

National STIC Network Showcase 2023



Category:

Pavement & Structures



U.S. Department of Transportation
Federal Highway Administration



National STIC Network Showcase

The EDC-7 virtual summit, held in February 2023, included a platform for the State Transportation Innovation Councils (STICs) to showcase homegrown innovations that their members developed and implemented in their state. The purpose of this National STIC Network Showcase was to celebrate and share innovations with a wider audience to expand their potential use and impact. These innovations are saving lives, building sustainable infrastructure, growing an inclusive workforce, saving time, and making our transportation system more efficient. Over 100 innovations were shared by STIC members and are grouped into the following categories.

- Asset Management & Finance
- Maintenance & Emergency Response
- Operations
- Design & Construction
- Technology & Materials
- Planning & Environment
- Safety
- Pavement & Structures
- Civil Rights, Workforce, and Equity

This event also featured short presentations from State and local agencies on some of these homegrown innovations, which are also [available on-demand](#).

Disclaimer

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OH: Drone Bridge Inspection

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WA: Design Technology for Ultra High Performance Concrete (UHPC) Precast, Prestressed Bridge Girders

Road Marking Templates: Reducing Time and Cost of Pavement Preservation Projects



OVERVIEW OF INNOVATION

Road markings typically have a lifespan of 10 years, but ADOT's pavement preservation cycles are every 3 to 4 years. When road markings are not protected during a pavement preservation project, additional time is needed to spray the oil by hand and refresh the markings. If the markings are covered in oil, the additional cost of installing new markings is incurred.

In order to maximize the lifespan of existing road markings, the road marking template was created. This template covers individual road markings so they are preserved when the spray truck passes. The template is removed by maintenance crews and transported around the spray truck to the next road marking.

Use of the road marking template has reduced project time and cost, resulting in more efficient project delivery.



Source: Joe Ferguson

BENEFITS

Cost Savings: Between \$700 - \$2000 per marking (depending on the marking protected). In multiple cases, this has led to a savings of over \$20,000 per project.

Time Savings: Allowed completion of a 155 lane mile project in 16 hours

FIND OUT MORE . . .

Video Links:

[Reverse Diamond Stencil-CI on Vimeo](#)

<https://www.youtube.com/watch?v=p5jBKu6E-3c>

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Pavement, Maintenance

Extending Centerline Marking Life



OVERVIEW OF INNOVATION

Schweitzer Mountain Road in the Independent Highway District (IHD), Idaho gets anywhere from 100 to 300 inches of snow annually. Maintenance crews plow the road multiple times per day, which results in the scraping away of pavement markings. The reduction in visibility presented a safety hazard for drivers and for snowplow teams trying to get up and down the well-traveled route to the local ski area.

The Independent Highway District developed the Recessed Lane Indicator. The process involves making indentations or divots along the roadway's centerline using metal plates and then covering them with thermoplastic markings that can remain visible for up to 10 years.

Initial cost to implement innovation was \$940 for materials and labor.



Source: Independent Highway District, Idaho

BENEFITS

- Increased safety for drivers
- Less spending for road maintenance

FIND OUT MORE . . .

https://www.fhwa.dot.gov/clas/pdfs/2021_mousetrap_entries_booklet.pdf

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Keywords: Centerline Markings; Road Maintenance; Pavement; Divots; Snow; Safety

Unlocking Building Information Modeling (BIM) for Bridges with the BIM Execution Plan



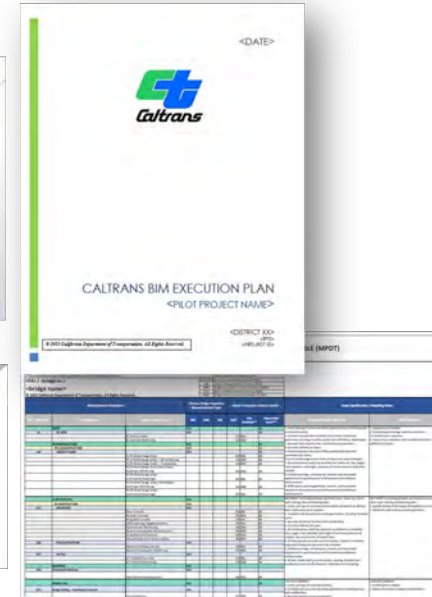
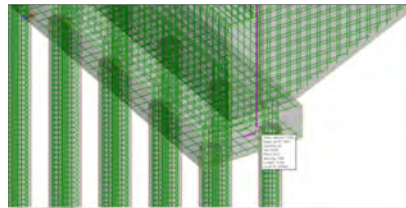
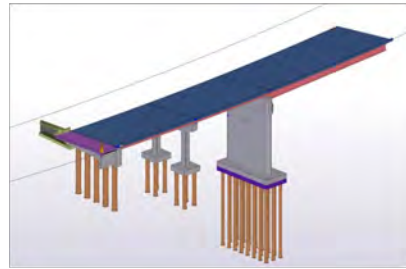
OVERVIEW OF INNOVATION

Federal Highway Administration (FHWA) calls the BIM Execution Plan (BEP) “critical to the success of BIM for infrastructure implementation¹”

To unlock BIM’s powerful digital data structures and visualization capabilities, California Department of Transportation (Caltrans) identified the need for a BEP Template that would align its information modeling requirements and govern its information management. The Caltrans BEP Template is based on the ISO 19650 standard and has established a framework to apply a consistent approach to several different bridge types, while accelerating the organization’s understanding of BIM for bridges in pilot projects.

