SHRP2
STRATEGIC HIGHWAY RESEARCH PROGRAM

Highway Renewal
Detailed Planning For Research On Accelerating The Renewal Of America's Highways

Draft Revised Research Plan

August 2007

TABLE OF CONTENTS

1. STATUS SUMMARY

This document provides the updated research plan for the Renewal focus area of the Strategic Highway Research Program (SHRP 2). The document outlines the revised Renewal research projects, re-scoping activities, and current budget and duration allocations. This revised plan replaces the strategy originally developed for the Renewal research plan.

The re-scoping of the Renewal research plan has been carried out under the advice of the Oversight Committee, the Renewal Technical Coordinating Committee (TCC), and project Expert Task Groups (ETGs). Additionally, a new project numbering scheme has been adopted from the original SHRP 2 plan. Renewal projects have an "R" designation; Safety is "S"; Capacity is "C"; and Reliability is "L." The new numbering system is used in this document to designate the projects.

The TCC for Renewal met in October 2006 to refine program and project priorities. As a result of the proposed prioritization, some projects have been redirected to other focus areas, merged with other projects, or eliminated from the research program. Three of the remaining projects (R03, R10, and R11) will remain in a contingency status. Any or all of these contingency projects will be carried out if additional funds become available. Table 1 presents the Highway Renewal projects that remain in the SHRP 2, their status, and budgets. These projects are listed in ranking order, from highest to lowest priority.

Expert Task Groups (ETGs) met in the summer and fall of 2006 to prepare Request for Proposals (RFPs) and evaluate the received proposals. The Oversight Committee approved all the award recommendations from the ETGs on November 2006. Contracts for this round were signed in February and March, 2007. The on-going projects that are under contract, project available budgets, contract budgets (for ongoing phases), and contract durations are shown in Table 2.

Expert Task Groups met again in February and March 2007 to prepare RFPs for 5 additional projects (R09, R21, R02, R19, and R04). The issues related to these projects were clear enough that the ETGs were able to write the RFPs for the entire available budgets. The RFPs for these projects were released on March 13, 2007. The ETGs for these projects evaluated the received proposals during May and June 2007. Contract negotiations for Projects R09, R21, R02, and R04 are ongoing. No contract award was recommended for Project R19.

Based on the recommendation from the ETG and with concurrence from the Oversight Committee, Project R19 has been divided into two separate projects, R19-A and R19-B. A RFP for Project R19-A was advertised on July 30, 2007, while the RFP for Project R19-B will be advertised in March 2008.

Expert Task Groups met in June and July to prepare RFPs for Projects R05, R16, R23, and R26. The issues related to these projects were clear enough that the ETGs were able to write RFPs for the entire available budget. The RFPs for these projects were released on July 30, 2007. The proposals are due on September 18, 2007.

Table 1. Prioritization of Highway Renewal Research Projects

Status	Project No.	Renewal Research Projects	Total budget (x1,000)	Estimated duration (months)
In progress	R01	Encouraging Innovation in Locating and Characterizing Underground Utilities	$5,000	
	R06	A Plan for Developing High-Speed, Nondestructive Testing Procedures for Both Design Evaluation and Construction Inspection	$5,000	
	R07	Performance Specifications for Rapid Highway Renewal	$3,000	
	R15	Strategies for Integrating Utility and Transportation Agency Priorities In Renewal Projects	$1,000	
Projected for 2007	R09	Risk Manual for Rapid Renewal Contracts	$250	18
	R21	Composite Pavement Systems	$4,000	48
	R02	Geotechnical Solutions for Soil Improvement, Rapid Embankment Construction and Stabilization of the Pavement Working Platform	$3,000	48
	R19-A	Durable Bridges for Service Life beyond 100 Years: Innovative Systems, Subsystems, and Components	$2,000	48
	R04	Innovative Bridge Designs for Rapid Renewal	$2,000	48
	R16	Railroad-DOT Institutional Mitigation Strategies	$400	18
	R26	Preservation Approaches for High Traffic Volume Roadways	$250	18
	R05	Modular Pavement Technology	$1,000	36
	R23	Using Existing Pavement in Place and Achieving Long Life	$1,000	36
2008	R19-B	Durable Bridges for Service Life beyond 100 Years: Service Limit State Design	$1,000	30
		Total Budget	**$28,900**	
Contingency	R03	Identifying and Reducing Worker, Inspector, and Manager Fatigue in Rapid Renewal Environments	$1,000	36
	R10	Innovative Project Management Strategies for Large, Complex Projects	$750	24
	R11	Strategic Approaches at the Corridor and Network Level to Minimize Disruption from the Renewal Process	$500	24

Table 2. Contracted projects

Project	**Available Budget**	**Contract Budget**	**Contract Duration**
R01 Encouraging Innovation in Locating and Characterizing Underground Utilities	$5,000,000	$300,000	20 months
R06 A Plan for Developing High-speed, Non-Destructive Testing Procedures for Both Design Evaluation and Construction Inspection.	$5,000,000	$350,000	12 months
R07 Performance specifications for Rapid Highway Renewal	$3,000,000	$3,000,000	5 years
R15 Strategies for Integrating Utility and Transportation Agency Priorities in Highway Renewal Projects	$1,000,000	$250,000	18 months

2. RENEWAL BACKGROUND

Three strategic objectives will achieve renewal:

1. Perform rapidly.
2. Cause minimum disruption.
3. Produce long-lived facilities.

Inherent within the strategic objectives identified above is that renewal will be achieved consistently throughout the highway system, not just on isolated, high-profile projects.

The researchers have identified 8 tactics for overcoming the barriers to achieving these objectives. Table 3 identifies the tactics and shows the relationships of each research project to the tactics and strategic objectives.

Rapid renewal has only been achieved under special, high-profile circumstances because very real barriers exist to consistent application of these tactics. 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. Similarly, 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. Coordination with railroads and utilities is a major barrier to construction and can be a disruption to their services. Research is necessary that allows highway agencies to develop financing strategies and mutually satisfactory mitigation strategies for railroads and utilities. Until these technical problems are solved, the tactics cannot be implemented broadly and consistently.

Shorter facility life spans cannot be accepted as the price of rapid renewal. A tactic to achieve long 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 research plan provides a path to circumvent these barriers.

Table 3. Relationship of Research Projects to Research Objectives

Strategic Objectives	**Tactics**	**Barriers**	**Research Projects**
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.	R01. Encouraging Innovation in Locating and Characterizing Underground Utilities R02. Geotechnical Solutions for Soil Improvement, Rapid Embankment Construction, and Stabilization of the Pavement Working Platform R03. Identifying and Reducing Worker, Inspector, and Manager Fatigue in Rapid Renewal Environments. (Note: project in contingency status)

<table>
<tr><th>Strategic Objectives</th><th>Tactics</th><th>Barriers</th><th>Research Projects</th></tr>
<tr><td rowspan="3"></td><td>2. Minimize Field Fabrication Effort</td><td>• Traditional techniques for bridge and pavement construction are built on site.</td><td>R04. Innovative Bridge Designs for Rapid Renewal
R05. Modular Pavement Technology</td></tr>
<tr><td>3. Perform Faster Construction Inspection and Monitoring</td><td>• Limits on sensing technology.</td><td>R06. A Plan for Developing High-Speed, Nondestructive Testing Procedures for Design Evaluation and Construction Inspection</td></tr>
<tr><td>4. Facilitate Innovative and Equitable Contracting Environment</td><td>• 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.</td><td>R07. Performance Specifications for Rapid Highway Renewal
R09. Risk Manual for Rapid Renewal Contracts
R10. Innovative Project Management Strategies for Large, Complex Projects (Note: project in contingency status)</td></tr>
<tr><td rowspan="2">Minimize Disruption (for users on and adjacent to project)</td><td>5. Plan Improvements to Mitigate Disruption</td><td>• Planning not corridor based.
• Traditional project-based objectives.
• Financing constraints.</td><td>R11. Strategic Approaches at the Corridor and Network Level to Minimize Disruption from the Renewal Process (Note: Project in contingency status)</td></tr>
<tr><td>6. Improve Customer Relationships</td><td>• Difficult to mitigate impact to users and public services
• Ineffective coordination with utilities and railroads.
• Insufficient consideration to adjacent environment.</td><td>R15. Strategies for Integrating Utility and Transportation Agency Priorities in Highway Renewal
R16. Railroad-DOT Institutional Mitigation Strategies</td></tr>
</table>

Strategic Objectives	Tactics	Barriers	Research Projects
Produce Long-Lived Facilities	7. Design and Construct Low-Maintenance Facilities	• Maintenance is not adequately considered during design and construction. • Lack of predictable performance models.	R19-A. Durable Bridges for Service Life beyond 100 Years: Innovative Systems, Subsystems, and Components R19-B. Durable Bridges for Service Life beyond 100 Years: Service Limit State Design R21. Composite Pavement Systems R23. Using Existing Pavement in Place and Achieving Long Life
	8. Preserve Facility Life	• High traffic volumes. • Lack of methods to extend life.	R26. Preservation Approaches for High Traffic Volume Roadways

The following sections include descriptions of the projects that remain in the research plan as recommended by the Highway Renewal TCC.

3. 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.

New construction processes will specifically address high-intensity, compressed schedule construction projects. High-speed, one-pass renewal operations are attractive in areas where traffic must be maintained or closure times must be kept at an absolute minimum. Such renewal methods could be continuous projects where a portion of the road is closed to all traffic. In other cases, renewal may occur at off-peak times with methods that allow a contractor to complete work during the nighttime or during the day in between morning and afternoon peak times. Machinery that can be quickly mobilized and demobilized must be used if renewal will occur at off peak times. Real-time quality control should be instituted so the operator does not continue to build something that has hidden flaws that need to be corrected.

Designers must be able to account for new materials and streamlined construction techniques in facility design. Designs should consider and plan for the eventual need for repair. For example, to facilitate modular repair of a bridge, the use of standardized member dimensions may be desirable. One-pass paving operations may significantly reduce construction time. How will the use of such techniques affect structural design? For asphalt, will thicker pavements be needed if less time is available for working each layer of the pavement, or will improved materials and construction procedures allow for the use of thinner pavements? For PCC, will "just-right thicknesses" eliminate curling and avoid cracking? The use of new materials and techniques will involve tradeoffs that must be understood and accounted for in the design phase in order to ensure the desired service life is attainable.

This tactic envisions that information technology (IT) will play a pivotal role in helping to accelerate the work pace and minimize disruption on renewal projects. The benefit IT can provide is the rapid sharing of information among the participants on renewal projects on a real-time basis to facilitate decision-making and accelerate development of changes, facilitate the distribution of field inspection results, and achieve a better understanding of the project. All offices will share all data involved in the project delivery process, including project planning through maintenance. This approach will ultimately lead to a reduction in delivery time, costly overruns, and errors.

3.1 Project R01: Encouraging Innovation in Locating and Characterizing Underground Utilities

Budget: $5,000,000. The R01 ETG allocated $300,000 to this project as an initial phase in a multi-phase investigation.

Status: The ETG for Project R01 agreed that field work is necessary to identify problems in detail and identify potential technologies to address them. The ETG decided to spend $300,000 for this purpose, reserving the remainder of the funds for specific projects to be announced later. An RFP for Project R01 was issued in September 2006 for $300,000. The contract for this initial phase of the project was executed in February 2007. The Renewal TCC will receive recommendations from project R01 and will select additional work on this topic based on those recommendations.

Duration: 20 months for ongoing initial phase.

Objectives:

- Document today's technologies for locating and characterizing various types of underground utilities.

- Identify new, emerging or potential technologies and develop a research plan that will encourage the development of these technologies into useful tools for transportation agencies, consultants, utility owners, and construction personnel.

