Vanguard Technologies on the Move

Delivering Innovations into the Mainstream of Practice

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Many proven innovations can save time, boost safety and quality, and decrease congestion during highway construction projects. Through its Vanguard Technologies initiative, the Federal Highway Administration (FHWA) is encouraging transportation agencies to consider these innovations when planning and building projects.

Vanguard technologies are a key component of Highways for LIFE—which stands for Long-lasting, Innovative, and Fast construction of Efficient and safe highway infrastructure—FHWA's program to accelerate the adoption of innovations in the highway community. Created by the U.S. Congress under the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users, Highways for LIFE aims to improve the American driving experience.

The program is promoting five high-payoff innovations through the Vanguard Technologies effort: road safety audits, prefabricated bridge elements and systems, precast concrete pavement systems, techniques for making work zones work better, and the safety edge to prevent roadway departure crashes. Moving these innovations rapidly to full implementation requires a focused approach.

Highways for LIFE offers incentives to highway agencies to adopt innovations and customer-focused performance goals in building better highways and bridges. The program also helps private industry move promising prototypes from late-stage development into the marketplace. The approach employs communication tools, training, technical assistance, and highway community stakeholder involvement.

PHOTO: UTAH DOT

Prefabricated bridge sections at Utah's "bridge farm" on I-80 await use on a project.

PHOTO: FHWA

An aging bridge in Old Town, Maine, was replaced with three precast spans, saving months from the schedule required for cast-in-place concrete construction.

Rapid Deployment

In the past, an innovation could take years to gain national acceptance, even with tens of millions of dollars dedicated to its deployment. For example, FHWA's effort to implement Superpave® technology—which tailors the mix recipes for hot-mix asphalt to an area's climate and pavement-loading characteristics—took 12 years for all 50 states.

Barriers to innovation in the highway community include procurement practices—such as the low-bid process, restrictions on proprietary products, and a reliance on standards and specifications instead of performance goals. Moreover, agencies that face public scrutiny and accountability have a low tolerance for risk-taking. Although innovations can improve performance and save money over the long term, the initial implementation costs may be higher because of the learning curve and the risks involved.

The Vanguard Technologies initiative eliminates these barriers through dedicated teams, proven marketing approaches, and designated funding for quick and broad deployment. A team of technical and marketing experts identifies the critical needs and obstacles for each innovation, develops a marketing plan, and creates implementation tactics and communication tools. The teams make presentations to potential users at technical meetings, workshops, peer exchanges, and demonstration projects. The teams partner with organizations throughout the highway community to champion the technologies.

A marketing plan details specific, measurable strategies and tactics to help the deployment team achieve its goals. Marketing is a standard practice in private industry but has not been adopted universally in the public sector—few highway agencies have marketing expertise on staff. To help agencies become more marketing-savvy, Highways for LIFE developed a *Guide to Creating an Effective Marketing Plan*, a step-by-step manual for agencies and organizations deploying innovation and other highway-related initiatives.[1] The publication includes sample marketing plans and guidance for forming innovation deployment teams.

In addition, FHWA teamed with the National Highway Institute to create a course, Leap Not Creep: Accelerating Innovation Implementation.[2] The course provides transportation professionals with the tools to put innovations to work quickly and to make implementation part of the agency's standard procedures. The course addresses successful implementation, the implementation plan, and strategies for overcoming barriers to adoption.

Road Safety Audits

An example of the success of the Vanguard Technologies approach is the road safety audit, a tool to improve the safety of roadway design, construction, and operation and to reduce highway deaths and injuries. In a road safety audit, an independent, multidisciplinary team examines the safety performance of an existing or planned roadway or intersection to identify safety issues. The audit can help produce designs that may reduce the number and severity of

[1] For a free Technology Transfer Toolkit DVD that contains the *Guide to Creating an Effective Marketing Plan* and other information, contact the Highways for LIFE office at 202-366-0131.

[2] FHWA-NHI-134073, www.nhi.fhwa.dot.gov.

PHOTO: FHWA

A road safety audit team of experts from various disciplines studies safety issues at a busy suburban intersection in Northern Virginia.

crashes, promote awareness of safety design practices, and cut costs by eliminating potential safety problems.

Road safety audits have proved more effective than the usual safety review processes of highway agencies, by engaging people from diverse disciplines—and with no involvement in the project's design or implementation—to look at the safety issues only. In this way, the safety review can be more objective and comprehensive.

The road safety audit first assembles a team to study the project or area. The audit teams typically have three to five members, representing a variety of disciplines, including the fields of highway safety, traffic engineering, planning, operations, geometric design, construction, maintenance, human factors, and enforcement.

