ millions)
Research methodology—WZ exposure data	WZ 1a: Estimate WZ exposure characteristics from FMIS	Applied	High 4	30	1
	WZ 1b: Develop VMT temporal distributions to estimate WZ exposure	Applied	Very high 5	18	0.5
Research methodology—WZ crash data	WZ 2a: Incorporate new WZ data elements into CDS crash investigations	Advanced	Moderately low 2	60	2
	WZ 2b: Investigate likelihood of WZ crash reporting	Applied	Very high 5	18	0.5
Determine WZ crash causation	WZ 3a: Feasibility and validity of regionwide WZ crash risk estimation techniques	Advanced	Moderate 3	30	1
	WZ 3b: Project-level crash consequences of WZ design features	Applied	Moderate 3	60	2.5
Identify/evaluate countermeasures to mitigate WZ crash risk	WZ 4a: Improve the understanding and measurement of driver behavior in high driver workload environments	Advanced	Moderate 3	36	1.5
	WZ 4b: Evaluate dynamic queue-end warning systems for WZ	Applied	Moderate 3	60	1.5
Develop/apply/evaluate WZ management procedures	WZ 5: Analyze state WZ monitoring and management programs and procedures	Applied	High 4	48	1

NOTE: CDS = Crashworthiness Data System; FMIS = Financial Management Information System; VMT = vehicle miles traveled; WZ = work zone.
SOURCE: Kantowitz et al. 2004.

FMIS data and additional field data obtained from a statistically representative sample of regions to develop unit values of key work zone exposure characteristics.

Committee reviewers note that successful completion of this project would identify FMIS data factors pertinent to the establishment of a database that would guide highway operating agencies in predicting and planning for work zone traffic exposure, crash risk, and mobility. However, considerable effort would need to be placed on the collection of additional data to augment the existing FMIS data, and for this reason the viability of the project is questionable.

WZ 1b: Exposure Data: Develop Vehicle Miles Traveled Temporal Distributions to Estimate Work Zone Exposure

The objective of this project is to establish methods for adjusting daily traffic to obtain vehicular exposure during work zone activity for vehicle type, roadway type, traffic control, and the like. The proposed method involves using the Highway Performance Monitoring System database and a sample of traffic data from intelligent transportation system centers to assess hourly temporal distributions of traffic volumes as a function of several traffic characteristics, including daily traffic volumes, region, and roadway type. This approach involves the use of appropriate statistical techniques to identify the significant characteristics. The development of a plan for collecting additional data at work zones nationally and for the use of this data set to validate these temporal distributions is also proposed.

In the view of committee reviewers, it is doubtful that the data required for this project are readily available. For this reason, the viability of the project is questionable.

WZ 2a: Crash Data: Incorporate New Work Zone Data Elements into Crashworthiness Data System Crash Investigations

The objectives of this project are to establish a method for obtaining work zone configuration data at time of crash for inclusion in the Crashworthiness Data System database and to determine the impact of specific features and conditions on crash risks at work zones nationally. The data elements related to work zone crashes, such as queue length and length

and lateral clearance of lane shifts, will first be defined. A pilot study to evaluate these data elements will then be conducted at selected sites, and the results of this pilot study will be used to revise the original list of data elements. This activity will be followed by a more widespread implementation effort using the revised set of data elements to collect additional data and conduct analyses to validate expected causal relationships in work zones.

Addressing the failure of work zones to provide reasonably safe conditions for public travel depends on the ability to review and analyze specific elements and details of the work zone configuration. The review and analysis are expected to lead to the identification of specific features and conditions that create high-risk situations at work zones so that alternative controls may be considered. If conducted properly, the research will enable these data elements to be identified for use in developing safer work zones that are less likely to create risks for the public.

Committee reviewers note that crash risk, as noted above, cannot be measured only with crash data. The methodology must also capture the characteristics of crash-free times or of a random sample of periods both with and without crashes. This will require careful planning of the study method. Again, review of methodologies and issues in NCHRP Project 17-30, in which crash risks are compared, will be valuable.