Statement of the Problem: It is commonly held among transportation officials that the accurate location and characterization of underground utilities and other similar facilities, especially deeply buried ones, and their timely protection or relocation is a major, if not the major, cause of delay in highway renewal projects. Such delays can extend the period of project development and impede construction initiation. Inaccurate location of utilities contributes to traffic and community disruption when service lines are encountered unexpectedly or access by utility repair crews is blocked by construction activities. Inadvertent damage to underground utilities can lead to environmental damage or even put the health and safety of construction workers and the public at risk. Because of the frequency with which utilities are co-located on highway rights of way, renewal projects are vulnerable to utility-related delay and disruption.

New and/or improved tools are needed to better locate and identify underground utilities during the preliminary engineering phase of a project, well before construction activities commence. These tools will make it possible to develop accurate plans that fully consider underground utilities and, by knowing this information early in the project development process, develop effective and cost efficient strategies to protect or relocate the utility or provide alternative service to utility customers if service must be interrupted temporarily.

Currently, many underground utilities that are difficult to locate and characterize might impede progress of transportation projects. Utilities can become "lost" as construction alters the landscape and pre-existing benchmarks are removed. In the worst cases, no information exists until the utility is encountered during construction. That often results in significant delays to construction progress because work is suspended while utilities are relocated or the facility is redesigned. Unplanned service interruptions have even wider impact on communities served by the utility.

The importance of this topic has led to an increased focus by project and utility owners in recent years as the current capabilities are taxed by renewal projects of increasing complexity.

This project will develop a research plan to identify technologies and facilitate their development to more effectively and accurately locate and characterize underground utility locations.

Anticipated Research Products:

Phase I Report (12 months)

- A summary of frequently encountered problems in locating and characterizing underground utilities.
- Documentation of currently available techniques and practices useful for locating and characterizing underground utilities.
- Identification of technologies potentially useful for locating and characterizing underground utilities. Discussion of the relevance, underlying technical principles, current status, and potential benefit should be included.
- A bibliography of pertinent literature, with abstracts, supporting parts a, b, and c.

Phase II A plan of research to encourage development of innovation tools and methods for locating and identifying utilities (8 months)

- Specific applications common to renewal projects to be addressed by these technologies.
- Performance measures to be met by the subject technologies.

- Typical experiment designs recognizing applications and performance measures.
- Effectiveness of alternative public/private or cost-share funding arrangements for carrying out the research and development and analyze the impact of such arrangements on intellectual property rights and future implementation.
- An examination of the cost implications to the utilities of implementation of these new technologies.
- Estimate of the cost and time required for successful execution of the plan.

Related Projects:
- R06 – High-speed, Non-Destructive Testing Procedures for Both Design Evaluation and Construction Inspection
- R15 – Strategies for Integrating Utility and Transportation Agency Priorities in Highway Renewal Projects

3.2 Project R02: Geotechnical Solutions for Soil Improvement, Rapid Embankment Construction, and Stabilization of the Pavement Working Platform

Budget: $3,000,000

Status: The RFP was advertised in March 2007. The project is currently under contract negotiations.

Duration: 4 years

Objectives:
To facilitate rapid highway renewal, this project is intended to:
- Identify existing alternative materials and systems for constructing embankments and roadways over unfavorable ground conditions.
- Develop or compile design guidelines, procedures, and QA/QC test procedures for construction of ground improvements.
- Develop performance-based construction specifications for selected soil improvement technologies.
- Determine which existing and emerging technologies offer promise for treating areas of unfavorable subsurface conditions.

This project will focus on three elements: (1) construction of new embankments and roadways over areas of unstable soils, (2) widening and expansion of existing roadways and embankments, and (3) improvement and stabilization of the support beneath the pavement structure. In all cases, construction as well as service loads will be considered.

1. Construction of new embankments and roadways over unstable soils
The long-term performance of the roadway is directly related to the stability of the subsurface. This is particularly important on rapid renewal projects where traditional approaches for dealing with deformation and stability are too time-consuming. NCHRP Synthesis 147 describes a suite of methods that were available in 1989 for embankment construction over unstable ground. Since then, new techniques, particularly in the ground improvement field, have been developed and implemented by the FHWA's The Geotechnical Engineering Group of the Office of Bridge Technology in Demonstration Project No. 116 (DP116) "Ground Improvement Methods." There is a need to develop and refine these guidelines and procedures to accelerate the utilization of these solutions or other technologies that are poised for implementation.

2. Widening and expansion of existing roadways and embankments

Existing roadways are located at grade, on fill, or in cuts, or on some combination of these situations. Every widening project is confronted by a unique set of non-geotechnical constraints that can limit the applicability of potential geotechnical solutions. Examples of such constraints are the proximity of existing utilities, project geometry, and traffic. SHAs can benefit from proper selection of geotechnical materials and systems to address these situations. Many techniques have been developed to deal with these situations, such as deep foundations, soil improvement or reinforcement, and soil removal and replacement with different materials. There is a need to develop and refine guidelines and procedures to accelerate the full utilization of such materials and systems.

3. Stabilization of the pavement working platform: Rapid renewal will, in many cases, require the speedy improvement of underlying unbound materials while at the same time keeping traffic disruptions to a minimum. This may mean limiting the hauling of materials to and from the project site. These constraints can be accommodated by reusing the existing on-site material in the new construction. Rapid subsurface improvement techniques may include chemical or mechanical stabilization and the use of geosynthetics. There is a need to develop and refine guidelines and procedures to accelerate the full utilization of these materials and systems.

Anticipated Research Products:

- Guidelines for application of new alternatives to facilitate rapid embankment widening.
- Development of new techniques to widen roads in cut-fill sections.
- Performance-related specifications and construction inspection certification programs.
- Integrated pavement design procedure.
- Guidelines and recommendations for design, construction, and quality control of mechanical and chemical treatment of base, sub-base, and subgrade layers.
- Guidelines for treatment and material specifications for the use of marginal soils.

Related Projects:

- R05 – Modular Pavement Technology

3.3 Project R03: Identifying and Reducing Worker, Inspector, and Manager Fatigue in Rapid Renewal Environments

Budget: $1,000,000

Status: The TCC for Highway Renewal recommended maintaining project R03 in a contingency basis.

Duration: 3 years

Objectives:

- Determine the impact of human fatigue on work activities commonly associated with highway construction projects, including the impact on quality, cost, and schedule.
- Quantify the fatigue element in hourly, weekly, and monthly scenarios for workers, inspectors, and the management team.
- Develop a range of techniques that reduce fatigue for the workforce.
- Develop strategies for organizing, structuring, and executing rapid renewal projects that incorporate fatigue reduction into the project planning process.
- Develop strategies for educating the community and its leaders on the importance of mitigating fatigue on rapid renewal projects.

Project Background: The impact of fatigue on the quality of work and the safety of workers, inspectors, and managers, especially on rapid renewal highway projects, is considered serious and in need of further investigation and solutions. "We put our best people on the most difficult projects and work them long and hard in difficult situations at night and on weekends. And when they do a good job, we reward them with more of the same" (Graff, 2002). Many contractors report that employee family life is negatively impacted the longer the rapid renewal project lasts.

Worker, inspector, and manager fatigue on rapid renewal projects could eventually contribute to more on-site accidents, lower overall productivity rates, and lower quality of work. This in turn could lead to lower morale and less teamwork. Ultimately, fatigue could lead to higher costs to the construction work, delays, and higher employee turnover rates.

This project will investigate fatigue as it relates to rapid renewal projects, providing an overview of sleep, fatigue, and alertness and how they impact performance, teamwork, and the potential for accidents and injury. The project will then discuss ways to mitigate fatigue by identifying safe limits for workers and supervisors.

The project will also identify different rapid renewal scenarios (night work, continuous extended hours, monthly, and yearly) and how fatigue may be minimized within each of them. The researcher will prepare reduced-fatigue work-hour scenarios and relate the scenarios to the size of the workforce needed to accomplish a targeted level of renewal activity. The researcher will also identify bidding strategies for rapid renewal projects that support reducing worker fatigue and allow additional flexibility to the contractor while not compromising overall project cost, quality, or schedule. All of these will be put into the context of an overall fatigue management program document.

Finally, the project will develop a range of techniques that could be used by both DOTs and contractors to help educate and condition the workforce about fatigue issues, to improve alertness, and to identify ways that fatigue can be mitigated during work time and between work shifts. While ample information on fatigue and its impact on safety and teamwork are available in non-highway environments, this information is not well documented in the highway construction environment.

There appears to be three discrete responses to fatigue issues on a rapid renewal project:
1. Individual workers, inspectors, and managers need to know more about fatigue, its relationship to work hours, stress conditions, rest periods, and diet, and ultimately to overall performance and safety.
2. Owners and contractors need to analyze the construction schedule set for rapid renewal projects to determine the potential for fatigue on the overall workforce. This will include some analysis of the number of shifts required along with the time allotted for potential rest periods.
3. Finally, it is important that DOTs and contractors understand the impact of how fatigue in individuals collectively causes stress and deterioration in team working relationships.

Anticipated Research Products:

- Recommendations for reducing worker fatigue and improving safety
- Fatigue management plans
- Toolbox of best practices
- Estimate of impacts on future workforce
- Tools, including those for management, that address team fatigue and increased stress
- Different types of organizational structures that promote worker fatigue reduction

Related Projects:
None

4. TACTIC 2 – MINIMIZE FIELD FABRICATION EFFORT

This tactic examines approaches that will minimize the amount of fabrication at the 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 maintenance requirements.

Design engineers must have a variety of tools that allow quick and cost-effective decisions to be made. In the past, when an asset was replaced, it was completely demolished and a new one constructed in its place. A need exists to develop complete systems that allow for short on-site construction times. This includes developing and applying sustainable materials, products, systems, and technologies that reduce life-cycle costs, extend useful life, and improve constructability. New bridge and pavement systems, compatible with short construction timeframes, will minimize disruption to motorists. Rapid construction and repair systems will help reduce traffic disruption and improve the level of performance of the highway infrastructure. The research plan addresses prefabrication, modular, standardized, and roll-in strategies for bridges and pavements.

4.1 Project R04: Innovative Bridge Designs for Rapid Renewal

Budget: $2,000,000

Duration: 4 years

Status: The RFP was advertised in March 2007. The project is currently under contract negotiations.

Objectives:
The objective of this project is to develop standardized approaches to designing, constructing, and reusing (including future widening) complete bridge systems that address rapid renewal needs and efficiently integrate modern construction equipment.

Statement of the Problem: The nation's aging bridge inventory, combined with increasing traffic congestion and increasing work-zone safety concerns, requires new approaches to how bridges are designed and built. Typical construct-in-place processes, such as erecting beams, erecting formwork, tying deck reinforcing steel, placing deck concrete, and allowing concrete to cure, are time consuming. On rapid renewal projects, these and other sequential onsite construction activities also disrupt traffic and degrade highway safety. Needed now are approaches to reform these sequential processes into complete bridge systems that come ready for immediate installation at the site, bridges that can be replaced in totality or incrementally with no impact to rush hour traffic, and bridges that can be readily moved to new locations for reuse to address traffic pattern changes and emergency replacements. Innovative construction equipment, such as self-propelled modular transporters (SPMTs), is now available in the United States to move such bridge systems.

A few innovative approaches for bridge superstructure replacements have been used in the United States to date. For example, in 2004 following hurricane Ivan, the Florida Department of Transportation (FDOT) used conventional modular transporters on barges, in combination with crane-mounted barges, to quickly lift and move spans from the eastbound to the westbound I-10 bridge over Escambia Bay to return one of the bridges back in service in just 17 days. In 2006 FDOT used SPMTs overnight to remove and replace superstructure spans crossing I-4 northeast of Orlando, with just hours of impact to I-4 traffic. Also in 2006, the Louisiana Department of Transportation and Development removed and replaced superstructure spans on the interstate overnight in a few hours using SPMTs after an over-height load damaged both the eastbound and westbound I-10 bridges over LA 35 in Rayne near Lafayette. In 2006 the Oregon Department of Transportation skidded a bridge into position in just hours. Data from these experiences have been compiled in various documents.

