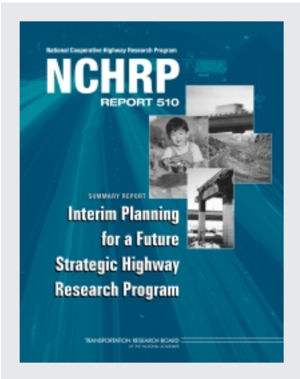

Summary Report: Interim Planning for a Future Strategic Highway Research Program (F-SHRP)

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 510

SUMMARY REPORT

Interim Planning for a Future Strategic Highway Research Program

ANN M. BRACH
Content Editor
Transportation Research Board

SUBJECT AREAS

Planning and Administration • Energy and Environment • Highway and Facility Design •
Highway Operations, Capacity, and Traffic Control • Safety and Human Performance

Research Sponsored by the American Association of State Highway and Transportation Officials
in Cooperation with the Federal Highway Administration

TRANSPORTATION RESEARCH BOARD

WASHINGTON, D.C.
2003
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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PREFACE[1]

By Ann M. Brach
Staff Officer
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In June 1998, the U.S. Congress passed the Transportation Equity Act for the 21st Century (TEA-21). This bill, which reauthorized the federal-aid highway program, called for the Transportation Research Board (TRB) "to conduct a study to determine the goals, purposes, research agenda, and projects, administrative structure, and fiscal needs for a new strategic highway research program."[2] This congressional request was prompted by the success of an earlier Strategic Highway Research Program (SHRP) and led to a proposal for a future Strategic Highway Research Program (F-SHRP), which is summarized in this report. This Preface provides background on the activities that preceded the work described in the remainder of the report.

THE ORIGINAL STRATEGIC HIGHWAY RESEARCH PROGRAM

The first Strategic Highway Research Program was a highly successful effort by Congress, state departments of transportation (DOTs), and highway industry leaders that addressed critical needs facing the nation's highway network at the time. The quality of asphalt and the integrity and longevity of pavements, for instance, were major problems. The economic and highway safety impacts of winter storms affected almost every state. Concrete bridge decks and other bridge components were deteriorating prematurely for reasons that were not entirely clear. Several reports drawing attention to the deteriorating condition of America's infrastructure were widely publicized and moved highway officials to address the problem actively. Although existing research programs addressed aspects of these problems, none was able to concentrate sufficient resources to produce implementable solutions in an accelerated time frame.

A small group of leaders from highway agencies and the transportation research community began to articulate an approach to address this situation. This approach consisted of a highly focused, time-constrained research program aimed at critical needs

SHRP and F-SHRP:
A Program Model to Address Evolving Needs

SHRP (1987–1991)	**F-SHRP** (2003–2008, proposed)
• Driven by agency costs and operations	• Driven by customer costs and expectations
• Focused on engineering disciplines	• Includes social science and other disciplines
• Outcomes include materials, equipment, specifications, methods	• Outcomes also address operations, safety, behavior, institutional issues

[1] The background material in this preface is summarized from *Special Report 260, Strategic Highway Research: Saving Lives, Reducing Congestion, Improving Quality of Life*, TRB, National Research Council, Washington, D.C., 2001.
[2] Transportation Equity Act for the 21st Century, Public Law 105-178, Section 5112, "Study of a Future Strategic Highway Research Program."

recognized by those within the highway industry, particularly the state DOTs. This approach was designed to complement existing research programs by utilizing additional funding over a prescribed time frame. Other programs would continue to pursue their broad mission-oriented agendas, coordinating with the new program as appropriate.

The new program was described in TRB *Special Report 202: America's Highways: Accelerating the Search for Innovation* (TRB, 1984), also known as the Strategic Transportation Research Study or the STRS ("Stars") report. A steering committee of highway leaders directed the STRS work. The committee focused on developing a national research program aimed at high priorities that were not being adequately addressed by existing programs. The committee chose six research areas in which focused, accelerated, results-oriented research promised significant benefits: performance of asphalt pavements; long-term performance of various pavement types; technologies and management approaches for highway maintenance; protection of concrete bridge components from deterioration; better performing concrete for pavements and structures; and improved snow and ice control.

The STRS report provided a vision of a focused, management-driven, time-constrained research program and a general outline of what needed to be done in each of the above six research areas. The National Cooperative Highway Research Program (NCHRP) and the Federal Highway Administration (FHWA) provided funds to translate this vision and outline into the detailed plans required to execute a research program.

In 1987, Congress passed the Surface Transportation and Uniform Relocation Act, which authorized SHRP. The program was funded over five years through a 0.25% takedown of federal-aid highway funds. Overall guidance for SHRP was provided by an executive committee. The six major research areas were condensed to four, and an advisory committee was formed for each. Exhibits 1 and 2 provide examples of products and benefits from SHRP.

Exhibit 1. Selected Products and Benefits of SHRP

SHRP Product	Dollars of Benefit for Each Dollar of R&D and Implementation (Little, et al., 1997)
Superpave® is an **asphalt pavement design system** that allows pavement designers to tailor asphalt mixes to specific traffic loads and climates, thus producing pavements that are more durable and less likely to rut in extremely hot weather or to crack in extremely cold weather. Superpave consists of three elements: a process for selecting the most appropriate asphalt binder, a laboratory procedure for optimizing the mix design, and tests for predicting how well the mix will perform in real-world conditions.	26–43 for agencies 72–116 for users
SHRP developed an **approach to winter maintenance** that allows agencies to be prepared for storms and to deploy materials, crews, and equipment in appropriate amounts. The system involves a combination of anti-icing strategies (treating the pavement with chemicals before a storm to prevent ice from forming) and road weather information systems (a network of sensors that lets the agency know pavement and atmospheric conditions, including temperature, rate of precipitation, and amount of chemicals remaining on the pavement from previous applications).	15–29 for agencies 62–124 for users

Other SHRP products include manuals and guidelines for pavement repairs that are durable and cost-effective; evaluation and development of improved concrete materials for bridges and pavements; and work zone safety products to help protect both workers and motorists.

Exhibit 2. Selected SHRP Benefits Reported by States

- South Carolina found that the spray-injection pothole repair method evaluated by SHRP takes less time, requires fewer workers, and lasts longer than the state's traditional method.
- North Carolina expects the crack-sealing method endorsed by SHRP to increase the life of crack seals by 40%—from 5 to 7 years.
- Alaska saves $1,400 per bridge using a new test for evaluating chloride content. In a year and one-half, this test saved the state $95,000.
- Idaho gets rapid results from a new test designed to detect alkali–silica reactivity, which causes severe cracking in concrete, at about one-tenth the cost of old tests.
- Oregon has preserved three landmark bridges and saved $50 million using cathodic protection technology evaluated by SHRP.
- Electrochemical chloride extraction, another test evaluated by SHRP, has increased the lives of two Virginia bridges by 12 to 15 years at a lower cost and with less disruption as compared with replacement or rehabilitation. A SHRP-developed specification for high-performance concrete encouraged the use of this material on bridges, allowing them to be built lighter and stronger.
- Nevada expects its expanding road weather information system (RWIS) network to provide motorists and shippers with safer, more reliable travel conditions; save $7 million in labor, materials, and other costs during the next 25 years; and protect the environment by reducing the amount of chemicals and abrasives used.
- In Colorado, an anti-icing/RWIS strategy is helping to improve air quality by reducing the use of sand and other abrasives, which are responsible for about 20% of Denver's persistent winter air quality problems.

SOURCE: RoadSavers website: http://www.fhwa.dot.gov/winter/roadsvr/casehome.htm.

STUDY FOR A FUTURE STRATEGIC HIGHWAY RESEARCH PROGRAM

When Congress requested a new SHRP study in 1998, TRB established the Committee for a Future Strategic Highway Research Program, which was composed of leaders from the highway community. (See Exhibit 3 for committee members.) After two and one-half years of study and outreach to the highway community, the F-SHRP committee published TRB *Special Report 260: Strategic Highway Research: Saving Lives, Reducing Congestion, Improving Quality of Life*. *Special Report 260* recommended a Future Strategic Highway Research Program encompassing the following four strategic focus areas:

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

The F-SHRP committee also outlined the administrative characteristics of the program and recommended a funding level of $450 to $500 million dollars, provided through a 0.25% takedown of federal-aid highway funds under the next surface transportation authorizing legislation.

INTERIM PLANNING FOR F-SHRP

Special Report 260 provided a strategic direction and general outline for F-SHRP, but before the research could be carried out, much more detailed research plans would

Exhibit 3. Committee on a Study for a Future Strategic Highway Research Program

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Anthony R. Kane, *Liaison*, AASHTO

Ann M. Brach, *Study Director*, Transportation Research Board

have to be developed. In December 2001, the AASHTO Board of Directors passed a resolution supporting F-SHRP and authorizing an NCHRP project to develop these plans. FHWA matched the NCHRP funds. Work began on the interim planning phase of F-SHRP in January 2002.

The interim work was carried out as four studies—one for each research area—and included tasks such as the following:

- Perform in-depth search of relevant efforts in the United States and abroad.
- Develop detailed "roadmaps" of the research projects necessary to achieve the objectives identified by the F-SHRP report for each topic area.
- Obtain input on concepts, criteria, and general content of the research design from stakeholders and experts.
- Identify any particular issues, problems, or opportunities related to the proposed research and recommend actions to be taken.

Five panels provided leadership and technical guidance for the interim work. The leadership guidance for the overall program was provided by an oversight panel of highway industry leaders.[3] They were responsible for the overall direction of the program, development of an administrative structure for F-SHRP, and decisions about overall funding and coordination matters. Technical guidance was provided in each research topic area by a technical panel with the appropriate mix of technical expertise. The development of the research plans was carried out by competitively selected, interdisciplinary contractor teams. The four technical panels provided oversight and guidance to the contractor teams throughout the duration of the interim work, with periodic reports to the oversight panel. The members of all five panels, as well as liaisons, principal investigators, and staff, are listed at the beginning of this report.

[3] The members of this panel also formed the AASHTO F-SHRP Task Force.

CONTENTS AND AUTHORSHIP OF THIS REPORT

This report was prepared under the direction of the oversight panel for NCHRP Project 20–58, Interim Planning for a Future Strategic Highway Research Program, which was responsible for review and approval of its contents.

Chapter 1 provides an overview of F-SHRP. Its content, as well as the background material in the Preface, is summarized from TRB *Special Report 260*. Chapters 2 through 5 describe each of F-SHRP's four strategic focus areas. These chapters were summarized by the F-SHRP contractors from the reports they prepared for the four F-SHRP technical panels responsible for guiding and reviewing the contractors' work. Chapter 6 was prepared by Ann M. Brach of TRB staff to frame some of the administrative and implementation issues to be addressed if F-SHRP is funded. The contents of Chapter 6 do not reflect decisions of the project panels involved in NCHRP Project 20–58. The final disposition of these matters will be left to whatever governing structure is put in place if F-SHRP is authorized. Appendices A through D provide brief descriptions of each research project taken from the contractor reports. The full texts of the research plans (which total more than 700 pages) are available on TRB's website at www.trb.org.

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CONTENTS

CHAPTER 1

OVERVIEW OF F-SHRP[4]

America's highway system comprises more than 3.9 million miles of highways, arterials, local roads, and streets (FHWA, 2001, Table VM–2). These roads are critical to meeting the mobility and economic needs of local communities, regions, and the nation as a whole. They carry more than 90% of passenger trips (Bureau of Transportation Statistics, 1999, p. 14) and 69% of freight value (Bureau of Transportation Statistics, 1999, Table 1–43). In addition to commercial and private vehicles, they accommodate buses, bicycles, and pedestrians. They also provide vital links to all other modes of transportation, so that the influence of their physical and operational condition extends well beyond the impacts experienced directly by highway users. The prominent role that highways play in the transportation system led to the congressional request for a future strategic highway research program.

In meeting customer expectations, the highway community faces both challenges and opportunities that require new ways of thinking about moving people and goods. The challenges represent a broadening set of performance demands on the highway system, including technical, environmental, economic, safety, social, and political requirements. Examples of such demands include the following:

- The increasing number of highway facilities in need of major renewal, together with decreasing economic and social tolerance for disruptions resulting from renewal work, requires that highway agencies discover and adopt new techniques, technologies, and systems for highway renewal.
- Increases in vehicle-miles traveled (VMT), along with inadequately decreasing fatality and injury rates, necessitate entirely new approaches to highway safety to prevent the number of deaths and injuries from rising.
- Growing congestion and the consequent increase in the impact of incidents on system reliability, combined with greater user demand for travel time predictability, make incident management and response an ever more critical element of highway operations.
- Demand for more capacity provided more quickly, in the face of increasingly stringent environmental and social requirements, calls for an altogether new way of planning and designing highways.

Developments in several areas of research and technology, such as advanced materials, new data collection technologies, communications technology, and human factors psychology, offer opportunities to address these issues if sufficient resources can be concentrated within a relatively short time frame. The fact that these opportunities exist is due to decades of research in fields outside the highway enterprise and to the further development of these ideas and technologies by traditional highway research and technology programs. However, these traditional programs are usually unable to dedicate sufficient resources to a few well-defined problems of large magnitude over a relatively short period of time. This kind of intense, large-scale focus, requiring the integration of multiple fields of research and technology, is not suited to the broad, mission-oriented, discipline-based research programs that have been the mainstay of the highway industry for half a century.

[4] This chapter is summarized from *Special Report 260, Strategic Highway Research: Saving Lives, Reducing Congestion, Improving Quality of Life*, TRB, National Research Council, Washington, D.C., 2001.

Given these considerations—significant highway needs, opportunities provided by research and technology, and constraints on existing research programs—a large-scale, special-purpose, time-constrained research program is justified if the highway industry is to meet its customers' demands over the next several decades. The success of this approach in the first SHRP reinforces this conclusion.

OVERARCHING THEME

Special Report 260 recognized the central importance of meeting customer needs for any future program of strategic highway research. Accordingly, the committee articulated the following overarching theme for F-SHRP:

> *Providing outstanding customer service for the 21st century*

This theme informed all of the committee's work, as well as the proposed research program that resulted from those efforts.

VISION

Special Report 260 articulated a vision for the highway system that guided the development of the F-SHRP program:

> A highway system that actively contributes to improved quality of life for all Americans by providing safe, efficient mobility in an economically, socially, and environmentally responsible manner.

This vision arises from a recognition that the mobility of persons and goods is a key part of the foundation of the nation's economic system and quality of life, that the highway system has historically played a critical role in providing mobility and fostering economic growth, and that this system promises still further advancement for all citizens.

STRATEGIC FOCUS AREAS

F-SHRP's four strategic focus areas are designed to help realize this vision. They are built on the results of an extensive outreach process summarized in Exhibit 1–1 and the application of selection criteria listed in Exhibit 1–2. The strategic focus areas are the following:

- *Renewal*—Accelerate the renewal of America's highways. The overall goal of this research is to develop a consistent, systematic approach to performing highway renewal that is rapid, causes minimum disruption, and produces long-lived facilities.
- *Safety*—Make a significant improvement in highway safety. The overall goal of this research is to prevent or reduce the severity of highway crashes through more accurate knowledge of crash factors and of the cost-effectiveness of selected countermeasures in addressing these factors.
- *Reliability*—Provide a highway system with reliable travel times. The overall goal of this research is to provide highway users with reliable travel times by preventing and reducing the impact of nonrecurring incidents.
- *Capacity*—Provide highway capacity in support of the nation's economic, environmental, and social goals. The overall goal of this research is to develop approaches and tools for systematically integrating environmental, economic, and community requirements into the analysis, planning, and design of new highway capacity.

OVERALL PHILOSOPHY

The F-SHRP program design adheres to the principal features of the SHRP model—a focused, time-constrained, management-driven program designed to complement existing

Exhibit 1–1. Stakeholder Involvement

Highway stakeholders are individuals and groups having an interest in the highway system and its performance. Stakeholders were involved throughout the development of F-SHRP, during both the policy report phase (corresponding to the first three stages of stakeholder involvement described below) and the interim planning phase (corresponding to the last two stages) as follows:

- *Stage 1—Develop the themes of the research program.* This was the broadest level of outreach, in which input was sought across the highway stakeholder community to help identify strategic focus areas for the proposed research program. Hundreds of letters were sent to public, private, and academic organizations to solicit their input. Nearly 50 presentations on the F-SHRP development effort were made to various stakeholder groups, and 25 presentations on strategic highway needs were made by stakeholders at committee meetings. An interactive website was also established so that input could be provided electronically, and stakeholders could track the study's progress. The input obtained during this first stage served as the foundation for the vision, overarching theme, and strategic focus areas of F-SHRP.
- *Stage 2—Identify the specific research programs within the strategic focus areas.* In this stage, input was sought from technical experts on specific types of research that would best address the strategic focus areas. Again, public, private, and academic input was solicited—from AASHTO committees; TRB technical committees; the working groups of the National Research and Technology Partnership Forum; and technical experts representing universities, industry, private consultants, and federal agencies. The result of this stage was a reduced number of research program areas from which the F-SHRP committee formulated its recommendations.
- *Stage 3—Broadly define the research agenda.* This stage was even more focused as it contributed to the agenda under each research program. Input for this stage was received through small meetings, focus groups, and e-mail exchanges. The results of this stage helped the committee define the research programs proposed in this report.
- *Stage 4—Develop detailed research plans.* Five panels—one technical panel for each strategic focus area and an oversight panel for the whole project—were established to carry out the interim planning stage of F-SHRP. Panel members represented a broad spectrum of stakeholders and included both individuals involved in earlier stages and new participants who brought specific technical expertise or a fresh perspective. These panels chose the interim planning contractors and guided their work. Each contractor team obtained additional input from users and experts as it developed its research plan. In addition, a workshop was held in January 2003 to present the draft plans to a broader audience and provide a forum for discussion and feedback. A special gathering of international highway research leaders was convened to initiate a dialogue that may lead to an exchange of research results if F-SHRP is funded.
- *Stage 5—Publish F-SHRP research plans.* Once the interim planning phase was completed, the research plans, totaling more than 700 pages, along with this summary report and a short brochure, were published and made available on TRB's website at www.trb.org. Notification of the posting of the research plans was published in TRB's e-newsletter and in *TRNews* magazine and was disseminated through a number of association e-mail groups and other avenues.

research programs. The F-SHRP approach is also based on a decidedly customer-oriented view of highway needs. In addition, the approach has the following characteristics:

- It addresses highway needs from a systems perspective,
- It is open to research in nontraditional highway-related areas, and
- It explicitly acknowledges the interdependence of highway research and technology programs.

Each of these characteristics is described below.

Systems Approach

Highways are not isolated facilities. They form part of local, regional, and national highway systems and the global economy; they are an integral part of intermodal transportation systems; and they operate within a broad context, or system, of social, environmental, and economic issues. Numerous stakeholders in the public and private sectors bring a wide variety of perspectives and many disciplines—engineering, environmental science, the social sciences, and law, to name a few—must be involved in finding solutions. The F-SHRP outreach

Exhibit 1–2. Development of Selection Criteria

Many avenues of research could be pursued to support the vision and strategic focus areas arising from the outreach process described in Exhibit 1–1. Following the SHRP model and adding some further considerations, the committee developed a set of criteria to help select among hundreds of excellent research ideas. Three categories of criteria were used, as follows:

1. Significance of the issue
   - The research addresses one or more national transportation goals: safety, mobility, economic growth and trade, human and natural environment, and national security.
   - It reflects a major concern of state DOTs and other state and local agencies that will continue well into the future.
2. Appropriateness for a SHRP-style research program
   - A research program of critical mass and continuity is necessary to achieve the program goals.
   - An integrated systems approach is needed, involving multiple players (industry, government, academia) and issues (technology, aesthetics, management, institutional issues).
   - The area is receiving insufficient attention (in scope or scale) in existing research programs because of a lack of funding, incompatibility with the missions of those programs, or other institutional constraints.
   - The area has a significant component of public-sector responsibility.
3. Effectiveness or expected impact of the research
   - There is a reasonable prospect for significant improvements, rather than just incremental improvements, from the research.
   - Results are likely to have a major impact (benefit/cost) if successful.
   - Research results would be forthcoming within a reasonable time frame.
   - Barriers to innovation are likely to yield to implementation efforts within a realistic time frame.
   - The research community has the potential to address the topic.
   - The implementing community has the potential to implement the results of the research (including the capacity to cooperate at the research and development stage to the extent necessary for effective implementation).

process sought insights from a wide array of highway stakeholders and resulted in research topics that represent an attempt to take a broad view of the problems at hand, to apply a combination of tools and approaches, and to take a spectrum of potential impacts into account.

Nontraditional Research Areas

Traditional research for highways is typically in the areas of materials, design, roadside hardware, traffic operations, and planning. While the repertoire of highway research has broadened in recent years to include human factors, the environment, and other topics, some of these areas are still not well integrated into the set of tools used by highway professionals. In the research proposed for F-SHRP, some emphasis is given to areas that are relatively neglected by the highway community from a research point of view. These areas may be characterized as falling within the purview of business, economics, and other social sciences. For example, the proposed research on highway renewal and system reliability includes identifying customer performance requirements, relating these requirements to system performance, and quantifying and assessing user impacts. The proposed work on highway travel time reliability also includes study of the institutional issues that are so critical to highway operations, especially with regard to incident management and response. Research under the Safety focus area will need to address legal and privacy issues. Similarly, the proposed research on providing new capacity will address environmental and economic impacts and community involvement. Research on all four topics will need to address management and workforce issues as they relate to proposed solutions to major highway challenges.

Finally, the inclusion of these topics in a highway research program will necessitate the involvement of new players in developing and guiding the research and will draw new research talent from other fields into the highway arena. It may be hoped that the cross-pollination of ideas and experiences resulting from this approach will extend beyond the conduct of F-SHRP.

Interdependence of Highway Research and Technology Programs

The history of the highway system in the United States has been characterized by a steady flow of research and technology development that has supported national and local highway needs since the 19th century. The major programs involved in highway research and technology on an ongoing basis are the NCHRP, FHWA's research and technology program, state DOT research programs, and university transportation research programs. These programs have differing missions. With the exception of some of the university programs, which can be tightly focused, each must address a large number of issues to support highway agencies and cannot afford to focus all their resources on a small number of topics to the neglect of all others. The work is also focused on differing time frames: state DOTs tend to solve very short-term problems, while NCHRP and FHWA address issues that have relatively longer-term horizons. The types of work typically conducted differ as well: states do the most applied work, involving technology transfer and addressing state-specific operational needs; NCHRP addresses issues that are being faced by a large number of states; FHWA covers a broad range of disciplines and technologies focused on issues of national concern; and universities perform independent research, as well as research in cooperation with the other programs. Corresponding to these differences in type of work and time horizon are differences in stakeholders and in the amount of resources and types of expertise required. (See Exhibit 1–3.)

Exhibit 1–3. What Makes F-SHRP Different from Other Highway Research Programs?

F-SHRP differs from the major ongoing highway research programs in several ways.

The program has

- A **strategic focus:** a few outcomes chosen,
- A very **large-scale investment:** more resources for each of the four areas than any ongoing research program could dedicate,
- An **accelerated time frame:** the research program itself has a fixed time frame (expected to be funded over six years) and the size of the investment is calculated to provide significant progress in that time frame, and
- An **independent administrative structure:** stakeholder governance of the program and open competition and merit review of research proposals is recommended.

Each of the four research program areas takes

- **A multi-disciplinary approach** to addressing the desired outcome, while most ongoing research programs are divided into subprograms by discipline, and
- **A comprehensive research and technology approach** that includes pursuing fundamental knowledge, developing new technologies, and integrating existing technologies.

Together, these characteristics are expected to lead to **breakthrough innovations**—that is, to significant improvements in the way we do business in the highway industry.

One of the lessons from SHRP was that an occasional infusion of additional resources into a focused, independent research program can accelerate significant improvements in strategically chosen areas. An earlier example of this approach is the American Association of State Highway Officials (AASHO) Road Test, performed in the late 1950s, under which the pavement design standards for the Interstate highway system were developed. This model is implicitly founded on the existence of the ongoing highway research programs mentioned above that advance the state of the art, although at a more moderate pace, across a broader spectrum of highway needs. The missions of these programs are not altered by the existence of selected high-profile, focused programs. Pavement and bridge research, for example, did not cease to be conducted by NCHRP, FHWA, state DOTs, and universities simply because SHRP focused some additional resources on particular aspects of this research. Many infrastructure issues not addressed by SHRP continued to be pursued by these other programs, and dozens of other areas not covered by SHRP were advanced.

Just as neither SHRP nor the AASHO Road Test obviated the need for the various ongoing programs, F-SHRP is not in competition with the latter programs; rather, it complements existing highway research. In fact, while all of the research topics proposed for F-SHRP are broad and integrated in nature, each is highly dependent on the vitality of established highway research and technology programs for many of the technical elements of the solutions to be sought. In many cases, F-SHRP will perform only selected types of research, the results of which will be integrated with the products of other programs to accelerate the latter's effective implementation.

OPERATIONAL ORIENTATION OF F-SHRP: A POINT OF INTEGRATION

Although F-SHRP was not originally conceived as a research program focused on operational and management issues, the development of the strategic focus areas has taken a strong operational approach. This reflects the nature of the challenges facing a maturing highway and road system. Since the highway system is so heavily relied upon, its efficiency and reliability are critical to the economy and to personal and social activities. Roads in more developed areas are often the most congested and least able to be expanded, making operational performance the main objective of highway agencies in these areas. Preservation, maintenance, and renewal are frequent activities on an aging system and are operational in nature even when they involve an element of construction.

Aspects of an operational orientation can be found in each of the F-SHRP strategic focus areas as follows:

Renewal is concerned with highway renewal from the perspective of reducing disruptive impacts on users, communities, and the environment. This operational goal can be supported by research in areas more directly associated with operations, such as traffic control, as well as in materials, construction, equipment, and institutional areas.

Safety is focused primarily on driver behavior, but this behavior takes place under different roadway design and operational circumstances, which may turn out to be important factors in the research. In addition, better knowledge of driver behavior and performance may lead to better operational strategies and roadway and roadside designs to promote safety.

Reliability is the most operations-oriented aspect of F-SHRP since it is directly focused on incident reduction, management, response, and mitigation. The research plan exemplifies the wide array of issues involved with operations, including design of facilities, technologies (both high tech and low tech), institutions, communication with users, and performance measurement.

Capacity is aimed at producing a decision-making and solutions screening process that will incorporate operational strategies along with construction and intermodal approaches to capacity needs.

Taken together, the four F-SHRP strategic focus areas constitute a research program oriented toward a fundamental reengineering of the whole process of highway planning, development, construction, and operations. Capacity focuses largely on processes occurring prior to construction and incorporates delivery of new highways. Renewal involves some preconstruction activities, but also emphasizes those activities that take place in the field on existing highways. Reliability focuses on events and activities that take place on a day-to-day basis on operating roads. Safety will contribute critical life-saving knowledge that can be incorporated at planning, design, renewal, and operational stages. All four areas are aimed at meeting a wide range of customer needs while minimizing user and social costs. These four research areas are linked together in their vision of the highway process as a system that must be operated in the context of social, economic, technological, and environmental systems.

FUNDING REQUIREMENTS AND MECHANISM

On the basis of the precedent set by SHRP, *Special Report 260* recommends that F-SHRP be funded by a 0.25% takedown from apportionments from the Highway Trust Fund. Using the federal-aid highway funding levels of current law (TEA-21) and assuming a reauthorization period of six years, this recommended funding mechanism can be expected to produce approximately $450 million. Since the funding in question would otherwise go to states for highway programs, the support of the states for this funding mechanism is critical. At its December 2, 2001, meeting, the AASHTO Board of Directors passed a resolution supporting F-SHRP funded at the $450 million level through a Trust Fund takedown.

