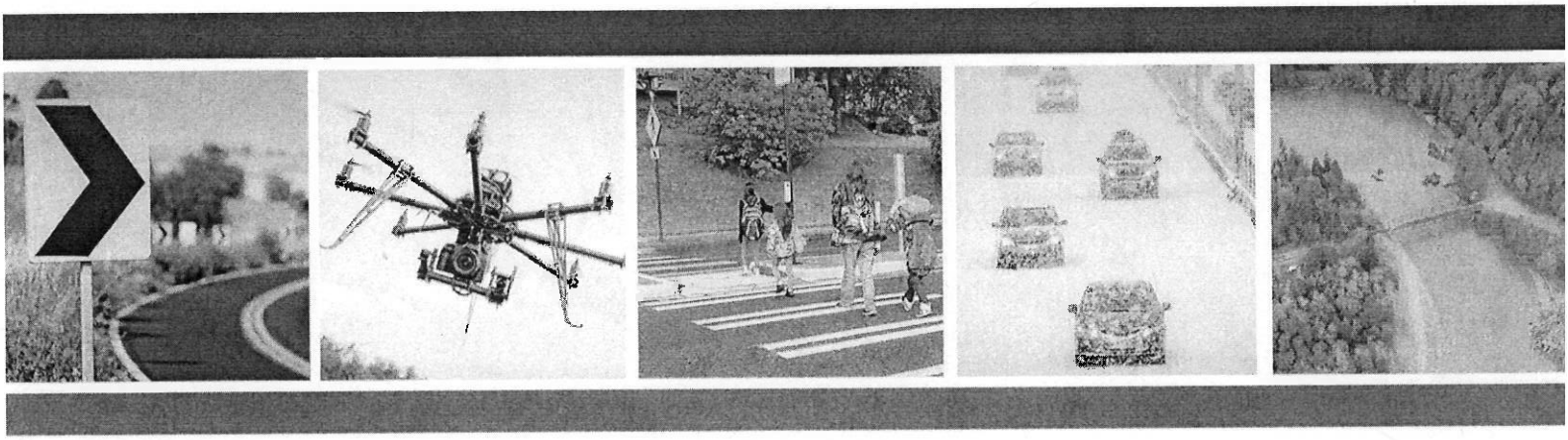
# Innovations of Interest

## Stakeholder Report

## *Spring 2018*

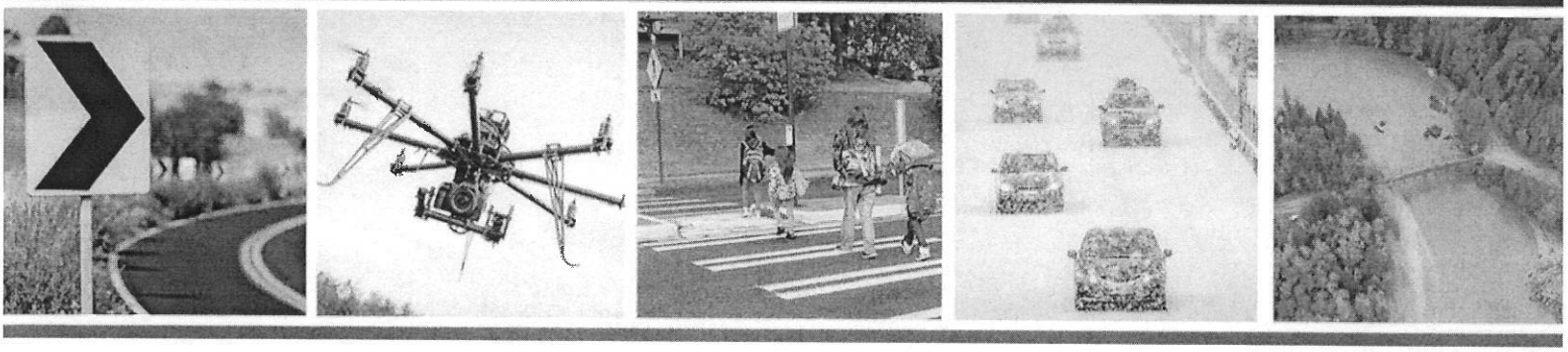
## *EDC-5 (2019-2020)*



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

**On-Ramp to Innovation**
every day counts

# On-Ramp to Innovation, Innovations of Interest (EDC-5)



## FOREWORD

The Federal Highway Administration (FHWA) published a Request for Information (RFI) in December 2017 for innovations to be considered for round five of the Every Day Counts program (EDC-5). The RFI is FHWA's opportunity to hear from our State, Local, Academia, and Industry partners regarding ideas for accelerated deployment of proven, market-ready processes and technologies with the potential to provide efficiencies at all levels of the transportation system.

Respondents to the RFI were asked to consider the following:

- **National Impact**: Potential to benefit the transportation system.
- **Readiness**: Whether the innovation is ready to be deployed nationally.
- **Game Changing**: How the innovation is transformative in saving time and money or improving quality.
- **Urgency and Scale**: Potential to shorten project delivery and positively impact the environment, safety, congestion, freight movement, construction techniques, contracting methods, project costs, maintenance, preservation, or emergency response.

FHWA received more than 160 suggestions and comments beyond the innovations FHWA identified in the RFI. Ideas similar in content were combined for reporting in this document. Suggestions that needed additional research or development, preventing their deployment under the rapid process used by EDC, and suggestions that were proprietary or required congressional action were removed from consideration.

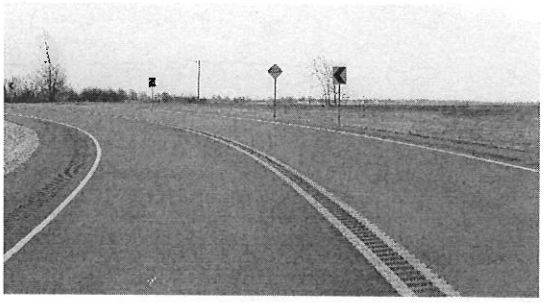
This report provides a summary of the *Top Tier Innovations* under consideration for EDC-5. All promising ideas remaining after the EDC-5 innovations are established, including suggestions that may work in small deployment markets, will be considered by other programs within FHWA.

EDC

## MAKING RURAL ROADS SAFER: REDUCING ROADWAY DEPARTURES

### Description

This initiative will provide tools and other resources to assist both State departments of transportation (DOTs) and local agencies in systemically reducing the number and severity of roadway departures on the rural road network, which account for 32 percent of all traffic fatalities in the United States. Technical assistance will be provided to stakeholders to address head-on, rollover, and fixed-object crashes—the most harmful events for approximately 80 percent of all fatal rural roadway departures. The overall objective will be to systemically apply a suite of proven safety countermeasures to keep vehicles in their travel lanes, reduce the potential for crashes, and reduce the severity of those crashes that do occur.



Various analysis, diagnostic, and countermeasure selection tools will be promoted to State DOTs and Local Technical Assistance Program (LTAP) Centers to set high-priority parameters for implementing the full range of roadway departure countermeasures at a regional and local level.

- Signing and markings delineate lane edges, alignment changes, and help drivers navigate.
- Rumble strips alert drowsy and distracted drivers drifting from their lane.
- Friction treatments at curves or other important locations reduce loss of control.
- Shoulders, SafetyEdge[SM], and Clear zones provide opportunities for a safe recovery when drivers leave the roadway.
- Roadside hardware can reduce the severity of roadway departure crashes.

### Transformative Aspects

Rural roads comprise approximately 70 percent of the public road mileage and are typically designed, built, and maintained by local public agencies. State and local agency application of proven safety countermeasures on rural roads is expected to have a large impact on safety and reduce traffic deaths.

