NUMBER 310

JULY–AUGUST 2017

# TR NEWS

## Moving Research into Practice

*Technology Transfer Successes*

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Photo courtesy of Pamela Murray-Tuite

Transportation systems resilience is the focus of articles in the September–October issue of *TR News*, addressing advance preparation, mitigation, and recovery from systemwide disruptions; the roles and interdependencies of the private sector, government agencies, nongovernment organizations, and universities; establishing and safeguarding business continuity; the human aspects of resilience-building activities in the transportation sector, including the development of social capital; strategies for evacuation and emergency transportation; the status of resilience-related research and critical needs; and more.

The Texas Department of Transportation has installed Evaculane shoulder signs on US-290 between Houston and Hempstead.

INTRODUCTION

# Moving Research into Practice

PATRICK CASEY

*The author is CEO, CTC & Associates LLC, Madison, Wisconsin, and chair of the TRB Standing Committee on Technology Transfer.*

For *TR News* readers, everything about the research process is interesting: closing in on a problem, like premature pavement cracking or crash-prone intersections, and developing a research plan to identify the root causes and evaluate solutions. Even more exciting is the active research stage, with practitioners conducting field research on ways to improve accelerated bridge construction techniques, running laboratory pilots on flocculation agents to mitigate runoff contaminants, or developing algorithms to improve ramp metering.

The culminating step pulls all the data together in a final report, clearly states the research design and hypotheses, and presents compelling conclusions for a better way to plan, design, build, or operate the transportation system.

The final report, however, is not the last step of research. Though vitally important, it is just the first step in a transformation that is only complete when the research is applied to practice. This may be the most exciting step of all: new materials, technologies, and methods are incorporated into the everyday activities of transportation agencies.

## Moving Research into Practice

Digitized designs, plans, and contracts speed the project development process. Pavements and bridges last longer. Cars and trucks flow more reliably and safely. Public and private transportation organizations manage their tangible and intangible assets more effectively. All of these advances save time and money and make the transportation system safer, more energy efficient, and more environmentally sustainable.

For decades, the transportation research community has heard about the importance of implementation and technology transfer. In the past five years, however, a systematic, sustained effort has focused on understanding, resourcing, and accomplishing this last, critical step: moving research into practice.

This issue of *TR News* explores lessons learned and assimilated about the application of research findings to practice. A dozen dedicated transportation professionals, many of them members of the TRB Technology Transfer Committee, share their insights on the science and art of moving transportation research into practice.

The introductory article from Barbara T. Harder, "Moving Research Results to Practice: The Changes Generating Today's Successes," provides a sweeping summary of the milestones since the 1950s that have led to today's effective approaches to research implementation.

In "Research Results Go Statewide: Virginia Transportation Research Council's Implementation Program," Cathy McGhee, Kevin Wright, and Jimmy White present a case study of a state organization whose focus on implementation includes a designated research implementation coordinator and an $8 million annual budget.

At the national level, the Federal Highway Administration (FHWA) has launched aggressive programs to support implementation of research and of innovation in general. In "State Transportation Innovation Councils: Partnering for Continuous Innovation," Tom Harman describes some of FHWA's efforts, along with those of the American Association of State Highway and Transportation Officials (AASHTO), to foster a culture of innovation among state departments of transportation (DOTs).

The Transportation Research Board's (TRB's) National Cooperative Highway Research Program (NCHRP) created a new position in 2016 to support state DOTs as they move NCHRP-funded research into practice. Waseem Dekelbab, a senior program officer for many projects, was appointed to the new post; with coauthors Christopher Hedges, Director of the Cooperative Research Programs, and Lori Sundstrom, NCHRP Manager, Dekelbab describes the philosophy of active implementation and the dedicated funding that have been adopted by NCHRP and by AASHTO's Standing Committee on Research in "Active Implementation at the National Cooperative Highway Research Program: Frameworks for Moving Research into Practice."

## Variety of Approaches

Another successful approach to research implementation has been adopted by the Technology Transfer Program at the University of California, Berkeley. In "Going, Seeing, Showing, and Doing: Low-Tech Technology Transfer Works," Laura Melendy and Ann Brody

Guy explain the effectiveness of on-site safety assessments, demonstration showcases, peer exchanges, and other person-to-person technology transfer methods.

Similarly, Janet Leli of the New Jersey Local Technical Assistance Program (LTAP) highlights the successes of local and tribal technical assistance programs in "National Network for Technology Transfer to Local Agencies: The Local and Tribal Technical Assistance Programs." Targeting local and tribal transportation agencies, LTAP and Tribal TAP centers across the country provide information and training services to customer agencies responsible for more than 3 million miles of roads and 300,000 bridges.

Finally, Aquilino Alvarez-Castro and Javier Bonilla-Díaz present the private-sector and international perspective in "Technology Transfer at a European Construction Company: Case Study of ACCIONA Construction, Spain." Examined are examples of successful technology transfer in the company's use of composite materials in bridge construction, its systematic incorporation of building information modeling techniques, and its development of a European standard for the sustainability assessment of roads.

In addition, sprinkled throughout the issue are sidebars on effective, creative examples of moving research into practice:

◆ Assessing a technology's readiness for practice has been shown to increase use of research results. FHWA's David Kuehn explains how.

◆ Implementation of results from a pooled fund study on maintenance decision support systems leads to cost savings and better service, as outlined by David Huft of South Dakota DOT.

◆ U.S. DOT's Santiago Navarro points to the four key roles of the implementation coordinator and other principles of effective technology transfer.

◆ Utah DOT's David Stevens and Cameron Kergaye calculate the benefits of bringing implementable ideas from the TRB Annual Meeting back to the agency.

◆ Edward Bury of the University of Illinois at Chicago explains, in four straightforward steps, how public relations can energize the technology transfer process.

An updated issue of *TR News* on moving research into practice, with new examples and insights, could be published in two months and again every two months well into the future. Such is the pace of new technology transfer successes for transportation—an exciting and long-awaited development.

Moving Research into Practice

# Moving Research Results to Practice

## *The Changes Generating Today's Successes*

BARBARA T. HARDER

*The author is Principal, B. T. Harder, Inc., Philadelphia, Pennsylvania, and Emeritus Member, TRB Standing Committee on Conduct of Research.*

U.S. transportation systems are experiencing remarkable—and in some cases, astonishing—successes in implementing changes that benefit infrastructure, safety, and mobility for commerce and the traveling public. These changes range from accelerated bridge construction to innovative traffic safety solutions and are great news for transportation professionals.

Yet the ready and intentional adoption of changes to produce success at the current pace has taken a while. More work remains to address transportation challenges and to increase the rate at which changes are adopted.

### Burdens and Disruptions

The transportation community is justifiably conservative—the wise stewardship of public-sector transportation resources and applications is a necessity. Change can be burdensome. Changing from conventional to new solutions can involve financial or safety risks or can foster unknown technical consequences. Often the perceived risks are too great, and the new approach is rejected.

Change is also disruptive. Changing a technical solution, its procurement, or its financing can disrupt carefully made plans. New approaches can be more resource intensive until the effort becomes standard practice. Gaining competence in new techniques or procedures can reduce productivity until staff and contractors gain expertise. Integrating innovations into operations may raise unforeseen distractions that interrupt project delivery.

Nevertheless, in the past decades, transportation professionals have incorporated beneficial changes into transportation applications by adopting innovations and research findings. Some of the progress came about with significantly less difficulty than anticipated.

PHOTO: VERMONT AGENCY OF TRANSPORTATION

Using accelerated bridge construction technology, the Vermont Agency of Transportation constructed an Interstate bridge in a single weekend. Communication, demonstration, and other strategies can accelerate the process of technology adoption.

## Effective Applications

Strategies, tactics, and activities connected with technology transfer and implementation have contributed greatly to the successful applications of innovations (*1*). A process for incorporating technology transfer and implementation is essential on a project that introduces innovations and research results into practice. In particular, processes that integrate technology transfer and the implementation of research results throughout the research and development stages have had notable success in advancing the practical applications of transportation innovations. (For definitions of terms, see sidebar, below).

## Early Experiences

Before and after World War II, state highway departments—now departments of transportation (DOTs)—actively sought solutions to pervasive problems in roadways and structures and were making efforts to have the research results adopted. For example, in 1948, the qualifications for the first research director of the Virginia Transportation Research Council included "[the capability] of translating theory into field practice" (*3*, pp. 2–3).

The Virginia Transportation Research Council also formed an advisory board modeled after the Joint Project Board—now the Joint Transportation Research Program—at Purdue University. The board was charged with providing "advice and counsel" and enabling the researchers to "cooperate with other divisions of the department."

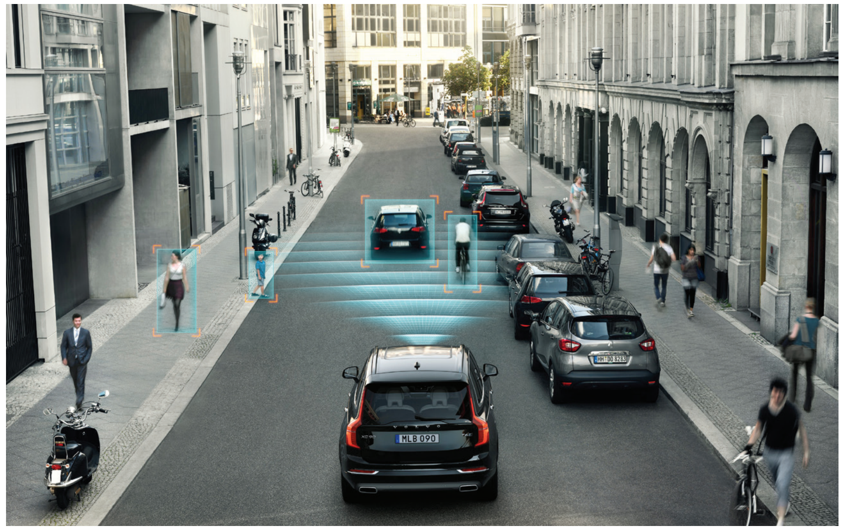

PHOTO: VOLVO CARS

Technology integration often raises new safety risks. Auto-brake systems, for example, must account for all possible traffic situations.

During the 1950s and 1960s, highway needs increased significantly, and states intensified research efforts to meet those needs through "formalized processes, programs, and assignment of funds to research to maximize their outputs" (*4*). During this time, the American Association of State Highway Officials (AASHO)—now the American Association of State Highway and Transportation Officials (AASHTO)—along with federal agencies, the Bureau of Public Roads—now the U.S.DOT Federal Highway Administration (FHWA)—the Department of Defense, industry associations and institutes, and others sponsored the landmark

### Defining Terms

Technology transfer, implementation, innovation, adoption to practice, and a few other terms have a variety of meanings that may depend on the industry context. In the past 20 years, transportation research and innovation managers have worked to define these terms and to jump-start their usage. The National Cooperative Highway Research Program (NCHRP) has promoted standard terminology for transportation professionals. NCHRP project results are widely accepted in the transportation community, and many reports include definitions of terminology and concepts.

◆ **Technology transfer** is a way of sharing ideas, knowledge, practices, products, processes, or techniques between and within organizations. Technology transfer involves at least two parties—a source and a recipient—engaged in the sharing of knowledge about new practices, products, processes, or other elements of technology. Technology transfer may be initiated by the source, the recipient, mutually by both, or by a third party acting to facilitate the sharing (*2*).

◆ **Implementation of research results and innovations** includes "the various activities required to put an outcome of a research project into widespread use." Confusion arises when some transportation research professionals include technology transfer in the definition of implementation. Implementation of innovations—technology, products, and processes that are new to the adopting organization—"may be pilots or demonstrations, training, technical assistance, provision of needed resources, or any activity that fosters use of the research result" (*1*).

PHOTO: VIRGINIA DEPARTMENT OF TRANSPORTATION

Accelerated bridge construction allowed crews to complete the 1995 reconstruction of Coleman Bridge in Virginia in record time—nine days from closing to reopening.

AASHO Road Test (see sidebar, below). With a budget of $27 million (in 1960 dollars), the test was the most ambitious research of its kind.

One objective of the AASHO Road Test was that findings and products—for example, instrumentation, test procedures, data, and formulas—were to be "helpful in future highway design and in evaluation of load-carrying capabilities of existing highways" (*5*). Another stated intent was that results were "to flow to the sponsor and its member departments."

The resources, however, encompassed the research only; the adopting organizations were responsible for the application of the results to practice. The research results gained wide use—technology transfer and implementation took place—yet standard processes that equipped the agencies to apply the innovations efficiently and to realize the benefits speedily were not documented. Transportation professionals accomplished the technology transfer and implementation by pulling the innovations into their own organizations.

## Closing the Gap

The scope of the AASHO Road Test, the uniqueness of its broad-based support, and the genuine need among state agencies for the research results facilitated acceptance and use. The approach for technology transfer and implementation was ad hoc—each agency addressed the acceptance of innovations as it saw fit, with varying levels of resources and outcomes.

By the early 1970s, movement was under way for "managed efforts to translate research results into practice, to assure the realization of full return from research expenditures" (*4*). State agencies were keenly aware of the need to enhance the effectiveness of technology transfer and the implementation of research results.

Facilitating action were findings published in 1968 by an AASHO Special Committee on Utilization of Research that concluded additional skills were needed to span the gap between research and operations:

PHOTO: TRB ARCHIVES

The AASHO road test consisted of 7 miles of two-lane pavement; half of the segments were asphalt and half concrete, to facilitate the study of highway wear under a variety of conditions.

### The AASHO Road Test

The AASHO Road Test, from 1956 to 1960, studied the performance of highway pavements of known thickness under moving loads of known magnitude and frequency. The test facility included portland cement concrete and asphaltic concrete pavements, as well as various types of bridges, along

- 7 miles of two-lane pavements;
- Six loops and a tangent;
- 836 test sections, with equal numbers concrete and asphalt;
- A range of surface, base, and subbase thicknesses; and
- 16 short-span bridges.

For more details, see *Highway Research Board Special Report 61A* (*5*) and the FHWA Highway History website, https://www.fhwa.dot.gov/infrastructure/50aasho.cfm.

> The first interim report…pointed to an unnecessary and undesirable time lag between completion of the research and the utilization of the findings from that research. The committee concluded that the lag was caused by a "missing link" between research and operations. The missing link might be a "new breed of professional generalist" who has a background in research and who would be responsible for getting proven research findings into use. (*4*, p. 4)

In 1974, the National Cooperative Highway Research Program (NCHRP)[1] published a synthesis study offering guidance from successful practices—these included considering implementation needs when defining a project; involving users in planning the research; and providing funds for implementation activities such as drafting specifications, pilot testing, demonstrations, and user training (*4*). The synthesis documented some of the basic elements of technology transfer and implementation efforts.

## Accelerating Innovations

The transportation community saw the need for more effective strategies and processes for getting research results into use, as a variety of public-sector highway research programs and research-related activities were producing innovations across the spectrum of transportation disciplines. More research was being performed, and more results were available.

At the same time, a greater number of findings emerged that were not immediately usable by the practicing professional, indicating the need for more targeted technology transfer and implementation. By the 1980s and 1990s, many research efforts were in full operation: the State Planning and Research Program, the Transportation Pooled Fund Program, state-funded research programs, NCHRP, U.S. DOT and FHWA research programs, and a new nationwide endeavor, the first Strategic Highway Research Program (SHRP), which sought to accelerate the search for innovation.

## Resource Intensity

In general, an understanding of the resource intensity required to facilitate and accelerate the adoption of innovations was lacking. Identifying this gap in transportation research and technology management was difficult, because the standard practice was to commit resources, including funding and technical expertise, to the conduct of research only.

For the most part, funding for technology transfer and implementation was not available, and the organizations adopting the innovations had to supply the resources to get the findings into use. State Planning and Research federal-aid funds committed only a small, optional portion to the implementation of the research results.

Some significant exceptions, however, developed implementation strategies, and their experiences contributed to the toolkit for today's best practices.

PHOTO: WASHINGTON STATE DOT

Washington State DOT crew applies new concrete techniques.

## Demonstrating the Benefits

Several programs were instrumental in demonstrating the benefits of effective implementation activities and exemplified a developing trend throughout the domain of transportation for programmatic, intentional efforts in technology transfer and implementation.

In the 1980s and into the 1990s, the FHWA Implementation Division and later its Office of Technology Applications promoted best practices in the planning, packaging, promotion, and evaluation of research results. FHWA's Experimental Projects, Demonstration Projects, Test and Evaluations Projects, and National Highway Institute programs helped the states to understand concepts important to implementation and technology transfer. Notably, experienced FHWA staff provided practical processes and training for getting research results into use.

FHWA also committed expertise to the newly created Rural Technical Assistance Program—now the Local Technical Assistance Program (LTAP) and the Tribal Technical Assistance Program—modeled after the Extension Service of the U.S. Department

[1] NCHRP is a forum for coordinated and collaborative research that provides practical, ready-to-implement solutions to pressing problems facing the transportation industry. Administered by TRB, NCHRP is sponsored by AASHTO in cooperation with FHWA. The program addresses issues integral to state DOTs and transportation professionals at all levels of government and the private sector. For more information, www.trb.org/NCHRP/NCHRP.aspx.

Photo: Richard Hurd, Flickr

The Rural Technical Assistance Program—now the Local Technical Assistance Program and Tribal Technical Assistance Program—was created to provide technical transportation expertise and outreach to rural communities.

of Agriculture. Drawing in part on federal-aid State Planning and Research funds, the new program provided technical transportation expertise and outreach to rural communities.

Through state DOT program organizations, local technical assistance centers rapidly developed the expertise to transfer technology and to enable effective implementation of innovations at the municipal level. The program raised a small cadre of experts in the strategies and processes for technology transfer.

LTAP's insular funding and program structure, however, proved a significant drawback for advancing technology transfer principles for comprehensive efforts at the state DOT level. LTAP activities were only for municipal or local applications, and the expertise that was developed was not generally available at the state level.

## Strategic Research

The first SHRP, conducted in the late 1980s, was a large-scale, \$150 million program addressing asphalt, long-term pavement performance, maintenance, bridge components, concrete pavements and structures, and chemical control of snow and ice on highways. The funding came through provisions in the 1987 highway legislation and used a takedown from federal-aid funds that the states would have used for highway construction.

> SHRP was designed to be a focused, short-term research program, performed by a special-purpose organization that would cease to exist once its mission had been accomplished…. Little funding for implementation was budgeted in the SHRP program; funding for significant implementation activities required additional legislation…. In December 1991, Congress passed the Intermodal Surface Transportation Efficiency Act, which included special funding for SHRP implementation. (*6*, pp. 36–37)

The first SHRP produced a host of valuable findings and products, but many were not ready for immediate application. The partner organizations for the research—AASHTO, FHWA, and the National Research Council—saw the need for a large-scale implementation effort to realize benefits from the program's findings. Subsequent highway legislation funded SHRP implementation and tasked FHWA to manage the efforts.

SHRP implementation activities included the identification of state coordinators, the appointment of loaned staff from state DOTs, the establishment of a lead states program in which technically proficient states assisted others in facilitating SHRP technologies, creation of the AASHTO SHRP Implementation Task Force as an oversight body, and the structuring of the peer review for major components.

SHRP demonstrated several best practices for implementation activities: intentional and broad-based funding from user agencies; the development of expertise in implementation and technology transfer; the involvement of technically proficient staff from user organizations; facilitation by lead states; and peer collaboration. Together, these initiatives spanned the gap between research results and users.

## Documenting the Methodologies

Up to that time, little work had been done to identify successful strategies for transportation technology transfer or to document a methodology and best practices for implementation activities. Building a body of evidence that showed the benefit of investing resources for such research management topics was difficult—solving technical, operational, and safety problems continued to dominate funding for research.

Through NCHRP, however, state DOTs took the lead and sponsored projects to document best practices and to communicate strategies that would enable more effective application of research results. The Research Advisory Committee of the AASHTO Standing Committee on Research, as well as TRB's standing committees on the Conduct of Research and on Technology Transfer, continued to emphasize the importance of building expertise in these critical management areas. Strategies and tactical guidance for technical topics were published—for example, the 23-volume NCHRP Report 500 series, *Guidance for Implementing the AASHTO Strategic Safety Plan,* issued from 2003 to 2009.

From the mid-1990s, progress had been made in building implementation expertise, but the expertise was isolated in widely diverse pockets of practice. Progress relied on individual champions, who pushed ahead with the systematic processes that worked for the project at hand. The severe under-resourcing of implementation efforts slowed the sharing of successful practices and the gaining of support from top management. Advancing technology transfer concepts and developing increasingly effective methods for implementation took more than 20 years to gather sufficient strength to command attention.

Photo: Virginia DOT

The first Strategic Highway Research Program (SHRP) found that anti-icing is more cost-effective, travel-friendly, and environmentally sound than deicing.

## Adopter Categories

In his landmark work, *Diffusion of Innovations*, E. M. Rogers notes the protracted experiences of various professional communities in promoting more effective implementation (7). Rogers describes the process of adoption—making a decision to use an innovation—and identifies five categories of adopters: innovators, early adopters, early majority, late majority, and laggards (see sidebar, below). His research incorporates public- and private-sector experiences in varying domains, with cases similar to those in transportation.

As new methods, technologies, and other research results are identified, determined to be beneficial solutions to pressing needs, and proved applicable in context, individuals or groups influence the manner and speed at which the innovation is adopted and integrated into operations (see Figure 1, below).

### Adopter Categories

In *Diffusion of Innovations*, E. M. Rogers describes adopter categories as follows (*7*, *8*, pp. 4–5):

◆ **Innovators**. Innovators immediately see the benefits of new ideas and are willing to accept the risks; they may have an organizational culture that routinely embraces innovation or may have a strong champion for the change.

◆ **Early adopters**. Not far behind the innovators, early adopters may have a strong interest in an innovation but want to look more closely before deployment.

◆ **Early majority**. This group helps colleagues move from wondering about deployment to asking why they have not yet deployed the change; ultimately, the early majority brings the majority into the practice.

◆ **Late majority**. These want to wait until the innovation has been accepted by the majority of peers and may require a push to remove any barriers to deployment.

◆ **Laggards**. Last to adopt new ideas or innovations, the laggards may have a strong aversion to risk, reinforced by a strong inclination to continue doing things the way they always have

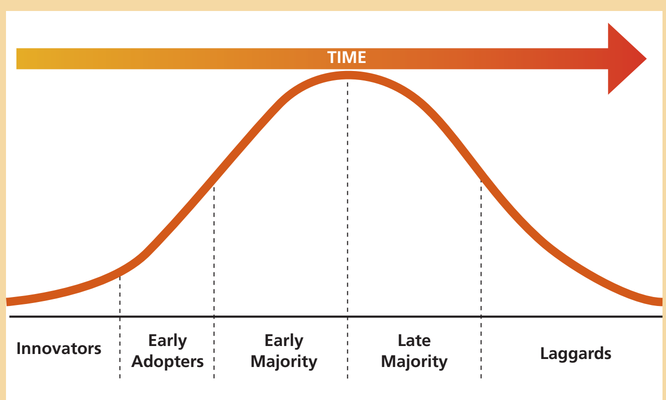


**FIGURE 1 Adopter categories (*7*).**


PHOTO: NEW YORK STATE DOT

FHWA led a large-scale effort to implement research findings and products from the first SHRP, like the falling weight deflectometer calibration system.

For example, champions promoted one of the early technologies that emerged from research—variable message signs. The innovators acted as champions, communicating the vision to early adopters, who implemented the technologies and spread positive reports of successes. In time, others—the early majority—followed. These practitioners were of sufficient number and possessed the necessary credibility to tip the balance to make variable message signs standard operating practice, included in the AASHTO specifications for highway signs.