The funding is distributed among F-SHRP's four strategic focus areas as follows:

- Renewal 25% or $112.5 million over six years
- Safety 40% or $180 million over six years
- Reliability 20% or $90 million over six years
- Capacity 15% or $67.5 million over six years

F-SHRP TOPICS AND PROJECTS

In total, the research plans for F-SHRP's four strategic focus areas contain 106 research projects organized under 26 topics. Table 1–1 lists all F-SHRP topic and project titles. Throughout F-SHRP reports, the following numbering system is used: *x-y.z,* where *x* designates the strategic focus area (Renewal is 1, Safety is 2, Reliability is 3, and Capacity is 4); *y* designates the topic area; and z designates the project.

The budgets in Table 1–1 are approximate and subject to reevaluation by project panels when detailed requests for proposals are drawn up.

TABLE 1–1 F-SHRP topics and projects

Topic and Project Titles	Budget ($ Millions)
Renewal	
1–1 Perform Faster In-Situ Construction	
1–1.1 Utilities Location Technology Advancements	5.000
1–1.2 Geotechnical Solutions for Soil Improvement and Rapid Embankment Construction	2.000
1–1.3 Replacement of Conventional Materials with High-Performance Materials in Bridge Applications	2.150
1–1.4 Rapid Rehabilitation Strategies of Specialty Structures	4.000
1–1.5 Micropiles for Renewal of Bridge Foundations	1.000
1–1.6 Needs Assessment and Implementation Plan for Developing a Comprehensive Intelligent Project Delivery System	1.000
1–1.7 Facilitating the Use of Recycled Aggregates	2.500
1–1.8 Identifying and Reducing Worker, Inspector, and Manager Fatigue in Rapid Renewal Environments	1.500
Total for 1–1	*19.150*
1–2 Minimize Field Fabrication Effort	
1–2.1 Modular Bridge Systems	9.550
1–2.2 Develop Bridge Designs That Take Advantage of Innovative Construction Technology	4.000
1–2.3 Modular Pavement Technology	2.500
Total for 1–2	*16.050*
1–3 Perform Faster Construction Inspection and Monitoring	
1–3.1 High-Speed, Nondestructive Testing Procedures for Both Design Evaluation and Construction Inspection	5.000
Total for 1–3	*5.000*
1–4 Facilitate Innovative and Equitable Contracting Environment	
1–4.1 Performance Specifications	2.225
1–4.2 Alternate Contracting Strategies for Rapid Renewal	2.000
1–4.3 Incentive-Based Specifications to Assure Meeting Rapid Renewal Project Goals	1.500
1–4.4 Development and Evaluation of Performance-Based Warranties	1.500
1–4.5 Risk Manual for Rapid Renewal Contracts	1.000
1–4.6 Innovative Project Management Strategies for Large, Complex Projects	0.750
Total for 1–4	*8.975*
1–5 Plan Improvements to Mitigate Disruption	
1–5.1 Strategic Approaches at the Corridor and Network Level to Minimize Public Disruption from the Renewal Process	1.250
1–5.2 Integrating the “Mix of Fixes” Strategy into Corridor Development	1.500
1–5.3 Strategic Approaches for Financing Large Renewal Projects	1.000
Total for 1–5	*3.750*
1–6 Improve Customer Relationships	
1–6.1 New Guidelines for Improving Public Involvement in Renewal Strategy Selection	2.500
1–6.2 New Guidelines for Improving Business Relationships and Emergency Response During Renewal Projects	1.500
1–6.3 Utilities–DOT Institutional Mitigation Strategies	3.000
1–6.4 Railroad–DOT Institutional Mitigation Strategies	1.750
1–6.5 Context-Sensitive Designs and Construction Operations to Minimize Impact on Adjacent Neighborhoods	0.750
Total for 1–6	*9.500*
1–7 Improve Traffic Flow in Work Zone	
1–7.1 Design, Installation, and Maintenance of Work Zones for High Consistency, Visibility, and Safety	2.000
Total for 1–7	*2.000*
1–8 Design and Construct Low-Maintenance Facilities	
1–8.1 Durable Bridge Subsystems	6.000
1–8.2 Design for Desired Bridge Performance	3.000

TABLE 1–1 (Continued)

Topic and Project Titles	Budget ($ Millions)
1–8.3 Composite Pavement Systems	5.000
1–8.4 Stabilization of the Pavement Working Platform	1.600
1–8.5 Using Existing Pavement in Place and Achieving Long Life	1.000
Total for 1–8	*16.600*
1–9 Monitor In-Service Performance	
1–9.1 Nondestructive Evaluation Methodology for Unknown Bridge Foundations	1.000
1–9.2 Development of Rapid Renewal Inputs to Bridge Management and Inspection Systems	4.000
1–9.3 Monitoring and Design of Structures for Improved Maintenance and Security	5.000
Total for 1–9	*10.000*
1–10 Preserve Facility Life	
1–10.1 Preservation Approaches for High Traffic Volume Roadways	0.750
1–10.2 Bridge Repair/Strengthening Systems	2.000
1–10.3 Techniques for Retrofitting Bridges With Nonredundant Structural Members	1.500
Total for 1–10	*4.250*
Total for Renewal	***95.275***
Safety	
2–1: Research Tools and Methods	
2–1.1 Legal and Privacy Issues in Recruiting Volunteer Drivers and Vehicles for Field Studies of Driving Safety	0.500
2–1.2 Development of Analysis Methods for Site-Based Risk Studies Using Recent Data	3.000
2–1.3 Development of Analysis Methods for Vehicle-Based Risk Studies Using Recent Data	3.000
2–1.4 Development of Comprehensive Roadway Information in a GIS Database	0.500
2–1.5 Application of OEM Electronic Data Recorders for Risk Studies	0.300
Total for 2–1	*7.300*
2–2 Risk Studies	
2–2.1 Vehicle-Based Risk Study—Phase I: Study Design	5.000
2–2.2 Vehicle-Based Risk Study—Phase II: Pilot Study	10.000
2–2.3 Vehicle-Based Risk Study—Phase III: Field Study	70.000
2–2.4 Vehicle-Based Risk Study—Phase IV: Intersection Analysis and Countermeasure Implications	5.000
2–2.5 Vehicle-Based Risk Study—Phase IV: Road Departure Analysis and Countermeasure Implications	5.000
2–2.6 Site-Based Risk Study—Phase I: Study Design and Pilot	5.000
2–2.7 Site-Based Risk Study—Phase II: Field Study	25.000
2–2.8 Site-Based Risk Study—Phase III: Analysis and Countermeasure Implications	5.000
Total for 2–2	*130.000*
2–3 Countermeasure Evaluation	
2–3.1 Identify Countermeasure Evaluation Topics	0.500
2–3.2 Retrospective Countermeasure Evaluation Projects	15.000
Total for 2–3	*15.500*
Total for Safety	***152.800***
Reliability	
3–1: Improving the Knowledge Base for Addressing the Root Causes of Unreliable Travel Times	
3–1.1: National and International Scans of Best Practices in Traffic Incident, Weather, Work Zone, and Special Event Management	1.500
3–1.2: National Outreach Program for Transportation Operations Practices	5.000
Total for 3–1	*6.500*
3–2: Improvements in Data, Metrics, and Analytic Methods for Measuring Reliability	
3–2.1: Data Requirements for Operations and Performance Monitoring	1.200
3–2.2: Establishing National and Local Monitoring Programs for Mobility and Travel Time Reliability	3.000
3–2.3: Analytic Procedures for Determining the Impacts of Reliability Mitigation Strategies	2.000
3–2.4: Incorporating Reliability Estimation into Planning and Operations Modeling Tools	2.000

(*continued on the next page*)

TABLE 1–1 (Continued)

Topic and Project Titles	Budget ($ Millions)
3–2.5: Incorporating Mobility and Reliability Performance Metrics into the Transportation Programming Process	2.000
3–2.6: Quantifying the Costs of Travel Time Reliability	1.500
Total for 3–2	*11.700*
3–3: Overcoming Institutional Barriers to Effective Transportation Operations	
3–3.1: Institutional Architectures for Implementation of Operational Strategies	3.500
3–3.2: Public Official and Senior Management Education Program on the Benefits of Improved Transportation Operations	1.500
3–3.3: Highway Funding and Programming Structures to Promote Operations	1.500
3–3.4: Personnel Requirements for Conducting Effective Traffic Incident, Work Zone, and Special Event Management	2.000
Total for 3–3	*8.500*
3–4: Development of Advanced Technologies to Improve Operational Response	
3–4.1: Advanced Surveillance Technologies for Operations	4.000
3–4.2: Technologies to Communicate Traffic Control and Queue Propagation to Motorists	4.000
3–4.3: Systems for Tracking Hazardous Material Movements Nationwide	1.500
Total for 3–4	*9.500*
3–5: Incorporating Weather Information into Traveler Information and Agency Operation Functions	
3–5.1: Improvement in Knowledge of Existing Weather and Pavement Conditions	1.500
3–5.2: Improved Forecasting of Near-Term Weather and Pavement Conditions	2.500
3–5.3: Using Road Weather, Safety, and Travel Reliability Data to Identify Ways to Improve Travel Time Reliability	1.500
3–5.4: Development of Better Mitigation Options for Weather Events	2.500
Total for 3–5	*8.000*
3–6: Highway Design Practices to Mitigate the Impact of Recurring and Nonrecurring Bottlenecks	
3–6.1: Identification and Evaluation of the Cost-Effectiveness of Highway Design Features to Reduce Nonrecurrent Congestion	3.500
3–6.2: Incorporation of Nonrecurrent Congestion Factors into the Highway Capacity Manual	2.750
3–6.3: Incorporation of Nonrecurrent Congestion Factors into the AASHTO Policy on Geometric Design	2.750
3–6.4: The Relationship between Recurring and Nonrecurring Congestion	1.000
Total for 3–6	*10.000*
3–7: Improving Driver Behavior under Extreme Environmental and Bottleneck Conditions	
3–7.1: Quantification of the Causes and Effects of Inappropriate Driver Response to Adverse Weather, Roadside Distractions, Traffic Incident Scenes, and Queues	3.000
3–7.2: Measures for Reducing Inappropriate Driver Response to Adverse Weather, Roadside Distractions, Traffic Incident Scenes, and Queues	3.000
3–7.3: Improving Merging Behavior on Urban Freeways	3.000
Total for 3–7	*9.000*
3–8: Improved Traveler Information to Enhance Travel Time Reliability	
3–8.1: Delay and Reliability Impacts of Traveler Information Systems	3.000
3–8.2: Increasing the Credibility of Travel Time Predictions with Travelers	1.000
3–8.3: Near-Term Analysis of Traveler Information Market and Its Impact on Public-Sector Operational Strategies	2.000
3–8.4: Real-Time Data Fusion to Support Traveler Information Systems	2.000
Total for 3–8	*8.000*
3–9: Traffic Control and Operational Response to Capacity Loss	
3–9.1: Implementation of Alternative Traffic Operation Strategies	4.000
3–9.2: Advanced Queue and Traffic Incident Scene Management Techniques	1.800
3–9.3: Simulation and Gaming Tools for Incident Response	3.000
Total for 3–9	*8.800*
Total for Reliability	***80.000***

TABLE 1–1 (Continued)

Topic and Project Titles	Budget ($ Millions)
Capacity	
4–1: Fundamental Knowledge	
4–1.1: Improving Our Understanding of Highway Users and the Factors Affecting Travel Demand	1.000
4–1.2: Improving Our Understanding of Transportation System Performance	2.000
4–1.3 Understanding the Contribution of Operations, Technology, and Design to Meeting Highway Capacity Needs	3.000
4–1.4: Improving Our Understanding of Approaches to Integrate Watershed and Habitat Fragmentation Considerations into Transportation Planning and Development, with an Emphasis on Highways	2.000
4–1.5: Improving Our Understanding of Interactions between Transportation Capacity and Economic Systems	2.000
4–1.6: Improving Our Understanding of the Relationship between Highway Capacity Projects and Land Use Patterns	1.000
Total for 4–1	*11.000*
4–2: Data and Tools	
4–2.1: Applying Location- and Tracking-Based Technologies to Collect Data for Systems Planning and Project Development	1.000
4–2.2: Applying Remote Sensing Technologies to Collect Data for Transportation Systems Planning and Project Development	1.000
4–2.3: Facilitating Systems Planning and Project Development via an Integrated Environmental Resource Information System	1.000
4–2.4: Improving Public Participation by Enhancing Project Visualization Tools	2.000
4–2.5: Developing and Applying a Decision-Support Tool for Integrated Systems Planning and Project Development	16.000
Total for 4–2	*21.000*
4–3: Integrated Decision Making in Planning and Project Development	
4–3.1: Integrating Environmental Stewardship and Enhancement into System Planning and Project Development	3.000
4–3.2: Integrating Economic Considerations into Project Development	1.000
4–3.3: Reducing Duplication and Process Delays in Planning and Project Development	1.000
4–3.4: Ensuring Support for Highway Capacity Projects by Improving Collaborative Decision Making	5.000
4–3.5 [not used]	
4–3.6: Screening Transportation Solutions in an Integrated Systems Planning and Project Development Process	10.000
Total for 4–3	*20.000*
4–4: Project Delivery	
4–4.1: Improving Project Management during the Development and Delivery of Highway Projects	2.000
4–4.2: Improving Project Cost Estimates	1.000
4–4.3: Satisfying Commitments and Meeting Customer Expectations in Final Project Design and Construction	2.000
Total for 4–4	*5.000*
Total for Capacity	***57.000***
Administration, Overhead, Publication, and Dissemination of Products	64.925
GRAND TOTAL FOR F-SHRP	**$450.000**

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CHAPTER 2

RENEWAL—ACCELERATING THE RENEWAL OF AMERICA'S HIGHWAYS[5]

STATEMENT OF THE PROBLEM

Throughout the United States, highways and roads that are operating at or near capacity are in need of major renewal. This renewal work—which includes preservation, rehabilitation, and reconstruction—causes significant disruption by creating bottlenecks at work zones, disturbing local communities and businesses, and propagating disruption to other parts of the highway and roadway system. New methods and technologies are needed to carry out renewal work that is accomplished more quickly with minimum disruption and results in longer-lasting facilities.

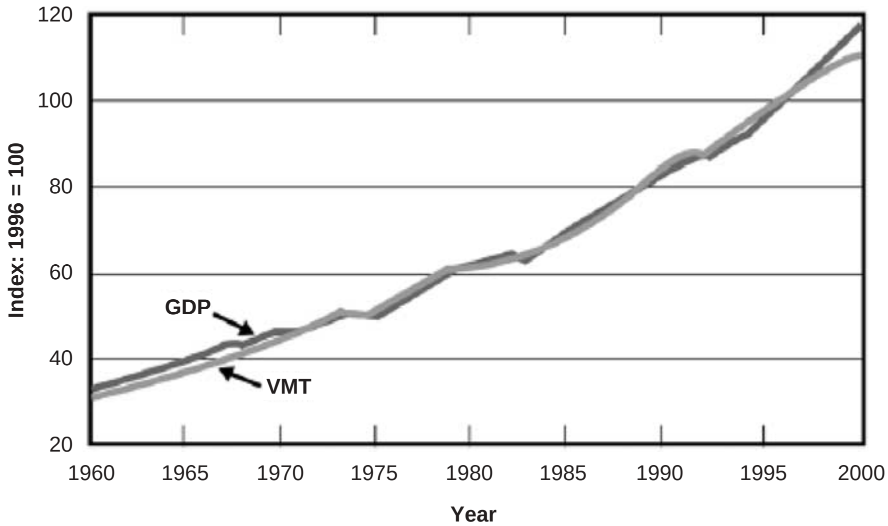
Several factors contribute to the magnitude of the problem. First is the significant role that highways play in the economy and in personal mobility. The close relationship between highways and the economy is illustrated in Figure 2–1. Highway VMT increased 76% between 1980 and 1999 and is projected to increase another 50% by 2020. Trucks carry about 70% of the value of the country's freight traffic; truck volume is predicted to double from 8 billion tons to 16.8 billion tons by 2020.

The second factor is the increasing congestion on many of the most critical highway and road segments. The National Highway System (NHS), which comprises the high end of the transportation arteries in the nation and represents 4% of the national system, carries 44% of total VMT (Figure 2–2). In many cases, this traffic load is well in excess of the design capacity of these roads, resulting in their being heavily congested. A recent Texas Transportation Institute study (Schrank, et al., 2001) estimates the cost of congestion in just 68 urban areas has grown from $21 billion in 1982 to $78 billion in 1999 (36 hours per driver a year and 6.8 billion gallons of wasted fuel). The study also estimated that congestion results in 4.4 billion person hours of delay annually in the 68 urban areas studied.

The third major factor is the aging of significant portions of the highway and road system, which will continue over the next several decades as the Interstate system and other major roads reach the end of their design life. According to the Federal Highway Administration *2002 Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance* report, 57% (91,000 miles) of the pavement on the National Highway System is in the fair, mediocre, or poor range. Urban pavements are in poorer shape than average, with 67% in the fair, mediocre, or poor range. The report also indicates that 29% of the NHS bridge inventory is structurally deficient or functionally obsolete. Thirty-two percent of bridges in urban areas, including nearly 27% of urban Interstate bridges, are deficient. These bridges carry high traffic volumes, and over half of them are under local jurisdiction, making the renewal problem a concern for local highway agencies as well as state agencies.

A fourth factor is that additional capacity, in highway lane miles, is not expected to grow very significantly in the next 20 years, even as traffic volumes increase. This will compound the problem of accommodating traffic during renewal operations.

[5] The material in this chapter is summarized from *Detailed Planning for Research on Accelerating the Renewal of America's Highways*, Final Report, prepared for NCHRP Project 20–58(1) by Stephen J. Andrle and E. Thomas Cackler of the Center for Transportation Research and Education at Iowa State University; Theodore Ferragut of TDC Partners, Ltd.; and Rebecca McDaniel of Purdue University, April 2003.



SOURCE: Federal Highway Administration, *Our Nation's Highways 2000*

Figure 2–1. Gross domestic product and travel relationship.

F-SHRP RENEWAL RESEARCH

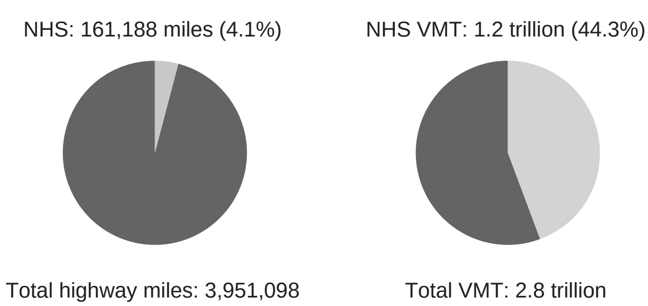
The need for major renewal is clear. How to fund this work, deliver the projects without public outcry over the delays, and deliver a superior highway product is not so clear.

The major research renewal objectives as stated in *Special Report 260* are as follows:

1. Achieve renewal that is performed rapidly, causes minimum disruption, and produces long-lived facilities, and
2. Achieve such renewal not just on isolated, high-profile projects but consistently throughout the highway system.

The strategic objectives for the research plan focus on developing a continuous, systematic approach that includes tactics in the following areas:

1. Rapid renewal of highways,
2. Minimum disruption to the public, and
3. Long-lived facilities.



SOURCE: *Our Nation's Highways 2000*, FHWA

Figure 2–2. National Highway System miles and vehicle miles traveled.

BARRIERS AND TACTICS TO OVERCOME THEM

In several isolated, high-profile "rapid renewal" projects, highway agencies have successfully reduced traffic disruption to a bare minimum. (See Figure 2–3 for an illustration of the successful renewal continuum and Exhibit 2–1 for examples of successful projects.) In nearly every case, however, doing so required extensive human and financial resources. So, although rapid renewal can be accomplished successfully, the expected increase in the number and complexity of these projects will stress agencies' human and financial resources. Renewal projects must now be analyzed as to their impacts on the entire system within a region or jurisdiction.

Rapid renewal has been achieved only under special high-profile circumstances because very real barriers exist to consistent application of renewal methods. For instance, to build facilities more quickly, it is necessary to perform in situ work faster, do as much as possible away from the site, monitor and inspect construction rapidly, and provide a contracting environment that allows this to happen. However, limitations of current prefabricated structural systems technology prevent maximizing off-site work. Likewise, limits on sensing technology inhibit rapid inspection and construction acceptance.

Transfer of risk to contractors makes innovative contracting strategies unworkable without financial or other contractual adjustments. Financing is a barrier to planning renewal projects to minimize disruption, because the systems approach often leads to bigger projects. Timely coordination with railroads and utilities is a major barrier to rapid construction and can be a disruption to their services as well. Research is necessary to enable highway agencies to develop financing strategies and mutually satisfactory mitigation strategies for railroads and utilities. Until these technical problems are solved, the rapid renewal methods cannot be implemented broadly and consistently.

The nation cannot accept shorter facility life spans as the price of rapid renewal. A method for achieving long facility life is to optimize designs and materials, but current designs do not consider constructability, material performance, and in-service performance to the extent necessary to achieve this strategic objective. The researchers identified 10 tactics for overcoming the barriers to achieving the strategic objectives. The 10 tactics are described below, and Table 2–1 summarizes the relationship between the strategic objectives and the tactics, the barriers, and the projects. (Appendix A contains brief descriptions of the F-SHRP Renewal projects.)

Rapid Approaches

Tactic 1. Perform Faster In Situ Construction—Renewal time can be defined as the time it takes to complete those on-roadway construction activities that impact traffic flow and the communities and businesses that rely on that roadway for services. Rapid renewal

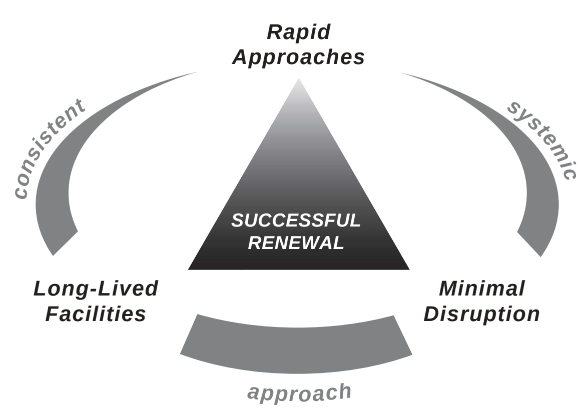


Figure 2–3. Rapid approaches to renewal.

Exhibit 2–1. Examples of Successful High-Profile Renewal Projects

The Washington State DOT took a bold step when faced with the prospect of lengthy work zone projects to reconstruct three intersections on US–395 in Kennewick. It shut down each intersection completely for one weekend. The work was done in hours instead of days using quick-setting portland cement concrete (PCC), and an intensive information campaign for motorists was developed. This major project was completed using innovative methods with minimal impacts on mobility and safety, and an ahead-of-schedule completion was realized (Nelson, 2002).

The reconstruction of the "Big I" in Albuquerque, New Mexico—a $220 million reconstruction of the I–40/I–25 interchange—was completed in 24 months instead of the 4 to 10 years that would have been required using traditional methods. Forty-five new bridges and ten rehabilitated bridges were involved, including eight "flyover" bridges that employed precast, segmental construction—the first use of this type of structure in New Mexico. The rapid progress is attributed largely to a unique oversight agreement between the New Mexico State Highway and Transportation Department and FHWA. FHWA representatives were closely involved in the design phase, facilitating the request for Interstate modification and designation as a special experimental project for innovative financing. FHWA approvals were expedited for unique and critical bridges, design exceptions, bid plans, specifications, and estimates. Approvals that usually take months were completed in days. The close working relationship allowed the FHWA to participate first hand, resolving construction and design issues as they arose. The project was let under a low-bid system, but time-driven performance-based specifications were used instead of traditional process specifications. A lane rental fee of $2,000 per hour was used to ensure that traffic was maintained as planned. An aggressive public outreach program employed a website, toll-free hotline, and a public advisory group (*Civil Engineering News,* 2002).

The I–15 reconstruction in Utah involved 142 bridges, 18 miles of Interstate, 8 interchanges with urban crossroads, and three major junctions with other Interstates. All work had to be completed before the 2002 Winter Olympic Games. The FHWA and the Utah DOT used design-build contracting to complete on time and on budget, and they developed a public relations initiative to offer the latest traffic information to the traveling public via website, real-time photos, toll-free telephone numbers, faxes to businesses, advertising, and public meetings. The public relations campaign achieved widespread public approval of the project despite significant disruption to travel in the Salt Lake Valley (FHWA, 2002).

The Michigan DOT developed the Michigan Capital Preventive Maintenance Program to preserve pavement and bridge structures, delay future deterioration, and improve overall conditions cost-effectively and efficiently. A strategy has been implemented for pavement preservation, preventive maintenance, and management. The strategy combines long-term fixes (reconstruction), medium-term fixes (rehabilitation), and short-term fixes (preventive maintenance) in a "mix of fixes" approach. Combining all three programs into a single comprehensive strategy achieves the most manageable highway network. The "mix of fixes" approach helps optimize available funds to meet network condition needs (Galehouse, 2002).

applies innovative activities or technologies to reduce the time traditionally allocated to these on-roadway activities, thereby minimizing the impact.

Tactic 2. Minimize Field Fabrication Effort—This tactic examines approaches that will minimize the amount of fabrication at the actual project site, thus speeding up the on-site construction phase of the work that actually impacts traffic. New systems need to be developed that consider design approaches, construction processes, material selection, and safe inspection and maintenance requirements.

Tactic 3. Perform Faster Construction Inspection and Monitoring—To be rapid, a renewal project must be built and accepted quickly before opening to the public. However, current acceptance testing procedures are not done in real time, and if there are problems, subsequent rework requires additional time and money. In a high-pressure, time-constrained project, the demands to keep moving can overwhelm the construction inspection process. The intent is to focus on the development of an innovative, high-speed construction inspection process that can be used to make sure that the overall quality is obtained without delaying the project.