WZ 2b: Investigate Likelihood of Work Zone Crash Reporting

The objectives of this project are to determine systems trends in underreporting of work zone crashes and to estimate the amount of underreporting nationwide. By using the FMIS database, a variety of work zone projects in jurisdictions across the country will be identified, and information on the date and time of each crash that occurred at these work zones will be obtained. An analysis will be conducted to determine those crashes that were recorded as work zone crashes and those that were not. Appropriate statistics will then be used to determine any trends that exist in the nonreporting of work zone crashes.

Historically, work zone crashes have been underreported both in their numbers and in their qualitative value, that is, where, under what circumstances, why, and so on. Also, the lack of a good definition of a work

zone is problematic. The research will accumulate work zone crash data and compare them with the presence of work zone data to determine the extent of underreporting and offer corrective action to increase the quantity and accuracy of work zone crash data. The success of this study depends mainly on the extent to which the data required can be extracted from the FMIS database. For example, linking crashes to work zones requires both the location ("milepost" or set of coordinates) of each crash, as well the mileposted location of the zones. It is not clear whether this information is available in the FMIS. It is also not clear whether the nonreporting problem is specific to work zones or is simply a representation of known nonreporting across the entire highway system. If the research is an attempt to improve on existing police reporting, it will require unique data collection efforts, since existing police-reported data will not suffice. Thus, the viability of the project is questionable.

WZ 3a: Crash Causation: Feasibility and Validity of Regionwide Work Zone Crash Risk Estimation Techniques

The objectives of this project are to determine the feasibility of using regionwide FMIS data for selected regions to identify alternative model structures for estimating regionwide work zone crash risk for countermeasures evaluation and to validate the model structures identified by using crash data from other regions. Work zone exposure estimates from the FMIS database and temporal vehicle miles traveled distributions at each work zone will be used to determine the appropriate model structures for estimating regionwide work zone crash risk. Data obtained in conducting other projects (e.g., Project WZ 1a) will augment data obtained from the FMIS database.

In the judgment of committee reviewers, this project on its own has a low probability of success. It could, perhaps, be of some value if combined with Project WZ 1a.

WZ 3b: Project-Level Crash Consequences of Work Zone Design Features

The purpose of this project is to determine the effect of various design elements and operating characteristics on crash potential. First, a fairly large number of work zone sites will be classified with respect to their design elements. A before–during study using control sites will then be

conducted to determine crash adjustment factors associated with the design elements and their interactions.

Committee reviewers note that preparing for work zone traffic control (WZTC) is no longer solely an operational concern. It is essential that project designers and planners recognize the importance of WZTC as the functional and construction plans are prepared. Project staging and specific design elements can profoundly influence the safety and well-being of the road users as they traverse the work area. The research will identify the relationship between design and operating characteristics and the work zone crash experience in terms of road user expectancy and perception as the work area is traversed.

In the judgment of committee reviewers, the proposed project would be extremely difficult and expensive to conduct, since it would involve extracting data from handwritten work zone "diaries" in many cases. In addition, the WZTC changes almost daily, and sometimes hourly. The difficulties of characterizing these changes in work zones (and thus defining the design and operating characteristics of these zones for a period of time during which crashes can be linked to them) would have to be overcome for the project to be successful as described. Again, review of NCHRP 17-30 would be needed.

WZ 4a: Crash Risk: Improve the Understanding and Measurement of Driver Behavior in High Driver Workload Environments

The objectives of this project are to develop a realistic model of driver cognition and behavior at work zones, identify driver performance measures that correspond to workload, and determine the relationship between crash outcomes and driver performance measures.

The proposed methodology has four parts: (*a*) developing a theoretical model of driver workload based on conditions and features at work zones, (*b*) identifying appropriate performance measures corresponding to workload, (*c*) calibrating the performance measures through laboratory studies, and (*d*) validating the correlation between workload estimates and crash risk by using before–during studies. Committee reviewers found this proposed methodology unclear and questioned what field measurements would be made and how they would be used. The reviewers suggest that this project, which they do not consider viable,

be reclassified under Human Factors, since its broad subject area goes well beyond the scope of work zone crashes.

