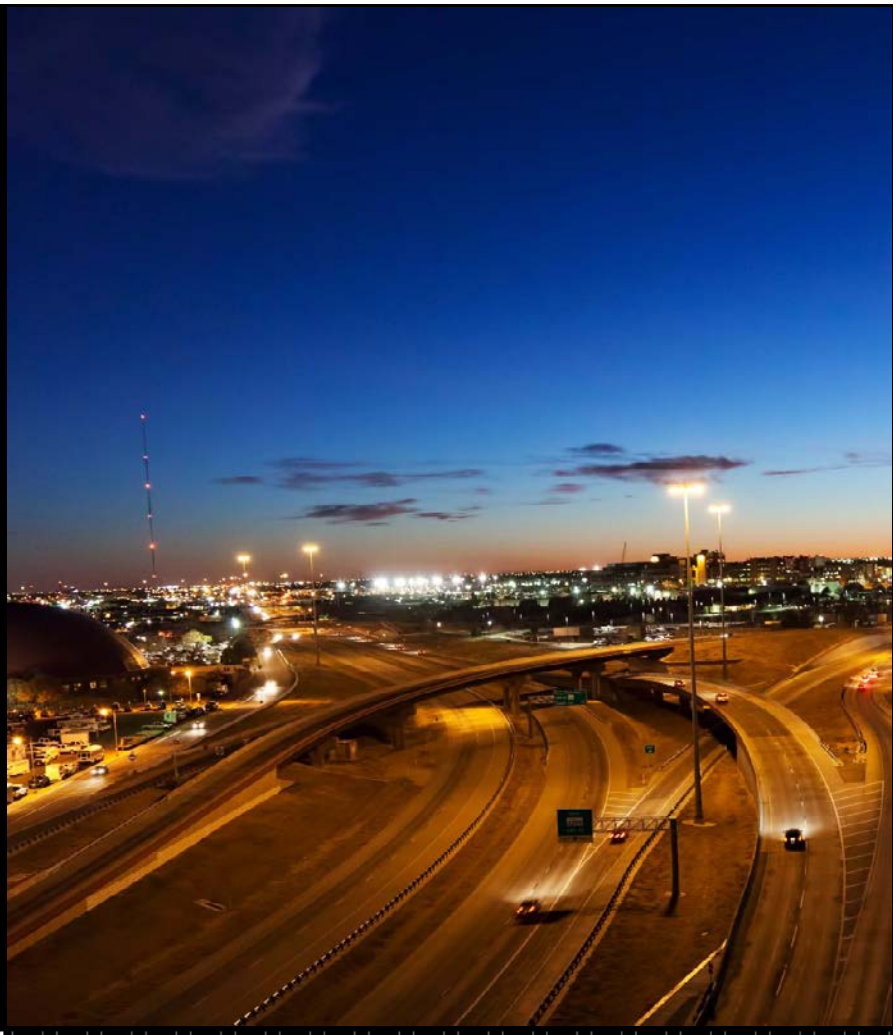
# FHWA Research and Technology Evaluation



## Program Summary Report

## Spring 2016

U.S. Department of Transportation
**Federal Highway Administration**

**FHWA R&T EVALUATION**

# FOREWORD

The Federal Highway Administration (FHWA) Research and Technology (R&T) Program furthers the FHWA's office of Research, Deveopment and Technology's (RD&T) goal of ensuring transparency, accessibility, and responsiveness of RD&T for all stakeholders.

This report summarizes the 16 evaluations being conducted by the Volpe National Transportation Systems Center on behalf of FHWA's Office of Corporate Research, Technology, and Innovation Management. Summaries for completed projects include initial findings as well as background on each project.

**All information in this report is as of April 2016.**

This report should be of interest to program managers, office directors and executives within FHWA as well as others within the Department of Transportation (DOT) or other portions of the Federal Government interested in the outcomes and impacts of FHWA research.

# Notice



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## SI* (MODERN METRIC) CONVERSION FACTORS

### APPROXIMATE CONVERSIONS TO SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| in | inches | 25.4 | millimeters | mm |
| ft | feet | 0.305 | meters | m |
| yd | yards | 0.914 | meters | m |
| mi | miles | 1.61 | kilometers | km |
| | | **AREA** | | |
| $in^2$ | square inches | 645.2 | square millimeters | $mm^2$ |
| $ft^2$ | square feet | 0.093 | square meters | $m^2$ |
| $yd^2$ | square yard | 0.836 | square meters | $m^2$ |
| ac | acres | 0.405 | hectares | ha |
| $mi^2$ | square miles | 2.59 | square kilometers | $km^2$ |
| | | **VOLUME** | | |
| fl oz | fluid ounces | 29.57 | milliliters | mL |
| gal | gallons | 3.785 | liters | L |
| $ft^3$ | cubic feet | 0.028 | cubic meters | $m^3$ |
| $yd^3$ | cubic yards | 0.765 | cubic meters | $m^3$ |
| | NOTE: volumes greater than 1000 L shall be shown in $m^3$ | | | |
| | | **MASS** | | |
| oz | ounces | 28.35 | grams | g |
| lb | pounds | 0.454 | kilograms | kg |
| T | short tons (2000 lb) | 0.907 | megagrams (or "metric ton") | Mg (or "t") |
| oz | ounces | 28.35 | grams | g |
| | | **TEMPERATURE (exact degrees)** | | |
| °F | Fahrenheit | 5 (F-32)/9<br>or (F-32)/1.8 | Celsius | °C |
| | | **ILLUMINATION** | | |
| fc | foot-candles | 10.76 | lux | lx |
| fl | foot-Lamberts | 3.426 | $candela/m^2$ | $cd/m^2$ |
| | | **FORCE and PRESSURE or STRESS** | | |
| lbf | poundforce | 4.45 | newtons | N |
| $lbf/in^2$ | poundforce per square inch | 6.89 | kilopascals | kPa |

### APPROXIMATE CONVERSIONS FROM SI UNITS

| Symbol | When You Know | Multiply By | To Find | Symbol |
|---|---|---|---|---|
| | | **LENGTH** | | |
| mm | millimeters | 0.039 | inches | in |
| m | meters | 3.28 | feet | ft |
| m | meters | 1.09 | yards | yd |
| km | kilometers | 0.621 | miles | mi |
| | | **AREA** | | |
| $mm^2$ | square millimeters | 0.0016 | square inches | $in^2$ |
| $m^2$ | square meters | 10.764 | square feet | $ft^2$ |
| $m^2$ | square meters | 1.195 | square yards | $yd^2$ |
| ha | hectares | 2.47 | acres | ac |
| $km^2$ | square kilometers | 0.386 | square miles | $mi^2$ |
| | | **VOLUME** | | |
| mL | milliliters | 0.034 | fluid ounces | fl oz |
| L | liters | 0.264 | gallons | gal |
| $m^3$ | cubic meters | 35.314 | cubic feet | $ft^3$ |
| $m^3$ | cubic meters | 1.307 | cubic yards | $yd^3$ |
| mL | milliliters | 0.034 | fluid ounces | fl oz |
| | | **MASS** | | |
| g | grams | 0.035 | ounces | oz |
| kg | kilograms | 2.202 | pounds | lb |
| Mg (or "t") | megagrams (or "metric ton") | 1.103 | short tons (2000 lb) | T |
| g | grams | 0.035 | ounces | oz |
| | | **TEMPERATURE (exact degrees)** | | |
| °C | Celsius | 1.8C+32 | Fahrenheit | °F |
| | | **ILLUMINATION** | | |
| lx | lux | 0.0929 | foot-candles | fc |
| $cd/m^2$ | $candela/m^2$ | 0.2919 | foot-Lamberts | fl |
| | | **FORCE and PRESSURE or STRESS** | | |
| N | newtons | 0.225 | poundforce | lbf |
| kPa | Kilopascals | 0.145 | poundforce per square inch | $lbf/in^2$ |

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

# Contents

# List of Figures



# List of Tables

# Executive Summary

The Federal Government has the responsibility to fund and conduct research and technology (R&T) activities of national interest that will lead to solutions to highway transportation issues and significantly advance technology innovation with a clear public benefit when private investment is neither present nor sufficient.(1) In 2003, Federal Highway Administration (FHWA) leadership adopted a strategic management framework called the *Corporate Master Plan (CMP) for Research and Deployment of Technology & Innovation*.(2) Performance evaluation and measurement together form a major part of the CMP. FHWA shapes and executes a national R&T program comprising eight research components. Four of these components take place under the guidance of the Turner-Fairbank Highway Research Center (TFHRC) in McLean, VA. TFHRC leadership has adopted a Strategic Plan to guide the Center's continued development and capitalize on its significant accomplishments.(3) The research evaluation efforts described in this report focus directly on Goal 5 of the Strategic Plan: Research activities and outcomes are appropriately advanced through effective alignment of resources, dissemination of knowledge, and technology transition. In support of the CMP and the Strategic Plan, FHWA's R&T program has developed a research agenda to:(4)

- Communicate the agenda to external customers, stakeholders, and within FHWA.
- Provide a means for input and comment across the entire FHWA R&T portfolio.
- Open opportunities for greater R&D coordination and collaboration.
- Support system performance measures.
- Guide the investment of FHWA resources.

This report furthers the research agenda, summarizing 16 evaluations currently being conducted by staff at Volpe, The National Transportation Systems Center sponsored by FHWA's R&T Program. The evaluations are grouped into two waves. The first wave consists of six retrospective evaluations and four prospective evaluations. The second wave consists of six evaluations, all prospective. The report provides more detail about evaluations that are closer to completion. Many of the evaluations leverage both qualitative data (e.g., document review, semistructured interviews) and quantitative data (e.g., website statistics) to trace the diffusion of FHWA R&T recommendations, track the adoption of those recommendations, and determine the impact of adoption. An overview of the initial findings for the six retrospective evaluations is provided below. All findings can be found in the main text of this report and are discussed in more detail in the respective final reports for each project.

## Adaptive Signal Controls (ASC) (5)

- FHWA's development and outreach activities, particularly its Every Day Counts (EDC) program, played a major role in overcoming initial reluctance in the market to adopt ASC technologies.
- FHWA-funded teams and FHWA-influenced technology firms have continued to develop ASC systems that improved travel time and reduced congestion.

## Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS)(6)

- FHWA activities raised awareness and understanding of GRS-IBS technology and construction guidelines among the majority of stakeholders interviewed.
- The pace of GRS-IBS bridge construction increased and FHWA activities supported local stakeholders. Ongoing analysis seeks to clarify links between FHWA activities and GRS-IBS deployment.

### Gusset Plates [7]

- FHWA's technical expertise in bridge infrastructure and its prior history of working with the National Transportation Safety Board (NTSB) was critical during the I–35W bridge investigation.
- FHWA's commitment to bridge research and the decision to jointly fund the National Cooperative Highway Research Program (NCHRP) effort accelerated the research timeline, resulting in faster development of revised specifications for load rating and designing gusset plates.

### National Household Travel Survey (NHTS)[8]

- Nearly half of the publications using the 2014 NHTS are in the transportation field has increased. with the share of nontransportation publications growing and website data access increasing.
- Interviews suggest that NHTS informs policy and legislative decisions within transportation and other fields such as: The FHWA Report to Congress, The Nation's *Highways, Bridges and Transit: Conditions and Performance Report*; U.S. DOT Secretary Foxx's "Beyond Traffic" Report; calculations of the model year Corporate Average Fuel Economy Standards (CAFÉ); and the Centers for Disease Control and Prevention's (CDC's) ten year agenda, *Healthy People 2020*. The nature and extent of the impact on these decisions remains unclear.

### Roadside Revegetation [9]

- *Use of Roadside Revegetation: An Integrated Approach to Establishing Native Plants* helps to reinforce already mandated agency policies to end users.[10]
- Survey respondents and interviewees believed guide implementation has generally improved erosion, sustainability and environmental stewardship, and visitor experience outcomes.

### Roundabouts [11]

- FHWA R&T's research activities throughout the 1990s led to a significant increase in the amount of published material on roundabouts in the United States.
- FHWA efforts have helped to shape State policies towards roundabouts and have changed the attitude of transportation professionals towards roundabouts as an intersection alternative.

The remaining 10 evaluation teams do not yet have initial findings. The prospective wave 1 projects are continuing to refine evaluation plans with results expected over the next few years. Wave 2 projects have recently launched and evaluation planning will continue throughout the next year.