The audit team reviews project information and performs field studies, often following checklists to make sure all safety issues are addressed. The team looks at everything from traffic signal operation and the installation of roadway barriers to the location of bus stops so that pedestrians can cross the street safely. The team analyzes the findings and prepares a report suggesting safety improvements. The final step is to incorporate the findings as appropriate into the project or roadway and to track the results.

The marketing plan developed by the FHWA road safety audit deployment team aims to have all state Strategic Highway Safety Plans document road safety audits this year. The plan promotes a workshop on how to conduct audits[3] and has targeted 34 states to undergo audit training. The team also developed a peer exchange program to provide technical assistance on conducting audits.[4]

Workshops have been held in 38 states. Three states have full-time road safety audit coordinators. Several states—including Arizona, Delaware, Iowa, Nevada, New Jersey, South Carolina, Tennessee, and Virginia—have made the audits a standard procedure. FHWA policy guidance now endorses road safety audits as a proven safety countermeasure.

Follow-up research shows that after safety audits are conducted and team recommendations are implemented, crashes and injuries decrease. The South Carolina Department of Transportation (DOT), for example, conducts road safety audits on projects during the development stage and on roads in use. A safety audit of South Carolina Highway 14 yielded nine suggestions to improve safety; all were implemented. As a result, fatalities on the road in 2004 dropped 60 percent from the 2003 total, avoiding more than $3.6 million in potential economic losses.

Prefabricated Bridge Elements and Systems

Many states are trying prefabricated bridge elements and systems, a Vanguard Technology that is a main ingredient in accelerated bridge construction (ABC). Prefabricated bridge elements are manufactured away from or next to the work zone and moved to the construction site for installation. Among the benefits are decreased disruption of traffic, improved work zone safety, greater durability, and lower construction costs.

The deployment team has set a goal for all states to make prefabricated bridge elements and systems a standard practice this year. Product demonstration showcases combine workshops and construction site

[3] FHWA-NHI-380069, www.nhi.fhwa.dot.gov.
[4] E-mail safetyP2P@dot.gov or call 866-P2P-FHWA.

PHOTO: OREGON DOT

In an Oregon project, an old bridge superstructure was moved sideways onto temporary piers after being lifted by hydraulic jacks.

PHOTO: OREGON DOT

The old steel truss bridge (*right*) rests on temporary piers. The new bridge (*left*) was built next to the structure on temporary supports.

visits to show highway professionals how the technology works. Enabling potential users to witness new construction techniques firsthand is an effective way to advance the implementation of innovations—the opportunity provides a better understanding of the uses and benefits and builds confidence in the innovation.

More than a dozen states have used prefabricated bridge elements and systems on projects, and others are considering the technology. Seven states—Florida, Iowa, Louisiana, New York, Oregon, Texas, and Utah—have adopted ABC as a standard practice. Highways for LIFE has provided incentives to several state highway agencies to use ABC and prefabricated bridge elements and systems on projects. One project replaced a bridge over Interstate 215 in Salt Lake City, Utah, in a weekend (see sidebar, page 17).

In another Highways for LIFE project, Maine DOT used prefabrication and full road closures to accelerate construction and reduce the effects on drivers in replacing two bridges on Highway 116 in Old Town and Route 4 in Addison. The precast, prestressed concrete substructure and superstructure elements, built off-site in a controlled environment, also enhanced the durability of the bridges. With the shortened schedule, the work was completed during the summer, avoiding long detours for school buses.

Innovative construction techniques also reduced reconstruction time for two single-span rural bridges on Maryland 28 in Frederick County and on Maryland 450 in Anne Arundel County. With prefabricated concrete superstructures and full road closures, the Maryland State Highway Administration shortened the project completion from more than 1 year to 60 days, so that the bridges reopened to traffic before the start of the school year.

Oregon DOT replaced five bridges on Oregon 38 between Drain and Elkton, using prefabricated bridge elements made with high-performance concrete. The agency built the new bridges on temporary supports next to the existing structures and slid them into place overnight on a rail system. The technique eliminated the need for a 50-mile detour, minimizing disruptions to the traveling public and freight carriers.

On a Virginia DOT project, a prefabricated superstructure was used to replace a bridge on US-15/29 in a congested area of Prince William County near Washington, D.C. The prefabricated elements were constructed off-site and assembled on-site over three weekends. As a result, workers were able to finish the project in six days of full closure; conventional construction would have required 100 days. All traffic lanes remained open during peak traffic periods, without construction of a temporary lane.