While the above bridge superstructure replacement examples were installed in minutes or hours, it still took weeks and months of preparation time to be able to accomplish these short onsite construction activities. The time required for the entire process of design, fabrication, and installation needs to be reduced, not just the time for onsite installation. There is a need to extrapolate from these past experiences to develop generalized approaches for design, construction, future performance expectations, and contracting challenges for rapid renewal. The design of these systems should also include consideration of detailing, fabrication, handling, and erection to allow reuse for rapid replacement or expansion to accommodate changing demands. These approaches should focus on typical bridges, for example, bridges with one to three or so spans with a maximum span length of 200 feet.

In addition, to date approaches have been mainly limited to superstructure replacements. Standardized approaches are also needed to install bridge systems complete with substructures to further streamline onsite construction processes and minimize traffic disruption. While unique aspects may exist for a bridge project, the goal is to develop standardized approaches that streamline all activities required to get complete bridge replacement systems designed, procured, fabricated, and erected in less time, and then installed in minutes or hours.

Anticipated Research Products:

- AASHTO-formatted LRFD design specifications and analysis methods, details, standard plans, and construction specifications for complete bridge systems that are designed and fabricated in less time, and then installed onsite in minutes or hours using innovative construction equipment. The products should accommodate the future reuse of these systems.
- An accompanying AASHTO-formatted LRFD construction specification for the new construction techniques and technologies and to address the procurement and contracting along with user issues. The document is to include simple language addressing contracting tools that bridge professionals should consider.
- Training materials.

Related Projects:

- R19 – Durable Bridges for Service Life beyond 100 Years

4.2 Project R05: Modular Pavement Technology

Budget: $1,000,000

Duration: 3 years

Status: The RFP was advertised in July 2007. The proposals are due on September 18, 2007.

Objectives:

The objective of this project is to develop tools for public agencies to use for the design, construction, installation, maintenance, and evaluation of modular pavement systems. It is anticipated that these tools should include, at a minimum: (1) guidance on the potential uses of modular pavement systems for specific rapid renewal applications; (2) generic design criteria; (3) project selection criteria; (4) guidelines and draft or model specifications for construction, installation, acceptance, and maintenance; and (5) a long-term evaluation plan to assess the performance of modular systems and lead to refinements in designs and materials.

Statement of the Problem: Modular pavements use pre-fabricated segments for quick placement of entire pavements or the replacement of pavement segments. This type of technology has been used by the military for rapid repair of airfields and has seen some civilian highway use. The process allows most of the work to occur outside the traffic stream. One example of a modular pavement technology is the use of prefabricated portland cement concrete (PCC) slabs, where all curing and strength gain can occur without impeding traffic. In addition, the concrete placers and finishers can work in relative safety off the roadway. It should be noted that modular pavement technology is not limited to PCC products.

Modular pavement technology has great potential for rapid pavement repair, rehabilitation or reconstruction. Applications include but are not limited to isolated repairs, intersection and ramp rehabilitation, pavement replacement under overpasses, and construction of longer mainline pavement segments. Modular pavement technology can speed up construction without sacrificing quality while minimizing lane closures and traffic disruption. Off-site fabrication has the potential to permit lighter, thinner, or more durable pavement sections through more stringent quality control and use of design details not feasible for in-place construction.

Challenges to the implementation of modular pavements by public agencies include but are not limited to understanding the following issues:

- Load-carrying capacity and load transfer between modular units, and between modular units and existing pavement
- Seating and support for uniformity and longevity
- Maintaining modular unit riding surface safety characteristics (smoothness)
- Vertical alignment between adjacent modular units and between modular and existing pavement segments
- Design criteria, construction practices, and maintenance guidelines
- Generic or alternate specifications needed to facilitate implementation of modular pavement technology. Many of the modular pavement technologies and components currently available are proprietary.

Anticipated Research Products:

- A feasibility study on the potential uses of modular pavement systems for specific rapid renewal applications.
- Uniform Modular Pavement Design Procedures.
- Guidelines and model specifications for construction, installation, and acceptance criteria for modular pavements.
- A long-term evaluation plan to assess the performance of modular systems and lead to refinements in designs and materials.

Related Projects:

- R02 – Geotechnical Solutions for Soil Improvement, Rapid Embankment, and Stabilization of the Working Platform

5. TACTIC 3 – PERFORM FASTER CONSTRUCTION INSPECTION AND MONITORING

As the saying goes, "it takes 10 workers one day to pave a mile; it takes 10 days for one worker to say it meets specifications." 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 inspection process. An innovative, high-speed inspection process could make sure that the overall quality is obtained without delaying the project.

In an era of rapid construction, it is more important than ever that we develop methods to rapidly assess the quality of the product supplied. Assessing the quality of materials and construction in civil engineering has been problematic historically. Infrastructure projects typically consist of large volumes of highly variable materials that are being placed under less than ideal conditions. Rapid assessment should provide sufficient information to predict the value of the facility over a long period of time. The application of more rapid nondestructive testing will require that we reconsider the number of locations that can be sampled, thereby improving our understanding of the constructed facility and reducing variability.

5.1 Project R06: A Plan for Developing High-Speed, Nondestructive Testing Procedures for Both Design Evaluation and Construction Inspection

Budget: $5,000,000. The R06 ETG allocated $350,000 to this project as an initial phase in a multi-phase investigation.

Status: The SHRP 2 Oversight Committee allocated $5 million to this project. The ETG for this project, however, agreed that a plan is needed to determine which tests are most appropriate for SHRP 2 funding. An RFP for Project R06 was issued in September 2006 for $350,000. The contract for this initial phase of the project was executed in March 2007. Project R06 will examine existing and emerging technologies that could benefit the rapid renewal process. It will also examine needs for high-speed non-destructive tests for which no existing or emerging technology is available. A plan to develop new testing methods will be produced, followed by future work to actually develop certain tests. The Renewal TCC will receive recommendations from Project R06 and will program the remaining funds based on the recommendations.

Duration: 12 months for ongoing initial phase.

Objectives: The overall objective of this work is to develop a process to identify existing or, if necessary, to develop new and quickly implementable technologies for rapid, nondestructive testing of *in situ* conditions for purposes of design, construction inspection, and performance monitoring. These technologies would limit or reduce traffic disruption on existing facilities during preliminary engineering investigations, and provide more rapid and reliable information on as-built conditions. Similarly, rapid inspection of new construction would facilitate timely re-opening of roadways and structures during re-construction.

Statement of the Problem: Highway renewal connotes the reconstruction or extensive rehabilitation of roadways and structures currently in service. Interruptions in service are necessarily disruptive to highway users and to communities and business interests that depend on the uninterrupted use of these facilities. The public has little tolerance for repeated or extended lane closures or traffic restrictions. Lane closures and other traffic restrictions also increase personal safety risks to highway users and highway workers. Consequently, there are strong incentives to reduce to a minimum those periods of disruption related to highway design and construction. High-speed nondestructive testing and data collection techniques for purposes of design, construction quality control, quality assurance, and final acceptance have the potential to significantly reduce disruption related to highway renewal. Nondestructive or minimally destructive testing techniques can further reduce traffic disruption by improving construction quality and reducing the need for rework or removal and replacement of substandard work or materials. Similar techniques available to agencies could reduce delay associated with quality assurance and acceptance and accelerate the removal of traffic restrictions. Such techniques should also be applied to pre- and post-construction performance monitoring and data collection improving both design and asset management while minimizing traffic restrictions related to field data collection.

To the extent possible, data from construction inspection and acceptance tests should share attributes with data from tests for design and performance monitoring so that they can be incorporated into an asset management system. The move to performance specifications and construction warranties implies that the characteristics monitored during and after construction should be those related to ultimate performance and not merely those properties that are convenient to measure. This also implies that entities responsible for the inspection and monitoring of roadways and structures should have test methods available that permit assessment of factors critical to performance.

Anticipated Research Products:

- AASHTO-format test procedures for rapid design evaluation and construction inspection

Related Projects:

- R05 – Modular Pavement Technology
- R07 – Performance Specifications
- R21 – Composite Pavement Systems

6. TACTIC 4 – FACILITATE INNOVATION 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. For example, design-build contracting, identified nearly 10 years ago in Europe as a way of decreasing the time it takes to design and construct a project, has only now been approved by the FHWA for use in federal-aid work. This does not address the lengthy time it will now take for state highway agencies to gain approval with their legislative officials. This topic focuses on developing an environment that may be more conducive to delivery of the type of services needed in the future.

Most renewal projects are not positioned for success with traditional specification and contracting approaches. A new generation of specifications will allow the contractors to exercise more innovation and attention to quality, especially in rapid renewal projects. Well-developed performance-based specifications are the key to achieving optimum contracting potential. Performance-based specifications, especially as they apply to rapid renewal, will allow the contractor to exercise more innovation and pay more attention to quality. Method or prescriptive specifications have been the staple in the industry for nearly 75 years. Other specifications types such as end-result, statistically based specifications, performance-related specifications, and performance-based specifications have been developed for some products, but rarely do they eliminate method specifications.

Agencies need project management strategies to implement rapid renewal. There is a clear need for rapid decision-making, for the elimination of accidents related to worker fatigue, and for sustainable project management and inspection. Agencies and contractors need to develop management structures that can effectively deliver complicated projects. Many large projects require fairly complex management structures and reporting responsibilities. Large projects also involve cooperation to ensure that the projects are delivered within time, budget, quality, and safety requirements. Improved management of the design and delivery process as well as the design-build process calls for consideration of new management techniques to handle paper flow and decision-making. Agencies will have several innovative project management strategies to select from, depending on the type and extent of the renewal process.

6.1 Project R07: Performance Specifications for Rapid Highway Renewal

Budget: $3,000,000

Phase 1:	Current Status and Associated Risks	$300,000
Phase 2:	Specifications and Development	$1,000,000
Phase 3:	Draft Specifications	$600,000
Phase 4:	Validation	$1,100,000

Duration: Five years
Phase 1: 12 months
Phase 2: 18 months
Phase 3: 12 months
Phase 4: 18 months

Status: The RFP was advertised in September 2006. The contract was awarded in February 2007. This is an ongoing project.

Objectives:

- Reduce the completion time of renewal projects while maintaining or improving quality.
- Encourage further innovation by reducing mandatory method requirements and defining the end products.
- Develop different ***specifications*** that can be used effectively in various contracting scenarios (design-bid-build, design-build, warranties, etc.).
- Develop recommendations on the transition to the use of these ***specifications*** (i.e., an implementation plan).
- Quantify relative shared risk between project owners (state DOTs) and contractors and between contractors and subcontractors through the use of warranties and guarantees, and identify strategies to equitably manage and minimize the short- and long-term risk to all parties.

Statement of the Problem: Many states are experimenting with specifications and warranties to assure that all work is performed properly the first time, and to reduce or eliminate construction delays, particularly on highway renewal projects where the need to minimize disruption is paramount.

Specifications used by state departments of transportation (DOTs) generally attempt to describe how a construction contractor should conduct certain operations using minimum standards of equipment and materials. These prescriptive specifications, commonly known as method specifications, have served admirably in the past when an experienced workforce conducted repetitive operations. However, rapid renewal projects often require more creativity and innovation.

Alternative specification language is needed that is less prescriptive and that more adequately describes the performance required in the final product, while ensuring that accelerated timelines are met and quality is maintained. Language that describes how a product should perform in service will reduce prescriptive requirements and concentrate on measurement of factors critical to the performance of the final product. The term “performance specifications” is becoming more commonplace, but general agreement on a definition is still developing.