# List of Abbreviations and Acronyms

**Abbreviations and acronyms.**

| Acronym or Abbreviation | Meaning |
|---|---|
| ABMS | Agent-Based Modeling and Simulation |
| ALF | Accelerated Loading Facility |
| APT | Accelerated Pavement Testing |
| ASC | Adaptive Signal Control |
| ASCT | Adaptive Signal Control Technology |
| CMAQ | Congestion Mitigation and Air Quality Improvement Program |
| CMP | Corporate Master Plan for Research and Deployment of Technology & Innovation |
| EDC | Every Day Counts |
| FHWA | Federal Highway Administration |
| GRS-IBS | Geosynthetic Reinforced Soil Integrated Bridge System |
| NHTS | National Household Travel Survey |
| PCP | Precast Concrete Pavements |
| R&D | Research and Development |
| R&T | Research and Technology |
| RAS | Reclaimed Asphalt Shingles |
| SHRP2 | Second Strategic Highway Research Program |
| TFHRC | Turner-Fairbank Highway Research Center |
| TIM | Traffic Incident Management |
| VASTO | Evolutionary Agent System for Transportation Outlook |
| VOC | Vehicle Operating Costs |
| WMA | Warm Mix Asphalt |

# FHWA R&T and the Evaluation Program

The Federal Government has the responsibility to fund and conduct research and technology (R&T) activities of national interest that will lead to solutions to highway transportation issues and significantly advance technology innovation with a clear public benefit when private investment is neither present nor sufficient.(1) Research results—when implemented appropriately—can save millions of dollars, save lives, extend the life of highway infrastructure, reduce congestion, improve travel time, increase productivity, and positively impact the environment. FHWA's R&T program has developed a research agenda to:(4)

- Communicate the agenda to external customers, stakeholders, and within FHWA.
- Provide means for input and comment across the entire FHWA R&T portfolio.
- Open opportunities for greater R&D coordination and collaboration.
- Support system performance measures.
- Guide the investment of FHWA resources.

The FHWA R&T agenda considers future transportation needs from two perspectives: national-level challenges, and research programs designed to meet those challenges. FHWA research targets six of the Nation's high-priority highway challenges:(12)

1. *Advancing Safety Toward Zero Deaths*—a highway system free of fatalities.
2. *Improving the Mobility of People and Goods*—moving people and goods reliably and safely, to where they need to go.
3. *Maintaining Infrastructure Integrity*—keeping pavements, bridges, and structures in good condition.
4. *Enhancing System Performance*—decreasing highway congestion, safety risks, and wear-and-tear on roadways.
5. *Promoting Environmental Sustainability*—improving public health, enhancing the environment, and conserving natural resources.
6. *Preparing for the Future*—transforming big ideas into the innovations of tomorrow.

As the Table 1 shows, four of the eight research components take place under the guidance of the Turner-Fairbank Highway Research Center (TFHRC) in Virginia.

**Table 1. FHWA Research Components by Type and Lead Office.**

| Component Type | Component Name | Lead FHWA Office |
|---|---|---|
| Topical Area | Infrastructure | TFHRC |
| Topical Area | Operations | TFHRC |
| Topical Area | Safety | TFHRC |
| Topical Area | Planning, Environment, and Realty | Planning, Environment, and Realty |
| Topical Area | Policy | Policy and Government Affairs |
| Cross-Cutting Program | Exploratory Advanced Research | TFHRC |
| Cross-Cutting Program | Innovative Program Delivery | Innovative Program Delivery |
| Cross-Cutting Program | Federal Lands | Federal Lands Highway |

**Modified from FHWA. "Strategic Plan for the Turner-Fairbank Highway Research Center" (3)**

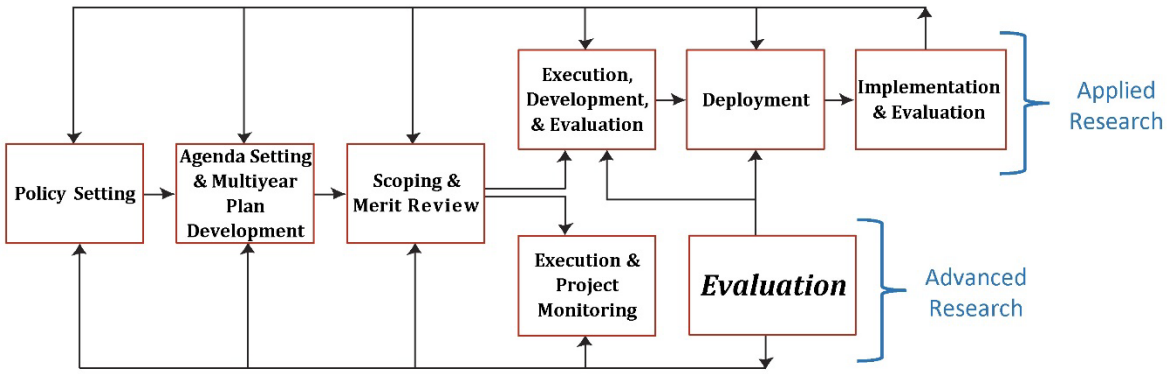
Furthering these research components and meeting the Nation's high-priority highway challenges will require the cooperation and collaboration of numerous stakeholders in the public and private sectors, academia, industry, and the international community.[1] It will also require continually reexamining and improving the process of selecting and executing research projects, disseminating findings, supporting user adoption, and assessing impact.

# The Role of Evaluation in FHWA R&T

In 2003, FHWA leadership adopted a strategic management framework called the *Corporate Master Plan (CMP) for Research and Deployment of Technology & Innovation* developed with input from stakeholders.[2] The purpose of the plan is to continue to improve the effectiveness and efficiency of R&T, including the end goal of deploying and implementing technologies and innovations that improve the quality, cost-effectiveness, and timeliness of products, procedures, processes, and practices. It lays out guiding principles, commitments, and key actions to strengthen FHWA roles as innovator and leader in national highway R&T. FHWA leadership pursued this strategic management framework to guide the organization as public demands for safety and efficiency grow faster than available resources.

The CMP is a response to *Highway Research: Systematic Selection and Evaluation Processes Needed for Research Program*, a report by the General Accounting Office (GAO) to Congress, which recommended that FHWA "develop a systematic process for evaluating significant ongoing and completed research that incorporates peer review or other best practices in use at Federal agencies that conduct research."[13] Performance evaluation and measurement form a major element of the CMP, both in the guiding principles and the FHWA R&T framework for applied and advanced research, as shown in figure 1.

**Figure 1. FHWA R&T framework for applied and advanced research.**




**Emphasis Added. Source: FHWA, "Corporate Master Plan for Research and Deployment of Technology & Innovation."[2]**

Guiding Principle #6 is particularly relevant; it states:

> *Guiding Principle #6—FHWA measures the performance of R&T on the Agency, program, and project levels.*
>
> *The Agency commits to:*
>
> - *Developing, defining, and adopting a framework for measuring performance.*
> - *Using merit review for conducting research evaluations and measuring performance.*[2]

TFHRC leadership has adopted a strategic plan to guide the Center's continued development. The plan sets forth broad principles and long-term goals to be planned and executed over several years. One of the long-term goals is to calibrate the Center's efforts to promote the adoption of research findings:

> *Goal 5 of the Strategic Plan: Research activities and outcomes are appropriately advanced through effective alignment of resources, dissemination of knowledge, and technology transition.*[3]

From a highway research perspective, technology transition is the incorporation of technology into operating transportation systems to achieve increased performance (safety, capacity, speed, energy efficiency, and emissions reductions) and/or to reduce costs. The plan recognizes that the dissemination of knowledge and technology transition require engaging external partners and targeting outreach.[3] Evaluation can help in the search for effective alignment by revealing the relationships between outreach, dissemination, transition, and increased performance. These relationships are the focus of the FHWA R&T Evaluation Program.

# The FHWA R&T Evaluation Program

The FHWA R&T Evaluation Program has been designed to further the transparency, accessibility, and responsiveness of R&T at TFHRC for stakeholders. Although designed to achieve long-term benefits, stakeholders may request that R&T programs show near-term benefits as well. Governmental R&T programs have the added obligation to justify spending public funds. Many highway research and technology stakeholders have come to recognize that the current, decentralized system for planning, conducting, sharing, and evaluating highway research and technology development is not fully meeting the collective needs of the public and national priorities.[14]

To support a more coordinated research agenda, FHWA and the Volpe Center have organized, clarified, and communicated FHWA's R&T mission, vision, goals, and priorities; and past, current, and planned projects. By sharing this information, FHWA hopes to encourage highway researchers to identify and fill research gaps, to reduce unnecessary duplication of research efforts, to stimulate collaborative research efforts, and to accelerate innovation.

Additionally, FHWA and Volpe have initiated an evaluation of FHWA's R&T program to guide the further development of the FHWA R&T Agenda and to identify and communicate its full range of benefits to the public. The FHWA R&T Evaluation Program seeks to answer these fundamental questions:

- Are we doing the right kinds of research?
- What portfolio mix best supports our strategic objectives?
- What kinds and extent of risk should we take on?
- Have the research results been deployed?
- Is the research having the desired impact?
- What is the public getting for the funds we spend?

In its initial year, the FHWA R&T Evaluation Program worked with 9 FHWA offices to identify 16 projects for evaluation across all program areas. The evaluations represent a mix of retrospective and prospective studies and range in schedule from 6 months to 4 years or more. The table below shows the 16 projects selected for evaluation, arranged by FHWA R&T research component, the type of evaluation—either prospective or retrospective—and whether the project belongs to the first or second wave of start dates.

**Table 2. FHWA R&T Evaluations by Research Component, Wave, and Type**

| Research Component | Wave 1 | Wave 2 |
|---|---|---|
| Safety | Roundabouts **[R]**<br>High Friction Surface Treatments (HFST)**[P]** | — |
| Operations | Adaptive Signal Control (ASC)**[R]** | Traffic Incident Management (TIM) Training **[P]** |
| Policy | National Household Travel Survey (NHTS)**[R]**<br>Vehicle Operating Cost (VOC)**[P]** | — |
| Innovative Program Delivery | — | Managing Risk on Rapid Renewal Projects **[P]**<br>Public-Private Partnership (P3) Toolkit **[P]** |
| Infrastructure | Gusset Plate **[R]**<br>Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS)**[R]**<br>Warm Mix Asphalt **[P]** | Precast Concrete Pavements (PCP)**[P]** |
| Planning and Environment | eNEPA **[P]** | Eco-Logical **[P]** |
| Federal Lands | Roadside Revegetation **[R]** | — |
| Exploratory Advanced Research | — | Agent-Based Modeling and Simulation (ABMS) related to Driver Behavior in Traffic and Evolutionary Agent System for Transportation Outlook (VASTO) projects **[P]** |

**Evaluation Type: [R] = Retrospective; [P] = Prospective; — = No Data**

# Program Status and Annual Report

Each evaluation progresses through an ordered series of deliverables, including the task management plan, preliminary evaluation plan, draft evaluation plan, final evaluation plan, draft report, and final report. Some evaluations—especially those spanning several years—also involve a data acceptability memo, periodic data reports, interim technical memos, and interim briefings. Six evaluation teams have completed data collection and finalized a report, and one other has submitted a final phase I report and is in the process of preparing its phase II report. Three evaluation teams have submitted their final evaluation plans (with one recently delivering an interim tech memo) while five other teams have submitted their draft evaluation plans. Of the remaining two, one team has submitted a preliminary evaluation plan and the other is preparing to initiate planning activities. Table 3 shows the status of each evaluation by the most recently completed deliverable.

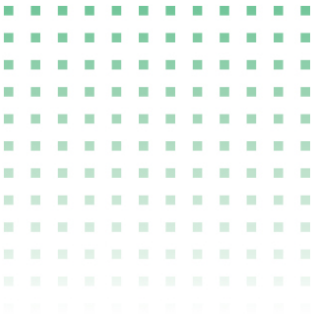
**Table 3. Evaluation of Latest Deliverables**

| Name of Project | Start Date | Last Completed Deliverable | Date Delivered |
|---|---|---|---|
| Adaptive Signal Controls | Sept. 2014 | Final Phase II Report | Jan. 2016 |
| Eco-Logical | June 2015 | Final Evaluation Plan | Jan. 2016 |
| eNEPA Tool | Oct. 2014 | Interim Tech Memo | Feb. 2016 |
| Exploratory Advanced Research | July 2015 | Draft Evaluation Plan | Mar. 2016 |
| GRS-IBS | Oct. 2014 | Revised Draft Report | Nov. 2015 |
| Gusset Plate | Sept. 2014 | Final Report | Jan. 2016 |
| High Friction Treatments | Oct. 2014 | Final Evaluation Plan | July 2015 |
| Managing Risk and Managing Complex Projects guidance | Oct. 2015 | Revised Preliminary Evaluation Plan | Apr. 2016 |
| National Household Travel Survey | Sept. 2014 | Final Report | Nov. 2015 |
| Precast Concrete Pavements | June 2015 | Updated Draft Evaluation Plan | Mar. 2016 |
| P3 Toolkit | Oct. 2015 | Draft Evaluation Plan | Mar. 2016 |
| Roadside Revegetation | Oct. 2014 | Final Report | Mar. 2016 |
| Roundabouts | Sept. 2014 | Final Phase 1 Report | Nov. 2015 |
| TIM Training | Oct. 2015 | Not Available | Not Available |
| Vehicle Operating Costs Study | Nov. 2014 | Draft Evaluation Plan | Nov. 2015 |
| Warm Mix Asphalt | Nov. 2014 | Draft Evaluation Plan | Oct. 2015 |

A full inventory of completed and planned deliverables is available in the appendixes. FHWA R&T Evaluation Program deliverables have been presented at Research and Technology Coordinating Committee (RTCC) meetings, program reviews, and other venues.