PHOTO: FHWA

Ribboncutting for Virginia DOT's US-15/29 project; prefabrication and accelerated construction techniques enabled workers to complete the bridge project over three weekends instead of the 100 days needed for traditional construction methods.

Precast Concrete Pavement Systems

Precast concrete pavement systems, another Vanguard Technology, are revolutionizing highway renewal and repair. Cast off-site and installed when traffic volume is low, precast concrete pavement panels reduce traffic congestion and increase durability.

In high-traffic areas, the construction process for precast systems is safer and more efficient than that for traditional cast-in-place construction, because the roadwork can be completed during off-peak periods in as little as 5 hours, reducing the need for road closures. The panels offer improved durability and can be fabricated under environmentally controlled conditions. In addition, because the panels can be made thinner than cast-in-place sections, they are ideal for installation under overpasses with limited height clearances.

PHOTO: FHWA

Precast concrete pavement systems speed work and cut congestion during renewal and repair projects in high-traffic areas.

A California DOT test project showed that a precast concrete pavement system could have a service life of approximately 30 years.

Photo: Dynatest Consulting Inc.

In the construction of precast concrete pavement systems, adjacent panels are assembled sequentially and tied together on site through either posttensioning or cast-in-load transfer systems. Nonproprietary and proprietary systems are available. The nonproprietary system is the result of FHWA research to strengthen concrete panels by prestressing, a decades-old technique used in cast-in-place concrete construction.

Parallel to FHWA's efforts, several private companies have worked independently to refine jointed precast concrete pavement technologies; products include the Fort Miller Super-Slab® system, the Uretek Stitch-in-Time® system, and the Kwik Slab® system. Each system has unique design features for installation and for transferring load across panels.

The deployment team's goal is for a dozen states to adopt the use of precast concrete pavement systems as a standard approach by 2013. Demonstration showcases are available, along with web conferences and videoconferences on the technology.[5] Technical information also is being disseminated through DVDs and the Highways for LIFE website.[6] To date, nine states—California, Delaware, Florida, Missouri, New Jersey, New York, Pennsylvania, Texas, and Virginia—have used or are planning to use precast concrete pavement systems.

Highways for LIFE grants are assisting several states to try out the technology. On a pavement rehabilitation project on Interstate 15 near Ontario, California, a portion of the concrete pavement will be replaced with a concrete panel system precast off-site and installed during off-peak traffic periods. This technique will enable California DOT to speed construction, enhance traveler and construction worker safety, reduce the impact on motorists during construction, and produce a longer-lasting, lower-cost roadway. The highway agency anticipates that the precast slabs will have a 30- to 40-year service life; in comparison, fast-setting concrete would have lasted approximately 10 years.

Virginia DOT accelerated construction and enhanced durability by replacing distressed pavement slabs with precast concrete pavement panels on an access ramp for Interstate 66 in Fairfax County. Conventional repair with cast-in-place concrete would have required at least 100 days, with traffic congestion from lane closures, but the precast slab approach required the closing of only one lane at a time during 35 nights of work, so that all lanes were available for rush-hour traffic on the heavily traveled route near Washington, D.C.

Making Work Zones Work Better

To make work zones work better, Vanguard Technologies are helping highway agencies gain a better understanding of the potential impacts of work zones, improve work zone management programs, and apply a suite of product and system innovations to decrease the negative effects of work zones on construction workers and motorists.

The work zone effort also is helping agencies comply with the regulations and the goals of FHWA's Work Zone Safety and Mobility Rule. The rule applies to all

(continued on page 18)

[5] Download the precast concrete pavement systems web conference at www.nhi.fhwa.dot.gov/about/innovationseries.aspx.
[6] www.fhwa.dot.gov/hfl.

Installing a Bridge Superstructure on a Weekend

In June 2006, Utah DOT staff observed a Florida project in which a prebuilt bridge was moved into place overnight with innovative equipment, saving motorists months of traffic disruption. The staff members were impressed and recommended that Utah DOT try the technique.

With the help of a demonstration project grant from FHWA's Highways for LIFE program, the agency adopted the accelerated bridge construction (ABC) techniques—including prefabricated bridge elements and systems—to build a new superstructure alongside the 4500 South Bridge over Interstate 215 in Salt Lake City while traffic continued to flow.

Under a carefully coordinated plan, Utah DOT removed the old superstructure and shifted the new superstructure into place in one weekend in October 2007. The rapid move was accomplished with a self-propelled modular transporter (SPMT), a computer-controlled vehicle that transfers heavy loads with precision. Equipped with 256 articulating wheels and operated remotely by a single operator using a joystick control, the SPMT made two trips to remove the four-span superstructure on Saturday. The next day, the SPMT moved the new 172-foot-long single-span superstructure to its final destination. I-215 reopened to traffic at 1 a.m. on Monday.