As used in this project, ***specification,*** if bolded and italicized, is meant to include performance specifications, incentive-based specifications, performance-based warranties, and contracting strategies that achieve a performance measure goal, such as a shorter time line, and that maintain or improve quality. Examples of such contracting strategies include A+B, lane rental, incentive/disincentive, and value engineering.

Specification language must work effectively and properly in all types of contracts, from traditional design-bid-build to design-build-maintain-operate-warrant-transfer (D-B-M-O-W-T) and other innovative contract types.

This effort will examine the special needs for ***specifications*** of rapid highway renewal projects, and will address the key factors that determine a successful project. It will examine, define, and propose quantifiable and measurable renewal goals including:

- Product quality—pavements, bridges, and other structures, etc.
- Time management
- Traffic management
- Work zone safety of public and workforce
- Pre-construction activities including utility, railroad, and highway coordination and completion
- Public relations
- Project goals—an overall index covering time, quality, cost, and safety

Anticipated Research Products:

- Guidelines for ranking important performance parameters (e.g., time, quality, cost, risk, complexity) based on project type
- ***Specifications*** for different highway renewal scenarios (e.g., road, bridge, structures, traffic control) and guidelines for their implementation

Related Projects:

- R09 – Risk Manual for Rapid Renewal Contracts
- R15 – Strategies for Integrating Utility and Transportation Agency Priorities in Renewal Projects

6.2 Project R09: Risk Manual for Rapid Renewal Contracts

Budget: $250,000

Duration: 18 months

Status: The RFP was advertised in March 2007.

Objective:
The objective of this project is address the general lack of understanding of risk and risk transfer decisions associated with the differing contracting approaches that may be used for rapid renewal. This project will develop practical guidance for the application of risk management methods to the project development process in a manner consistent with the business practices of State Highway Agencies (SHAs).

Statement of the Problem: Fulfilling the objectives of rapid renewal will require the use of innovative contracting processes and a departure from business as usual. Many of these innovative techniques involve shifts in the burden of risk from the state to the contractor. This project addresses the general lack of understanding of risk and risk transfer decisions associated with contracting approaches.

Different contracting approaches, such as design-build-operate-maintain-transfer (D-B-O-M-T), build-operate-transfer, warranties, design-bid-build, and design-build, generate different levels of risk for all parties involved. No standardized systematic process exists to quantify the risks for the parties involved (e.g. the transfer of risk from DOT to the contractor, etc). Objective guidance on the level and management of risk is needed to ensure industry acceptance of the concept and to assist states and industry in assessing the level of risk associated with various contracting approaches.

This project will develop a guide for implementing processes for risk management on rapid renewal contracts. The guide is intended for use by SHAs to manage risk during the project development process. The guide will illustrate methods that could be used to address risk identification, assessment, analysis, mitigation, allocation, and monitoring. The guide will include methods to determine the economic consequences of the risk transfer to the various parties involved in the project.

Anticipated Research Product:

- Guide for implementing processes for risk management on rapid renewal contracts
- Training materials to aid transportation agencies with the implementation of the Guide.

Related Projects:

- R07 – Performance Specifications for Rapid Highway Renewal

6.3 Project R10: Innovative Project Management Strategies for Large, Complex Projects

(Contingency as of October 2006)

Budget: $750,000

Status: The TCC for Highway Renewal recommended maintaining project R10 in a contingency basis.

Duration: 3 years

Objectives:
To develop for rapid-renewal projects:

- A guidebook for innovative project management with case examples of successful strategies;
- Workshop and training packages to support adoption of these management strategies by all stakeholders.

Statement of the Problem: This project will address the managerial and workforce challenges associated with rapid renewal projects. Large projects involve complex logistical requirements, contractual procedures, multiple contracts, and regulatory requirements that need careful planning and execution from inception to construction completion. State transportation agencies (STAs), contractors, and other stake holders will have to ensure that strong partnerships are in place that may be very different from traditional approaches. For example, the roles of the STA in the design-build process, implementation and execution of project warranties, and/or the use of Public Private Partnerships (PPP), are very different from how the traditional organization approaches highway construction The decision-making practices and commitments of each of these entities must be harmonized to promote cooperation and efficiency.

A systematic research effort is required to study the unique requirements of large-complex renewal projects. The research should describe how STAs, contractors, and other stake holders work together on such projects including how they:

(1) Configure lines of communication and authority
(2) Organize to promote harmonization,
(3) Utilize decision-making mechanisms to promote efficiency and
(4) Establish streamlined processes to minimize the impact of state and federal requirements.
(5) Develop common goals and approaches to meet those goals

Based on the results of this study, STAs should be able to develop innovative and effective project management strategies that will accelerate sound decision-making during rapid renewal projects.

Anticipated Research Products:
Products will include training materials, pilot workshops, and subsequent workshop templates for use by STAs. An additional product will be guide contract language that promotes the most promising concepts.

Related Projects:

- R09 – Risk Manual for Rapid Renewal Contracts

7. 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 items of work that need 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 maximize overall initial and life-cycle costs.

The only way to simultaneously optimize the SHRP 2 objectives is to plan and develop improvements from both a corridor and network perspective, and then specifically select renewal strategies that are appropriate for the subject infrastructure. This tactic outlines specific research needed to fully capture this new concept. It investigates current practices both in the United States and overseas, examines several innovative strategies such as "mix of fixes" and "route management." It also addresses the impact of corridor concepts on traffic flow, public relations, contractor capabilities, work selection, long-term and short-term funding requirements, downstream implications, and overall corridor performance.

On projects that significantly impact the level of service and safety of the traveling public during repair or reconstruction, the tradition of dividing contract work by type—bridge, pavement, safety, signing, etc.—is more and more coming under scrutiny. Additionally, the public has voiced concern about the constant sight of orange barrels on major routes, which in certain corridors may last up to 10 years. This is a direct result of a sequential approach to project selection. Instead of planning and executing construction projects as a function of funding, contractor capabilities (scope of work, bonding, etc), and completion of discrete elements of work, agencies will take a broader view. They will define and analyze highway corridors for renewal so as to minimize traffic impositions, balance network costs, address human and environmental considerations, and still maintain a high level of customer service.

7.1 Project R11: Strategic Approaches at the Corridor and Network Level to Minimize Disruption from the Renewal Process

(Updated April 2007)

Budget: $500,000

Status: The TCC for Highway Renewal recommended maintaining project R11 in a contingency basis.

Duration: 2 years

Objectives:
The objective of this project is to (1) develop and implement a more structured definition of "corridor" as it relates to the selection of construction improvements and disruptions to the traveling public, (2) integrate constructability alternatives and construction packaging strategies early in the planning process, (3) address the impact of multiple corridor and project work on regional network flow, (4) establish the limits or work to minimize disruption during construction, (5) minimize downstream construction requirements that will cause disruption, and (6) improve timelines and optimize budget considerations from both an initial and life-cycle analysis.

Statement of the Problem: Over the last several years, the transportation planning community has begun using the concept of corridor improvements to describe the current status and future needs for transportation improvements. However, the planner's transportation corridor analysis may not consider the entirety of infrastructure needs within that corridor. The analysis may not consider the impact that significantly different construction strategies may have on the overall budget, disruption to traveling public, disruption to commerce, and impacts on the local community during the actual construction operations.

Many transportation corridors are increasingly congested, limiting construction during traditional work times. DOTs are now recognizing the need to examine various construction alternatives within that corridor to determine the potential disruption these alternatives may have over time. In addition, many DOTs are seeing the need to examine regional networks with multiple corridors in order to examine the impact of constructing multiple corridors concurrently. Without examination of the constructability options early in the planning process, the impact on the traveling public and the local communities may increase dramatically.

Future corridor improvement analyses should address several important constructability factors, such as the following:

- What is the optimal selection of renewal activities—roadway, bridge, soils, drainage, safety improvements, signing, and other upgrades—that should be packaged into discreet construction contracts?
- How should DOTs address those components within the corridor that have significantly different remaining service lives?
- How should construction limits be set to minimize disruption to the traveling public and businesses while considering DOTs staffing limitations?
- What is the impact on the regional network when multiple corridors are being considered for reconstruction?
- What is the best way to calculate the benefits gained from various strategies as they relate to work accomplished, budget flow, and traffic mitigation?

One major consideration in packaging of construction work is the impact to the private sector highway construction industry. In most states, the industry consists of small to medium-sized companies that have limitations as to the amount and type of work they are qualified to perform. Experience to date shows that establishing longer project limits to accommodate traffic flow (10–15 miles, for example, rather than 4–6 miles) and to increase the amount of work done within the construction limits to minimize future disruptions might negatively impact the existing industry structure. This project should also consider the effectiveness of construction activities while managing risk.

<u>Anticipated Research Products</u>:

- Recommend practices and methodologies for establishing and planning corridor improvements including construction alternatives, budget constraints and management of traffic.
- Life-cycle cost analysis manual for optimizing corridor improvements. Additionally, a concise product that a legislator could use should be developed (i.e. brochure with appropriate charts, graphs, etc.)
- Guidelines and training materials that will help to facilitate the adaptation of corridor management in the planning phase of the renewal process.
- Procedure or process that can be employed by public agencies including recommendations and adjustments to the Projects Procedure Manuals

<u>Related Projects</u>:

- R02 – Geotechnical Solutions for Soil Improvement, Rapid Embankment Construction, and Stabilization of the Pavement Working Platform
- R03 – Identifying and Reducing Worker, Inspector, and Manager Fatigue in Rapid Renewal Environments
- R04 – Innovative Bridge Designs for Rapid Renewal

- R05 – Modular Pavement Technology
- R09 – Risk Management

8. TACTIC 6 – IMPROVE CUSTOMER RELATIONSHIPS

Renewal project planners must accommodate the needs of utilities and railroads that share roadway Right of Ways (ROWs) and have a huge stake in renewal activities. Utility and railroad conflicts can frustrate efforts to keep renewal projects on schedule and budget. Utilities and railroads, many of which are unfamiliar with the highway design and building industry, have a variety of needs and many different ways of conducting business. These entities cannot simply be ordered to quickly make way for a renewal project because they are providing vital services to their clientele, and planning is needed to make moves. New streamlined permitting and relocating processes will allow for timely and efficient progression of renewal projects for agencies, utilities, and railroads.

8.1 Project R15: Strategies for Integrating Utility and Transportation Agency Priorities in Highway Renewal Projects

Budget: $1,000,000 (The R15 ETG allocated $250,000 to Project R15 as a first step in a multi-phase investigation)

Status: An RFP was issued in September 2006. During the on-going phase, Project R15 will develop a plan for approaching this issue which will be funded through one or more follow-on projects/phases. An RFP for Project R15 was issued in September 2006 for $250,000. The contract for this initial phase was executed on February 2007. The Renewal TCC will receive recommendations from project R15 and program the remaining funds with the aid of those recommendations.

Duration: 18 months for ongoing initial phase.

Objectives:

- Propose appropriate procedures to facilitate effective utility management during the entire project development process, from inception to design to construction completion.
- Investigate and develop innovative strategies, including partnering and other techniques, whereby utilities and the highway agencies can work more cooperatively and mitigate delay.
- Develop and plan for the evaluation of prospective strategies to mitigate utility related delay to highway renewal projects, including an analysis of institutional barriers to successful implementation of the prospective strategies.