The six evaluation teams that have submitted draft reports all relied on document reviews and interviews. Half of these teams (GRS-IBS, Roadside Revegetation, and NHTS) also analyzed FHWA Web page usage statistics. Additionally, the Roadside Revegetation report draws from the results of a survey conducted by the evaluation team.

This annual report provides FHWA's Office of R&T with an overview of the entire evaluation effort to date and specific findings for each evaluation. The report provides more detail about evaluations closer to completion. Initial findings are available for each of the wave 1 retrospective evaluations. Proposed evaluation areas, methodology, and schedule are available for each of the wave 1 prospective evaluations. Program descriptions, initial scoping ideas, and anticipated schedules are available for each of the wave 2 evaluations. The evaluation summaries are provided in alphabetical order by wave and research design (retrospective and prospective).



# R&T Evaluation Summaries: Wave 1 Retrospective Evaluations

# Adaptive Signal Control (Operations)

## Program Description

Conventional traffic signal systems use preprogrammed daily signal timing schedules that do not automatically adjust to traffic conditions and can therefore contribute to traffic congestion and delay. Adaptive signal control (ASC) improves upon these systems by adjusting signal timing parameters that control the duration of red and green intervals to accommodate variability in demand using current traffic data. FHWA's ASC research program, which was initiated in the early 1990s, supported both development and deployment of ASC in the United States. This research program, which spanned over 20 years, can be divided into three major phases:

- Phase 1: R&T ASC Research and Development (Real-Time Traffic Adaptive Signal Control Strategy (RT-TRACS)).
- Phase 2: Adaptive Control Software-Lite (ACS-Lite) Development and Outreach.
- Phase 3: Every Day Counts (EDC) Adaptive Signal Control Technology (ASCT) Outreach.

The first two phases focused on technology development. FHWA funded two iterations of ASC technology development, managed pilot deployments, and developed informational materials to introduce the technology to traffic agencies. When development activities were complete, the program switched gears, focusing in the third phase on fostering ASC adoption by expanding outreach activities, developing guidance documents and materials, conducting training sessions, and providing technical assistance to agencies interested in pursuing the technology.

## Purpose of the Evaluation

The purpose of the ASC program evaluation is to assess the effects of FHWA's efforts related to developing ASCT and supporting the adoption of technology by State and local agencies.

## Methodology

The evaluation covered the three phases of FHWA research and outreach activities in two parts. The first part examined the entire ACST program through secondary research and interviews. The second part, which is ongoing, examines phase 3 through a survey of potential purchasers of ASCT.

The evaluation team reviewed research and documentation on the development, deployment, and impact of ASC to: identify stakeholders; understand the timing of relevant development activities, outputs, and short-term outcomes; and refine evaluation hypotheses. The documents reviewed included FHWA program material, websites of vendors and adopters, relevant research on ASC, and literature on technology diffusion models. Volpe conducted 19 interviews with ASC developers, vendors, local agencies, and FHWA program staff to provide context for the literature review. The team transcribed each interview and analyzed the notes to fill in gaps for the timeline analysis and to identify findings for each phase of FHWA research.

## Initial Findings

### Hypothesis 1: The FHWA R&T ASC activities accelerated the development of ASCTs.

#### Finding: FHWA had both a direct and indirect effect on ASC technology development [5]

In phase 1, FHWA directly funded the development and pilot testing of ASC algorithms through the RT-TRACS program. Of the four algorithms funded for development, three were pilot tested and two eventually came to market—Optimization Policies for Adaptive Control (OPAC) and Real Time Hierarchical Optimized Distributed Effective System (RHODES). Also, several of the signal control vendors and technology firms interviewed for this evaluation said that RT-TRACS encouraged them to begin or continue ASC research programs.

In phase 2, FHWA used lessons learned from RT-TRACS to develop ACS-Lite, a new algorithm that was less costly and complex for agencies to purchase and maintain. The contract firm developed the algorithm and four National Electrical Manufacturers Association (NEMA) signal control vendors partnered with FHWA to adapt their signal control equipment to run the technology. Two of the NEMA vendors went on to develop their own algorithms—one based on ACS-Lite. Outside these FHWA efforts, several vendors and technology firms developed or improved ASC products, often crediting RT-TRACS and ACS-Lite.

In phase 3, FHWA moved away from technology development to supporting ASCT in general. Eight additional ASCTs launched or came under development.

### Hypothesis 2: FHWA R&T ASC activities accelerated the deployment of ASCTs.

**Finding: FHWA development and outreach activities, particularly EDC, played a major role in overcoming initial reluctance in the market to adopt ASCT. (5)**

During the first two phases, only a handful of agencies deployed technologies developed independently of FHWA: Sydney Coordinated Adaptive Traffic System (SCATS), Split Cycle Offset Optimization Technique (SCOOT), Los Angeles Adaptive Traffic Control System (LA ATCS), and Insync. Interviews, document review, and timeline analysis suggest that without FHWA's programs, it is unlikely that many agencies would have been aware that the technologies were being developed and deployed in the United States at this time.(5) In phase 3, EDC shifted FHWA's efforts from ASCT development to supporting the growth of the industry. The program reached State and local traffic agencies in 42 States, providing general information about ASCT through workshops, presentations, and meetings. The hallmark of the EDC effort was the development of the Model Systems Engineering Document for ASCT Systems, which provided guidance for State and local agencies on assessing and selecting ASCT systems. Interview responses suggest that EDC had a significant effect on encouraging agencies to adopt ASCT by providing the knowledge, training, and support needed to get the technology deployed. Since 2009, over 176 ASCT systems have been implemented, and many other agencies are considering the technology.

### Hypothesis 3: The FHWA ASC activities improved mobility and reduced emissions.

**Finding: Through the three phases of the FHWA R&T ASC program both FHWA-funded teams and FHWA-influenced technology firms have continued to develop ASCT systems, which improved travel time and reduced congestion in recent studies.(5)**

Because there were few deployments of ASCT in the United States prior to 2009, the analysis of ASCT effectiveness is based on a relatively small number of performance evaluations in each phase (8 in phase 1, 18 in phase 2, and in phase 3). Therefore, the results speak primarily to the potential of the technology to impact congestion and travel time rather than its fully realized impact. Phase 1 studies showed mixed results in the ability of ACST to reduce travel time and delay. Phase 2 studies revealed improvement. Phase 3 studies show that the majority of ASCTs on the market—including all of those directly affected by FHWA—reduce travel time, delay, and congestion.

# Geosynthetic Reinforced Soil Integrated Bridge System (Infrastructure R&D)

## Program Description

Geosynthetic reinforced soil (GRS) technology consists of closely spaced layers of GRS and compacted granular fill material. The technology was first applied by the United States Forest Service (USFS) in the 1970s to build walls for roads in steep mountain terrain. Since then, FHWA has worked to evolve the technology into the Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS), a fast, cost-effective method of bridge support that blends the roadway into the superstructure. The claimed advantages of GRS-IBS are that it is easy to design, uses low cost materials, can be built in variable weather conditions, and can easily be modified in the field.

The technology was selected for FHWA's EDC initiative, which aims to accelerate the implementation of proven, market-ready technologies. To promote the technology to State departments of transportation (DOTs) and local transportation agencies, EDC conducted a total of 62 outreach events across the country between February 2011 and July 2015, including 24 State DOT workshops, 15 showcases of GRS-IBS projects, and numerous presentations at conferences and on webinars.(6) FHWA's TFHRC disseminated several technical documents to assist transportation agencies in implementing GRS-IBS.

## Purpose of the Evaluation

The purpose of the GRS-IBS program evaluation is to determine how effective FHWA's outreach and technical assistance efforts were in increasing awareness, understanding, and deployment of GRS-IBS technologies by State and local transportation agencies. The evaluation also aims to determine the extent to which deployment of GRS-IBS technologies resulted in time or cost savings for infrastructure owners. The evaluation also examines the organizational supports and barriers to GRS-IBS deployment.

## Methodology

The evaluation team focused the evaluation of the GRS-IBS research program on outreach and deployment activities during the first two cycles of the FHWA EDC Program (2011–2014). The team reviewed FHWA documents and conducted 37 semistructured phone interviews. Relevant documents included FHWA materials, FHWA website statistics, and attendance at EDC events for GRS-IBS. Those interviewed included staff from TFHRC, the Resource Center, EDC, Federal Lands, and the Office of Infrastructure; local and State engineers, both from States that had attended outreach events and/or used GRS-IBS implementation materials, and those who had not. Design consultants, American Association of State Highway Transportation Officials (AASHTO) board members, and academic researchers were also interviewed. The evaluation is based primarily on these qualitative sources because of shortcomings in the quantitative data collected.

An additional study on GRS costs and a revision to the draft GRS-IBS evaluation report are forthcoming.

## Initial Findings

**Hypothesis 1: FHWA activities raised awareness and understanding of GRS-IBS technology and construction guidelines.**

**Finding: FHWA activities raised awareness and understanding of GRS-IBS technology and construction guidelines among the majority of stakeholders interviewed.**

While 8 of the 11 State and local engineers interviewed said that they had not heard of GRS-IBS prior to attending an EDC event and many of the stakeholders interviewed spoke very positively about FHWA activities, this study cannot determine whether FHWA activities raised awareness nationwide.(6)

### Hypothesis 2: FHWA activities accelerated the deployment of GRS-IBS technologies.

#### Finding: FHWA activities have supported local stakeholders and the pace of GRS-IBS bridge construction has increased.

But the degree to which the former contributed to the latter remains unclear. Stakeholders interviewed reported that FHWA materials and resources supported engineers implementing GRS-IBS. The data show that 34 GRS-IBS bridges were constructed in 23 different counties between 2011 and 2014 following exposure to FHWA outreach and technology transfer activities. This is an increase over the 11 GRS-IBS bridges constructed in 2 different counties between 2005 and 2010.(6)

### Hypothesis 3: Accelerated deployment of GRS-IBS technologies resulting from FHWA activities reduced design and construction costs and time.

#### Finding: Preliminary analysis shows GRS-IBS technologies can reduce bridge construction costs and construction time, but conflicting evidence exists.

Research is underway to explain discrepancies. Most State DOT and local agency stakeholders who were involved in the construction of a bridge using GRS-IBS technology believed the technology helped to achieve cost and/or time savings in bridge construction. Some stakeholders said that the construction of a GRS-IBS bridge took as little as one-third to two-thirds of the time that a standard bridge took to build. Several stakeholders also reported cost savings up to 50 percent by using GRS.(6) However, some agencies reported higher costs. FHWA is sponsoring Volpe to investigate the source of these cost discrepancies. One possible explanation is that unfamiliarity with the technology leads some users to stray from GRS-IBS guidelines in ways that inflate costs.

## Additional findings

#### Finding: Stakeholders reported hesitancy to embrace GRS-IBS technology both within FHWA and local agencies.

Some interviewees noted there was debate within FHWA as to whether GRS-IBS was ready for deployment. One FHWA engineer commented that “the implementation push got ahead of the ability to answer technical questions.”(6) Some engineers are also hesitant to depart from traditional methods of bridge construction. Interviewees noted that the “interim” status of GRS-IBS guidance led to uncertainty in the engineering field.

#### Finding: Initial support for GRS-IBS may be stronger at the county and municipal levels than at the State DOT level.

After multiple county and municipal agencies constructed GRS-IBS bridges in Pennsylvania, PennDOT adopted and approved the use of GRS-IBS design for low-volume local roads throughout the State.(6) Defiance County, OH, engineers are among the most aggressive adopters of GRS-IBS technologies.(6)

# Gusset Plates (Infrastructure)

## Program Description

The main span of the Interstate 35 West (I–35W) Bridge deck truss in Minneapolis, MN, collapsed on August 1, 2007, killing 13 people and injuring 145.[15] While investigating the incident, the National Transportation Safety Board's (NTSB) turned to FHWA for technical expertise, focusing on the gusset plate construction of the deck truss. A gusset plate is a thick sheet of steel used to join structural components, such as connecting girders, to bracing or linking truss members. Before the I–35W Bridge collapse, bridge designers were given considerable discretion in designing gusset plates. Additionally, it was assumed that gusset plates should not have to be load rated unless there were changes in their condition, such as a section lost due to corrosion.