Tactic 4. Facilitate Innovative and Equitable Contracting Environment—One of the main challenges facing agencies in the future is the reduction in human resources available

TABLE 2–1 Relationship of research projects to research objectives

Strategic Objectives	Tactics (Topics)	Barriers	Research Projects	Budget
Rapid Approaches	1. Perform Faster In-Situ Construction	• Traditional approaches are slow and costly • Limited data collection and sharing • Not enough emphasis given to human limitations and performance	1–1.1. Utilities Location Technology Advancements	$5,000,000
			1–1.2. Geotechnical Solutions for Soil Improvement and Rapid Embankment Construction	$2,000,000
			1–1.3. Replacement of Conventional Materials with High-Performance Materials in Bridge Applications	$2,150,000
			1–1.4. Rapid Rehabilitation Strategies of Specialty Structures	$4,000,000
			1–1.5. Micropiles for Renewal of Bridge Foundations	$1,000,000
			1–1.6. Needs Assessment and Implementation Plan for Developing a Comprehensive Intelligent Project Delivery System	$1,000,000
			1–1.7. Facilitating the Use of Recycled Aggregates	$2,500,000
			1–1.8. Identifying and Reducing Worker, Inspector, and Manager Fatigue in Rapid Renewal Environments	$1,500,000
	2. Minimize Field Fabrication Effort	• Traditional techniques for bridge and pavement construction are built on site	1–2.1. Modular Bridge Systems	$9,550,000
			1–2.2. Develop Bridge Designs That Take Advantage of Innovative Construction Technology	$4,000,000
			1–2.3. Modular Pavement Technology	$2,500,000
	3. Perform Faster Construction Inspection and Monitoring	• Limits on sensing technology	1–3.1. High-Speed, Nondestructive Testing Procedures for Design Evaluation and Construction Inspection	$5,000,000
	4. Facilitate Innovative and Equitable Contracting Environment	• Methods specifications constrain efficiency in quality • Sub-optimized contracting approaches and use of incentives • Unbalanced risk allocation between owners and contractors • Lack of rapid decision making can constrain project activities	1–4.1. Performance Specifications	$2,225,000
			1–4.2. Alternate Contracting Strategies for Rapid Renewal	$2,000,000
			1–4.3. Incentive-Based Specifications to Assure Meeting Rapid Renewal Project Goals	$1,500,000
			1–4.4. Development and Evaluation of Performance-Based Warranties	$1,500,000
			1–4.5. Risk Manual for Rapid Renewal Contracts	$1,000,000
			1–4.6. Innovative Project Management Strategies for Large, Complex Projects	$750,000
Minimize Disruption (for Users on and Adjacent to Project)	5. Plan Improvements to Mitigate Disruption	• Planning is not corridor based • Traditional project-based objectives • Financing constraints	1–5.1. Strategic Approaches at the Corridor and Network Level to Minimize Public Disruption from the Renewal Process	$1,250,000
			1–5.2. Integrating the "Mix of Fixes" Strategy into Corridor Development	$1,500,000
			1–5.3. Strategic Approaches for Financing Large Renewal Projects	$1,000,000
	6. Improve Customer Relationships	• Difficult to mitigate impact to users and public services • Ineffective coordination with utilities and railroads • Insufficient consideration to adjacent environment	1–6.1. New Guidelines for Improving Public Involvement in Renewal Strategy Selection	$2,500,000
			1–6.2. New Guidelines for Improving Business Relationships and Emergency Response during Renewal Projects	$1,500,000
			1–6.3. Utilities–DOT Institutional Mitigation Strategies	$3,000,000
			1–6.4. Railroad–DOT Institutional Mitigation Strategies	$1,750,000
			1–6.5. Context-Sensitive Designs and Construction Operations to Minimize Impact on Adjacent Neighborhoods	$750,000
	7. Improve Traffic Flow in Work Zone	• Traditional approaches are inadequate for high traffic volumes	1–7.1. Design, Installation, and Maintenance of Work Zones for High Consistency, Visibility, and Safety	$2,000,000

(*continued on the next page*)

TABLE 2–1 (Continued)

Strategic Objectives	Tactics (Topics)	Barriers	Research Projects	Budget
Produce Long-Lived Facilities	8. Design and Construct Low-Maintenance Facilities	• Maintenance is not adequately considered during design and construction • Lack of predictable performance models	1–8.1. Durable Bridge Subsystems	$6,000,000
			1–8.2. Design for Desired Bridge Performance	$3,000,000
			1–8.3. Composite Pavement Systems	$5,000,000
			1–8.4. Stabilization of the Pavement Working Platform	$1,600,000
			1–8.5. Using Existing Pavement in Place and Achieving Long Life	$1,000,000
	9. Monitor In-Service Performance	• Lack of performance-related metrics and analysis systems	1–9.1. Nondestructive Evaluation Methodology for Unknown Bridge Foundations	$1,000,000
			1–9.2. Development of Rapid Renewal Inputs to Bridge Management and Inspection Systems	$4,000,000
			1–9.3. Monitoring and Design of Structures for Improved Maintenance and Security	$5,000,000
	10. Preserve Facility Life	• High traffic volumes • Lack of methods to extend life	1–10.1. Preservation Approaches for High Traffic Volume Roadways	$750,000
			1–10.2. Bridge Repair/Strengthening Systems	$2,000,000
			1–10.3. Techniques for Retrofitting Bridges with Nonredundant Structural Members	$1,500,000

to conduct renewal operations. It is safe to expect that these agencies will be transferring more responsibilities to consultants and contractors. An examination of trends in other countries shows that the transfer can be accomplished but requires new strategies and cooperation among the various interests. This topic focuses on developing an environment that is more conducive to delivery of the type of services needed in the future.

Minimize Disruption

Tactic 5. Plan Improvements to Mitigate Disruption—There are more ways to minimize the impact of renewal if the analysis starts early in the project development process: not only selecting the renewal items of work that need to be done but also the best way to assemble and procure the work. Agencies need to strategically define, analyze, package, and renew highway corridors and projects so as to minimize current and future traffic disruptions as well as overall initial and life-cycle costs. Financial solutions are urgently needed to provide the ability to address very high-cost renewal projects in a sustainable manner.

Tactic 6. Improve Customer Relationships—The key to improving customer relations is to get customers involved in the decision-making process as partners with the agency. Customers include those using the facility and those who live near it and are affected by the renewal activities. In addition, utilities and railroads share roadway right-of-way and have a huge stake in renewal activities. Unresolved or undetected utility issues have been recognized as one of the leading causes of construction delays. It behooves the highway agencies to address fundamental relationships and explore innovative arrangements to minimize this impact. This tactic directly addresses those most affected by the renewal work and looks for creative solutions and partnerships.

Tactic 7. Improve Traffic Flow in Work Zone—Traffic must move efficiently and safely through work zones. Many of the traditional work zone approaches are simply inadequate to address the high-traffic environment of some rapid renewal projects. The goal is that work zones and work sites of the future will be safer and more efficient for both motorists and construction workers.

Produce Long-Lived Facilities

Tactic 8. Design and Construct Low-Maintenance Facilities—Producing long-lived facilities not only reduces ownership costs but also significantly reduces the disruption to the users over the life cycle of the facility. Building for long life, using low-maintenance designs and materials, and designing facilities for easier maintenance need to be simultaneously achieved. Through improved material selection, design processes, and integration with construction technologies, facilities must be designed to reliably achieve the desired performance life. The goal is to integrate performance-related designs with innovative construction processes that will result in long-life solutions.

Tactic 9. Monitor In-Service Performance—Technology provides an opportunity to address a key strategy for providing improved service to the public both for planned maintenance and for security. Having the ability to continuously monitor in-service performance and the necessary decision support systems will result in lower life-cycle user and ownership costs as well as improve safety to the public.

Tactic 10. Preserve Facility Life—One of the essential components of a rapid renewal program is preservation of existing facilities for the longest possible time at the required level of performance. Additional techniques are needed to extend the life of roadways that carry high traffic volumes, to strengthen bridges without total reconstruction, and to retrofit bridges that were not built with redundant structural members.

RELATIONSHIP TO OTHER RESEARCH PROGRAMS

Renewal research projects within F-SHRP are closely related to research conducted in the major highway research programs, which are sponsored by FHWA; other federal agencies, such as the National Institute of Standards and Technology (NIST) and the National Science Foundation (NSF); the state DOTs, whether individually or through pooled-fund research; and AASHTO (through NCHRP). F-SHRP will work closely with these programs to build on their results. However, F-SHRP is distinct from these other programs in several important ways as follows:

1. F-SHRP is aimed at bringing about a completely new way of approaching highway renewal, rather than creating incremental improvements in current practice;
2. F-SHRP is structured around a practical outcome to which multiple scientific and technical disciplines must contribute, rather than around specific engineering or other disciplines, as is generally the case with other research programs; and
3. F-SHRP will focus a large scale investment over a fixed time frame on addressing the renewal goal.

Table 2–2 shows a simple schematic of where F-SHRP fits with respect to other major highway research programs.

TABLE 2–2 Public-sector research programs related to highway renewal

		Program Structure			
		Generally structured around highway-related or scientific disciplines, such as pavements, safety, materials science, etc.			Structured around outcomes to which multiple disciplines will contribute
	Scope	State	Regional/Multi-State	National	
Type of Outcome Anticipated	Shorter-term projects aimed at incremental improvements in current practices	State DOT Infrastructure and Operational Research Programs	Pooled Fund Studies	NCHRP	
	Mission oriented, gap filling, and longer-term applied research to advance the state of the practice			FHWA Infrastructure RD&T Program	F-SHRP
	Breakthroughs in knowledge and/or practice			FHWA Advanced Research Program, NIST, NSF	F-SHRP

NOTES:
1. University research is not included as a separate program; many universities participate in the programs mentioned by performing the research under contracts, grants, or other agreements. Several university transportation centers (UTCs) include some aspect of infrastructure renewal in their center theme.
2. Private-sector research is not included. Equipment manufacturers, construction materials associations, and the largest construction firms sponsor research in their respective product areas.

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CHAPTER 3

SAFETY—MAKING A SIGNIFICANT IMPROVEMENT IN HIGHWAY SAFETY[6]

STATEMENT OF THE PROBLEM

Highway safety improvements are not keeping up with increasing travel. Even the steady declines in the rate of collisions per VMT have diminished in the past decade. While travel continues to increase, the expansion of highway miles and lanes has slowed so that traffic volume and congestion are increasing. The demographics of the driver population are shifting, with a substantial increase expected in the percentage of older drivers, from about 15% in 2010 to about 25% in 2030. Significant safety improvements are needed to advance safety under these changing conditions.

The changing traffic environment both complicates and heightens the need for fundamental traffic safety research (see Exhibit 3–1). Low-risk research has a greater chance of short-term success, but will provide only incremental improvements over the longer term. High-risk research is necessary to move safety solutions to a new level to address the mounting highway safety problem. Each 1% improvement in safety results in 400 lives saved, 30,000 injuries avoided, and $2.3 billion in annual savings.

Fundamental research could lead to sizeable reductions in deaths and injuries, despite the anticipated growth in VMT. Such research produces an improved understanding of the factors responsible for collisions and casualties, and this information fuels development of new or improved countermeasures. In the early days of injury prevention research, for example, expert investigators looked only at injury-producing collisions and inferred the risk factors responsible. A significant milestone occurred when the National Highway Traffic Safety Administration (NHTSA) adopted the practice of taking systematic samples of injury and *noninjury* collisions, providing an objective estimate of injury risk, or the probability of injury in a collision. This change allowed objective analytic methods for risk analysis that had been used effectively in medical and other fields to be applied to traffic injury prevention. This advancement was an essential step in the development of the sophisticated occupant protection systems in today's cars.

Collision prevention is at a similar crossroad. The interrelationship of driver performance and behavior with roadway design and traffic conditions and how these variables affect the risk of collisions and casualties is largely an unknown area, despite the fact that driver behavior is widely believed to be responsible for most collisions. Accurate information on the contribution of human, vehicle, roadway, and environmental factors to the risk of collisions will support improvements in existing countermeasures and the development of future countermeasures. Advanced technologies, like those utilized in intelligent transportation systems (ITS), offer the potential for future traffic safety advances. This same technology is enabling new research methods that can provide objective, exposure-based risk estimates and detailed information on driving performance that could not be measured before. Future countermeasures will require a more rigorous and detailed understanding of the relationship of multiple factors responsible for collisions and casualties.

[6] The material in this chapter is summarized from *Detailed Planning for Research on Making a Significant Improvement in Highway Safety*, Draft Final Report, prepared for NCHRP Project 20–58(2) by Kenneth L. Campbell of Oak Ridge National Laboratory and Mark Lepofsky and Alvah Bittner of Battelle, April 15, 2003.

Exhibit 3–1. Future Challenges That Guide F-SHRP Safety Research

- Growth in VMT
- Changes in vehicle size and design (SUVs)
- Population demographic changes (older drivers)
- New vehicle technologies (antilock brakes, automated collision avoidance)
- Changing driver behavior (aggressive driving)
- Increasing driver distraction (more vehicle-based devices)
- Increasing truck travel
- High-speed congestion

F-SHRP SAFETY RESEARCH

Safety research within F-SHRP focuses on two high-priority highway safety issues: road departure and intersection collisions. Road departure and intersection collisions combined represent a majority of traffic fatalities (58%). Intersection collisions are nearly half of all police-reported accidents. Better information on the role of human behavior and performance in these collisions is critical to the development of improved or new countermeasures.

Road Departure Collisions

The F-SHRP research plan addresses road departure collisions by focusing on the risk of road departure. The objective of this risk analysis is to determine driver performance and behavior in road departure crashes, including their interaction with alternative design, operational, and other factors. Examples of the highway safety issues to be addressed are shown in Exhibit 3–2 and include the effect of lane-edge markings, rumble strips, curves, grades, and speed management in driver lane-keeping performance. Driver factors include age, gender, inattention, impairment, and aggressive driving. This risk analysis is expected to identify highway design and operating conditions that will reduce the incidence of road departure, as well as driver errors or behavior, such as risk-taking, that may be more effectively addressed through education or enforcement.

Exhibit 3–2. Sample Research Questions on Road Departure

- How do lane edge-markings affect lane keeping?
- How do driver factors (inattention, fatigue) affect lane keeping?
- How do drivers differ in lane-keeping performance?
- What is the influence of surrounding traffic on lane keeping?
- Does lane keeping vary with driver age and gender or with vehicle type?
- How do rumble strips change driver behavior?
- Do rumble strips on the right shoulder increase deviations into the lane on the left?
- How do grade, curvature, and other road design factors affect lane-keeping performance?

Intersection Collisions

Intersection issues are more complex than road departure issues. Road departure commonly involves only a single driver negotiating the roadway, whereas there are many maneuvers and interactions among vehicles at intersections. The objective of this research is to study driver behavior and safety issues while traversing intersections, as well as to determine the interaction of driver behavior with intersection design and operation in the risk of intersection crashes. Examples of intersection issues to be addressed are shown in Exhibit 3–3 and include dedicated left-turn lanes, left-turn signal phases, yellow phase, and access points near intersections. Risk estimates will be developed for each intersection maneuver. This information will identify intersection design and operation characteristics associated with improved driver performance in intersection maneuvers, as well as driver errors or behavior that may be more effectively addressed through education or enforcement.

Research Methods

Several current projects serve as examples pointing toward the future of traffic safety research. The same advanced technology that enables intelligent vehicle safety also enables the near-continuous collection of a vast array of data including driver inputs and vehicle motion and position relative to the roadway and other vehicles. This new capability allows study of the entire driving process, including pre-collision and collision events, with an accuracy that could previously be achieved only under laboratory conditions. In particular, objective measures of driver actions in normal driving are now achievable. Continuous recording capability can provide accurate and detailed exposure data as well. The F-SHRP Safety research plan adapts these emerging research methods to the F-SHRP research questions. These methods include vehicle-based data collection technology, a site-based video data collection technology, and the application of crash surrogates for risk estimation with each of these data collection technologies. The risk studies, in turn, complement and support traditional retrospective countermeasure evaluations.

Crash Surrogates

If risk is based only on actual collisions, large amounts of exposure must be combined across many drivers to get a risk estimate. The use of collision surrogates—such as near-collisions, critical incidents, or traffic conflicts—would greatly increase the power of these field studies since the surrogates occur much more frequently than crashes, and without harm. The concept of traffic conflicts was first introduced by Harris and Perkins at General

Exhibit 3–3. Sample Research Questions on Intersection Collisions

- What is the relative risk of different intersection maneuvers?
- How much do left/right-turn lanes and/or signal phases reduce the collision risk of turns?
- How do turn lanes change the pattern of conflicts?
- What is the role of illegal maneuvers?
- How does the relative risk of different intersection maneuvers vary with driver age and gender?
- How does driver behavior (speeding, aggressive driving) affect the collision risk of intersection maneuvers?
- What is the role of inattention?
- How does the pattern of conflicts vary with traffic volume?

Motors (Harris and Perkins, 1968). The use of surrogates continues to develop and is currently being applied to traffic simulation models at FHWA (Gettman and Head, 2003). The new data collection technologies will support continuous measurement of crash margin measures such as the time-to-lane departure, or the time-to-collision. These are examples of measures that can be used to form surrogate risk estimates for specific traffic maneuvers.

Vehicle-Based Instrumentation

NHTSA has been developing portable, vehicle-based data collection packages since the early 1990s. They have also sponsored several field studies of intelligent vehicle technology, such as adaptive cruise control, that used special research vehicles with extensive instrumentation packages and volunteer drivers to support evaluation of the advanced technology. The "100 Car Naturalistic Driving Study" (Neale, et al., 2002) is a current NHTSA project to measure driver behavior and performance in near-crash situations. The instrumentation package installed in the subject's vehicle includes forward and rear video views, video of the driver's face and instrument panel (see Figure 3–1 for an example of video output), forward- and rearward-looking radar concealed in the license plate bracket, a machine vision lane position monitor, global positioning system (GPS) location, connections to the vehicle data network, communications, and data storage. Similar instrumentation can be used to address the F-SHRP research questions, particularly in the area of roadway departure. In addition, F-SHRP will require data on roadway characteristics, which must be linked to the vehicle data using the GPS location at each instant.

Site-Based Instrumentation

A site-based data collection approach will be used to augment vehicle-based data. Site-based data collection uses multiple video cameras that can be placed at selected sites to record detailed information on the motion and relative position of traffic moving through the selected road segment or intersection. Prior work sponsored by NHTSA in this area is described in two papers (Ervin, et al., 2001a, 2001b) on the System for Assessment of the Vehicle Motion Environment (SAVME). SAVME is a semi-automated, portable system that lends itself to designed experiments. For example, an intersection can be monitored under different traffic conditions or with different signal phases, or before and after design modifications. Figure 3–2 shows counts of individual vehicle maneuvers from the initial

Figure 3–1. Sample video from the NHTSA Naturalistic Driving Study (VTTI).

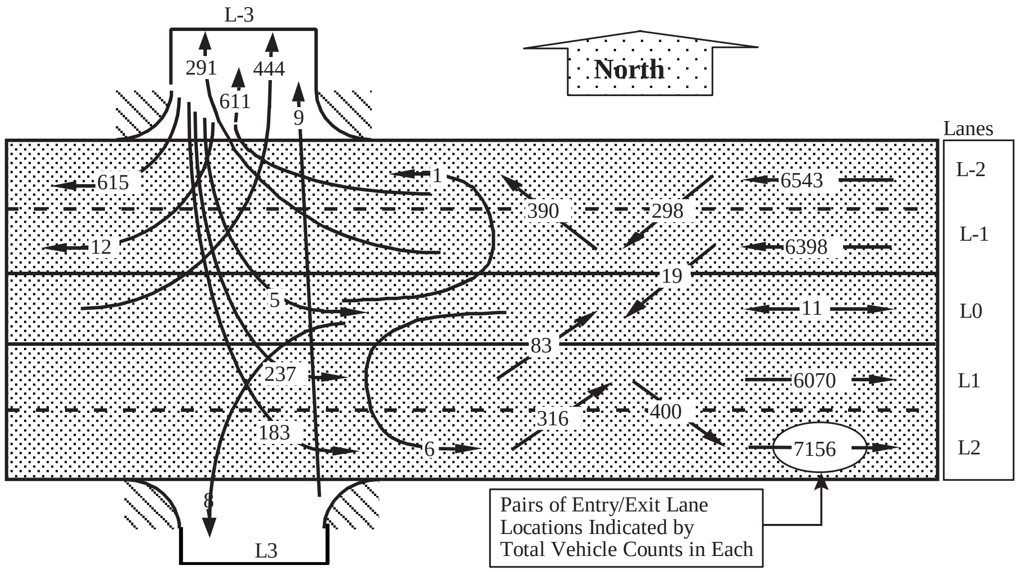

Figure 3–2. Counts of individual vehicle maneuvers from the initial SAVME test site (UMTRI).

SAVME test site. With several systems, multiple intersections, differing only in one or two important characteristics, could be selected for simultaneous study for more direct control of intervening variables. NHTSA reports that information on the signal phase can be linked in using the GPS time signal. Information on the individual drivers is not provided; however, the spectrum of driver performance is more broadly observed in that the vehicle motions can be used to derive patterns of steering, acceleration, and deceleration during various maneuvers as well as their associated distributions. Intersection design, including signage, pavement marking, traffic signal control, visibility, and other roadway factors, can be related to observed driver behavior. This data collection technology lends itself to the traffic conflicts approach to collision surrogates, but an extension of the current data processing is required due to the significantly increased levels, and integration, of information collected.

Retrospective Countermeasure Evaluation

Countermeasures have traditionally been evaluated by making before and after comparisons based on crash data. Frequently, these results are inaccurate due to limited data samples and lack of control for other factors. The F-SHRP Safety plan emphasizes the use of more rigorous methods, such as Empirical Bayes, with both treatment and control sites. These methods can also incorporate the effects of additional control factors. Accurate countermeasure effectiveness information is necessary for implementation.

FRAMEWORK FOR F-SHRP SAFETY RESEARCH

The framework for the F-SHRP Safety plan shown in Figure 3–3 organizes the overall research plan into three topic areas. The first topic area addresses the development of improved research tools to support the use of advanced technology to conduct exposure-based risk studies (the second topic area). The tools and methods include the development of analytic methods for the risk studies, privacy and informed consent issues for volunteer drivers, the development of improved data on roadway characteristics in a geographic information system, and exploration of issues associated with using data recorders installed by vehicle manufacturers to collect information on collision risk. In the second topic area, large field studies employing two different data collection technologies will be used to study the factors contributing to collision risk. These are the vehicle-based and site-based data collection technologies described

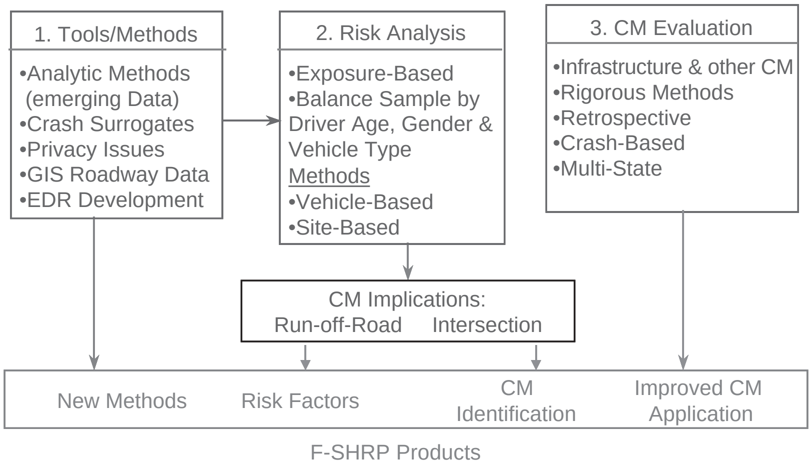

Figure 3–3. F-SHRP safety plan framework.

previously. The third topic area addresses the cost-effectiveness of existing countermeasures (CMs) through rigorous, retrospective studies of the crash experience for both treated and control sites. More rigorous evaluation of the cost-effectiveness of countermeasures will assist highway safety practitioners in selecting the most cost-effective treatment.

Projects are listed in Table 3–1 by number and title. (Appendix B includes brief descriptions of the F-SHRP Safety projects.)

CRITICAL ISSUES

The projects in the F-SHRP Safety research plan incorporate the most recent research methods and adapt them to the needs of the highway community. In order to take full advantage of current and planned research by NHTSA and others, these projects must be closely coordinated with similar field studies, such as the Naturalistic Driving Study that NHTSA already has initiated.

TABLE 3–1 Safety topics, projects, and budget

Topic and Project Titles		Budget
Topic 2–1: Research Tools and Methods		
2–1.1	Legal and Privacy Issues in Recruiting Volunteer Drivers and Vehicles for Field Studies of Driving Safety	$500,000
2–1.2	Development of Analysis Methods for Site-Based Risk Studies using Recent Data	$3,000,000
2–1.3	Development of Analysis Methods for Vehicle-Based Risk Studies using Recent Data	$3,000,000
2–1.4	Development of Comprehensive Roadway Information in a GIS Database	$500,000
2–1.5	Application of OEM Electronic Data Recorders for Risk Studies	$300,000
Topic 2–2: Risk Studies		
2–2.1	Vehicle-Based Risk Study—Phase I: Study Design	$5,000,000
2–2.2	Vehicle-Based Risk Study—Phase II: Pilot Study	$10,000,000
2–2.3	Vehicle-Based Risk Study—Phase III: Field Study	$70,000,000
2–2.4	Vehicle-Based Risk Study—Phase IV: Intersection Analysis and Countermeasure Implications	$5,000,000
2–2.5	Vehicle-Based Risk Study—Phase IV: Road Departure Analysis and Countermeasure Implications	$5,000,000
2–2.6	Site-Based Risk Study —Phase I: Study Design and Pilot	$5,000,000
2–2.7	Site-Based Risk Study—Phase II: Field Study	$25,000,000
2–2.8	Site-Based Risk Study—Phase III: Analysis and Countermeasure Implications	$5,000,000
Topic 2–3: Countermeasure Evaluation		
2–3.1	Identify Countermeasure Evaluation Topics	$500,000
2–3.2	Retrospective Countermeasure Evaluation Projects	$15,000,000

Several issues critical to the research plan have been mentioned already and are listed in Exhibit 3–4. All of these issues will be addressed in the early projects. Subsequent projects will have to be adjusted, depending on the resolution of each issue.

Because this area is so dynamic, much can change between now and the implementation of F-SHRP. Anticipated progress is reflected in the proposed research plan. However, revisions inevitably will be necessary to accommodate the state of the art when F-SHRP begins.

RELATIONSHIP TO OTHER RESEARCH PROGRAMS

Public-sector highway safety research programs are carried out by three federal agencies—FHWA, NHTSA, and the Federal Motor Carrier Safety Administration (FMCSA)—state departments of transportation (individually and through pooled fund studies), and NCHRP. As shown in Table 3–2, these programs can be characterized roughly along two axes—scope and primary intended sphere of influence.

Generally, these programs support highway safety by focusing research on continuous, incremental improvement in existing approaches to design, enforcement, education, or regulation. Two programs are focused on creating significantly new approaches to highway safety. These are the intelligent vehicle initiative (IVI), which is part of the U.S. DOT's ITS program, and F-SHRP.

F-SHRP and IVI are complementary programs that share certain similarities, but also have important differences as currently conceived. Both programs involve gaining new knowledge about driver behavior in order to develop fundamentally improved safety countermeasures. NHTSA's naturalistic driving study, described earlier, is part of IVI. This study is intended to be a pilot for a larger-scale IVI study and is also effectively a pilot study for F-SHRP's use of similar data-gathering technologies and methods. However, the larger-scale IVI study and F-SHRP have different goals, will collect different data, and will perform different analyses. The IVI study will instrument a very large fleet using vehicle instrumentation only, with a very modest instrumentation package. The intent will be to capture a statistically representative sample of nearly all crash types, except for lateral intersection crashes, to support causal factor analyses for the development of advanced technology crash countermeasures. The F-SHRP study is interested in behaviors associated with particular crash types (road departure and intersection-related) and will use both highly instrumented vehicles and roadside data collection. F-SHRP is interested in analyses that could lead to a variety of potential countermeasures (whether high-tech or low-tech) involving vehicle, infrastructure, driver, or enforcement. If both the large-scale IVI study and F-SHRP are funded, they will be coordinated as appropriate. For example, if they use a common data format, the studies could share relevant data, which would effectively increase the sample size and statistical power of each study, while allowing each to perform independent analyses and contribute to the development of different countermeasures.

Exhibit 3–4. Critical Issues

- Legal and privacy issues for the volunteer drivers/vehicles
- Crash surrogates (traffic conflicts, near-collisions, critical incidents)
- Base maps with roadway information
- Vehicle sensors for all conflict situations
- Video processing
- Analytic methods for very large datasets
- Size of the instrumented-vehicle field study
- Role of surrounding traffic

TABLE 3–2 Public-sector research programs related to highway safety

<table>
<tr><td colspan="2">Basic objectives of program</td><td colspan="4">To fill knowledge gaps in or improve existing ways of handling highway safety.