Statement of the Problem: The independent and often conflicting interests of utilities and highway agencies in particular work zones are a major cause of construction delays on highway projects. Many factors contribute to this, including lack of information on the existence and location of underground or overhead utility assets; incomplete consideration and budgeting of the time needed by utilities to budget for and mobilize utility asset relocation activities; the complexity of utility asset relocation during highway construction; and inadequate coordination and cooperation between project and utility owners. Because of the frequency with which utilities occupy existing highway rights of way, highway renewal projects are particularly prone to delays related to the relocation or pre-construction protection of existing utilities. The accelerated work schedules demanded by many highway renewal projects also place extraordinary demands for coordination and cooperation on both highway agencies and utilities—demands that current practices frequently fail to meet. Consolidation within the utility industry in recent years also makes it more difficult to address concerns at the state level when utilities are regionally and nationally structured.

This project will explore how to improve utility and transportation agency coordination and reduce the negative impacts to both, and to the public. This project is intended to facilitate an interactive and creative discussion on how to more effectively address the common public interest in highway renewal with minimal disruption, while mitigating the impact to utilities. The research will identify strategies to be evaluated in future projects.

Anticipated Research Products:

- A Summary Report on the causes of delay to highway renewal projects related to utility asset relocation and policies, practices, procedures, and techniques that have mitigated such delays.
- A plan for testing and evaluation of innovative strategies to eliminate or mitigate utility asset relocation delays and overcome institutional barriers to implementation of these strategies.
- Draft Final Report and Final Report.

Related Projects:

- R01 Utilities Location Technology Advancements

8.2 Project R16: Railroad-DOT Institutional Mitigation Strategies

Budget: $400,000

Duration: 18 months

Status: The RFP was advertised on July 2007. The proposals are due on September 18, 2007.

Objectives:

- Identify strategies and institutional arrangements that will facilitate beneficial relationships between railroads and public agencies.
- Investigate and develop innovative partnering techniques whereby railroads and the highway community are working cooperatively.
- Develop a draft model agreement and streamlined permitting processes.
- Identify barriers that impact effectiveness and propose remedies, including alternate project delivery techniques (e.g. design-build).

Statement of the Problem:
The presence of a railroad presents a unique challenge to rapidly renewing a highway facility. Because of the potential for train delays caused by highway construction near railroads and the need to preserve rail corridors for future capacity improvements, most railroads are very protective of any project that could impact the use of their facilities. In addition, highway projects usually require the railroad's review of design plans and agreements for any work on railroad property. This project will provide the forum for railroad-DOT collaboration and the framework for model business agreements.

Railroads are private entities that own and maintain their own rights-of-way and provide their own financing for improvements. Each railroad company is unique in their approach to operating requirements, design criteria, and coordinating highway projects near railroad facilities. Most highway renewal projects do not provide any inherent benefits to the railroad and may adversely impact operations and future capacity.

Negotiating highway-related changes that could impact rail operations is often much more challenging than anticipated. In many ways railroads have considerably less flexibility than do public agencies in making changes. Rail operations can tolerate little delay, which often restricts construction options for the highway contractor and requires railroad personnel to coordinate rail service with construction activity.

Railroad force account work is performed by railroad employees whose work schedule may conflict with the requirements of the highway project.

This research project is focused on enhancing cooperation between railroads and public agencies on highway renewal projects. This will be accomplished by seeking creative and cooperative approaches. The goal is to develop a systematic approach for performing highway renewal that is rapid, causes minimum disruption, and produces long-lived facilities.

Anticipated Research Products:

- Best practice document with an assessment of the potential benefits.
- Model agreements for cooperation between the railroads and the appropriate highway organizations.
- Streamlined permitting procedures.
- Recommended specification, institutional, and policy changes that are necessary to implement streamlined procedures and model agreements.

Related Projects:

- R04 – Innovative Bridge Designs for Rapid Renewal
- R05 – Modular Pavement Technology
- R09 – Risk Manual for Rapid Renewal Contracts
- R10 – Innovative Project Management Strategies for Large, Complex Projects
- R11 – Strategic Approaches at the Corridor and Network Level to Minimize Disruption from the Renewal Process
- R15 – Strategies for Integrating Utility and Transportation Agency priorities in Highway Renewal Projects

9. TACTIC 7 - 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 needs 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.

This tactic will narrow the gap in professional practice between design life and actual performance. In order to achieve long-lived, low-maintenance pavements and structures, the performance of the entire system as well as those of the individual components need to be considered. This will require research and development efforts in the areas of materials, mixture composition, structural systems and components, pavement structure, and modeling. Through improved material selection, design processes, and integration with construction technologies, designers will be able to choose a desired performance life and facilities that will reliably achieve that life.

For many years researchers have investigated life-cycle cost analysis techniques and test methods to predict performance of various pavement elements, such as hot mix asphalt (HMA) materials. These concepts are proving their worth but need to be expanded to other pavement types, refined as needed, and integrated with other considerations. Reliable predictive techniques are critical to the ability to design for a particular service life and must account for the effects of construction and material variability and degradation on performance.

9.1a Project R19-A: Bridges for Service Life beyond 100 Years: Innovative Systems, Subsystems, and Components

Funding: $2,000,000

Duration: 4 years

Status: The RFP was advertised on July 2007. The proposals are due on September 18, 2007.

Objectives:
The objective of this project is to improve existing systems, subsystems, and components that historically limit the service life of bridges, and to identify and prove promising concepts for alternative systems, subsystems, and components. During the investigative phase of this project, the research team shall consider all bridge span lengths. However, the outcome of this project should focus on typical bridges, for example, bridges with one or multiple spans, with a maximum single span length of 300 feet.

Statement of the Problem: Historically, durability has been a problem for some individual bridge components, such as bridge bearings, deck joints, columns and piles. This problem is not unique to the United States. Recent bridge management data from the Netherlands confirms that joints and bearings are the leading maintenance costs for highway bridges. When one component undergoes deterioration at a faster rate than other bridge components, it requires repair, rehabilitation, or even replacement. If these weaker components could be designed with enhanced durability characteristics, or if they could be hardened, protected, or eliminated, disruptions may well be significantly reduced. The resulting structures could be expected to last longer before they undergo additional renewal efforts.

In an emerging European approach[1], component service life design takes four different levels of sophistication in the performance-based design approach: 1) A Full Probabilistic Design can be imposed where performance data and variability are known; 2) A Partial Factor Design (semi-probabilistic) requiring some engineering judgment in the initial period of deployment is also outlined with strategies; 3) A Deemed-to-Satisfy Design approach, which is theoretically what the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Code hopes to achieve; 4) The most expensive and conservative approach, Avoidance of Deterioration**,** by using materials that will not deteriorate. Regarding this kind of approach, this project (Project R19-A) will concentrate on levels 3 and 4. A later project, R19-B, will concentrate on levels 1 and 2.

To some extent, work done in the earthquake engineering arena applies concepts similar to this. The equivalent of performance levels was proposed in work done by Mander, et. al.[2]. One performance level, termed DAD (for Damage Avoidance Design), attempts to ensure that at Ultimate Limit State (ULS) the structure could provide full service and functionality for a prescribed limit state. The second level, termed CARD (for Control and Repairability of Damage), provides alternate methods to allow damage in a controlled manner, but forces the designer to recognize these damage mechanisms and allow for repair and restoration of full structure functionality (via elements like fuses, replaceable hinges, and even replaceable prefabricated elements and systems). These approaches are examples of current relevant performance-based design methodologies. These alternate approaches will only be used when there is no statistical approach.

Currently, many bridge components are designed and constructed based on proven ULS performance without regard for Service Limit States (SLS). In fact, in some cases, by focusing solely on the ULS, performance at a SLS may actually be less than optimal. Unfortunately, some of the commonly used component details (e.g., bearings, joints, concrete cover, and structural steel coatings) have inherent design flaws and limitations. Although many of the specific flaws are recognized, they have not been eliminated under current design procedures and specifications. The environment and location in which these components are placed within a bridge often contribute to accelerated deterioration rates and reduced service life. Inspection of these components is frequently difficult, hindering timely maintenance and reducing service life. As a result, the need for corrective action may be identified only after irreparable damage has occurred. This deterioration in difficult-to-inspect locations results in bridge components and systems that must be replaced frequently. If bridge designers had better and a greater number of options for reducing problematic bridge components, bridge systems could be designed to deliver a 100+ year service design life. By enhancing the performance, protection, and accessibility of these vulnerable areas, or by significantly reducing the number of problematic components, longer life facilities could be designed and constructed.

The goal of this project is to enhance the durability and performance of existing systems[3], subsystems[4], and components, and develop alternative concepts to realize the target 100+ years service life threshold.

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1 Fédération internationale du béton (fib). “Model Code for Service Life Design.” First Edition 2006. <**http://www.fib-international.org/publications/fib/34/**>

2 C-T. Cheng, J. B. Mander, "Seismic Design of Bridge Columns Based on Control and Repairability of Damage", Publication Number NCEER-97-0013, Multidisciplinary Center for Earthquake Engineering Research, December 1997; and
J. B. Mander, C-T. Cheng, "Seismic Resistance of Bridge Piers Based on Damage Avoidance Design", Publication Number NCEER-97-0014, Multidisciplinary Center for Earthquake Engineering Research, December 1997.

3 In this document, the term “system” refers to the combination of components and subsystems that form the entire bridge.

4 In this document, the term “subsystem” refers to two or more components acting together to serve a common structural purpose. In this context, a “subsystem” is a part of the whole bridge system.

The research team should also identify promising concepts for further investigation by other agencies. Since a certain level of maintenance is inevitable within a 100-year service life, maintenance considerations should also be addressed in the research. The project should focus on the conceptual development[5] of systems, subsystems, and components that are rapidly and economically maintained and replaced. Proof-of-concept[6] testing of modified and new conceptual bridge systems, subsystems, and components will be also included in this project. While this project will focus on conceptual development and proof-of-concept, detailed development of these systems, subsystems, and components will be left to industry.

The future Project R19-B will focus on SLS design and calibration to achieve durable bridges with service life beyond 100 years.

Anticipated Research Products:

- ASHTO-formatted LRFD design and construction specifications and analysis methods, details, standard plans, construction processes, and detailed design examples for bridge systems, subsystems, and components that will achieve a bridge service life of 100+ years.

Related Projects:

- R04: Innovative Bridge Designs for Rapid Renewal
- R19-B: Bridges for Service Life beyond 100 Years: Service Limit State Design

9.1b Project R19-B: Bridges for Service Life beyond 100 Years: Service Limit State Design

Funding: $1,000,000

Duration: 30 months

Status: The RFP is expected to be advertised on March 2008.

Objectives:

- Develop new design codes that incorporate a rational approach based on SLS for durability and performance of bridge systems, subsystems, and components, including problematic components.
    - The proposed SLS will include data sets related to durability, fatigue, fracture, and redundancy as integral issues of service life as reported in SHRP2 Project R19-A, which will address system, subsystems, components, and details that are critical to reaching the expected service life and assuring an actual life beyond 100 years.
- Develop bridge system performance measures, incorporating predefined component classifications that will utilize full probability-based service life design criteria to maximize the actual life of the system. Consider material performance (including durability), structural performance of bridge systems and subsystems (optimum joints and bearings), and design practices leading to longer and more predictable service life.
- Develop comprehensive design procedures, proposed specification changes, and implementation tools

[5] Conceptual development will involve formulation of general requirements and preliminary engineering designs and specifications.

[6] In general, "proof-of-concept" refers to the evidence that demonstrates that a particular concept or idea is feasible. In this project, "proof-of-concept" will involve testing of physical models of the identified concepts to provide evidence of their potential to fulfill the desired 100+ year service life time. "Proof-of-concept" will not require prototyping (i.e. full-scale and usually functional form of new systems, subsystems, or components).

that include durability design in addition to structural design. In the conduct of this development, consider structural and material redundancy, and system, subsystem, and component performance measures that will utilize service life design criteria to maximize the actual life of the system. Current calibrated ULS approaches cannot integrate the daily, seasonal, and long-term SLS stresses that will directly affect long-term performance.