WZ 4b: Crash Risk: Evaluate Effectiveness of Real-Time Queue-End Warning Systems

The objectives of this project are to determine the impact of real-time dynamic warning systems on driver performance measures and to identify work zone characteristics for which real-time queue-end warning systems may be most appropriate. First, laboratory studies, possibly using a driving simulator and possibly augmented with some field studies, will be conducted to determine the effect of real-time queue-end warning systems on driver maneuvers related to rear-end crashes at work zones, such as speed change and erratic maneuvers. If the results of these studies indicate some potential benefit in terms of altered driver maneuvers, then a controlled before–during field study will be conducted at appropriate work zones in several regions to obtain crash comparisons.

One of the more perplexing situations in the urban high-traffic, high-speed situation is the end-of-queue crash. Often the queue length cannot be easily predicted or identified because of varying traffic, work, and weather conditions. Unexpected, though prepared for, incidents cause queues that were unanticipated in both their presence and their extent. The research will need to identify the measurable traffic and highway characteristics, the needed surveillance techniques, and the possible strategies that establish the needed real-time controls. For example, one would need to be able to measure the ever-changing length of the queue and "move" the warning device to warn the appropriate drivers. The research also would need to define clearly and validate the surrogate measures to be used (that is, the erratic behaviors and speed changes that are true predictors of possible crashes). Although the concept of the research project is viable, the link between laboratory measures and actual crashes is not available. The SHRP 2 naturalistic driving study may provide information on viable surrogates.

If a viable warning system is developed, the committee reviewers would support a well-designed, scientifically sound before-and-after (or "with/without") crash-based evaluation of its effectiveness. This would likely require implementation at multiple work zones and would need to be carefully planned.

WZ 5: Management Procedures: Analyze State Work Zone Monitoring and Management Programs and Procedures

The purpose of this project is to determine the effect of monitoring and management programs and procedures on work zone safety. State DOTs will be surveyed to obtain information on the monitoring and management procedures that are used nationally. This information will include the data being collected, any specific activities that are conducted, and the decisions that are made on the basis of these data. An analysis will then be carried out to compare crash experiences between states that have specific work zone monitoring and management procedures and those that do not.

In the view of committee reviewers, the payoff of this research appears limited for several reasons. First, no definite correlation has been established between the best monitoring and management procedures and safety at work zones. Second, the best monitoring and management procedures have not been defined. Third, it will be difficult to isolate the effect of all other factors that influence safety at work zones to identify the direct effect of the monitoring and management procedure. And finally, differences in crash-reporting procedures among states (and sometimes among jurisdictions within a state) will cloud the results. It appears unlikely that these problems will be eliminated with the implementation of the FHWA Work Zone Safety and Mobility Final Rule in October 2007. Although states should "develop and implement systematic procedures to assess work zone impacts on project development, and to manage safety and mobility during project implementation" (FHWA 2004, 54570), a review of several states' implementation plans does not clearly indicate that data collected will facilitate the identification of the best management procedures, nor will the problem of differences in crash-reporting procedures among states be eliminated.

FUNDAMENTAL ADVANCED RESEARCH

General Comments

Opinions concerning the needs for fundamental research in road safety differ. In the view of committee reviewers, however, a number of topics requiring attention are not included in the white paper on fundamental

advanced research. Three of these topics are presented briefly here: how the driver behaves and reacts to changes in the environment, development and validation of surrogate measures of safety, and methods for evaluating the causal effect of interventions and other factors.

Fundamental research is needed on how the driver behaves and reacts to changes in the environment (road, car, traffic). It is suggested that, in this work, particular emphasis be placed on the determinants of group behavior as opposed to individual traits. Changes in behavior such as wearing seat belts, driving under the influence, choice of speed, and red light running are all reflections of a culture that characterizes a group. Fundamental research is needed to understand what fashions and what changes group behavior. In addition, there is the related question of whether any driver model that is developed should predict normal driving behavior or driver errors, as recognized by the author of the white paper. Given that many normal drivers accumulate a vast number of crash-free miles, it appears that modeling the tails of the distribution of driver behaviors may be more useful than modeling the average behavior.

Deriving information from crash occurrence data is not practical in many circumstances due to the long periods required for crashes to accumulate. Ideally, one would like to be able to make quick measurements of surrogates from which to draw safety conclusions. The problem is that the relationship of many promising surrogates to crash frequency and severity will remain unknown in the absence of fundamental research. Thus, development and validation of surrogate measures of safety are fundamental research problems. Committee reviewers note that research related to the development of surrogates is an integral part of the SHRP 2 safety research project and recommend that any surrogate development be coordinated with that research.