Typically looking to short term (1–6 years) for implementable results</td><td colspan="2">To seek improvements that are likely to lead to a new way of handling highway safety.

Typically looking to long term (6–12+ years) for implementable results</td></tr>
<tr><td colspan="2">Scope</td><td>State</td><td>Regional/Multi-State</td><td colspan="4">National</td></tr>
<tr><td rowspan="3">Primary Intended Sphere of Influence of Research</td><td>Owners of Public Infra-structure</td><td>State DOT Research Programs</td><td>Pooled Fund Studies</td><td colspan="2">NCHRP Safety Projects, FHWA's Safety R&T Program</td><td rowspan="3">IVI: Focus on cooperative crash avoidance using new technologies, new vehicle designs for safety, driver behavior, and acceptance of new technology</td><td rowspan="3">F-SHRP: Focus on development of fundamental knowledge about driver behavior for application to wide range of potential counter-measures</td></tr>
<tr><td>Private-Sector Vehicle Manufacturers</td><td></td><td></td><td rowspan="2">NHTSA (Light Vehicles)</td><td rowspan="2">FMCSA (Heavy Vehicles)</td></tr>
<tr><td>Private Citizens</td><td>State DOT Research Programs</td><td></td></tr>
<tr><td colspan="2">Research Supporting Safety Data and System Management</td><td>State DOT Research Programs</td><td>FHWA, Highway Safety Information System</td><td colspan="2">NHTSA and FMCSA National Databases, BTS Information Support, NCHRP</td><td>IVI: Large-scale pre-crash data collection and analyses</td><td>F-SHRP Tools and methods research</td></tr>
</table>

NOTES:
1. University research is not included as a separate program; many universities participate in the programs mentioned by performing the research under contracts, grants, or other agreements. Several UTCs include some aspect of safety in their center theme.
2. Private-sector research is not included. Vehicle manufacturers, suppliers, and the insurance industry sponsor or perform highway safety research particularly with respect to vehicles and driver behavior.
3. "Private citizen" refers to drivers, vehicle occupants, pedestrians, and cyclists.

F-SHRP's Safety research is also unique in the following ways:

1. Part of the F-SHRP study involves instrumenting intersections, rather than vehicles, something which is not part of the IVI study.
2. F-SHRP will be developing methodologies, which do not currently exist, for the use of advanced technologies in safety research, including methods for data gathering, access, storage, analysis, and management.
3. A segment of the F-SHRP Safety program will involve rigorous scientific evaluation of selected existing safety countermeasures, which is not to be carried out by other research programs.

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CHAPTER **4**

RELIABILITY—PROVIDING A HIGHWAY SYSTEM WITH RELIABLE TRAVEL TIMES[7]

STATEMENT OF THE PROBLEM

By its very nature, roadway performance is consistent and repetitive while at the same time highly variable and unpredictable. It is consistent and repetitive because peak usage periods occur regularly and can be predicted with a high degree of reliability. The relative size and timing of "rush hour" is well known in most communities. At the same time, it is highly variable and unpredictable because, on any given day, unusual circumstances such as crashes can dramatically change the performance of the roadway, affecting both travel speeds and volumes.

The traveling public experiences these large performance swings, and their expectation or fear of unreliable traffic conditions affects both their view of roadway performance and how and when they choose to travel. For example, if a road is known to have highly variable traffic conditions, a traveler using that road to catch an airplane routinely leaves a great deal of extra time to get to the airport. In other words, the reliability of this traveler's trip is directly related to the variability in the performance of the route she or he takes.

Definition of Travel Time Reliability

Travel time reliability can be defined in terms of how travel times vary over time (that is, from hour to hour or from day to day). This concept of variability can be extended to any other metrics based on travel time, such as average speed and delay. For the purpose of the F-SHRP research plan, travel time variability and reliability are used interchangeably.

The Reliability research program targets the variation in travel times—that frustrating characteristic of the transportation system that prompts motorists to allow an hour to make a trip that normally takes 30 minutes because the actual trip time is so unpredictable. Not only is reliability an important component for travelers and freight shippers, it is also a piece of the congestion problem in which transportation agencies can make significant gains, even as travel demand grows.

Sources of Unreliable Travel Times (Travel Time Variability)

The traditional way of measuring and reporting travel times experienced by highway users is to consider only average or typical conditions. However, the travel times experienced by users are never fixed, even for travel on the same facility in the same time period. Travel time variability is due to changes in several conditions present in the roadway environment, which vary over time and are discussed as follows:

[7] The material in this chapter is summarized from *Detailed Planning for Research on Providing a Highway System with Reliable Travel Times*, prepared for NCHRP Project 20–58(3) by Cambridge Systematics, Inc.; Texas Transportation Institute; University of Washington; and Dowling Associates, April 24, 2003.

1. *Traffic incidents* are events that disrupt the normal flow of traffic, usually by physical impedance in the travel lanes. Events such as vehicular crashes, breakdowns, and debris in travel lanes are the most common form of incidents. In addition to events that physically block travel lanes, events that occur on the shoulder or roadside can also influence traffic flow by distracting drivers, leading to changes in driver behavior and, ultimately, in quality of traffic flow.
2. *Work zones* are construction activities on the roadway that involve physical changes to the highway environment. These changes may include a reduction in the number or width of travel lanes, lane shifts, lane diversions, reduction or elimination of shoulders, or temporary roadway closures. Delays caused by work zones have been cited by travelers as one of the most frustrating conditions they encounter on trips.
3. *Weather* refers to environmental conditions, which lead to changes in driver behavior that affect traffic flow. Due to reduced visibility, drivers will usually lower their speeds and increase their headways when precipitation, bright sunlight on the horizon, fog, or smoke are present. Wet, snowy, or icy roadway surface conditions also will lead to the same effect, even after precipitation has ended.
4. *Fluctuations in demand* refers to day-to-day variability in demand that results in some days having higher traffic volumes than others. Varying demand volumes superimposed on a system with fixed capacity result in variable travel times.
5. *Special events* are a special case of demand fluctuations whereby traffic flow in the vicinity of the event will be radically different from typical patterns. Special events may include parades, sporting events, large conventions, and other infrequent occurrences that attract a large number of travelers to a particular locale.
6. *Traffic control devices*, such as railroad grade crossings, drawbridges, and poorly timed signals, also contribute to travel time variability by producing intermittent disruption of traffic flow.
7. *Inadequate base capacity*, by itself, does not contribute to travel time variability. The *interaction* of capacity with the six other sources of variability, however, does have an effect on variability. This is due to the nonlinear nature of the relationship between delay, volume, and capacity: when saturation levels are approached, small changes in volume or capacity lead to large changes in delay. Furthermore, facilities with greater base capacity are less vulnerable to disruptions: an incident that blocks a single lane has a greater impact on a highway with two travel lanes than on a highway with three travel lanes.

Identifying these contributing factors is a valuable step in establishing the F-SHRP Reliability research plan because they indicate the root causes of travel time variability. Ideally, knowledge of the relative importance of the contributing factors would indicate which areas have the highest potential payoff. However, the profession's understanding of how these factors contribute to travel time variability is embryonic at best. Recent work conducted by Oak Ridge National Laboratory (Chin, et al., 2001) provides an assessment of the relative contribution of these factors, but must be viewed only as a first step because of the indirect methods used to quantify each factor (Figure 4–1). Due to a lack of measured data on the subject, modeling efforts must be used instead. However, the accuracy of decomposing delay into its component sources through the use of modeling efforts remains unproven. Even with these limitations, a few broad statements may be made based on the information in Figure 4–1, as follows:

- Most of the seven factors affecting travel time variability are classified as nonrecurrent; that is, they do not occur on a regular, predictable schedule. The contribution of nonrecurrent delay to total delay is substantial. Therefore, *strategies aimed at reducing travel time variability will also have the effect of reducing total delay.*
- Traffic incidents (crashes, breakdowns), weather, and work zones are the major components of nonrecurrent delay. Regardless of their relative size, it is clear that these three factors dominate the picture.

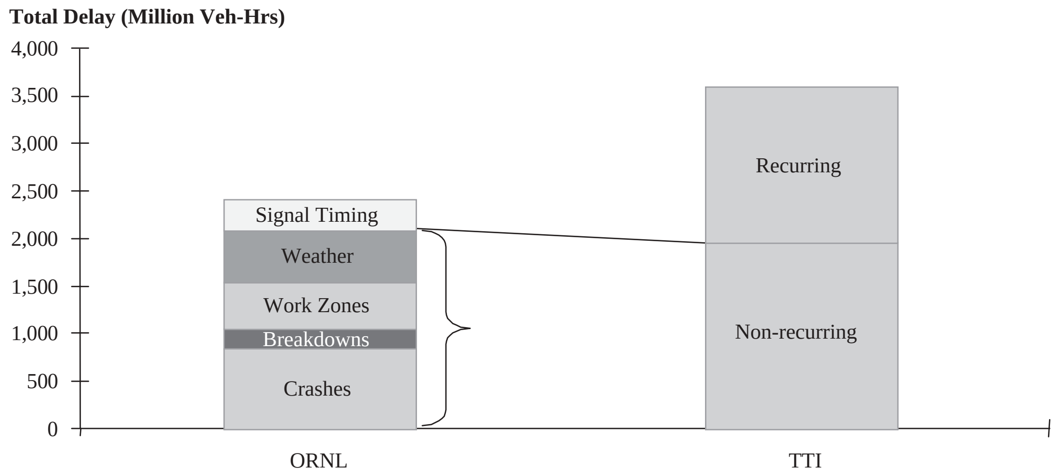

Figure 4–1. Comparison of Oak Ridge National Laboratories (ORNL) and Texas Transportation Institute (TTI) delay estimates.

F-SHRP RELIABILITY RESEARCH

The F-SHRP Reliability research program has been crafted to address the root causes of unreliable travel times, as discussed above. With the exception of addressing inadequate base capacity, strategies to deal with the root causes of unreliable travel times relate to the *operation* of the highway system. Only recently has the transportation profession more fully developed the philosophy of operating the highway system, and experience with effective implementation strategies is limited. The Reliability research program is specifically designed to address the gaps in our knowledge about these events and how to handle them. By concentrating research resources over the six-year lifespan of F-SHRP, significant gains can be made in effectively dealing with these causes of unreliable travel times.

The major objective of the Reliability component of F-SHRP is to *greatly improve the reliability of highway travel times by reducing the frequency and effects of events that cause travel times to vary from day to day.* The research program outlined here and the actions of local, state, and national agencies can result in travelers and shippers knowing their travel time within a 10% window on 9 out of 10 trips. Improvements will include a range of elements that reduce the number of crashes, reduce the slowdowns associated with traffic incidents, improve the driver response to weather conditions, decrease the time to perform road construction and maintenance, reduce the congestion and reliability effects of special events, improve the reliability of traffic control devices, expand and improve the information available to travelers so that they can make better-informed decisions, and implement improved roadway system designs that get the maximum productivity out of the available roadway.

The seven sources of unreliability account for approximately half of the total delay. Hypothetically, if the improved practices, policies, operating strategies, and communication mechanisms envisioned to come out from the research program were implemented this year, reliability-related delay (the total of delay caused by the seven sources of travel time reliability) could be reduced by 40–50%. Looking into the future, travel delay would not grow as rapidly because several of the growth factors would have been reduced or contained. Reducing reliability-related delay will also result in fewer crashes, reduced vehicle emissions and fuel use, and other benefits. These benefits will come from a mix of leading-edge research into new technology and practices, as well as a focus on reducing institutional barriers and improving communication mechanisms so that our existing knowledge can be more fully exploited.

Most of the F-SHRP Reliability research projects deal with transportation operations and the interface of operations and the physical infrastructure. Operations involves both transportation agencies and nontransportation agencies that cooperate in developing response strategies to events that cause unreliable travel times. Thus, many of the projects have scopes that go beyond the traditional transportation realm and will require working with nontransportation entities such as law enforcement, security professionals, fire and rescue personnel, and many others.

FRAMEWORK FOR F-SHRP RELIABILITY RESEARCH

Specific goals of the Reliability research program are built around the sources of travel time variability. Generally, program goals track directly to the seven sources of travel time reliability, but several goals are overlapping in nature. For example, shifts in travel demand and improvements in driver reactions to adverse situations and traveler information will affect all of the seven sources of travel time reliability. A component of the reliability effect is to reduce uncertainty—improvements in communication can reduce the frustration levels of travelers even in serious cases when lengthy delays occur.

Figure 4–2 shows the goals, actions, and outcomes of the F-SHRP Reliability research program. The goals have been expressed in terms of quantifiable targets that will serve the program's major research objective. Although the major objective is primarily to reduce reliability-related delay, the goals have been expressed in terms that are easy to track and will be relevant to the personnel who will be responsible for accomplishing them. It will be easier to track the elements that generate each delay component rather than the delay attributable to each component. For example, reductions in the duration of traffic incidents, work zones, and weather events lead directly to reductions in reliability-related delay. Since "what you measure is what you get," the goals provide a way to tie actions to outcomes.

The basic approach in developing the Reliability research plan was to identify broad topic areas that address the seven sources of travel time reliability. Nine topics were identified:

Improving the Knowledge Base for Addressing the Root Causes of Unreliable Travel Times. Practices to address the root causes of unreliable travel times are scattered and largely undocumented. A substantial improvement in travel time reliability can be made by compiling current best practices and developing application guidelines for practitioners, who often

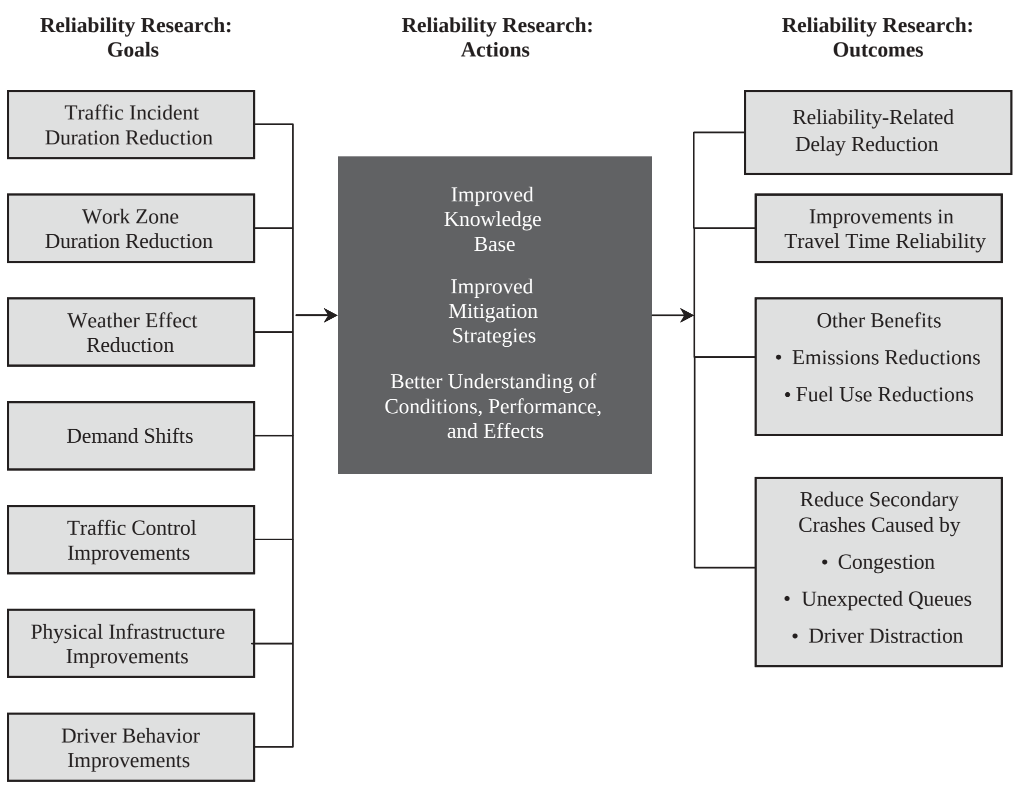

Figure 4–2. Goals, actions, and outcomes of the Reliability research program.

do not have knowledge of the best available technologies and methods or how to implement them. Moving the “state of the practice” (what exists in the field now) up to the level of the “state of the art” (best practices) will have a major impact on travel time reliability.

Improvements in Data, Metrics, and Analytic Methods for Measuring Reliability. Many of the fundamental travel time reliability concepts are still being developed—such as the relative contribution of different sources to unreliability—and practitioners are not well versed in data and methods to measure travel time reliability. Further, the expected impacts of mitigation strategies aimed at improving reliability have not been adequately quantified, which greatly hinders the incorporation of these strategies in transportation planning and programming activities.

Overcoming Institutional Barriers to Effective Transportation Operations. Most of the mitigation strategies focused on improving travel time reliability are oriented to the operation of the highway system. Operational strategies require that many different public- and private-sector organizations communicate, coordinate, and cooperate with each other. These organizations (including transportation, law enforcement, fire and rescue, towing professionals, and media) have distinct missions that pose challenges to effective cooperation.

Development of Advanced Technologies to Improve Operational Response. Certain operational strategies to address traffic problems use technology to aid responders. In particular, traffic incident management strategies use technologies to clear incident scenes. These strategies include data collection for fatal crashes, clearance of involved vehicles, cargo offloading, and spill remediation. Advanced technology to address these functions offers the potential for dramatically reducing response time.

Incorporating Weather Information into Traveler Information and Agency Operation Functions. Weather causes some of the most disruptive travel delays and uncertainty, as well as some of the most significant problems for public-sector agency operations. Weather forecast information can be used more effectively to enhance traveler information, operations or maintenance crew responses, and a variety of maintenance, operations, and investment decisions that are affected by weather.

Highway Design Practices to Mitigate the Impact of Recurring and Nonrecurring Bottlenecks. The objective of this topic is to improve highway design practice, capacity analysis, and facility design to mitigate the impact of recurring and nonrecurring congestion. Current highway design practice treats capacity as a constant, unvarying number, essentially considering only recurrent congestion. The designer has no information to evaluate the tradeoffs of providing excess capacity to accommodate nonrecurrent congestion and no information on the incorporation of features to facilitate incident management and work-zone management into the design. Research in the topic area will provide designers with this information.

Improving Driver Behavior under Extreme Environmental and Bottleneck Conditions. Drivers often react inappropriately to unusual environmental and roadway conditions. For example, they may not slow down during poor visibility conditions (like fog or dust storms), or they may over-react to interesting roadside conditions. This research will identify undesirable driver behaviors that increase nonrecurrent congestion and measures for modifying these behaviors.

Improved Traveler Information to Enhance Travel Time Reliability. Providing timely and accurate traveler information—in terms of delay expectations and alternative routes—is an effective means of reducing delay to travelers. However, a number of problems have hindered the advancement of traveler information strategies and products beyond a rudimentary form. Among these problems are data quality, system coverage, integration of data sources, currency of data, market penetration, and information delivery devices.

Traffic Control and Operational Response to Capacity Loss. There are a variety of operating strategies that can mitigate congestion problems caused by disrupted traffic flows. The disruptions might be planned actions by transportation agencies—maintenance or construction activity—or they might include unplanned events such as weather or collisions. Many of these ideas are not innovative, but their deployment is nonetheless sporadic and uneven. This research effort will examine typical barriers to implementation and identify good practices.

Table 4–1 lists the Reliability program's topics and corresponding projects.

TABLE 4–1 Reliability topics, projects, and budget

Topic and Project Titles	Budget
3–1: Improving the Knowledge Base for Addressing the Root Causes of Unreliable Travel Times	
3–1.1: National and International Scans of Best Practices in Traffic Incident, Weather, Work Zone, and Special Event Management	$1,500,000
3–1.2: National Outreach Program for Transportation Operations Practices	$5,000,000
3–2: Improvements in Data, Metrics, and Analytic Methods for Measuring Reliability	
3–2.1: Data Requirements for Operations and Performance Monitoring	$1,200,000
3–2.2: Establishing National and Local Monitoring Programs for Mobility and Travel Time Reliability	$3,000,000
3–2.3: Analytic Procedures for Determining the Impacts of Reliability Mitigation Strategies	$2,000,000
3–2.4: Incorporating Reliability Estimation into Planning and Operations Modeling Tools	$2,000,000
3–2.5: Incorporating Mobility and Reliability Performance Metrics into the Transportation Programming Process	$2,000,000
3–2.6: Quantifying the Costs of Travel Time Reliability	$1,500,000
3–3: Overcoming Institutional Barriers to Effective Transportation Operations	
3–3.1: Institutional Architectures for Implementation of Operational Strategies	$3,500,000
3–3.2: Public Official and Senior Management Education Program on the Benefits of Improved Transportation Operations	$1,500,000
3–3.3: Highway Funding and Programming Structures to Promote Operations	$1,500,000
3–3.4: Personnel Requirements for Conducting Effective Traffic Incident, Work Zone, and Special Event Management	$2,000,000
3–4: Development of Advanced Technologies to Improve Operational Response	
3–4.1: Advanced Surveillance Technologies for Operations	$4,000,000
3–4.2: Technologies to Communicate Traffic Control and Queue Propagation to Motorists	$4,000,000
3–4.3: Systems for Tracking Hazardous Material Movements Nationwide	$1,500,000
3–5: Incorporating Weather Information into Traveler Information and Agency Operation Functions	
3–5.1: Improvement in Knowledge of Existing Weather and Pavement Conditions	$1,500,000
3–5.2: Improved Forecasting of Near-Term Weather and Pavement Conditions	$2,500,000
3–5.3: Using Road Weather, Safety, and Travel Reliability Data to Identify Ways to Improve Travel Time Reliability	$1,500,000
3–5.4: Development of Better Mitigation Options for Weather Events	$2,500,000
3–6: Highway Design Practices to Mitigate the Impact of Recurring and Nonrecurring Bottlenecks	
3–6.1: Identification and Evaluation of the Cost-Effectiveness of Highway Design Features to Reduce Nonrecurrent Congestion	$3,500,000
3–6.2: Incorporation of Nonrecurrent Congestion Factors into the Highway Capacity Manual	$2,750,000
3–6.3: Incorporation of Nonrecurrent Congestion Factors into the AASHTO Policy on Geometric Design	$2,750,000
3–6.4: The Relationship between Recurring and Nonrecurring Congestion	$1,000,000
3–7: Improving Driver Behavior under Extreme Environmental and Bottleneck Conditions	
3–7.1: Quantification of the Causes and Effects of Inappropriate Driver Response to Adverse Weather, Roadside Distractions, Traffic Incident Scenes, and Queues	$3,000,000
3–7.2: Measures for Reducing Inappropriate Driver Response to Adverse Weather, Roadside Distractions, Traffic Incident Scenes, and Queues	$3,000,000
3–7.3: Improving Merging Behavior on Urban Freeways	$3,000,000
3–8: Improved Traveler Information to Enhance Travel Time Reliability	
3–8.1: Delay and Reliability Impacts of Traveler Information Systems	$3,000,000
3–8.2: Increasing the Credibility of Travel Time Predictions with Travelers	$1,000,000
3–8.3: Near-Term Analysis of Traveler Information Market and Its Impact on Public-Sector Operational Strategies	$2,000,000
3–8.4: Real-Time Data Fusion to Support Traveler Information Systems	$2,000,000
3–9: Traffic Control and Operational Response to Capacity Loss	
3–9.1: Implementation of Alternative Traffic Operation Strategies	$4,000,000
3–9.2: Advanced Queue and Traffic Incident Scene Management Techniques	$1,800,000
3–9.3: Simulation and Gaming Tools for Incident Response	$3,000,000

Because there is substantial overlap in strategies to address the seven sources, the topic areas do not match one-to-one to the sources of unreliable travel times. Table 4–2 shows how the topic areas track to the sources of unreliable travel times. (Appendix C contains brief descriptions of the F-SHRP Reliability projects.)

RELATIONSHIP TO OTHER RESEARCH PROGRAMS

Research related to travel time reliability is part of the general area of operations, which can cover topics ranging from maintenance operations to traffic signal timing to ITS. Because the area of operations is still being formed, it is difficult to compare programs consistently. Table 4–3 suggests different emphasis areas related to travel time reliability among the major public-sector highway research programs.

The most meaningful comparison for F-SHRP is with the programs of the U.S. DOT, including the work of FHWA and the ITS Joint Program Office (JPO). Key points of comparison include the following:

1. F-SHRP plans to develop implementable strategies for systematically addressing a wide range of causes of travel time unreliability. While current research programs are effectively addressing pieces of the travel time reliability problem, none has the resources or the institutional ability to address the problem comprehensively. Even where F-SHRP projects have a strong applied focus and could conceivably be funded as U.S. DOT projects, F-SHRP offers the opportunity to significantly increase and concentrate research resources on high pay-off topics. The F-SHRP research plan has been coordinated with U.S. DOT staff to avoid possible overlap.
2. F-SHRP includes both research to gain more fundamental knowledge about travel time reliability and development of new technologies, areas that U.S. DOT does not

TABLE 4–2 Research topic areas mapped to source of unreliable travel times

Research Topic Areas	Source of Unreliable Travel Times						
	Unplanned		Planned		Systemic		
	Incidents	Weather	Work Zones	Special Events	Day-to-Day Demand Fluctuations	Traffic Control Devices	Inadequate Base Capacity
3–1 Improving the Knowledge Base for Addressing the Root Causes of Unreliable Travel Times	●	●	●	●			
3–2 Improvements in Data, Metrics, and Analytic Methods for Measuring Reliability	●	●	●	●	●	●	●
3–3 Overcoming Institutional Barriers to Effective Transportation Operations	●	○	○	○		○	
3–4 Development of Advanced Technologies to Improve Operational Response	●		○				
3–5 Incorporating Weather Information into Traveler Information and Agency Operation Functions		●					
3–6 Highway Design Practices to Mitigate the Impact of Recurring and Nonrecurring Bottlenecks	●	○	●				●
3.7 Improving Driver Behavior Under Extreme Environmental and Bottleneck Conditions	●	●	●				●
3–8 Improved Traveler Information to Enhance Travel Time Reliability	●	○	●	○	○		
3–9 Traffic Control and Operational Response to Capacity Loss	●	○	●	○	○	●	○
● Primary Effects ○ Secondary Effects							

TABLE 4–3 Emphasis areas related to travel time reliability in public-sector research programs

		Program Structure				
		Generally structured around one or a few causes of travel time reliability				Structured around a comprehensive approach to all major causes
	Scope	State	Regional/Multi-State	National		
	Major Programs	State DOT	Pooled Fund Studies	NCHRP	FWHA, ITS JPO	F-SHRP
Type of Research, Development, and Technology Activity	Fundamental Knowledge				(JPO/NSF Program)	✓
	Data, Analysis, Performance Measures		Urban Mobility Study (TTI)			✓
	Applied Research: Design, Traffic Management	✓	✓	✓	✓	✓
	Applied Research: Technology Development					✓
	Applied Research: Behavioral and Institutional					✓
	Implementa-tion-Related Activities	✓			✓	✓

NOTES:
1. University research is not included as a separate program; many universities participate in the programs mentioned by performing the research under contracts, grants, or other agreements. Several UTCs include some aspect of highway operations in their center theme.
2. Private-sector research is not included. Examples of private-sector research and development potentially related to travel time reliability include development of traffic control technologies and traveler information systems.

often fund. (A recently initiated, experimental program, jointly funded by the ITS JPO and NSF, funds basic technology-oriented research for ITS.)

3. The F-SHRP Reliability research plan also stresses the fuller context in which particular technologies and methods must be implemented, including institutional issues, human behavior, data needs, performance measurement, analytical methods, and design and traffic management procedures.
4. A key aspect of the F-SHRP Reliability component that distinguishes it from current efforts is the emphasis on involving agencies beyond the transportation realm. Effective operations require interagency cooperation and these relationships are highlighted in the research plan.
5. F-SHRP has a strong emphasis on implementation, which U.S. DOT is unable to focus on as much because of limited funding.