Statement of the Problem: Historically, durability has been a problem for some individual bridge components, such as bridge bearings, deck joints, and column and piles. This problem is not unique to the United States. Recent bridge management data from the Netherlands confirms that joints and bearings are the leading maintenance costs for highway bridges. When one component undergoes deterioration at a faster rate than other bridge components, it requires repair, rehabilitation, or even replacement. If these weaker components could be designed with enhanced durability characteristics, or if they could be hardened, protected or eliminated, disruptions may well be significantly reduced. The resulting structures could be expected to last longer before they undergo additional renewal efforts.

In an emerging European approach[7], component service life design takes four different levels of sophistication in the performance-based design approach: 1) A Full Probabilistic Design can be imposed where performance data and variability are known. 2) A Partial Factor Design (semi-probabilistic) requiring some engineering judgment in the initial period of deployment is also outlined with strategies. 3) A Deemed-to-Satisfy Design approach, which is theoretically what the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Code hopes to achieve. 4) The most expensive and conservative approach, Avoidance of Deterioration**,** by using materials that will not deteriorate. Regarding this kind of approach, this project (Project R19-B) will concentrate on levels 1 and 2.

To some extent, work done in the earthquake engineering arena applies concepts similar to this. The equivalent of performance levels was proposed in work done by Mander, et. al.[8]. One performance level, termed DAD (for Damage Avoidance Design), attempts to ensure that at Ultimate Limit State (ULS) the structure could provide full service and functionality for a prescribed limit state. The second level, termed CARD (for Control and Repairability of Damage), provides alternate methods to allow damage in a controlled manner, but forces the designer to recognize these damage mechanisms and allow for repair and restoration of full structure functionality (via elements like fuses, replaceable hinges, and even replaceable prefabricated elements and systems). These approaches are examples of current relevant performance-based design methodologies. These alternate approaches will only be used when there is no statistical approach.

Currently, many bridge components are designed and constructed based on proven ULS performance without regard for Service Limit States (SLS). In fact, in some cases, by focusing solely on ULS, performance at SLS may actually be less than optimal. Unfortunately, some of the commonly used component details (e.g., bearings, joints, concrete cover, structural steel coatings, etc.) have inherent design flaws and limitations. Although many of the specific flaws are recognized, they have not been eliminated with current design procedures and specifications. The environment and location in which

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[7] Fédération internationale du béton (fib). “Model Code for Service Life Design.” First Edition 2006. <http://www.fib-international.org/publications/fib/34/>

[8] C-T. Cheng, J. B. Mander, "Seismic Design of Bridge Columns Based on Control and Repairability of Damage", Publication Number NCEER-97-0013, Multidisciplinary Center for Earthquake Engineering Research, December 1997; and
J. B. Mander, C-T. Cheng, "Seismic Resistance of Bridge Piers Based on Damage Avoidance Design", Publication Number NCEER 97-0014, Multidisciplinary Center for Earthquake Engineering Research, December 1997.

these components frequently exist, which often factors into their accelerated deterioration rates, reduces the service life of components in these areas. Inspection of these components is frequently difficult, hence hindering timely maintenance and reducing service life. As a result, the need for corrective action may be identified only after irreparable damage has occurred. This erratic performance in difficult-to-inspect locations results in bridge components and systems that must be replaced frequently. If bridge designers had a greater number of SLS design options for problematic bridge components, better decisions could be made and bridge systems could be designed to deliver a 100+ year service design life. However, to date limited statistical effort has been dedicated to the development of new components, systems, and approaches to better provide for a satisfactory performance using SLS methodology.

During the investigative phase of this project the research team shall consider all bridge span lengths. However, the outcome of this project should focus on typical bridges, for example, bridges with one and or multiple spans with a maximum single span of 300 feet in a structure.

New design codes are needed that incorporate a rational approach based on SLS for durability and performance of problematic bridge components. This is in addition to traditional structural design within the framework of the current AASHTO LRFD Bridge Design Specifications. The absence of a traffic- and load-based (e.g. transient loads, permanent loads, and environmental exposures) SLS calibration may make some of these developments challenging. Therefore, the development of an SLS calibration will be the first step in setting this global direction. This project will develop bridge design procedures and proposed specification changes that include durability design in addition to structural design, as well as develop the tools required for SLS implementation.

The second major focus will be to work with the Federal Highway Administration (FHWA), SHRP2 Project R19-A, *Durable Bridges for Service Life beyond 100 Years: Innovative Systems, Subsystems, and Components*, and other ongoing efforts to capture a bridge component classification scheme, including exposure and deterioration mode, to develop comprehensive SLS design procedures. This will be key to establishing and maintaining the contents, format, and implementation using a tool-box approach for the new SLS specifications. Further, with the ability to collect bridge performance data more efficiently, there is a need to investigate how to incorporate information from the data sets being developed and captured by FHWA's Long-Term Bridge Performance Program and other national and local initiatives into new or revised design specifications beyond this effort.

Anticipated Research Products:

- AASHTO-formatted LRFD design and load rating specifications and analysis methods, and detailed examples for bridge systems, subsystems, and components that will complement SHRP 2 Project R19-A

Related Projects:

- R04: Innovative Bridge Designs for Rapid Renewal
- R19-A: Bridges for Service Life beyond 100 Years: Innovative Systems, Subsystems, and Components

9.2 Project R21: Composite Pavement Systems

Budget: $4,000,000

Duration: 4 years

Status: The RFP was advertised on March 2007. The project is currently under contract negotiations.

Objectives:
This project will investigate the design and construction of new composite pavement systems, and not those resulting from the rehabilitation of existing pavements. The research will focus on two promising applications of composite pavement systems: (1) an asphalt layer(s) over a PCC layer and (2) a PCC surface over a PCC layer. Specifically this effort shall:

- Determine the behavior and identify critical material and performance parameters
- Develop and validate mechanistic-empirical performance models and design procedures consistent with the Mechanistic-Empirical Pavement Design Guide (MEPDG)
- Recommend specifications, construction techniques and quality management procedures.

Statement of the Problem: Based on statistics compiled in 2000, approximately 30 percent of the urban interstate system and just over 20 percent of the rural interstate system is classified as "composite" pavement – asphalt concrete overlay on a Portland cement concrete (PCC) pavement (*Highway Statistics 2000*). While asphalt overlays over PCC are commonly used to rehabilitate a pavement, the use of a high-quality asphalt concrete layer(s) over a new concrete layer is rare. This technique has great potential to provide a long-lasting pavement needing minimal maintenance. The concrete substructure provides a durable, strong, long-lasting base, while the asphalt concrete provides a rapidly renewable riding surface as well as protective layer from salts and other harmful substances to concrete. Additionally, the asphalt surface provides performance in terms of acceptable friction, noise reduction, improved ride quality, and reduced splash and spray. This technique may be well suited for meeting the goals of rapid renewal. Initial construction of a composite pavement may not be rapid, but the pavement would be long-lasting and traffic disruption would be minimized throughout the life by providing a surface that can be quickly and easily maintained (i.e. – patched, milled and replaced, overlaid, etc.).

Another promising strategy in the construction of new pavements is the use of a relatively thin, high-quality concrete surface atop a thicker, less expensive concrete layer. The lower concrete layer may include high proportions of recycled or substandard materials that are not suitable for use in the surface layer. Construction may be accelerated by placing the concrete surface layer on top of the other concrete layer before that layer has set to facilitate an excellent bond between the two layers of concrete; this construction technique has led to use of the term "wet on wet" concrete. While the use of this technique is rare in the United States, these types of pavements have been constructed in Austria and elsewhere.

While many transportation agencies may have performance data and models for conventional pavement systems (flexible and rigid), the behavior of new composite pavements is not well understood. Models for the performance of these hybrid systems are needed for design, performance prediction, and life-cycle cost analysis. Guidance on specifications, construction techniques and quality management procedures are also needed by the transportation community.

Anticipated Research Products:

- Procedures and methodologies for the development, acceptance, and adoption of composite pavement systems.
- Design, materials, and construction manuals.
- Composite pavement training materials.

Related Projects:

- R05 – Modular Pavement Technology
- R23 – Using Existing Pavement in Place and Achieving Long Life

9.3 Project R23: Using Existing Pavement in Place and Achieving Long Life

Funding: $1,000,000

Status: The RFP was advertised on July 2007. The proposals are due on September 18, 2007.

Duration: 3 years

Objectives:
The objective of this project is to provide guidance to public agencies for achieving long-lived pavements, reducing construction time, and minimizing the impact to the public by utilizing existing pavement in-place in a rapid renewal environment. Specifically this project will:

- Identify approaches for using existing pavements in-place for rapid renewal projects.
- Determine the advantages and disadvantages for each approach under different project conditions.
- Develop detailed criteria on when an existing pavement can be used in-place, with or without significant modification.
- Identify practices and techniques to construct these types of pavements in a rapid renewal environment.
- Determine the optimal way to integrate the renewed pavement with adjacent pavements and structures.

Statement of the Problem: On roadways that have acceptable geometric features, renewal could be greatly accelerated and costs reduced if the existing pavement can be incorporated into rapid renewal projects without having to be removed from the project site. Comprehensive guidance is needed to help public agencies select the appropriate solution for specific circumstances. Project owners need reliable procedures that allow them to identify when an existing pavement can successfully be used in place and how to incorporate it into the new pavement structure to achieve long life under conditions of service likely not considered in the original design. Approaches using the existing pavement in-place to achieve long life on rapid renewal projects include the use of asphalt, concrete, and other innovative materials.

This effort will concentrate on understanding the state of the art of rapid renewal approaches currently used both nationally and internationally to construct long-lived (50-years or longer) pavements for high-volume roadways. This effort will also identify promising alternatives to renewal approaches currently in use, or imminently on the horizon. This project does not address “routine” overlays designed for maintenance or preservation purposes, which are considered in SHRP 2 Project R26: Preservation Approaches for High Volume Roadways.

Anticipated Research Products:
- Review and summary of pavement options available for rapid renewal
- Criteria on when each technique is appropriate
- New and updated design guides
- New construction procedures and specifications

Related Projects:
- R21 – Composite Pavement Systems

10. TACTIC 8 - PRESERVE FACILITY LIFE

Total highway investment by all units of government reached $128.5 billion in 2000. Extending facility life through proactive preservation activities not only shows good stewardship of the public's investment but also significantly reduces disruption. In spite of this significant investment, needs greatly outpace the current investment levels, and the ability to finance renewal projects without jeopardizing other programs remains the biggest challenge facing facility owners.

Therefore, it is imperative that one of the essential components of a rapid renewal program is the preservation of existing facilities for the longest possible time at the required level of performance. Specifically, techniques are needed to extend the life of roadways that carry high traffic volumes.

10.1 Project R26: Preservation Approaches for High Traffic Volume Roadways

Budget: $250,000

Status: The RFP was advertised on July 2007. The proposals are due on September 18, 2007.

Duration: 18 months

Objectives:
The objective of this project is to develop guidelines on pavement preservation strategies for high traffic volume roadways that can be used and implemented by public agencies. A secondary objective is to identify promising preservation strategies for application on high traffic volume roadways that may not commonly be used and make recommendations for further research opportunities.

Statement of the Problem: Extending the life of infrastructure elements with the timely use of preservation techniques has been an important strategy for many years, particularly when the demands on capital budgets greatly outpace current revenue. Relatively small investments for preservation activities, if properly timed and applied, can significantly increase infrastructure life. Many helpful proprietary products as well as generic products are currently available. Additional product development and research are ongoing as agencies seek ways to better preserve their investment in existing infrastructure.

However, the application of preservation strategies to high traffic volume roadways, whether existing or part of a renewal project, 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. Guidance is needed on more effectively matching the condition of the infrastructure element to specific treatments suitable for application in high volume situations and in computing appropriate life cycle costs.