Safety management is impossible without knowing the effects of interventions. At present, the effect of many interventions remains uncertain because different evaluations of the same intervention have produced different results. While the impediments to evaluation are many, some are rooted in uncertainty about the circumstances under which different approaches can yield valid results about cause and effect. Much can be learned from other disciplines, but evaluative research in road safety differs from econometrics (in which causality is thought to derive from

TABLE B-5 Summary of Fundamental Advanced Research Projects

Category	Project Title	Type of Research	Likelihood of Success (1–5 scale)	Duration (months)	Cost ($ millions)
Understanding the driver	ADV 1a: Development of a driver modeling structure	Advanced	Very high 5	24	2
	ADV 1b: Development of a prototype driver model	Advanced	High 4	36	4
	ADV 1c: Development of a driver model	Advanced	Moderate 3	60	15
Data collection/ analytical tools	ADV 2a: Evaluation of advanced sensors and data mining techniques	Advanced	Moderate 3	36	4
	ADV 2b: Development of safety decision aids for planners	Advanced	Moderate 3	36	5
Advanced technology for countermeasures	ADV 3: Evaluation of nanotechnology for safety countermeasures	Advanced	High 5	12	0.25[a]

[a]The proposed $250,000 is for a project to develop a nanotechnology research program at FHWA.
SOURCE: Kantowitz et al. 2004.

economic theory) or medicine and education (in which randomized experiments are possible). Thus, there is a need for fundamental research into methods for evaluating the causal effect of interventions and of other factors.[1]

Comments on Specific Projects

(See Table B-5 above.)

ADV 1a, 1b, 1c: Understanding the Driver

Committee reviewers do not consider that they have the necessary expertise in human factors, driver modeling, or other associated areas

[1] Initial research on this topic was recently completed for FHWA (Hauer 2005). A January 2006 workshop further defined possible research avenues (TRB 2006).

to assess accurately the importance of the proposed research initiative or its chances of success. They strongly suggest that independent expert opinion be sought before any decision is taken to fund this project. As discussed in Chapters 3 and 6, the experts consulted should be well versed in what is known and what can and cannot be done and should be capable of assessing the benefit of the knowledge to be generated. They should also be independent and should not stand to benefit from the funding of the proposed research.

Since this effort is similar to that proposed under the Human Factors white paper, committee reviewer comments there would also apply here.

ADV 2a: Evaluation of Advanced Sensors and Data Mining Techniques

The text of the original white paper and the author's response to reviewer comments suggest that the sensor and data mining technique development are intended to support methods for safety data collection and analysis in general, rather than for specific projects. Committee reviewers did not find any arguments in the text suggesting that sensor technologies will be insufficient to support the collection of safety data or that data mining techniques developed in other fields cannot be used on safety data. Key questions appear to be, "What is unique about safety data that requires that they have their own sensor development or data mining techniques?" and "What aspects of these developments would not take place unless supported by FHWA?" Answers to these questions are needed to inform assessments of the proposed effort. If the development of safety-specific sensors and data mining techniques were to have a large research-enabling payoff and if such development is unlikely to take place without FHWA support, the project would merit consideration. At this point, however, that argument has not been made.

ADV 2b: Development of Safety Decision Aids for Planners

Committee reviewers agree that the "justification for the need for this is that there is a lot of development and re-development going on in our urban and suburban areas, and a lot of decisions need to be made on where you put intersections and what type of intersections do you put in. So, we feel we could help traffic engineers and planners explicitly consider safety in that decision-making process if we develop the right tools and

models" (Hanscom 2002, 27). The effort described here appears to be similar to that described in two NCHRP projects: NCHRP 8-44, Incorporating Safety into Long-Range Transportation Planning (Washington et al. 2006), and NCHRP 8-44(02), Transportation Safety Planning: Forecasting the Safety Impacts of Socio-Demographic Changes and Safety Investments (www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=919). Future efforts should be coordinated with these and other similar projects.

Committee reviewers question whether the need to develop safety decision aid tools should be categorized as fundamental research. Rather, this activity appears to be high-priority applied research that would be better listed under an alternative category.