The adopter category model does not make excuses for the length of time it takes to adopt innovations fully into transportation practice. The model does show, however, the frequently laborious process of changing long-standing methods or of adopting new technologies. Furthermore, the changes and adoptions are taking place among a large and diverse professional population within many independent transportation organizations.

## Reaching Critical Mass

Rogers likens the diffusion and adoption of innovations throughout a group or system to the concept of reaching critical mass, "the point at which enough individuals in a system have adopted an innovation so that the innovation's further rate of adoption becomes self-sustaining" (*7*, p.343). This concept of critical mass plays out time and again through technology transfer and implementation activities that promote transportation innovation.

The critical mass concept is relevant not only on an individual project level but for viewing the way in which strategies and methods are enhancing the adoption of innovations systemwide. Today's transportation environment, especially in the public sector, shows that critical mass is building for practices that enhance and accelerate the application of research results.

A greater number of respected and broadly supported programs are using technology transfer and

## Model Programs

◆ **SHRP 2 Implementation**. This effort, a follow-up to SHRP 2, involves large-scale innovation projects and recognizes that implementation is essential to the program's success; FHWA is applying its organizational expertise to facilitate implementation. The implementation plans are detailed, funding is stable and predictable, and a stakeholder advisory structure guides implementation efforts (*9*). Success stories about maximizing the use of the research products are posted on the web: http://shrp2.transportation.org/Pages/default.aspx.

◆ **NCHRP Implementation**. In the past year, NCHRP appointed a senior program officer to institute a systematic implementation strategy. This strategy will enable the program to span the gap between research findings and the implementation of those findings in user agencies. In addition, in the past several years, the AASHTO Standing Committee on Research has committed substantial funds for technology transfer and implementation to foster the application of NCHRP research results.

◆ **Every Day Counts**. This FHWA program, sponsored in cooperation with AASHTO, provides a state-based model to identify and deploy proven but underutilized innovations rapidly. Every Day Counts recommends proven technologies, supports financial incentives for technology, supplies expert technical assistance and training to enhance deployment, and more. Detailed information is available at https://www.fhwa.dot.gov/innovation/everydaycounts/.

◆ **Virginia Department of Transportation**. Virginia DOT has dedicated funding and has committed expert staff to facilitate the implementation of research results produced by the Virginia Transportation Research Council. The expert staff identify "'early adopter' advocates for the implementation of research recommendations… to improve…agency operations and efficiency." Additional information is posted at http://vtrc.virginiadot.org/DynamicPage.aspx?PageId=4.

PHOTO: GARRETT, FLICKR


Variable message signs—an example of an early technology developed from transportation research—now are standard highway features.

implementation techniques to reap the benefits from transportation innovations. This emergent activity also documents the state of the practice for a key aspect of transportation research and technology management.

## Application of Innovations

Planned and systematic uses of technology transfer and implementation processes are rapidly becoming essential elements in transportation innovation (see sidebar, page 12). Drawing on the experiences of the 1980s and 1990s and on the subsequent documentation of best practices, leading transportation research and technical professionals are capitalizing on lessons learned.

Exemplary programs have shown the way to accelerating and streamlining the application of innovations. Strategies, processes, and methods from these programs are models for today's dynamic transportation applications.

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8. Hood, M. M., S. R. Thompson, R. J. Vance, M. S. Renz, B. T. Harder, J. Toole, and S. T. Hunter. *NCHRP Report 768: Guide to Accelerating New Technology Adoption Through Directed Technology Transfer*. Transportation Research Board of the National Academies, Washington, D.C., 2014.
9. *Special Report 296: Implementing the Results of the Second Strategic Highway Research Program: Saving Lives, Reducing Congestion, Improving Quality of Life*. Transportation Research Board of the National Academies, Washington, D.C., 2009.


## Select Publications on Transportation Technology Transfer and Implementation Methodologies

◆ *NCHRP Synthesis 216: Implementation of Technology from Abroad,* 1995.

◆ *NCHRP Report 382: Facilitating the Implementation of Research Findings: A Summary Report,* 1996.

◆ *NCHRP Report 442: Systems Approach to Evaluating Innovations for Integration into Highway Practice,* 1998.

◆ *NCHRP Synthesis 280: Seven Keys to Building a Robust Research Program,* 1999.

◆ *NCHRP Synthesis 355: Transportation Technology Transfer: Successes, Challenges, and Needs,* 2005.

◆ *NCHRP Synthesis 461: Accelerating the Implementation of Transportation Research Results,* 2014.

◆ *NCHRP Report 768: Guide to Accelerating New Technology Adoption Through Directed Technology Transfer,* 2014.

◆ *Conference Proceedings 51: Transport Research Implementation: Application of Research Outcomes: Summary of the Second EU-U.S. Transportation Research Symposium,* 2015.

# Assessing Technology Readiness Levels to Increase Implementation

DAVID KUEHN

With support from the Volpe National Transportation Systems Center, the Federal Highway Administration (FHWA) Exploratory Advanced Research (EAR) Program developed a technology readiness level (TRL) assessment process to improve communication and to increase the use of program-funded research results.[a] The EAR program addresses higher-risk, longer-term research that can transform the planning, building, renewal, and operation of safe, congestion-free, and environmentally sound transportation systems.

## Adapting the Concept

In 2010, the initial set of EAR-funded projects was nearing completion, and program researchers, seeking a better way to understand and communicate the research results, adapted the TRL concept—originally developed for NASA in the 1980s and adopted across other agencies, such as the Department of Defense—for use in highway transportation research, development, and deployment. As a funder of early-stage research, the EAR program managed projects at various levels of maturity, from the conceptual focus on building knowledge in the laboratory to ready-for-real-world testing.

By 2015, the EAR program had implemented the TRL assessment process across its portfolio, using the assessments to identify potential initial applications and interested stakeholders and to tailor methods for accelerating the transition of results to the stakeholders. Building on the EAR program's success, FHWA has begun to expand the use of TRL assessments across other programs.

## Assessments in Action

The EAR program used the TRL assessment on research projects that addressed wayfinding and navigation for blind and visually impaired pedestrians.[b] The research integrated advances initially developed for connected vehicle mapping and localization.

A panel of technology experts, practitioners, and researchers on the needs of pedestrians and of blind and visually impaired travelers considered both the mapping and the navigation elements. The panelists found that the readiness of these technologies ranged from TRL 5 to 6 on a scale of 1 to 9. Research at TRL 5 is ready to move from the laboratory to a relevant environment outside the laboratory; with that move, the research becomes TRL 6.

Guided by the assessments, FHWA identified the need for interoperability across mapping systems, particularly as people move from indoors to outdoors and vice versa, as well as for improved ways to map the location of pedestrian features like outdoor curb ramps or elevators.

Photo: FHWA

Federal Highway Administration staff works with a volunteer trying out new mobile technology for blind and vision-impaired pedestrians.

FHWA also identified stakeholders who would be interested in—or who might fund—research on pedestrian mapping, particularly for blind and visually impaired pedestrians. A review of technology trends in navigation suggested that advances in commercial mobile and wearable devices soon would provide the necessary requirements without further EAR program support.

The transportation industry and its research enterprise are highly dispersed, with work proceeding across different sectors and levels of government and with results implemented in a range of physical and organizational environments. Applying technologies from other domains to transportation—or applying research that began in transportation to other industries, such as construction—requires interaction with more extensive set of stakeholders.

With so many contributors, whose ideas about technology deployment are as varied as their disciplines and training, misunderstandings about research results and new technologies can occur. A TRL scale and TRL assessments can help find a common language.

[a] More information about the TRL methodology is available at www.fhwa.dot.gov/advancedresearch/trl_h.cfm.

[b] For more information on the research projects, visit www.fhwa.dot.gov/advancedresearch/pubs/15040/index.cfm.

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# Research Results Go Statewide

## *Virginia Transportation Research Council's Implementation Program*

CATHY McGHEE, KEVIN WRIGHT, AND JIMMY WHITE

*McGhee is Director of Research, and Wright is Implementation Coordinator, Virginia Transportation Research Council (VTRC), Virginia Department of Transportation, Charlottesville. White is a consultant and former VTRC Implementation Coordinator.*

Established in 1948 as a partnership with the University of Virginia, the Virginia Transportation Research Council (VTRC) is a leading transportation research center and the research arm of the Virginia Department of Transportation (DOT). VTRC specializes in applied research to support Virginia DOT and, through its work with Virginia's colleges and universities, provides technical consulting and training for future transportation professionals.

For Virginia DOT, research is one of its core functions; the agency develops and delivers a robust transportation research program to save lives, time, and money. Not all of VTRC's research projects lend themselves to easily quantifiable monetary benefits, but conservative estimates have demonstrated that savings from VTRC research have paid for Virginia DOT's investment several times over.

VTRC promotes advances in the following four areas:

◆ Systems operations and traffic engineering;
◆ Environment, planning, and economics;
◆ Structures, pavements, and geotechnical engineering; and
◆ Materials.

VTRC's staff of 45 full-time employees—as well as part-time employees, interns, and graduate students—maintains strong relationships with many of the state's academic institutions.

### Implementation Coordinator

In 2009, after having conducted more than 60 years of research, primarily for Virginia DOT, VTRC began to focus on the outcomes of its many recommendations for improvements to department policies, methods, materials, and processes. Encouragingly, most of the recommendations had made their way into practice; however, VTRC lacked a formal way to organize and track the outcomes. As a solution, VTRC created an implementation program with a dedicated coordinator and a budget to implement research recommendations, working with other Virginia DOT staff members.

Clearly, to find someone with a depth of knowledge in every technical area included in VTRC's research

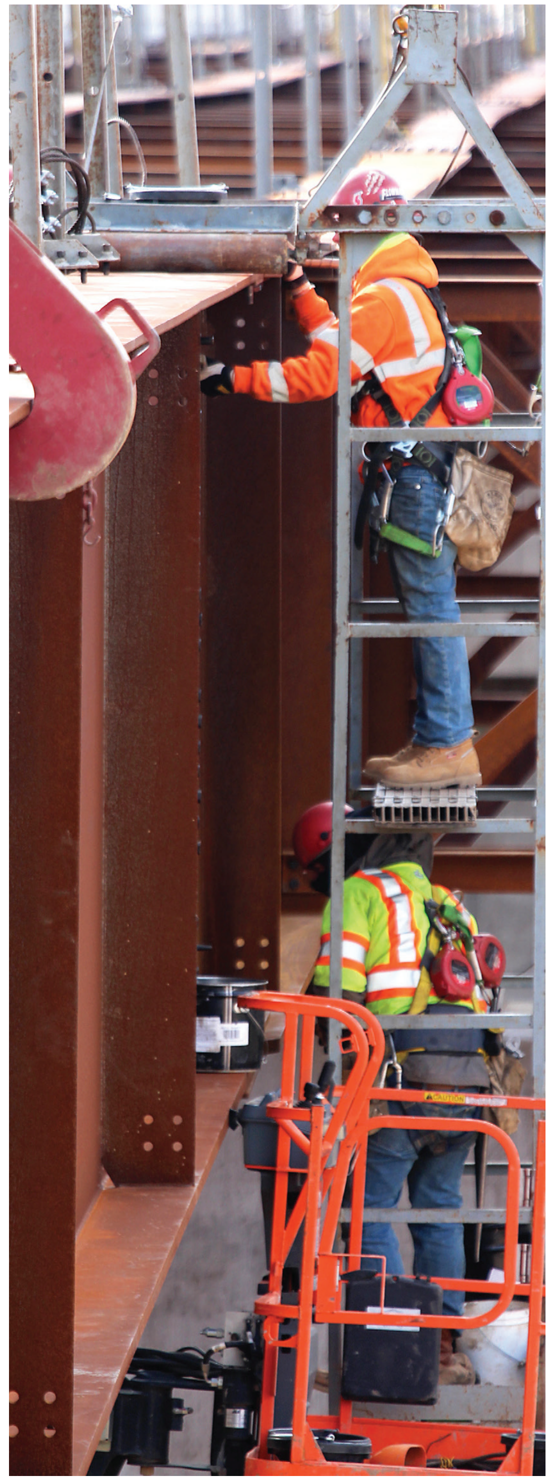

PHOTO: VIRGINIA DEPARTMENT OF TRANSPORTATION

Anchor nuts, corrosion-resistant steel girders and cross frames, and the development of an inverted-T bridge superstructure system are topics of Virginia Transportation Research Council (VTRC) research.

program would be challenging, if not impossible; the coordinator would work closely with and rely on researchers as subject matter experts. Therefore, significant thought was given to the qualities that would be most beneficial in an implementation coordinator: most importantly, a solid understanding of Virginia DOT and how its many divisions and districts work together. Combining such knowledge with an understanding of VTRC would provide a much-needed bridge between research and day-to-day agency operations.

As a spokesperson for change, a successful implementation coordinator would need to understand traditional approaches and act as an enthusiastic advocate for innovation.

The implementation coordinator position has evolved over the past seven years, incorporating lessons learned from successes and challenges. The experience has shown that the coordinator adds value by working within Virginia DOT to link research with field adoption and has clarified three core responsibilities:

◆ **A liaison between researchers and field personnel**. The third-largest state-maintained transportation system in the country, Virginia DOT has nearly 7,500 employees across the Commonwealth. To maintain contact with field researchers, the implementation coordinator needs to interact regularly with statewide working groups, managers, and leaders across all levels of the organization. These contacts and connections to field operations help the implementation coordinator locate champions for research implementation—key employees who are passionate about improving the agency and advancing innovation.

◆ **A project manager**. With more than 75 individual implementation projects around the state, the implementation coordinator must maintain contact with project champions, principal investigators, and others involved in each project. To facilitate the acceptance of a research recommendation as standard practice, it is important to demonstrate it in a way that reduces concerns and mitigates risks. Regular communication and interaction with project personnel provides opportunities to work out bugs, to make adjustments, and to build teamwork for a positive experience.

◆ **Manager of the implementation program budget and tracking implementation of research recommendations**. Implementation is a team effort that requires everyone to contribute; monitoring and tracking allows implementation coordinators to communicate clearly with everyone involved in implementation, ensuring an understanding of roles and responsibilities. Improvements to the tracking system are under way. Managing budgets wisely also is imperative—as is effectively leveraging every available dollar. The coordinator ensures that projects are funded, kept on schedule, and closed out so that any remaining funds may be applied to other projects.

Photo: Tom Saunders, Virginia DOT

VTRC manager Bridget Donaldson (*left*) supervises installation of a wildlife fence along I-64.

## Begin with the End in Mind

VTRC's robust program of research is developed with input from a variety of sources, guided by nine research advisory committees (RACs) comprising staff from Virginia DOT's central office and districts. In addition to their voting members, many RACs also invite regular participation from industry representatives, university partners, and the Federal Highway Administration.

RACs focus on particular technical areas such as traffic and safety, planning, asphalt, and more; provide input on proposed research topics; help to prioritize research needs; and give feedback on project progress and results. Discussions of research needs and topic prioritization help to ensure that the projects selected will benefit Virginia DOT and will align with agency goals and objectives; the discussions also are vital to implementation.

The implementation coordinator attends all RAC meetings to gain insight into potential future projects and to offer broad operational experience related to the prioritization of research. RAC meetings also allow coordinators to identify possible champions and to develop an implementation strategy—even in the early stages of a project.

## From Kickoff to Closeout

Every research project begins with the identification of a project champion and development of a research proposal. A technical review panel next is established to provide feedback and assistance throughout the project.

A kickoff meeting offers the opportunity to discuss panel comments on the research plan and the expected outcomes of the project, including an anticipated implementation plan. Although exact outcomes cannot always be predicted—after all, these are research projects—it is important to discuss what implementation might look like and who might be involved to optimize the chances of success. The implementation coordinator plays an important role in these discussions.

As research is conducted, the coordinator stays in contact with the scientists; this communication allows the coordinator to provide feedback and to find out more details about the project's direction. By staying abreast of the work, the coordinator may refine the plan and build support from the field.

At the closeout meeting, the researchers and the technical review panel discuss and create an implementation plan, which is incorporated into every research report. Details then can be worked out: who will act as implementation champion, what resources are needed, and what the implementation timeline should be.

PHOTO: VIRGINIA GUARD PUBLIC AFFAIRS, FLICKR

VTRC's Hurricane Evacuation Route Analysis used simulation modeling to determine traffic flow impact of evacuations in Hampton Roads.

Implementation can take many forms, from a division memorandum or edited best practices manual to a specification change or a major shift in a material or process. In some cases, implementation is complete at the end of the project, when a memo or manual is issued. In other cases, field demonstrations are needed to gain acceptance and to minimize risk. In those cases, implementation funds often are used to cover "delta" costs, or the increased costs associated with a new or innovative material or process, typically encountered the first time a product or method is used.

## Focus on Implementation

After the research project is completed, the implementation coordinator role becomes more critical. From the project's beginning, the coordinator has been an active team member, working with the researcher and the project panel; once the recommendations are finalized, the coordinator assumes responsibility for managing the implementation program.

Many projects are implemented at no cost, but others need funding to cover associated delta costs. The current implementation budget is approximately $8 million per year; the goal is to manage those funds so that all research recommendations are applied. The implementation coordinator works with the research team and the designated implementation champions to distribute these funds in the most effective manner.

## Pilot Projects

Depending on the scale of the implementation, an initial phase that consists of small pilot projects may be enacted. This allows project participants to learn more about how the new technology or practice

PHOTO: VALERIE, FLICKR

The Blue Ridge Parkway (*above*) and the city of Norfolk in the Tidewater region (*below*). Virginia's transportation needs are diverse, encompassing rural, urban, mountainous, and coastal regions.

works under field conditions and with Virginia DOT operations. By taking this phased approach, problems can be resolved on a small scale in preparation for statewide implementation.

Virginia is a diverse state, with a mix of rural and urban environments and coastal and mountainous regions. With some parts of the state separated by more than 6 hours of travel time, pilot projects facilitate the sharing of experiences across district boundaries. It was clear early on that if the goal was to change statewide practice, multiple pilot projects might be necessary to gain support and to allow more people to learn about the project through their own peer networks—shared experiences build momentum for statewide acceptance.

As with any Virginia DOT project, on-time and on-budget delivery helps build trust with stakeholders. Projects must be planned and scoped properly and must include sound estimates of cost and time.

PHOTO: VIRGINIA DOT


Once the budget and completion date are set, the implementation coordinator tracks the projects, working with champions, field personnel, and the researcher to meet targets. This includes the interim phases of implementation projects as well as the full completion of the research according to the implementation plan.

## Success Stories

### *Roadkill Composting*

A 2010 research report studied Virginia DOT's animal carcass disposal practices. With more than 57,000 miles of state highways to maintain, Virginia DOT must dispose of many animal carcasses each year. In FY 2008, Virginia DOT allocated $4.4 million for carcass removal; local maintenance areas were facing budget challenges associated with disposal, as well as regulatory challenges in some portions of the state.

The research determined that composting animal carcasses could provide a solution to many of the challenges faced. Used regularly in the agriculture industry, composting facilities at strategic locations could cut costs and solve problems of landfill acceptance restrictions and tipping fees related to disposal, the report found. In addition, composting facilities located on site at Virginia DOT's maintenance area headquarters would eliminate a significant amount of travel time.

The first phase of the implementation effort involved installing a forced-air composting system in the Halifax Residency. This location was chosen based on a large number of animals collected, as well as challenges in disposing the carcasses. The implementation coordinator worked closely with personnel at the area headquarters to learn more about their operations, expected quantity of carcasses, availability of materials needed for implementation, space required at the facility for operation, and acceptance by maintenance personnel.

Although the composting process was known to work, it had to be adapted to meet the needs of Virginia DOT. Previous work with the composting industry facilitated the development of the equipment and expedited its procurement; with the eager participation of Virginia DOT personnel, the unit was installed and has been operating successfully.

In subsequent projects, the design of the composting units has been modified to meet the needs of the area headquarters, and new ways to facilitate procurement have been developed. Virginia DOT recently implemented its third-generation composter, a modular design that can be scaled as needed by the area headquarters.

Through this learning and adapting process, the agency has been able to develop options for the equipment, making it easily implementable in any area headquarters in the state but also a cost-effective alternative to traditional disposal methods.

### *High-Polymer Asphalt*

Another research project addressed one of Virginia DOT's major problems, reflective pavement cracking. As jointed concrete pavement ages throughout the state, Virginia DOT must find effective methods for preservation and maintenance. Traditional asphalt overlays offer an inexpensive solution to restore surface properties; within two to three years, however, the concrete joints reflect through the new surface. VTRC research identified high-polymer asphalt mixes as a solution to this problem.

The introduction of high-polymer asphalt binders to the market offered an easily implementable remedy. Because modifications could be made at the binder terminal, asphalt mix producers faced no significant changes.

A question surrounding the use of the new, modified asphalts was ease of placement—that the high polymer content might make it difficult to place the mix and that the new mix might not be workable, especially in gore areas and around obstacles such as manholes that required hand work.

To learn more about the properties of the new mix, Virginia DOT initiated an implementation project in the Northern Virginia District. The implementation coordinator worked with district personnel who were interested in the product and were willing to find a location to test the material.

A subdivision street that had some transverse cracking and utilities was chosen, offering opportunity for hand work trials as well as the ability to evaluate the mix's resistance to cracking. Delta costs were covered with implementation funds and the project proceeded successfully, turning up no issues with placement of the high-polymer material. To date, the mix shows no reflective cracking.

Photo: National Rural Knowledge, Flickr

Budget and regulatory challenges spurred Virginia DOT to find new ways to dispose of animals killed on Virginia roads. By implementing roadkill composting, the agency has reduced the cost of carcass disposal significantly.

Photo: Virginia DOT

The Occoquan Bridge on I-95 in Northern Virginia was among the first sites of high-polymer asphalt mix overlay testing in the state.

When the implementation project was completed, the new mix was used on overlay projects on I-95 in the Richmond area, as well as on I-95 and I-495 in Northern Virginia. Even before the final report was published, discussions about this research project sparked interest among field staff that has led to substantial implementation. Seen as a cost-effective solution, high-polymer asphalt mixes now are widely accepted for use throughout the state.

## Keys to Success

In the seven years since the implementation coordinator position was established, Virginia DOT has identified three keys to successful implementation:

◆ Employ a coordinator with a broad knowledge of department operations and with network connections to potential change agents throughout the organization—this facilitates the rapid building of trust, which enables quick and effective implementation.

◆ Begin research with implementation in mind, ensuring that research projects add value to the department and that implementation is considered in all stages of the project. By maintaining this focus, implementation becomes a natural part of the process.

◆ Recognize that implementation is a learning process. Very few projects move forward without adjustments—to build on successes, implementation coordinators must be prepared to learn, experiment, document experiences, and share with others. Each successful implementation project is a building block that helps Virginia DOT fulfill its mission of bringing innovation to transportation.

# Making Cost-Effective Highway Maintenance Decisions

## *State Pooled Fund Develops System, Supports Implementation*

DAVID L. HUFT

*The author is Research Program Manager, Office of Research, South Dakota Department of Transportation, Pierre. He was the 2009 recipient of the TRB W. N. Carey, Jr., Distinguished Service Award.*

Transportation agencies are responsible for providing safe, reliable highways throughout the winter, which presents significant challenges:

◆ Severe weather conditions are often difficult to forecast,
◆ Drivers and commercial carriers with demanding delivery schedules have high expectations,
◆ Funding and staff are limited,
◆ New winter maintenance treatments are introduced,
◆ Seasoned maintenance workers move or retire, and
◆ Common deicing materials pose environmental problems.

A maintenance decision support system (MDSS) can help transportation agencies accomplish winter maintenance missions in an efficient and cost-effective way. An MDSS requires the following data and inputs:

◆ Current road conditions;
◆ Weather predictions for the near-to-medium term;
◆ Models of the chemistry and physics of the road surfaces under varieties of weather, traffic, and maintenance treatments; and
◆ The maintenance resources available—including the equipment, materials, operators, and time.