This project will look at domestic and international strategies for infrastructure preservation and develop guidance on which approaches and products are appropriate for high traffic volume applications. Additionally, promising opportunities for further development will be documented.

Products:

- Guidelines on preservation strategies for high traffic volume roadways
- Methodology and supporting data for life cycle considerations for high traffic volume roadway preservation approaches

- Recommendations for further research opportunities

Related Projects:

- None

11. APPENDIX A: PROJECTS REMOVED FROM RESEARCH PROGRAM

Cutbacks in the anticipated budget have required a re-scoping of the Highway Renewal focus area of the SHRP 2. This appendix provides details on the Highway Renewal projects that have been removed from SHRP 2 as recommended by the Oversight Committee, Renewal TCC, and ETGs.

11.1 Project R08: Alternate Contracting Strategies for Rapid Renewal

Tactic: Facilitate Innovation and Equitable Contracting Environment Budget

Status: NCHRP is conducting a synthesis on the same topic. SHRP 2 Renewal funds will be used to supplement the Synthesis if needed. Because of the synthesis effort, funding for R08 was removed.

Budget: $250,000

Proposed Duration: 2 years

Objectives:

- Determine how various alternative contracting strategies can be used effectively in various rapid renewal scenarios.
- Quantify the sharing or transfer of risk between the DOTs and the contracting industry as a result of these strategies.

Statement of the Problem: This project will organize, evaluate, and further implement alternative contracting mechanisms to accommodate a greater variety of contracting methods for specific application related to rapid renewal projects. 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. To date, individual DOTs have conducted state-only experiments (as opposed to national experiments) with alternative contracting practices. There is the need for better controlled experiments with several states involved in applying the new techniques. This will aid in understanding the effectiveness and limitations of the new strategies.

This work will define and organize all the new contracting strategies that have moved into the highway contracting nomenclature over the last 10 years. The work will also explore other contracting innovations from the international community and non-highway public works projects. From this all-encompassing list, the researcher will identify the current barriers associated with implementing these new procedures. Finally, the researcher will identify ways to “mix and match” the strategies in a way that advances the delivery of rapid renewal projects.

Anticipated Research Products:

- Guidebook on alternative contracting strategies with clear descriptors, uses, experiences, strengths, weakness, and perceived benefits and risks
- Decision support tools
- Implementation manual that identifies barriers and ways to overcome them
- Documentation on lead state evaluations of various practices

Related Projects:

- R07 – Performance Specifications for Rapid highway Renewal

11.2 Project R12: Strategic Approaches for Financing Large Renewal Projects

Tactic: Plan Improvements to Mitigate Disruption

Status: Removed from Highway Renewal Research Program

Budget: $250,000 (original budget was $1,000,000)

Proposed Duration: 1 year

Objectives:

- Better understand the impact of mega-projects on the overall highway capital budget and in order to meet rapid renewal requirements and expectations.
- Organize and study financing strategies for both planned and completed “mega” renewal projects.
- Identify ways to fund and finance large or “mega” renewal projects while addressing their impact on other DOT programs.
- Identify innovative ways that finance and revenue streams could be linked closer to those that are specifically benefiting from the mega-project.

Statement of the Problem: One of the very first criteria for determining the scope of a renewal project is the available funding needed to build the project, both conventionally and then 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.

DOTs expect increasing pressure to organize and build mega-projects. Project R11 addresses the corridor analysis strategies and the best way to assemble projects. While consolidation of projects may minimize disruption, additional funds will also be required to expeditiously complete the work. This project attempts to develop creative financing strategies for this expected increase in large renewal projects.

This work will analyze the financing of mega-projects and their impacts on rapid renewal requirements, including current and downstream funding requirements. The work will use national and state needs study data. The work will identify creative ways to fund these efforts.

Anticipated Research Products:

- Guidelines
- Policy statements
- Financing strategies

Products should be stratified—a set for managers, legislatures, financial managers, and the general public.

Related Projects:

- R04 – Innovative Bridge Designs for Rapid Renewal
- R05 – Modular Pavement Technology

- R11 – Strategic Approaches at the Corridor and Network Level to Minimize Disruption from the Renewal Process
- R26 – Preservation Approaches for High Traffic Volume Roadways

11.3 Project R13: New Guidelines for Improving Public Involvement in Renewal Strategy Selection

Tactic: Improve Customer Relationships

Status: Removed from Highway Renewal Research Program

Budget: $500,000 (original budget was $2,500,000)

Proposed Duration: 1.5 Years

Objective: Improve agency and public interaction and collaboration before and during renewal operations.

Statement of the Problem: 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. The scope of this project is to organize best practices and procedures by which project owners address the needs of various public groups, including resource agencies and special interest groups.

Anticipated Research Products:
- Guidelines manual for establishing successful public and agency relationships

Related Projects:
- R14 – New Guidelines for Improving Business Relationships and Emergency Response During Renewal Projects

11.4 Project R14: New Guidelines for Improving Business Relationships and Emergency Response During Renewal Projects

Tactic: Improve Customer Relationships

Status: Removed from Highway Renewal Research Program

Budget: $750,000 (original budget was $1,500,000)

Proposed Duration: 4 years (reduced from original plan)

Objective:
- Provide businesses affected by renewal operations the information they need to operate and ensure the continuity of emergency response services during renewal projects.

Statement of the Problem: Both business activity and response to emergencies are impacted by highway renewal work. For businesses, this project involves capturing information from design and construction phasing plans and presenting it in a block-by-block or street-by-street format. Project planners should be able to show a business what will happen in its immediate environment over time. The impact on businesses includes access, shipments, and parking for fixed-location businesses and other impacts on delivery businesses. A bridge or ramp closure, parking ban, or detour can have a dramatic impact on businesses in a particular block. This impact may not last the length of the renewal project and may vary in severity.

Similarly, any of these changes can increase the response time of emergency services. The construction work introduces the potential for accidents, and revised traffic patterns increase the potential for crashes. The volume of emergency response activity may increase during renewal work, and the routes to emergency sites may be circuitous. Emergency responders must be aware of all street and bridge closings and areas of increased congestion at each project phase. Continuously updated maps should be available to first responders so they can revise their routes in response to changing access conditions.

The project should consider the inclusion of alternative routes in the planning process plus signing and communication during the design and construction phases. A process would be designed to capture the impacts block by block as a renewal project progresses so businesses can plan. It is assumed that applications of existing technologies can provide the tools to reach the objective.

This project would also develop guidelines for working with first responders before, during, and after a renewal project and develop a framework for producing continuously up-to-date maps of the area affected by renewal. This project would describe the data needs and step-by-step process to create a first responder assistance product.

Anticipated Research Products:

- Method to present site-specific impacts to business owners for each phase of a renewal project
- Guidelines document for working with businesses
- Guidelines to aid DOTs and public road-building agencies in working with first responders
- Framework and step-by-step process for customizing commercial off-the-shelf GIS software to create a first responder assistance product

Related Projects:

- R12 – New Guidelines for Improving Public Involvement in Renewal Strategy Selection

11.5 Project R17: Context-Sensitive Designs and Construction Operations to Minimize Impact on Adjacent Neighborhoods

Tactic: Improve Customer Relationships

Status: Removed from Highway Renewal Research Program

Budget: $750,000

Proposed Duration: 3 years

Objectives:

- Apply context-sensitive design principles to specific applications related to rapid renewal projects.

- Identify and apply context-sensitive construction operations to minimize the impact of renewal projects on their surroundings.

Statement of the Problem: Construction work can have a dramatic impact on neighborhoods, businesses, and traffic on local roads. Various local ordinances attempt to control the elements through noise generation, traffic restrictions, water quality, and other factors. These restrictions may not be in harmony with broader project goals for rapid renewal. The owner agency wants to ensure that they are meeting the goals and objectives of the project, the contractor wants as many options as possible to build the project, and those impacted by the project directly want it completed with as little inconvenience as possible. Context-sensitive designs can help to balance the community's desires with those of the agency. The concept of context-sensitive design principles arose from a 1998 workshop called "Thinking Beyond the Pavement: A National Workshop on Integrating Highway Development with Communities and the Environment." NCHRP Project 15-19 developed a guide to implementing context-sensitive design principles to help agencies mitigate a given project's impact on the neighborhood or community surrounding the site. These principles should be carried beyond the design phase through construction, maintenance, and operation.

Context-sensitive construction operations may be especially appropriate for rapid renewal projects. By planning and implementing context-sensitive construction, the contractor can ensure that the work will proceed efficiently, while the impact on the adjacent community is minimized. Urban areas in particular often have limited space available for construction, posing major obstacles for the contractor and potentially major impacts on the public. The principles of context-sensitive design can be extended to construction to help balance the agency, contractor, and community needs, while also facilitating speed of construction and minimizing disruption.

This work will build on the concept of context-sensitive design principles, as outlined in NCHRP Project 15-19. This work will identify potential conflicts between rapid renewal goals and neighborhood disruption during construction operations. Factors to be considered include impact on traffic movement in and around neighborhoods, local environmental considerations, delivery of materials to and from the site, establishment of construction limits, impacts on local businesses, and noise ordinances.

Anticipated Research Products:
The major product of this research will be a guide to context-sensitive construction, including options for various renewal scenarios. The guide will offer alternate approaches to managing construction operations to minimize disruption to the areas surrounding the renewal project, including traffic moving through the project, adjacent home and business owners, the environment, and others. Implementation suggestions in the guide will facilitate the adoption of context-sensitive construction operations by agencies and industry.

Related Projects:
- R07 – Performance Specifications for Rapid Highway Renewal
- R09 – Risk Manual for Rapid Renewal Contracts
- R13 – New Guidelines for Improving Public Involvement in Renewal Strategy Selection
- R14 – New Guidelines for Improving Business Relations During Renewal Projects

11.6 Project R18: Design, Installation, and Maintenance of Work Zones for High Consistency, Visibility, and Safety

Tactic: Improve Traffic Flow in Work Zones

Most motorists and commercial vehicle operators experience the renewal process as delay. "Road Construction Ahead" is the bane of all travelers. Motorists are quick to observe and report poor motorist information, dangerous merges, and misleading signs. A poor job of work zone management or the perception that repairs are done every summer without the appearance of a "game plan" undermines the public confidence. Meeting the public's expectation of a safe, predictable trip through a work zone with minimum delay requires the integration of design, construction, and communications expertise and application of ITS technologies in the harsh environment of a construction zone. Many of the traditional work zone approaches are simply inadequate for the high-traffic environment of 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.

<u>Status</u>: Removed from Highway Renewal Research Program

<u>Budget</u>: $750,000 (original budget was $2,000,000)

<u>Proposed Duration</u>: 3 years (reduced from original plan)

<u>Objectives</u>:

- Develop a work zone design, installation, and maintenance plan for high consistency, visibility, and safety. ITS technologies should be addressed regarding road user information and communication media.
- Provide guidance on development of Transportation Management Plans, including impact analysis, avoidance, and design to improve safety and mobility.
- Provide guidance on engineering and economic analysis, contract time, and road closure factors, as well as work zone factors that relate to constructability/construction quality.
- Develop a process to recommend when total road closure is the best option and other contract duration issues that relate to work zones.

<u>Statement of the Problem</u>: Lack of a high level of safety in work zones coupled with the task of renewing the aging infrastructure with a minimal disruption brings about a challenge in the coming years. Despite the advancement in traffic control techniques, more than 800 deaths a year are still attributed to crashes in work zones nationwide. The challenge becomes more significant as growth in highway demand is projected to increase 50 percent by 2020. Thus, development of a "model" work zone is needed to establish consistent traffic control, geometric configuration, and traffic control devices in work zones across the country, particularly on high-volume roadways.