ADV 3: Evaluation of Nanotechnology for Safety Countermeasures

In response to earlier comments by the initial reviewers of the white papers, the author suggested that only an "initial study" be done to develop a "nanotechnology research program focusing on the area of safety." It is unclear to committee reviewers whether potential links between nanotechnology and safety have already been identified. The white paper author also notes that the "FHWA Advanced Research Program is currently engaged in a small number of nanotechnology projects." Committee reviewers suggest that this activity may be sufficient for FHWA safety research personnel to keep a current awareness lookout for potential safety uses of nanotechnology. Further activity in this area might subsequently be warranted if safety-specific uses of nanotechnology were identified and if the necessary development would not take place without support from FHWA.

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Abbreviations

FHWA	Federal Highway Administration
TRB	Transportation Research Board

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APPENDIX C

Workshop Agenda and Participants

Workshop on Research in Highway Infrastructure and Operations Safety

Keck Center of the National Academies
500 Fifth Street, N.W.
Washington, D.C.

Monday, April 10, 2006

Agenda

9:30 a.m.	Welcome and Workshop Objectives, *Forrest Council, committee chair*
	Introductions
9:50 a.m.	Brief Overview of Committee's Activities, *Forrest Council*

10:05 a.m.–12:30 p.m. A National Research Agenda

10:05 a.m.	Developing a National Research Agenda, *Forrest Council*
10:40 a.m.	Break
10:50 a.m.	Breakout Groups Discuss National Research Agenda

Each group is asked to respond to the following four questions:

1. Do you see a need for a national research agenda in highway infrastructure and operations safety? Why or why not?

2. Would you use the national agenda in setting your research portfolio? Why or why not? Qualifications?
3. Do you agree with the committee's idea for how the agenda would be developed (i.e., by an independent scientific advisory group)? Why or why not? Would you suggest any modifications to the agenda development process?
4. If you agree that a national agenda is needed and would be used, would your organization be willing to help fund such an ongoing effort?

Each group will nominate a rapporteur to deliver its feedback when the full workshop reconvenes.

11:40 a.m. Results from Breakout Group Discussions on a National Research Agenda

- Participants reconvene
- Rapporteurs deliver feedback from breakout groups
- Discussion

12:30 p.m. Lunch

1:30–4:00 p.m. Research Coordination

1:30 p.m. Research Coordination, *Daniel Turner, committee member*

2:00 p.m. Breakout Groups Discuss Opportunities and Possible Mechanisms for Coordinating Research Among Different Organizations

Each group is asked to respond to the following three questions:

1. Is coordination among funding agencies needed? Advantages or disadvantages?
2. Will coordination happen, given the political realities? Who is likely to get "in" and who "out"?
3. If coordination is needed, what mechanisms or processes would be needed to cause this coordination to occur?

Each group will nominate a rapporteur to deliver its feedback when the full workshop reconvenes.

2:45 p.m. Break

2:55 p.m. Results from Breakout Group Discussions on Research Coordination

- Participants reconvene
- Rapporteurs deliver feedback from breakout groups
- Discussion

3:45 p.m. Break

4:00–4:30 p.m. Workshop Conclusions

4:00 p.m. Summing Up and Conclusions, *Forrest Council, discussion leader*

4:30 p.m. Adjourn

Workshop Participants

Alan Blatt
Calspan–University of Buffalo Research Center

Ann Brach
Strategic Highway Research Program 2, Transportation Research Board

Rebecca Brewster
American Transportation Research Institute

Tom Dingus
Virginia Tech Transportation Institute

Monique Evans
Ohio Department of Transportation

Mike Griffith
Federal Motor Carrier Safety Administration

Mike Halladay
Federal Highway Administration

Peter Kissinger
AAA Foundation for Traffic Safety

Ken Kobetsky
American Association of State Highway and Transportation Officials

Chris Lawson
Federal Highway Administration

Kunik Lee
Federal Highway Administration

Richard Long
Florida Department of Transportation

Wes Lum
California Department of Transportation

Chuck Niessner
National Cooperative Highway Research Program, Transportation Research Board