An MDSS can evaluate feasible winter maintenance strategies—the treatments, the application rates, and the timing—in accordance with predictions of the road conditions and can recommend the most effective and economical treatments.

## Essential Functions

The MDSS developed under the Federal Highway Administration's Transportation Pooled Fund Program through the collaboration of several states (see box, page 21) incorporates the scientific framework and computational tools to identify sound winter maintenance treatment strategies:

◆ *Road conditions*—The MDSS accepts information about current road conditions from manually recorded observations, snowplow-mounted sensors, and GPS location equipment.
◆ *Maintenance treatments*—Manual entries or data from instrumented snowplows report on the plowing and chemical applications.
◆ *Weather conditions*—The MDSS considers current and recent weather conditions that affect the road surface—such as the temperature, dew point, wind speed and direction, precipitation type and rate, blowing and drifting snow, cloud cover, and visibility.
◆ *Weather predictions*—Sophisticated ensembles

PHOTO: DIANA ROBINSON, FLICKR

Winter road conditions present significant challenges.

of computer models, supplemented with input from meteorologists, make site- and time-specific weather predictions covering the next 48 hours.

◆ *Roadway state*—Physical and chemical models of the pavement and of the mix of water, ice, chemical, and grit yield predictions of the temperature, the moisture type and depth, and the chemical concentration.

◆ *Feasible treatments*—The MDSS considers maintenance treatments that fall within agency-defined constraints affecting equipment, materials, operating hours, and crew size at each road segment.

◆ *Agency priorities*—The MDSS considers acceptable levels of service for each highway segment.

◆ *Prediction of road surface behavior*—Physical and chemical models in the MDSS predict the behavior of the road surface under every feasible maintenance treatment—chemical application, plowing, or a combination of both. The models predict whether the road will become dry, wet, snowy, or icy during the next several hours.

◆ *Treatment recommendations*—Finally, the MDSS recommends to maintenance supervisors and truck operators the treatments that will maintain the level of service most economically.

## MDSS Implementation

The pooled fund study has supported not only the research and development but the implementation of the MDSS. Member agencies typically have deployed the system on a few highway segments initially. Some have selected segments that are geographically distributed around the state, but others may concentrate the segments within certain districts.

The MDSS contractor configures the chosen routes in the MDSS and provides fully functional operation during one or more winters, giving the state agency valuable experience with the system, the supporting technology, the application to winter maintenance, and the associated institutional and workforce issues. With experience, agencies can expand the MDSS to a significant portion or to all of the highways in the state and can secure the MDSS services, automatic vehicle location, and other mobile sensors and communications equipment through normal procurement processes.

To make the MDSS as accessible and as easy to use as possible, the system is being moved from the original client-server environment to web-based and mobile apps.

## Benefits of MDSS

The MDSS demonstrates potential for significant cost savings and improvements in service (*1*). A case study of five New Hampshire winters showed that use of the MDSS would have provided the same level of service but with 23 percent less salt use and a benefit–cost ratio of 8:1. In deploying the MDSS in 2008 to 2009, Indiana estimated a savings of $11 million—27 percent of the winter maintenance budget. After experience within limited areas, several participating states are moving to statewide deployment.

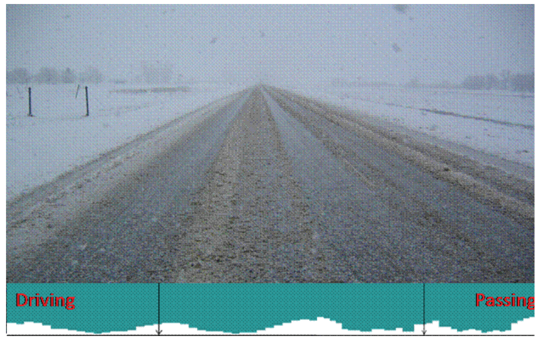


**FIGURE 1 MDSS predictions match actual road conditions.**

MDSS users have realized other intangible but important benefits:

◆ Winter weather information from a single source,

◆ Improved anticipation of storm events and road conditions,

◆ More consistent winter maintenance by all maintenance units,

◆ Reduced environmental exposure to deicing chemicals, and

◆ Powerful reporting and analytical tools for managers.

The success of the pooled fund study is a direct result of strong collaboration between the participating states and the contractor.

## Reference

1. *Analysis of Maintenance Decision Support System Benefits and Costs*. SD2006-10 Final Report, Western Transportation Institute, Montana State University, Lewiston, May 2009.

**Transportation Pooled Fund Study TPF-5(054): Development of Maintenance Decision Support System**

*Lead State*: South Dakota

*Participating States*: California, Colorado, Idaho, Indiana, Iowa, Kansas, Kentucky, Maryland, Michigan, Minnesota, Nebraska, New Hampshire, New York, North Dakota, Pennsylvania, Virginia, Wisconsin, Wyoming

*Contractor*: Iteris, Inc., Grand Forks, North Dakota

# State Transportation Innovation Councils

## *Partnering for Continuous Innovation*

THOMAS HARMAN

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This is an era of rapid change, and the transportation community is looking to capitalize on innovative technologies and practices that can enhance highway safety, expedite project delivery, decrease traffic congestion, and improve environmental sustainability. State Transportation Innovation Councils (STICs) are instrumental in this nationwide effort.

A STIC is a group of public and private transportation stakeholders that evaluates innovations and spearheads deployment statewide. The councils consist of representatives from federal, state, and local agencies, as well as from industry, academia, and other partners. Through each STIC, these stakeholders come together from a state's transportation community to consider all sources of innovation comprehensively and strategically and to advance the technologies and processes that promise the greatest impact.

## Culture of Innovation

National initiatives such as Every Day Counts, the Implementation Assistance Program of the second Strategic Highway Research Program (SHRP 2), and the Innovation Initiative of the American Association of State Highway and Transportation Officials (AASHTO) are promoting innovations and supporting the transportation community in putting innovations into practice. Working through the STICs, state

PHOTO: PRIYA SAHGAL, FLICKR

Innovations like ultra-high-performance concrete and precast deck panels allowed construction crews to remove and replace an entire bridge deck in Hennepin County, Minnesota, in 17 weeks.

departments of transportation (DOTs) can consider the innovations recommended by these sources and others.

The Federal Highway Administration (FHWA) launched Every Day Counts in 2009 in cooperation with AASHTO. Under the program, FHWA places a request every two years in the *Federal Register* calling on transportation stakeholders to nominate innovative technologies and processes that have proved effective and that are market ready although underutilized—in other words, innovations that have a capacity for success in widespread use.

FHWA selects approximately one dozen innovations for deployment. The agency highlights these at regional stakeholder summits, and state DOTs choose the innovations that will work best for them and their customers.

The concept of a nationwide network of STICs grew out of the Every Day Counts program as a way to reach a range of stakeholders with transportation responsibilities at all levels. By April 2016, STICs were at work in all 50 states, the District of Columbia, Puerto Rico, the U.S. Virgin Islands, and the jurisdictions associated with the Office of Federal Lands Highway. This widespread, continuous effort to foster innovation has had a positive effect on the adoption of new technologies and processes.

PHOTO: NEW YORK STATE THRUWAY AUTHORITY

Seven innovations from the Every Day Counts program and three products from the second Strategic Highway Research Program were included in the Tappan Zee Bridge replacement design–build project.

## Gaining Traction

For example, the Massachusetts STIC, formed in 2011, has implemented 32 of the Every Day Counts innovations. For each of these, the STIC assembles a deployment team that develops an implementation plan and reports on progress at quarterly STIC meetings. The STIC's innovation success stories include projects involving design–build contracting,

INNOVATION

### Traffic Incident Management

Every Day Counts and SHRP 2 are promoting training in traffic incident management (TIM). The multidisciplinary program focuses on response efforts that protect motorists and responders while minimizing the impacts on traffic flow. In 2013 to 2014, during the second round of Every Day Counts, more than 80,700 responders received training in the best practices for clearing crashes, and by August 2016, the number had reached 200,000. In the fourth round of Every Day Counts, FHWA is encouraging adoption of three national performance measures that agencies can focus on when collecting and reporting TIM data:

- ◆ Time of lane closure,
- ◆ Time that responders are on the scene, and
- ◆ Number of secondary accidents.

PHOTO: FHWA

*Traffic Incident Management is a unique, multidisciplinary training program aimed at protecting motorists and responders while minimizing the impacts on traffic flow. Every Day Counts is supporting improvements in TIM data collection (*above*) and reporting.*

Maine DOT applied STIC Incentive funds to create a TIM Exchange that integrates its 511 advanced transportation management system with the computer-aided dispatch system of the state's Department of Public Safety. Through an automated process, the exchange conveys incident location data from the dispatch system to the 511 system, circumventing exclusive reliance on human communication systems. The system is expected to decrease the times for traffic incident response and clearance and to enhance responder safety and travel reliability.

With STIC Incentive funding, Missouri DOT is accelerating TIM data collection by integrating the data feeds with regional integrated transportation information systems. Missouri DOT is hosting a TIM summit to inform all partners about effective TIM practices and to gather input for specific strategies.

**FIGURE 1 Through the STICs, state DOTs can engage with additional stakeholders, learn their priorities, and collaborate in selecting and deploying innovations from Every Day Counts or other sources.** (Graphic: FHWA)


e-construction technologies, smarter work zones, and ultrahigh-performance concrete connections for prefabricated bridge components.

In New York State, the STIC's action plan for Every Day Counts innovations includes a dashboard that highlights the implementation status and accomplishments of each initiative. The dashboard keeps management up to date and informs new employees.

The New York STIC also emphasizes the combination of multiple innovations on a project or program. In replacing the Tappan Zee Bridge, for example, the state used seven Every Day Counts innovations, including design–build project delivery, 3-D modeling, and e-construction, as well as three SHRP 2 products, including complex project management strategies.

These two examples show how the national STIC network and Every Day Counts are gaining positive traction. As of May 2017, each state has used 14 or more of the 43 innovations promoted through Every Day Counts, and some states have adopted more than 30. Many of these innovations have become mainstream practices across the country.

## Partnering for Impact

Each STIC represents a partnership between federal, state, and local governments, as well as the private sector and the academic community (see Figure 1, above, left); the dynamics are unique to each state. In striving to advance innovations, each STIC forms a link between the research community, proven technologies, and statewide implementation.

INNOVATION

## Accelerated Bridge Construction

Methods of accelerated bridge construction (ABC) include slide-in bridges, prefabricated bridge elements and systems, and the geosynthetic-reinforced, soil-integrated bridge system—all championed in more than one round of Every Day Counts. ABC enables highway agencies to replace bridges in hours, to reduce planning and construction efforts by years, to decrease traffic delays, and potentially to increase safety and to lower project costs.

In collaboration with the Kentucky Transportation Cabinet, Indiana DOT used ABC and design–build project delivery on the Milton–Madison Bridge, a $103 million project. The innovations allowed the old bridge to stay open to traffic while the new one was built. The procedure slid the 2,428-foot-long structure from temporary piers 55 feet laterally onto the refurbished original piers; the Milton–Madison Bridge is the longest bridge to be slid laterally into place in North America.

The new steel truss bridge over the Ohio River weighs 30 million pounds and is 40 feet wide—twice as wide as the 1929 structure it replaced—and accommodates two 12-foot lanes and 8-foot shoulders. With the bridge slide approach, the river crossing was closed for only 41 days, in contrast to the 1 year that conventional construction would have required.

PHOTO: MILTON–MADISON BRIDGE PROJECT

*The Milton–Madison Bridge over the Ohio River is the longest in North America to be moved into place by sliding laterally, an ABC technique. The joint Indiana–Kentucky DOT effort also used design–build project delivery.*

Maine DOT used STIC Incentive funds on an ABC project that called for prefabricated concrete deck panels with ultra-high-performance concrete connections. With innovative materials and technologies, the project team replaced the deck of the Western Avenue Bridge in 52 days—78 days faster than traditional methods would have required—and is developing standards from the lessons learned.

STIC Incentive funds helped Mississippi DOT write guidelines for ABC technologies. The guidelines provide a step-by-step process for determining the suitability of projects for ABC and to outline lessons learned from ABC projects.

*For more information about ABC, visit https://www.fhwa.dot.gov/innovation/everydaycounts/edc-2/abc.cfm.*

Photo: Russell Sekeet, Flickr

Kentucky's Utilities and Rail Coordination Program and its STIC conduct research to improve railroad coordination.

Although the makeup and operation of the STICs may vary somewhat, each state's FHWA division office and the state DOT typically cochair the STIC, which may include representatives from the Local Technical Assistance Program, the Tribal Technical Assistance Program, and university transportation centers.

Local agency representatives often include county engineers and representatives from metropolitan planning organizations, local transit and tollway authorities, and city public works departments. Industry representatives may come from trade associations, as well as from private construction and consulting firms. Many councils also have representatives from federal agencies such as the Federal Transit Administration, the U.S. Environmental Protection Agency, and the U.S. Army Corps of Engineers.

Through established partnerships, the Kentucky STIC is working to accelerate deployment of an unmanned aircraft systems program, to implement e-construction, and to improve railroad coordination. The Kentucky STIC's ability to deploy innovative ideas statewide quickly and effectively is a result of involving all partners and has improved services to state citizens.

## STIC Incentive Program

FHWA administers a STIC Incentive program that offers up to $100,000 per state in each federal fiscal year to support or offset the costs of standardizing innovative practices in a state transportation agency or other public-sector stakeholder. The funds provide a federal share of 80 percent on a project, and project sponsors or other allowable funding sources supply the 20 percent nonfederal match. The STIC Incentive funds have helped states to mainstream innovations and to expedite project delivery.

The Idaho Transportation Department applied incentive funds in developing design standards for geosynthetic-reinforced, soil-integrated bridge system construction, an innovation promoted by Every Day Counts. The department also hosted a workshop to demonstrate the technique to approximately 100 local agency representatives.

Maine DOT applied STIC Incentive funds for an accelerated bridge construction project with prefabricated concrete deck panels and ultrahigh-performance concrete connections. By using the innovative materials and technologies, the project team replaced the deck in 52 days—an estimated 78 days faster than with traditional methods. Maine DOT is applying the lessons learned to develop standards, specifications, and design guidance for projects.

INNOVATION

### e-Construction

E-construction uses readily available technologies to improve document management for construction projects. E-construction saves money by decreasing the costs of paper use, printing, and document storage and saves time by reducing communication delays and by speeding transmittal. Supported by Every Day Counts, the method improves communication by allowing faster approvals, increased accuracy, and better document tracking. AASHTO has designated e-construction as an Innovation Initiative focus technology.

Photo: Michigan DOT

*Highway projects require a significant amount of documentation. State DOTs using e-construction—the paperless management of construction documents—report savings in time and money.*

Florida DOT has used an e-construction documentation process for all construction contracts since July 2016, when the state institutionalized paperless processes. STIC Incentive funds enabled Florida DOT to complete efforts to provide field staff with mobile devices for e-construction. Florida DOT reports that e-construction benefits include instantaneous data collection and the ability to troubleshoot and resolve issues in the field. After spending $1.1 million to implement e-construction, the agency estimates a savings of approximately 1 hour per day per field user, or $22 million a year.

Michigan DOT has implemented a successful e-construction program that is estimated to save $12 million, to have eliminated six million pieces of paper per year, and to have slashed construction modification times from 30 days to three. The agency claims to be 99 percent paperless.

## Excellence Awards Recognize STICs

AASHTO and FHWA recognized STICs in Kentucky, Massachusetts, and Vermont in 2016 with the inaugural STIC Excellence Awards for success in fostering a culture of innovation.

◆ The Kentucky Transportation Cabinet created a senior management position to spearhead the integration and standardization of innovative processes throughout the state. High-friction surface treatments and Safety Edge contributed to an 85 percent drop in roadway crashes. Kentucky's policy of accelerated bridge construction has encouraged continuous innovation on bridge projects.

◆ Massachusetts DOT formed a committee named READi—for review, evaluate, accelerate, and deploy innovation—to identify innovations for deployment. The agency holds an annual Innovation and Tech Transfer Exchange to share the newest ideas in transportation technology. Massachusetts DOT used accelerated bridge construction to replace 14 bridges on I-93 over 10 weekends.

◆ The Vermont STIC Executive Council meets monthly to discuss new ideas, technology advances, and the applications to today's challenges. The Vermont STIC holds an annual meeting at which participants from industry, municipalities, and associations brainstorm innovative ideas. The Vermont Agency of Transportation has established a Performance, Innovation, and Excellence Section to lead innovation efforts.

STIC Incentive funds have helped Ohio DOT develop guidance for improving the quality and for streamlining the production of feasibility studies and alternative evaluation reports. The project was part of an ongoing effort by the state DOT to improve the quality of the project documents required under the National Environmental Policy Act.

In addition to the STIC Incentive program, FHWA offers other resources to help states and their transportation partners deploy innovations. Several funding options are available for states that are incorporating innovations into projects—for example, the Accelerated Innovation Deployment Demonstration program and the Increased Federal Share for Project-Level Innovation. FHWA also provides training, technical assistance, workshops, and peer exchanges to assist states in incorporating Every Day Counts innovations into standard practices.

### Strengthening the Network

As all of the STICs work toward the goal of strategically deploying innovation, the number of projects implementing advanced technologies and practices has increased significantly nationwide. The new task is to nurture the network to ensure that the focus on innovation becomes a permanent part of transportation practice.

Leadership is essential. Leadership support, even when an innovation proves unsuccessful, creates an environment in which people are willing to take the risks of doing something differently from the way it always has been done. FHWA's senior leader in each state, the division administrator, is part of the STIC, and in many cases, the state DOT's chief engineer or executive officer is actively engaged.

Although leadership support is a necessity, engagement from all stakeholders makes a STIC thrive. In addition to their role in Every Day Counts initiatives, these dynamic partnerships encourage collaboration, so that stakeholder representatives from throughout the state can brainstorm, learn from each other, and generate new ideas and tools that also benefit their organizations.

### Next Steps

Now that a STIC network is in place, what can maximize the potential for innovation deployment? At the Transportation Research Board (TRB) 96th Annual Meeting in January 2017, transportation professionals shared their perspectives on this question during a workshop on the elements of effective STICs. Sponsored by the TRB Standing Committees on Technology Transfer and on the Conduct of Research,

Lawyers Road in Herndon, Virginia, before and after the incorporation of bike and turn lanes. An Every Day Counts study on road diets, or roadway reconfiguring, shows increased mobility, access, and safety.

Photos: Virginia DOT

Photo: Pennsylvania DOT


Victor Mendez (*center*), U.S. Department of Transportation, speaks at a meeting of the Pennsylvania State Transportation Innovation Council.

the workshop presented key strategies for innovation deployment gleaned from transportation leaders. Several strategies centered on outreach and communication, including developing resources for training transportation practitioners and for educating a range of other audiences.

FHWA assists in training by assembling deployment teams that provide technical assistance and support to the transportation community for each Every Day Counts innovation. The teams are adding an education component this year by creating content for high school and college curriculums, ensuring that the innovations are discussed with future transportation leaders. The goal is to foster an interest in the transportation industry among high school and college students and to expose the college audience to the innovations and practices they will encounter as they begin their careers in transportation.

One way to inform stakeholders and help them relate to the innovation deployment is to tell a compelling story about STIC activities. Whether the result is shortened project delivery, improved safety or environmental sustainability, or reduced congestion or costs, presenting the data that quantify the successes can make the results more meaningful for internal and external audiences.

Pennsylvania DOT, for example, enlists its communications department to spread news stories about the STIC's successes, including the quantifiable benefits from the innovations. This involves outreach and communication to provide updates on STIC efforts that relate to the traveling public and other stakeholders.

Pennsylvania DOT uses a variety of communication tools, such as the agency's web page, newsletter, social media, and informational videos to increase awareness of the innovations. The agency also has held a local government innovation day for elected officials to learn firsthand about the STIC and its role in improving the transportation services and facilities of municipalities and communities. These are only a few of the strategies that STICs can employ to support innovation deployment and to make innovation part of everyday operations.

## Connections and Solutions

Each STIC and the national STIC network are providing the connections for government, industry, and academia to work together to identify, advance, and deploy the best project delivery solutions. With continued support from the transportation community, the STICs can establish a permanent, nationwide culture of innovation to deliver, build, maintain, and manage transportation improvements at all levels in a better, smarter, and faster way.

*FHWA welcomes ideas and comments on this topic at innovation@dot.gov.*

### Related Websites

- FHWA Center for Accelerating Innovation
  https://www.fhwa.dot.gov/innovation/
- Power of the STIC (video)
  https://www.youtube.com/playlist?list=PL5_sm9g9d4T20L20Dh1U4cf_Ke8olS5Tn
- Presentations from the National STIC Meeting
  https://www.fhwa.dot.gov/innovation/stic/national_stic_meeting_recordings.cfm
- Presentations from the TRB STIC Workshop
  https://www.fhwa.dot.gov/innovation/stic/best_practices.cfm
- Tapping Innovation Councils to Lead Change
  March–April *Innovators* magazine
  https://www.fhwa.dot.gov/innovation/innovator/issue59/issue59.cfm

# Successful Approach to Technology Transfer

## *Volpe Center Introduces Primer*

SANTIAGO NAVARRO

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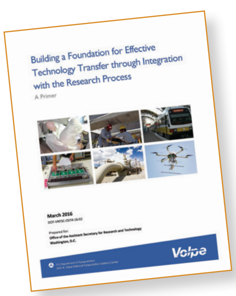



Transportation research is the foundation for tangible improvements in U.S. airspace, pipelines, railways, roads, and waterways—people and businesses rely on an efficient transportation system. The current highway funding legislation—the Fixing America's Surface Transportation Act—emphasizes the importance of conducting research that leads to real-world results. Technology transfer is the process by which the transportation community receives and applies the results of research.

To ensure that transportation research reaches practitioners and does not languish unused, the Volpe National Transportation Systems Center recently published *Building a Foundation for Effective Technology Transfer Through Integration with the Research Process: A Primer.* Analysts and planners at the Volpe Center created the primer with support from the U.S. Department of Transportation's (DOT's) Office of the Assistant Secretary for Research and Technology (OST-R).

### Holistic, Proactive Approach

Technology transfer occurs when a technology is handed over for further development or when it is put into practice and can involve a collection of activities leading to these pivotal points. A main theme of the primer is that work on technology transfer should take place before the research and development, while the research is under way, and after the research is finished.

The primer coalesces insights from in-depth publications on technology transfer—many from the Transportation Research Board (TRB)—and presents a high-level plan for agencies looking to undertake technology transfer proactively. To ensure that the primer would be useful for the intended audiences, OST-R consulted with stakeholders early on, including the Federal Highway Administration, state DOTs, TRB, and academics, researchers, and practitioners across the transportation enterprise.

Transportation agency and organization leaders can use the primer as a guide for building a proactive technology transfer program. Successful technology transfer depends on a holistic approach—an organization creates a plan for technology transfer, engages stakeholders, secures resources, and executes the plan. For a larger organization, the technology transfer process may flow through a dedicated coordinator. For a smaller organization, a coordinator may conduct technology transfer along with other responsibilities.

### Coordinator Tasks

According to the primer, a technology transfer coordinator pursues four key tasks:

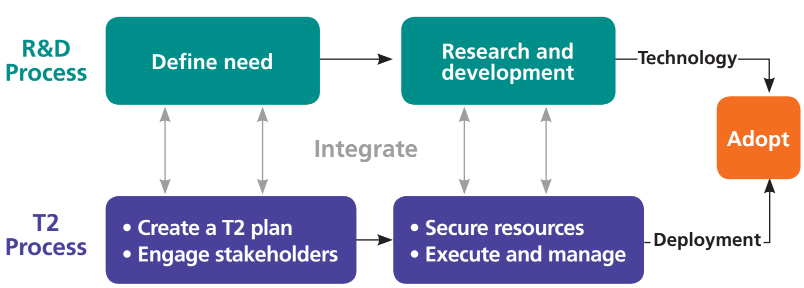
◆ Understand adopters' needs—know the problem that a technology is expected to solve and the constraints that adopters face in deciding whether to put the technology into use.