To achieve the goal of improved work zone performance, it will be necessary to (1) design the work zone for expected traffic and lane closure conditions, (2) ensure that recommended work zone traffic control procedures are implemented consistently, and (3) provide accurate and consistent real-time information to motorists; (4) develop Transportation Management Plans, (5) accurately determine contract time to minimize land closure time; and assess when total road closure is the best option. Measures to monitor and reward contractors for application of recommended procedures are needed to ensure application of good practices.

Part 6 (Temporary Traffic Control) of the *Manual on Uniform Traffic Control Devices* (MUTCD) provides standards and guidelines for every element of a work zone (e.g., advance warning and transition areas, tapers, detours and diversions, and flagger control methods). This goes a long way toward establishing uniform practice, but a more thorough companion document is needed to achieve model or standard work zone scenarios that are applied consistently from state to state. Safety and operational performance standards for contractors will make the application of these practices self-enforcing.

This project will document best practices, recommend performance measures to monitor contractors to ensure that work zone traffic control procedures are implemented consistently, and recommend work zone ITS treatments to provide accurate, consistent, real-time information to motorists. .

Anticipated Research Products:

- Best practices report
- Measures for contractor safety performance
- Model for work zone planning

Related Projects:

- R17 – Context-Sensitive Construction Operations

11.7 Project R20: Design for Desired Bridge Performance

Tactic: Design and Construct Low-Maintenance Facilities

Status: Removed from Highway Renewal Research Program

Budget: $2,000,000 (original budget was $3,000,000)

Proposed Duration: 3 years

Objectives: Develop comprehensive design procedures that integrate material performance (including durability), construction practices, and structural performance, leading to longer and more predictable service life and that consider structural and material redundancy. Project focuses on load and resistance factors for performance-based design. (Note: Development and implementation of specifications was eliminated by the SHRP 2 Oversight Committee)

Statement of the Problem: Faced with infrastructure renewal, designers must design bridges with a greater emphasis on long-term performance. Many new bridge systems will utilize new materials and many will be constructed with modular components. Current design specifications are not suited to address many of these and other issues associated with renewal. A strategic plan will first have to be developed to determine the contents and format of new specifications. Further, with the ability to collect bridge performance data more efficiently, there is a need to investigate how to incorporate the information from these data into new or revised design specifications. In addition, with an ever-increasing demand for bridges that are easily constructed, inspected, and repaired, designers must be provided guidance in how to prepare these designs.

For a number of years the FHWA has rated over a quarter of the nation's bridges structurally deficient or functionally obsolete. Part of the bridge renewal effort will require changes to conventional design procedures and will require that the transportation industry develop a new approach to facilitate renewal efforts. During the 1990s, the bridge industry made significant revisions to the design procedures for conventional bridge systems in developing the load and resistance factor design (LRFD) specifications. A concerted similar effort, with a much broader scope to the one undertaken in developing the LRFD specifications, will be required to develop performance-based specifications. However, any new provisions that incorporate a rational approach to include design for durability in addition to structural design should be considered within the framework of the current AASHTO Bridge Design Specifications. A strong training/education program also needs to be developed.

In the bridge industry, durability, fatigue, fracture, and redundancy are important issues of service life. These will continue to be significant issues in addressing bridge renewal efforts. Particular focus should be given to addressing these areas in the development of performance-based specifications. An important issue that requires a solution is the selection of the optimum reliability level for bridges. Performance-based design sets the requirements for structural parameters; however, user and owner expectations must also be considered within the framework. As a result, there is a need for the development of risk-analysis procedures as the basis for selection of acceptance criteria.

It is also significant to note the effort by the AASHTO bridge community in the past several years to develop compatible design (OPIS) and rating (VIRTIS) software. Part of the development of new design procedures must include implementing new designs, specifications, etc. into the next generation of AASHTO BRIDGEWARE.

This project will develop bridge design procedures that include durability in addition to structural design and will develop tools required for implementation.

Anticipated Research Products:

- Design procedures

Related Projects:

- R04 – Innovative Bridge Designs for Rapid Renewal
- R07 – Performance Specifications for Rapid Highway Renewal
- R24 – Development of Rapid Renewal Inputs to Bridge Management and Inspection Systems
- R25 – Monitoring and Design of Structures for Improved Maintenance and Security

11.8 Project R24: Development of Rapid Renewal Inputs to Bridge Management and Inspection Systems

Tactic: Monitor In-Service Performance

Technology provides an opportunity to address a key strategy for improving 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 and improved public safety.

Facility owners will be able to continuously monitor the physical condition of roadways and structures in order to improve maintenance and security and to revise design specifications. The ability to monitor changes in pavement and bridge behavior due to normal deterioration or through isolated events (e.g., floods and impact by over height vehicles) can be a valuable resource for pavement and bridge owners. Specifically, bridges with known problems or suspect details can be closely monitored for sudden failure. In addition, continuous health monitoring provides a mechanism for owners to actively monitor bridges from a security standpoint.

Status: Removed from Highway Renewal Research Program

Budget: $2,000,000 (original budget was $4,000,000)

Proposed Duration: 6 years (reduced from original plan)

Objectives:

- Identify the performance-based metrics, including material deterioration and bridge life-cycle information required to quantify bridge performance.
- Develop protocols for collection, integration, and dissemination of performance data.
- Evolve Pontis into a nationwide system that includes performance data, life-cycle information, and RRR operations.

Statement of the Problem: Rational (i.e., accurate data coupled with effective algorithms) bridge management systems (BMSs) are an important tool for bridge owners. Unfortunately, the development and use of these systems are still in their infancy and BMSs are not widely used in making decisions. As bridge renewal begins in earnest, a great opportunity exists to begin the steps needed to evolve effective management systems, including identifying the type of information that can be most useful and that can be realistically and accurately obtained. If these management systems are developed properly, decisions for bridge RRR can be made that significantly increase bridge life. Changes are needed to get all of the facets of work currently in progress with the Pontis bridge management system completed. Developing and tailoring a management system to correspond with the specific needs of renewal systems being developed makes this effort unique compared to current work in progress on existing BMSs.

To effectively evolve Pontis into a system that is useful to all bridge owners, a next generation of Pontis that is a nationwide system needs to be developed. With this approach, greater national communication with respect to the use of Pontis will be established and, as a result, better decisions will be made. However, care must be given to create a system that is flexible enough to accommodate a wide variety of bridge configurations that are exposed to varying environmental conditions. In other words, the system must be flexible enough and customizable to allow regional trends, as well as national trends, to be input. Users of this system would input life-cycle information, including collected performance data, rehabilitation operations and associated costs, repair operations and associated costs, and replacement operations and associated costs. To use this system for making decisions, a bridge owner would query the national Pontis system for potential RRR solutions based on the specific need. Given additional parameters such as cost, time, and conditions, the bridge owner could then refine those RRR solution hits to a smaller subset. Using this approach, it can be ensured that as the nation's bridges are renewed, they will be, based on past performance, near-optimal solutions. With continued input of performance and RRR data, bridge owners will have greater numbers of past experiences in the database. This will allow bridge owners across the county to learn from others' RRR operation successes and failures, thus ensuring long-life structures.

This project will focus on performance-based metrics to enhance Pontis and provide the ability to more accurately model in-service performance.

Anticipated Research Products:

- Protocols for collection, integration and dissemination of performance data
- Database of performance data, life-cycle information, and RRR operations
- Tools to predict performance

Related Projects:

- R07 – Performance Specifications for Rapid Highway Renewal
- R20 – Design for Desired Bridge Performance
- R25 – Monitoring and Design of Structures for Improved Maintenance and Security

11.9 Project R25: Monitoring and Design of Structures for Improved Maintenance and Security

Tactic: Monitor In-Service Performance

Status: Removed from Highway Renewal Research Program

Budget: $1,500,000

Proposed Duration: 6 years

Objectives:

- Continuously monitor key infrastructure assets (including long-term durability assessment, catastrophic event monitoring, general asset management assessment, and security).
- Reduce interruption to the traveling pubic and increase safety for inspectors.
- Merge information from construction measurements with long-term health monitoring information.

Statement of the Problem: The effectiveness of bridge renewal systems is directly related to performance assessment and asset management. Active bridge monitoring is the most effective way to accomplish this. Bridge monitoring is an important tool for bridge health monitoring, for determining bridge performance for developing and validating effective design specifications, and for bridge security (including potential terrorist acts, acts of nature, accidents, etc.).

It is critical to develop a systematic and focused process for collecting bridge performance data. These data provide useful information for determining appropriate design specifications and for making informed maintenance decisions that contribute directly to a bridge's long life.

Bridge monitoring can be performed by collecting data continuously or by performing isolated tests. Historically, bridges have been monitored while maintaining traffic and/or with the aid of traffic control, diversion, or stoppage. As technology improves, it is becoming increasingly more common to use in situ sensors for the continuous monitoring of the built infrastructure using ambient traffic for the loading. The use of wireless transducers will eliminate the need for site access, which will reduce potential safety risks. Bridge monitoring also includes load testing for providing accurate load ratings and bridge performance. This type of testing differs from continuous monitoring in that data are taken from isolated, "point-in-time" load tests using controlled loading. It is desirable to improve this process by reducing the time and cost associated with this process and developing methodologies for using ambient data collected from continuous monitoring.

Standards are needed for monitoring (monitoring protocols, data collection and processing, etc.) bridges in a cost-effective and efficient manner. Data collection from monitoring is just one aspect of the process. State highway agencies frequently collect data; however, processing these data requires extensive time, so significant evaluation may not always be possible. The development of custom data reduction tools could facilitate the input of real-time data into databases directly, and facilitate their reduction using engineering analysis. The tools could supply the data, as needed, in a manageable form to bridge management and maintenance groups, design divisions, and asset management groups.

This project will investigate cost-effective monitoring capabilities of the nation's infrastructure systems.

Anticipated Research Products:

- Data processing techniques and a generic monitoring plan, including data-reduction procedures

Related Projects:

- R24 – Development of Rapid Renewal Inputs to Bridge Management and Inspection Systems

11.10 Project R27: Bridge Repair/Strengthening Systems

Tactic: Preserve Facility Life

Status: Removed from Highway Renewal Research Program

Budget: $500,000

Proposed Duration: 2 years

Objective:
Develop evaluation options for repairing and strengthening bridges.

Statement of the Problem: Significant speed of construction, minimized traffic disruption, reduced costs, etc. 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. The use of such systems will avoid extended delays and traffic disruption due to costly replacements when rehabilitation is adequate. In addition, tools are needed to determine whether or not it is most cost-effective to repair/strengthen a bridge or to replace it.

This project will focus on evaluation options for repairing and strengthening bridges.

Anticipated Research Products:
The products of this work will be standard drawings and specifications for the repair and strengthening of bridges. The benefits of this work will be that the developed systems will allow existing bridges to continue to be used without the need for new construction. Successful implementation of the results of this project will rely on successful demonstrations and easy-to-use tools.

Related Projects:

- R02 – Develop Bridge Designs That Take Advantage of Innovative Construction Technology

11.11 Project R28: Techniques for Retrofitting Bridges with Non-redundant Structural Members

Tactic: Preserve Facility Life

Status: Removed from Highway Renewal Research Program

Budget: $1,000,000

Proposed Duration: 3 Years

Objective:
Develop renewal techniques for addressing and removing non-redundant bridge characteristics.

Statement of the Problem: 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. There exists a need to study the concept of redundancy, recommend a definition of "non-redundant," and to develop renewal techniques for removing "non-redundant" characteristics.

This project will develop techniques for addressing non-redundant bridges.

Anticipated Research Products:
- Standard drawings and specifications for addressing "non-redundant" bridges

Related Projects:
- R04 – Innovative Bridge Designs for Rapid Renewal