Leni Oman
Washington State Department of Transportation

Bob Reilly
Cooperative Research Programs, Transportation Research Board

Calvin Roberts
Michigan Department of Transportation

Michael Trentacoste
Federal Highway Administration

Maria Vegega
National Highway Traffic Safety Administration

Nic Ward
University of Minnesota

Study Committee Biographical Information

Forrest M. Council, *Chair,* is a senior research scientist at the University of North Carolina Highway Safety Research Center (HSRC), where he served as Director from 1993 through 1999. He is also a senior research scientist at BMI-SG, a transportation engineering firm in Vienna, Virginia. In his 35 years at HSRC, Dr. Council has directed more than 20 projects and written more than 80 articles and reports. His research has ranged from studies of motor vehicle injury for specific populations (children, beginning drivers, seat-belted occupants) to projects aimed at identifying and strengthening research methodologies in the roadway safety field. For the past 15 years, he has directed the planning, development, and implementation of the Federal Highway Administration's (FHWA's) Highway Safety Information System, a database that contains crash, roadway inventory, and traffic volume data for nine states. Dr. Council chaired the National Research Council (NRC) Committee for Review of the Federal Motor Carrier Safety Administration's Large Truck Crash Causation Study and served on the Research and Technology Coordinating Committee and the Committee for Guidance on Setting and Enforcing Speed Limits. He has also served on several Transportation Research Board (TRB) standing committees and National Cooperative Highway Research Program (NCHRP) project panels. He is a national associate of the National Academies and a two-time winner of TRB's D. Grant Mickle Award for best paper in the area of operations, safety, and maintenance. Dr. Council earned a BS, an MS, and a PhD, all in civil engineering, from North Carolina State University.

Ann M. Dellinger is an epidemiologist and leader of the Motor Vehicle Injury Prevention Team at the Centers for Disease Control and

Prevention's (CDC's) National Center for Injury Prevention and Control in Atlanta, Georgia. Her research uses epidemiologic, biostatistical, and behavioral science methods to investigate injury prevention, and she provides technical advice on public health problems to the general public, federal and nonfederal agencies, and international researchers. Dr. Dellinger has served as a scientific consultant to the state of Maine Bureau of Motor Vehicles for the study of traffic crash risk due to medical conditions, as well as to the state of Oklahoma during the Oklahoma City bombing disaster. In 1994, she spent a 3-month detail as the CDC's Acting Deputy Associate Director for Science. She is a reviewer for a number of technical journals, including *Accident Analysis and Prevention,* of which she is associate editor. Dr. Dellinger served on the NRC Committee on School Transportation Safety. She earned a BA degree in biology from the University of San Diego, an MPH degree from San Diego State University, and a PhD from the School of Public Health at the University of California, Los Angeles.

Leanna Depue is Director of the Highway Safety Division within the Missouri Department of Transportation. She oversees the division's efforts to reduce deaths, injuries, and property damage caused by traffic crashes on Missouri roadways. She also chairs the executive committee for the Missouri Coalition for Roadway Safety and was instrumental in the coordination and development of *Missouri's Blueprint for Safer Roadways.* Before assuming her current position in September 2005, Dr. Depue was Director of the Missouri Safety Center at Central Missouri State University in Warrensburg for 14 years. The center brings together university personnel, state and local agencies, business and industry, safety professionals, and members of the public in efforts to reduce deaths and injuries on the highways, as well as at work, during recreation, and in the home. In 2004, Dr. Depue visited Finland, Norway, Sweden, Denmark, the Netherlands, and France as a member of the international scanning review team on roadway human factors and behavioral safety in Europe; this activity was sponsored by FHWA, the American Association of State Highway and Transportation Officials (AASHTO), and NCHRP. Dr. Depue chairs the Highway Traffic Safety Division of the National Safety Council and the Safety Section of TRB's Technical Activities Division, and cochaired the Safety Working Group of the National

Research and Technology Partnership from 1999 to 2002. She received a distinguished service to safety award from the National Safety Council in 2000. Dr. Depue earned a BS in physical education from Southern Illinois University and an MS and a PhD in health education, specializing in safety, from Southern Illinois University at Carbondale.