◆ Understand the technology, how it performs, and how it may affect policy.

◆ Address the barriers to adoption within legal frameworks, markets, policies, and society.

◆ Communicate the value of a technology throughout the research and development—not only at the conclusion. The authors of the primer suggest several communications activities for each phase of research and development, including identifying champions, publishing research alerts, and conducting showcases.

Successful technology transfer (T2) starts with a plan and depends on a proactive, integrated approach.




The tips and case studies in the primer are useful for organizations that are building a technology transfer program or that already have a program in place. To read the primer, please visit http://ntlsearch.bts.gov/tris/record/ntl/57403.html; for questions not covered in the primer, send an e-mail to TechTransfer@dot.gov.

# Active Implementation at the National Cooperative Highway Research Program

## *Frameworks for Moving Research into Practice*

WASEEM DEKELBAB, CHRISTOPHER HEDGES, AND LORI SUNDSTROM

*The authors are with the Transportation Research Board, Washington, D.C. Dekelbab is Senior Program Officer–Implementation Coordinator, National Cooperative Highway Research Program (NCHRP); Hedges is Director, Cooperative Research Programs; and Sundstrom is Deputy Director, Cooperative Research Programs, and Manager, NCHRP.*

The National Cooperative Highway Research Program (NCHRP) manages practical, applied research that addresses problems identified by practitioners and managers in state departments of transportation (DOTs). NCHRP publishes the research results and delivers implementable products.

The benefits from the project findings, however, begin with implementation by state DOTs and other transportation agencies. To ensure that the research products are viable, NCHRP considers implementation throughout the course of a project—from the development of the problem statement (see sidebar, page 30) to the awarding of the research contract and beyond to the completion of the research.

The transportation community has employed a variety of strategies, methods, and techniques to implement research products, but these approaches have been ad hoc. A lack of dedicated funding and a dependence on champions who must rely on available resources have constrained successful implementation. In short, the ad hoc approaches have not produced the desired effects (*1, 2*). As noted in 1984 in *NCHRP Synthesis 113: Administration of Research, Development, and Implementation Activities in Highway Agencies*, "most … departments currently approach the incorporation of new research findings in practice on an informal basis" (*3*).

To address this situation, NCHRP has adopted

### Definitions

**Implementation**—A specified set of activities designed to put into practice an activity or product of known dimensions (*4*). Implementation includes diffusion but is not defined by it. Similarly, implementation includes dissemination but is not defined by it. Diffusion and dissemination focus on the innovation. Implementation focuses on how to use innovations as intended and achieve the promised results in typical practice settings (*2*).

**Implementation science**—The systematic study of specified activities designed to put into practice activities or products of known dimensions (*4*).

PHOTO: PAUL KRUEGER, FLICKR

A case study in NCHRP Report 750 involved context-sensitive solutions including redesigned roads that integrated bike lanes, planters, and vehicle traffic.

**TABLE 1 Comparison of Ad Hoc and Systematic Active Implementation**

| Ad Hoc | Systematic Active |
|---|---|
| Cumbersome or variable activities | Implementation infrastructure within the state DOT (for policy, guidance, training, etc.) |
| Lack of funding and expertise | Dedicated funding and expertise (e.g., NCHRP Project 20-44: Administration of Highway and Transportation Agencies, SHRP 2, and FHWA's Every Day Counts) |
| Champions needed | Implementation by teams |
| Incremental change or no impact | Accelerated implementation |

a systematic approach called "active implementation" (see Table 1, above), which builds on a solid implementation infrastructure, dedicated funding, expertise, and implementation teams. The process aligns with the findings of implementation science, which has identified the factors influencing the full and effective use of innovations in practice.

## National Network

In 2005, the National Implementation Research Network (NIRN) released a monograph synthesizing the implementation of research findings across a range of fields (*5*). The monograph summarized findings from a review of the literature.

The review identified efforts to collect data on implementation practices or programs in any domain, including agriculture, business, child welfare, engineering, health, juvenile justice, manufacturing, medicine, mental health, nursing, and social services. The researchers located nearly 2,000 citations; 1,054 met the criteria for the review, and 743 remained after a full text review. Out of those citations, 377 were deemed most relevant; 22 studies included an experimental analysis of factors influencing implementation.

From these findings, NIRN developed five overarching frameworks, called the active implementation frameworks. NCHRP has adapted its active implementation procedures largely from these frameworks.

### *Active Implementation Components*

A formula for successful product implementation multiplies three components: effective products, effective implementation, and enabling contexts (see Figure 1, below). If any component is weak, the intended outcomes will not be achieved, sustained, or deployed on a socially significant scale.

The three components of the equation signify what is implemented, how it is implemented, and where it is implemented. To achieve a significant impact, the product must be be well specified, well matched to the needs of the users, implemented in a deliberate and adaptive manner, and supported by a hospitable environment and learning processes (*4*).


**FIGURE 1 Implementation formula for success** [adapted from National Implementation Research Network (*4*)].

### *Active Implementation Frameworks*

NIRN translated the formula and the components into the five active implementation frameworks. NCHRP modified the frameworks to accommodate processes that implement research outcomes as products instead of as interventions (see Figure 2, page 31).

NCHRP recognizes that there is no one-size-fits-all solution for successful implementation. Each research product is unique and requires particular treatment. Some projects may not yield implementable results. A systematic approach based on active implementation frameworks is key in selecting the most appropriate strategies and activities for technology transfer for each NCHRP product.

## Framework 1: Effective Products

The implementation plan aims at well-defined, effective products that are usable and implementable. Detailed knowledge is required for a product to be implementable. The details enable the training of staff to implement the product with confidence and to measure the use of the product.

A product must be teachable, learnable, doable,

## NCHRP Requirements for Problem Statements

NCHRP requires all problem statements to include plans for implementation, to maximize the timely deployment of the research results. Problem statements should identify the following:

- ◆ The appropriate target audience for the research findings and products;
- ◆ Key decision makers who can approve, influence, or champion the implementation of the research products;
- ◆ AASHTO committees, individuals, and other organizations with likely responsibility for the adoption of the results; and
- ◆ Early adopters—state DOTs that would be willing to evaluate the research products in their agency.

The problem statement also should identify any institutional or political barriers to the implementation of the anticipated research products.

Photo: Washington State DOT


Washington State Department of Transportation (DOT) workers paint bike lanes green. The agency has used the process presented in *NCHRP Report 803*: *Pedestrian and Bicycle Transportation Along Existing Roads*, throughout the state.

and readily assessible in practice. Table 2 (page 32) presents the NCHRP criteria for evaluating research products for implementation.

## Framework 2: Implementation Stages

Implementation is a process, not an event. According to NIRN, implementation entails "a specified set of activities designed to put into practice an activity or product of known dimensions" (*4*). These activities occur in stages that overlap and are revisited as necessary. Implementation proceeds through four functional stages:

1. Exploration,
2. Product development,
3. Initial implementation, and
4. Full implementation.

One stage does not cleanly end as another begins. The stages often overlap, with activities for one stage continuing while activities for the next stage begin. Moreover, changes in circumstances may require revisiting the work of earlier stages (*4*).

### *Exploration*

The exploration stage assesses the needs of users. NCHRP focuses on user needs during the development of problem statements, with input from committees of the Transportation Research Board (TRB) and the American Association of State Highway and Transportation Officials (AASHTO), as well as from representatives of state DOTs and the Federal Highway Administration (FHWA). One task is to identify programs and practices that can meet the needs identified; this helps to determine gaps in knowledge.

The exploration stage also assesses the fit and feasibility of implementing and sustaining the product to be developed. The findings assist the AASHTO Standing Committee on Research in selecting problem statements and the NCHRP project panel in drafting a request for proposal.

### *Product Development*

Product development involves communication with the project oversight panel, AASHTO committees, and the identified stakeholders, as well as ensuring that the necessary resources are in place for funding the project and selecting the research team. At this stage, contracts are awarded and the research is conducted to develop effective products. In addition, evaluations of the usability of the developed product continue from Framework 1, and analyses of the factors that will drive implementation begin—a focus in Framework 3.

**FIGURE 2 NCHRP active implementation frameworks** [adapted from Fixsen et al. (*5*)].

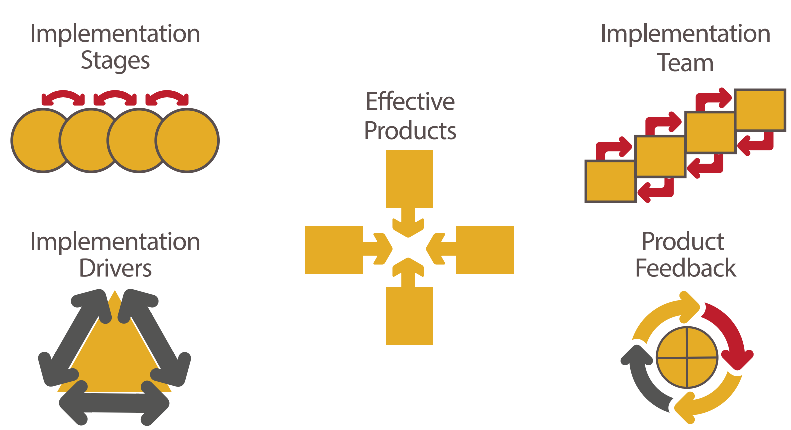


**TABLE 2 Product Evaluation Scorecard**

| Criterion | Considerations | Score[a] |
|---|---|---|
| Need | Did this product meet the panel's expectations? | |
| Readiness | Is the product fully developed and ready to implement? | |
| Resource availability and fit | Do you expect that implementation of the product will be relatively straightforward (e.g., in relation to training, policy, and state priorities)? | |
| Evidence | Was there evidence of positive results during the project through field testing or simulation? | |
| Return on investment | Do you anticipate the product will yield significant benefits compared with the costs of implementing it? | |
| Total score (≤25) | | |

[a] *5-point rating scale: 5 = high and 1 = low.*


**FIGURE 3 Implementation drivers and infrastructure** [adapted from Fixsen et al. (*5*)].

**TABLE 3 Implementation Drivers**

| Leadership Driver | Organization Driver | Competency Driver | Effective Product | Possible Implementation Outcome |
|---|---|---|---|---|
| Generally enabling | Strong | Strong | Strong | High |
| | | Weak | Weak | Low |
| | Weak | Strong | Strong | Medium |
| | | Weak | Weak | Low |
| Generally hindering | Strong | Strong | Strong | Medium |
| | | Weak | Weak | Low |
| | Weak | Strong | Strong | Low |
| | | Weak | Weak | na |

*Note: na= not applicable. Implementation drivers influence the implementation outcome of a product. Understanding the influence of implementation drivers is crucial during the product development stage in selecting appropriate technology transfer strategies and addressing any adverse influences or shortcomings during the initial and full implementation stages.*

***Initial Implementation***

Initial implementation plans out the strategies for technology transfer that are appropriate for the developed product. The barriers to implementation are identified, addressed, and rapidly resolved. The monitoring of the implementation drivers continues, and any unexpected problems are addressed. Work concentrates on moving the product into adoption—primarily through AASHTO—and on providing support before and after the product's adoption.

***Full Implementation***

Skilled practitioners—for example, DOT staff and consultants—are now using the developed product. NCHRP verifies that the implementation is correct, provides support to practitioners, and documents feedback on the outcomes for product assessment and improvement.

## Framework 3: Implementation Drivers

Implementation drivers are key components of capacity and infrastructure that influence a product's success (see Figure 3, left)—the infrastructure that is needed to make use of effective and well-defined innovations. Implementation drivers can be sorted into three types: competency, organization, and leadership (*5*); when integrated and used collectively, the three types of drivers ensure effective and sustainable implementation (see Table 3, left).

◆ **Competency drivers** influence the developing, improving, and sustaining of users' competence to apply the product effectively. Competency drivers include staffing, training, coaching, and related feedback.

◆ **Organization drivers** develop the support and infrastructure to create a hospitable environment for new product implementation, including the alignment of programs, policies, procedures, and opportunities, as well as the buy-in from all involved (*4*). Organization drivers include the following:

– Decision support data systems to assess the outcome of product implementation and of related implementation strategies, to help staff members make good decisions;

– Facilitative administration, which provides leadership and makes use of a range of data to inform decision making, support implementation, and keep staff organized and focused on the implementation outcomes—the goal is to give careful attention to the alignment of an organization's policies, procedures, structures, culture, and climate with the needs of stakeholders; and

– Identification of the barriers and the facilitators for using new products.

◆ **Leadership drivers** guide leaders to the right strategies for dealing with the technical and adoption challenges that often emerge in managing changes that affect decision making, guidance, and an organization's functioning (*4*).

## Framework 4: Implementation Teams

Members of the implementation team need special expertise in program processes, implementation science and practice, cycles of improvement, and methods of change for organizations and systems. The work of the implementation team does not have to wait for the completion of the research; the team can help create readiness throughout the implementation stages and by applying the implementation drivers. Implementation teams also do not have to wait for a champion; they can help organizations and systems provide environments more hospitable to effective innovations and more supportive of implementation.

Although NCHRP cannot directly implement the products of its research in state DOTs, each project's implementation team and research team can assemble an implementation plan that offers the following:

◆ A clear description of the developed research product, including the essential functions that define the product;

◆ A realistic assessment of the drivers that will move the product's implementation forward; and

◆ A plan for technology transfer that identifies strategies to expedite or facilitate implementation in state DOTs or other agencies (see Figure 4, page 35).

### *Team Selection*

The NCHRP project panel selects an implementation team soon after selecting the research team. The implementation team may include the NCHRP project manager and implementation coordinator plus stakeholders—for example, panel members, the research team members, representatives from the AASHTO and TRB technical committees, and representatives from state DOTs and other agencies. The composition of the implementation team depends on the project and the products.

### *Team Responsibilities*

The implementation team leverages principles of implementation science and best practices in change management to support the widespread use of the developed products. Team members are accountable for making implementation happen and for ensuring the use of product implementation methods that effectively yield the intended outcomes. Team members work purposefully, actively, and effectively toward implementation and perform additional activities:

## Evaluating the Effectiveness of Products

*NCHRP Report 750: Strategic Issues Facing Transportation, Volume 3: Expediting Future Technologies for Enhancing Transportation System Performance* presents the Systematic Technology Reconnaissance, Evaluation, and Adoption Methodology (STREAM) (*6*).

STREAM is a tool for identifying, assessing, shaping, and adopting new and emerging technologies to help achieve objectives for long-term system performance. The process reflects relevant trends in technologies and their applications and is designed to help transportation agencies anticipate, adapt to, and shape future changes.

Three case studies in the report illustrate STREAM applications. The report targets state DOT research units and other units and organizations responsible for evaluating new technologies.


*NCHRP Report 750 Volume 3,* Expediting Future Technologies for Enhancing Transportation System Performance*, is available online at http://www.trb.org/Main/Blurbs/170083.aspx.*

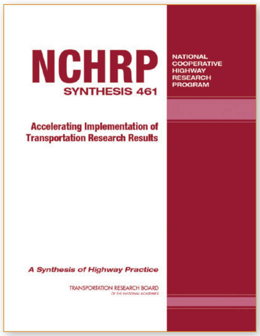
An NCHRP project panel meets to develop guidelines for solid-state roadway lighting.

## NCHRP Implementation Support Program

Part of NCHRP's Moving Research into Practice initiative, the Implementation Support Program has funding of approximately $2 million a year to facilitate implementation of research results. The range of eligible products and activities is broad; the *Guide to NCHRP Implementation Plans* lists several examples. Eligible expenses include essential travel, production of materials, professional services, meeting costs, and necessary equipment.

Recipients awarded funds for activities must deliver a report to NCHRP within three months of completion. The report must describe the activities that were carried out, assess how the activities have facilitated implementation, and indicate plans to continue monitoring the impacts.

*For more information, contact Waseem Dekelbab, NCHRP Implementation Coordinator, 202-334-1409, wdekelbab@nas.edu.*




*NCHRP Synthesis 461: Accelerating Implementation of Transportation Research Results* examines implementation practices of nontransportation agencies in the public sector, nonprofits, and academia that have accelerated the practical application of research results. The synthesis focuses on practices useful for transportation agencies in creating responsive research programs and presents a series of implementation case examples and practices. (www.trb.org/Publications/Blurbs/171446.aspx.)

PHOTO: MICHAEL ESTIGOY, FLICKR

Fort Point, which sits at the foot of the Golden Gate Bridge in San Francisco, California, served as a case study for NCHRP Project 25-25, which explored construction vibration and its effects on historic buildings adjacent to transportation projects.

◆ Increasing users' buy-in and readiness;

◆ Installing and sustaining the implementation infrastructure;

◆ Assessing and reporting on outcomes of product implementation; and

◆ Solving problems and promoting sustainability.

## Framework 5: Product Feedback

The NCHRP implementation team uses feedback from users of the product to maintain the product's quality and practical value and to incorporate improvements. In this way, product feedback supports the purposeful process of change.

Implementation teams also measure a product's impact on practice and determine the return on investment to the first users—the innovators and early adopters, according to the terminology developed by Rogers in his work on the diffusion of innovations (7)—with the goal of persuading those who would resist the change as long as possible—whom Rogers terms the late majority and laggards. As Rogers makes clear, the way adopters behave in response to an innovation is one of many influences on the rate of change within an organization.

## How It Works

NCHRP active implementation frameworks are applied in research product development and in research product implementation.

### *Product Development*

The implementation team collects data about the drivers or influences that affect the implementation outcome of the developed product. The analysis of the implementation drivers helps the implementation team select appropriate strategies for technology transfer.

Technology transfer is a process of communication that brings the results of scientific research into use. Technology transfer often includes implementation strategies and activities. Technology transfer strategies for the adoption of products may include knowledge transfer, training and education, demonstrations and showcases, communications and marketing, technical assistance, managing the complex

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CASE STUDY: NCHRP PROJECT 5-20

## Implementing Guidelines for Nighttime Visibility of Overhead Guide Signs

◆ *Dissemination*—Panel members have been sharing project results in several ways, including a presentation at the 2017 TRB Annual Meeting.

◆ *Policies*—States can use the guidelines to reassess lighting policies for urban and suburban highways that have high visual complexity.

◆ *Assistance*—The principal investigator and project panel members, as well as members of the TRB Standing Committee on Signing and Marking Materials, are available to help and advise state DOTs in implementing the guidelines.

◆ *Guidance*—AASHTO is incorporating the guidelines developed in this research into Chapter 10 of the Roadway Lighting Design Guide.

*For more information, http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=2954.*


**FIGURE 4 Technology transfer strategies.**

processes of change, and dealing with cultural and technical issues (see Figure 4, above).

The project implementation team selects the appropriate technology transfer strategies and activities, considering such factors as the potential users, the potential uses at different stages, and the resources needed to conduct the implementation activities.

### *Product Implementation*

NCHRP facilitates collaboration among stakeholders by managing communication, reinforcing technology transfer activities, measuring outcomes, and keeping all stakeholders moving toward the same goal during the active implementation process. The selection of implementation strategies depends on the research product, but organizations' responses to change can range from embracing change with excitement—characteristic of Rogers' innovators and early adopters (7)—to resisting change as long as possible, like Rogers' late majority and laggards.

## Implementation Activities

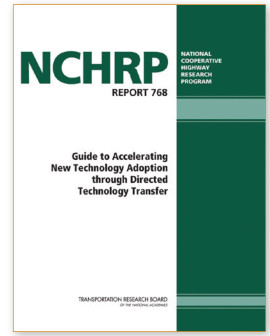
Implementation activities may include workshops or peer exchanges; webinars; presentations, posters, or exhibits at committee meetings or at state, regional, and national meetings and conferences; training; software beta-testing; focus groups; the development of promotional materials such as flyers, brochures, or videos for target audiences; the development of briefing materials for senior management; follow-on NCHRP contracts for proof of concept, validation, development of prototypes, or further development; and demonstrations or pilot projects in a host agency. (See the case studies of two NCHRP projects, outlined on page 34 and page 36.)

Effective implementation strategies accomplish the following:

- ◆ Ensure a continuing, high level of involvement by the product developers;
- ◆ Use multilevel approaches to implementation with clear goals;
- ◆ Implement only those attributes of a product or practice that are replicable and that add value; and
- ◆ Know what has to be in place to achieve the desired results for consumers and stakeholders.

These activities affect the speed and effectiveness of implementation.

In contrast, implementation that relies on access to information appears to have little effect on practitioners' performance. Experimental studies have shown that the dissemination of information alone does not result in positive implementation, in changes in practitioner behavior, or in benefits to




*NCHRP Report 768: Guide to Accelerating New Technology Adoption Through Directed Technology Transfer* presents a framework for using technology transfer to guide and accelerate innovation within a state DOT or other agency (*8*). The guidance assists agency personnel at any level of experience in adopting new technology. The report includes illustrative examples of innovations in organization and policy as well as in design, materials, and operations. (www.trb.org/Publications/Blurbs/171082.aspx.)

Photo: Bossi, Flickr


NCHRP Project 03-41, completed in 1993, offered procedures for setting work zone speed limits to increase safety.

Wildlife crossing over Highway 9 in Colorado. NCHRP Project 25-27 created guidelines for the use and effectiveness of wildlife crossings.

PHOTO: JEFFREY BEALL, FLICKR

consumers. Similarly, a reliance on training alone, even well done, has proved ineffective as a strategy for implementation.

## Driving Implementation

Through active implementation, NCHRP is managing research projects and moving the results into practice by building on a procedural infrastructure, applying dedicated funding, and relying on proven expertise and on implementation teams. NCHRP's national partners drive the implementation of the research products, in conjunction with the following:

◆ **Innovative outreach**—NCHRP staff develop innovative dissemination tools to circulate research findings and solicit feedback to confirm or to improve the effectiveness of each outreach effort.

◆ **On-target findings**—The appointment of AASHTO committee members to NCHRP project panels helps ensure that the research produces findings implementable by state agencies and practitioners.

◆ **National networks**—Partnerships among AASHTO, FHWA, and NCHRP underscore the importance of relationship building at the national level to implement research findings that advance transportation practice and infrastructure.

CASE STUDY: NCHRP PROJECT 3-110

### Estimating the Life-Cycle Cost of Intersection Designs

◆ *Awareness*—A webinar posted on the TRB website provides an overview of the Life-Cycle Cost Estimation Tool (LCCET).

◆ *Policy*—Use of the LCCET may require revision of an agency's procedures. The FHWA Office of Safety includes the LCCET as a resource during presentations on intersection control evaluation policies.

◆ *Promotion*—The LCCET needs an agency champion who also can encourage use of the tool by local agencies and consultants.

◆ *Training*—Key staff must be trained in the use of the LCCET. FHWA is introducing the LCCET via Every Day Counts workshops, customized intersection safety and design courses, and several National Highway Institute programs.

*For more information, http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3392.*

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# Pioneering Ideas from the TRB Annual Meeting

## *Utah DOT Realizes Savings from Innovations*

DAVID STEVENS AND CAMERON KERGAYE

To foster learning and innovation, the Utah Department of Transportation (DOT) sends a group of employees each year to the TRB Annual Meeting. Since 2003, 84 Utah DOT employees have attended the Washington, D.C., conference, gathering novel ideas from around the country and the world and networking with highway transportation experts.

Utah DOT leadership selects personnel from the central and regional offices, considering those who have shown an initiative for innovation and who are active on TRB committees. Utah DOT encourages each attendee to bring back at least two ideas that can be deployed within the agency.

### Reporting and Tracking

Traditionally, the attendees delivered a brief presentation of the ideas to Utah DOT senior leaders shortly after the TRB Annual Meeting; approximately nine months later, they would report on the status at an update meeting. In 2017, the agency's Annual Meeting attendees began gathering every other month to support each other and to share information on implementation progress.