REFERENCES

Chin, S.M., Franzese, O., Greene, D.L., Hwang, H.L., and Gibson, R. *Temporary Loss of Capacity Study (Draft Final Report).* Office of Operations Technology Services, Operations Core Business Unit, U.S. Department of Transportation, Washington, D.C., November 1, 2001.

CHAPTER 5

CAPACITY—PROVIDING HIGHWAY CAPACITY IN SUPPORT OF THE NATION'S ECONOMIC, ENVIRONMENTAL, AND SOCIAL GOALS[8]

STATEMENT OF THE PROBLEM

Growing population, economic activity, and incomes are expected to result in increasing demand for vehicle travel into the near future. Between 2000 and 2020, the U.S. population is expected to grow nearly 20%. It is expected that personal VMT will grow by nearly 40% over this time period, and truck travel is expected to see an even more rapid increase. Increased international trade will mean more products going through the nation's borders and ports, which must be served by efficient highway connections. At the same time, trends such as e-commerce and just-in-time manufacturing will continue to result in more trucks on the road carrying electronically ordered goods and serving as mobile warehouses for industry.

Improvements in reliability and safety will increase the effective capacity of the current system. Operational improvements, alternative travel options, public transportation, travel demand management options, and greater land use and transportation coordination will accommodate some of the demand and may be able to reduce or avoid the need for new capacity in some locations. However, those measures are not expected to be able to meet all of the capacity needs to allow for the mobility options that customers demand and to sustain economic growth. There will continue to be places where additions to the highway system, either new roads or expanded capacity on existing roads, are needed to accommodate growing personal travel and freight movement. Customers also want highway capacity to be provided more rapidly in order to maintain acceptable levels of mobility and to reduce the personal, economic, and social costs of traffic congestion.

At the same time that customers demand new highway capacity, they also demand a healthy environment and livable communities (see Figure 5–1). Frequently, these needs are regarded as conflicting because of understandable concerns about adverse impacts of highways. In recent years, the highway program has increased its focus on providing context-sensitive design, mitigating environmental impacts, and addressing community values via better public involvement. Indeed, it is widely recognized that the highway development process must address a wide range of concerns, including efficiency, safety, aesthetics, environment, and community livability. Yet, many of the existing methods, tools, and institutional approaches to highway planning and development do not foster an integrated approach.

The nation's highway system represents but one of many systems—including natural, social, economic, political, and technological—that interact with each other. The planning and design of highways, therefore, must be performed with adequate attention to how these systems interact and influence one another. *Special Report 260* articulates the overall research program goal for the Capacity focus area of F-SHRP as follows:

> To develop approaches and tools for systematically integrating environmental, economic, and community requirements into the analysis, planning, and design of new highway capacity.

[8] The material in this chapter is summarized from *Interim Planning Activities for a Future Strategic Highway Research Program: Study 4—Capacity, Research Plan (Revised Draft)* prepared for NCHRP Project 20–58(4) by ICF Consulting, April 30, 2003.

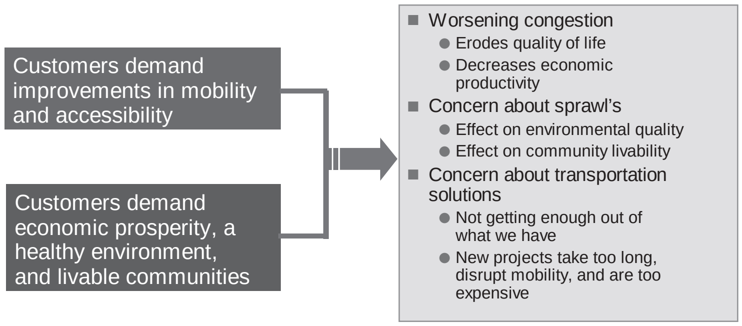

Figure 5–1. What do customers want?

The Capacity focus area is designed to build on past successes and move the transportation community to a new paradigm for highway decision making that is efficient, equitable, and takes into account a systems approach for developing the best highway projects for communities and our nation. To meet this challenge, significant changes in the way that we currently make our transportation decisions are needed.

- First, the transportation planning process needs to do a better job of looking at transportation options from a *"transportation-as-a-system perspective."* This perspective requires a careful and robust assessment of the various options available to planners and decision makers for addressing accessibility, safety, and mobility needs. To do that, transportation professionals need an *integrated process that guides consideration of alternative solutions* (from operations to land use measures). Such broad alternatives must be considered individually and as "solutions packages."
- Second, as part of the planning process, the manner in which transportation interacts with other systems (such as urban, economic, ecological, and other infrastructure) needs to be better addressed by using *integrated institutional arrangements and state-of-the-art decision-support tools*. In essence, alternative solutions packages identified in the initial steps of the planning process need to be evaluated in a systems-oriented fashion and prioritized accordingly.
- Third, all activity needs to take place under an *integrated institutional construct that allows for early, inclusive, and iterative collaboration* across stakeholder groups. For example, appropriate mechanisms (such as memoranda of understanding) need to be developed to promote cross-agency coordination that enables stakeholders to work together to create plans and programs that optimize our ability to meet our social, environmental, and economic objectives.
- Fourth, by creating plans that meet the prescribed social, environmental, and economic tests (as defined through integrated institutional processes), *project delivery can be accelerated and the quality of projects can be improved*. National Environmental Policy Act (NEPA) processes, for example, can then focus on the specific consequences of a particular project that has already met environmental feasibility criteria, given the environmental capacity constraints of the region. Mitigation options can be focused, and opportunities for enhancing the natural and human environments can be identified. Integrated planning and highway development processes would help to ensure that the "best" possible projects are implemented in a timely manner—projects that best balance our social, environmental, and economic goals.

CONCEPTUAL FRAMEWORK FOR TRANSPORTATION DECISION MAKING

The conceptual framework for transportation decision making, developed in the research plan, is based on the needs and concepts described above and hinges on an integrated systems planning and highway development process. The framework (see Figure 5–2) is characterized by three primary components as follows:

1. *Transportation as a system*—The first component of the framework is the identification of alternative transportation solutions to accessibility, safety, and mobility needs. Given the need, solutions may include a combination of operations, technology, infrastructure, demand/supply management, multi-modal strategies, and other tactics. The conceptual framework recognizes the need for integrated judgments of how to best provide transportation solutions that recognize the interconnectivity of the components that make up the transportation system (for example, users, modes, infrastructure, intermodal connectors, and stakeholders). The challenge to transportation planning is to provide the coordination and foresight for all of these components to work together effectively.

   For example, current approaches to freight planning have created a disproportionate load on the highway system. Integrated freight planning would effectively leverage other modes and focus on improvements to the overall freight system. Likewise, strategies that focus on the provision of new highway capacity must effectively integrate operational, ITS, and demand management considerations, rather than treat such considerations as competing alternatives. In this manner, this component of the framework represents a more holistic and integrated process for planning transportation programs and projects to address regional needs. It places a strong emphasis on early, inclusive, and iterative public involvement during development of broad regional development visions; identification of associated transportation needs; and the development of solutions packages. Outcomes resulting from this component of the conceptual framework include the following:

   - Transportation priorities are established to support broad visions for how we want our neighborhoods, towns, and regions to prosper;

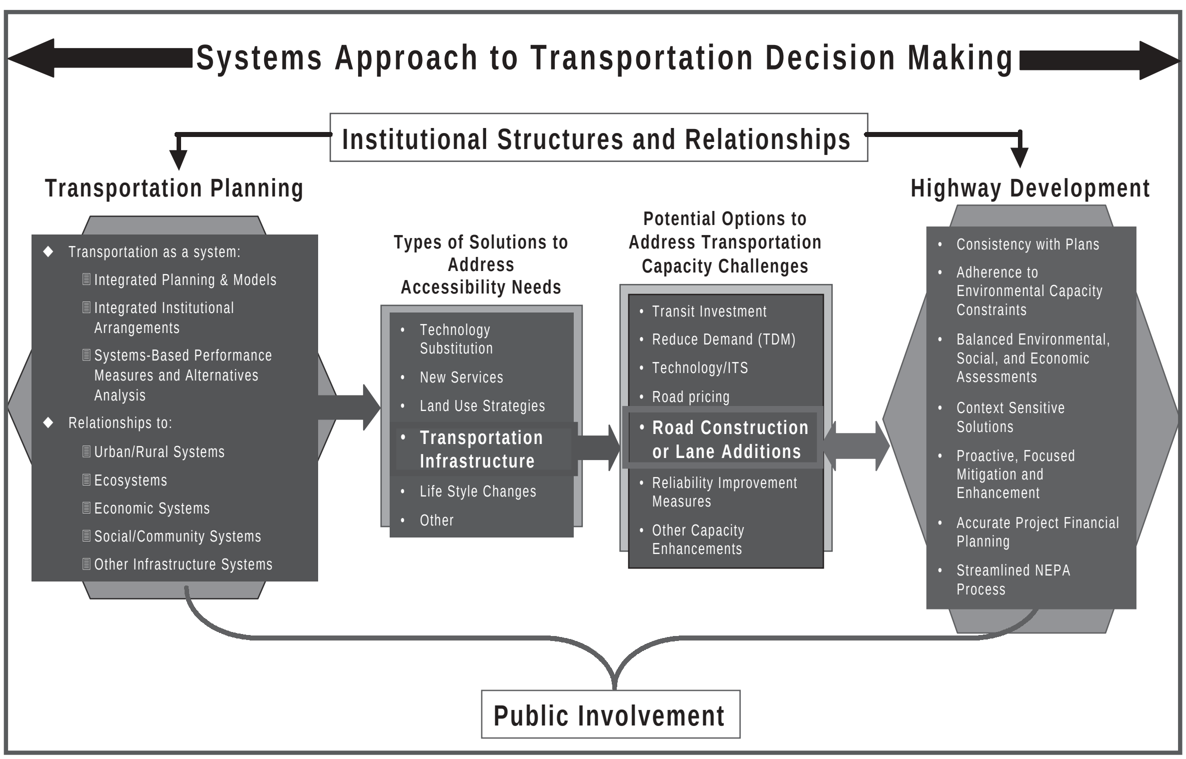

Figure 5–2. Conceptual framework for decision making.

- Early consideration is given to safety, mobility, environmental, economic, community, and land use goals; and
- A broad range of potential solutions, including operational improvements, transit, highway capacity, and demand management are fully considered.

2. *Transportation's relationships to other systems*—The second component of the conceptual framework deals with the inter-relationship of transportation to the other human and natural systems that define urban or rural areas, including: (1). water, energy, and communications infrastructure; (2). local, state, national, and global economies; (3). land uses; and (4). ecosystems. Successful integration of these related systems hinges on a process that can prioritize transportation solutions based on the environmental, economic, and social footprints of alternatives.

   This component centers on evaluations of the transportation solutions packages that are developed under the first component. Alternative solutions are evaluated against economic, environmental, community livability, and other social goals developed via an inclusive and iterative stakeholder involvement process. Using new performance measures that reflect these broader social objectives, solutions are screened using decision-support systems that predict the footprint of a solutions package on the environment, economic development, land development, and other considerations deemed to be important to the community, practitioners, politicians, and other affected parties. Only those solutions packages that meet (or best approach) societal objectives move forward to the project development stage. In this manner, the outcomes resulting from this component of the framework will include the following:

   - Transportation agencies effectively communicate with the public, decision makers, and politicians;
   - The public is involved and engaged in the development of solutions and throughout the decision-making process;
   - Agencies and key stakeholders work together to reach decisions collaboratively, in a timely manner, and with clear decision points; and
   - Development of solutions to transportation capacity needs balances and integrates economic, safety, mobility, social, and environmental considerations.

3. *Highway development*—The third component of the conceptual framework reflects the culmination of an integrated systems planning and project development process. The first two components of the framework help to ensure that only those transportation solution packages that meet (or best approach) the combination of economic, environmental, and social goals and objectives are considered in the programming phase. This component of the framework results in the following outcomes:

   - Project decisions are consistent with plans and satisfy commitments made in planning and project development;
   - Projects enhance the natural environment and communities, with a focus on environmental performance, community goals, and economic performance, rather than on narrow impact mitigation;
   - The environmental review process is accelerated and is based on clear and firm decision points that build consensus and reduce project delivery delays;
   - The best technical skills are applied in all aspects of transportation project management (from planning to implementation); and
   - Project cost estimates are accurate.

F-SHRP CAPACITY RESEARCH

Given the conceptual framework for transportation decision making presented above, research topics for the strategic plan can be articulated. Figure 5–3 depicts and briefly describes the research topics that serve as the organizing principle for the plan. Table 5–1

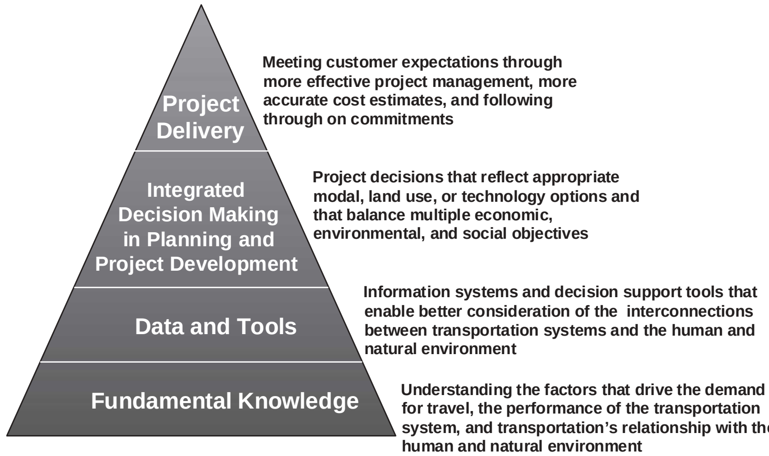

Figure 5–3. Research topics.

lists the projects under each topic area and their estimated budgets. (Appendix D contains brief descriptions of the F-SHRP Capacity projects.)

Topic 4–1: Fundamental Knowledge. The tools we use to predict the effects of transportation capacity and the approaches we use in decision making are built on our under-

TABLE 5–1 Capacity topics, projects, and budget

Topic and Project Titles	Budget
4–1: Fundamental Knowledge	
4–1.1: Improving Our Understanding of Highway Users and the Factors Affecting Travel Demand	$1,000,000
4–1.2: Improving Our Understanding of Transportation System Performance	$2,000,000
4–1.3: Understanding the Contribution of Operations, Technology, and Design to Meeting Highway Capacity Needs	$3,000,000
4–1.4: Improving Our Understanding of Approaches to Integrate Watershed and Habitat Fragmentation Considerations into Transportation Planning and Development, with an Emphasis on Highways	$2,000,000
4–1.5: Improving Our Understanding of Interactions between Transportation Capacity and Economic Systems	$2,000,000
4–1.6: Improving Our Understanding of the Relationship between Highway Capacity Projects and Land Use Patterns	$1,000,000
Topic 4–2: Data and Tools	
4–2.1: Applying Location- and Tracking-Based Technologies to Collect Data for Systems Planning and Project Development	$1,000,000
4–2.2: Applying Remote Sensing Technologies to Collect Data for Transportation Systems Planning and Project Development	$1,000,000
4–2.3: Facilitating Systems Planning and Project Development via an Integrated Environmental Resource Information System	$1,000,000
4–2.4: Improving Public Participation by Enhancing Project Visualization Tools	$2,000,000
4–2.5: Developing and Applying a Decision-Support Tool for Integrated Systems Planning and Project Development	$16,000,000
4–3: Integrated Decision Making in Planning and Project Development	
4–3.1: Integrating Environmental Stewardship and Enhancement into System Planning and Project Development	$3,000,000
4–3.2: Integrating Economic Considerations into Project Development	$1,000,000
4–3.3: Reducing Duplication and Process Delays in Planning and Project Development	$1,000,000
4–3.4: Ensuring Support for Highway Capacity Projects by Improving Collaborative Decision Making	$5,000,000
4–3.5: [not used]	
4–3.6: Screening Transportation Solutions in an Integrated Systems Planning and Project Development Process	$10,000,000
4–4: Project Delivery	
4–4.1: Improving Project Management during the Development and Delivery of Highway Projects	$2,000,000
4–4.2: Improving Project Cost Estimates	$1,000,000
4–4.3: Satisfying Commitments and Meeting Customer Expectations in Final Project Design and Construction	$2,000,000

standing of fundamental relationships between transportation systems, human behavior, the environment, the economy, land use, and our communities. Research on this topic addresses areas where we lack sufficient understanding to build tools, methods, or approaches that can predict the effects of transportation options on systemwide performance, and on environmental, social, and economic performance and goals. Better understanding of fundamental relationships will enhance our ability to assess the systems effects of transportation, which, in turn, can help us to better balance potential tradeoffs among social, environmental, and economic objectives.

Priorities for fundamental knowledge research are driven by needs that are most pressing for improving or completing key tools, and for making better use of existing data sets. Moreover, fundamental research directly affects integrated decision making and project delivery. For example, without a fundamental understanding of the role that transportation plays in an ecosystem, it is difficult to determine the types of decision-making processes that are needed to progress towards an integrated, systems-oriented approach to planning and highway development. Likewise, without improving our fundamental knowledge of the land use, economic, and community effects of alternative transportation solutions, it will be difficult to design and implement collaborative and productive institutional arrangements.

Topic 4–2: Data and Tools. Information, tools, and techniques for analysis are important because they enable better assessments of the potential effects of alternative transportation solutions on mobility, the environment, communities, the economy, and other systems, which, in turn, help to support effective transportation decision making.

A number of models exist to forecast transportation behavior, predict direct impacts, and evaluate indirect economic development, land use, and environmental effects. There are also tools for characterizing existing systems and collecting data that feed models. Despite the number of tools (and the volume of data) available to practitioners, they are poorly integrated and often have flaws that prevent their application to common forecasting circumstances. Moreover, new approaches to data collection, such as remote sensing, can greatly enhance the quality and fidelity of data for regional transportation planning, project planning, and impact assessment.

Research under this topic focuses on ensuring access to appropriate data to support analysis; integration of analysis tools, including new forecasting tools that are able to predict systemwide impacts and better able to deal with uncertainty; and tools and methods to better communicate the results of analyses to the public and to decision makers.

Topic 4–3: Integrated Decision Making in Planning and Project Development. Fundamental decisions about transportation capacity are made during development of long-range transportation plans, as well as during short-range programming of projects and corridor-specific studies. Throughout these planning and programming processes, effective decision-making systems are needed to identify and choose among competing transportation solutions at the local, regional, and state level. Aspects of decision-making systems include planning processes and requirements; the institutional relationships behind them; and the analytical tools, performance measurement, and public involvement that support them.

The outcomes of effective decision-making systems are project decisions that make use of all appropriate modal, land use, or technology options to provide timely and workable transportation solutions, which balance multiple objectives including economic development, fiscal responsibility, mobility, safety, accessibility, environmental quality, and community quality of life. Most practitioners agree that there are significant shortcomings in current decision-making processes that may result in suboptimal project-level solutions or delay. Decision making frequently fails to incorporate a comprehensive system-level perspective in considering options for meeting transportation needs (for example, how modal options—such as highway, transit, bicycle, or pedestrian land use, or technology-based solutions interact). Decision making also frequently fails to fully consider project- or system-level impacts on communities; land use patterns; the environment; and local, regional, or even national economies in an integrated manner. Underlying these weaknesses are problems with institutional relationships, adequacy of tools and processes, and coordination with stakeholders.

This research topic focuses on improving the transportation decision-making process with the result being selection and development of projects that meet social, economic, environmental and accessibility needs in a timely and equitable manner. This topic addresses research related to the broad identification of transportation needs in the planning and programming processes (as currently conducted through preparation of long-range transportation plans, Transportation Improvement Programs [TIPs], and State Transportation Improvement Programs [STIPs]) and decision making throughout project development (as currently conducted under NEPA and other federal and state laws). An important focus is on translating community visions and long-range plans (regarding land use, economic development, aesthetics, and sustainability) into appropriate projects, and assessing the direct and indirect impacts of projects on systems such as the economy, natural environment, and the human environment. Another important focus is on techniques and institutional processes within project development, including practical strategies for public involvement and interagency coordination, to ensure that decisions are made in a timely manner. This topic addresses issues associated with institutional relationships and support of public and political leaders.

Topic 4–4: Project Delivery. The project delivery topic addresses research needs for ensuring implementation of projects that meet expectations of stakeholders and the public. This topic focuses on research related to the use of effective project management techniques throughout the project development process. This includes approaches for ensuring that projects are developed in a cost-effective and timely manner. It also includes approaches for ensuring that once project decisions are made, final design of projects is consistent with prior commitments and meets the aesthetic standards of the community and other stakeholders, and that construction occurs with minimal disruption to communities and environmental resources.

The two most pervasive barriers to new capacity projects appear to be: (1). objections on community, social, and environmental grounds and (2). financial constraints. Improvements in project delivery also require significant advances in project financial planning. For example, significant project cost overruns help feed community and interest group distrust of the project planning and delivery processes. Improvements in project management and costing, including research to develop new tools, are covered under this research topic.

RELATIONSHIPS AMONG TOPICS AND PROJECTS

An important criterion for selecting projects for the research plan dealt with the inter-relationships among research topics and projects. Such inter-relationships are needed to ensure that the plan is strategic, rather than simply a laundry list of research initiatives. Consequently, topics and projects recommended for the Capacity focus area of F-SHRP build upon one another. Together, recommended topics and projects culminate in a strategic research program that, when executed, will achieve the vision, goals, and objectives that have been defined for this area of F-SHRP. Figure 5–4 depicts the interconnections between the recommended research topics.

Specifically, work to improve our fundamental knowledge about the factors that drive the demand for travel, the performance of the transportation system, and transportation's relationship with the human and natural environment will generate data and information on critical relationships necessary for the development of new information systems and decision-support tools. Work on information systems and decision-support tools that enable better consideration of the interconnections between transportation systems and the human and natural environment will enable the implementation of new systems planning and project development processes. In addition, work to develop an integrated systems planning and project development process that is consistent with the conceptual framework, as well as improvements in project management, costing, and innovative project delivery approaches, will ensure that resulting projects satisfy commitments and meet customer expectations.

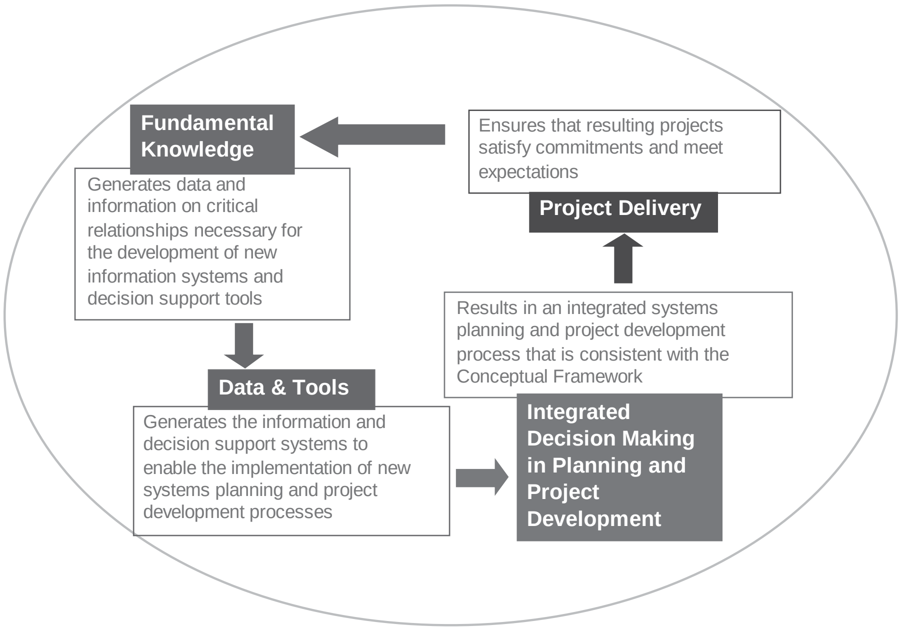

Figure 5–4. Relationships among topics.

The following two projects are the cornerstones of the strategic research plan:

- Project 4-2.5: Developing and Applying a Decision-Support Tool for Integrated Systems Planning and Project Development ("The Virtual Workstation for Systems Planning and Project Development")
- Project 4-3.6: Screening Transportation Solutions in an Integrated Systems Planning and Project Development Process

Together these two projects are designed to significantly advance the state of the art by developing the institutional process and technical tools that will help enable the timely and efficient delivery of projects that meet customer expectations by balancing accessibility, economic, environmental, and social objectives. The two projects build upon all the other projects under the topic areas of Fundamental Knowledge, Data and Tools, and Integrated Decision Making in Planning and Project Development and are critical to accomplishing the overall vision of the Capacity focus area. They focus on improving transportation decisions by addressing the process of long-range planning through project development, including evaluation of alternatives, impacts, and mitigation approaches.

In addition to these cornerstone projects, the research plan proposes a wide range of projects that address the "nuts and bolts" of project development, including research to address community impacts, land use impacts, environmental enhancement, economic development considerations, aesthetics, and design, as well as the costing and scheduling of projects in order to reduce project delay and meet customer expectations. Research on these topics—and the development of practical implementation strategies for improving project management, public involvement, project costing, and context-sensitive design—are also critical for advancing the state of the practice.

RELATIONSHIP TO OTHER RESEARCH PROGRAMS

A number of other programs conduct research in areas related to the goals of F-SHRP's Capacity research. These programs include those of state DOTs; federal agencies such as FHWA, the Environmental Protection Agency (EPA), and the National Aeronautics and

Space Administration (NASA); and NCHRP. In addition, there are proposals for a new environment and planning cooperative research program—the Surface Transportation and Environment Cooperative Research Program (STECRP) or the Surface Transportation Environment and Planning (STEP) Cooperative Research Program. Table 5–2 depicts emphasis areas of these programs. A more detailed analysis would reveal that many of these programs are conducting or proposing to conduct research in more areas than are reflected in the table; however, the table provides a general sense of how the programs compare to each other in terms of their primary focus.

The main characteristics that distinguish the Capacity focus area of F-SHRP can be summarized as follows:

1. F-SHRP is oriented toward outcomes to which multiple disciplines can contribute. This is reflected in the systems approach to transportation planning and project development. It is also reflected in that F-SHRP is not structured around particular disciplines, such as environment and planning, but seeks to integrate these disciplines in support of the overall goals of the program. Other research programs tend to be orga-

TABLE 5–2 Emphasis areas related to capacity in public-sector research programs

		Program Structure					
		Generally structured around transportation-related or scientific disciplines, such as environmental sciences, planning, operations, human health, construction					Structured around outcomes to which multiple disciplines will contribute
	Scope	State	Regional/ Multi-State	National			
	Major Programs	State DOT	Pooled Fund Studies	NCHRP	Federal Agencies	STECRP/ STEP	F-SHRP
Type of Research, Development, and Technology Activity	*Fundamental Knowledge*						
	Environmental science				EPA, FHWA	✓	
	Behavior				FHWA		✓
	System performance, operation, design				FHWA		✓
	Economics, planning, land use	✓		✓	FHWA	✓	✓
	Data and Tools						
	Data collection technologies				DOT-NASA		✓
	Management and decision-support systems			✓	FHWA		✓
	Communication and visualization tools			✓			✓
	Modeling		✓	✓	EPA, FHWA	✓	
	Applied Research and Development						
	Decision making in planning and project development				FHWA		✓
	Project delivery	✓	✓	✓	FHWA		✓
	Operational strategies		✓	✓	FHWA		
	Public involvement and institutional issues				FHWA		✓

NOTES:
1. University research is not included as a separate program; many universities participate in the programs mentioned by performing the research under contracts, grants, or other agreements. Several UTCs include some research related to capacity in their center theme.
2. Private-sector research is not included. Examples of private-sector research and development potentially related to capacity include development of software for management and decision support systems and visualization technologies.

nized around disciplines and are driven by the scientific and technical needs of those disciplines.