Nicholas J. Garber is the Henry L. Kinnier Professor of Civil Engineering at the University of Virginia, where he has been a faculty member since 1980. Previously he taught at the University of Sierra Leone and the State University of New York at Buffalo and worked as an engineer in London and Sierra Leone. Dr. Garber's research interests include traffic operations and highway safety, intelligent transportation systems, speed management on high-speed roads, and work zone safety. He has published extensively in these areas and coauthored a textbook, *Traffic and Highway Engineering.* Dr. Garber was elected to the National Academy of Engineering in 2004. He is a fellow of both the American Society of Civil Engineers (ASCE) and the Institute of Civil Engineers of the United Kingdom. Dr. Garber is a member of the TRB Executive Committee and has served on several NRC committees, including the Committee for Guidance on Setting and Enforcing Speed Limits and the Committee for the Study of the Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles. He also chaired the TRB Committee on Traffic Safety in Maintenance and Construction Operations for several years. His awards include the 1995 TRB D. Grant Mickle Award for best paper in the area of operations, safety, and maintenance and the 2003 Institute of Transportation Engineers Edmund R. Ricker Transportation Safety Award. Dr. Garber earned a BS in civil engineering from the University of London and an MS and a PhD from Carnegie Mellon University.

Ezra Hauer is Emeritus Professor of Civil Engineering at the University of Toronto, where he taught from 1970 until 1997. His research is in methodologies for the evaluation of safety countermeasures, the design of experiments in traffic safety research, and transportation safety management. He has been active in road safety research since 1970 and has authored more than 200 publications, including a book entitled *Observational Before–After Studies in Road Safety: Estimating the Effect of Highway and Traffic Engineering Measures on Road Safety.* Dr. Hauer served on the NRC Committee for the Study of Geometric Design Standards for

Highway Improvements and, more recently, the Committee for the Study of the Regulation of Weights, Lengths, and Widths of Commercial Motor Vehicles. He is an emeritus member of the TRB Committee on Safety Data, Analysis, and Evaluation. Dr. Hauer was the 1999 recipient of TRB's Roy W. Crum distinguished service award, which recognizes outstanding achievement in the field of transportation research. He earned BSc and MSc degrees from the Technion Israel Institute of Technology and a PhD from the University of California, Berkeley.

Thomas Hicks is the Director of the Office of Traffic Safety at the Maryland State Highway Administration, a position he has held since 1991. Previously he held posts in the transportation departments of the District of Columbia, New Jersey, and Oklahoma, and in the Department of Civil Engineering at the University of Oklahoma. He is active in a number of professional organizations and has served on the AASHTO Committee on Traffic Engineering since 1962. Mr. Hicks helped develop Maryland's Traffic Engineering Skills Training Program with the University of Maryland and private business and served on the faculty of a mentoring program on transportation management systems at Texas A&M University. He has served on TRB committees on freeway operations, traffic operations, traffic control devices, work zone traffic control, highway communications, geometric design, and hazardous material routing, and he is a member of the NCHRP Project Panel on Human Factors Guidelines for Road Systems, Phase 2. Mr. Hicks received AASHTO's 2004 Alfred E. Johnson Achievement Award for contributions to management in the field of highway engineering. He holds a BS degree in civil engineering from the University of Maryland and a certificate from the Yale University Bureau of Highway Traffic.

Timothy R. Neuman is Vice President and Chief Highway Engineer with CH2M Hill in Chicago, Illinois. He has more than 30 years of experience in the planning and design of major highways, freeways, and interchanges for more than 20 state departments of transportation. Mr. Neuman is an expert in highway safety and traffic operations related to geometric design and has led or participated in many related NCHRP projects. His research has resulted in revisions to AASHTO's design policy values. Mr. Neuman has served as a consultant to FHWA on development of

the Interactive Highway Safety Design Model and is active in the field of context-sensitive design through both project work and research. Mr. Neuman wrote the chapter on geometric design in the Institute of Transportation Engineers (ITE) *Traffic Engineering Handbook* and the chapter on urban intersections in the ITE *Traffic Safety Toolbox.* He is a recipient of the ITE Past Presidents' Award and of the TRB D. Grant Mickle Award. Mr. Neuman serves on the NRC Research and Technology Coordinating Committee, the TRB Committee on Geometric Design of Highways, and the Task Force for Development of a Highway Safety Manual. He earned a BS degree in civil engineering and an MS degree in engineering, both from the University of Michigan.