### Readiness

The proposed countermeasures are regularly used on higher-type roads and are proven methods for reducing crashes and improving the safety of the transportation system. Crash modification factors have been developed and promoted for several of these countermeasures and are mainstream at the State level, which has prepared the way for implementation at the local level. The data, analysis tools and processes to identify and implement effective treatments at prioritized locations are available in many States and, to a lesser extent, corresponding local agencies.

Minnesota has developed viable safety implementation plans for each of its counties, made funding readily available, and promoted partnerships for efficient construction management. North Dakota has also developed plans for all their counties, while Iowa, Nebraska, and Kansas are working on a similar

effort. FHWA has been working with a dozen State DOTs and LTAP Centers to pilot the development of Local Safety Implementation Plans. In addition, over 200 Tribal Safety Plans have been developed. This initiative will expand the planning to a wider variety of agencies nationwide and focus on implementation of the plans.

**National Significance**

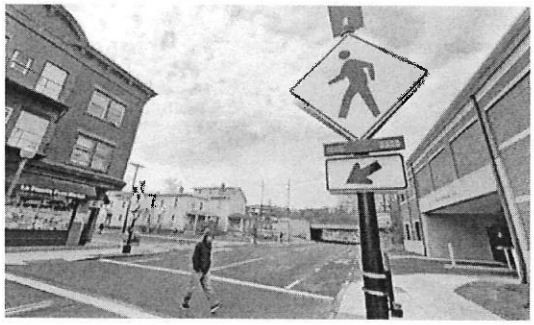
Reducing fatalities on rural roads remains a major challenge in the United States. In 2016, 18,590 lives were lost on rural roads—more than half of all traffic deaths—even though only 19 percent of the U.S. population lives in rural areas. Substantial safety improvements on these roads can be difficult to make because they account for approximately 70 percent of public road mileage and are often operated by local agencies with limited resources and technical expertise in safety analysis or planning.

This initiative has the potential to make great strides on the Road to Zero by using a systematic approach to address one-third of all traffic fatalities in the United States—those resulting from roadway departures on rural roads. It will further engage Federal, State, tribal, and local agencies in the ongoing effort to drive down crashes on rural roads by providing the knowledge and resources necessary for quick deployment of countermeasures that will significantly improve rural road safety.

## SAFE TRANSPORTATION FOR EVERY PEDESTRIAN (STEP) 2.0

### Description

According to the National Highway Traffic Safety Administration (NHTSA), 2016 witnessed the most pedestrian fatalities since 1990. Pedestrians accounted for approximately 16 percent of all roadway fatalities (5,987), and many of these occurred while crossing the roadway at both midblock and intersection crossing locations. Seventy two percent occurred away from intersections and 18 percent at intersections. Building upon the efforts started in EDC-4, this initiative will advance cost-effective countermeasures with known safety benefits at uncontrolled and signalized pedestrian crossing locations including the rectangular rapid flashing beacon (RRFB), leading pedestrian interval (LPI), crosswalk visibility enhancements, raised crosswalks, pedestrian crossing/refuge islands, pedestrian hybrid beacons (PHB), and road diets.



These countermeasures all improve pedestrian safety when used in the appropriate roadway context:

- At signalized intersections, LPIs allow pedestrians to walk, usually 3 to 4 seconds, before vehicles get a green signal to turn. The LPI increases visibility, reduces conflicts, and improves yielding.
- The Rectangular Rapid Flashing Beacons (RRFB) are user-actuated amber LEDs that use an irregular flash pattern at mid-block or uncontrolled crossing locations. They significantly increase driver yielding behavior.
- Crosswalk visibility enhancements, such as crosswalk lighting and enhanced signing and marking, help drivers detect pedestrians—particularly at night.
- Raised crosswalks can reduce vehicle speeds.
- Pedestrian crossing/refuge islands allow pedestrians a safe place to stop at the midpoint of the roadway before crossing the remaining distance. This is particularly helpful for older pedestrians or other pedestrians with limited mobility.
- PHBs provide positive stop control in areas with high pedestrian traffic volumes. The PHB is an intermediate option between a flashing beacon and a full pedestrian signal.
- Road Diets can reduce vehicle speeds and the number of lanes pedestrians cross, and create space to add new pedestrian facilities.

## Transformative Aspects

Uncontrolled crossing locations generally have inadequate pedestrian crossing facilities, creating barriers to safe, convenient, and complete pedestrian networks. At signalized intersections equipped with pedestrian signals, conflicts with turning vehicles may occur when pedestrians see a walk signal and vehicles see a left turn signal. By focusing on all pedestrian crossing locations, agencies can comprehensively address a significant national safety problem and improve quality of life for pedestrians of all ages and abilities.

## Readiness

All the countermeasures except LPI and the RRFB are currently being promoted through EDC-4. Communities across the Nation are benefitting by using LPI. In New York City, the effects of this treatment were dramatic. Where LPIs were installed, the overall number of pedestrians and bicyclists killed or severely injured dropped 37 percent. LPI use in Florida also yielded positive results, including reducing the percentage of vehicle-pedestrian conflicts between 25 and 100 percent at different intersections. The RRFB has greatly increased driver yielding rates in several communities, including St. Petersburg, Florida. They can be extremely effective at trail crossings or near schools. The continuation of STEP 2.0 will help more communities deploy these proven pedestrian safety countermeasures based on their specific roadway contexts and needs.

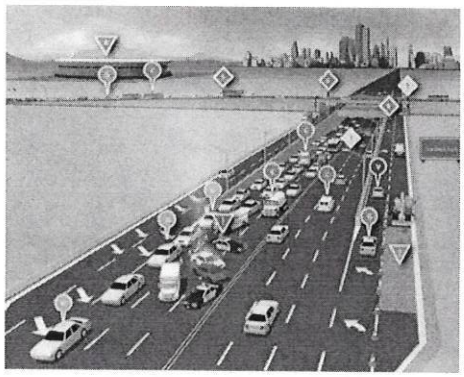
## National Significance

This effort supports numerous Federal, State, and non-profit agency initiatives to improve pedestrian safety, including the U.S. DOT's Strategic Plan (2018-2022), which includes a goal to reduce transportation-related fatalities and serious injuries across the transportation system. STEP complements the Road to Zero Coalition, a joint initiative among three U.S. DOT Operating Administrations (NHTSA, FHWA, and the Federal Motor Carrier Safety Administration) and the National Safety Council. The Road to Zero is designed to encourage stakeholders to implement proven, lifesaving strategies to reduce crashes and eliminate traffic fatalities by 2050. This innovation also supports the latest Governors Highway Safety Association *Spotlight on Highway Safety* report on Pedestrian Traffic Fatalities by State.

## USE OF CROWDSOURCING TO ADVANCE OPERATIONS

### Description

Building on previous EDC efforts pertaining to traffic incident management (TIM), as well as deployments of active traffic management (ATM) strategies across the country, this initiative focuses on the value that the crowdsourced traffic data adds to the advancement of transportation system management and operations.



Using crowdsourced data from smartphone- and cellular-based data sources and enhanced law enforcement communications through Computer Aided Dispatch Systems (CAD) public agencies are increasing their situational awareness of real-time traffic conditions (e.g., crashes, weather, work zones). The crowdsourced data provides a new, real-time data source, outside of the boundaries of fixed sensors and cameras, to actively manage traffic. This enables agency staff to make decisions with a very low latency and larger geographic coverage, leading to improved responses to traffic incidents and other congestion-causing events along with optimization of traffic flow through the system.

The real-time data set on traffic movement and traffic flow throughout the transportation network integrates with active traffic management (ATM) systems to inform travelers of current conditions, such as travel times on dynamic message signs (DMSs). Through 511 systems and queue warnings real-time data enables management of that traffic through integration with traffic signal timing controls, dynamic speed limits, and ramp metering.

### Transformative Aspects

Current data sources in TIM and ATM often comes from fixed sensors that monitor traffic conditions at fixed locations. The use of crowdsourced data turns smartphones and other mobile data sources into traffic sensors that significantly increase the data volume and geographic dispersion. Agencies using crowdsourced data get a higher volume of real-time data from larger geographic areas, which can provide earlier incident notification for quicker response and the integration with ATM to optimize travel.