2. Although the F-SHRP Capacity plan includes some projects that develop fundamental knowledge, such research is not the primary focus of this part of F-SHRP. The projects under the topic area of Fundamental Knowledge are chosen because of the critical role they play in achieving the goal of a significantly improved planning, project development, and delivery process. Other programs, such as those of EPA, FHWA, and STECRP, are expected to focus more on fundamental knowledge across a wider spectrum of topics and needs.
3. Although F-SHRP includes some research on technologies for data collection, analysis, decision support, and communication, it is expected that F-SHRP will be able to build on existing systems in the private and public sectors and ongoing research in federal programs. The Data and Tools topic area is oriented toward the specific outcomes under the Integrated Decision Making in Planning and Project Development topic area and the Project Delivery topic area, which will radically change the way that transportation is planned and delivered.

CHAPTER 6

ADMINISTRATION AND IMPLEMENTATION

The material in this chapter was prepared by Ann M. Brach of TRB staff to frame some of the administrative and implementation issues to be addressed if F-SHRP is funded. The contents of the chapter do not reflect decisions of the project panels involved in NCHRP Project 20–58. The final disposition of these matters will be left to whatever governing structure is put in place if F-SHRP is authorized.

ADMINISTRATION

The administrative requirements of F-SHRP are predicated on the special characteristics of the research program. These characteristics can be summarized as follows:

- F-SHRP is to be a time-constrained, accelerated program;
- Research must be coordinated and integrated to produce implementable products; and
- Efforts are aimed at producing results that go beyond existing research programs in scale, scope, and/or kind.

This section summarizes the implications of these characteristics for the administration of F-SHRP.

Criteria for Administrative Structure

TRB *Special Report 260* presents four criteria to be met by the administrative structure of F-SHRP.

1. *The F-SHRP organization should possess essential quality control mechanisms*. This criterion includes the use of open solicitation and selection based on merit, mechanisms for avoiding biases and balancing interests and perspectives, and appropriate review procedures.
2. *The F-SHRP organization should be competent to carry out a large contract research program.* This criterion includes experience in managing such a program, appropriate administrative and contract support functions, ability to attract and retain talented staff and other resources, and central administration with distributed conduct of research.
3. *The F-SHRP organization should have focused core staff and secure funding over the program's time frame.* This criterion includes a core staff of appropriate size plus the possibility of additional loaned staff and a reasonably predictable budget that can be managed on a multi-year, program basis.
4. *The F-SHRP organization should have the flexibility to institute stakeholder governance mechanisms.* This criterion includes the use of stakeholder guidance for both the governance of the overall program and for technical guidance at the subprogram level.

Recommended Administrative Home for F-SHRP

At its December 12, 2002, meeting, the AASHTO F-SHRP Task Force voted to recommend that F-SHRP be housed at the National Research Council (NRC), as was its predecessor, SHRP. NRC (through TRB) is experienced in managing a large contract research program (NCHRP) and has the required administrative and contracting support functions. It has the ability to attract talented staff and other resources. NRC is experienced with convening diverse stakeholder groups and balancing various perspectives and interests. It offers the advantage of a reputation for bringing together a broad array of transportation stakeholders in an open and unbiased forum while utilizing access to experts in other fields. Stakeholder governance and external peer review are part of its normal operating procedures. Among existing private-sector organizations, NRC, through TRB, is a well-known and trusted organization in the transportation community. In contrast to government agencies, NRC is much less constrained in certain management practices. As shown in the following examples, NRC is able to

- More quickly increase the size of its staff to support the program and similarly readjust staff size when the program draws to a close;
- Provide greater flexibility and speed in negotiating and awarding contracts;
- Fully implement merit-based selection processes; and
- Establish stakeholder governance mechanisms using processes based on those employed in TRB's Cooperative Research Programs and similar to the processes used for typical NRC committees.

Governance Structure

The committee structure for F-SHRP is expected to be similar to the structure used in SHRP. That is, a high-level or executive committee would be responsible for the overall program, including matters such as major program modifications, program budget, overall program policies, technical panel membership and oversight, and contract awards. Technical panels would oversee major parts of the program, presumably the four strategic focus areas, and handle matters such as preparation of requests for proposals, proposal review and recommendations for contractor selection, oversight and evaluation of technical program progress, report review, as well as outreach, dissemination, and implementation for their program area. SHRP also used a third level of panels, called expert task groups, to assist with peer review of proposals and reports. F-SHRP technical panels may wish to enlist the assistance of such additional groups in carrying out their responsibilities.

Administrative Issues to Be Addressed

The details of F-SHRP administration have yet to be determined. This section outlines some of the major issues to be addressed in this area.

Human resources. The success of F-SHRP will depend on the involvement of hundreds of volunteer stakeholders; nevertheless, there are increasing demands on everyone's time. Therefore, F-SHRP will need to develop stakeholder involvement processes that are both effective and efficient. Some F-SHRP projects will require the involvement of new groups of stakeholders. It will be necessary to identify critical nontraditional stakeholders early in the program and start building relationships with them so that they will be interested in serving on F-SHRP panels. The research calls for over 200 person-years per year of research talent, in addition to what is needed for all of the ongoing research programs. Some new talent (in the social sciences, for example) will be needed from other fields. A dedicated professional staff will be required to run F-SHRP, and they will possibly require the help of loaned staff from other organizations.

Contracting. Several special issues relate to contracting for F-SHRP. The proposed Safety research has never been carried out at such a large scale. Some projects in other areas of F-SHRP require a range of research disciplines that may not be easily found in one institution. In several focus areas the plans call for research more suited to the social sciences, such as organizational behavior, psychology, and economics. While there are some researchers who apply these disciplines to transportation issues, there may be some areas—organizational behavior, in particular—where a whole new group of researchers will need to be attracted to this field. For these reasons, it may be necessary to consider alternative approaches to contracting for some of the research. For example, incentives may be needed to encourage traditional research institutions to seek out and involve nontraditional expertise. Public–private, academic–private, academic–academic, and other partnership combinations may be needed for high-quality and effective results. In addition, oversight and coordination contractors, such as SHRP employed in two areas, may be advisable for pulling together the results of other contractors' work within a strategic focus area.

Organizational structure. Although SHRP was an NRC unit separate from TRB, it seems likely that F-SHRP will be administered within TRB. Nevertheless, the size, visibility, and accelerated time frame of F-SHRP suggest that the program should be carried out with significant independence from other TRB programs. The establishment of an F-SHRP executive committee, as well as a dedicated F-SHRP director and staff, should provide the necessary autonomy even while some support functions may be furnished through TRB offices that already provide these services.

Coordination. F-SHRP will have two major coordination challenges: coordinating with other research programs and coordinating across its own research programs. Other programs with which F-SHRP may need to coordinate include federal, state, academic, private-sector, and international highway research programs. Coordination could be handled by having liaisons from other programs serve on F-SHRP panels or through the establishment of F-SHRP coordinator positions (as SHRP did with state DOTs and international highway research laboratories).

There are a number of areas in which projects should be coordinated across strategic focus areas within F-SHRP.

1. *Data Sharing.* Some projects may be able to use the same databases for research; for example, Reliability and Safety projects may both need traffic volume data. In some cases, it may be necessary to supplement data collection planned in one project so that the needs of another project can be met. For example, data concerning certain driver behaviors relevant to Reliability may be added to the Safety data collection protocol.
2. *Joint Projects Between Reliability and Capacity*. The F-SHRP Capacity program has several projects that may be conducted jointly with the Reliability program. A preliminary list of joint projects between the Reliability and Capacity focus areas is shown in Table 6–1.
3. *Renewal Projects Related to Reliability.* Several of the projects under the Renewal component of F-SHRP deal with construction and management techniques that have the potential to reduce the duration and impacts of work zones. Special consideration should be given to ensuring that travel time effects are explicitly considered in the scopes of these projects. This coordination is required because work zones are a major influence on travel time reliability. The Reliability plan does not include any projects that deal specifically with work zones under the assumption that Renewal will cover the topic more comprehensively.

Even where projects are not conducted jointly, it may be beneficial to share information across strategic focus areas. This type of coordination may be accomplished at the staff level, through volunteers who serve on more than one panel, or through periodic workshops that bring staff, researchers, and panel members together to discuss coordination opportunities.

TABLE 6–1 Potential joint projects between the Reliability and Capacity focus areas of F-SHRP

Reliability	Capacity
3–2.1 Data Requirements for Operations and Performance Monitoring	4–1.1 Improving Our Understanding of Highway Users and the Factors Affecting Travel Demand
3–2.2 Establishing National and Local Monitoring Programs for Mobility and Travel Time Reliability	4–1.2 Improving Our Understanding of Transportation System Performance
3–2.3 Analytic Procedures for Determining the Impacts of Reliability Mitigation Strategies	4–1.3 Understanding the Contribution of Operations, Technology, and Design to Meeting Highway Capacity Needs
3–2.4 Incorporating Reliability Estimation into Planning and Operations Modeling Tools	4–2.5 Developing and Applying a Decision-Support Tool for Integrated Systems Planning and Project Development
3–2.5 Incorporating Mobility and Reliability Performance Metrics into the Transportation Programming Process	4–3.4: Ensuring Support for Highway Capacity Projects by Improving Collaborative Decision Making
3–2.6 Quantifying the Costs of Travel Time Reliability	4–1.5 Improving Our Understanding of Interactions between Transportation Capacity and Economic Systems
3–4.1 Advanced Surveillance Technologies for Operations	4–1.2 Improving Our Understanding of Transportation System Performance 4–2.1 Applying Location- and Tracking-Based Technologies to Collect Data for Systems Planning and Project Development

Program evaluation. In addition to the peer review that will be carried out by the technical panels and expert task groups at the project and strategic focus area level, it may be advisable to institute a programwide evaluation process. Such a process might include a mid-course evaluation half-way through the conduct of the program, and a final evaluation toward the end of the program. The evaluations would be oriented toward the relevance and administration of the research, as well as preliminary outcomes; evaluation of implemented benefits would need to be carried out some years after the program is completed.

IMPLEMENTATION

Implementation is essential if research findings are to have an impact on solving critical problems or taking advantage of strategic opportunities. This section presents: (1). a summary of implementation under SHRP; (2). types of activities associated with implementation; (3). implementation as considered in *Special Report 260*; (4). a brief summary of implementation activities in the research plans, and (5). an analysis of implementation to be carried out during the research stage of F-SHRP.

Background: SHRP Implementation

SHRP was designed to be a focused, short-term research program, performed by a special-purpose organization that would “sunset” when its mission was accomplished. SHRP funding was focused on research, although implementation was considered during the program by identifying the types and most usable forms of products that the research would produce; however, funding for full-scale implementation support activities was not included in the budget and required additional legislation. In 1991, the Intermodal Surface Transportation Efficiency Act (ISTEA) provided such funding, which was administered by FHWA. In addition to specifically authorized ISTEA funding, many states used a portion of the State Planning and Research funds, state funds, and in-kind activities to implement SHRP products. AASHTO maintained a high-level task force to oversee SHRP implementation until the late 1990s. The SHRP Implementation Task Force facilitated coordination among the states and maintained SHRP implementation as a high priority on AASHTO’s agenda. Exhibit 6–1 lists some of the highlights of SHRP implementation.

Exhibit 6–1. Highlights of SHRP Implementation Activities

During Performance of the Research

- SHRP state coordinators: Every state assigned a person to coordinate SHRP implementation in that state. These coordinators met annually and received regular newsletters. Many states also had a SHRP implementation committee that oversaw state implementation activities.
- Loaned staff: Transportation agencies sent staff to work at SHRP offices for short periods. These persons often focused on implementation preparation activities during the research phase.

After Completion of the Research

- Lead State program: In this program, a small number of states would agree to implement particular SHRP products first and then coach other states on effective implementation strategies.
- Superpave and LTPP Committees: These committees provide stakeholder input to and oversight of FHWA's development efforts in Superpave and their continued conduct of the LTPP program.
- Development of specifications: AASHTO coordinated the development of specifications, which were necessary for states and local governments to implement many SHRP products.
- Implementation support activities: These activities were funded and administered through FHWA.

Activities Associated with Implementation

The process of research-development-implementation is a continuum, and, ideally, one set of activities flows into the next. For the purposes of F-SHRP, three types of activities in the area of implementation are distinguished:

1. *Implementation* per se is the actual use of something, in this case the use of a technology or approach that has resulted from research and development conducted under F-SHRP. It is, by definition, carried out by users: state DOTs, MPOs, environmental agencies, vehicle manufacturers, tow truck operators, police officers, emergency personnel, and others, depending on the product in question. In the long run, if research is successful, these users will incorporate the results into their ordinary way of doing business and into their budgets.
2. *Implementation support activities* encompass a wide range of products and services that can help a user implement a result of research and development. These activities can include things like training, conferences and workshops, demonstration projects, and technical support.
3. *Implementation preparation activities* help prepare for and lead up to implementation by identifying potential users, getting them involved in the research and development effort, and disseminating information about research results. These activities do not constitute implementation itself, nor do they directly support the implementation efforts of users, but they are a necessary component of the overall process of getting research results into practice.

Consideration of Implementation in the F-SHRP Report

Special Report 260 identifies the following activities associated with implementation that should be addressed during the research phase. They are generally in the category of implementation preparation activities, as defined above.

- Identification of expected research products and their users,
- Engagement of potential users,

- Determination of where the long-term responsibility for implementation coordination and facilitation will lie,
- Dissemination of research findings,
- Coordination of research efforts,
- Testing and evaluation of research findings, and
- Evaluation and feedback.

Implementation Activities in the Research Plans

In addition to the implementation preparation activities identified in *Special Report 260*, the four research plans include efforts that fall into the implementation-support category, such as training, conferences and workshops, and demonstration projects. Each plan handles these activities differently.

- The Renewal plan tends to integrate dissemination and implementation activities into individual research projects or groups of projects. The plan recommends the development of a Renewal clearinghouse and mechanisms to partner with the private sector to bring products to market.
- The Safety plan is less oriented toward short-term application of results, so implementation activities do not figure significantly in the plan. The countermeasure evaluation component is expected to produce results that support implementation in a fairly straightforward manner, while the risk studies will produce new knowledge and analysis of countermeasure implications, which may require additional developmental work to produce actual implementable countermeasures.
- The Reliability plan concentrates its implementation activities in Project 3–1.2, National Outreach Program for Transportation Operations Practices. This project will synthesize results of F-SHRP (and other) research and develop products and product delivery mechanisms.
- The structure of the Capacity plan—fundamental knowledge supporting data/tools development leading to applications—causes implementation to be concentrated toward the end of this chain, integrated into appropriate projects. The Capacity plan also clearly identifies both interim and final products.

Overall Approach to F-SHRP Implementation

The ultimate impact of F-SHRP will depend upon how effectively the research results are incorporated into the day-to-day activities of the highway sector. The majority of the effort necessary to effect this outcome—that is, implementation per se and implementation support activities—will take place outside of F-SHRP's time frame and budget. Nevertheless, there are several implementation preparation activities that should be carried out in concert with the research, as indicated in *Special Report 260* and summarized earlier in this chapter. Until research products can be identified with some specificity, it is not possible to determine the appropriate implementation activities in detail nor estimate the time and resources required for implementation. This section briefly describes the main implementation preparation tasks that can be undertaken within F-SHRP and suggests activities and potential roles of other institutions in longer-term implementation support.

1. *Implementation preparation activities during the research phase*. These activities may be carried out with F-SHRP funding and account for approximately 5% to 10% of F-SHRP's budget. In addition to the items mentioned in *Special Report 260* and the area-specific implementation activities covered in the research plans, the following efforts may be included here:

- Implementation plan: Once the types of research products are better defined, perhaps in the second or third year of the program, an implementation plan can be developed. This plan will guide early implementation preparation activities and be revised as research progresses and experience is gained by early adopters of the products.
- F-SHRP coordinators: State coordinators, like those involved with SHRP, could provide continuity between research and longer-term implementation by remaining involved into the implementation stage. Coordinators from other major stakeholder groups might also be considered.
- Communication unit: The F-SHRP organization could have an office dedicated to activities like marketing and dissemination of information. This office would be responsible for publishing newsletters, articles, press releases, and research reports; maintaining F-SHRP website(s); and handling outreach and coordination activities.
- Crosscutting implementation unit: The F-SHRP organization could centralize market research and implementation preparation activities. This unit could work with researchers and stakeholder groups to configure research findings and prototypes to user needs to permit effective evaluation of the research products and facilitate eventual implementation. This could possibly be the same office as the communication unit; these are distinct but related functions—the implementation unit will be more concerned with technical issues related to the content of and ability to implement the research.

2. *Longer-term implementation support activities.* These activities represent the bulk of the implementation effort, most of which will take place after the conclusion of the research program. Such ongoing implementation support activities may best be funded and carried out by organizations that will exist beyond the life of F-SHRP. Some examples of these activities include the following:

   - Training: Programs like the National Highway Institute (NHI) and Local Technical Assistance Program (LTAP) could provide training through their ongoing programs. F-SHRP could work with NHI and LTAP to develop training and assist with initial training sessions that may take place while the research program is still underway.
   - Field testing and implementation incentives: While F-SHRP research funding could support pilot field testing, full-scale field tests and incentives for widespread implementation would be handled through other programs, such as those of FHWA and NHTSA or through pooled fund projects. Research funds would not be used to help a large number of states or local agencies try a new technology to see how well it works in their circumstances ("testing" from their point of view, but not from a research point of view).
   - Long-term technical support: Private, public, or academic institutions will need to be identified to provide long-term maintenance of valuable databases produced in F-SHRP (a large database for safety plus additional data for the other areas) and long-term technical support for software products developed in several of the research areas.
   - Direct implementation activities: Actual implementation by users will entail activities such as training personnel, purchasing equipment and software, and modifying existing practices to meet best practices developed through research. These activities represent agency investments in advancing the state of their practice and are not included in the research budget. They are generally expected to be covered through agency budgets, with the assistance of federal-aid funds such as State Planning and Research and other eligible categories and possibly

through additional federal funding for implementation support activities as was the case with SHRP.

As the scope and scale of long-term implementation activities become more well-defined during the research phase, F-SHRP will seek commitments from organizations suited to support these activities to ensure a smooth transition from research to practice.

APPENDIX A

BRIEF DESCRIPTIONS OF RENEWAL PROJECTS

Rapid Approaches

Topic 1–1 (Tactic 1): Perform Faster In-Situ Construction

Renewal time can be defined as the time it takes to complete those on-roadway construction activities that impact traffic flow and the communities and businesses that rely on that roadway for services. Rapid renewal applies innovative activities or technologies to reduce the time traditionally allocated to these on-roadway activities, thereby minimizing the impact.

Project 1–1.1: Utilities Location Technology Advancements

Improving identification tools and enabling the accurate location of underground utilities during the preliminary engineering phase of a project, well before construction activities are in progress, will reduce construction delays. This research will provide tools to develop accurate plans that fully consider underground utilities and, by knowing this information early in the project development process, alternative contracting strategies and pre-location of utilities will be possible.

Project 1–1.2: Geotechnical Solutions for Soil Improvement and Rapid Embankment Construction

Alternative methods are needed to facilitate rapid roadway and embankment construction with improved long-term performance. The project will provide methods and guidelines for: (1). construction of new embankments and roadways over soft soils and (2). rapid widening of existing embankments and roadways.

Project 1–1.3: Replacement of Conventional Materials with High-Performance Materials in Bridge Applications

Construction processes typically associated with bridges are often time consuming, which leads to traffic disruptions, which in turn are sources of safety problems for the traveling public. This project will develop techniques for using high-performance materials in bridge applications that will significantly reduce these problems, are readily inspected, and have adequate strength and serviceability requirements.

Project 1–1.4: Rapid Rehabilitation Strategies of Specialty Structures

Specialty structures (long-span bridges, very high traffic volume interchanges, tunnels, etc.), although relatively small in number, represent significant assets. Construction processes typically associated with specialty structures are relatively time consuming and disruptive to traffic. This project will develop rapid renewal systems and construction processes for the repair and rehabilitation of specialty structures that significantly reduce disruptions while increasing safety. This research will develop guidelines for management systems, rapid repair and rehabilitation, and monitoring of specialty structures.

Project 1–1.5: Micropiles for Renewal of Bridge Foundations

Renewal of structures over waterways frequently requires work to be done on the structural foundations because of structural deterioration of the foundation elements, scour of the supporting foundation materials, or a need to widen the structure. Repair methods using cofferdams are neither cost-effective nor timely. This research will provide guidelines for use of new foundation techniques involving micropile elements that can be used for both renewal and widening applications without the need for road closure or time-consuming over-water construction operations.

Project 1–1.6: Needs Assessment and Implementation Plan for Developing a Comprehensive Intelligent Project Delivery System

A strong IT communication system will influence the way we rebuild and renew our nation’s highways. An intelligent project delivery system (IPDS) will consider enhancements to all phases of a project using appropriate information technologies. There are four components to an effective IPDS: intelligent design, intelligent procurement, intelligent construction, and intelligent maintenance and operations, all of which could operate in a web-based project environment. This project will provide the framework for an integrated approach to data management so that highway infrastructure managers can beneficially use information that exists or can be captured but is currently under optimized.

Project 1–1.7: Facilitating the Use of Recycled Aggregates

Hauling old materials off the worksite and new materials to the site can significantly increase traffic congestion, noise, dust, and air pollution. Increasing the use of in situ recycled aggregates can eliminate hauling, obviate the need to landfill old materials, reduce the need for new quarries, and speed up construction. This research will synthesize existing information; quantify the environmental benefits of recycling, especially in situ recycling; assess the performance of recycled materials and impacts on life-cycle and user costs; and recommend methods to facilitate the increased use of recycled materials for rapid renewal.

Project 1–1.8: Identifying and Reducing Worker, Inspector, and Manager Fatigue in Rapid Renewal Environments

While there is substantial evidence that fatigue can lead to employee problems, lower work quality, and reduced safety, this issue has not been put into the context of exactly how it may impact the overall structuring, management, and operation of rapid renewal projects in the future. The project will give an overview of sleep, fatigue, and alertness and how they impact performance, teamwork, and the potential for accidents and injury. It will identify different rapid renewal scenarios and how fatigue may be minimized within each of them.

Topic 1–2 (Tactic 2): Minimize Field Fabrication Effort

Minimizing the amount of fabrication at the project site will speed up the on-site construction phase of the work, the phase that actually impacts traffic. New systems need to be developed that consider design approaches, construction processes, material selection, and maintenance requirements.

Project 1–2.1: Modular Bridge Systems

Recent developments in modular bridge systems have already been made for both superstructure and substructure applications. With fabrication of these systems completed off site at the same time that foundation work is completed on site, these systems help minimize traffic disruptions and improve safety in the work zone. Prefabrication can also increase quality and thereby lower life-cycle costs. This project will develop modular bridge systems that significantly reduce traffic safety problems, are readily inspected, and have adequate strength and serviceability requirements.

Project 1–2.2: Develop Bridge Designs That Take Advantage of Innovative Construction Technology

This project will develop bridge designs that consider the conditions of rapid renewal projects, incorporate features and approaches that encourage optimal construction efficiency, are easy to inspect, and meet adequate strength and serviceability requirements. The intent is not to duplicate the work under Project 2.1, Modular Bridge Systems for New Construction, but to focus on how to modify current approaches to designing various types of structures so that modern construction technologies can be fully utilized.

Project 1–2.3: Modular Pavement Technology

Modular pavements use pre-fabricated segments for quick pavement replacement. Modularization can accelerate renewal by facilitating multi-tasking in lieu of sequential construction and allowing fabrication of the replacement slab off-site while subgrade and base repairs are in progress. Design procedures are needed for modular systems, as well as joint and material specifications, quality control/quality assurance procedures, and more. The research will develop design protocols for modular pavement renewal systems, perform accelerated testing, and develop detailed operation guidelines.

Topic 1–3 (Tactic 3): Perform Faster Construction Inspection and Monitoring

To be rapid, a renewal project must be built and accepted quickly before opening to the public. However, current acceptance testing procedures are not done in real time, and if there are problems, subsequent rework requires additional time and money. In a high-pressure, time-constrained project, the demands to keep moving can overwhelm the construction inspection process. The intent is to focus on the development of an innovative, high-speed construction inspection process that can be used to ensure that overall quality is obtained without delaying the project.

Project 1–3.1: High-Speed, Nondestructive Testing Procedures for Both Design Evaluation and Construction Inspection

Defects in materials or construction must be identified during construction so that corrections can be made quickly and with a minimum of disruption. This research will provide rapid test procedures to facilitate rapid design, construction inspection, and performance monitoring. Such procedures would minimize disruption by avoiding returning to the site to correct problems discovered after construction and would extend service life by ensuring construction and material quality.

Topic 1–4 (Tactic 4): Facilitate Innovative and Equitable Contracting Environment

One of the main challenges facing agencies in the future is the reduction in human resources available to conduct renewal operations. It is safe to expect that these agencies will be transferring more responsibilities to consultants and contractors. An examination of trends in other countries shows that the transfer can be accomplished but requires new strategies and cooperation among the various interests. This topic focuses on developing an environment that may be more conducive to delivery of the type of services needed in the future.

Project 1–4.1: Performance Specifications

DOT specifications are generally prescriptive—they attempt to describe how a contractor *should* conduct certain operations using minimum standards of equipment and materials. Prescriptive (or method) specifications have performed admirably in the past with an experienced workforce and fairly repetitive operations. However, rehabilitation and reconstruction projects, especially in a rapid renewal scenario, demand more creativity and innovation. This research will address two major challenges: (1). developing alternative specification language that is less prescriptive, adequately describes the performance required in the final product, and is contractually sound and defensible; and (2). developing performance specification language that works effectively and properly in contracts to design, build, maintain, operate, warrant, transfer.

Project 1–4.2: Alternate Contracting Strategies for Rapid Renewal

Many states are looking at contracting options that might accelerate project completion time, reduce overall costs, improve quality, and reward contractors for exceptional performance. However, there are inherent risks associated with any new contracting procedure. It is important to fully understand and evaluate different options and apply those that will return the most benefit to the state. This research will assess contracting strategies, develop a decision tool to assist agencies in selecting appropriate strategies, and evaluate strategies used on experimental projects.

Project 1–4.3: Incentive-Based Specifications to Assure Meeting Rapid Renewal Project Goals

There is no overall project quality index that rewards a contractor for exceptional quality in both process and product. Some believe the success in meeting time incentives may be coming at the expense of quality, since there is no overall measurement system. This project will focus on identifying rapid renewal project goals, identifying performance indices, developing incentives, and experimenting with new contract clauses.

Project 1–4.4: Development and Evaluation of Performance-Based Warranties

Many states are experimenting with warranties to improve product quality, reward high performing contractors, and reduce inspection work force requirements. Warranties are controversial but may be an important part of the future rapid renewal contracting mix. This project will examine in detail the current warranty situation, identify ways to make it more “balanced” from a risk perspective, and add enhancements such as early release or incentive rewards.

Project 1–4.5: Risk Manual for Rapid Renewal Contracts

This project addresses the general lack of understanding of risk and risk transfer decisions associated with alternate contracting approaches. This project will develop a risk assessment manual for departments of transportation. The manual could be used to determine the nature of risk, risk transfer, risk management, and risk mitigation from a contractual and life-cycle point of view.