Within months of the collapse, NTSB issued its first recommendation—H-08-001—to FHWA, requiring that bridge owners conduct load capacity calculations to verify stress levels in all structural elements, including gusset plates.[16] In response to this recommendation, FHWA's R&T conducted research and analysis on the failure modes of gusset plates and proposed recommendations for necessary gusset plate design and inspection standards through the NCHRP. The project culminated in NCHRP Web-Only Document 197, which was used to develop new AASHTO load and resistance factor design (LRFD) specifications for the design and rating of gusset plate bridges.[17]

## Purpose of the Evaluation

This evaluation seeks to understand how FHWA's investment in gusset plate research impacted the design and rating of gusset plate bridges. This report documents the process by which FHWA responded to NTSB's recommendations—particularly Recommendation H-08-001—by conducting and disseminating key research to improve specifications for gusset plate design and load rating. The evaluation also examines how FHWA research contributed to the revision of AASHTO LRFD Bridge Design Specifications (BDS) and the Manual for Bridge Evaluation (MBE).

## Methodology

The evaluation team conducted interviews with key stakeholders and reviewed documents from FHWA, NTSB, and a selection of States. The Volpe team interviewed three NTSB staff members who worked on the I–35W Bridge investigation, two FHWA staff members who worked on key related efforts (the I–35W Bridge investigation, the Performance and Design of Steel Gusset Plate Connections project, and NCHRP Project 12-84), and four current and former members of the AASHTO Committee on Structural Steel Design.

The evaluation team also reviewed numerous documents and found six documents especially helpful: NTSB's final report on the I–35W Bridge, NTSB's first recommendations to FHWA, a set of correspondences between NTSB and FHWA, FHWA's load rating recommendations, FHWA's guidelines to bridge owners, and NCHRP's gusset plate load rating specifications.

## Initial Findings

**Hypothesis 1: FHWA's R&T activities led to the development, adoption, and application of improved specifications for the design and load rating of gusset plates.**

**Finding: FHWA's technical expertise in bridge infrastructure and its prior history of working with NTSB was critical during the bridge investigation.[7]**

FHWA ultimately provided the knowledge and expertise on gusset plate performance that led NTSB to conclude a gusset plate design error caused the collapse. Few truss bridges are being constructed, but many such bridges will exist in State inventories for a long time. FHWA's input helped constructively refocus the conversation away from preventing gusset plate design errors to how States should maintain existing structures to prevent another collapse.

### Finding: FHWA's coordination with key stakeholders contributed to an accelerated timeline to closing NTSB recommendations.[7]

While Minnesota DOT and the engineering firm that designed and constructed the bridge were involved in discussions with NTSB, FHWA was the predominant party that participated in NTSB meetings about the problem and potential solutions. It became clear during the investigation phase that the gusset plate design problem had national implications, and FHWA was in a position to provide support on a far-reaching solution. FHWA's close collaboration and coordination with NTSB was a major contributing factor to closing out NTSB's recommendations.

### Finding: FHWA's commitment to bridge research and the decision to jointly fund the NCHRP effort accelerated the research timeline, resulting in expedient development of revised specifications for load rating and designing gusset plates.

Initial scoping efforts for what would eventually become NCHRP Project 12-84 began in May 2008. Within 2 months, FHWA and NCHRP reached an agreement to jointly fund the research. The project kicked off in October 2008, less than 1 year from initial scoping. The typical life of a NCHRP project concludes about six to seven years after funding is approved, and in the case of 12-84, it was determined that answers were needed much quicker for gusset plates than this typical time range. FHWA was able to hit the ground running without going through the development of a Request for Proposal and contractor selection that usually takes approximately 2 years. The quick initiation of the research project was integral to promptly updating AASHTO's LRFD BDS and MBE

## Hypothesis 2: FHWA's R&T activities led to diffusion of new knowledge about the design and load rating of gusset plates.

### Finding: FHWA's active and ongoing engagement of transportation stakeholders expedited the delivery of new information regarding the design and load rating of gusset plates.

A review of correspondence between NTSB and FHWA concerning Recommendation H-08-001 shows that FHWA embarked on a series of internal and external outreach efforts related to gusset plate research.[7] FHWA, in conjunction with AASHTO, provided ongoing technical assistance and guidance to FHWA field offices and bridge owners about load rating and the evaluation of gusset plates on steel truss bridges. In 2009, FHWA published *Load Rating Guidance and Examples for Bolted and Riveted Gusset Plates in Truss Bridges*.[18] The agency also sponsored several national teleconferences and a conference to familiarize FHWA and State bridge engineers with using the FHWA guidance.

# National Household Travel Survey (NHTS, Policy)

## Program Description

National travel surveys have been conducted by the FHWA for over 45 years. The most recent versions, known as the National Household Travel Surveys (NHTS), were conducted in 2009 and 2001.(19,20) The surveys are the only data in the country that link individual personal travel behavior, household demographic and socioeconomic characteristics, vehicle ownership, and vehicle attributes. The NHTS data are used to monitor and track national travel behavior and also to provide information to States and metropolitan planning organizations (MPOs), where local data are oftentimes lacking.

## Purpose of the Evaluation

The purpose of the evaluation is to understand the extent of use of FHWA's NHTS data and the longer term impacts of their availability and use on policy, program, and regulatory decisions.

## Methodology

Volpe determined the range of users of NHTS data by reviewing FHWA documents and outreach efforts (including NHTS Web page usage statistics and by conducting interviews with lead users (academic, government, and consultants). The impact of FHWA's NHTS data on decisionmaking relied on a review of Federal, State, MPO, and academic research products and interviews with NHTS staff and lead users. Measurement of the responsiveness of the NHTS program to user feedback was supported by document reviews and interviews. Lessons learned were also compiled through the interviews. Information gathered from documents and interviews was organized in a spreadsheet by key hypothesis, enabling a synthesis and comparison of information across sources.

## Initial Findings

**Hypothesis 1: NHTS activities produce data used by a range of users across multiple fields**

**Finding: Nearly half of the publications using the 2014 NHTS are in the transportation field with the share of non-transportation publications growing and website data access increasing.**

An analysis of the 2014 NHTS Compendium of Uses document demonstrates that the NHTS are used across a range of fields.(21) While 46 percent of publications are primarily transportation focused, more than half of publications have a primary application in some other field, including energy (25 percent), survey methods or analysis (12 percent), environment (9 percent), and health (8 percent).(8) The evaluation team also found that NHTS publications cover a range of transportation topics. When Compendium publications are analyzed over time (2011 through 2014), the team found that the share of publications in nontransportation fields (e.g., health, environment, energy) grew significantly. Monthly website usage statistics for July 2013 through May 2015 indicate that use is robust with growth in some (but not all) metrics. For example, the number of monthly visits to the website increased from 5,118 to 8,443 over this time period.(8) The data also reveal a cyclical trend to usage, with spikes in the spring and fall.(8)

## Hypothesis 2: NHTS data informs policy, projects, and regulatory decisionmaking

### Finding: While it is difficult to trace the precise decision outputs of NHTS, the interviews suggest that NHTS informs policy and legislative decisions within transportation and other fields.

With respect to legislative uses, the evaluation team found NHTS data referenced in congressional reports, including "The Nation's Highways, Bridges and Transit: Conditions and Performance Report" and in a series of reports produced by The National Surface Transportation Policy and Revenue Study Commission, established by Congress.[22] As an input to U.S. DOT Secretary Foxx's "Beyond Traffic", NHTS informs the national dialogue on the state of transportation.[23] Likewise the Safer People, Safer Streets: Pedestrian and Bicycle Safety Initiative by Secretary Foxx relies on NHTS data to provide an understanding of the use of biking and walking for daily travel.[24] NHTS data is also an input to the calculation of the model year Corporate Average Fuel Economy (CAFE) Standards.[25] In addition, NHTS is used in other fields including health, energy and the environment. For example, the CDC has incorporated NHTS data in its ten year agenda, *Healthy People 2020*, and most recently in the Surgeon General's Call to Action to Promote Walking and Walkable Communities.[26,27] States and MPOs also utilize the data for a range of purposes, including to develop, calibrate, or validate their travel demand models. Interviewees indicated that these models are critical to transportation planning and also inform corridor level, interchange and transit projects, as well as air quality reports required by the Environmental Protection Agency (EPA) (e.g., in non-attainment areas).[8] However, tracing how and to what extent NHTS informs policy and legislative decisions is challenging since policy and legislative proceedings do not provide such information. One interviewee explained, "[NHTS] builds a mosaic of understanding and provides context, based on data; evidence can ripple through the system and have an effect. [NHTS] informs the conversation about important topics."[8] Following such ripples through the system could serve as the basis for a future evaluation.

## Hypothesis 3: The NHTS program is responsive to user feedback

### Finding: NHTS reaches out to its user community through its website, direct contact, and formal events.

NHTS provides user support via its website and through direct contact with users who have questions and requests. NHTS also conducts a number of formal outreach activities, including Transportation Research Board (TRB) sessions, committee updates, workshops, and conferences. In 2011, NHTS organized the NHTS Task Force, which serves as a bridge between the NHTS team and the user community. Based on user feedback, NHTS has introduced more online tools (e.g., academy modules) and has changed its survey methodology.

# Roadside Revegetation (Federal Lands)

## Program Description

Twenty-eight percent of land in the United States is under Federal stewardship, including national parks, forests, wildlife refuges, and tribal and other Federal lands.[28] Native roadside revegetation involves establishing or reestablishing appropriate plant material on areas that road construction projects disturb. Its benefits include soil and slope stabilization, improved water quality, aesthetics, carbon sequestration, weed suppression, and enhanced wildlife habitat. Recognizing that sharing information about roadside revegetation processes and techniques is one way to advance the practice and achieve these benefits, FHWA's Federal Lands Highway Division (FLH) teamed up with the USFS to develop an assessment and monitoring protocol for roadside revegetation. That protocol is documented in *Roadside Revegetation: An Integrated Approach to Establishing Native Plants*.[10]

## Purpose of the Evaluation

The purpose of this evaluation is to determine how effective the guide and related materials (such as a website and training course featuring the guide) have been in achieving their stated goals, which are to:

- Change end user revegetation practices and adopt those put forth in the guide.
- Improve the establishment of native plants and generate other positive outcomes.

## Methodology

The evaluation team reviewed the literature on revegetation, analyzed website usage and feedback from website users, and conducted an online survey with followup interviews. Literature was collected primarily from screening relevant websites and through library scans on keywords such as "roadside revegetation" and "native revegetation." The review included manuals, policy documents, and guides from State agencies, the Bureau of Reclamation (BLM), and the National Park Service (NPS). FHWA's Western Federal Lands (WFL) provided the project team with historical Web visitation statistics for all dates between January 1, 2010 and February 17, 2015, and recent examples of emails from end users. The emails offer insights about the perceived quality and effectiveness of the guide and website. From April 1, 2015, to approximately July 31, 2015, the project team administered an online survey to agencies that may have implemented practices from the *Roadside Revegetation* guide, receiving 39 responses from individuals in 21 States. Responding agencies included FHWA (23), USFS (7), NPS (5), and the U.S. Fish and Wildlife Service (2). Two State DOTs also responded. The survey asked questions regarding the level of awareness of *Roadside Revegetation* and its website, the extent to which stakeholders have adopted the practices described in the guide, and how effective the changed practices have been in achieving the establishment of native plants and other positive outcomes along roadsides.[29] The project team contacted 10 respondents for interviews based on responses to the online survey and conducted 4 interviews.

## Initial Findings

### Evaluation Area 1: The extent to which end users have adopted *Roadside Revegetation* guide practices

**Finding: End users have adopted the *Roadside Revegetation* practices, using the guide as a reference tool to reinforce practices that agency policies already mandated.**

The NPS, USFS, and some State DOTs have policies aligned with roadside revegetation.[30,31] Additionally, visits to the nativevegetation.org have increased over time, with 44,621 total users from January 1, 2010 to February 17, 2015—approximately 24 per day. Over 7,000 of those users (nearly 16 percent) returned to the website more than once.[9] The data show that the most visited Web pages are in the technical guide itself. Multiple survey respondents noted that they primarily use *Roadside Revegetation: An Integrated Approach to Establishing Native Plants* as a general reference guide, while at the project site and when writing revegetation plans, designing monitoring protocols, developing scopes of work, and analyzing data.[9] The technical guide has enabled some practitioners to better define future conditions and end goals for project sites.

### Evaluation Area 2: The extent to which *Roadside Revegetation* has improved the establishment of native plants and resulted in other positive outcomes

**Finding: Survey respondents and interviewees believed *Roadside Revegetation* has generally improved erosion, sustainability and environmental stewardship, and visitor experience outcomes.**

Interviewees and several survey respondents pointed out that the application of nonnative plants is probably less expensive than using native plants, but in the long term the maintenance of nonnative plants is more costly than native plants.[9] There is less indication that the technical guide has helped to improve safety or reduce maintenance costs. The majority of survey respondents neither agreed nor disagreed with the statement, “safety has been improved.”