Use of crowdsourced data could reduce the need for roadside sensors and systems that provide data in only a single location and require installation and maintenance. Further, crowdsourced data is being collected continuously throughout the system and will not suffer from local sensor or system outages associated with our current systems. Crowdsourcing turns the transportation system users into the sensors on system performance, providing real-time, high-quality data on traffic operations, conditions, and driver behavior.

## Readiness

A number of State and local agencies are using crowdsourced data in traffic operations. As of 2016, 73 State or local agencies are using crowdsourced data from Waze to understand their system performance and improve operations. Iowa, Ohio, Pennsylvania, and other DOTs are working with INRIX® to provide real- time traffic and road conditions to measure and manage the transportation network.

The use of crowdsourced data in traffic management and operations is showing improvements in incident response and for traffic management. Some examples include:

- Florida DOT is using crowdsourced data in combination with CAD to improve the response for crashes and road closures.
- Iowa DOT receives crowdsourced data from multiple sources in their traffic management centers for detecting incidents on urban and rural roads in real time.
- Michigan DOT receives minute-by-minute crowdsourced data that goes directly into its traffic management centers for posting travel time messages on dynamic message signs.
- Pennsylvania DOT and DCDOT are using minute-by-minute crowdsource data to assess the performance of arterials and signals and produce web performance measures dashboards (performance at a glance) so that signals are retimed actively.

## National Significance

The USDOT Strategic Plan (2018-2022) establishes goals for safety (systemic safety approach), system operations and performance (improving reliability and efficiency), and deployment of innovation (advancing new technologies into systems to improve safety and performance). This initiative advances all of these key strategic goals. Having better real-time situational awareness and monitoring capability of the transportation system is the foundation for ATM systems. Crowdsourced data improves the availability and accuracy of traffic data that feeds ATM systems which in turn will enable better management and operations of the transportation system.

## WEATHER-RESPONSIVE TRAFFIC AND MAINTENANCE MANAGEMENT STRATEGIES

### Description

This initiative builds on the EDC-4 road weather management–weather-savvy roads innovation to support transportation agencies deploying improved traffic management and traveler information systems, and includes anti-icing strategies that reduce chloride use. This initiative will significantly reduce highway delays and crashes resulting from adverse weather conditions.

The FHWA Road Weather Management Program has been actively engaged in developing and deploying weather-responsive traffic management (WRTM) strategies to help agencies respond to adverse weather conditions by providing traffic advisories and warnings to travelers and controlling the flow of traffic on the highways during inclement weather. A recent focus of the program is using mobile observations and connected vehicle data to support WRTM. Many agencies have improved their winter maintenance strategies using these new tools and processes; however, there is still a need to implement anti-icing processes that reduce chloride use. With more than 25 States implementing Pathfinder and Integrating Mobile Observations (IMO), it is now much easier for them to adopt WRTM and anti-icing strategies that use mobile and connected vehicle road weather data.

### Transformative Aspects

Over the last 10 years, vehicle crashes have averaged 5,760,800 per year. Twenty-two percent of those crashes—nearly 1,259,000—were weather-related. On average, nearly 6,000 people are killed and over 445,000 are injured in weather-related crashes each year. Likewise, the delays associated with weather can be profound, resulting in significant losses in efficiency.

WRTM and anti-icing strategies are transformative and build on the success of IMO and Pathfinder. Adopting WRTM and anti-icing strategies that use road weather data from IMO and connected vehicle technologies, and making informed decisions stemming from Pathfinder, will enable State and local agencies to be proactive and manage the system before negative impacts occur. In addition, more accurate and location-specific road weather condition data will allow appropriate traffic management strategies to be deployed where they are needed, as well as the right quantities of chlorides and other chemicals to be applied where they are warranted.

Implementing these strategies will improve transportation system performance in terms of reduced delays and crashes during weather events, and transportation agency performance by helping them be more informed and effective in managing traffic operations and reducing costs associated with winter maintenance, including salt and chemical applications. Moreover, the negative environmental impacts of road salt use by many agencies can be reduced.

## Readiness

States that have readily adopted Pathfinder and IMO will facilitate the deployment of this new effort pertaining to WRTM and winter maintenance. States that are implementing or have already implemented WRTM strategies using mobile observations from vehicles include Wyoming, Washington, South Dakota, Michigan, and Delaware. States that have implemented winter maintenance/anti-icing strategies using IMO data include Minnesota, Michigan, and Nevada.

## National Significance

Section 6503 of the Fixing America's Surface Transportation (FAST) Act requires a strategic plan that includes improving mobility, reducing congestion, and promoting safety. This weather-responsive traffic and maintenance management innovation will improve road management during adverse events and help agencies respond by providing traffic advisories and warnings to travelers before and during these inclement weather events. Travelers will be informed before they make the trip and during their trip about road weather and traffic conditions. Agencies will have more accurate information about the need for appropriate traffic intervention strategies to mitigate the impacts of weather-related road and traffic conditions. The result will be improved mobility, reduced delays, and safer travel during adverse weather conditions.

## PROJECT BUNDLING

### Description

Project bundling is a process by which a single contract award is used to contract for the preservation, rehabilitation, or replacement of several projects. The contract may be procured in several different ways and may include both design and construction in the overall scope, depending on the procurement method. The contract could cover a single county, district, or State, and it may be tiered to allow a combination of work types (design, preservation, rehabilitation, or complete replacement). In some cases, the contract may include option years. Bundling design and construction contracts saves procurement time, leverages design expertise, achieves economies of scale, and builds momentum to maintain critical assets that are too often in a deficient condition.

### Transformative Aspects

Many States continue to see an increase in highways and bridges that need attention, often on their local systems. As a result, many of these highways and bridges are being posted for reduced loads, which adversely affects travel time, freight movements, and emergency response times. Project bundling offers the potential for cost and time savings directly beneficial to reducing the transportation project backlog. It allows the opportunity to address large numbers of projects facing similar needs using common or innovative rehabilitation and replacement strategies and tactics in a cost-effective manner.

### Readiness

Project bundling efforts by State DOTs in Missouri, Ohio, Pennsylvania, Georgia, Delaware and Oregon have reduced costs and streamlined design and construction. Bundling allowed them to take advantage of funding opportunities and quickly improve large numbers of bridges. For example, the Pennsylvania DOT (PennDOT) conducted a three-county pilot project that rebuilt, replaced, or removed 41 county-owned structures for $25 million, resulting in a 25–50 percent savings on design and 5–15 percent savings on construction. PennDOT followed up on this success by pursuing a statewide, 558-bridge bundling contract.

Project bundling represents the next maturation step toward expediting project delivery. Examples of project bundling programs include the following:

- Delaware DOT uses a series of bridge bundling contracts to address preservation issues on bridges in good and fair condition. The Bridge Management Section prioritizes the work and the Maintenance Districts administer the contracts. Project scopes include deck sealing, bridge painting, deck patching, and joint repair.

- Ohio DOT's Bridge Partnership Program is replacing or rehabilitating 220 county bridges over 3 years funded through $120 million in Grant Anticipation Revenue Vehicles (GARVEE bonds).

- Georgia Design-Build Bridge Replacement Program (begun 2016), which will replace 25 local bridges over 1,095 calendar days through new revenue available under the Transportation Funding Act of 2015.

- Missouri DOT's $685 million Safe & Sound Bridge Improvement Program replaced or rehabilitated 802 State bridges over 3.5 years, including 554 bridges replaced through a single design-build contract.

- Oregon DOT's $1.3 billion Oregon Transportation Investment Act (OTIA) III State Bridge Delivery Program replaced or repaired 271 bridges using 87 project bundles.