Project 1–4.6: Innovative Project Management Strategies for Large, Complex Projects

Large projects involve complex logistical requirements, contractual procedures, multiple contracts, and regulatory requirements that need careful planning and execution for design and construction. The unique requirements of a mega project include how contractors work on large projects, what organizational setup is required to make it a success, what the effective contractual arrangements are, and what the impact of FHWA requirements on the outcome of a mega project is. This project will address the managerial and workforce challenges associated with rapid renewal projects and develop innovative and effective project management strategies for project owners and contractors for large complex projects.

Minimize Disruption

Topic 1–5 (Tactic 5): Plan Improvements to Mitigate Disruption

There are more ways to minimize the impact of renewal if the analysis starts early in the project development process. This means not only selecting the renewal work that needs to be done but selecting the best way to assemble and procure the work. Agencies need to strategically define, analyze, package, and renew highway corridors and projects so as to minimize current and future traffic disruptions and minimize overall initial and life-cycle costs. Financial solutions are urgently needed to provide the ability to address very high-cost renewal projects in a sustainable manner.

Project 1–5.1: Strategic Approaches at the Corridor and Network Level to Minimize Public Disruption from the Renewal Process

DOTs recognize the need to examine renewal projects along with new construction projects within an entire corridor in order to develop reasonably accurate timelines and budgets. Additionally, many DOTs are examining regional networks with multiple corridors in order to examine the impact of constructing multiple corridors simultaneously. Without a new approach to constructability of the corridor, however, the negative impact on the traveling public and the local communities may increase dramatically. This project consists of developing a new corridor planning process that will integrate a constructability assessment and construction packaging strategy early in the planning process; address the impact of multiple corridor and project work on regional network flow; establish the limits of work to minimize disruption during construction; minimize downstream construction requirements that will cause disruption; and improve timelines and optimize budget considerations from both an initial and life-cycle analysis.

Project 1–5.2: Integrating the "Mix of Fixes" Strategy into Corridor Development

Using the corridor concept, a DOT will need to determine optimal renewal strategies for specific bridges and pavements within a given corridor. Such strategies must consider the nature and extent of renewal required, what service life to reconstruct for, and associated life-cycle and user costs. This project will identify current and next generation "mix of fixes" options and provide assessment tools on how to choose the optimal combination of solutions along a corridor.

Project 1–5.3: Strategic Approaches for Financing Large Renewal Projects

DOTs expect increasing pressure to organize and build mega projects. One of the very first criteria for determining the scope of a renewal project is the available funding needed to build the project, whether conventionally or in an expedited fashion. Over the last decade, several DOTs have bundled work into relatively high-cost packages in order to complete work expeditiously while minimizing disruptions. These mega projects, while generally credited with getting the job done quickly, may have had significant impacts on the entire state highway program. Without new money and/or new tools other than borrowing against the future to leverage existing resources, much of the research and process improvement to deal with renewal with minimum disruption may be unrealized. This project will develop creative financing strategies for this expected increase in large renewal projects.

Topic 1–6 (Tactic 6): Improve Customer Relationships

The key to improving customer relations is to get customers involved in the decision-making process with the goal that they become willing partners with the agency as decisions are made and implemented. Customers include those using the facility and those who live near it and are impacted by the renewal activities. Additionally, utilities and railroads share roadway right of way and have a huge stake in renewal activities. Unresolved or undetected utility issues have been recognized as one of the leading causes of construction delays. It behooves highway agencies to address fundamental relationships and explore innovative agreements to minimize this impact. This tactic directly addresses those most impacted by the renewal work and looks for creative solutions and partnerships.

Project 1–6.1: New Guidelines for Improving Public Involvement in Renewal Strategy Selection

Successful renewal projects engage the public and other agencies early and communicate plans continuously throughout. The renewal agency must embrace public input to the design, which affects the environmental and human impacts of the project during and after renewal. Resource agencies and affected interest groups should be contacted early and provided the opportunity for two-way communication. This project will organize procedures in which project owners address the needs of various public groups, including resource agencies and special interest groups. Ideally, interactive visualization tools will be incorporated into the process. Because much of the communication process involves visualization, this project will also identify advances in engineering animation technologies that would improve the ability to communicate dimensions, impacts on property, and project phasing.

Project 1–6.2: New Guidelines for Improving Business Relationships and Emergency Response During Renewal Projects

Both business activity and response to emergencies are impacted by highway renewal work. Changes resulting from renewal work can impact businesses and increase the response time of emergency services. Work zones introduce the potential for accidents, and revised traffic patterns increase the potential for crashes. For businesses, this project will capture information from design and construction phasing plans to show a business what will happen in its immediate environment over time. For emergency responders, the project will develop guidelines on how to ensure that responders are aware of all street and bridge closings and areas of increased congestion at each project phase so they can revise their routes in response to changing access conditions.

Project 1–6.3: Utilities–DOT Institutional Mitigation Strategies

Utilities are the primary cause of construction delays. There are many factors that contribute to this, including lack of information on the existence and location of utilities, not fully considering the complexity of working around and relocating utilities during highway construction, poor coordination and cooperation between project and utility owners, and, in some cases, lack of responsiveness by the utility owner. Consolidation within the utility industry in recent years makes it more difficult to address concerns at the state level when utility providers are regionally and nationally structured. This project will explore how to improve working relationships and reduce negative impact to both the project and utility owner, and ultimately the public consumer.

Project 1–6.4: Railroad–DOT Institutional Mitigation Strategies

Railroads are private entities that own and maintain their own rights of way and provide their own financing for improvements. The stance that a railroad will take with regard to a highway renewal project will depend, to some extent, on the benefits that it receives from the project and the disincentives for not cooperating. Most railroads are very challenging to deal with at the state level and are extremely defensive regarding any operation that could impact the use of their facility. This project will provide the forum for railroad–DOT collaboration and the framework for model business agreements.

Project 1–6.5: Context-Sensitive Designs and Construction Operations to Minimize Impact on Adjacent Neighborhoods

Context-sensitive design helps agencies mitigate a given project’s impact on the neighborhood or community surrounding the site. This concept should be carried beyond the design phase through construction, maintenance, and operation. By planning and implementing context-sensitive construction, the contractor ensures that work can proceed efficiently, while the impact on the adjacent community is minimized. This research will extend context-sensitive design principles into the specific applications related to rapid renewal construction operations to minimize the impact of renewal projects on their surroundings.

Topic 1–7 (Tactic 7): Improve Traffic Flow in Work Zone

There will always be a need to move traffic quickly and safely through work zones. Many of the traditional work zone approaches are simply inadequate to address the high-traffic environment of rapid renewal projects. The goal is to make work zones and work sites of the future safer and more efficient for both motorists and construction workers.

Project 1–7.1: Design, Installation, and Maintenance of Work Zones for High Consistency, Visibility, and Safety

Despite the advancement in traffic control techniques, more than 800 deaths per year nationwide are still attributed to crashes in work zones. As more facilities require renewal and growth in highway demand is projected to increase 50% by 2020, the challenge becomes more significant. This project will develop model work zones to establish consistent traffic control, geometric configuration, and traffic control devices in work zones across the country, particularly on high-volume roadways.

Produce Long-Lived Facilities

Topic 1–8 (Tactic 8): Design and Construct Low-Maintenance Facilities

Producing long-lived facilities not only reduces ownership costs but also significantly reduces the disruption to the users over the life cycle of the facility. Building for long life, using low-maintenance designs and materials, and designing facilities for easier maintenance need to be simultaneously achieved. Through improved material selection, design processes, and integration with construction technologies, facilities must be designed to reliably achieve the desired performance life. This tactic seeks to integrate performance-related designs with innovative construction processes that will result in long-life solutions.

Project 1–8.1: Durable Bridge Subsystems

Historically, durability has been a problem for bridge subsystems, especially bridge bearings and deck joints. If these subsystems could be designed with enhanced durability characteristics, or if they could be eliminated (e.g., joints), disruptions could be significantly reduced and structures could be expected to last longer after they undergo renewal efforts. This research will develop bridge systems that minimize or eliminate deck joints and bearings in order to allow rapid construction and long life.

Project 1–8.2: Design for Desired Bridge Performance

Current bridge design specifications do not address new materials, modular components, and other issues associated with renewal. This research will develop comprehensive design procedures that integrate material performance (including durability), construction practices, and structural performance that will lead to more predictable and longer service life.

Project 1–8.3: Composite Pavement Systems

Composite pavements have great potential to provide a long-lasting pavement needing minimal maintenance. However, the behavior of composite pavements is not well understood. This research will develop performance models and design procedures for new composite pavements; develop material requirements for all layers of the composite pavement, including the subgrade; recommend construction and quality control procedures for composite pavements; and develop a long-term evaluation program to provide for future refinements of the design procedures and models.

Project 1–8.4: Stabilization of the Pavement Working Platform

Subgrade preparation and base construction constitute time-consuming stages when building new or replacement pavements. This research seeks to improve pavement performance and increase the speed of construction by integrating the behavior of the unbound pavement layers into the overall performance of the pavement for new construction and rehabilitation and by investigating rapid mechanical and chemical soil stabilization technologies for pavements. The project will develop guidelines and design procedures for each treatment.

Project 1–8.5: Using Existing Pavement in Place and Achieving Long Life

On roadways that have acceptable geometric features, renewal can be greatly accelerated and costs reduced if the existing pavement can be incorporated into rapid renewal projects without having to be removed. Some of the techniques include rubblizing and crack and seat for ACC over PCC pavements and concrete over concrete, concrete over asphalt, and concrete over asphalt/concrete for PCC overlays. There is insufficient knowledge, experience, and confidence, however, in these techniques on very high-volume, high-load roadways, especially for projects looking for long life (50 years or longer). This project will provide reliable procedures that allow project owners to identify when an existing pavement can successfully be used in place and how to incorporate it into the new structural pavement to achieve long life.

Topic 1–9 (Tactic 9): Monitor In-Service Performance

Technology provides an opportunity to address a key strategy for providing improved service to the public both for planned maintenance and security. Having the ability to continuously monitor in-service performance and the necessary decision-support systems will result in lower life-cycle user and ownership costs as well as improved public safety.

Project 1–9.1: Nondestructive Evaluation Methodology for Unknown Bridge Foundations

In 2000, FHWA reported that over 91,000 water-crossing bridges in the National Bridge Inventory had unknown foundations. Quick, simple, and inexpensive methods are needed to determine whether techniques to repair/strengthen/widen a bridge are more cost-effective than replacement. This is especially important on rapid renewal projects where time is of the essence, minimizing traffic disruption is key, and project costs typically exceed available budget. This project will demonstrate nondestructive evaluation equipment and guidelines for development of standards and specifications.

Project 1–9.2: Development of Rapid Renewal Inputs to Bridge Management and Inspection Systems

Rational bridge management systems are an important tool for bridge owners. If these management systems are developed properly, decisions for bridge rehabilitation, repair, and replacement can be made that significantly increase bridge life. This project will enhance PONTIS and provide the ability to more accurately model in-service performance. Developing and tailoring a management system to correspond to the specific needs of renewal systems makes this effort unique compared to current work in progress on existing bridge management systems.

Project 1–9.3: Monitoring and Design of Structures for Improved Maintenance and Security

Bridge monitoring is an important tool for determining bridge performance, developing and validating effective design specifications, and ensuring bridge security. Standards for protocols, data collection, and processing are needed for monitoring bridges in a cost-effective and efficient manner. This project will investigate cost-effective monitoring technologies for the nation’s infrastructure systems.

Topic 1–10 (Tactic 10): Preserve Facility Life

One of the essential components of a rapid renewal program is preservation of existing facilities for the longest possible time at the required level of performance. Additional techniques are needed to extend the life of roadways that carry high traffic volumes, to strengthen bridges without total reconstruction, and to retrofit bridges that were not built with redundant structural members.

Project 1–10.1: Preservation Approaches for High Traffic Volume Roadways

The application of preservation strategies to high traffic volume roadways presents a complicated set of challenges. Many of the products and approaches that are acceptable on lower traffic volume roadways are simply not acceptable or workable on high traffic volume roadways. Often, either the impact to traffic is too great to use a particular product or application, or the treatment is not successful under high traffic conditions. This project will develop guidance for matching the condition of the infrastructure element to a specific treatment and identifying what the benefit/cost will be.

Project 1–10.2: Bridge Repair/Strengthening Systems

Significant speed of construction, minimized traffic disruption, and reduced costs can be achieved by repairing or strengthening existing structures rather than replacing them. Systems are needed to repair and strengthen structures quickly and simply with good connections and other details that are economical and that produce long-lasting performance. This research will develop and test bridge repair and strengthening systems.

Project 1–10.3: Techniques for Retrofitting Bridges with Nonredundant Structural Members

One particular class of steel bridges that requires special attention is fracture-critical bridges, many of which are nearing the end of their design lives. Failure of a member in a fracture-critical bridge would likely force the closing of the bridge, resulting in major traffic disruption. Often, fracture-critical bridges must be shut down, or other highways they cross must be shut down, so that inspections can be performed. This research will study the concept of redundancy, recommend a definition of “nonredundant,” and develop renewal techniques for removing nonredundant characteristics.

APPENDIX B

BRIEF DESCRIPTIONS OF SAFETY PROJECTS

Topic 2–1: Research Tools and Methods

Projects in this topic provide necessary building blocks for the subsequent research and also will provide some early products. By the time F-SHRP Safety projects begin, several field studies employing instrumented vehicles and roadside technologies will be underway or completed. Analytic methods that take full advantage of the large and complex data sets produced by such field studies have been identified as a focus area for F-SHRP. A strategic, and relatively low-cost, activity for F-SHRP will be to use the data from some of these recent field studies to explore and develop analytic methods for the subsequent F-SHRP field studies. These projects have the potential to demonstrate the benefits of the later projects and produce some early findings.

Project 2–1.1: Legal and Privacy Issues in Recruiting Volunteer Drivers and Vehicles for Field Studies of Driving Safety

The objective of this project is to develop recommended procedures to address legal and privacy issues inherent in a large-scale field study with volunteer drivers using their own vehicles equipped with extensive data recording capabilities. Research involving human subjects involves complex issues related to the conditions of participation by the subject and the ownership and uses of the data. In addition, the subject's own vehicle may be fitted with extensive equipment and used in the experiment. This adds additional issues of liability for both the owner's vehicle and the research equipment. Another aspect of this project is the transfer of any such provisions to sponsors or other research users of the data.

Project 2–1.2: Development of Analysis Methods for Site-Based Risk Studies Using Recent Data

The objective of this project is to further develop the hardware and software used for the site-based data collection approach. The goal is a semi-automated system that identifies the primary conflict situations and calculates the conflict severity incrementally as the vehicles move through the site. Continuous conflict, or traffic events should be uniquely identified so they can be extracted as a unit for analysis. For example, the minimum value of the relevant crash margin measure could be extracted for vehicle pairs observed in a particular conflict situation, such as the left-turn-across-path conflict. The goal of this project is to enhance the performance of current systems so they can meet the needs of the site-based risk study.

Project 2–1.3: Development of Analysis Methods for Vehicle-Based Risk Studies Using Recent Data

The objective of this project is to develop the analytic approach for the F-SHRP instrumented-vehicle field study and carry out a demonstration of the method using data from recent field studies for the road departure and intersection safety issues. Key aspects include the application of crash surrogate approaches (traffic conflicts, critical incidents, near collisions) and the development of data storage and retrieval methods to implement these analytic approaches with the very large data sets produced by instrumented-vehicle field studies. The project includes: (1). analysis of national accident data files; (2). identification of research questions; (3). development of an analysis plan that specifies risk measures to be used (including crash surrogates), independent variables, control variables, and analysis methods; (4). demonstration of the method using data from recent field studies; and (5). preparation of a detailed analysis plan for the data from the F-SHRP instrumented-vehicle field study.

Project 2–1.4: Development of Comprehensive Roadway Information in a GIS Database

Most states and metropolitan planning organizations (MPOs) are working toward improving their base maps and incorporating them in a geographic information system (GIS). Generally, some roadway data are included. However, the maps are not comprehensive in that they sometimes only cover roads under the jurisdiction of the state or MPO. More importantly, sufficient roadway data to support safety analysis focused on roadway issues generally are not available—particularly information on the shoulder, such as the type and location of rumble strips, that is critical for the planned study of the relationship of road characteristics to the risk of road departure. The need for comprehensive roadway data in a GIS database has been identified as critical for the F-SHRP Safety program. The objective is to review the available sources of roadway data linked to a base map by location in a GIS and make recommendations to the instrumented-vehicle design project (2–2.1) for each roadway data element. The scope includes: identify a comprehensive list of roadway characteristics to support safety studies; review existing data; review new sources of information; and evaluate the alternative sources for each data element, including the costs.

Project 2–1.5: Application of OEM Electronic Data Recorders for Risk Studies

This project addresses the use of electronic data recorders put in the vehicle by the original equipment manufacturer (OEM) to support studies of collision risk. This is an alternative to large field studies using specially instrumented vehicles. The objective of this project is to explore the extension of this technology to support studies of collision risk. Important issues include determining the appropriate data and procedures for access and use of the information.

Topic 2–2: Risk Studies

These are large-scale research studies of multiple factors related to the risk of collisions and casualties for high-priority roadway safety issues. Understanding the interrelationship of driver performance/behavior, roadway characteristics, and the risk of collisions will support countermeasure development. Projects in this area will address two highway problems: road departure and intersection accidents. A large instrumented-vehicle study is designed to address both road departure and intersections. A study employing site-based data collection technology will address the intersection issues and, possibly, high-incidence road departure locations. Both risk studies should coordinate to the extent possible with Project 2–3.1 to select countermeasures for traditional retrospective evaluation. It is hoped that some of the same countermeasures will be addressed in both the risk studies and retrospective evaluations.

1. Road Departure Risk Study. The objective of this study is to determine the interaction of driver performance/behavior with highway design in road departure crashes. Examples of the highway safety issues to be addressed include the effect of lane-edge markings and rumble strips in driver lane-keeping performance, the effect of curves and grades, and speed management. Driver factors include age, gender, inattention, impairment, and aggressive driving. The project is expected to identify highway design and operating conditions that will reduce the incidence of lane departure, as well as driver errors or behavior, such as risk-taking, that may be more effectively addressed through education or enforcement.

2. Intersection Risk Study. The objective of this study is to determine the interaction of driver behavior with intersection design and operation in the risk of intersection crashes. Risk estimates will be developed for each intersection conflict type. Each conflict situation will be examined to determine the role of driver behavior and performance and the relevant intersection characteristics. This project is expected to identify intersection design and operation characteristics that are associated with improved driver performance in intersection maneuvers, as well as driver errors or behavior, such as risk-taking, that may be more effectively addressed through education or enforcement.

The individual projects that will form the basis for both risk studies are described below.

Project 2–2.1: Vehicle-Based Risk Study—Phase I: Study Design

This project will develop the design for a field study involving 4,000 to 5,000 instrumented vehicles operated for a period of 2 to 3 years. The data collection package must accommodate the needs of the road departure and intersection studies to follow. The fleet is to be split between at least two to four geographic areas to provide good coverage of both urban and rural areas. Data for the road departure and intersection studies will be separated and archived for analysis as part of the data processing. The study will be conducted with volunteer drivers using instrumented vehicles for their everyday use. Ideally, an instrumentation package can be developed that could be installed on any (or at least many) vehicle models. This would allow the subject-driver to use his or her own vehicle during the study period, and the instrumentation package would be removed at the end of the experiment, leaving the car in its original condition. It is anticipated that it will be desirable to turn over the driver/vehicle pool approximately once per year by reinstalling the vehicle instrumentation package in a new driver’s vehicle. In this way, a fleet of 5,000 vehicles (and instrumentation packages) will collect data on 15,000 drivers (and vehicles) over a 3-year period.

Project 2–2.2: Vehicle-Based Risk Study—Phase II: Pilot Study

A pilot test of the instrumented vehicles follows the study design. The objective of this project is to demonstrate the data collection system for the instrumented-vehicle risk study. The scope includes instrumenting a test fleet of 100 vehicles and operating them for a 6-month period to evaluate the data collection system. The results of the pilot test will be reported and recommendations made for the full study.

Project 2–2.3: Vehicle-Based Risk Study—Phase III: Field Study

The objective of Phase III is to carry out the instrumented-vehicle field study. This project follows the pilot study. The field study includes recruiting drivers/vehicles; performing intake testing of drivers and installing the data collection package in each owner's vehicle; acquiring data and monitoring for quality; addressing problems encountered; investigating crashes; data processing and archiving; and preparing a report documenting the field study activities and resulting data archive. This project is guided by the results of the sample design and pilot study.

Project 2–2.4 Vehicle-Based Risk Study—Phase IV: Intersection Analysis and Countermeasure Implications

The objective of this project is to quantify the contribution of driver, roadway, vehicle, and environmental factors to the risk of specific intersection conflicts and assess the countermeasure implications of the findings. Risk measures will be developed for specific intersection events, or traffic maneuvers. Research questions will address the role of driver behavior, age, gender, and vehicle type in the risk of specific intersection conflicts. Determining the role of driver behavior in intersection conflicts will be a strength of the instrumented-vehicle field study. This method will provide the best assessment of driving styles and factors such as inattention, distraction, and impairment. Quantifying the role of driver behavior in the risk of specific intersection maneuvers, or conflicts, will have direct countermeasure implications. The scope of this project is to acquire the intersection data from the field study, 2–2.3, carry out the analysis described in the study design, 2–2.1, and address the countermeasure implications of the findings. The project is conducted in parallel with the field study so that methods can be tested with the early data and refined as the project progresses. Data problems can be identified and addressed as the field study continues.

Project 2–2.5: Vehicle-Based Risk Study—Phase IV: Road Departure Analysis and Countermeasure Implications

The objective of this project is to quantify the contribution of driver, roadway, vehicle, and environmental factors to lane-keeping performance and assess the countermeasure implications of the findings. This is the analysis of driver, vehicle, roadway, and environmental factors that affect lane-keeping performance. The objective of the analysis is to quantify the relationship of the factors above, either individually or in combination, to the risk of lane departure. Research questions will address the affect of driver factors such as age, gender, speeding or inattention; roadway characteristics such as edge markings, rumble strips, grade and curvature; vehicle factors such as vehicle type (car, SUV, van, pickup); and environmental factors such as lighting or road surface condition. Quantifying the relationship of these factors, individually or in combination, to the risk of road departure will have direct countermeasure implications. The scope of this project is to acquire the data subset for this project from the field study, 2–2.3; carry out the analysis described in the study design, 2–2.1; and address the countermeasure implications of the findings. The project is conducted in parallel with the field study so that methods can be tested with the early data and refined as the project progresses. Data problems can be identified and addressed as the field study continues.

Project 2–2.6: Site-Based Risk Study—Phase I: Study Design and Pilot

The objectives of this project are to: develop a road-side study design employing sets of SAVME, or analogous systems, that will provide for direct and systematic comparison of selected roadway and operational design variables; and carry out a demonstration of the study design. The project will: (1). review previous research efforts to identify both roadway and operational variables and site-based study design methodologies, (2). identify one or more locales with sets of intersections reflecting the roadway design and operational variables of interest, (3). identify research questions that may be addressed employing the identified locales, (4). develop an initial experimental plan that provides for comparisons of the effects of the most salient design and operational variables using the identified locales, (5). perform pilot demonstration of the method comparing intersections in a single locale differing on one or two dimensions, and (6). prepare the final detailed study plan based upon the demonstration experience.

Project 2–2.7: Site-Based Risk Study—Phase II: Field Study

This project will follow the study design developed in 2–2.6. The project includes both the collection of data using site-based technology and processing of the data. The work will be presented in a report that documents the data collection program and provides guidance on the use of the data archive for the subsequent analysis project, 2–2.8. The objectives are to: (1). conduct site-based studies that will provide for direct and systematic comparison of selected roadway and operational design variables, and (2). demonstrate the relationship of surrogate measures to collision risk based on historical accident records.

Project 2–2.8: Site-Based Risk Study—Phase III: Analysis and Countermeasure Implications

This project is the analysis and countermeasure implication phase of the site-based study of intersection risk. The objectives are to: (1). quantify the contribution of intersection characteristics and traffic operations to the risk of specific intersection conflicts, and (2). assess the countermeasure implications of the findings. The scope of this project is to acquire the data from the site-based field study, 2–2.7; carry out the analysis described in the study design, 2–2.6; and address the countermeasure implications of the findings. The project is conducted in parallel with the field study so that methods can be tested with the early data and refined as the project progresses.

Topic 2–3: Countermeasure Evaluation

Countermeasures have traditionally been evaluated by making before and after comparisons based on crash data. Frequently, these results are inaccurate due to limited data samples and lack of control for other factors. The F-SHRP Safety plan emphasizes the use of more rigorous methods, such as Empirical Bayes, with both treatment and control sites. These methods can also incorporate the affects of additional control factors. Accurate countermeasure effectiveness information is necessary for implementation.

Project 2–3.1: Identify Countermeasure Evaluation Topics

The objective of this project is to revisit the identification of countermeasures for evaluation. While a tentative list of high-priority countermeasures was developed by the technical panel and used in this research plan, it is appropriate to revisit this process with broader representation at the start of work in this topic area. This project will conduct a more thorough evaluation of the needs of researchers and practitioners, consider the available data, and recommend a prioritized list of countermeasures for evaluation. It is envisioned that this project will be supported by a TRB committee to facilitate access to researchers and practitioners and guide the overall selection process. This project will: (1). survey researchers and practitioners to determine their perspectives on pressing research needs, (2). review the literature and obtain relevant data from existing studies, (3). review the priorities and available data, and (4). make recommendations.

Project 2–3.2: Retrospective Countermeasure Evaluation Projects

This project is a placeholder for the evaluation topics identified in Project 2–3.1. The objective is to conduct a rigorous evaluation to determine the benefits, in reduced casualties and crashes, and costs of the subject countermeasure based on retrospective crash data using the best analytic approach. It is preferred that both treatment and control sites are available and that control factors be incorporated in the analysis. This project will: (1). review the literature and obtain relevant data from existing studies, (2). develop a detailed evaluation plan, (3). collect data, (4). perform analysis, and (5). provide a final report.

APPENDIX C

BRIEF DESCRIPTIONS OF RELIABILITY PROJECTS

Topic 3–1: Improving the Knowledge Base for Addressing the Root Causes of Unreliable Travel Times

Practices to address the root causes of unreliable travel times are scattered and largely undocumented. A substantial improvement in travel time reliability can be made by compiling current best practices and developing application guidelines for practitioners, who often do not have knowledge of the best available technologies and methods, or how to implement them. Moving the “state of the practice” (what exists in the field now) up to the level of the “state of the art” (best practices) will have a major impact on travel time reliability.

Project 3–1.1: National and International Scans of Best Practices in Traffic Incident, Weather, Work Zone, and Special Event Management

Transportation agencies (and other agencies that work cooperatively with transportation agencies) in the U.S. have largely developed their own internal procedures for dealing with the management of traffic incidents, weather, work zones, and special events. Many other countries have addressed these sources of unreliability in their own ways. This project will develop a baseline of knowledge from practices in the United States and abroad.

Project 3–1.2: National Outreach Program for Transportation Operations Practices

The benefits of F-SHRP Reliability research will only be realized through implementation of the results. This project will develop materials that transportation and other practitioners can readily adopt into their practices. It will also spur implementation through outreach and other dissemination efforts.