# Roundabouts (Safety)

## Program Description

Roundabouts are circular intersections where approaching traffic yields to circulating traffic. Interest in roundabouts began internationally in the 1970s and 1980s for their ability to reduce speed and dangerous left-hand turns compared to traditional signalized intersections. In the mid-1990s, FHWA initiated research on roundabouts safety and design, leading to several papers and the publication of *Roundabouts: An Informational Guide* in 2000.[32] Later work led to higher quality performance data, refined roundabout design practice, and safety solutions for cyclists and pedestrians. Subsequent FHWA activities included the development and sharing of educational resources, training, technical assistance, and a partnership with NCHRP for the second edition of *Roundabouts: An Informational Guide*.[33]

## Purpose of the Evaluation

The purpose of this evaluation is to assess the effects of FHWA's investment in roundabout research on the availability and quality of roundabouts research, adoption of roundabouts in the United States, and the impacts of those roundabouts on the safety, operational, and environmental performance of the transportation system in the United States.

## Methodology

To benefit from active data collection efforts and reduce duplication, the evaluation team split the evaluation into two phases. The current report covers phase 1. The methodology and findings from the phase 2 will be covered in the final report.

- Phase 1: November 2014–September 2015: This first phase focuses on metrics related to FHWA research products and short-term outcomes, as well as long-term outcomes of adoption, and safety and operational impacts.
- Phase 2: December 2015–July 2016: The second phase updates the phase I report with additional evaluation of intermediate and longer term outcomes related to States' changes in attitudes, policies, behavior, and adoption of roundabouts, using inputs from State DOT interviews and information from two forthcoming NCHRP syntheses.[34,35]

The evaluation team employed a logic model to identify four evaluation areas with related primary hypotheses, secondary hypotheses, and performance measures. These are used to organize the initial findings.

The evaluation relies primarily on documentary evidence, supplemented by data analysis and interviews. The literature search included FHWA documents, relevant research on roundabouts, TRB Annual Meeting programs, Roundabouts List Serve archives, and literature on technology diffusion. To assess the influence of FHWA research and outreach on State DOTs, evaluators reviewed State-level materials, including Strategic Highway Safety Plans (SHSPs) and State highway design manuals, and State DOT websites.

The team used quantitative analysis—when available—to better understand the funding of roundabouts, the number of roundabouts, and the safety impacts of roundabouts. The evaluation team conducted interviews with FHWA staff and the TRB Roundabouts Committee chair to better understand the scope and extent of FHWA activities and to complement other analyses.

## Initial Findings

The findings for the evaluation of roundabouts research highlight evidence from each of four evaluation areas.

## Evaluation Area 1: The availability and reliability of roundabouts safety and performance data.

### Finding: FHWA R&T research activities throughout the 1990s and up to the publication of the *Informational Guide* in 2000 led to a significant increase in the amount of published material on roundabouts in the United States.[32]

Initial FHWA contributions increased the availability of domestic roundabouts information by synthesizing international and the limited domestic safety and design research. The considerable impact of these contributions is evidenced by the number and breadth of citations to FHWA research and research influenced by FHWA. The interviews revealed that FHWA played an important role in accelerating consideration of roundabouts as a research topic and the development of domestically focused safety and performance studies.[11]

## Evaluation Area 2: A change in awareness and knowledge of and attitudes towards roundabouts.

### Finding: FHWA efforts have helped to shape State policies towards roundabouts and have changed the attitude of transportation professionals towards roundabouts as an intersection alternative.[11]

FHWA research, culminating in the 2000 *Roundabouts: An Informational Guide*, increased the availability of information on roundabouts in the United States. These products provided states and stakeholders with more information on how to utilize roundabouts as a safety countermeasure, and an FHWA endorsement of the technology. FHWA Safety R&D worked closely with the FHWA Office of Safety and the FHWA Resource Center to conduct sustained outreach, including making policy changes and recommendations within FHWA. This, in turn, shaped state policies towards roundabouts and resulted in changes of attitudes of transportation professionals towards the roundabout as an intersection alternative.

## Evaluation Area 3: The adoption of roundabouts as a safety countermeasure

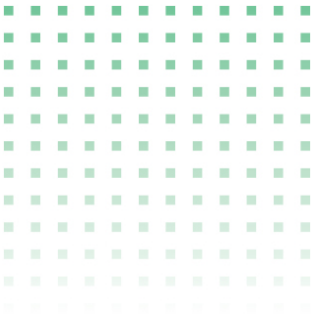
### Finding: FHWA played an active role in accelerating the early adoption of roundabouts.

Through leadership and research and by meeting the needs of the earliest adopters, FHWA led to an increase in the total number of roundabouts. Funding provided under programs designed to increase safety (e.g., the Highway Safety Improvement Program (HSIP)), and traffic flow improvement and environmental benefits (e.g., the Congestion Mitigation and Air Quality Improvement Program (CMAQ)), provided continued support to the earliest and most confident adopters, while also providing confidence to later adopters.[36,37]

## Evaluation Area 4: The safety, operational, environmental, and economic impacts of roundabouts

### Finding: A review of the existing literature suggests there are significant emissions, operational flow, and safety benefits to roundabouts.

FHWA's work to promote roundabouts in the United States has resulted in their increase in number. While considering the multidimensional impacts of all the roundabouts installed due to FHWA's influence lies beyond the scope of this evaluation, the Volpe team reviewed the literature, which confirms that significant benefits accrue from installing modern roundabouts, including reduced emissions and improved operational flow. FHWA-influenced roundabout adoption has helped to reduce the number of crashes at U.S. intersections. The evaluation team calculated that the roundabouts installed in the United States between 1990 and 2014 averted between 38,000 and 53,000 injurious crashes, resulting in a societal cost savings upwards of $9 billion.[11] While FHWA cannot claim direct responsibility for this impact, its continued research and promotion of roundabouts has had a significant, positive impact on roadway safety in the United States.



# Evaluation Summaries: Wave 1 Prospective Evaluations

# eNEPA (Planning, Environment, and Realty)

## Program Description

eNEPA is an online workspace and collaboration forum for major projects requiring an environmental impact statement (EIS) or an environmental assessment (EA), as required by the National Environmental Policy Act (NEPA).[38,39] Since the Transportation Equity Act for the 21st Century a central focus of FHWA efforts to accelerate project delivery has been to establish coordinated environmental review processes with concurrent interagency reviews and established time periods.[40] FHWA developed eNEPA for State DOTs to use in support of interagency reviews with the intent of creating a transparent and streamlined process across States and transportation projects. The tool was rolled out nationally in August 2013.

## Purpose of the Evaluation

This evaluation will determine eNEPA's effectiveness at creating a transparent and streamlined process across States and transportation projects that improves the quality of environmental documents and reduces the time needed to conduct environmental reviews for EAs and EISs.

In addition to documenting current use and outcomes, the evaluation will identify how to improve eNEPA to better meet the needs of the transportation and regulatory agencies involved in project development.

## Proposed Evaluation Areas, Questions, or Hypotheses

The evaluation team will focus on four evaluation areas:

- *Breadth and Depth of Use:* Documentation of eNEPA users, the type of projects for which they are using eNEPA, and the purpose for which they are using eNEPA.
- *Usability:* Documentation of eNEPA user friendliness, challenges of using the tool, and additional features desired.
- *Project Environmental Review Timeline:* Determination of the extent to which eNEPA has affected the time required to complete the environmental review process.
- *Interagency Collaboration:* Determination of the extent to which eNEPA has affected the timing, quantity, and quality of collaboration among agencies while developing environmental review documents.

## Proposed Methodology

The evaluation team has developed evaluation criteria, measures of effectiveness, data inputs, and preferred data sources for each evaluation area. The team will collect data through interviews, eNEPA statistics of users and projects, and a review of agency standard operating procedures (SOPs). The team will conduct interviews with two FHWA Planning, Environment, and Realty program staff members and NEPA staff members from up to nine State DOTs using eNEPA and up to nine State DOTs *not* using eNEPA. Users will be asked about how they employ eNEPA for projects, the usability of eNEPA, how eNEPA has impacted the environmental review timeline, and how eNEPA has impacted interagency collaboration on the environmental review. Quantitative data collection will include—to the extent availability allows—eNEPA statistics on users, projects, and milestone completion dates (e.g., Notice of Intent (NOI), draft environmental impact statement (DEIS), final environmental impact statement (FEIS), and record of decision (ROD)).

## Activities to Date and Anticipated Schedule

The eNEPA evaluation plan was finalized in August 2015. The evaluation activities, such as the interviews and data collection, will began in September 2015 and continue through Fiscal Year 2018, culminating in a draft report to be delivered in March 2018.

# High Friction Surface Treatments (Safety)

## Program Description

High Friction Surface Treatments (HFST) involve the overlay of calcined bauxite on a base of epoxy along portions of roadways that are susceptible to vehicle slippage. Calcined bauxite supports the grip of tires along the road and inhibits a plane of water from forming between the road and tires.

The HFST project culminated in the report, *Evaluation of Pavement Safety Performance* (EPSP).[41] The report supports the use of HFST to improve safety, although the findings were constrained by limitations in the data and method. Ongoing research on developing crash modification factors (CMFs) will be published in the CMF Clearinghouse and Interactive Highway Safety Design Manual (IHSDM).[42,43]

Intended outcomes of the EPSP and associated outreach include the establishment of accepted CMFs; supporting HFST as a road improvement alternative through an increased adoption by State and local transportation agencies; and the inclusion of HFST as both a safety and pavement feature in pavement design and roadway design guides.

## Purpose of the Evaluation

The purpose of the evaluation is to understand the effect of FHWA R&T activities on the knowledge and deployment of high friction surface treatments by State decisionmakers.

## Proposed Evaluation Areas, Questions, or Hypotheses

Through initial scoping activities, discussions with FHWA staff, and an analysis of HFST program documentation, the evaluation team identified three areas for evaluation:

- *Change in awareness, knowledge, and attitudes:* Changes in awareness of, attitude about, and confidence in, HFST as a safety countermeasure, both within FHWA and among FHWA stakeholders.
- *Adoption as a safety countermeasure*: The extent to which the number of HFST projects in the United States grew and the extent to which FHWA research contributed to this growth.
- *Safety impacts:* The extent to which the growth in the number of HFST projects in the United States contributed to improved safety of investments by transportation agencies.

## Proposed Methodology

The evaluation team has developed evaluation criteria, measures of effectiveness, data inputs, and preferred data sources for each evaluation area. The team will collect data through interviews and document review. The documents will include transportation meeting proceedings, HSIP reports, and State and MPO materials (design manuals, SHSPs, Transportation Improvement Programs (TIPs), and Highway Safety Plans (HSPs)). The evaluation team will also access materials from the CMF Clearinghouse.[42]

To assess the extent to which FHWA HFST-related research is likely to influence the attitude of the transportation community towards HFST as a safety countermeasure, the evaluation team will identify indicators and evidence of confidence in HFST. Assessing the impact of R&T research on HFST adoption will rely on changes in the number of HFST projects relative to competing countermeasures. Evaluators will also gauge the incremental safety impact of R&T HFST research.

## Activities to Date and Anticipated Schedule

The final evaluation plan was completed in July 2015. The evaluation team will submit quarterly data acceptability reports upon receiving data and annual interim tech memos starting in February 2016. The draft report is expected in October 2018.

# Vehicle Operating Costs (Policy)

## Program Description

FHWA uses vehicle operating costs (VOC) estimates as inputs to the Highway Economic Requirements System (HERS) model.[44] The HERS model uses benefit-cost analysis to rank and select potential improvement projects and estimates the investment levels that would be needed to attain various targets. The HERS model is also an important component of the biennial *Status of the Nation's Highways, Bridges, and Transit: Conditions and Performance Report to Congress* (C&P Report), which is read by a range of decisionmakers.[22] The current VOC equations are based on a 1982 study discussed in the report, *Vehicle Operating Costs, Fuel Consumption, and Pavement Type and Condition Factors*.[45] In 2014, FHWA's Office of Transportation Policy Studies contracted the University of Nevada, Reno (UNR) to conduct 5 years of research and analysis related to VOC estimation. The evaluation team will provide oversight of UNR's work and focus on long-term or indirect outcomes of the updated methodology.

## Purpose of the Evaluation

The purpose of this evaluation is to build from UNR's work by determining the long-term or indirect outcomes of the updated methodology. The level and nature of Volpe assistance will be determined pending ongoing UNR evaluation scoping.

## Proposed Evaluation Areas, Questions, or Hypotheses

The evaluation team has identified three evaluation areas to complement UNR research activities.

- *Breadth and Depth of Use:* Determine who utilizes the VOCs, equations, and methodologies, in what capacity they use these resources, and what impact the update had on their work.
- *Policy, Project, or Regulatory Decisions:* Identify the governmental and nongovernmental policy and regulatory decisions impacted by these changes and the nature and magnitude of impact.
- *Response to VOC and Methodology* Update*:* Understand stakeholders' perceptions of these changes.