*Stevens is Research Project Manager, and Kergaye is Director of Research, Utah Department of Transportation, Salt Lake City.*

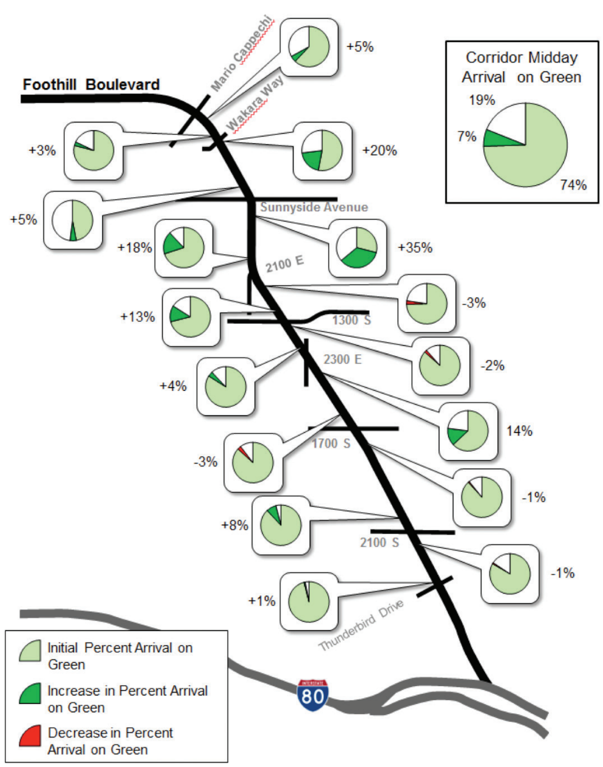


**FIGURE A Midday green light arrival along Foothill Boulevard, Salt Lake City, Utah.**

PHOTO: UTAH DOT

Automated traffic signal performance measures, which a Utah DOT engineer learned about at the TRB Annual Meeting, have relieved congestion, reduced fuel consumption, and improved air quality in the state.

For several years after the implementation of these projects, Utah DOT tracks the cost savings that result—that is, the public and user savings from increased operational efficiency, safety improvements, and more—and gathers information on additional intangible benefits. Data on the implementation of more than 200 innovative ideas at Utah DOT since 2003—from contracting methods and safety improvements to accelerated bridge construction and traffic signal performance—have shown more than $180 million in savings.

### Cost Savings in Action

At the 2012 TRB Annual Meeting, one Utah DOT engineer learned about a technique developed at Purdue University to monitor the quality of traffic signal timing in real time, called automated traffic signal performance measures (ATSPM).[a]

Utah DOT partnered with Purdue and Indiana DOT to implement ATSPM, using the measures as a cost-effective method to measure vehicle delay, speeds, and travel times. The measures have improved corridor performance, reduced fuel consumption, and improved air quality. Along the Foothill Boulevard corridor in Salt Lake City, for example, 7 percent more vehicles now arrive at a green signal (see Figure A, left).

A cost–benefit analysis of ATSPM in Utah, calculated several years ago for a 9-month period, showed a user-cost savings of more than $3 million from reduced delays at traffic signals. The savings have increased since then with the addition of new metrics and updated software.

Utah DOT has shared ATSPM software with other agencies and national and industry organizations and will continue to send employees to bring back the benefits of the TRB Annual Meeting.

[a] The Utah DOT ATSPM application is available online at http://udottraffic.utah.gov/atspm/.

# Going, Seeing, Showing, and Doing

## *Low-Tech Technology Transfer Works*

LAURA MELENDY AND ANN BRODY GUY

*Melendy is Assistant Director, Institute of Transportation Studies (ITS), and Director, Technology Transfer Program, University of California, Berkeley. Guy is an independent science writer and editor based in Oakland, California, and former Communications Director, ITS Berkeley.*

When a car ran over a school crossing guard's foot—inside a crosswalk—a messy local traffic situation came to a head. Tensions were already running high at Pyles Elementary School in Stanton, California; the principal called the Public Works Department of the suburban Southern California city, complaining that parents were not respecting the crosswalk even when children were walking in it. Public Works Director Allan Rigg then called in surveyors from the Complete Streets Safety Assessments program based at the University of California (UC), Berkeley to evaluate the school environs, as well as other serious traffic safety issues in the town.

Transportation engineer Nazir Lalani and transportation planner Bruce Appleyard researched collision statistics, listened to a team of local stakeholders, and visited the site of the accident. They recommended one-way traffic to mitigate the school circulation problem.

"We had to look at the circumstances specific to that one parking lot and that one crosswalk," says Lalani, a past international president of the Institute of Transportation Engineers who has performed more than 70 safety assessments for cities, counties, and tribes. It is a solution that may not have been right for another town, he notes, but that addressed the particular behaviors in the community surrounding Pyles Elementary School.

Safety assessments are examples of in-person, on-site, peer-to-peer technology transfer to solve problems and to accelerate the implementation of technological advances and research-based best practices. High-tech solutions are part of any technology transfer process, but even webinars, online resources, and virtual reality do not replace human beings observing a situation or technology, talking about what they see, and querying the immediate experience and expertise of local stakeholders.

The crosswalk near Pyles Elementary School in Stanton, California.

PHOTO: NAZIR LALANI

"Traffic engineering is similar to science and sociology—often, designs are more like experiments that are tested and then adjusted. One must observe in person how all the factors of a particular traffic situation work—or don't," Rigg says. "This is especially true when dealing with parents who are in a hurry and children who still are learning how to be safe."

## Demonstration Showcase

Another core person-to-person tool is the demonstration showcase, which consists of briefing and education sessions followed by a real-time, in situ technology implementation. Mary Lou Ralls, former head of the bridge division at the Texas Department of Transportation (DOT), used the format to advance the adoption of accelerated bridge construction (ABC) in the United States—a technology transfer success story.

To help people overcome concerns about trying something new, Ralls comments that "nothing beats being on the ground, talking one on one with the people who actually have implemented this technology and solved problems along the way."

No matter how consistently technologies perform, humans are complex and unique creatures; although webinars and other online collaboration and information-sharing tools are practical and expedient, it often is necessary to meet in person to share innovations, observations, and insights.

When stakeholders talk directly to each other about a transportation issue, they can address such critical human factors as risk aversion, skepticism, and stress, and can deliver stronger, more lasting solutions to transportation technology implementation challenges. Personal technology transfer is becoming rare, however; in an environment of budget belt-tightening and virtual meeting access, travel budgets often are seen as dispensable.

A closer examination of on-site safety assessments, demonstration showcases, and peer exchanges can illuminate and demonstrate the value of people talking directly to each other about problems and solutions. These methods never will be obsolete; when applied to the correct situations, they can improve, accelerate, and strengthen the technology transfer process.

## On-Site Safety Assessments

The Complete Streets Safety Assessment program is a multiday blitz. At the request of a city, town, county, or tribe, a pair of UC Berkeley evaluators will research, observe, and report on local traffic safety issues and then will recommend solutions.

To prepare for a site visit, the evaluation team reviews and analyzes information provided by the local agency and researches statewide traffic incident databases. The team then leads a conference call with the local stakeholders before heading to the site. The call is an important step that allows all participants in the project to look at the data, develop a list of key issues, refine the scope of work, and consider outsiders' perspectives.

After the initial review, the team presents an analysis of the area's worst traffic problems and then asks the stakeholders what they think. The answers they get vary dramatically—crash data can point to intersections that may or may not be of top concern to a particular community. In Stanton, the collision statistics did not flag the Pyle Elementary School traffic issue at all; nonetheless, it was a priority for the local agency.

Many towns and cities have highly capable city engineers or other experts but call for the safety assessment anyway. The prospect of a visit catalyzes action, forcing agencies to assemble the right people to address a complex or thorny issue. Busy agencies constantly must prioritize problems and put out fires; according to Lalani, a safety assessment visit also provides an opportunity for an agency to stop and actively focus on the most urgent problems.

## Domino Effect

Technology transfer involving innovation requires a different type of problem solving: building confidence that a technology's gains outweigh its perceived risks and the challenges of its implementation. Before potential end users invest money and human power, they want to know whether it will work.

To answer that question about ABC, Ralls connected the technology with problem solvers on the ground. She self-identifies as an innovator, having served as head of the American Association of State Highway and Transportation Officials' (AASHTO's) Technology Implementation Group prefabricated

Photo: Nazir Lalani

Students and parents walk home from Pyle Elementary. Observing a site in person—not just examining statistics—provides practical insights into safety issues and mitigation measures.

Photo: Arizona Department of Transportation

Demonstration showcases of innovative techniques like accelerated bridge construction (ABC) have facilitated widespread implementation.

bridge implementation panel, but she understands that many people and most government entities are not as comfortable with risk.

Demonstrations mitigate risk by allowing agencies and other stakeholders to become familiar with on-the-ground implementation details. That familiarity has propelled ABC and other technologies like tow plows to broad implementation. Such successes are why the demonstration showcase is the "gold standard" for accelerating technology transfer, according to Ralls.

Technology showcases enable transportation professionals to observe other projects as innovations are applied, to see real-world challenges, and to question stakeholders about concerns without commitment or risk, according to a *Public Roads* article on demonstration showcases (*1*).

## Success Story

In 2004, Ralls chaired an AASHTO delegation that traveled to Belgium and the Netherlands and observed a new way to build bridges. "We saw these self-propelled modular transporters actually lifting up whole prefabricated bridges, ready to go and putting them into place overnight," Ralls says. Such transporters only were used in the United States for novelty applications that required the movement of unusually large, heavy objects—not for bridges.

The benefits of the technology were evident: bridge construction that previously would have required weeks or months of expensive, disruptive traffic detours was completed in a matter of hours with staged prefabricated elements that simply were dropped into place.

When the delegation returned, the Florida state bridge engineer vowed to implement the technology. In 2006, Florida DOT hosted the first ABC demonstration in the United States. Representatives from Utah DOT attended; a year later, Utah DOT moved its first bridge with a self-propelled modular transporter.

From there, Utah DOT adopted accelerated approaches to bridge design and construction as the state's new standard. According to *Public Roads*, by January 2014 the agency had used the transporters to build more than two dozen precast superstructures and had used ABC methods and elements more than 230 times (*1*).

Utah was one of many U.S. states and Canadian provinces to implement ABC techniques as a direct result of seeing the Florida demonstration. "The demonstration built a sense of comfort and familiarity with a technology that bridge engineers had never seen before," Ralls says. "Nothing replaces seeing something with your own eyes—it shows that it can be done."

Self-propelled modular transporters (SPMTs) lift prefabricated bridge panels at Pioneer Crossing, Utah. Utah DOT learned about SPMTs at a Florida demonstration and, by 2014, had deployed the technology to build more than two dozen precast superstructures.

Photo: Utah DOT

## Assembling Stakeholders

Cross-pollination between stakeholders is a critical element of in-person technology transfer. It assuages concerns, overcomes skepticism, and provides people with the confidence that they can reap the benefits of a technology while reasonably anticipating implementation challenges.

"Sitting down and talking one on one with the construction contractor or the designer, or the person who did the construction inspection for the project, and hearing all the details of how it went and what the issues were, are instrumental in technology adoption," Ralls notes. "A web presentation may or may not include answers to the questions asked by individual construction, design, or administrative professionals."

Tennessee DOT bridge engineer Wayne Seger, who participated in Florida's ABC demonstration and activated the technology in his home state, observes that he found the presentations from local stakeholders especially valuable. "Attendees were given both the contractor's perspective as well as the state's perspective on the project," Seger says. "The contractor shared the challenges he faced in constructing the superstructure spans and how he used the self-propelled modular transporters to haul the new spans."

Safety assessments share this stakeholder interaction; visits bring together public works, planning, and public health departments as well as school districts and law enforcement. The collaboration starts early, with a conference before the visit.

"It's surprising how many stakeholders have never been to the table before," Lalani says. "The conference gets law enforcement talking to engineering staff, building relationships that maybe existed but have since drifted." Having different perspectives at the table yields different types of insights, he adds.

Complete Streets Safety Assessment teams incorporate multiple perspectives. In addition to a traffic engineer, an evaluation team often includes a law enforcement specialist, who works with the local police department on optimizing traffic management and record keeping to improve safety. The team also might include a planner, who works with the agency on development strategies for policies and funding to support safety recommendations, and on long-range planning that considers how future growth and development might affect traffic.

## Same Technology, Different Transfer

A single technology often is applied differently to individual situations. Even within the categories of urban, suburban, rural, and tribal, no one solution fits all locations, Lalani notes. For example, the Stanton assessment report included not only a long-term plan designed for that particular school's travel patterns, but also a short-term, inexpensive solution to diffuse a tense community situation quickly.

ABC demonstrations gave several agencies the confidence to adapt the technology for related uses that were unique to their location's needs. "The value of the showcases is not necessarily to have other owners implement carbon copies of the projects or technologies," says Wayne Symonds, a Vermont Agency of Transportation bridge engineer who attended a 2011 ABC demonstration on I-93 in Massachusetts.

Symonds described the traffic at the I-93 demonstration site as "an order of magnitude larger than anything in Vermont and two orders larger than our typical bridge projects." After speaking with contractors and designers at the demonstration, however, Symonds and his team realized that the same methods—using short-term road closures and prefabricated elements—could improve bridge projects in Vermont.

Photo: MarceSala, Flickr

Face-to-face communication of information, research, and experience can help promote the acceptance of innovative solutions such as roundabouts.

"We could use the same approach for planning, materials, engineering, and public outreach, but could make it Vermont-specific," Symonds says. When Tropical Storm Irene arrived in Vermont months after the I-93 bridge demonstration, it hit the state hard. Symonds applied ABC-related lessons learned to address the state's immediate needs.

Demonstrations frequently yield improvements as observers and implementers explore the whys and what-ifs. Sitting next to the expert who solved the problem is a different experience from talking on a phone, Ralls observes: "You don't get a uniform response—you get disagreements and discussions. These interactions are hard to capture in web-based training—they're personal."

## Case Study: Tow Plows

It can be difficult to document such nonlinear influences, but the adoption of tow plows provides a case

Photo: Frank Fedele, U.S. Army Corps of Engineers

After the widespread destruction of Tropical Storm Irene in 2011, engineers with the Vermont Agency of Transportation undertook large bridge repair, applying lessons learned from a Massachusetts demonstration of ABC techniques.

Photo: Lubin Gao

FHWA peer exchanges allow transportation specialists to share technology practices and experiences.

study of cumulative improvements. The devices attach to a snowplow and expand the vehicle's plow width from one to two full lanes, increasing fuel efficiency, productivity, and efficiency.

Originally developed in Missouri, the plow acquired innovations with other states' adoption: several DOTs added salt spreaders to the plows, Tennessee added a Kupper ceramic blade for packed snow, Minnesota added a laser guidance system, and Utah added a stainless steel spreader.

According to National Cooperative Highway Research Program Report 768, *Guide to Accelerating New Technology Adoption Through Directed Technology*, tow plows are one of the top technologies advanced by demonstration showcases (2).

## Peer Exchanges

Before AASHTO selected the tow plow as a focus technology for national implementation, the innovation was shared with other DOTs in a peer exchange run by Missouri DOT.

Valuable cross-pollination can occur at events for people who do the same job or need to solve the same problem. In the same way that a conference inspires participants to incorporate new ideas and different perspectives into their work, peer exchanges energize activity and thought around a particular technology or professional function.

Photo: Utah DOT

As states adopted new tow plow technologies—aided by demonstration showcases—they also added innovations of their own, like stainless steel spreaders.

Although the Federal Highway Administration's (FHWA's) Peer Exchange program primarily is focused on how DOTs manage research—that is, processes like technology transfer or performance measurement—the FHWA also supports in-person workshops, roundtables, and sessions in which peers share technology-specific information.

Many other in-person forums and formats focus primarily on technical operations and topics; a notable example is the National Winter Maintenance Peer Exchange. The Western Transportation Institute (WTI) of Montana State University has spearheaded the biennial event since 2007.

The 2015 National Winter Maintenance Peer Exchange in Bloomington, Minnesota, included state best practices reports; a panel on managing traffic operations during a winter storm; and breakout sessions investigating topics from equipment procurement and maintenance methods to the relative merits of salt, brine, and slurry.

Although the WTI peer exchange sets the research agenda for the field, participants greatly value the practical technology transfer exchange. According to an announcement for the 2015 peer exchange, attendees from 2013 overwhelmingly cited the sharing of best practices and innovations as the most helpful part of the event.

## High and Low Tech

In-person collaborations and high-tech tools are not mutually exclusive. They enhance each other, and acceleration occurs within these interactions—for example, electronic information exchange that supports on-site visits. In addition to collision databases, the safety assessment team asks agencies for such documents as speed limit databases, traffic signal maps, and traffic calming maps.

The data for Stanton, California, revealed that the leading cause of pedestrian–car collisions at a dangerous Beach Boulevard crossing was drivers failing to yield to pedestrians in the crosswalk. Were Stanton residents scofflaws who did not care about the safety of pedestrians? The on-site inspection revealed that drivers just needed better visibility as they approached the crosswalk.

### *Doing It Right*

A Complete Streets Safety Assessment in the small city of Modesto, California, kicked off with a meeting that used teleconferencing to include all stakeholders. Together, the group used data analyses, Google Earth, and street views to establish a shared perspective of the locations under review before the observation team arrived. According to Lalani, technology deployed in the preparation process helps streamline and focus the 50- to 60-hour on-site visit.

Similarly, demonstrations are supported by research, webinars, reports, and other online materials before, during, and after the event. The demonstration showcase format always starts with a session to review materials and information, and ends with a follow-up that provides additional documentation.

Webinars and other virtual communications amplify findings and insights from in-person events. Both Lalani and Ralls use data, videos, photographs, and PDFs from their events in webinars to help to train experts and inform agencies. Ralls conducts a monthly webinar on ABC technology that draws between 400 and 1,000 registrants, with multiple viewers at many of the sites.

### *Value of Documentation*

Digital photo and video documentation collected at in-person events become part of the digital archives, which document a technological advance, create a visual baseline, and yield new observations at a later date—ones an on-site observer may have missed. Videos also broaden the audience for demonstrations, with free, global access to platforms like YouTube and Vimeo.

Whether written or visual, documentation from in-person events has many applications. Such materials can provide the evidence that helps convince a city council or state agency that an improvement is worth paying for. Documentation can support a variety of grant applications and can validate an agency's own findings in negotiations with a partner on solutions to a shared problem. A technology champion also can use documentation to get other stakeholders on board.

Nothing is more low-tech than spontaneous conversation. Personal interactions are opportunities for experts to promote technological improvements like roundabouts, which face resistance despite an expanding body of research demonstrating effectiveness in intersection management, Lalani notes. Conversation also helps dispel myths, mitigate concerns, and cite research and personal experience.

### *Travel Pays Off*

As states face budget cuts and constraints, DOTs align their remaining resources to support such priorities as maintenance efforts and safety-related services. Out-of-state travel funds typically are slashed, along with other seemingly expendable line items.

Although maintaining roads and addressing safety issues are imperative, cutting all travel is penny wise and pound foolish. Innovations improve services and save lives and money; confining agency personnel to their offices limits access to the very collaborations that will help them serve their state's transportation needs most effectively.

Photo: FHWA

Representatives from Iowa DOT, FHWA, local agencies, construction companies, and universities attend an ABC demonstration showcase.

## Technological Tools

Technological advancement is well established as the present and the future of transportation, and high-tech tools show much promise in helping people teach and facilitate the adoption of new technologies.

Augmented reality and virtual reality are up-and-coming collaborative media platforms. So-called virtual showcases will improve upon video conferences and webinars, bringing remote spectators to a location. In *Public Roads*, authors suggest that virtual technology can allow users to play and replay a bridge replacement animation independently, to examine it from different viewpoints, to strip away ground layers and construction material layers, and to bring up technical documents related to the equipment in real time (*1*).

New collaboration tools constantly are in development; however, low-tech technology transfer plays an important role in the implementation process. In-person, peer-to-peer interactions in collaborative and contextual settings make complex technologies more accessible, forge relationships, spur discussions, and build confidence. This helps people overcome impediments and helps amplify and iterate innovations.

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# Energizing Transportation Technology Transfer with Effective Public Relations

EDWARD M. BURY

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Public relations too often is equated with publicity generated through articles in newspapers and magazines or through reports aired on television and radio—but effective public relations is much more. Modern, ethical public relations involves strategic communications driven by management to engage, influence, and build mutually beneficial relationships with targeted audiences or stakeholders, whom the profession terms publics.

In today's competitive business and academic environments, sharing the outcome of research with relevant audiences, particularly with potential adopters, is prudent and essential—this entails communicating what was learned, invented, or discovered. In transportation, the results of new research can make systems operate safer and more efficiently, can introduce new technology, or can navigate ways to fund, finance, and secure necessary legislative and public support.

Research departments within transit agencies, private companies, and universities can gain exposure for transportation findings and can advance other technology transfer initiatives by incorporating proven public relations procedures, strategies, and tactics. The following guidelines can provide a template for developing and executing an effective and strategic public relations plan:

◆ **Establish realistic goals**. Goals establish the framework for the plan and should be broad-based and encompassing. For example, one goal could be to build greater awareness among key audiences for the value of the research, and a second could be to inspire better coordination or implementation of the findings. The goals should be realistic and attainable.

◆ **Develop a sound strategy**. Strategy guides the development and execution of the entire communications plan. Sound strategies are realistic, driven by the scope of work presented in the research and by other factors. The guiding strategies should promote the relevance of the research and the experience of the research team.

◆ **Identify target audiences**. In transportation, the primary audience for research findings most likely consists of other researchers, agencies or departments, and private companies—groups that can learn from or adopt the findings. Nevertheless,


To communicate the need for animal fencing with members of the public, the Virginia Transportation Research Council shared images from motion-activated roadside cameras on social media and in news releases.