Alison Smiley is President of Human Factors North, Inc., a Canadian consulting firm specializing in human factors research, and adjunct professor in the Department of Mechanical and Industrial Engineering at the University of Toronto. Her research on human factors aspects of highway safety has addressed a variety of topics, including driver distraction due to advertising displays; comprehension and legibility of highway signs; the effectiveness and applications of rumble strips; work zone issues; and methods of evaluating driver response to signs, signals, and markings. Clients include the Insurance Bureau of Canada, the Ontario Ministry of Transportation, Transport Canada, Parks Canada, the Midwest Research Institute, and the Greater Toronto Airport Groundside Association. Dr. Smiley has served on several NRC committees, including the Committee for the Review of the Intelligent Vehicle Initiative, and has chaired or been a member of numerous TRB standing committees. She is a national associate of the National Academies and the 1999 winner of TRB's D. Grant Mickle Award for best paper in the area of operations, safety, and maintenance. She also received the 1997 A. R. Lauer Safety Award given by the Human Factors and Ergonomics Society for outstanding contributions to the human factors aspects of highway safety. She is a fellow of the Association of Canadian Ergonomists and a former chair of the board of the Canadian College for the Certification of Professional Ergonomists. Dr. Smiley earned a BSc degree in applied mathematics from the University of Western Ontario and an MASc and a PhD in systems design engineering from the University of Waterloo.

Daniel S. Turner is Professor of Civil and Environmental Engineering at the University of Alabama and Director of the University Transportation Center for Alabama. He is currently Vice President of the Council of University Transportation Centers. Dr. Turner's research focuses on traffic safety, highway design, and transportation management and policy, and he has published numerous articles and technical reports in these areas. He is a fellow of both ITE and ASCE and served as the national president of ASCE in 1998–1999. He has received outstanding professor and faculty leadership awards from the University of Alabama and was ITE's Alabama Transportation Engineer of the Year in 1990. Dr. Turner chairs the Operations Section of TRB's Technical Activities Division and the NCHRP Project Panel to Prepare Parts I and II of the Highway Safety Manual. He is also a member of several TRB standing committees and served on the Safety Working Group of the National Research and Technology Partnership. Dr. Turner earned BS and MS degrees from the University of Alabama and a PhD from Texas A&M University, all in civil engineering.

Safety Research on Highway Infrastructure and Operations: Improving Priorities, Coordination, and Quality

Fatalities and injuries resulting from road traffic crashes remain a major public health concern in the United States, with more than 42,000 people killed and 2.5 million injured in 2006. Research on road traffic safety over the past five decades has led to important reductions in death and injury rates. This report addresses how best to use the limited available research funding to achieve further reductions, particularly now that some of the most obvious and effective strategies, such as seat belt legislation, already have been widely implemented.

The committee that produced this report recommends the creation of an independent scientific advisory committee (SAC). The SAC would be charged with development of a transparent process for identifying and prioritizing research needs and opportunities in highway safety, with emphasis on infrastructure and operations. The process would be used to recommend a national research agenda focused on highway infrastructure and operations safety. The report also explores opportunities for improving the quality of highway safety research.

Also of Interest

Highway Safety Manual Data Needs Guide
National Cooperative Highway Research Program (NCHRP) Research Results Digest 329, 11 pages, 8.5 x 11, paperback, 2008, $19.00

Statistical Methods, Safety Data, Analysis, and Evaluation 2007
Transportation Research Record: Journal of the Transportation Research Board, No. 2019, ISBN 978-0-309-10446-3, 264 pages, 8.5 x 11, paperback, 2007, $70

Building the Road Safety Profession in the Public Sector
TRB Special Report 289, ISBN 978-0-309-10442-5, 100 pages, 6 x 9, paperback, 2007, $31.00

Public Information and Education in the Promotion of Highway Safety
NCHRP Research Results Digest 322, 13 pages, 8.5 x 11, paperback, 2007, $17.00

The Domain of Truck and Bus Safety Research
Transportation Research Circular E-C117, 151 pages, 2007, free for download at http://onlinepubs.trb.org/onlinepubs/circulars/ec117.pdf

Improving Road Safety in Developing Countries: Opportunities for U.S. Cooperation and Engagement
TRB Special Report 287, ISBN 0-309-09423-2, 71 pages, 6 x 9, paperback, 2006, $26.00

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