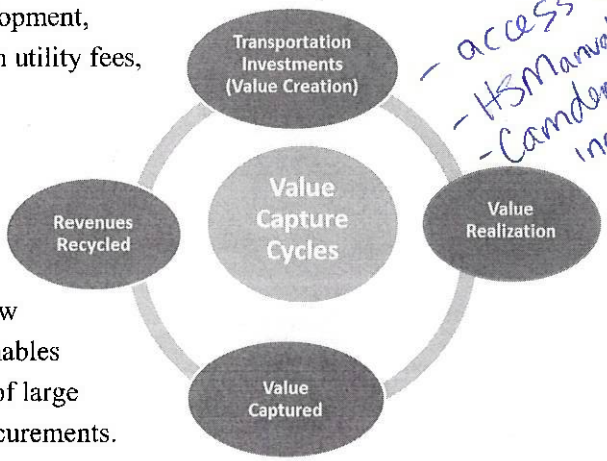
## National Significance

Project bundling can help address the national issue of backlogged transportation projects. Section 1111 of the Fixing America's Surface Transportation (FAST) Act adds a new subsection (j) to section 144 of title 23 of the U.S. Code, "encouraging States to bundle multiple bridge projects as one project to save cost and time." This initiative would expand bundling beyond bridges to include all project types and promote it to additional States and local public agencies, efficiently improving the condition of the Nation's highways and meeting congressional requirements.

## VALUE CAPTURE: CAPITALIZING ON THE VALUE CREATED BY TRANSPORTATION

### Description

Transportation infrastructure development enhances access, and access creates value for underutilized assets. Value creation is followed by value realization through subsequent private sector investment and induced economic activity. Value capture refers to the potential for public agencies to recover some of that increased value, usually through mechanisms that tap property valuation. This initiative will provide a toolbox of strategies for public agencies to recover a portion of the increased property value created because of public infrastructure investment. Value capture techniques include special assessment districts, development impact fees, traffic mitigation fees, joint development, negotiated exactions, tax increment financing, transportation utility fees, and developer contributions.




### Transformative Aspects

Using value capture strategies on transportation improvements provides a new revenue source that can be pooled with other funding to expedite implementation of new transportation projects. The availability of future funding enables project sponsors to accelerate construction and, in the case of large construction programs, bundle more work in individual procurements.

Value capture promotes equity by reinforcing the "beneficiary pays" principle of economics. When all taxpayers help create value, it is fair for them to receive part of the benefit of their investment as a return. Private landowners who reap a windfall from their investment would return a portion of that gain to fund the assets that were foundational to the investment they undertook. Properly implemented, value capture can help prevent sprawl by providing a disincentive for speculative land holding.

### Readiness

States such as California, Colorado, Florida, Georgia, Massachusetts, Missouri, Ohio, Oregon, Pennsylvania, Texas, and Virginia, as well as the District of Columbia, are using value capture options successfully. The following are examples of different value capture applications supporting highway improvements across the United States:

- Several small towns in Oregon have instituted transportation utility fees through monthly utility bills that fund programs paying for local road maintenance and safety projects.
- The Cap at Union Station project over I-670 in Columbus, Ohio, is an example of joint development and right-of-way use agreements to improve highway traffic and provide retail and commercial space in the void created with I-670 construction.

- California's Orange County Transportation Corridor Agencies (TCA) are using development impact fees to generate funds that have provided seed capital for transportation facilities and continue to be an integral feature of TCA's debt management strategy.

- In Texas, the Fort Worth City Council established transportation impact fees in July 2008 on new development projects to help fund transportation improvements. In April 2013, the council approved a transportation impact fee increase from $2,000 to $3,000 on new single-family homes.

- The City of Chicago used tax increment financing districts to fund a variety of projects, including street improvements, transit stations, and neighborhood redevelopment.

### National Significance

Funding for transportation continues to be a challenge at the Federal, State, and local levels. While Congress has increased the amount of Federal funds provided to the States in successive surface transportation legislation, the increase has not kept pace with inflation. Additionally, the buying power of Federal funds has dropped steadily from the last time the gas tax was raised in 1993. State and local officials must find funding sources to build, maintain, and operate their systems and to generate the match necessary to leverage the Federal funds they do receive. Value capture revenue sources are proven, market-ready, and underutilized options for States and local agencies to generate revenue and help leverage existing funding to advance transportation improvement projects and operate the system.

## UNMANNED AERIAL SYSTEMS (UAS)

### Description

The benefits of unmanned aerial systems (UAS) technology are wide ranging and impact nearly all aspects of highway transportation. UAS provide high-quality survey and data mapping that can be collected automatically or remotely. Large areas can be mapped relatively quickly in comparison to traditional survey and mapping practices. UAS are also used for survey and imagery as part of emergency response events where traditional surveying and mapping practices are inadequate or impossible. Nineteen States are already exploring using high-definition cameras, light detection and ranging (LiDAR), and other sensors to enhance construction inspection, bridge inspection, and incident response operations. This initiative would assist States new to UAS technology to better understand its capabilities and assist States already using it broaden the range of potential applications focused on inspection, construction, and operations.

### Transformative Aspects

Using UAS can provide several transformative aspects for highway transportation, including improvements in safety, productivity, and cost.

**Inspection—work zone, bridge condition.** Keeping workers out of harm's way is a major benefit of using UAS. Traditional bridge inspection requires setting up temporary work zones, detouring traffic, and using heavy equipment. Each of these causes risk to the crew and the traveling public. UAS technology can speed data collection while reducing the impact on work crews and the traveling public.

**Construction—surveying, aerial photography, routine and high-risk inspections.** UAS technology can accelerate the rate of data collection operations such as survey or aerial photography. It can be used for routine inspections, such as flying a programmed path over silt fencing after a rain event to check for sediment buildup. High-risk inspections, such as crane or falsework construction, can be done to reduce the risk to the inspector.

**Operations—landslides, rock slides, flooding, avalanche, traffic incident management.** The ability to routinely and consistently map terrain offers the potential for isolating problem areas before an emergency occurs, which can save lives and reduce costs for asset maintenance. If there is an emergency event, UAS technology can be used to quickly and inexpensively survey the damage, allowing for better-informed and efficient recovery operations.

### Readiness

UAS use is expanding across the State DOTs, and the number of UAS applications is increasing steadily. A 2016 survey by the American Association of State Highway Transportation Officials found that 17 State DOTs had studied or used UAS and another 16 were either exploring drone usage, assisting in the development of drone policies, or supporting drone research.

- Washington has evaluated UAS applications in aerial roadway surveillance and potentially for situational awareness for avalanche control.
- North Carolina is using UAS to support construction inspection and perform accident scene reconstructions to open travel lanes more quickly.
- New Jersey is currently using UAS to support structural inspections, real-time construction project monitoring, traffic incident management, aerial 3D corridor mapping, emergency response assessment, and traffic congestion assessment.
- Ohio is using UAS technology for traffic monitoring, emergency response operations, and construction inspection.

### National Significance

UAS will improve operations, construction, inspection, and safety in collecting the data needed to design, build, and operate the highway system. Bridge inspection enhanced by UAS also improves safety for the bridge inspection team and the traveling public by reducing the need for temporary work zones. Construction inspection with UAS allows for a bird's eye view of construction progress and for the development of three-dimensional (3-D) terrain models that document the construction process. UAS technology gives DOTs eyes-in-the-sky during incident response for roadway disturbances such as rockslides, avalanches, and floods. It will allow the States to obtain more data to make more informed decisions, all collected from a relatively low-cost platform.

## ADVANCED GEOTECHNICAL EXPLORATION METHODS

### Description

This initiative accelerates project delivery by promoting a suite of mature and underutilized subsurface investigation methods for mitigating risks due to subsurface characterization. Differing site conditions represent a significant number of claims on highway and bridge construction projects. These claims arise when the site conditions encountered differ from those documented in a geotechnical report developed from a conventional subsurface exploration program. Design engineers rely on limited investigation data for subsurface characterization and extrapolate to generate the geotechnical profile used for the design. Unfortunately, since the ground conditions that influence design can vary widely within the project site, this method can result in costly constructability issues and claims.