## Proposed Methodology

The evaluation team has developed evaluation criteria, measures of effectiveness, data inputs, and preferred data sources for each evaluation area. These are subject to change based on the final outcomes of UNR's efforts. The Volpe team will employ a document review (including HERS model documentation and FHWA Annual C&P Reports), interviews with applicable staff members, and possibly surveys of FHWA staff and stakeholders.[22,45]

## Activities to Date and Anticipated Schedule

The team delivered a draft evaluation plan in November 2015. The plan will be updated annually based on UNR's ongoing work. The main data collection activities will begin in 2019 as UNR researchers complete their activities. The Final Report is anticipated by mid-2020.

# Warm Mix Asphalt (Infrastructure R&D)

## Program Description

The use of recycled materials, including reclaimed asphalt pavement (RAP) and reclaimed asphalt shingles (RAS), reduces both the amount of new materials required for asphalt mixes and the amount of material going to landfills. At the same time, use of warm mix asphalt (WMA) technologies is growing, enabling producers of asphalt pavement to lower the temperatures at which the material is mixed and placed on the road, resulting in reductions in energy consumption and emissions. FHWA is conducting accelerated load facility (ALF) and laboratory testing of WMA and to determine RAP/RAS limits and binder performance grade needs. FHWA will provide States with performance-based specifications for testing mix designs that utilize RAP/RAS. The TFHRC Infrastructure Materials Team makes its dataset and core samples available to researchers in other organizations.

## Purpose of the Evaluation

The evaluation team will evaluate both the research process and research products of the FHWA R&T project, Advance Use of Recycled Asphalt in Flexible Pavement Infrastructure: Develop and Deploy Framework for Proper Use and Evaluation of Recycled Asphalt in Asphalt Mixtures.[46] The team will assess short-term outcomes, summarize anticipated long term impacts, and provide a framework for measuring long term outcomes and impacts.

## Proposed Evaluation Areas, Questions, or Hypotheses

The team identified three research areas, each with specific research questions, including:

- *Research Selection and Scoping:* What process was used to select WMA for accelerated pavement testing (APT) and what were the challenges and lessons learned? What changes, if any, were made because of stakeholder input?
- *Collaboration with other organizations:* How did FHWA R&T collaborate with other research organizations and what was the impact of these collaborations on FHWA and stakeholder research?
- *Initial acceptance of FHWA research report:* What is the initial response of the Expert Task Group (ETG) to the FHWA research report? Does AASHTO provisionally adopt the guidance?

While the longer term impacts are outside the scope of this evaluation, in the future FHWA may want to consider measuring these longer term impacts, including:

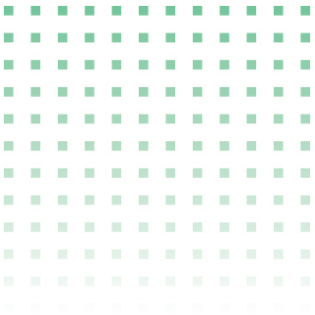
- *Utilization of FHWA guidance and data:* What States and industries are using FHWA guidance regarding WMA/RAP? How do these States and industries use that guidance?
- *Impacts on sustainability, cost, and performance:* What is the expected environmental and economic benefits? How do projects using FHWA guidance compare against projects that do not?

## Proposed Methodology

The evaluation team will investigate research selection and scoping using document reviews (e.g., the FHWA Strategic Plan and NCHRP reports) and interviews of FHWA staff (e.g., Infrastructure Materials Team) and the ETG. The Volpe team will investigate collaboration using document reviews and interviews with members of collaborating organizations. Evaluators will investigate initial acceptance through followup interviews with ETG members, review of ETG meeting notes, and review of AASHTO proceedings.

## Activities to Date and Anticipated Schedule

The draft evaluation plan was submitted in October 2015 and the final evaluation plan will be submitted in June 2017. The first interim tech memo will be delivered May 2016. A draft report is anticipated 9 months following AASHTO's adoption of the research report.



# Evaluation Summaries: Wave 2 Evaluations

# Exploratory Advanced Research (EAR)

## Program Description

In 2009, the FHWA Exploratory Advanced Research (EAR) Program began investigating the use of agent-based modeling and simulation (ABMS) techniques for transportation modeling, simulating, planning, and policy purposes. To date, FHWA has sponsored three projects investigating this topic: Driver Behavior in Traffic; Evolutionary Agent System for Transportation Outlook (VASTO); and Agent-Based Approach for Integrated Driver and Traveler Behavior Modeling.[47,48,49]

## Purpose of the Evaluation

The Volpe evaluation team will evaluate EAR agent-based modeling activities to assess their effectiveness in meeting intended goals and outcomes.

## Proposed Evaluation Areas, Questions, or Hypotheses

The team identified three research questions, each with specific research questions, including:

- *Acceleration of the state-of-the-practice, awareness, and knowledge of ABMS approaches in transportation:* What were the direct outcomes of the EAR-funded ABMS work on the transportation community?
- *Accelerated adoption of and investment in ABMS approaches in transportation:* What were the intermediate outcomes relating to research, applications, and continued investment, based on the EAR-funded ABMS work?
- *Potential impacts of ABMS use:* What were the long-term outcomes and impacts of the EAR-funded ABMS work on transportation, particularly in terms of transportation tools and system mobility, reliability, and safety?

## Proposed Methodology

The Volpe evaluation team will monitor and assess relevant ABMS literature, including using citation analysis to determine the effect of EAR-funded work on ABMS tools and techniques. The evaluation team will also conduct interviews with Federal and non-Federal stakeholders who can speak to the outcomes and impacts of the EAR-funded work. Data collection activities will culminate in analysis performed by the evaluation team and a final report delivered to EAR program, R&T, and FHWA management.

While the projects model different activities, they all seek to further the state of the art of agent-based modeling in transportation. For this reason, the evaluation will consist of a single evaluation plan with similar logic model, goals, and measures to cover the three projects, evaluating Driver Behavior in Traffic retrospectively and the others prospectively.[47]

## Activities to Date and Anticipated Schedule

The final evaluation plan was delivered May 2016. Data collection has begun and the team anticipates completing the draft report March 2017.

# Eco-Logical (Planning, Environment, and Realty/SHRP2)

## Program Description

Developed by a team of representatives from FHWA and seven other Federal agencies, Eco-Logical articulates a vision for an infrastructure development process that endorses ecosystem-based mitigation through integrating plans and data across agency and disciplinary boundaries. Following Eco-Logical's initial development as a guidebook, Second Strategic Highway Research Program (SHRP2) funds were used to create specific tools and techniques to implement Eco-Logical practices at State DOTs and other planning agencies. FHWA has funded 2 rounds of pilot projects through the Eco-Logical Grant Program in 2007 and the current SHRP2 implementation assistance grant program that is funding 14 Lead Adopter and User Incentive grants nationwide.(50,51)

## Purpose of the Evaluation

The purpose of this evaluation is to assess the effectiveness of Eco-Logical in meeting intended goals and outcomes, including understanding the effect of FHWA R&T activities on the implementation of the Eco-Logical approach (i.e. ecosystem-based infrastructure planning and mitigation) to transportation project delivery by State DOTs and MPOs.

## Proposed Evaluation Areas, Questions, or Hypotheses

The evaluation team has developed two overarching research questions, each with subquestions and hypotheses:

- How effective has the program been in getting agencies to adopt the Eco-Logical approach?
- How effective has the Eco-Logical approach been at improving project delivery processes and environmental mitigation for agencies that adopt the approach?

## Proposed Methodology

The evaluation team has identified measures of effectiveness, potential data inputs, and preferred data sources for each research question. The effect on adoption will be investigated through a review of Eco-Logical program materials and interviews with State DOT and MPO recipients of funding under the program. Evaluators will also consider using recipients' agency-specific documents (memorandums of understanding (MOUs), programmatic agreements, agency procedures, plans, or project documentation). The effect on project delivery will be investigated through interviews to determine whether Eco-Logical helps agencies mitigate projects in a different way or whether the approach has led to better mitigation projects. The evaluation team plans to analyze data in the U.S. Army Corps of Engineers (USACE) Regulatory In-lieu Fee and Bank Information Tracking System (RIBITS) with the goal to identify trends in practitioner use of in-lieu fees and mitigation banking over time, which are some of the later steps of the nine-step Eco-Logical approach.(52)

## Activities to Date and Anticipated Schedule

The final evaluation plan was submitted January 2016. A draft report will be delivered August 2016.

# Managing Risk on Rapid Renewal Projects (Innovative Program Delivery/SHRP2)

## Program Description

Rapid renewal projects are transportation design and construction projects intended to minimize delivery schedule and construction disruption. The *Guide for the Process of Managing risk on Rapid Renewal Projects* (R09) is a SHRP2 product written to provide a framework for managing risk on such products.(53) The guide proposes an iterative risk management process: defining a base project scenario, identifying risks, assessing risks, analyzing risk, and planning and implementing risk management. Training was also developed for DOT facilitators to use the process on small projects.

## Purpose of the Evaluation

The purpose of this evaluation is to identify and track internal changes to risk management policy in State DOTs and adoption of the R09 guidebook processes following risk workshops and other implementation assistance developed and provided by FHWA.

## Proposed Evaluation Areas, Questions, or Hypotheses

Evaluation areas include:

- Increased agency capacity to do risk management: Did R&T research and SHRP2 implementation assistance increase the capacity within States to implement the R09 process?
- Increased adoption of R09 processes: Did R&T research and SHRP2 implementation assistance lead to the institutionalization of R09 processes within agencies?
- Impacts: Is use of the R09 process improving project delivery within States?

## Proposed Methodology

The evaluation will focus on the four State DOTs that received lead adopter implementation assistance grants through round 2 of the SHRP2 implementation assistance program (IAP): Florida, Minnesota, Oregon, and Pennsylvania.(54) The specific changes will vary by State, so the evaluation will attempt to measure outcomes both common among all projects and unique to individual projects. Options include following specific projects using the R09 process to identify schedule and cost changes attributable to risk management. Detailed data sources and methods will be determined in collaboration with the sponsor.

## Activities to Date and Anticipated Schedule

The last IAP grants were awarded in 2014 and close out in 2016. A revised preliminary evaluation plan was submitted in April 2016 and a final evaluation plan is expected in July of 2016. A draft report is expected by the end of December 2017.

# P3 Capacity Building Program (Innovative Program Delivery)

## Program Description

In October 2008, FHWA established the Office of Innovative Program Delivery, which launched the Public-Private Partnership (P3) Toolkit in June 2013.[55] The P3 Toolkit is an educational resource consisting of analytical tools and guidance documents to assist public sector policymakers, legislative and executive staff, and transportation professionals in implementing P3 projects. The P3 Toolkit forms the foundation of a broader P3 capacity building program that includes a curriculum of courses and webinars. The toolkit contains fact sheets, publications (e.g., primers and guidebooks), analytical tools (e.g., spreadsheet-based calculation tools), webinars, training materials, a P3-SCREEN checklist, and frequently asked questions. The evaluation will cover the use of resources added by the Office of Innovative Program Delivery to the P3 Toolkit through December 31, 2015. The goal of the P3 Toolkit is to build State DOT capacity for choosing public-private partnerships appropriately and executing them well; it is not to promote the use of more public-private partnerships in general.

## Purpose of the Evaluation

The purpose of the evaluation is to understand how the toolkit influences user decisions and actions regarding implementation of public-private partnerships.

## Proposed Evaluation Areas, Questions, or Hypotheses

The team identified three research questions, each with specific research questions, including:

- Has the P3 Program helped build an environment (within States) that supports the use of P3s for major highway transportation projects?
- Has the P3 Program improved the decisionmaking capabilities of practitioners in the areas of P3 planning and evaluation, procurement, and oversight?
- Has the P3 Program led to better alignment of P3s with appropriate major transportation projects? Does the P3 Program provide the most complete, up-to-date resource for (U.S.-focused) P3 information, tools, and training?

## Proposed Methodology

This prospective evaluation will focus only on resources developed from the launch of the toolkit through publication of the model contract guide and be based on existing P3 data and literature. The evaluation plan will set a specified year through which to answer the research questions.

## Activities to Date and Anticipated Schedule

The draft evaluation plan was submitted in March 2016 and a final evaluation plan will be submitted June 2016. The evaluation team anticipates submitting a draft report in December 2016.

# Precast Concrete Pavements (Infrastructure/SHRP2)

## Program Description

Precast Concrete Pavement (PCP) is the practice of using prefabricated concrete panels for pavement and roadway maintenance and rehabilitation. This practice can be utilized in high traffic volume areas and in marginal weather. Over the last 10 to 15 years, FHWA has led multiple research efforts, demonstrations, technical briefings, and technology refinements related to PCP, which has been incorporated as Project R05 within SHRP2.[56] Project R05 is within the renewal focus area, which concentrates on "enabling faster, minimally-disruptive, and longer-lasting improvements."[51]

Existing research suggests PCP provides time savings and other advantages, but these have not been quantified. Additionally, while cost information is known, it is unknown to what extent the advantages of PCP exceed the costs—if at all—compared to alternatives.