Topic 3–2: Improvements in Data, Metrics, and Analytic Methods for Measuring Reliability

Many of the fundamental travel time reliability concepts are still being developed—such as the relative contribution of different sources to unreliability—and practitioners are not well versed in data and methods to measure travel time reliability. Further, the expected impacts of mitigation strategies aimed at improving reliability have not been adequately quantified, which greatly hinders the incorporation of these strategies in transportation planning and programming activities.

Project 3–2.1: Data Requirements for Operations and Performance Monitoring

Measuring real-time system performance is key to operating the transportation system. The same information also can be used to monitor the system’s performance over time. This research will: (1). define what data are needed to implement operations strategies and performance monitoring; (2). develop common definitions for required data; (3). identify data collection requirements (coverage, frequency, accuracy); and (4). identify alternative business models for collecting, managing, and processing the data.

Project 3–2.2: Establishing National and Local Monitoring Programs for Mobility and Travel Time Reliability

This project will develop mobility metrics (measures) for recurring and nonrecurring delay and events and establish data collection and analysis programs to support mobility and reliability monitoring on local, state, and national levels.

Project 3–2.3: Analytic Procedures for Determining the Impacts of Reliability Mitigation Strategies

This project will quantify the effects that reliability mitigation strategies have on the performance metrics identified in Project 3–2.1. The results of this study will be used elsewhere in the Reliability research program and also will be available for stand-alone use by practitioners.

Project 3–2.4: Incorporating Reliability Estimation into Planning and Operations Modeling Tools

The models in common use by operations and planning personnel do not currently include estimates of reliability as part of their output. This project will add the capability of producing reliability metrics as output to planning and operations models and determine how travel demand forecasting models can use reliability estimates to produce revised estimates of travel patterns.

Project 3–2.5: Incorporating Mobility and Reliability Performance Metrics into the Transportation Programming Process

The technical procedures for incorporating performance measures into the transportation investment process have not been developed and the effect on traditional capital expenditures has not been determined. This study will determine how performance metrics can be used to develop short- and long-term strategies addressing mobility and reliability.

Project 3–2.6: Quantifying the Costs of Travel Time Reliability

The limited research that has been done suggests that users value the variability in travel times more than "expected" or "normal" travel times, but such research has several limitations. This project will: (1). determine quantitatively how highway system users value travel time reliability and (2). develop guidance for using measures of reliability when preparing cost-benefit analyses and planning for highway operational improvements.

Topic 3–3: Overcoming Institutional Barriers to Effective Transportation Operations

Most of the mitigation strategies focused on improving travel time reliability are oriented to the operation of the highway system. Operational strategies require that many different public- and private-sector organizations communicate, coordinate, and cooperate with each other. These organizations (including transportation, law enforcement, fire and rescue, towing professionals, and media) have distinct missions that pose challenges to effective cooperation.

Project 3–3.1: Institutional Architectures for Implementation of Operational Strategies

This project will identify mechanisms and organizational structures that promote intra- and inter-agency cooperation in a wide variety of operations. The project will consider issues such as: agency objectives and priorities; organizational roles and responsibilities for operations; human and financial resources; professional values, culture, and conventions; and homeland security initiatives.

Project 3–3.2: Public Official and Senior Management Education Program on the Benefits of Improved Transportation Operations

Transportation professionals engaged in operations often have difficulty conveying the value of their programs to upper management since operational deployments often do not have the visibility or immediate impact of traditional capital improvements. Yet operational improvements can be implemented more quickly and inexpensively without the disruptions caused by major capital projects. This project will demonstrate the benefits that operational improvements can have on system users.

Project 3–3.3: Highway Funding and Programming Structures to Promote Operations

Although the initial capital outlay for operations-oriented projects is often modest compared to traditional expansion projects, annual funding to sustain them can be substantial. Operations and management (O&M) costs must be considered simultaneously with initial capital costs, yet operational improvements have not been ingrained in the short-range programming and long-range planning processes. This project will identify methods to plan, program, and finance operational enhancements aimed at improving travel time reliability.

Project 3–3.4: Personnel Requirements for Conducting Effective Traffic Incident, Work Zone, and Special Event Management

The background, training, motivation, and professional development of operations personnel all must be considered when crafting operations programs. This study will identify and promote the personnel traits and organizational structure that enhance job performance in traffic incident, work zone, and special event management.

Topic 3–4: Development of Advanced Technologies to Improve Operational Response

Certain operational strategies to address traffic problems use technology to aid responders. In particular, traffic incident management strategies use technologies to clear incident scenes. These strategies include data collection for fatal crashes, clearance of involved vehicles, cargo off-loading, and spill remediation. Advanced technology to address these functions offers the potential for dramatically reducing response time.

Project 3–4.1: Advanced Surveillance Technologies for Operations

Increasing use has been made of "nonintrusive" technologies such as video image processing, radar, and acoustic devices to monitor real-time traffic conditions. A number of issues regarding these devices need to be addressed:

capital, installation, and maintenance costs; coverage; signalized highway conditions; data types; and probe vehicle shortcomings. This project will develop and test low-cost technologies for monitoring traffic and roadway conditions in real-time as an aid to operational strategies.

Project 3–4.2: Technologies to Communicate Traffic Control and Queue Propagation to Motorists

Rapid upstream propagation of a queue caused by a sudden lane blockage is a particular concern at work zones and incident scenes. This project will develop technologies that can instantaneously communicate information to motorists in rapidly changing conditions at incident and work-zone scenes. The main purpose of these technologies is to reduce the occurrence of secondary crashes at incident scenes and primary crashes in work zones.

Project 3–4.3: Systems for Tracking Hazardous Material Movements Nationwide

With certain high-visibility exceptions, knowledge of the amount and movement of hazardous materials has always been very limited. Recent national security concerns, however, make it likely that hazardous material tracking will become a facet of homeland security activities. The scope of this project is to determine how to tap into this information and use it for transportation purposes including identifying specific hazardous materials involved in traffic incidents as well as determining flow patterns so that local agencies can be prepared to respond if needed.

Topic 3–5: Incorporating Weather Information into Traveler Information and Agency Operation Functions

Weather causes some of the most disruptive travel delays and uncertainty, as well as some of the most significant problems for public-sector agency operations. Weather forecast information can be used more effectively to enhance traveler information; operations or maintenance crew responses; and a variety of maintenance, operations, and investment decisions that are affected by weather.

Project 3–5.1: Improvement in Knowledge of Existing Weather and Pavement Conditions

Weather conditions change dramatically over time and from one location to another. The extensive geographic coverage of transportation facilities and constantly changing environmental conditions make the collection of up-to-date, location-specific environmental data both difficult and expensive. The objective of this effort will be to improve the accuracy of current weather and pavement-condition measurements, while dramatically decreasing the cost of that data collection effort.

Project 3–5.2: Improved Forecasting of Near-Term Weather and Pavement Conditions

Although current weather and pavement condition information is needed to direct maintenance activities and operational decision making, having accurate short-term forecasts of both weather and pavement conditions allows an operating agency to undertake preventive actions, pre-position its resources, and prioritize its maintenance and operational actions to achieve maximum system reliability and cost efficiency.

Project 3–5.3: Using Road Weather, Safety, and Travel Reliability Data to Identify Ways to Improve Travel Time Reliability

The objective of this effort is to combine weather information with travel reliability and safety data to create new analytical tools that identify the locations and causes of significant weather-related safety and travel reliability problems. The intent is to provide better guidance for applying limited funds in ways that offer the greatest improvements to travel reliability.

Project 3–5.4: Development of Better Mitigation Options for Weather Events

The objective of this project is to identify roadway design, operating, and maintenance practices that can reduce travel time reliability problems caused by weather events.

Topic 3–6: Highway Design Practices to Mitigate the Impact of Recurring and Nonrecurring Bottlenecks

The objective of this topic is to improve highway design practice, capacity analysis, and facility design to mitigate the impact of recurring and nonrecurring congestion. Current highway design practice treats capacity as a constant, unvarying number, essentially considering only recurrent congestion. The designer has no information to evaluate the tradeoffs of providing excess capacity to accommodate nonrecurrent congestion and no information on the incorporation of features to facilitate incident management and work-zone management into the design. Research in the topic area will provide designers with this information.

Project 3–6.1: Identification and Evaluation of the Cost-Effectiveness of Highway Design Features to Reduce Nonrecurrent Congestion

There are many design features that have been tried in different urban areas which, if incorporated into standard design practices, could potentially reduce nonrecurrent delay caused by incidents, work zones, weather, and special events. This project will evaluate the cost-effectiveness of promising facility designs for reducing delays due to incidents, work zones, weather, special events, and other causes of nonrecurrent congestion.

Project 3–6.2: Incorporation of Nonrecurrent Congestion Factors into the Highway Capacity Manual

The *Highway Capacity Manual* (*HCM*), the main tool of designers for determining the appropriate size of a facility, currently has limited information on the impacts of weather, incidents, and work zones, or the effect of improvement treatments on capacity and other performance measures. This project will develop data on the impacts of the different causes of nonrecurrent congestion on highway capacity and incorporate this information into the performance measure and level of service estimation procedures contained in the HCM.

Project 3–6.3: Incorporation of Non-Recurrent Congestion Factors into the AASHTO Policy on Geometric Design

AASHTO's *Policy on Geometric Design of Highways and Streets* is the main document used by state DOTs and other public agencies to develop design guidelines for freeways, conventional highways, and urban streets. However, this book does not currently identify or provide guidance on the placement and dimensions of facilities designed to support incident management and to reduce the impacts of work zones. This project will develop design guidance for the facility design features that support the reduction of delays due to causes of nonrecurrent congestion.

Project 3–6.4: The Relationship between Recurring and Nonrecurring Congestion

The benefits of incident management strategies and other strategies to reduce nonrecurrent congestion will vary greatly depending upon the time of day when they occur. It is important therefore to take this effect into account in the estimation of benefits of all of the other research program projects to reduce nonrecurrent congestion. This project will determine the relationships between recurring and nonrecurring congestion and how the benefits of measures to reduce nonrecurrent congestion are increased when recurrent congestion is present.

Topic 3–7: Improving Driver Behavior under Extreme Environmental and Bottleneck Conditions

Drivers often react inappropriately to unusual environmental and roadway conditions. For example, they may not slow down during poor visibility conditions (like fog or dust storms) or they may over-react to interesting roadside conditions. This research will identify undesirable driver behaviors that increase nonrecurrent congestion and measures for modifying these behaviors.

Project 3–7.1: Quantification of the Causes and Effects of Inappropriate Driver Response to Adverse Weather, Roadside Distractions, Traffic Incident Scenes, and Queues

Secondary crashes often can be traced to driver inattention at incident scenes or to queues caused by a primary incident. This research will identify and quantify the causes and effects of inappropriate driver response in the bottleneck conditions caused by adverse weather conditions, roadside activity, incident scenes, and traffic queues.

Project 3–7.2: Measures for Reducing Inappropriate Driver Response to Adverse Weather, Roadside Distractions, Traffic Incident Scenes, and Queues

This project will identify and quantify the potential effectiveness of various measures to reduce inappropriate driver response to adverse weather conditions and roadside activity.

Project 3–7.3: Improving Merging Behavior on Urban Freeways

This research will perform an international scan for best practices in encouraging smoother merging behavior at lane closures, lane drops, and entrance ramps, and when changing lanes. Field research will be undertaken to assess the effectiveness of various candidate strategies to improve merging effectiveness.

Topic 3–8: Improved Traveler Information to Enhance Travel Time Reliability

Providing timely and accurate traveler information—in terms of delay expectations and alternative routes—is an effective means of reducing delay to travelers. However, a number of problems have hindered the advancement of traveler information strategies and products beyond a rudimentary form. Among these problems are data quality, system coverage, integration of data sources, currency of data, market penetration, and information delivery devices.

Project 3–8.1: Delay and Reliability Impacts of Traveler Information Systems

There is a strong need to determine the true impact of traveler information on congestion levels and the associated reliability of travel times. This study will involve extensive field evaluations of already-deployed traveler information systems in dynamic message signs (DMS), highway advisory radio (HAR), and traveler-based devices (hand-held, in-vehicle, or both).

Project 3–8.2: Increasing the Credibility of Travel Time Predictions with Travelers

Investigation of the influences of information accuracy and credibility upon traveler decisions and behaviors will most likely require more advanced theoretical constructs regarding decision-making behavior than have typically been used in operational settings. This research will identify the human factors requirements necessary to provide travelers with information that is timely, understandable, and credible.

Project 3–8.3: Near-Term Analysis of Traveler Information Market and Its Impact on Public-Sector Operational Strategies

Advanced Traveler Information Systems (ATIS) are entering their second decade of existence as integral components of urban and rural transportation systems around the United States. This project will determine what the potential is for ATIS in improving travel time reliability, how information should be collected and disseminated, and most importantly, what roles the public and private sectors should have in the “next level” of ATIS deployments.

Project 3–8.4: Real-Time Data Fusion to Support Traveler Information Systems

Various sources of data for traveler information systems are often maintained and disseminated by different agencies through different channels. This project will provide guidance to transportation agencies and information service providers in fusing, packaging, and presenting information on traffic, weather, incidents, and work zones that are affecting travel conditions.

Topic 3–9: Traffic Control and Operational Response to Capacity Loss

There are a variety of operating strategies that can mitigate congestion problems caused by disrupted traffic flows. The disruptions might be planned actions by transportation agencies—maintenance or construction activity—or they might include unplanned events such as weather or collisions. Many of these ideas are not innovative, but their deployment is nonetheless sporadic and uneven. This research effort will examine typical barriers to implementation and identify good practices.

Project 3–9.1: Implementation of Alternative Traffic Operation Strategies

Many areas only take advantage of more aggressive operating strategies in relatively major or crisis events, or they only use a few of the many potential strategies. The urban areas where these are more fully deployed have an operations focus, and many have developed institutional structures and public expectations that differ from other cities. This project will seek to identify the good practices and the methods used to move them to implemented strategies emphasizing the reliability improvements that can be achieved.

Project 3–9.2: Advanced Queue and Traffic Incident Scene Management Techniques

As response to an incident progresses, it is imperative that safety and positive guidance are both enhanced. This project will make improvements in incident response and management by police, fire, emergency management, and transportation personnel.

Project 3–9.3: Simulation and Gaming Tools for Traffic Incident Response

Using real world data, typical incidents occurring in queue backups on freeways will be categorized for severity, and probabilities developed for each type. Using these probabilities with simulation tools, a gaming tool can be developed for use in incident management workshops. The tool will be able to simulate multiple types of incidents and demonstrate the effects of choices made by responders. This project will: (1). develop a graphical simulation model (which may incorporate an existing core simulation model), and (2). from the knowledge base constructed for the simulation, develop an expert system that can be used as a tool for incident responders.

APPENDIX D

BRIEF DESCRIPTIONS OF CAPACITY PROJECTS

Topic 4–1: Fundamental Knowledge

This topic focuses on understanding transportation user characteristics, system performance, and fundamental relationships among transportation systems, human behavior, the natural environment, the economy, land use, and our communities in order to develop tools and decision-making approaches consistent with the conceptual framework for transportation decision making. Given the broad gaps in fundamental knowledge, research under this topic has been selected and prioritized to inform new modeling and forecasting tools and develop improved decision making and project delivery approaches.

Project 4–1.1: Improving Our Understanding of Highway Users and the Factors Affecting Travel Demand

This project will fill information gaps on critical relationships defining the demand for travel so that travel demand models can be further improved to reflect the systemwide effects of highway capacity expansion decisions. The purpose of this project is to build on work being conducted in other programs to increase our fundamental understanding of highway users and the factors affecting the demand for highway travel. The goal is to improve our ability to develop accurate forecasts based on improved data and analysis methods. In this manner, this project should be forward looking and reviews, analysis, and assessments should be placed in the context of expected changes in the level and nature of future economic and social structures.

Project 4–1.2: Improving Our Understanding of Transportation System Performance

This project will develop a methodology for creating performance measurement frameworks that reflect economic, mobility, accessibility, safety, environmental, community, and social considerations for use in integrated systems planning and project development. The focus of this project is on creating the frameworks to support system performance measurement, recognizing that individual agencies must tailor individual measures to best meet their needs, and acknowledging that a one-size-fits-all approach is not appropriate.

Project 4–1.3: Understanding the Contribution of Operations, Technology, and Design to Meeting Highway Capacity Needs

This project will develop approaches for redefining highway capacity given improvements in operations, vehicle technology, context-sensitive design, and other developments, so that highway capacity projects reflect transportation-as-a-system considerations. This project focuses on a retrospective and prospective review of supply-oriented capacity enhancement measures to ensure that as new highway projects are planned and designed, the full range of capacity enhancement measures available to practitioners is considered and incorporated.

Project 4–1.4: Improving Our Understanding of Approaches to Integrate Watershed and Habitat Fragmentation Considerations into Transportation Planning and Development, with an Emphasis on Highways

This project will develop approaches for integrating watershed and habitat fragmentation considerations into transportation planning and development with a focus on highways, so that environmental stewardship, enhancement, and impact mitigation can be improved at the systems level. This project will build on research grounded in environmental science to identify and evaluate approaches for improving water quality and watershed performance and to reduce habitat fragmentation and its effects on wildlife health and population. It will also explore the tradeoffs associated with these approaches and applicability in different environmental contexts. A necessary component of this research will be exploration of measures to reduce the secondary and cumulative impacts of transportation on wetlands, wildlife, and ecosystems.

Project 4–1.5: Improving Our Understanding of Interactions between Transportation Capacity and Economic Systems

This project will enable better understanding of the contribution of transportation, with an emphasis on highway capacity improvements, to the economic performance of regions and develop methodologies for capturing the regional economic effects of highway capacity projects. In particular, this project will focus on methods and tools for: (1). isolating distributive versus generative economic effects arising from improvements to a region’s highway system, and (2). better representing the contribution of highway improvements—vis à vis other determinants (such as labor costs)—to a region's economic performance, both of which are crucial to a systems-oriented approach to transportation planning and project development.

Project 4–1.6: Improving Our Understanding of the Relationship between Highway Capacity Projects and Land Use Patterns

This project will enable better understanding of the secondary effects of highway capacity expansion on development patterns and develop approaches for shaping and controlling these effects so that transportation and land use decisions can be coordinated. Although there has been substantial research on transportation–land use relationships and a great increase in the understanding of how land use patterns and urban form affect the demand for transportation, there remains a more limited understanding of the other side of the land use–transportation relationship: how transportation capacity influences development patterns. This research project seeks to develop a greater understanding of the extent to which transportation capacity influences development decisions, and to identify practical approaches for coordinating land use and transportation to meet community goals.

Topic 4–2: Data and Tools

Highway capacity decision making and project delivery should be informed by data and tools that effectively characterize user behavior and system performance and predict systemwide impacts of proposed plans and projects. Despite the number of tools and the volume of data available to practitioners, many tools are poorly integrated or have flaws that prevent their application to common forecasting circumstances. New approaches to data collection, such as remote sensing, can greatly enhance the quality and fidelity of data for regional transportation planning, project planning, and impact assessment. Moreover, improved modeling tools and visualization technologies can support decision making and public involvement. Research in this topic will focus on ensuring access to appropriate data to support analysis; integrating analysis tools, including new forecasting tools that are able to predict systemwide impacts and better deal with uncertainty; and providing tools and methods to better communicate the results of analyses to the public and to decision makers.

Project 4–2.1: Applying Location- and Tracking-Based Technologies to Collect Data for Systems Planning and Project Development

This project will enhance assessments of highway capacity needs by collecting data from ITS technologies that can monitor traffic at both the facility and highway system levels. Agencies such as the Federal Highway Administration are performing research on archiving processes and systems for data collected via point detection devices, approaches for probe detection to collect data on the performance of highway systems, and assessments of highway capacity needs. This project focuses on those approaches.

Project 4–2.2: Applying Remote Sensing Technologies to Collect Data for Transportation Systems Planning and Project Development

This project will improve the quality of decision making for integrated systems planning and project development by enabling the use of remote sensing technologies and data by transportation (and other) agencies. This research project focuses on closing the knowledge gap between the remote sensing and transportation communities to enable greater use of remote sensing technologies and new applications to meet the needs of transportation planning and project development. It involves demonstrating the application of remote sensing to transportation systems planning and highway capacity project development, and development of a guidance manual, a commercialization approach, and training to improve application of remote sensing technologies within transportation systems planning and project development.

Project 4–2.3: Facilitating Systems Planning and Project Development via an Integrated Environmental Resource Information System

This project will develop a spatially organized information management system that provides easy access to a comprehensive array of data on environmental considerations used during planning and project development, and investigate the feasibility of expanding the information system to include data on other factors (such as travel, land use, and economics). Ultimately, the environmental information management system should be expanded to be capable of handling a complete array of information needs that must be considered during system and project-level planning. In addition to environmental information needs, these include information about demographics, economics, safety, utilities and right-of-way, freight and personal travel demand.

Project 4–2.4: Improving Public Participation by Enhancing Project Visualization Tools

This project will improve visualization tools for public involvement during the development and delivery of transportation plans and projects. In some cases, existing visualization techniques are available but have not been widely applied due to cost concerns. In other cases, low-cost and less high-tech visualization methods (such as improved graphical displays) could be utilized but have not been used effectively to involve the public. As a result, part of this project involves development of a pilot program to test and evaluate new visualization tools that are developed through this project to ensure their usefulness and development of guidance and training on the appropriate use of visualization tools and techniques at different stages of project planning and development.

Project 4–2.5: Developing and Applying a Decision-Support Tool for Integrated Systems Planning and Project Development

This project will develop, apply, test, and commercialize a decision-support tool that leverages state-of-the-art computer technology for analyzing and selecting among packages of integrated transportation solutions that balance desired economic, environmental, and community considerations, thereby improving the timeliness and quality of highway development projects. Building on existing efforts and taking advantage of the latest information technology, the goal is to develop an integrated, probabilistic decision-support system that practitioners can use from their computer workstations to (1). develop solutions packages that address transportation needs and (2). visualize the dynamic interactions between a solutions package and associated changes in the region’s land development patterns, natural and human environments, and economic performance.

Topic 4–3: Integrated Decision Making in Planning and Project Development

This research topic focuses on improving the transportation decision-making process with the result being selection and development of projects that meet social, economic, environmental, and accessibility needs in a timely and equitable manner. This topic addresses research related to the broad identification of transportation needs in the planning process (as currently conducted through preparation of STIPs and long-range transportation plans) and decision making throughout project development (as currently conducted under NEPA and other federal and state laws). An important focus is on translating community visions and long-range plans (regarding land use, economic development, aesthetics, sustainability, etc.) into appropriate projects and assessing the direct and indirect impacts of projects on systems such as the economy, natural environment, and human environment. This research also focuses on processes to ensure that decisions are made in a timely manner by avoiding duplication and re-examination of earlier decisions. It addresses issues associated with institutional relationships and support of public and political leaders.

Project 4–3.1: Integrating Environmental Stewardship and Enhancement into System Planning and Project Development

This project will mainstream environmental stewardship and enhancement into the transportation systems planning and project development process. Many of the barriers to greater adoption of environmental stewardship by transportation agencies involve misconceptions that can be addressed through education and training. Development of stewardship models and information, as well as a program that mainstreams them into transportation agencies, will help to address these misconceptions.

Project 4–3.2: Integrating Economic Considerations into Project Development

This project will develop and apply the necessary institutional mechanisms and analytic frameworks for ensuring that project decisions reflect economic development considerations in the affected region. To better integrate economic development considerations into transportation decision making, significant advances in institutional and technical approaches are required and will be the focus of this project.

Project 4–3.3: Reducing Duplication and Process Delays in Planning and Project Development

This project will identify the sources of project delay and ways to compress planning and project development in order to deliver needed projects in a more timely manner while fully addressing environmental, community, economic, and accessibility considerations. This project will focus on identifying process improvements throughout planning and project development to improve coordination between transportation and resource agencies, involve the public and elected officials adequately to resolve project priorities and controversies, reduce internal process delays, get concurrence on project issues, and avoid duplication in processes.

Project 4–3.4: Ensuring Support for Highway Capacity Projects by Improving Collaborative Decision Making

This project will identify mechanisms for enabling and enhancing collaborative decision making within transportation agencies and between transportation and other agencies, elected officials, and the public. This project involves three components: (1). development of information to better understand barriers to collaborative decision making and approaches to overcoming them, (2). development and implementation of approaches to collaborative decision making, and (3). evaluation of these approaches as well as training on collaborative decision-making approaches and institutional structures.

Project 4–3.5:[not used]

Project 4–3.6: Screening Transportation Solutions in an Integrated Systems Planning and Project Development Process

Using the decision-support system developed under Project 4–2.5, this project will establish a new decision-making framework that supports screening of solutions as they move through the system planning and project development process, which draws on the use of system-based performance measures. This project involves the development and implementation of the conceptual framework for transportation decision making discussed earlier. The objective is to enable transportation agencies and their partners in the transportation planning process to work together efficiently to screen transportation solutions based on a comprehensive understanding of system performance needs, costs, and environmental and other effects of alternatives. In this manner, this project culminates in a solutions screening process that balances environmental, economic, social, and community livability considerations for project evaluation, selection, and programming. The product will allow transportation agencies to address the analytic, institutional, and process-related elements of decision making that hinder thorough and timely development of integrated long-range plans, capital programs, and projects that meet the needs of their stakeholders.

Topic 4–4: Project Delivery

The project delivery topic addresses research needs for ensuring well-managed implementation of projects that meet expectations of stakeholders and the public. This topic focuses on research related to the use of effective project management techniques throughout the project development process. This includes approaches for ensuring that projects are developed in a cost-effective and timely manner. It also includes approaches for ensuring that once project decisions are made, final design of projects is consistent with prior commitments and meets the aesthetic standards of the community and other stakeholders, and that construction occurs with minimal disruption to communities and environmental resources. It may address processes such as development of plans, specifications, and estimates (PS&E), and letting of contracts.

Project 4–4.1: Improving Project Management during the Development and Delivery of Highway Projects

This project will develop state-of-the-art project management implementation frameworks, guidance, and training that promote efficient, cost effective, and timely project delivery under an integrated systems approach to planning and project development. Some of the areas where current project management approaches could be improved include communication, accountability, coordination, and consistency. Given these many challenges, this project focuses on developing state-of-the-art project management implementation frameworks, guidance, and training to ensure that transportation agencies manage and deliver projects effectively under an integrated systems approach to planning and project development.

Project 4–4.2: Improving Project Cost Estimates

This project will develop a cost estimating methodology that promotes accurate prediction of project costs at every phase of integrated system planning and project development, as well as project delivery. Improvement of cost estimating practices and the tracking of estimates as they evolve should address five critical considerations: consistency, quality, coordination, accountability, and documentation. Moreover, a key issue is developing an effective process for developing and refining cost estimates given a process that involves the public and other agencies in decision making. A framework for accurate cost estimation must recognize that changes in the scope of a project are a natural part of a collaborative decision-making process and must anticipate these changes.

Project 4–4.3: Satisfying Commitments and Meeting Customer Expectations in Final Project Design and Construction

This project will ensure that state DOTs and other transportation agencies carry through commitments made during planning and project development to facility design and construction. The products of this research project will include guidance materials on flexible highway design approaches (including the integration of context-sensitive design principles into design-build projects) that best meet customer expectations; guidance on public involvement techniques for sustaining communications with stakeholders during the design and construction phases of project delivery; and training programs on context-sensitive design, innovative methods for project delivery, and customer satisfaction.

Abbreviations used without definitions in TRB publications:

AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ITE	Institute of Transportation Engineers
NCHRP	National Cooperative Highway Research Program
NCTRP	National Cooperative Transit Research and Development Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
TCRP	Transit Cooperative Research Program
TRB	Transportation Research Board
U.S.DOT	United States Department of Transportation