Photo: Virginia Department of Transportation

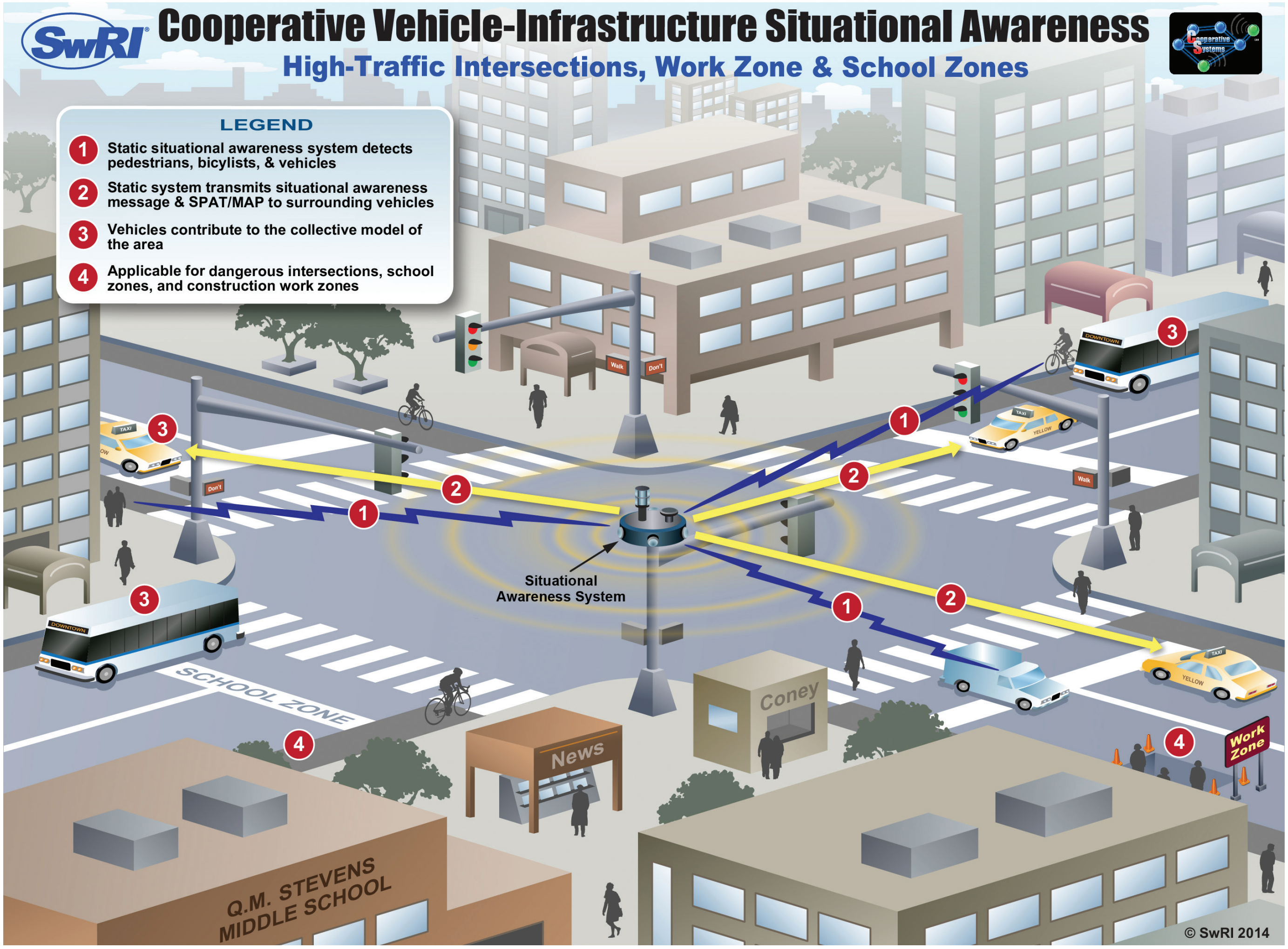


IMAGE: SwRI, FLORIDA DOT

trade, business, and some general interest media, advocacy, government, and community groups may be interested in the results.

◆ **Communicate via media relations, website, and social media**. The news release, the classic medium of public relations, remains an effective and valuable tool for disseminating research findings. A news release should focus on what the research team learned and on how the results will benefit the transportation industry, the community, and society. Following are some guidelines:

– Draft an impactful, but succinct, headline that contains key words related to the research.

– Avoid technical jargon, and keep the release to approximately 400 words. Post the research report on the organization's website and include a hyperlink in the news release to the complete report.

– Identify a graphic image—perhaps a chart or graph—related to the research, post the image on the website, and offer it for media use.

– Develop a distribution list of transportation and business media, industry professionals, bloggers, and organizations, and disseminate the release via e-mail.

– Post the news release on the organization's website, and share it on social media platforms.

◆ **Measure the results**. Gauge the results by monitoring the placements or references to the research in news reports; by checking website analytics for downloads and social media sites for views and comments; and by chronicling inquiries from governmental bodies and organizations.

Transportation is a critical component of business, economics, and modern society, and transportation challenges continue to require new research to provide viable solutions. Through strategic public relations, transportation research departments can communicate compelling, newsworthy findings to a wide audience and can inspire dialogue on the value of transportation.

Graphics, like this one from the Florida Connected Vehicle Initiative, are effective tools for communicating complex topics.

Moving Research into Practice

# National Network for Technology Transfer to Local Agencies

## *The Local and Tribal Technical Assistance Programs*

JANET LELI

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Communication powers technology transfer for innovations—the more effectively the message is conveyed, the higher the likelihood of technology deployment. Finessing the message depends on a thorough understanding of the audience.

The national networks of the Local Technical Assistance Program (LTAP) and the Tribal Technical Assistance Program (TTAP) are well-versed in developing technology transfer communication strategies to convert innovation into practice at the local agency level.

### Outreach to Locals

In 1982, the Federal Highway Administration (FHWA) created LTAP to provide training programs and information on rural roadway and bridge maintenance to local road and public works departments. Since then, the focus areas of LTAP—and of TTAP, established for outreach to tribal jurisdictions—have expanded to address issues of roadway and worker safety, infrastructure management, and workforce development.

LTAP–TTAP services allow local, rural, and tribal communities to maximize the performance of their transportation workforce and to create and manage a safe, efficient, and environmentally sound transportation infrastructure. All centers are funded by FHWA, with LTAPs requiring a 50 percent match from states, other sources, or both.

The LTAP–TTAP network comprises 58 centers: one in each state, one in Puerto Rico, and seven regional centers serving tribal governments. By offering constant access to information, these centers enable local counties, parishes, townships, tribal governments, cities, and towns to improve their infrastructure, including roadway networks and bridges.

Photo: Faungg's Photo, Flickr

Valley Drive in Monument Valley Navajo Tribal Park, Arizona. The Local Technical Assistance Program (LTAP) and the Tribal Technical Assistance Program (TTAP) work to solve the transportation issues unique to local, rural, and tribal communities.

A variety of training programs, a resource clearinghouse, technology updates, personalized technical assistance, and newsletters facilitate information exchange. All encourage widespread adoption of the safest, most efficient technologies and practices available. With these core services, LTAP–TTAP centers support local agencies responsible for more than 3 million miles of roads and more than 300,000 bridges—and the goal of the LTAP–TTAP program is to increase the capacity of these agencies.

The outreach of the network is impressive: the combined activities of LTAP–TTAP centers produce more than 6,000 training sessions that reach approximately 177,000 people each year; they also circulate more than 795,000 newsletters annually (*1*). Center stakeholders range from a tiny village with a single, part-time road department employee to large counties with substantial public works and engineering units. Nevertheless, centers tailor their activities to meet the needs of their constituents, accounting for the geographical, demographical, and economical variations within their states or jurisdictions.

## Time-Tested Approaches

Public transportation agencies are not usually thought of as quick adopters of leading-edge innovations or new practices. Barriers to implementation range from reluctance to take a financial risk to unwillingness to do something in a new way. Given these and other institutional challenges, effective technology transfer must keep agencies moving toward service delivery improvement. Because the nature of LTAP–TTAP is so deeply rooted in information sharing, many programs have renamed themselves "technology transfer centers."

LTAP–TTAP is a critical knowledge transfer link between the U.S. Department of Transportation (DOT) and local agencies. The programs often are the most prominent conduit for resource information and guidance on how to perform essential duties of local road and engineering departments, from maintenance to asset management to roadway safety.

Each center provides an average of more than 100 workshops and trains more than 3,000 people annually—these totals do not include the local agency personnel also reached through the delivery of technical assistance or information distribution. According to Michigan LTAP Director Tim Colling, LTAP–TTAP programs are a go-to resource for transportation best practices: "Local agencies trust LTAP centers as honest brokers of information, as there is a separation between centers, industry, researchers, and government," he observes.

LTAP–TTAP centers are unique in their ability to tailor activities to the specific needs of their communities and to maintain standard focus areas across the network. They maximize the success of their own technology transfer results by employing client-specific technology transfer methodologies, often developed through years of trial and error with their customer base, as well as with internal expertise and proven techniques.

Centers also will use a peer-to-peer approach when necessary, from sharing training materials and newsletter articles to sending a subject-matter expert from one state to another.

Photo: Truckee Meadows Community College

Truckee Meadows Community College near Reno houses Nevada's LTAP Center.

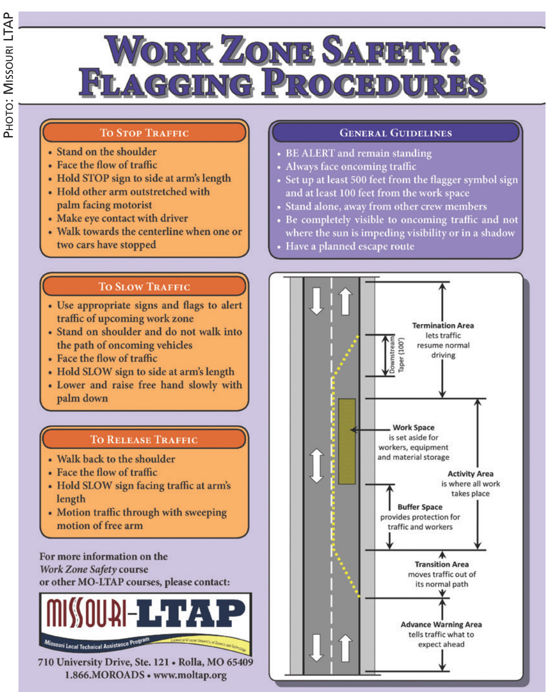


Photo: Missouri LTAP

State LTAP and TTAP centers facilitate knowledge transfer between researchers, government, industry, and communities.

PHOTO: OREGON DEPARTMENT OF TRANSPORTATION

Repair work on a rural Oregon bridge. Limited funding and a lack of information often keep local agencies from implementing new technology.

## Implementation Acceleration

Not unlike their larger-scale counterparts, local agencies face a variety of challenges when changing the way they do business. Limited funding resources are the most commonly cited reason that agencies do not consider a new product or process. The cost of switching from A to B is not always clear, and sometimes the change itself is perceived as a risk of financial liability.

Other concerns shared by agencies large and small include a lack of the human resources needed to try something new, insufficient information about alternative processes or technologies, and the preference to avoid change.

Agency environment also plays a role. Local officials often look to their state counterparts as models; if the state is not deploying a new practice or technology, the local agency will not. Similarly, local policy restrictions may prevent an agency from following in the implementation footsteps of a state DOT.

New York State LTAP Director David Orr notes that one of the most effective strategies of the Cornell Local Roads Program is to look for ideas that can be shared and to target them to the right segment of their audience. He used the example of Superpave® asphalt, which now is the standard in New York State. Many local agencies did not use it early on because some claimed it was a sophisticated technology. In reality, Superpave is a straightforward asphalt technology, and once a program instructor began calling it a "mighty good pave," it began to catch on.

Because technology transfer involves communications, sometimes a simpler term is more effective. Did referring to Superpave in a less formal way somehow make the technology more approachable? Orr points out that most local agencies do not need to know the calculus behind Superpave—they just need to know how to order it. Likewise, most local agencies do not need to understand gyratory compaction—they need to know how to roll it properly.

The New York State LTAP decided to conduct a demonstration on warm-mix asphalt (WMA). The goal was to show the audience how unsophisticated WMA is—that it is only another form of asphalt concrete. After a while, many local agencies felt comfortable enough with the WMA concept to begin use, Orr observes.

PHOTO: SNOHOMISH COUNTY PUBLIC WORKS

Communication about the ease of use of a technology like warm-mix asphalt can make it more accessible to local communities.

Photo: Janet Leli

"A few agencies will want to know the details behind an idea," he adds. "Most just want to know that it can do the job at a reasonable price, and how the new idea compares to what they are already doing."

LTAP–TTAP centers share information not only from FHWA and state DOTs but also from formal partner agencies: the American Association of State Highway and Transportation Officials (AASHTO), the National Association of County Engineers, the American Public Works Association, and the National Transportation Training Directors.

## Every Day Counts

In recent years, U.S. DOT has made a concerted effort to support rapid technology transfer among states. FHWA and AASHTO created the Every Day Counts (EDC) program in 2009. The EDC model comprises a two-year information blitz on selected proven innovations and business processes to improve efficiency. This initiative relies on marketing and public outreach during the two-year deployment cycle, through webinars and demonstration projects, along with publications to encourage widespread deployment (2).

A natural link emerged between EDC and LTAP–TTAP, with the programs' respective functions of promoting implementation and managing technology transfer. From the start, the LTAP–TTAP network has integrated EDC information into its technology transfer portfolio; for example, promoting and hosting a series of EDC Exchange webinars created by FHWA. Many centers host sites for participants to view the webinars, which are designed to highlight effective project development and delivery practices, tools, and technologies, and conduct local discussions to explore the potential for implementation.

EDC Exchanges often lead to increased implementation of the innovations in local and tribal transportation systems; they also provide a starting point for LTAP–TTAP and local agencies to move ahead with further training or technical assistance on the covered topics. Additional examples of EDC promotion include LTAP–TTAP newsletter articles, presentations on innovations at organizational meetings, product demonstration showcases, traditional workshop training, and distribution of EDC multimedia.

Showcases for such technologies as geosynthetic reinforced soil–integrated bridge systems help state LTAP–TTAP centers deploy innovations.

Vermont Agency of Transportation workers use ultrahigh-performance concrete (UHPC) for the first time. The Every Day Counts program demonstrated the advantages of UHPC and provided technical assistance and training.

Photo: Vermont Agency of Transportation

Now that EDC is in its fourth cycle, the program has fostered a solid partnership with LTAP–TTAP. More than 10 state and tribal centers have hosted product demonstration showcases on geosynthetic reinforced soil–integrated bridge systems, all locally installed. At least five LTAP–TTAP centers have collaborated with their state DOTs to develop locally administered federal-aid project training programs.

Local agencies in many states quickly adopted Safety Edge, an EDC innovation—largely through Safety Edge loaner programs set up with LTAP–TTAP centers. The deployment of National Traffic Incident Management Responder Training, a product of the second Strategic Highway Research Program, is another example. Many states have implemented the training through the second round of EDC, often in partnership with an LTAP–TTAP center.

## Build a Better Mousetrap

LTAP–TTAP not only serves as a champion of EDC but also encourages the dissemination of homegrown best practices. In 2009, LTAP–TTAP launched the Build a Better Mousetrap National Competition to highlight innovative solutions to everyday challenges faced by local transportation agencies (*3*). Many state and tribal centers conducted state-level competitions and nominated their top entries.

Contest entries represented a variety of creative gadgets, product modifications, and processes for improving everything from safety to time efficiency; the best ones combined local relevance with easy, broad adaptability. All entries were judged on cost, community savings and benefits, ingenuity, transferability, and effectiveness.

Some notable submissions to the Build a Better Mousetrap competition included the following:

◆ Virginia DOT's curve analysis application, a mobile app that improves upon the former process of ball-banking curves with greater safety and accuracy;

◆ A mineral-based dye used by the city of Wyoming, Michigan, to detect hydraulic leaks on snow-covered vehicles;

◆ A snow pusher developed by Mercer County, North Dakota; and

◆ An undervehicle washing system developed in 2012 by the town of Vernon, Connecticut.

The philosophy behind the competition not only encourages innovation within transportation agencies, but also conveys the technologies to others. To date, more than 100 local entries have reached the national competition, and a library of all of the projects is available through the National LTAP–TTAP Clearinghouse.

The underbody and frame pressure washer developed by the Mt. Sterling, Kentucky, Public Works Department won second place in the 2015 LTAP–TTAP Build a Better Mousetrap competition.

PHOTOS: LTAP–TTAP

## Research Showcases

For researchers and champions of innovation, implementation of new technologies or best practices marks a significant milestone and leads to the best measure of return on investment for research and development: the sharing of research outcomes within the transportation community.

Several LTAP–TTAP programs, such as those in Connecticut, Delaware, Iowa, Massachusetts, and New Jersey, have partnered with their state DOTs to host technology transfer expos and research showcases. These events spotlight the results of the state research projects, as well as transportation innovations from others in both the public and private sectors.

LTAP–TTAP and their state partners convene researchers, customers, and potential implementers—creating interactions among those with research needs, those who could spur local innovation deployment, and those with solutions. Repre-

Photo: TJfromAZ, Flickr

The Salt River Canyon Bridge connects the San Carlos and Fort Apache Indian Reservations. LTAP–TTAP centers provide a critical link in technology transfer among innovators and local and tribal transportation leaders and staff.

sentatives from all levels of government, academia, consulting firms, and industry often attend.

For the past 18 years, the New Jersey DOT Research Showcase has brought together representatives from the agency, academic research, local agencies, consulting firms, the roadway construction industry, transit, and public safety. Agendas highlight New Jersey DOT–sponsored research projects and research conducted elsewhere, with the goal of sharing information about recent products and practices with a multidisciplinary audience.

Additional benefits of showcases include the opportunity for state transportation research customers to network with innovators as well as with others who could implement the research findings in local transportation systems.

## Push to Deployment

By working with the innovator and the end user, LTAP–TTAP centers facilitate technology transfer. This critical conveyance pushes technologies and processes to deployment in local transportation systems. Because the pool of LTAP–TTAP stakeholders is both diverse and voluminous, centers have become adept at tailoring engagement methods.

Sometimes the innovation is complex, and other times it is uncomplicated. When useful innovations are complex, LTAP–TTAP centers share the information in ways beyond the results and conclusions of research reports. Messaging strategies become simpler—technical briefs, five-minute presentations, site visits and demonstrations, poster displays, short video clips, and summary articles that lead interested stakeholders to more information. In other cases, when uncomplicated innovations should be deployed more widely, LTAP–TTAP centers encourage innovators to share their work.

To find out more about the National Local Technical Assistance Program, part of the FHWA Office of Innovative Program Delivery Center for Local Aid Support, visit www.fhwa.dot.gov/innovativeprograms/centers/local_aid/ and the National Local Technical Assistance Program Association home page at www.nltapa.org.

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Moving Research into Practice

# Technology Transfer at a European Construction Company

## *Case Study of ACCIONA Construction, Spain*

AQUILINO ALVAREZ-CASTRO AND JAVIER BONILLA-DÍAZ

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Innovation is intrinsic to the design processes of private-sector construction companies, and a company's creativity flourishes as its designs become a reality. In meeting a project's challenges, construction companies must deliver infrastructure that balances the demands of technical performance, budget constraints, and customer expectations.

In the late 20th century, however, the pace of innovation in engineering practice slowed, as rigid codes and standards affected the development of transportation projects, with the intention of minimizing risks and ensuring performance without budget overruns. But new materials, the challenges of sustainability and climate change, new mobility needs, and the demand to optimize the use of physical and economic resources have offered opportunities for the design–build–manage infrastructure model, which draws on innovative concepts and technologies.

Research and development (R&D) programs have been a major activity at universities and research institutions, but private-sector organizations—particularly construction companies—have increased involvement in R&D in response to these challenges. As a result, private-sector organizations also are driving the transfer of technology into the transportation industry.

ACCIONA Construction in Spain provides a case study of technology transfer at a construction com-

PHOTO: LEE MORLEY, FLICKR

Durable infrastructure design relies on innovation. The Brooklyn Bridge was the first suspension bridge built with steel cables.

PHOTO: WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

Schedule and budget constraints, as well as client-specific requirements, can affect the development and deployment of innovations.

pany, as well as insights into the ways that many private-sector organizations have become critical partners in the transfer of technologies that can advance the transportation sector into the next technological frontier.

## Sector Characteristics

Aversion to risk is a unifying characteristic of the construction sector. Tight schedules, budget constraints, and limited project margins shape operational decisions. In addition, construction companies behave reactively to project requirements, striving to meet the client's specifications, and opportunities for innovation are scarce.

Nevertheless, construction companies can gain an advantage by investing in an R&D program. First, companies need ways to set themselves apart—almost all contractors execute projects according to similar procedures. Second, technology is creating opportunities to deliver projects with value-added engineering solutions that benefit all stakeholders.

But the process of technology transfer at a construction company is not easy. A new technology may have its attractiveness, but key issues arise about its maturity and its cost, whether the technology consists of tangible materials, or hardware, or of intangible know-how, or software. Because transportation infrastructure projects involve assets for the public benefit, the expenditure of resources on development must be justified, and the final performance must be guaranteed. If the technology is not mature enough, the risks may not be worth the implementation.

An additional problem in delivering technology is that the cycle of innovation in the construction sector is slow—sometimes a proven technology may require decades to become widely available and accepted. The following examples offer insights into how research results can move through a well-designed and managed process of technology transfer to benefit all stakeholders.

## Composite Materials

Fiber-reinforced polymer (FRP) composite materials are lightweight, have outstanding mechanical properties compared with concrete and steel, last longer than traditional materials, and require lower maintenance because of a low vulnerability to environmental effects. These characteristics raised the possibility of structural elements composed of FRP.

### *Applying Research Findings*

ACCIONA spent several years researching composites, and in 2004, in Asturias, northern Spain, the company built the first bridge made of FRP materials. At that time, composites mostly were used for the structural reinforcement of damaged or ill-designed elements. In addition, no civil engineering standard applied to the design of structural elements of FRP composite materials.

PHOTO: ACCIONA

ACCIONA Construction used insights gained from the use of fiber-reinforced polymer on another bridge project to build the twin bridges on the M111 highway in Madrid, Spain.

In 2004, the Ministry of Infrastructure Development (Ministerio de Fomento) accepted a proposal by ACCIONA to build a full-scale FRP composite bridge on a secondary road that passed over the A67 highway. The location would minimize risks to users and would accommodate uncertainties about the bridge's long-term performance.

Although the bridge project was to demonstrate the feasibility of composites as a cost-effective material for infrastructure development, the support of a public administration with a strong interest in exploring new materials was a key. The bridge has undergone an extensive monitoring process for more than 10 years, providing additional guarantees and allowing ACCIONA's engineers to gain insights into composite materials performance.

The experience led to the development of twin bridges constructed with FRP materials on the main axis of the M111 highway in Madrid in 2008. Each bridge was 34 meters long, with individual spans of 12 meters over four supports. In 2014, ACCIONA built a single-span bridge, 17 meters long, providing access to a hydroelectric plant in Iboundji, in the Republic of Gabon. In addition, between 2010 and 2015, the company built many other types of structures with FRP materials, including pedestrian bridges and a lighthouse.

PHOTO: ACCIONA

The completed M111 bridges.

### *Technology Transfer*

The technology transfer process evolved. The first bridge in Asturias had government support and therefore the stakeholders shared the risks. Technology transfer, however, requires not only managing the risks associated with new technologies but effectively integrating the experience of designing, manufacturing, and building a structure with novel materials into the organization's procedures.

The process builds on itself—the lessons learned from each project led to improvements in the design and manufacturing of the composite elements and to new research approaches. Each project required extensive efforts to convince public administrators about the benefits of composite materials. Also required were tests to demonstrate the material's performance, cost–benefit analyses, and careful quality control during the manufacturing, to provide guarantees to the client and to minimize risks.

The results from the first bridge and the others that followed were communicated to a broader audience of stakeholders at conferences, fairs, and technical committee meetings. These efforts created a critical mass of stakeholders who supported the implementation of composite materials on other transportation projects, who discussed related research opportunities, and who disseminated the benefits of composites.


PHOTO: THIERRY LLANSADES, FLICKR

The Urbos tram in Zaragoza, Spain, gained an Environmental Product Declaration—a favorable performance measurement related to life-cycle environmental impact.

## Role of Standards

Sustainability is a primary concern in the transportation sector. According to the European Commission's *EU Transport in Figures 2016*, the transport sector generates close to 25 percent of the total greenhouse gas emissions in Europe. Of this, the road transport sector contributes almost 73 percent. Many construction companies therefore decided to develop methods and tools to increase the sustainable performance of infrastructure projects.

In the early 2000s, few research initiatives were examining sustainability in relation to infrastructure projects. Several EU directives, then newly approved, enforced the recycling of wastes, including wastes from civil engineering projects. Nevertheless, the application of sustainability principles to infrastructure projects involved more than the recycling of waste materials and byproducts.

Stakeholder concerns about proper measures for assessing the sustainable performance of infrastructure projects increased between 2000 and 2010. In 2013, ACCIONA performed a life-cycle assessment of the N340 road in Elche, Valencia; the findings gained the first-ever Environmental Product Declaration (EPD) for a road project. Some EU countries, such as Sweden, are requesting EPDs for portions of transportation projects.

### *Certifying Sustainability*

Despite the usefulness of EPDs, additional work was required for performing a complete, holistic sustainability assessment of an infrastructure project. In 2013, the European Commission funded the LCE4ROADS Project under the 7th Framework Program, to create a holistic sustainability certification system for road pavements.