Issues resulting from inadequate subsurface investigations led the industry to develop nondestructive geophysical methods capable of efficiently measuring properties that can be correlated to engineering properties required for design and construction. These methods, in combination with boring data, improve the confidence in and reduce the uncertainty of the geotechnical characterization. This initiative would showcase underutilized geophysical subsurface investigation methods, such as seismic and electrical resistivity geophysical techniques and ground penetrating radar. Effectively implementing these technologies can reduce delivery time, reduce uncertainties with subsurface conditions, reduce unnecessary conservatism in design, and establish a more reliable basis for design and construction of foundations and geotechnical features impacting the highway system.

### Transformative Aspects

These methods offer improved solutions and nondestructive methods for generating the geotechnical profiles used for project design. Since a significant number of construction claims can be attributed to inadequate knowledge of subsurface site conditions, this initiative improves decision-making and design details, saving time and cost for transportation agencies.

For example, these methods provide two-dimensional (2-D) and three-dimensional (3-D) subsurface images, distinguishing material and groundwater changes both laterally and with depth across a project site. Mischaracterized groundwater and unanticipated "changed conditions," common construction claims that delay projects and escalate costs, can be reduced or altogether avoided. When coupled with rapid and reliable in-situ field testing, project designs become more efficient and less conservative by more accurate accounting for changes in ground conditions and assigning of design parameters and by reducing design uncertainties.

### Readiness

These and other advanced geotechnical exploration methods are mature. Advancements in computer processing, data acquisition, data management, and hardware have improved their functionality and time requirements. Lead highway agencies that have frequently incorporated advanced methods within project geotechnical site characterization efforts include California, Florida, Minnesota, Missouri, and the Office of Federal Lands Highway.

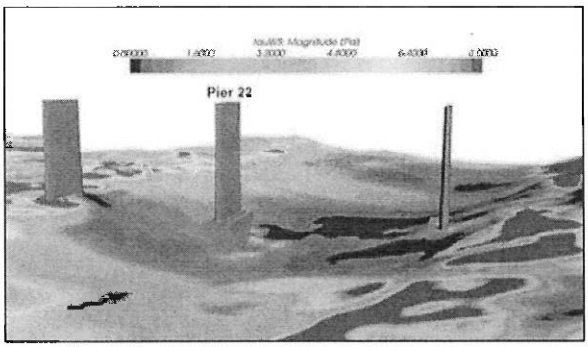
### National Significance

Understanding how the subsurface site conditions will affect project construction is critical to ensuring safe and cost-effective projects. This initiative can accelerate and improve the design and construction process while reducing risk associated with use of limited subsurface investigation data. Implementing these advanced geotechnical exploration methods will improve design decisions, leading to shortened project delivery time and reduced cost that significantly benefit the traveling public.

## CHANGE: COLLABORATIVE HYDRAULICS 2.0

### Description

In recent years, resource agencies have increased their focus on assessment of environmental impacts associated with river crossings. As a result, hydraulic engineers are responsible for demonstrating that impacts have been avoided or minimized to the fullest extent possible. Traditional hydraulic tools do not support these levels of inquiry and analysis. Current modeling techniques commonly used for hydraulic design apply several simplifying assumptions that can lead to overly conservative or inaccurate results. Recent developments in two-dimensional (2D) hydraulic modeling and three-dimensional (3D) computer visualization technology have made powerful tools available that can greatly enhance understanding of complex river and coastal hydraulics. Furthermore, the new technologies offer enhanced visualization tools to assist engineers' understanding of hydraulic conditions and help communicate those conditions to others within the project delivery process (i.e., planning, environmental, design, and construction), the public, resource agencies, and other stakeholders.




Advanced hydraulic modeling tools provide a much more comprehensive understanding of the complex flow patterns commonly encountered at many river crossings. These tools help locate and illustrate patterns of flow discharge, water surface elevations, depth, velocity, and shear stress. The results allow for more accurate estimation of flow conditions (e.g., scour), evaluation of hydraulic considerations (e.g., extent of a floodplain), and assessment of extreme event and climate variability scenarios.

### Transformative Aspects

Advanced hydraulic modeling technologies offer planners, scientists, and engineers the tools to depict specific physical, environmental, and habitat characteristics through 3D visualization of flow, velocity, and depth along an entire channel reach. These tools will increase the knowledge and ability of State DOTs to make more cost-effective hydraulic decisions within their project delivery. The advanced tools have many additional applications, including complex bridge crossings, analysis of bridge options, complex floodplain geometry, flood risk assessment, flood mapping, channel restoration, fish habitat analysis, sediment transport and scour analysis, channel stability and countermeasure analysis, and others. These additional applications will result in a wider range of users being able to use the tools.

While 2D modeling technologies have advanced significantly in recent years, notable advancements have also been made in bridge scour research and evaluation tools. Coupling these capabilities and promoting this technology through the CHANGE initiative will enable engineers to make more informed and accurate assessments of not only the scour depth potential, but also the location and extent of scour.

## Readiness

The advanced hydraulic modeling tools exist, have national applicability, and are available to the transportation community. FHWA has updated two National Highway Institute courses to support advanced modeling technologies: *Two-Dimensional Modeling of Rivers at Highway Encroachments* and *Hydraulic Design of Safe Bridges*. Through the EDC-4 CHANGE effort, more than two dozen States are now aware of the tools and recognize some of the benefits, but much more opportunity exists to further promote and develop the technology within DOTs and their stakeholders.

## National Significance

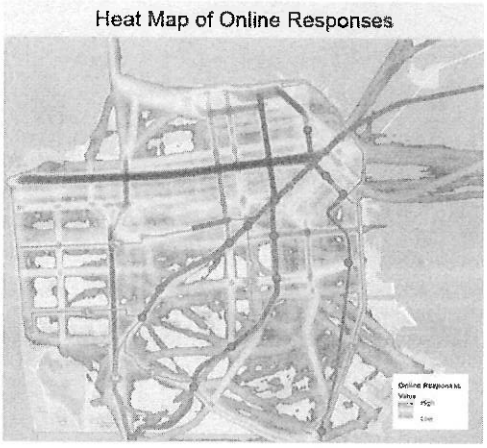
Technology developments in recent years have expanded the market of hydraulic modeling programs and tools. Highway agencies can benefit greatly from learning how to use these tools and implementing their usage. New regulations and requirements make it all the more necessary to advance the acceptance and use of advanced modeling technologies. Such tools constitute a significant evolutionary progression in the state of practice, with real potential for reducing environmental, regulatory, engineering, and other impediments to project delivery. The results significantly improve highway agencies' ability to design safer and more cost-effective and resilient structures on waterways.

## VIRTUAL PUBLIC INVOLVEMENT

### Description

Public involvement is a critical component in the transportation decision-making process, allowing for meaningful consideration and input from interested individuals. As daily users of the transportation system, the public has useful opinions, insights, and observations to share with their State DOT or metropolitan planning organization (MPO) on the performance and needs of the transportation system or on specific projects. Early and strong public engagement has the potential to accelerate project delivery and to help identify and address public concerns early in the planning process and reduce delays from previously unknown interests late in the project delivery process.

Virtual public involvement is a means for State DOTs and MPOs to inform the public and receive assistance on the development and implementation of new opportunities. Nearly all State DOTs and MPOs use websites to post information about their activities. With the increased use of social media tools and mobile applications, the public can access user-friendly features such as online videos, podcasts, and other interactive forums to provide input. While virtual communication will never be a complete substitute for face-to-face communication, it provides nearly boundless opportunities to engage those who would otherwise be unable to participate in transportation planning or project development.