## Purpose of the Evaluation

The purpose of this evaluation is to determine the benefits and costs of PCP projects individually and, where possible, to identify more general themes related to benefits and costs. The evaluation will also determine the outcomes and impacts of FHWA research, demonstrations, workshops, and related activities in the context of SHRP2 Project R05.

## Proposed Evaluation Areas, Questions, or Hypotheses

The team identified three eavaluation areas, each with specific research questions, including:

- *Technology diffusion and research.*
- *Costs of PCP.*
- *Benefits of PCP.*

## Proposed Methodology

To complete this evaluation, the Volpe team proposes using benefit-cost analysis on individual PCP projects, interviews with staff members in State agencies who have conducted PCP projects, and a review of documents. Phase 1 will include IAP round three awardees and routine users, while phase 2 will add IAP round six users.

## Activities to Date and Anticipated Schedule

The evaluation team will submit a draft evaluation plan in December 2015 and a final evaluation plan in June 2016. The Phase 1 draft report will be ready in December 2016 and final report in February 2017. The phase 2 draft and final reports will be completed in December 2017 and February 2018.

# TIM Training (Operations)

## Program Description

FHWA developed the Traffic Incident Management (TIM) Program to promote a comprehensive and multidisciplinary approach to restoring traffic capacity as quickly and safely as possible.(57) Through its TIM Program, FHWA provides guidance, doctrine, training, and peer-to-peer and other knowledge exchanges. TIM research and outreach efforts are designed to help transportation agencies, such as safety services patrols and traffic management center personnel, understand, plan for, and implement traffic incident response operations better.

## Purpose of the Evaluation

The purpose of this evaluation will be determined in collaboration with the sponsor. It will likely include assessing the extent to which the TIM training program has achieved its intended outcomes and impacts, including a reduction in the duration of traffic incidents, reduction in secondary crashes, and increase in passenger/vehicle throughput.

## Proposed Evaluation Areas, Questions, or Hypotheses

The evaluation areas, questions, and hypotheses will be determined in collaboration with the sponsor.

## Proposed Methodology

The evaluation will consist of an assessment of two to five sites that have participated in the SHRP2-sponsored TIM training program. Measures of effectiveness will likely include a reduction in the duration of traffic incidents, reduction in secondary crashes, and increase in passenger/vehicle throughput. Data sources and methods will be determined in collaboration with the sponsor.

## Activities to Date and Anticipated Schedule

Preliminary discussions with FHWA have identified a range of evaluation approaches and data collection sites. The evaluation team has assigned a project manager to this evaluation. The team has also enumerated potential data elements to guide site selection. A kickoff call with FHWA will be scheduled. The projected date for other deliverables will subsequently be determined.

# Conclusion

The Federal Government has the responsibility to fund and conduct R&T activities to meet highway transportation challenges and significantly advance technology innovation when private investment is neither present nor sufficient to meet public need.(1) The FHWA R&T Research Agenda considers future transportation issues from two perspectives: challenges and research components designed to meet those challenges.(4) Four of the eight research components (Infrastructure, Operations, Safety, and Exploratory Advanced Research) take place under the guidance of TFHRC.(3) Advancing these research components will require continually reexamining and improving the process of selecting and executing research projects, disseminating findings, supporting user adoption, and assessing impact. FHWA's *Corporate Master Plan (CMP) for Research and Deployment of Technology & Innovation* emphasizes performance evaluation and measurement.(2) Additionally, TFHRC leadership has adopted a *Strategic Plan* to guide the Center's continued development. One of the long-term goals (Goal 5) in the plan is to calibrate the Center's efforts to promote the adoption of research findings.(3) The plan makes explicit that dissemination of knowledge requires engaging external partners and targeting outreach. Evaluation can serve in the search for effective alignment by revealing the relationships between outreach, dissemination, transition, and increased performance. These relationships are the focus of the FHWA R&T Evaluation Program.

The FHWA R&T Evaluation Program has been designed to further TFHRC's transparency, accessibility, and responsiveness of R&T for stakeholders. To support a more coordinated research agenda, FHWA and the Volpe Center have organized, clarified, and communicated FHWA's R&T mission, vision, goals, and priorities.. By sharing this information, FHWA hopes to encourage highway researchers to identify and fill research gaps, to reduce unnecessary duplication of research efforts, to stimulate collaborative research efforts, and to accelerate innovation. In its initial year, the FHWA R&T Evaluation Program worked with 9 FHWA offices to identify 16 projects for evaluation across all program areas. The evaluations represent a mix of retrospective and prospective studies and range in schedule from 6 months to 4 years or more.

Each evaluation progresses through an ordered series of deliverables. Five evaluation teams have completed data collection and finalized a report, and one other has submitted a final phase I report and is in the process of preparing its phase II report. Three evaluation teams have submitted final evaluation plans (with one recently delivering an interim tech memo) while five other teams have submitted their draft evaluation plans. Of the remaining two, one team has submitted a preliminary evaluation plan and the other is preparing to initiate planning activities.

The Volpe evaluation team has developed and customized procedures to execute a large number of related evaluations of highway research simultaneously. Guides, templates, checklists, and other tools are in place to ensure quality control and prevent duplicated effort. These tools will enable the team to spend more energy on research design, data collection, and analysis while continuing to issue reports that are similar in style and highly readable. The evaluation team will continue to work with FHWA R&T and program offices to produce accurate evaluations that are useful in shaping the Nation's highway research and technology agenda.

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# Appendix A Project Status by Evaluation

**Project Status by evaluation**

| Project | Contact | Task Plan | Eval. Plan | Data Collection | Final Report |
|---|---|---|---|---|---|
| **Adaptive Signal Controls** *Retrospective* | **FHWA:** Eddie Curtis **Volpe:** Sari Radin | Final | Final | Completed | Final |
| **Eco-Logical** *Retrospective/SHRP2* | **FHWA:** Marlys Osterhues, David Williams, Mike Ruth **Volpe:** Gina Solman | Final | Final | In Progress | |
| **eNEPA Tool** *Prospective* | **FHWA:** Kreig "Chip" Larson **Volpe:** Gina Filosa | Final | Final | In Progress | |
| **Exploratory Advanced Research (EAR) Agent-Based Modeling** *Retrospective and Prospective* | **FHWA:** David Keuhn **Volpe:** Lydia Rainville | Final | Draft | In Progress | |
| **Geosynthetic Reinforced Soil (GRS) abutments** *Retrospective* | **FHWA:** Mike Adams **Volpe:** David Epstein | Final | Final | Completed | Draft |
| **Gusset Plate** *Retrospective* | **FHWA:** Justin Ocel **Volpe:** Sharon Chan-Edmiston | Final | Final | Completed | Final |
| **High Friction Surface Treatments** *Prospective* | **FHWA:** Roya Amjadi **Volpe:** Sean Puckett | Final | Final | In Progress | |
| **Managing Risk on Rapid Renewal Projects** *Prospective/ SHRP2* | **FHWA:** Carlos Figueroa **Volpe:** Emily Futcher | Final | Draft | | |
| **National Household Travel Survey (NHTS)** *Retrospective* | **FHWA:** Adella Santos **Volpe:** Margaret Petrella | Final | Final | Completed | Final |
| **P3 Capacity Building Program** *Prospective* | **FHWA:** Patrick DeCorla-Souza **Volpe:** Lora Chajka-Cadin | Final | Draft | In Progress | |

| Project | Contact | Task Plan | Eval. Plan | Data Collection | Final Report |
|---|---|---|---|---|---|
| **Precast Concrete Pavement**<br>*Prospective/ SHRP2* | **FHWA:**<br>Sam Tyson<br>**Volpe:**<br>Greg Bucci | Final | Draft | | |
| **Roadside Revegetation**<br>*Retrospective* | **FHWA:**<br>Victoria Peters<br>**Volpe:**<br>Carson Poe | Final | Final | Final | Final |
| **Roundabouts**<br>*Retrospective* | **FHWA:**<br>Wei Zhang<br>**Volpe:**<br>Lydia Rainville | Final | Final | Phase I: Complete<br>Phase II: Complete | Phase I: Complete<br>Phase II: In Progress |
| **Traffic Incident Management (TIM) Training**<br>*Prospective/ SHRP2* | **FHWA:**<br>Paul Jodoin<br>**Volpe:** David Epstein | In Progress | | | |
| **Vehicle Operating Costs Study**<br>*Prospective* | **FHWA:**<br>David Luskin<br>**Volpe:**<br>Greg Bucci | Final | Draft | | |
| **(High Recycle) Warm-Mix Asphalt**<br>*Prospective* | **FHWA:**<br>Nelson Gibson<br>**Volpe:**<br>Margaret Petrella | Final | Draft | In progress | |

# Appendix B Project Information by Evaluation

**Project information by evaluation**

| Project | Objectives | Methods | Key Metrics | Key Findings |
|---|---|---|---|---|
| Adaptive Signal Controls Retrospective | • Objective 1: Managing congestion by improving reliability and operating the system at peak performance. | • Comprehensive review of program documents, data gathering, and analysis.<br>• Qualitative interviews.<br>• Quantitative survey of arterial management agencies. | • ASCT products developed that can be qualitatively tied to results of actions of the R&T ASCT program.<br>• ASCT products adopted and deployed that can be qualitatively tied to outreach of the R&T ASCT program.<br>• Assessment of ASCT market adoption.<br>• Adoption Funnel (aware, consider, purchase, recommend).<br>• Adoption influencers (stated impact of information sources /influencers).<br>• Barriers to adoption. | • FHWA had both a direct and indirect effect on ASC technology development.<br>• FHWA development and outreach activities, particularly EDC, played a major role in overcoming initial reluctance in the market to adopt ASCT.<br>• Through the three phases of the FHWA R&T ASC program both FHWA-funded teams and FHWA-influenced technology firms have continued to develop ASCT systems, which improved travel time and reduced congestion in recent studies. |
| Eco-Logical Retrospective/ SHRP2 | • Objective 1: Promote more informed transportation planning, programming, operations, and coordination.<br>• Objective 2: Promote integrated planning that improves transportation safety and addresses environmental, social, and economic needs.<br>• Objective 3: Streamline the project delivery process.<br>• Objective 4: Minimize environmental impacts of transportation investments. | • Review of program documents, data gathering, and analysis.<br>• Qualitative interviews of recipients and nonrecipients of FHWA assistance. | • State DOTs and MPOs indicate increases in partnering, sharing data, analyzing effects, identifying key sites and actions, documenting, implementing and evaluating ecological information.<br>• Anecdotes of: potential reductions in project delivery time, improved environmental outcomes, more effective collaboration, better relationships, improved transparency. | • (Evaluation not yet complete) |

| Project | Objectives | Methods | Key Metrics | Key Findings |
|---|---|---|---|---|
| eNEPA Tool Prospective | • Objective 1: Promote more informed transportation planning, programming, operations, and coordination.<br>• Objective 3: Streamline the project delivery process.<br>• Objective 4: Minimize environmental impacts of transportation investments. | • Qualitative interviews, including interviews with transportation and resource agency staff using eNEPA.<br>• Collect quantitative data regarding specific project milestones (some data available through eNEPA statistics, other data will be requested from FHWA or State DOTs). | • Number of agencies actively using eNEPA.<br>• Number of projects by class of action in eNEPA.<br>• Length of time between specific project milestones (e.g., Notice of Intent (NOI), draft environmental impact statement (DEIS), final environmental impact statement (FEIS), record of decision (ROD), etc.).<br>• Qualitative measure on transparency of process. | • (Evaluation not yet complete) |
| Exploratory Advanced Research (EAR) Agent-Based Modeling Retrospective and Prospective | • Objective 3: Demonstrate and communicate the value and impact of exploratory advanced research and promote opportunities to move from advanced to applied research. | • A single evaluation plan with similar logic model, goals, and measures to cover three agent-based projects.<br>• Evaluate driver behavior in traffic retrospectively and the two others prospectively.<br>• Interviews (project researchers, academic community, FHWA (EAR, Safety R&D, Planning), relevant TRB committee members.<br>• Document and literature reviews, including citations and references to FHWA work in other publications, conference activities, ongoing research, etc. | • State DOTs and MPOs indicate increases in partnering, sharing data, analyzing effects, identifying key sites/actions, documenting, implementing, and evaluating ecological information.<br>• Anecdotes of: reductions in project delivery time, improved environmental outcomes, etc. | • (Evaluation not yet complete) |