Led by ACCIONA Construction, the project involved 13 partners, including small and medium-sized enterprises, public road authorities, research institutions, a certification body, and sectorial organizations from various EU countries. The project developed a methodology identifying 25 environmental, economic, and social indicators that facilitate analysis of the sustainability performance of a road project. The inclusion of indicators describing the technical performance of the road strengthened the methodology, because sustainability requires adequate technical performance.

The project's goal was to provide a widely accepted certification of sustainability performance—to accomplish this, the knowledge developed within the project would have to be transferred to the industry. After discussions within the group and with key industry stakeholders, the LCE4ROADS Project Consortium concluded that a standard would be an effective way of transferring the methodology to the industry.

PHOTO: ACCIONA

Pedestrian bridge in Almuñécar, Spain. From distributing risk among shareholders to integrating new processes and materials into organizational procedures, technology transfer leads to widespread adoption of innovative technologies.

PHOTO: PETITSINGE, FLICKR

Transportation is a major contributor to greenhouse gas emissions in Europe. The EU's LCE4ROADS Project developed a sustainability certification process for road projects.

The European Committee for Standardization (CEN) develops European standards through technical committees. A standard may require years in development; therefore the LCE4ROADS partners coordinated activities with the CEN technical committees on road materials[1] and sustainability in construction[2] to explore ways to shorten the time to standardization.

### *Consensus Approach*

AENOR, the Spanish certification body and a partner in the LCE4ROADS project, suggested developing a CEN Workshop Agreement (CWA) to help fast-track the standard. A CWA is a public document agreed to by interested industry stakeholders. Although not a European standard, a CWA has the weight of a recommendation from an interested group of stakeholders. In addition, these documents stand as industry references that ease the path to standardization.

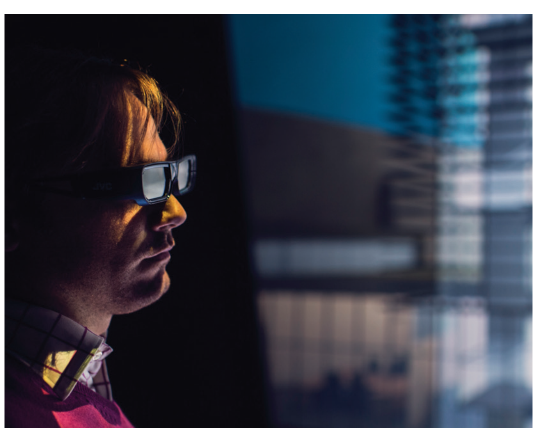
The resulting CWA, Indicators for the Sustainability Assessment of Roads,[3] reflected the consensus of 20 stakeholders, including public authorities, research institutions, road associations, and private companies from eight European countries. Most were not part of the LCE4ROADS Consortium.

The CWA has become an important means for transferring LCE4ROADS project results to the industry. The document serves as a reference on sustainability in road projects, listing indicators with harmonized, consensus definitions, as expected from the LCE4ROADS methodology. Private companies do not often lead this kind of initiative, but the outcome demonstrates that private-sector research can benefit the industry through the standardization process.

[1] CEN/TC 227.

[2] CEN/TC 350.

PHOTO: ACCIONA



Building information modeling (BIM) uses a virtual reality working environment to develop and manage construction products.

## Building Information Modeling

### *Exploring the Opportunities*

In early 2008, ACCIONA Construction recognized the potential of a new methodology, building information modeling (BIM), which uses a virtual reality working environment to develop and manage construction projects. BIM centralizes all project data in a digital information model, which can respond to any query throughout the construction project.

The use of BIM creates a collaborative environment for all stakeholders involved in the project; this significantly reduces errors during construction and improves the management of the project's schedule and resources. BIM also maximizes customer satisfaction by enabling clients to view projects before delivery and to make modifications with a proper understanding of the impacts on the design, construction, schedule, and cost.

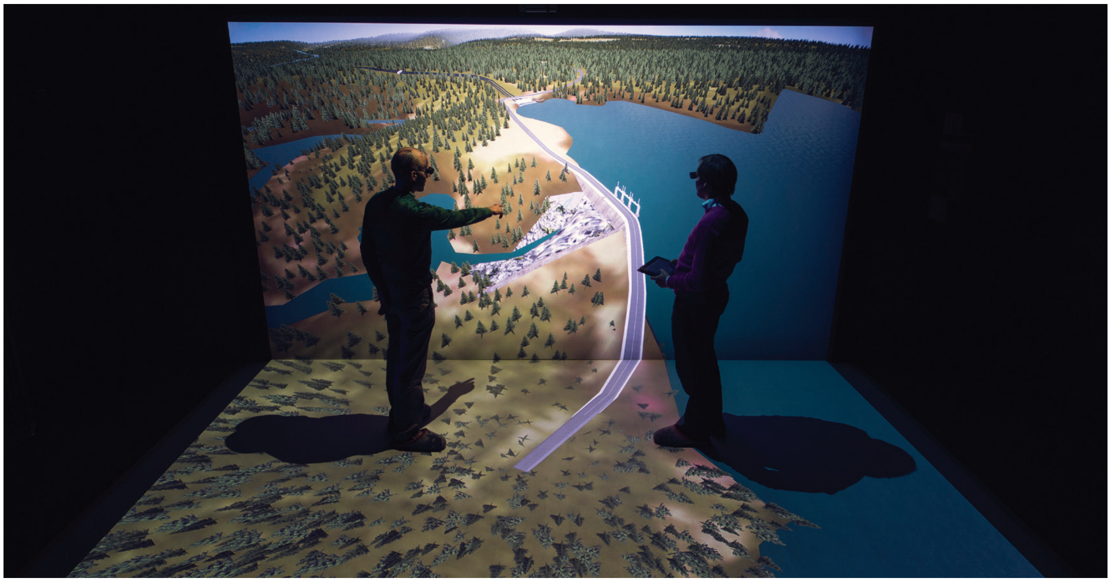
When ACCIONA researchers started to explore the opportunities of BIM, public administrations were not yet requesting this type of tool for project management. The researchers therefore sought to understand the potential of BIM and to demonstrate the benefits at all business levels within the company through minimizing redundancies and design overlaps, increasing stakeholder engagement, and enhancing productivity.

### *Transferring Know-How*

The formal process of transferring the know-how developed from the BIM research to the ACCIONA business units began in 2014. That year, some international markets, such as the United Kingdom, already were specifying these types of tools for the management of large and complex transportation infrastructure projects. To meet these specifications, all in-house stakeholders, from technical staff to business managers, would have to be aware of BIM and

[3] CWA 17089:2016.

PHOTO: ACCIONA



BIM gives managers and infrastructure owners access to a wide range of data and lessons learned from past projects, allowing greater innovation with less risk.

be able to interact with the interfaces as required.

ACCIONA inventoried its BIM capabilities and project needs. A team of researchers, engineers, project managers, and business managers analyzed 29 active projects with BIM requirements and identified the company's level of ability to use BIM for accomplishing the project goals.

BIM is an important tool for the construction sector. BIM 6D models, for example, can compile the physical, time, cost, and life-cycle parameters and data of a project; managers and infrastructure owners can receive accurate and reliable data to support decision making. In addition, the models can provide data about lessons learned from previous projects, so that older projects can serve as benchmarks; the stored data can yield accurate estimates of budgets and schedules and can help identify areas for improvement and opportunities for value engineering.

### *Expanded Efforts*

The transfer of BIM knowledge successfully throughout the company required initiatives to reeducate staff to gain competence in BIM. Efforts included in-house courses, both online and face to face; web platforms with video tutorials; a database of BIM project examples; and the assignment of BIM researchers to construction sites.

In addition, a remote access protocol was set up to facilitate and foster the use of BIM-based software from remote computers. A progressive upgrading of the information technology infrastructure and servers complemented the companywide focus on BIM.

The final step in the technology transfer was to split the BIM research team into small groups, with each group assigned to different business units across the company. This has sped up the adoption of BIM and is facilitating the timely transfer of know-how and of the associated technologies into daily business practices.

## Advancing Transportation

Private construction companies have been leaders in the delivery of innovation to the transportation sector. The need to provide competitive and cost-effective offerings to customers requires innovation and a readiness to capture opportunities. The fast pace of research is delivering a wealth of opportunities for improving infrastructure performance and for satisfying current and future stakeholder needs.

Although the examples drew on specific cases at ACCIONA Construction, many other construction companies are incentivizing technology transfer programs, either from internal R&D projects or from agreements with other stakeholders. For example, Ferrovial in Spain has hired researchers from the University of Texas. Hiring people who have been involved in specific research areas is a way to encourage technology transfer within a company and in the industry. Another approach is through investment in start-ups—the cement producer CEMEX, for example, has created a subsidiary, CEMEX Ventures, to nurture innovations.

The transportation public sector can benefit from the experience of private construction companies, as the case studies presented here demonstrate. Moreover, private-sector companies can find that investment in research is advantageous and can deliver the results through a variety of mechanisms for technology transfer. This industry leadership helps speed the adoption of technologies that will advance transportation into the next technological frontier.

# Patrick Casey

*CTC & Associates LLC*

Although a latecomer to transportation research, Patrick Casey has a diverse professional background in education, government, science, and communications. He formed Casey Technical Communications in 2000 to work with the Wisconsin Department of Transportation's (DOT's) research program, and since then has added other state DOT research programs, industry associations, and national programs to his client base.

His firm, based in Madison, Wisconsin, and renamed CTC & Associates in 2002, is focused exclusively on transportation research, especially as it affects state and local agencies. "We help our customers communicate their research successes and move them into practice," Casey notes. "We translate into plain English the technical advances coming out of the research, with a journalistic eye to how the results affect the real world."

**"We translate into plain English the technical advances coming out of the research, with a journalistic eye to how the results affect the real world."**

CTC & Associates employees—writers, editors, project managers, and designers, working from Wisconsin and six other states—bring a range of backgrounds to the company, Casey notes, adding that the team facilitates a steady stream of communication products and services, ranging from technical briefs, synthesis reports, and newsletters to annual program reports, websites, peer exchange facilitation, and pooled fund management. "The fact that they are excited to write about transportation research says a lot about them and about the dynamic nature of the field," he observes.

In the 1990s, Casey ran a Michigan research and testing laboratory that, among other things, generated and sold composition and performance data on multiviscosity engine oils marketed around the world.

"The background in chemistry, materials science, bench-test protocols, and statistical analysis that I gained at the lab was very helpful when I got into transportation research," Casey comments. He also was active in ASTM, serving for several years as chair of the Subcommittee on Recycled Petroleum Products. Casey became a certified quality auditor and developed the three-tier documentation system that enabled the lab to become certified for quality management by the International Organization for Standardization.

Casey graduated from Michigan State University with a bachelor's degree in English and worked as a high school teacher and administrator throughout the 1970s. In the early 1980s, he served as a staffer for a Michigan congressman who served on the U.S. House of Representatives Public Works and Transportation Committee. "I gained a lot of insight into the legislative and political process and the interplay between federal and state transportation agencies," Casey recalls.

Later in the 1980s, Casey worked in the Michigan governor's office in a variety of roles, charged with communicating the administration's proposals and policies to affected constituencies.

Casey joined the Transportation Research Board's (TRB's) Standing Committee on Conduct of Research in 2008. He also served on the Standing Committee on Disadvantaged Business Enterprises. "I saw the innovation that can come from the collaboration of public agency practitioners, university investigators, and private-sector consultants," Casey comments.

He now is chair of the Standing Committee on Technology Transfer, which focuses on methods for moving research and innovation into practice across all areas of transportation. The committee was asked to recommend improvements to TRB's Practice-Ready Papers initiative and is collaborating with subject-matter experts in other committees to develop joint papers and posters for annual meetings.

Since 2010, Casey and his team have developed many publications for TRB's National Cooperative Highway Research Program (NCHRP) to encourage implementation of research products. Publications include the Impacts on Practice and Paths to Practice series, which capture the effects of research on the transportation system and the various approaches taken by state DOTs to put NCHRP research findings into use.

Other series developed for NCHRP include Ready Results briefs of individual project results and Research Topic Highlights, which gather multiple projects' results into a single, theme-based publication. Casey's firm also authored the 2014 NCHRP report "Evaluating Implementation of NCHRP Products: Building on Successful Practices" and created a brochure and video for the program's 50th anniversary in 2012.

Casey is an active participant in the American Association of State Highway and Transportation Officials' (AASHTO's) Research Advisory Committee (RAC). CTC & Associates has conducted many AASHTO RAC surveys and research efforts on such topics as innovation, implementation, and the value of research and each year produces a brochure for AASHTO RAC showcasing the top 16 state DOT research projects selected by research directors.

# Douglas D. Gransberg

*Gransberg and Associates, Inc.*

For the past 20 years, Douglas D. Gransberg has balanced the academic responsibilities of a professor of construction engineering and construction science with the industry-related work of a project delivery consultant. Since 2010, he has taught construction engineering courses at Iowa State University and soon will retire from academia to focus full time on construction and transportation engineering research and practice.

Gransberg has applied his construction expertise to projects across the Western Hemisphere, from the new Panama Canal design–build project to guidelines for complex project management in more than a dozen states under the second Strategic Highway Research Program (SHRP 2). He also helped three states draft the legislation that enabled them to implement alternative project delivery.

"Even at the softest end of the construction engineering research spectrum, we are able to discern quantifiable benefits to improve the nation's transportation network."

"Most researchers do not get the opportunity to implement their research in the real world," comments Gransberg. "I feel fortunate that I have been able to do so with my research in alternative contracting methods."

Gransberg has assisted two dozen state departments of transportation (DOTs) in implementing his research in five-dimensional complex project management, design–build, construction manager–general contractor, indefinite delivery–indefinite quantity, alternative technical concepts, and preconstruction service cost estimating.

After graduating from Oregon State University with a civil engineering degree in 1974, Gransberg joined the U.S. Army Corps of Engineers as an engineer officer. He also received a master's degree from Oregon State and a Ph.D. from the University of Colorado. Gransberg traveled around the world with the Army until he retired at the rank of lieutenant colonel in 1994; he then took an assistant professor position at Texas Tech University, later moving to the University of Oklahoma in 1999.

"At the time, very little serious, funded research was being completed in transportation project construction management—and what passed for construction research was really laboratory-based material science," Gransberg notes. When Texas DOT sponsored research projects on design–build contracting and partnering, he drew on his experience in the field and won the projects, launching his research career.

"Those two projects signaled a shift in industry culture from a decades-long, adversarial, litigation-rife environment to one where collaboration among—and integration of all—project stakeholders were encouraged," he recalls, adding that he and his colleagues still work to facilitate that culture shift.

According to Gransberg, recent research indicates that, for the average DOT, claims now result in litigation only 2 percent of the time, as compared with 8 to 10 percent of the time in 1996. In 2010, the Federal Highway Administration's Every Day Counts initiative increased the momentum by supporting alternative contracting methods to accelerate the rapid renewal of U.S. highway infrastructure.

Alternative contracting methods require more collaboration between individuals, as well as among the contractor, designer, and owner in project delivery, Gransberg observes: "Even at the softest end of the construction engineering research spectrum, we are able to discern quantifiable benefits to improve the nation's transportation network."

He continues to apply the lessons of his research, from developing a data-driven business intelligence system for California DOT to estimate preconstruction services to assisting Georgia DOT to incorporate five-dimensional project management strategies for complex projects on its $11 billion Major Mobility Investment Program. These applications originated in research from the National Cooperative Highway Research Program and the second Strategic Highway Research Program.

"In 2017, more than $1 million of new construction engineering research was advertised at both the state and federal levels, across a broad spectrum of construction engineering topics," Gransberg comments. "As a researcher, that's the definition of success and clearly demonstrates the value added by alternative contracting methods to transportation agencies."

TRB research products help reduce the implementation risk for transportation agencies by providing objective documentation of experiences with new methods, he notes: "The ability for industry practitioners to commission objective analyses conducted by academic subject-matter experts provides both the information to justify making changes in current processes as well as the materials necessary to implement new construction engineering processes. The experiences of early adopters save agencies the grief of having to trial-and-error their own approaches."

Gransberg joined TRB's Standing Committee on Pavement Maintenance in 2005 and served on the Standing Committee on Pavement Preservation. He also is a member of the Subcommittee on Airport Pavement Management and chair of the Standing Committee on Project Delivery Methods, which he helped to establish.

## Mobility Options Limited for Rural Millennials

Although many studies have examined the mobility habits of the urban millennial generation, few have addressed the travel behavior of the 11 million American millennials who live in rural areas. The Western Transportation Institute at Montana State University recently surveyed more than 2,500 travelers in Minnesota, Montana, Washington, and Wisconsin who were born between 1983 and 2000. According to researcher Natalie Villwock-Witte, the travel behavior of rural young adults differs distinctly from that of their urban counterparts.

Personal automobiles are the most-used transportation mode among both segments of young adults, but 85 percent of rural millennials opt to drive themselves to work instead of taking the bus or walking, compared with 75 percent of those in urbanized areas. According to Villwock-Witte, factors contributing to this difference included education, income, and debt; in addition, people who live in rural areas have fewer transportation options.

The survey revealed an interest among millennials in Montana for more transportation options, including bicycle facilities in Bozeman, sidewalks in Billings, and public transit services in Great Falls.

*For more information, visit www.montana.edu/news/16753/msu-research-on-rural-millennials-featured-by-wired.*

Photo: Tracy/Flickr

Downtown Butte, Montana. With fewer buses, sidewalks, and bike paths, rural millennials opt to use personal vehicles more than their urban counterparts.

## Crash Hazards at Construction Sites

A survey of more than 700 contractors nationwide conducted in early 2017 by the Associated General Contractors of America (AGCA) showed that 44 percent of contractors had experienced a motor vehicle crash at a construction site in the past year. In nearly half of the crashes, car drivers or passengers were injured; 13 percent of the crashes were fatal. The report also noted that 25 percent of work zone crashes injured construction workers and that 11 percent were fatal—an 83 percent increase from the previous year.

In addition to the cost in human lives, work zone crashes affect construction costs and schedules. Crashes, particularly ones involving injury or death, delay construction, shutting down projects more than half of the time. According to the report, survey respondents favored greater police presence and stricter enforcement of traffic laws, increased use of barriers, and better safety training for construction workers.

*For more information, visit http://news.transportation.org/Pages/060217crashes.aspx.*

Photo: Washington State DOT

Washington State's annual memorial for employees killed in work zone crashes.

## In-Vehicle Messaging to Increase Safety

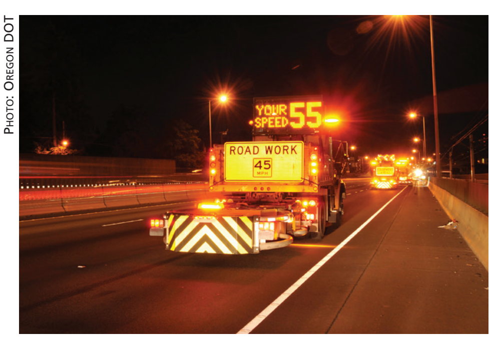
As work zone accidents have risen in the past four years, agencies have sought new ways to increase awareness and safety. A Minnesota Department of Transportation (DOT) study published in June 2017 investigated the risks and benefits of communicating work zone events through in-vehicle smartphone messages.

The study began with a survey of driver cellphone habits and research into design guidelines for in-vehicle messaging. A subsequent driving simulation tested drivers in different types of work zones and was repeated three times with various messaging techniques. Communication interfaces included a roadside, portable changeable message sign; a smartphone using auditory messages; and a smartphone using both auditory and visual messages.

According to researchers, the auditory and the visual–auditory in-vehicle messaging yielded better driver performance on speed and lane deviation than did the roadside signage. In addition, drivers reported significantly less mental workload, better recall of work zone events, and improved eye-gaze behavior when receiving the in-vehicle communications.

*To read the full report, visit http://dot.state.mn.us/research/reports/2017/201719.pdf.*

Photo: Oregon DOT




Research shows that in-vehicle messaging yields better driver performance in work zones than do roadside variable message signs.

## INTERNATIONAL NEWS

### Historic Preservation's Economic Benefits

Transportation activities generate risks and opportunities related to historic and cultural heritage, commonly expressed in terms of the impacts on heritage value and significance, a report from the New Zealand Transport Agency (NZTA) notes. The economic implications, however, are less well understood or quantified.

Road authorities encounter economic risks from project delays when minimal conservation efforts jeopardize heritage sites or archaeological remains are unexpectedly discovered. NZTA maintains that projects can benefit from smoother relations between *tangata whenua*—the indigenous peoples of New Zealand—and stakeholders.

NZTA has proposed a Heritage Economic Benefits Framework and tool for identifying and expressing the economic benefits of engaging in heritage conservation and minimizing project risks. The framework and tool suggest ways for expressing heritage values to assess project options, to identify and prioritize heritage impacts consistently across projects, and to facilitate comparisons between conservation costs and benefits. A key recommendation is to engage strategically with *tangata whenua* and to consider their views on heritage impacts at the earliest stages of a transportation project.

Photo: itravelNZ, Flickr

New Zealand's Victoria Park tunnel project was designed to ensure minimal impact on historic sites like the Rob Roy Hotel; the concerns of indigenous peoples also are a consideration in transportation projects.

*For more information, visit www.nzta.govt.nz/assets/resources/research/reports/601/601-understanding-the-value-of-transport-investment-in-historic-and-cultural-heritage.pdf.*

### Finland's Oldest Ferry Goes Electric

Finland's oldest operating ferry received an overhaul this spring, making it the nation's first all-electric passenger vessel.

*Föri*, derived from "färja," the Swedish word for ferry, has been shuttling passengers across the Aura River since 1904, when it was commissioned for commuters traveling between the Finland cities of Turku and Åbo. In its early days, the ferry ran on wood-burning steam engines; in 1955, those engines were replaced with diesel engines.

Photo: Martin Watters, Life Size Media

Finland's ferry is the country's first all-electric passenger vessel.

In March 2017, the City of Turku commissioned local boatyard Mobimar to remove the diesel-powered motor and control system, which used up to 80,000 liters of fuel per year, and to install two permanent magnet motor drives. The boat now draws power from batteries that are charged overnight. The double engines allow the ferry to run on one or both motors, which is important in icy conditions and for future motor maintenance. The battery-powered *Föri* is 8 tons lighter and runs more efficiently, quietly, and cheaply.

*For more information, visit https://www.ajot.com/news/finlands-oldest-ferry-goes-all-electric-with-visedo-power.*

### Shared Data for Safer City Streets

The International Transport Forum (ITF) is collecting and disseminating transportation data from 38 cities worldwide—from Amsterdam, Netherlands, to Rio de Janeiro, Brazil. Based on a 2003 pilot project of nine European and North American cities, the Safer City Streets network shares data on crashes, population, mobility, and traffic.

Cities provide data via a questionnaire; in return, they gain access to information from peer cities. ITF establishes a network of experts and manages and analyzes the data, which include such topics as the rates of helmet and seat-belt use, the influence of commuters on daytime populations, and modes of travel.

*For more information, visit https://www.itf-oecd.org/safer-city-streets.*

Photo: alobos life, Flickr

Rio de Janeiro, Brazil, is one of nine cities sharing transportation and safety data to help inform policy makers.