This initiative promotes new opportunities for information sharing and public involvement in the transportation planning, programming, and project development process using virtual public involvement tools and techniques. Strategies and methods such as telephone town halls, online meetings, pop-up outreach, street teams, social meetings/meeting-in-a box kits, story maps, quick videos, crowdsourcing, survey tools, real-time polling tools, social media following, visualization, and working with bloggers can make it more accessible, convenient, and easy for the public to be engaged.

### Transformative Aspects

Many States and MPOs find it challenging to engage the public in the transportation decision-making process. Innovative virtual public involvement techniques are providing new, convenient, and efficient mechanisms for informing the public and receiving their input. The time is ripe to provide a national framework that will increase State DOT and MPO awareness of these techniques and encourage their implementation. Virtual meeting tools and technology can lower the transaction costs for State DOTs and MPOs and create efficiencies in how information is disseminated and how input is collected and considered, which can potentially accelerate planning and project development processes.

## Readiness

Examples of States, MPOs, and local agencies successfully using some version of virtual public involvement include the following:

- Colorado DOT held telephone town halls to conduct large-scale outreach while developing their long-range statewide transportation plan, including one town hall for each MPO and rural transportation planning organization (RTPO) region in the State.
- Minnesota DOT targeted limited English proficiency (LEP) populations while updating their Statewide Multi-modal Transportation Plan using tablet-based surveys in multiple languages. The tablet-based surveys allowed Minnesota DOT staff to visit LEP communities and solicit stakeholders to easily point, click, and respond.
- North Jersey Transportation Planning Authority is using real-time polling as part of live meetings and webinars.
- Texas' Alamo Area MPO is using low-cost videos to post on social media.
- The Baltimore, Maryland, region MPO is using "street teams" to fan out in neighborhoods to provide information and gather input.
- The City of Richmond, Virginia, used targeted stakeholder meetings, a "wikimap," and innovative data collection via a cloud-based data-gathering tool to gather field observations and specific information from people with first-hand experience biking and walking along Richmond's streets.

## National Significance

This innovation provides State DOTs and MPOs throughout the country a platform to share information on innovative tools and techniques to make public involvement more accessible, thus providing agencies a better understanding of the public's concerns regarding transportation system performance and needs. Providing more options for public engagement in the transportation decision-making process can help alleviate the difficulty State DOTs and MPOs encounter with encouraging public participation. Virtual public involvement techniques help disseminate information and collect feedback that can aid in establishing a common vision for transportation, improve the quality of transportation projects, and ensure the opinions and needs of the public are understood and considered during transportation planning and project development.

## SUMMARY OF BENEFITS

| Categories | Reduces Project Development Time | Reduces Contract Procurement Time | Reduces Cost (construction & user cost) | Reduces Congestion & Enhances Mobility | Reduces Construction Impact on Public | Reduces Environmental Impacts | Improves Safety | Provides Societal & Economic Benefits | Increases Infrastructure Life | Benefits Local Agencies |
|---|---|---|---|---|---|---|---|---|---|---|
| ***Safety*** | | | | | | | | | | |
| Making Rural Roads Safer | | | | | | | ● | ○ | | ● |
| Safe Transportation for Every Pedestrian (STEP) 2.0 | | | | | | | ● | ● | | ● |
| ***Mobility*** | | | | | | | | | | |
| Use of Crowdsourcing to Advance Operations | | | | ● | | ● | ● | ● | | ○ |
| Weather-Responsive Traffic And Maintenance Management Strategies | | | | ● | | | ● | ● | | ● |
| ***Shortening Project Delivery*** | | | | | | | | | | |
| Project Bundling | | ● | ● | | ○ | | | ○ | | ○ |
| Value Capture: Capitalizing on the Value Created by Transportation | ● | | | | | | | ● | | ● |
| ***Quality*** | | | | | | | | | | |
| Unmanned Aerial Systems (UAS) | | | ● | | ● | | ● | ○ | | |
| Advanced Geotechnical Exploration Methods | ● | | ● | | ● | | ○ | | ● | |
| CHANGE: Collaborative Hydraulics | ○ | | ○ | | ○ | ● | | | ● | |
| ***Environment*** | | | | | | | | | | |
| Virtual Public Involvement | ○ | | | | | ● | | ● | | ● |

● Primary Benefit

- Secondary Benefit

## APPENDIX A – SUMMARY OF RESPONSES TO THE REQUEST FOR INFORMATION

### Asset Management & Planning

**Decision-Support Tools** – a toolkit containing rapid road rehabilitation applications, specifications, methods, materials, and costs that facilitates scheduling, traffic, and cost analyses for highway projects.

**LiDAR Data Collection** – the use of mobile LiDAR to collect, process, and analyze data to produce a three-dimensional digital terrain model that can be used for roadside asset management.

**Negotiated Maintenance Contracts** – a streamlined process used by the Minnesota Department of Transportation that allows direct negotiation of maintenance contracts if the estimated construction cost is under $150,000.

**Asset Management for Local Transportation Agencies** – a system that uses asset condition, performance models, and economic analysis to determine the benefit-cost ratio of different treatments to a roadway segment. Asset management systems generally move agencies from a "worst first" approach toward preservation and selecting treatments with a high return on investment.

**Radio Frequency Identification (RFID) Tags** – a class of technologies that can help track highway assets electronically, leading to the development of three-dimensional maps of new and existing utilities.

### Construction

**Accelerating Projects** – the use of construction processes that reduce overall project duration to decrease impacts on the traveling public.

**A+B Bidding Process** – a construction bidding process where the low bid is determined by both construction cost and duration. This balances the overall construction cost with the user delay cost.

**Project Budget Recovery Process** – an aggressive administrative process that de-obligates unused funds and quickly moves them into the next highest priority project.

**Streamlining Delivery of Local Public Agency Projects** – a system of simplifying and streamlining project contracting for local agency projects that would exempt them from Federal laws and regulations if their projects meet local and State requirements.

**Progressive Design-Build Project Delivery** – this alternative project delivery method combines the benefits of construction manager/general contractor and design-build delivery by simplifying the pre-award process, permitting the agency to get the design-builder under contract as early as practical while only being at risk for the cost of the preconstruction effort.

**Federal Funds Exchange** – a system enabling local agencies to exchange authorized Federal funding on a project for State funding at a discounted rate. This exchange would allow local agencies to implement projects under State and local requirements rather than Federal, State, and local requirements.

**3D Modeling/Visualization Group** – a strategy that uses an internal project group to build strategic visual communication content through 3D modeling, imagery, and video production.

**Early Release of 3D Models** – coordination and collaboration between an agency and contractors to facilitate release of the 3D model developed by the engineer to contractors during the pre-bid period to provide them with more accurate information for preparing bids.

**Mobile LiDAR with Ground Penetrating Radar** – a combination of technologies that collects accurate above-ground and below-ground assets and obstacles, reducing potential construction process conflicts.

**Model-Based Design and Construction** – an extension of the 3D design process, it provides for letting projects with the 3D model as the controlling document. This would facilitate using mobile devices in the field in lieu of plan sets and provide for populating existing condition data with mobile technologies.

**Dynamic Roadway Design** – a dynamic design software that links the separate design steps to allow for automatic revisions to all aspects of the design whenever revisions are necessary.

**Reality Modeling for Transportation Projects** – the process of capturing existing site conditions to provide real-world digital context for mapping, design, construction, operations, and inspection workflows.

**Electronic Ticketing for Material Delivery** – the use of electronic ticketing of construction materials (aggregate, asphalt, concrete, etc.) that includes the origin, destination, quantity, and associated quality measurements. These electronic tickets take the place of traditional paper tickets in the move toward a paperless construction process.

**Blockchain Managing for Transportation Projects** – a blockchain is a publicly distributed ledger of transactions that, in transportation projects, would allow data sharing and protection between agencies. The public ledger provides controlled access, reduces information silos, and improves sharing.