After using ABC techniques on this and other projects, Utah DOT decided to make ABC standard practice for all bridge projects by 2010, the first U.S. highway agency to take this step. Utah's experience exemplifies the changes that Highways for LIFE is working to effect—to bring high-payoff, readily available innovations into the mainstream of practice at highway agencies across the country.

Faster Construction

"For many of our urban projects, the critical path goes through the structures," notes James McMinimee, Utah DOT Director of Project Development. "If we can shorten the time it takes to build the structures, we can dramatically cut the time it takes to complete an entire urban project."

Innovation on the I-215 bridge project significantly sped up construction and reduced the impact on motorists. With conventional techniques, the 2007 project would have taken six to nine months, and construction-related impacts on travelers would have lasted at least 120 days. The ABC techniques reduced the traffic impact to one weekend on I-215 and to 10 days on State Route 266, which includes the bridge.

Quantifying the value of using innovation is a key aspect of Highways for LIFE projects. The net savings on the Utah bridge project were approximately $3.2 million. Traditional construction methods would have cost approximately $800,000 less than the accelerated construction techniques, but the ABC techniques reduced the impact of construction congestion, saving approximately $4 million in user costs. Moreover, the agency has noted that the initial costs for ABC are declining as contractors become more efficient and comfortable with the innovative techniques.

The project also garnered approval from Utah DOT customers. A postconstruction survey found that 92 percent of area residents and businesses were satisfied or very satisfied with the project performance by Utah DOT and its contractor, and 94 percent were satisfied or very satisfied with the project results.

Paying It Forward

On the weekend of the bridge move, Utah DOT and FHWA held a project showcase that drew 150 transportation professionals from around the country. They joined local residents and national media at the construction site to watch the SPMT remove the old bridge superstructure and shift the new one into place.

The transportation professionals also attended presentations on the design, construction, and innovative aspects of the project. Representatives from 14 highway agencies brought back to their states knowledge of the ABC and SPMT techniques, along with observations of the project.

"The workshop made it possible for many of the surrounding states and many Utah DOT employees to see the project firsthand," said Rukhsana Lindsey, Utah DOT Director of Bridge Operations and Research. "The interest and confidence created by this successful project and workshop helped Utah DOT construct 12 more ABC projects in 2008."

Since then, Utah DOT has pursued efforts to make ABC mainstream by conducting workshops with contractors and designers on ABC practices, working on standard drawings and specifications for ABC elements, and planning additional projects with ABC techniques.

To learn more about Utah DOT's ABC standards, visit www.dot.state.ut.us/main/f?p=100:pg:0::::T,V:1991.

Crews used an SPMT to move the 4500 South Bridge superstructure from the construction site to its final location over Interstate 215.

state and local governments that receive federal-aid highway funding and is intended to reduce crashes and congestion in and around work zones.

More than 100 innovative techniques and products are available to address safety and mobility challenges in work zones, ranging from sophisticated electronic equipment that notifies drivers of real-time road conditions to innovations in construction processes that speed up project completion. Approaches include full road closure during rehabilitation or maintenance to reduce construction time and eliminate the exposure of motorists to work zones and of workers to traffic.

More than a compilation of techniques, the effort presents a philosophy focused on decreasing the impact of work zones on motorists, nearby residents, local businesses, and workers by reducing the number of work zones, managing the time that travelers and workers are exposed to work zones, and enhancing the safety and mobility of travelers and workers in the work zones.

The deployment team's goal is to increase the number of states that use innovative strategies for work zone management, including analysis tools for assessing a work zone's impacts. Through a peer exchange program, agencies can obtain expert assistance on innovative work zone strategies and technologies, as well as advice on implementing the Work Zone Safety and Mobility Rule.[7] In addition, focused technical assistance workshops and project assessment assistance have enabled many states to use new technologies to enhance traffic flow and improve work zone safety for motorists and workers.

Manuals, guidance documents, and other resources—for example, for work zone traffic analysis—are in development. *Work Zone Modeling and Simulation: A Guide for Decision Makers* reviews the application and use of a range of analytical tools for work zone planning and management.[8]

In 2008, under a Highways for LIFE project to rehabilitate part of M-115 in Clare County, Michigan DOT tested temporary traffic-actuated signals and soon after adopted the work zone innovation as a standard practice. The rural route project replaced the superstructures of two small bridges, which required narrowing the road to one lane. To minimize motorist delay, the contractor used portable signal systems that detect the number of waiting vehicles and adjust the lights for efficient traffic control. The signal systems helped the contractor keep the vehicle queue lengths under half a mile and the travel time delays at less than 10 minutes throughout the project. Michigan DOT identified 11 projects to use the innovative signal system in 2009.