| Project | Objectives | Methods | Key Metrics | Key Findings |
|---|---|---|---|---|
| **Geosynthetic Reinforced Soil (GRS) abutments Retrospective** | • Objective: 5: Improve highway condition and performance through increased use of design, materials, construction, and maintenance innovations. | • Interviews with State and local engineers, FHWA staff, researchers, and consultants.<br>• Analysis of available data on bridge deployments. | • User friendliness/challenges of guidance documents.<br>• Extent of State DOT adoption of GRS-IBS.<br>• Reasons for and against adoption.<br>• Senior-level support for GRS-IBS.<br>• Cultural/organizational roadblocks to adoption.<br>• Preliminary cost comparison (GRS versus alternative). | • FHWA activities raised awareness and understanding of GRS-IBS technology and construction guidelines among the majority of stakeholders interviewed.<br>• FHWA activities have supported local stakeholders and the pace of GRS-IBS bridge construction has increased, but the degree to which the former contributed to the latter remains unclear.<br>• Preliminary analysis shows GRS-IBS technologies can reduce bridge construction costs and construction time, but conflicting evidence exists and additional research. Research is underway to explain discrepancies.<br>• Stakeholders reported hesitancy to embrace GRS-IBS technology both within FHWA and local agencies.<br>• Initial support for GRS-IBS may be stronger at the county and municipal levels than at the State level. |
| **Gusset Plate Retrospective** | • Objective 1: Improve the security of highway infrastructure and reduce the number of fatalities attributable to infrastructure design characteristics and work zones.<br>• Objective 2: Improve the management of infrastructure assets and advance the implementation of a performance-based program for the National Highway System.<br>• Objective: 5: Improve highway condition and performance through increased use of design, materials, construction, and maintenance innovations. | • Document searches and reviews.<br>• Interview State DOT bridge staff and members of AASHTO's Subcommittee on Bridges and Structures (SCOBS).<br>• Review of download/request statistics on FHWA gusset plate resources. | • Number of agencies that have adopted updated LRFD bridge design specifications.<br>• Number of agencies that have adopted revisions to the Manual for Bridge Evaluation.<br>• Number of downloads/requests for load rating guidance and examples for bolted and riveted gusset plates in truss bridges.<br>• Number of downloads/requests for technical advisory.<br>• Number of downloads/requests for NCHRP Web-Only Document.<br>• Number of downloads/requests for TechBrief: Guidelines for Design and Rating of Gusset-Plate Connections for Steel Truss Bridges. | • FHWA's technical expertise in bridge infrastructure and its prior history of working with NTSB was critical during the bridge investigation.<br>• FHWA's coordination with key stakeholders contributed to an accelerated timeline to closing NTSB recommendations.<br>• FHWA's commitment to bridge research and the decision to jointly fund the NCHRP effort accelerated the research timeline, resulting in expedient development of revised specifications for load rating and designing gusset plates.<br>• FHWA's active and ongoing engagement of transportation stakeholders expedited the delivery of new information regarding the design and load rating of gusset plates. |

| Project | Objectives | Methods | Key Metrics | Key Findings |
|---|---|---|---|---|
| **High Friction Surface Treatments**<br>**Prospective** | • Objective 1: Support the systematic planning, management, and evaluation of roadway safety.<br>• Objective 2: Accelerate the reduction in injury and fatal crashes at intersections. | • Quantitative analysis of project-level safety data.<br>• Quantitative analysis of safety portfolio level data.<br>• Qualitative and quantitative analysis of transportation safety literature, national and State technical documentation, and State transportation planning documentation.<br>• Qualitative analysis of communications among State DOTs and MPOs.<br>• Interviews with transportation safety professionals. | • Changes in the rate of appearance of HFST in strategic highway safety plans.<br>• Changes in the rate of appearance of approved and completed HFST projects.<br>• Estimated and projected safety impacts associated with changes in the prevalence of HFST.<br>• Changes in the prevalence of HFST within discussions among State DOTs and MPOs<br>• Changes in the prevalence of crash modification factors for HFST projects in key data bases and publications.<br>• Progress toward documentation of HFST in key publications. | • (Evaluation not yet complete) |
| **Managing Risk on Rapid Renewal Projects**<br>**Prospective/ SHRP2** | • (not categorized) | • Qualitative interviews.<br>• Review of State DOT documents, policies, and procedures.<br>• Quantitative analysis of project data. | • Adoption of R09 processes by State DOTs.<br>• Qualitative assessment of impact of R09 processes on project risk management.<br>• Changes in accuracy of project cost estimates for IAP recipients.<br>• Changes in accuracy of project schedule estimates for IAP recipients.<br>• Changes in project schedule compared with similar projects for IAP recipients.<br>• Changes in project cost compared with similar projects for IAP recipients. | • (Evaluation not yet complete) |

| Project | Objectives | Methods | Key Metrics | Key Findings |
|---|---|---|---|---|
| National Household Travel Survey (NHTS) Retrospective | • Objective 2: Promote the efficient, systematic, and comprehensive collection and utilization of national transportation data to improve highway management and investment decisions. | • Qualitative interviews.<br>• Document searches and reviews.<br>• Analysis of website usage statistics. | • Number of NHTS citations by field and transportation topic.<br>• Number of website visitors, visits, and page views per month.<br>• Number of datasets (2001, 2009) downloaded per month.<br>• Qualitative measure of the role NHTS has played in informing policy, program, or project decisionmaking.<br>• Lessons learned regarding NHTS planning, survey administration, and outreach.<br>• Qualitative assessment of the effort to collect, process, and act on user feedback. | • Nearly half of the publications using the 2014 NHTS are in the transportation field with the share of nontransportation publications growing and website data access increasing.<br>• While it is difficult to trace the precise decision outputs of NHTS, the interviews suggest that NHTS informs policy and legislative decisions within transportation and other fields.<br>• NHTS reaches out to its user community through its website, direct contact, and formal events. |
| P3 Capacity Building Program Prospective | • Objective 3: Develop innovative procurement and revenue generation tools and technical resources. | • Document searches and reviews.<br>• Qualitative interviews.<br>• Quantitative survey research (to be determined).<br>• Analysis of quantitative data (e.g., website usage statistics, training registration, etc.). | • Webinar/training attendance.<br>• Number of times documents cited in legislation, policy, etc.<br>• Use of planning, evaluation, and procurement resources.<br>• Number (%) of projects considered, evaluations undertaken, and project awards/rejections. | • (Evaluation not yet complete) |
| Precast Concrete Pavement Prospective/ SHRP2 | • Objective 3: Improve the ability of transportation agencies to deliver projects that meet expectations for timeliness, quality, and cost.<br>• Objective 4: Reduce user delay attributable to infrastructure system performance, maintenance, rehabilitation, and construction.<br>• Objective: 5: Improve highway condition and performance through increased use of design, materials, construction, and maintenance innovations. | • Case study analysis of relevant precast concrete pavement (PCP) projects.<br>• Analysis of project documentation (e.g., meeting notes and other relevant documents).<br>• Interview FHWA staff and stakeholders to determine impacts. | • Quantitative and qualitative assessment of the benefits and costs of utilizing PCP compared to a baseline construction technique.<br>• Attitudinal responses to interviews. | • (Evaluation not yet complete) |

| Project | Objectives | Methods | Key Metrics | Key Findings |
|---|---|---|---|---|
| Roadside Revegetation Retrospective | • Objective 1: Understand whether and how end users of the guide have changed their previous revegetation practices to adopt those put forth in the guide.<br>• Objective 2: Understand whether and how the establishment of native plants have been improved and resulted in other positive outcomes. | • Survey to Federal agencies, offices, and units asking about Roadside Revegetation awareness and implementation.<br>• Telephone interviews with subset of Federal, State, and local agencies to ask about the type of native roadside revegetation techniques the agency uses, the outcomes of using native roadside revegetation, and whether each organization is supportive of using native plants in the future. | • Percentage of projects (and types of projects) for which Roadside Revegetation techniques are used.<br>• Correlative data on accidents with and without use of the recommended practices; otherwise, qualitative views on the topic.<br>• Reduction of vegetation obscuring sight lines, contributing to icing conditions, covering guardrails, etc.<br>• Reduced sedimentation, incidence of landslide, use of herbicides, erosion; improved water quality or drainage.<br>• Cost comparison of revegetation practice with and without use of the recommended practices.<br>• Qualitative views on the topic; any available data on sustainability indicators (e.g., scores from FHWA's Web-based tool, INVEST), driver satisfaction, agency perception of benefits. | • End users have adopted the Roadside Revegetation practices, using the guide as a reference tool to reinforce existing measures mandated by agency policies.<br>• End users are aware of Roadside Revegetation and its associated materials and have found the guide to be very informative and useful.<br>• Overall outcomes on projects that apply Roadside Revegetation's recommended practices guide have been improved. Respondents and interviewees believed Roadside Revegetation has generally improved erosion, sustainability and environmental stewardship, and visitor experience outcomes.<br>• There is less indication that the guide has helped to improve safety or reduce maintenance costs. |

| Project | Objectives | Methods | Key Metrics | Key Findings |
|---|---|---|---|---|
| Roundabouts Retrospective | • Objective 2: Accelerate the reduction in injury and fatal crashes at intersections. | • Qualitative interviews.<br>• State document review (SHSPs, Highway Design Manuals) and qualitative interviews.<br>• Trend analysis of national roundabouts inventory database.<br>• Citation analysis of FHWA research products.<br>• Literature review. | • Number and growth in citations and references of FHWA work in non-Federally funded roundabouts research.<br>• Adoption of FHWA work into the AASHTO Green Book, Highway Capacity Manual, Highway Safety Manual, or other relevant standards documents.<br>• Number of States with roundabouts guidance in State Highway Design Manuals and number of States referencing FHWA in this guidance.<br>• Change in FHWA roundabouts-related policy or guidance practices.<br>• Number of States with roundabouts included in their in their Strategic Highway Safety Plans (SHSPs).<br>• Growth in the total number and number of States building roundabouts in the United States.<br>• Existing research demonstrates a reduction in number of crashes at roundabouts versus traditional intersections. | • There is strong evidence of FHWA's influence on the acceptance, consideration of, and adoption of roundabouts, beyond what might have occurred in the absence of FHWA research and activities.<br>• Early and continued FHWA research increased the quality and availability of domestic roundabouts-related safety and performance data and accelerated the development of design standards for roundabouts.<br>• FHWA laid the foundation for nationwide adoption of roundabouts by providing empirical evidence of the safety and operational benefits of roundabouts, increasing awareness of and confidence in them among stakeholders, and contributing to the development of the nationwide design standards for their implementation.<br>• FHWA played an active role in accelerating the early adoption of roundabouts through leadership in consideration of roundabouts. |
| Traffic Incident Management (TIM) Training Prospective/ SHRP2 | • Objective 1: Manage congestion by improving reliability and operating the system at peak performance. | • Quantitative analysis of incident (crash) data, TIM training records, and jurisdictional info. May use pre/post test, multiyear regression, or other method.<br>• Interviews with TIM trainees and local agency officials to assess plausibility of causality and identify mechanisms. | • Change in roadway clearance time.<br>• Change in incident clearance time.<br>• Change in rate of secondary collisions.<br>• Percent of responders who have received TIM training.<br>• Relevance of training to observed outcomes. | • (Evaluation not yet complete) |

| Project | Objectives | Methods | Key Metrics | Key Findings |
|---|---|---|---|---|
| Vehicle Operating Costs Study<br>Prospective | • Objective 1: Evaluate impacts of a broad range of policy options and analyze current and emerging issues that will affect surface transportation programs. | • Analyze literature and interview FHWA staff and stakeholders to determine impacts of updated vehicle operating costs and equations, specifically on policy/project decisions.<br>• In conjunction with FHWA contractor:<br>o Determine the users of the updated vehicle operating costs and equations.<br>o Survey users of the updated vehicle operating costs and equations to determine the impacts of the updates. | • Count (and description) of applicable users of the vehicle operating costs and equations.<br>• Count (and description) of uses of the updated vehicle operating costs and equations.<br>• Attitudinal responses to interview or survey questions. | • (Evaluation not yet complete) |
| (High Recycle) Warm-Mix Asphalt<br>Prospective | • Objective: 5: Improve highway condition and performance through increased use of design, materials, construction, and maintenance innovations. | • Qualitative interviews.<br>• Analysis of project documentation (e.g., meeting notes and other relevant documents).<br>• Survey of FHWA Division Offices. | • Qualitative assessment of the impacts of collaboration on FHWA research outputs and on the adoption of High Recycle WMA.<br>• Qualitative assessment of the benefits of State and industry experience in utilizing FHWA guidance on High Recycle WMA.<br>• Qualitative assessment of the challenges or barriers in utilizing FHWA guidance. | • (Evaluation not yet complete) |

**Note: Objectives are taken from the TFHRC Research Agenda.[12]**

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U.S. Department of Transportation
**Federal Highway Administration**

# FHWA R&T EVALUATION