**VDOT Job Books** – a reference tool implemented by the Virginia Department of Transportation that uses an electronic "mentor" to support the transfer of relevant resources, job responsibilities, expectations, and guidance from subject matter experts to new and inexperienced staff.

**Wiki-Scan Portable Laser Scanner Weld Inspection Tool** – a handheld, portable weld inspection tool that replaces traditional gauges with a laser-measured weld analysis and database management system that can integrate with e-Construction systems.

**Accurate Stockpile Measurement and Inventory Management** – use of mobile phone applications for frequent measurement of construction material stockpiles to ascertain the quantity delivered to a project and determine if an adequate supply is available for project needs.

**Intelligent Compaction Technology** – an advancement in roller technology that allows the roller to measure the stiffness and quality of the soils and aggregates being compacted. It provides improvements in compaction uniformity and stiffness, and it identifies areas with compaction issues or low stiffness.

### Hydraulics & Geotechnical

**Bridge Scour Early Warning Detection System** – a GIS-based system that displays bridge scour data on a map. The scour data is combined with additional sources of information on bridges that have the highest probability of experiencing scour-related damage.

**Lithification Technology** – a fast-curing process that accelerates lithification, turning soil into rock in a day rather than over many years.

**Geofoam** – the use of expanded polystyrene (EPS) geofoam blocks as an alternative embankment fill material to mitigate some differential settlements near bridge approach slabs.

**Trenchless Culvert Replacement Methods** – the installation of long-lasting, trenchless culvert pipes that reduce construction impacts.

**Storm Water Flow Control and Grading** – the use of enhanced grading and sizing of retention basins and storm water flow technology that allows high flow rates earlier during a storm to move water from retention basins to the storm water system.

### Pavements

**Precast Concrete Pavement** – a system of specific details, materials, and associated installation methods used to rapidly create a fully functioning concrete pavement from precast pavement panels, which are most often used for rapid repair of in-service pavements.

**Concrete Overlay Resurfacing** – the placement of a relatively thin concrete layer on the surface of (or as an inlay in) any existing pavement to create a new, long-lasting driving surface. This is an alternative to removing and reconstructing an existing pavement or placing other types of overlays.

**Long-Life (Perpetual) Pavements** – a design method for asphalt pavements that attempts to eliminate structural, bottom-up pavement distress. This long-life pavement is then managed and maintained by addressing any top-down pavement distress through maintenance and rehabilitation.

**Full-Depth Reclamation for Asphalt Pavement Rehabilitation** – a rehabilitation technique that involves in-place recycling of an existing distressed asphalt pavement and its underlying aggregate layers into a new structural pavement base.

**Interlocking Concrete Pavements** – a pavement system that uses solid concrete paving units (blocks) assembled into a pattern to make a pavement wearing surface. These pavements have similar structural capacity to the equivalent asphalt thickness and resist deterioration under traffic or in hot temperatures.

**Permanent Road Foundation** – a pavement structural system where geotextiles and geogrids are used between the subgrade soil and the aggregate base to separate and reinforce the base. This reduces aggregate contamination and provides for a uniform and consistent performance of the pavement base.

**Bender Elements to Quantify Aggregate Layer Stiffness** – a measurement system for quantifying in situ stiffness characteristics of a pavement aggregate base/subbase layer.

### Materials

**Promotion of Patented and Proprietary Products** – a program to encourage transportation agencies to use patented and proprietary technologies in highway construction that are allowed under Federal regulations.

**Balanced Asphalt Mix Design** – a system for asphalt mix design that uses performance tests to measure material properties that address different distress modes. This could allow the use of alternative mix designs and recycled materials and still provide a high-quality asphalt product.

**Modified Binders in Asphalt Pavement** – the use of polymer-modified asphalt binders to improve the long-term performance of hot mix asphalt and warm mix asphalt.

**Low-Cost Additives for Performance** – the use of readily available additive and recycled products, such as rubber, fibers, or shingles, to improve the performance of pavement materials.

**Polymer-Modified and Highly Modified Binders** – the use of high quantities of polymer-modified binders to enhance the long-term performance of asphalt materials. These highly modified binders are shown to increase cost by 5 percent and provide a performance improvement of 20 percent.

**High Tensile Strength, Fiber-Reinforced Asphalt** – a blend of synthetic fibers added to asphalt materials that controls and reduces thermal, fatigue, and reflective cracking and rutting.

**Rip Rap Size and Shape Determination** – a system for evaluating the size distribution of large-size rip rap aggregates based on analyzing images of the rip rap pile or project field application.

**Lightweight Aggregates** – the use of lightweight aggregates to reduce the density of concrete, to serve as a structural fill for embankments, to deliver water to the interior of concrete structural elements and pavements, and to provide long-lasting, skid-resistant pavement surfaces.

**Nanotechnology in Concrete** – the use of nanotechnology in concrete mixtures to improve permeability resistance, flexural strength, and abrasion resistance.

### Structures

**Folded Steel Plate Girder System** – a prefabricated bridge superstructure using steel girders fabricated from plate steel with precast deck panels for use in accelerated bridge construction.

**Smart Bridge Sensor Technology** – the use of installed sensors to capture data on strain, out-of-plane bending, and crack changes that can be used to determine bridge condition and deterioration.

**Stay-in-Place Precast Fascia Form** – a method for accelerating the construction of bridge overhangs in which stay-in-place precast fascia elements are used as the formwork.

**Ultra-High Performance Concrete (UHPC) for Bridge Deck Rehabilitation** – the use of UHPC as a deck overlay material for rapid repair and rehabilitation to improve the performance, strength, and durability of existing structures.

**Bridge Preservation Strategies Using UHPC** – the use of ultra-high performance concrete to repair steel beam ends or to link bridge segments that would convert jointed bridge decks into jointless bridge decks.

**Fiber-Reinforced Polymer Systems** – the use of commercially available, fiber-reinforced polymer technologies with reinforced and prestressed concrete elements, such as pre-tensioning and post-tensioning of concrete beams, cast-in-place and precast concrete, composite tube arch structures, and other bridge elements.

**Accelerated Bridge Construction Technologies** – the use of construction acceleration techniques that use technologies such as precast concrete overhangs, full-depth precast bridge deck panels, and stay-in-place form systems to accelerate construction.

**Orthotropic Steel Decks** – the use of metal bridge decks that are up to 70 percent lighter than conventional reinforced-concrete decks.

**Corrosion-Resistant Reinforcement (CRR)** – the use of corrosion-resistant structural-reinforcement steel to reduce bridge deck maintenance by increasing the durability and extending the service life of the bridge decks and other key bridge elements.

**Mobile Self-Propelled Tunnels** – a large-scale mechanism of traveling gantries furnished with a crane, drilling machinery, and other equipment that carries out the construction process directly under the existing highway without impeding traffic flow.

**Simplified Hydrostatic Pressure Relief for Bridge and Wall Preservation** – the installation or retrofitting of a retaining wall's geotextile drainage and erosion-control system from behind the wall to the front face of the wall.

**Seismic Design Using Shape Memory Alloy (SMA) and Engineered Cementitious Composites (ECC)** – the use of SMA/ECC in the plastic-hinge regions of bridge columns to improve the seismic resiliency of bridges by dissipating energy during an earthquake without causing permanent damage.

**Heated Bridge Technology** – a technology that uses electricity generated from solar panels placed adjacent to bridges to help dry bridge surfaces during rain, snow, or ice events and slow down or eliminate bridge deck freezing following rain and snow events.

### Safety

**Intersection Control Evaluation Policy** – a policy that allows agencies to make informed decisions on selecting the proper intersection form based on safety, operations, and cost and establishes guidelines for use based on the context of the project.

**Channelization** – the use of traffic safety products, typically orange plastic molded devices, to alert and direct traffic through roadwork or away from hazardous areas.