An Edge on Safety

The safety edge is the latest Vanguard Technology, designed to protect motorists from roadway departure crashes, 53 percent of which are fatal. Adoption of the safety edge, an asphalt paving technique, is gaining momentum across the country. FHWA recommends that states apply the safety edge on rural two-lane roads with unpaved or narrow shoulders, where roadway departure crashes are most prevalent.

When a tire goes off a paved surface, the driver can have difficulty reentering the roadway if the pavement edge is nearly vertical—especially if the height difference is 2 in. or more. When the driver tries to steer back on to the road, the nearly vertical edge can cause what is known as tire scrubbing, a condition that may cause oversteering. The driver can lose control of the vehicle and crash into oncoming traffic, roll over, or hit a fixed object.

Created with a simple paver attachment, the safety edge assures that the interface between the roadway pavement and the graded shoulder will be at an optimal angle to minimize the vertical drop-off and provide a safer roadway edge. The recommended angle of the taper is 30 to 35 degrees from horizontal.

The safety edge does not require an extra procedure, only a slight change in the paving equipment, and has little impact on project costs. In addition, the safety edge improves the consolidation of the pavement near the edge, enhancing pavement durability and potentially prolonging pavement life.

Approximately 15 state highway agencies have applied the safety edge, including Alabama, Georgia, Indiana, Iowa, Missouri, North Carolina, and Utah. FHWA's safety edge team is developing a marketing

[7] E-mail workzoneP2P@dot.gov or call 866-P2P-FHWA.
[8] http://ops.fhwa.dot.gov/wz/traffic_analysis/tatv8_wz/index.htm; Publication FHWA-HOP-08-029.

PHOTO: FHWA

After several years of materials settling, erosion, and tire wear, an aggregate shoulder originally flush with the pavement has left the vertical edge exposed. A car or motorcycle tire that has driven over this edge could have difficulty returning to the pavement safely.

PHOTO: FHWA

An extruded wedge will increase the pavement life. When the project is complete, the safety edge will be covered with an aggregate shoulder. After several years, when the edge becomes exposed, a vehicle tire going over it will have no trouble safely returning to the pavement.

plan to encourage more states to try the technique and to adopt it as standard practice for resurfacing and paving projects.

Lessons Learned

The Vanguard Technologies effort has generated several lessons for innovation deployment:

◆ **Although hundreds of millions of dollars are spent on highway research, only a fraction is dedicated to deploying innovations and making them standard practice.** Sometimes efforts to expand innovation stop at the research level under the assumption that the innovations will be adopted automatically. Adequate resources—qualified people and funding in addition to the funding for research—also should be dedicated to technology deployment. Successful deployment does not end with the introduction of the technology but requires focused follow-through until mainstream implementation is achieved.

◆ **Training is needed in marketing to accelerate technology deployment.** The use of proven marketing approaches is a key to accelerating technology deployment, but few transportation agencies have marketing professionals on their staffs. Just as effective marketing can persuade potential customers to try new consumer products, it can encourage highway professionals to try better ways to build roads and bridges. Marketing plans with specific goals and timelines can speed the implementation of innovation.

◆ **Peer group support and testimonials are valuable tools in advancing innovation implementation.** Highway professionals trust what their peers tell them. They can learn much from colleagues' experiences in using new technologies and can benefit from technical advice on how to implement innovation in their own agencies.

◆ **With its institutional knowledge and extensive network of contacts in the highway community, FHWA can play a national leadership role in technology advancement and deployment.** In many cases, highway community stakeholders become involved in initiatives such as Vanguard Technologies because FHWA is leading the effort and brokering the participation of other transportation agencies and industry.

◆ **Involving highway community stakeholders early in the innovation implementation process is important at both the national and local levels.** Stakeholder input and support are essential in making implementation a success. Early involvement helps overcome resistance to new techniques and practices, enabling stakeholders to offer insights and to gear up for using the innovations effectively.

Through the focused deployment approach of Vanguard Technologies, Highways for LIFE has developed a way to encourage faster, more widespread adoption of proven highway innovations that are available but infrequently used. The lessons learned will benefit highway community efforts to tap the full potential of innovations in improving the way that highways and bridges are built.

For more information on Vanguard Technologies, visit the Highways for LIFE website, www.fhwa.dot.gov/hfl.