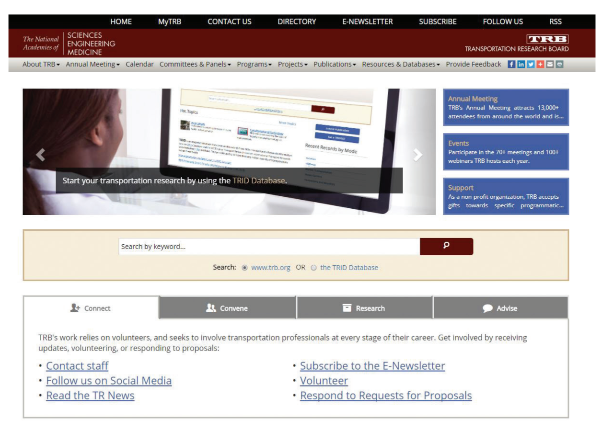

**GUIDING FUTURE RESEARCH**—TRB Executive Committee Chair Malcolm Dougherty (*left*) and Vice Chair Katherine Turnbull (*right*) discuss critical transportation issues at a meeting of the Subcommittee on Planning and Policy Review at the National Academies of Sciences, Engineering, and Medicine's Keck Center in Washington, D.C., in April. The subcommittee guides the policy study work of the Transportation Research Board (TRB) and explores opportunities for new Executive Committee initiatives.


**INFRASTRUCTURE GOALS**—(*Left to right:*) Roger Bohnert, Build America Bureau, U.S. Department of Transportation; Pauline Thorndike, U.S. Army Corps of Engineers; and Kathy Broadwater, Maryland Port Administration, present perspectives on funding marine transportation infrastructure at the Marine Board Spring Meeting in May at the Keck Center. Other panelists included Jeff Holt, BMO Capital Markets, and Scott Sigman, Illinois Soybean Association (*not pictured*).

**MANAGING SAFETY INFORMATION**—Michael Townes, former chair of the TRB Executive Committee and the Mineta Transportation Institute Board of Trustees, leads discussion in the second of four planned meetings of the Committee to Review Evidentiary Protection for Public Transportation Safety Program Information in July at the Keck Center. The committee convenes transportation leaders and legal researchers to evaluate whether evidence and information from public transportation safety investigations may be withheld from disclosure.

## TRB Website Earns Recognition

The Transportation Research Board's website, www.TRB.org, topped the 2017 Global Grid list of 20 best active transportation resources. The list ranked "the most essential and most visited websites of active transportation professionals," notably in the areas of walking, biking, bus, and rail. Highlighted were TRB's Cooperative Research Programs publications and the capability for site users to suggest topics of study. Global Grid is a media outlet that focuses on localized engineering, architecture, and urban planning news.



**NEW IDEAS TAKE FLIGHT—** Members of the Airport Cooperative Research Program University Design Competition for Addressing Airport Needs Committee meet to finalize the list of contest winners in the National Academy of Sciences Building in Washington, D.C., in May. The competition engages undergraduate and graduate students and teams in finding innovative approaches to airport issues.

## Evaluating the Effectiveness of Vibration-Mitigation Devices

Photo: Mescalino/Flickr

Because structural supports for signs, luminaires, and traffic signals typically are flexible and have low damping, they are prone to wind-induced vibration and are susceptible to fatigue and structural failure. Vibration-mitigation devices could increase the service life of new and existing structures; reduce the cost of new structures, maintenance, and repair; and improve traveler safety. Although several mitigation devices have been proposed, few have been used.

The University of Connecticut has received a $400,000, 27-month contract [National Cooperative Highway Research Program (NCHRP) Project 12-111, FY 2017] to develop test procedures for evaluating the effectiveness of vibration-mitigation devices and for considering the design effects.

*For more information, contact Amir N. Hanna, TRB, 202-334-1432, ahanna@nas.edu.*

Photo: Rick Payette/Flickr

## Cross-Frame Analysis and Design

Recent developments in bridge design and analysis have revealed a need to improve the cross-frame analysis and design for steel I-girder bridges. Past configurations generally were based on standard designs. Research on the following topics, however, could lead to dramatic improvement in the reliability and economy of cross frames: the definition of fatigue loading for cross frames in curved and severely skewed steel girder bridges; implementation of stability bracing strength and stiffness requirements in the context of the AASHTO load and resistance factor design (LRFD) specifications; and guidance for adjusting the effective stiffness of cross-frame members in refined analysis models.

The University of Texas at Austin has received a $590,000, 40-month contract (NCHRP Project 12-113, FY 2017) to propose modifications to the AASHTO LRFD Bridge Specifications to improve cross-frame analysis and design.

*For more information, contact Waseem Dekelbab, TRB, 202-334-1409, wdekelbab@nas.edu.*

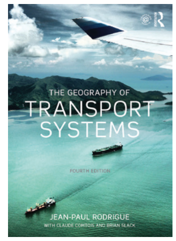
## Design and Construction with Ultrahigh-Performance Concrete

Accelerated bridge construction (ABC) reduces the impacts on traffic and on the environment, the on-site construction time, and the life-cycle costs. The use of prefabricated deck bub tee (DBT) girders, an ABC technique, has been limited to short-span and low traffic bridges because of difficulties in accommodating transitions and because of concerns about long-term performance. Using ultrahigh-performance concrete (UHPC) as closure pour material, however, could improve the reliability and economy of DBT girders.

Ohio University has received a $478,125, 39-month contract (NCHRP Project 18-18, FY 2017) to propose draft AASHTO LRFD specifications and AASHTO LRFD construction specifications for DBT girder bridges using UHPC.

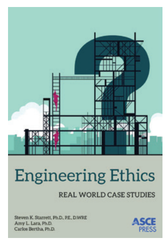
*For more information, contact Waseem Dekelbab, TRB, 202-334-1409, wdekelbab@nas.edu.*

Photo: VTrans/Flickr




***Geography of Transport Systems, 4th Edition***
*Jean-Paul Rodrigue, Claude Comtois, and Brian Slack. Routledge, 2016; 440 pp.; $190; 978-1-138-66956-7.*

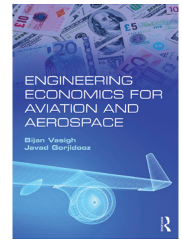
The expanded and revised edition of this volume offers a broad overview of the spatial aspects of transportation concepts, methods, and areas of application for an undergraduate audience. *Geography of Transport Systems* focuses on the linkages of passenger and freight mobility with geography. A companion website can be found at http://people.hofstra.edu/geotrans.




***Engineering Ethics: Real-World Case Studies***
*Steven K. Starrett, Amy L. Lara, and Carlos Bertha. American Society of Civil Engineers (ASCE) Press, 2017; 134 pp.; ASCE members, $30; nonmembers, $44; 978-0-78-441467-5.*

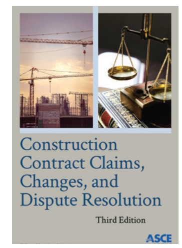
Through extended discussions and situational case studies, this volume examines such ethical concepts as rights and obligations, conflicts of interest, confidentiality, whistleblowing, bribery, fraud, and corruption in the contexts of engineering practice.

The titles in this section are not TRB publications. To order, contact the publisher listed.




***Engineering Economics for Aviation and Aerospace***
*Bijan Vasigh and Javad Gorjidooz. Routledge, 2017; 588 pp.; $152; 978-1-13-818578-4.*

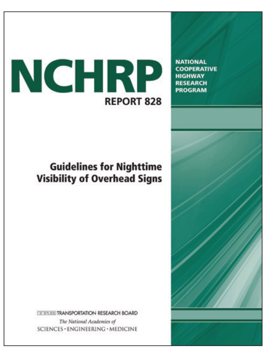
This book combines a theoretical and a limited applications approach to analyzing and evaluating the economics of aviation projects.




***Construction Contract Claims, Changes, and Dispute Resolution, 3rd Edition***
*Edited by Paul Levin. ASCE Press, 2017; 512 pp.; ASCE members, $75; nonmembers, $100; 978-0-78-447969-8.*

The new edition assembles the expertise of more than 30 attorneys and construction consultants on such subjects as contract specifications, pricing, negotiations, project schedules, dispute avoidance, resolution, and termination.

## TRB PUBLICATIONS




***Guidelines for Nighttime Visibility of Overhead Signs***
NCHRP Report 828

This report explores the effects, in controlled conditions, of the luminance and visual complexity of overhead and street signs on the distances at which drivers can read the signs.

*2016; 80 pp.; TRB affiliates, $43.50; nonaffiliates, $58. Subscriber categories: operations and traffic management, safety and human factors.*

***Leadership Guide for Strategic Information Management for State Departments of Transportation***
NCHRP Report 829

This guidebook presents the components of an effective strategy for information governance, techniques to assess an agency's practices in information governance, and ways to implement procedures for effective information management.

*2016; 112 pp.; TRB affiliates, $48; nonaffiliates, $64. Subscriber categories: administration and management, data and information technology.*

***Multistate, Multimodal, Oversize–Overweight Transportation***
NCHRP Report 830

Permitting requirements for the transportation of oversize–overweight (OSOW) freight throughout the United States, state-by-state differences in OSOW road transportation regulations and permitting practices, and the challenges that these differences may pose for carriers are described in this report.

*2016; 174 pp.; TRB affiliates, $57.75; nonaffiliates, $77. Subscriber categories: freight transportation, motor carriers.*

***Civil Integrated Management (CIM) for Departments of Transportation, Volume 1: Guidebook; Volume 2: Research Report***
NCHRP Report 831

This two-volume report offers guidance and provides background on collecting, organizing, and managing information in digital formats for highway or other transportation construction projects.

*2016; 153 pp.; TRB affiliates, $56.25; nonaffiliates, $75. Subscriber categories: administration and management, data and information technology, construction.*

## TRB PUBLICATIONS *(continued)*

***State DOTs Connecting Users and Rides for Specialized Transportation, Volume 1: Research Report; Volume 2: Toolkit for State DOTs and Others***
NCHRP Report 832

Through an analysis of programs, a literature review, and interviews, this two-volume report provides resources for agencies and organizations on connecting specialized transportation users with rides to access daily services. The stand-alone toolkit directs agencies and partners through the decision process and the consideration of budget limitations.

*2016; 85 pp.; TRB affiliates, $43.50; nonaffiliates, $58. Subscriber categories: administration and management, passenger transportation, public transportation.*

***Assessing, Coding, and Marking of Highway Structures in Emergency Situations, Volume 1: Research Overview; Volume 2: Assessment Process Manual; Volume 3: Coding and Marking Guidelines***
NCHRP Report 833

This three-volume report provides background and guidelines for assessing highway structures and the related coding and markings recognized by highway agencies and other emergency-response teams. Prioritization, coordination, communication, and helpful technologies are presented, along with specific assessment procedures and example photos.

*2016; 408 pp.; TRB affiliates, $75; nonaffiliates, $100. Subscriber categories: bridges and other structures, security and emergencies.*

***Post–Extreme Event Damage Assessment and Response for Highway Bridges***
NCHRP Synthesis 497

This synthesis reviews the procedures in Los Angeles County, California; New York City; and state departments of transportation for assessing the damage to bridges after extreme events with geological, hydrometeorological, man-made, or malicious sources.

*2016; 91 pp.; TRB affiliates, $48; nonaffiliates, $64. Subscriber categories: bridges and other structures, highways, safety and human factors, security and emergencies.*

***Application of Pedestrian Crossing Treatments for Streets and Highways***
NCHRP Synthesis 498

Through a survey of state and local transportation agencies and a literature review, this synthesis explores recommended practice and policy guidance for ensuring safety in pedestrian crossing treatments.

*2016; 145 pp.; TRB affiliates, $52.50; nonaffiliates, $70. Subscriber categories: highways, pedestrians and bicyclists.*

***Alternate Design–Alternate Bid Process for Pavement-Type Selection***
NCHRP Synthesis 499

This synthesis documents the contracting techniques that allow the selection of pavement types in the procurement process.

*2017; 77 pp.; TRB affiliates, $48; nonaffiliates, $64. Subscriber categories: construction, design, highways, pavements.*

***Control of Cracking in Bridges***
NCHRP Synthesis 500

This synthesis describes methods to control concrete cracking in bridge superstructures and substructures and explores the effects of cracking on long-term durability.

*2017; 104 pp.; TRB affiliates, $50.25; nonaffiliates, $67. Subscriber categories: bridges and other structures, construction, highways, materials.*

***Addressing Difficult Customer Situations***
TCRP Synthesis 127

Transit agency practices to prevent, prepare for, and deal with difficult customers or passengers are described.

*2017; 79 pp.; TRB affiliates, $45.75; nonaffiliates, $61. Subscriber categories: passenger transportation, public transportation, safety and human factors, society.*

***Practices for Evaluating the Economic Impacts and Benefits of Transit***
TCRP Synthesis 128

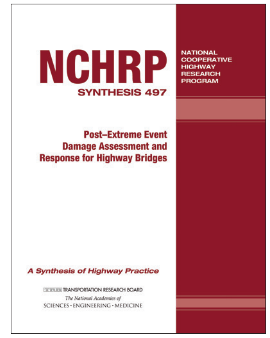
Methods are presented for assessing the economic impacts and benefits of transit, the types of effects covered by these methods, and the way that agencies can use the information for planning, prioritizing, funding, and stakeholder support.

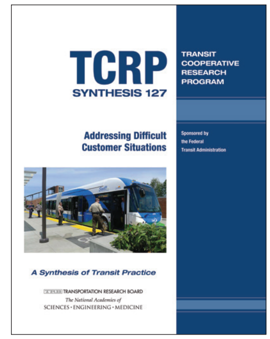
*2017; 84 pp.; TRB affiliates, $45.75; nonaffiliates, $61. Subscriber categories: economics, public transportation.*

***Managing Extreme Weather at Bus Stops***
TCRP Synthesis 129

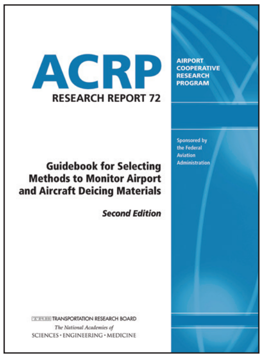
This synthesis reviews the state of the practice of transit agency responses to extreme weather events, including planning, standards and specifications, associated legal claims, and communication with customers.

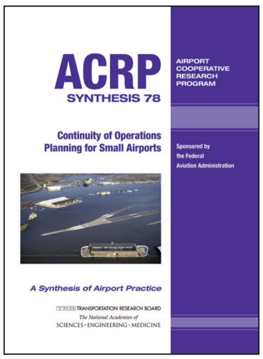
*2017; 67 pp.; TRB affiliates, $42.75; nonaffiliates,*



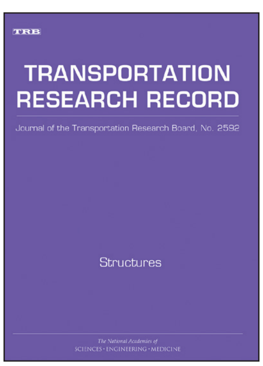



## TRB PUBLICATIONS *(continued)*








*$57. Subscriber categories: maintenance and preservation, passenger transportation, public transportation, safety and human factors.*

***Guidebook for Selecting Methods to Monitor Airport and Aircraft Deicing Materials***
**ACRP Research Report 72, 2nd Edition**

This report offers a step-by-step process for identifying, evaluating, and selecting methods to monitor stormwater runoff that contains deicing materials. Guidance is provided for the setup, operation, and maintenance of each monitoring method.

*2017; 128 pp.; TRB affiliates, $55.50; nonaffiliates, $74. Subscriber categories: aviation, environment.*

***Addressing Significant Weather Impacts on Airports: Quick Start Guide and Toolkit***
**ACRP Report 160**

A web toolkit is introduced to explore the vulnerabilities of airports to significant weather events and to assist in developing robust plans to address contingencies, recovery, and emergencies.

*2016; 84 pp.; TRB affiliates, $43.50; nonaffiliates, $58. Subscriber categories: aviation, energy, environment.*

***Guidelines for Improving Airport Services for International Customers***
**ACRP Report 161**

The guidelines in this report assist airport practitioners in implementing procedures for departures, arrivals, and passenger services for international travelers.

*2016; 248 pp.; TRB affiliates, $66; nonaffiliates, $88. Subscriber categories: aviation, passenger transportation, terminals and facilities.*

***Guidebook for Assessing Airport Lead Impacts***
**ACRP Report 162**

Strategies for minimizing the impacts of lead emissions from piston-engine aircraft are presented, along with a history of lead in aviation gasoline and of U.S. Environmental Protection Agency regulations.

*2016; 32 pp.; TRB affiliates, $34.50; nonaffiliates, $46. Subscriber categories: aviation, environment.*

***Continuity of Operations Planning for Small Airports***
**ACRP Synthesis 78**

This synthesis explores planning for the continuity of operations at airports of different sizes and determines the applications that are most effective for maintaining resilient operational and business capacity at smaller airports.

*2016; 236 pp.; TRB affiliates, $63.75; nonaffiliates, $85. Subscriber categories: administration and management, aviation.*

***Using Commodity Flow Survey Microdata and Other Establishment Data to Estimate the Generation of Freight, Freight Trips, and Service Trips: Guidebook***
**NCFRP Research Report 37**

Improved models are presented for the number of vehicle trips produced and attracted to an establishment, the amount of cargo produced by the establishment, and the number of service-related vehicle trips to the establishment.

*2017; 248 pp.; TRB affiliates, $69; nonaffiliates, $92. Subscriber categories: freight transportation, planning and forecasting.*

***Structures***
**Transportation Research Record 2592**

Structure design, materials, and regulations related to bridges, bridge columns, and tunnels, along with techniques such as ultrasonic imaging on reinforced concrete, are among the subjects covered in this 18-paper volume.

*2016; 176 pp.; TRB affiliates, $63.75; nonaffiliates, $85. Subscriber categories: bridges and other structures, design and construction.*

***Traffic Monitoring: Automobiles, Trucks, Bicycles, and Pedestrians 2016***
**Transportation Research Record 2593**

Papers in this volume explore various types of traffic monitoring, including bicycle traffic, urban freeways and trails, traffic in national parks, and rural highways.

*2016; 132 pp.; TRB affiliates, $54; nonaffiliates, $72. Subscriber categories: operations and traffic, administration and management, pedestrians and bicyclists.*

***Data and Methods to Understand Travel***
**Transportation Research Record 2594**

Analyzing long-distance and overnight travel planning, exploring the use of smartphone data in travel pattern analysis, and evaluating the accuracy of speed-measuring technology are a few of the subjects covered in this volume.

*2016; 176 pp.; TRB affiliates, $63.75; nonaffiliates, $85. Subscriber categories: data and information technology, planning and forecasting, operations and traffic management.*

## TRB PUBLICATIONS *(continued)*

***Informational Technology, Geospatial Information, and Advanced Computing***
**Transportation Research Record 2595**

This volume contains 15 papers that explore the use of informational technology, geospatial information, and advanced computing to solve such problems as pothole and pavement crack detection, traffic congestion, fare payment structure, and natural gas pipeline risk assessment.

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***Managing Performance and Assets; Freight Data and Visualization***
**Transportation Research Record 2596**

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**Transportation Research Record 2599**

Authors of papers in this volume offer guidance on planning for emergencies, including evacuation routing of highways and tunnels, and for maximizing resilience.

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***Public-Sector Aviation: Graduate Research Award Papers 2016***
**Transportation Research Record 2600**

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***Safety Data, Analysis, and Evaluation***
**Transportation Research Record 2601**

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***Human Performance, User Information, and Simulation***
**Transportation Research Record 2602**

Human factors—eyes-off-road time, older drivers' scanning patterns, overtaking maneuvers on two-lane roads, cell phone restrictions for young drivers, and use of caffeinated chewing gum—are examined in this volume.

*2016; 148 pp.; TRB affiliates, $60.75; nonaffiliates, $81. Subscriber category: safety and human factors.*

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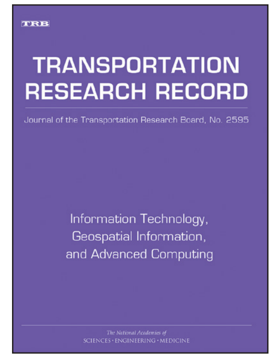

# CALENDAR

## TRB Meetings

### *August*

21–22 9th New York City Bridge Conference*
New York, New York

22–25 16th Biennial Asilomar Conference on Transportation and Energy*
Pacific Grove, California

27 American Society of Civil Engineers International Conference on Highway and Airfield Technology
Philadelphia, Pennsylvania

### *September*

6–8 Transit Geographic Information Systems Conference*
Washington, D.C.

11–13 2nd TRB Conference on Transportation Needs of National Parks and Public Lands: Partnerships for Enhancing Stewardship and Mobility
Washington, D.C.

26–27 11th University Transportation Centers Spotlight Conference: Rebuilding and Retrofitting the Transportation Infrastructure
Washington, D.C.

26–28 1st International Intelligent Construction Group Conference*
Minneapolis, Minnesota

### *October*

6 10th SHRP 2 Safety Data Symposium: From Analysis to Results
Washington, D.C.

15–19 American Concrete Institute Fall Convention
Anaheim, California

29–Nov. 2 Intelligent Transportation Systems World Congress
Montréal, Québec, Canada

### *November*

6–9 6th International Human Factors Rail Conference*
London, United Kingdom

12–15 2nd Pan American Conference on Unsaturated Soils*
Dallas, Texas

14–17 18th International Road Federation World Road Meeting 2017*
New Delhi, India

14–16 Applying Census Data for Transportation
Kansas City, Missouri

14–16 29th Road Profile Users Group Conference*
Denver, Colorado

14–15 5th Florida Automated Vehicle Summit*
Tampa, Florida

### *December*

7–8 National Accelerated Bridge Construction Conference*
Miami, Florida

17–20 4th Conference of the Transportation Research Group of India*
Mumbai, India

### *January 2018*


7–11 TRB 97th Annual Meeting
Washington, D.C.

### *April*

15–18 International Conference on Demand Responsive Transportation
New York, New York

16–19 Transport Research Arena 2018*
Vienna, Austria

Additional information on TRB meetings, including calls for abstracts, meeting registration, and hotel reservations, is available at www.TRB.org/calendar, or e-mail TRBMeetings@nas.edu.

*TRB is cosponsor of the meeting.

INFORMATION FOR CONTRIBUTORS TO

# TR NEWS

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**RESEARCH PAYS OFF** highlights research projects, studies, demonstrations, and improved methods or processes that provide innovative, cost-effective solutions to important transportation-related problems in all modes, whether they pertain to improved transport of people and goods or provision of better facilities and equipment that permits such transport. Articles should describe cases in which the application of project findings has resulted in benefits to transportation agencies or to the public, or in which substantial benefits are expected. Articles (approximately 750 to 1,000 words) should delineate the problem, research, and benefits, and be accompanied by one or two illustrations that may improve a reader's understanding of the article.

**NEWS BRIEFS** are short (100- to 750-word) items of interest and usually are not attributed to an author. They may be either text or photographs or a combination of both. Line drawings, charts, or tables may be used where appropriate. Articles may be related to construction, administration, planning, design, operations, maintenance, research, legal matters, or applications of special interest. Articles involving brand names or names of manufacturers may be determined to be inappropriate; however, no endorsement by TRB is implied when such information appears. Foreign news articles should describe projects or methods that have universal instead of local application.

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**BOOKSHELF** announces publications in the transportation field. Abstracts (100 to 200 words) should include title, author, publisher, address at which publication may be obtained, number of pages, price, and ISBN. Publishers are invited to submit copies of new publications for announcement.

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◆ All manuscripts should be supplied in 12-point type, double-spaced, in Microsoft Word, on a CD or as an e-mail attachment.

◆ Submit original artwork if possible. Glossy, high-quality black-and-white photographs, color photographs, and slides are acceptable. Digital continuous-tone images must be submitted as TIFF or JPEG files and must be at least 3 in. by 5 in. with a resolution of 300 dpi. A caption should be supplied for each graphic element.

◆ Use the units of measurement from the research described and provide conversions in parentheses, as appropriate. The International System of Units (SI), the updated version of the metric system, is preferred. In the text, the SI units should be followed, when appropriate, by the U.S. customary equivalent units in parentheses. In figures and tables, the base unit conversions should be provided in a footnote.

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