**Guardrail Barrier System Using Rubber Roller Elements** – a safety fixture on guard rails that absorbs impact energy and redirects the impacting vehicle back toward the road.

**Rumble Strips** – a road safety feature used at the edge of a road, or sometimes on the centerline, to alert inattentive drivers to potential danger by causing a tactile vibration and audible rumbling to be transmitted through the wheels into the vehicle interior.

**Reduced Noise Rumble Strips** – a class of non-traditional rumble strip designs aimed at reducing nuisance noise associated with their use.

**Flashing Red Beacon** – a fail-safe condition for traffic control signals that provides a flashing red condition during a power failure or other failure of the traffic signal.

**Traffic Spot Eliminator** – a roadway design modification that enhances visibility and reduces blind spots, resulting in fewer crashes.

**Wider Pavement Edge Lines** – the use of 6-inch edge lines to reduce run-off-the-road crashes on rural, two-lane highways when shoulder rumble strips are not feasible.

**U.S. Road Assessment Program** – a set of tools that allows for systemic data gathering, modeling, and prioritization of possible safety measures based on roadway physical characteristics.

**Roundabouts** – a safety countermeasure that reduces the potential conflict points in a typical intersection and reduces vehicle speeds.

**Traffic Safety** –a standard for traffic monitoring elements, such as loop detectors, closed-circuit television cameras, and electronic sign message boards, to inform and warn motorists of conditions.

**Wrong-Way Driver Prevention** – the placement of red on backside reflective pavement markers on arrows across limit lines and all freeway lane lines reduces the number of wrong-way driver reports.

**Intersection Conflict Warning Systems** – a collection of sensors and signage intended to warn vehicles on low-speed side streets of approaching vehicles on the intersecting high-speed mainline routes.

**eTraffic GIS System of Engagement** – an online, GIS-based data collection and sharing platform that integrates roadway characteristic data collected from multiple agencies with crash data to perform safety and operational analyses.

**Job Site Practices to Improve Work Zone Safety** – a series of approaches that includes increased use of positive-protection barriers, full road closures, project coordination by synchronizing projects at various levels, and the use of temporary rumble strips.

### Environmental, Planning, and Realty

**Improving Environmental Sustainability** – the acquisition of ample right-of-way to allow for areas landscaped with trees and plants that offset $CO_2$ emissions and other pollutants and to provide flexibility for future right-of-way needs.

**DOT Connects** – a system of collaboration between State departments of transportation and local government to enhance understanding of community values and concerns. A clear understanding of local issues will provide more accurate scopes of work and budgets and minimize complications late in the design process.

**Model for Accelerating Prosperity** – a blueprint for stimulating economic vitality using transportation data that leverages federally funded data and staffing to support efforts to stimulate local economies.

**Environmental Permitting** – an automated system for calculating what is needed to determine if a plot is considered a wetland that reduces both QA/QC processes and permitting errors.

**Promoting Environmental Streamlining Reform** – a standard resource that helps disseminate national-level information on project streamlining reforms.

**Digital Stakeholder Engagement Virtual Open House** – the hosting of virtual, online public meetings communicating project concepts using 3D models and visualizations to expand the audience and range of public input for highway projects. It would include tools and social media that engage the public and point them to a virtual open house, where they can immerse themselves in 3D visualizations and provide feedback through comment forms, idea boards, and other interactive engagement tools.

**Right-of-Way Acquisition Request for Proposals Process** – a process that uses existing assets and develops operational improvements projects to reduce costs and improve mobility.

**Accelerated Project Right-of-Way Acquisition** – the use of separate contracts for preparation of right-of-way in advance of highway construction contracts that provides improved site access for geotechnical investigation, utility adjustments, supplemental surveying, and contractors bidding the highway construction project.

**Environmental Compliance Monitoring and Tracking** – the use of innovative methods for compliance tracking (e.g., databases and field technologies) that meet National Environmental Policy Act-derived goals for minimizing impacts to the human and natural environment.

**Stormwater and Grading** – a device that delivers superior discharges and efficient flows through small-volume ponds with additional localized collection of skimmed waste.

### Operations

**Crowdsourced Traveler Data** – the use of crowdsourced, real-time traveler information from mobile phones and devices that can improve safety, operations, and maintenance.

**Law Enforcement Cooperation** – the use of police documentation and reporting to provide more immediate information on specific crash characteristics, leading to quicker implementation of countermeasures.

**Autonomous Technology Improving Work Zone Safety** – the use of autonomous crash trucks outfitted with truck-mounted attenuators that provide automated protection of workers in work zones.

**Autonomous Vehicle Lanes** – the use of smaller, dedicated autonomous vehicle lanes on interstates to allow more lanes for standard vehicles until autonomous vehicles are more widespread.

**Portable Variable Speed Limits in Work Zones** – the dynamic adjustment of speed limits in work zones to harmonize traffic while reducing the operating speeds of vehicles adjacent to workers.

**Emergency Response/Traffic Congestion Mitigation** – a program that utilizes both a mobile power inverter and quick-connect boxes at traffic signals to provide emergency backup power for signalized intersections during power loss or other emergencies.

**Traffic Volume Control/Pre-Freeway Entrance Status** – a meter or traffic management system that would allow drivers a non-commitment choice before they enter freeway approach ramps.

**Narrow Track Vehicle Fleets with Optional Support Lane Markings** – the use of single-width cars and lanes to mitigate congestion by allowing right-sized, width-efficient single and duo occupant driving.

**Traffic System Management and Operations** – a strategic approach to improving mobility for all modes of transportation by integrating planning and design with operations and maintenance to holistically manage the transportation network and optimize existing infrastructure.

**Smart City Vehicle to Infrastructure Data Communication Platform** – a communication platform that provides information, such as the number of vehicles, pedestrians, cyclists, and other objects in intersections and on the roadway, that enables predictive traffic analytics.

**Data Access via Advanced Traffic Control Devices** – the collecting, uploading, and storing of data captured at intersections and processed by smart technologies such as cameras and sensors.

**Salt and Snow Management** – a unified course that equips local public agency personnel with methods to optimize winter storm management activities.

**Optimal Anti-Icing Strategies** – a series of strategies and products intended to minimize the potential for ice to bond with pavements at the beginning of a storm, reducing the need for plowing and salting.

**Efficient Use of Chlorides and Alternatives** – the use of tools, such as on-board pavement temperature sensors, applicator control systems, forecast data, and application rate guidelines, to apply the right material, in the right amount, at the right place for snow and ice control.

**Proactive Traffic Signal Timing** – a proactive signal control system for optimizing signal phasing and timing plans by integrating data from traffic signals, loop detectors, and connected vehicles to reduce congestion on arterial roads and maximize the performance of intersections.

**Consolidation of Autonomous Transportation Infrastructure** – a network of continuously monitored stations that are evenly spaced along the traveled ways and used primarily for independent verification of autonomous vehicle data.

**Freight Container Movements** – the use of blockchain technology to record container shipping manifests at point of entry and point of delivery to move empty containers efficiently.

**Flashing Yellow Arrow** – the use of flashing yellow arrows at signalized left-turn lanes to reduce delay while not compromising the safety of the left-turning vehicles or opposing through vehicles.

**Improving Agency Performance Management Using Automated Traffic Signal Performance Measures (ATSPM)** – the continuation of the EDC-4 initiative with a change in the benchmark from ATSPM deployment to the use of ATSPM-driven decision-making for agency organization and business process improvement.

**Speed/Distracted Driver Initiatives** – a continuation of the EDC-3 Smarter Work Zones initiative to include additional approaches such as variable speed limits with automated enforcement, increased use of queue and speed management deployed through Intelligent Transportation Systems for dynamic management of work zone traffic, and partnering with Waze and other GPS navigation providers to share real-time road construction information.

**Wireless Irrigation Valves** – a secure wireless-integrated irrigation system for highway landscaping maintenance that provides a vandalism-resistant automated control system using off-the-shelf technologies.