Bridge Design is collaborating with Roadway Design, Construction, Maintenance, and other functional units to enable improvements in the way public bridges and structures in California are planned, designed, constructed, and maintained to benefit California taxpayers and stakeholders.

¹Ref: Federal Highway Administration, Advancing BIM for Infrastructure: National Strategic Roadmap (Washington, DC: 2021) <https://doi.org/10.21949/1521637>. Page 23



Source: Caltrans BIM for Bridges & Structures Committee

BENEFITS

The BIM Execution Plan (BEP) Template sets-up an information management framework for BIM that is consistent with ISO 19650. An Assessment of 11 UK Case Studies² found that “the use of Information Management (IM) could potentially secure ... \$8.50 in direct cost savings for every \$1 invested in IM.” Currently Caltrans is piloting the BEP in ten pilot projects.

²KPMG, The value of Information Management in the construction and infrastructure sector (UK: 2021) https://www.cdbb.cam.ac.uk/files/cdbb_econ_value_of_im_report.pdf. Page 5 Values are converted from GBP to USD

FIND OUT MORE . . .

Caltrans Innovation Expo Day 5: November 20, 2020. Unlocking BIM for Bridges & Structures: <https://www.youtube.com/watch?v=2jxN4nMNQGE>

“Developing a Strategic Roadmap for Caltrans implementation of Virtual Design/Construction/Civil Integrated Management” <https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/final-reports/ca20-3178-finalreport-a11y.pdf>

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Design, Structures

District 11 San Diego: South County Trade Corridors State Route 11 Enrico Fermi Diverging Diamond Interchange



OVERVIEW OF INNOVATION

Starting with policy and planning, multimodal considerations, safety, operational characteristics, geometric design, and completed construction and maintenance, The State Route 11 Enrico Fermi Diverging Diamond Interchange features an unconventional and innovative Diverging Diamond Interchange design.

As part of a larger purpose and transportation system in this corridor, this Enrico Fermi Diverging Diamond Interchange (DDI) will satisfy the increasing demand for California-Mexico trade at existing border crossings.

The efficient delivery of goods and services is critical to the customer's satisfaction – the success of individual businesses and the urban and global economies. Yet to reach the destination, goods distributors face significant challenges across urban and metropolitan environments, regional highway networks, and bottlenecked ports.

This Diverging Diamond Interchange design facilitates the most efficient traffic patterns from Mexico into the United States. Access to border wait times at the different Ports of Entry will reduce congestion and positively impacts the air quality of moving travelers and goods throughout the country.



Caltrans D11

BENEFITS

- Traffic patterns promoted by the DDI will facilitate continuous movement from Mexico into the California State Transportation System, helping to reduce the air quality impact created by the movement of goods and the traveling public.
- The novel DDI design also promotes intersection safety for pedestrians and bikers while meeting the conflicting demands for increasing capacity, decreasing congestion, and minimizing the cost of multiple infrastructures.

FIND OUT MORE . . .

2021 District 11 Innovation Fair

<https://youtu.be/OigDMS6pKqo>

Keep San Diego Moving
– State Route 11 Corridor

<https://www.keepsandiegomoving.com/SR-11-Corridor/SR11-intro.aspx>

Caltrans Innovation EXPO 2022

<https://caltrans-innovation-expo.constantcontactsites.com/enrico-fermi-diverging-diamond-interchange-with-border-wait-time-technologies>

South County Trade Corridors (SCTC) Contact Information

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Equity, Operations, Planning, Environment,
Structures, Design, Freight/Goods Movement

Low-Clearance Bridge and Tunnel Clankers



OVERVIEW OF INNOVATION

In response to over 70 overheight vehicles striking the CSXT bridge along Casho Mill Road over the past decade, DeIDOT implemented an overhead deterrent to alert drivers that the bridge is too low to safely pass under. A series of “clankers” were installed in conjunction with dynamic warning systems that include signage and flashing lights. The clankers, which have a devoted local following, are comprised of heavy-duty plastic suspended from steel mast arms that span the roadway. If struck, a vehicle is too tall to pass under the bridge prompting the driver to turn around.

Jokingly referred to as “Crasho Mill” and “Smasho Mill” by locals when conventional devices failed to prevent railroad bridge strikes, the new clankers provide a safe deterrent for overheight vehicles. **Materials used reduce the likelihood of flying projectiles injuring nearby pedestrians, bicyclists, properties, and infrastructure.**



BENEFITS

Source: DeIDOT

The clankers were a short-term compromise with CSXT that allowed Casho Mill Road to remain open for residents, commuters, and emergency personnel. When a bridge/tunnel strike occurred in the past, police and public works personnel had to initiate the vehicle extraction process and then a 3 to 4-hour, high-priority structural evaluation needed to be performed via CSXT and DeIDOT. There was also a traffic impact to a commuter route serving nearly 15,000 vehicles per day, plus the insurance costs and property damage to affected overheight vehicles/loads and the consequential personal injuries (about one-third of the reported strikes).

FIND OUT MORE . . .

[MUTCD Part 1 Clankers Memo](#)

Video evidence of the clankers effectiveness: [This boat owner's "catch of the day" was realizing they would not fit under the Casho Mill Road bridge](#)

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Safety, Asset Management, Emergency Response / Relief

eSTORM – an Innovative Emergency Management Device Operational Status Platform



OVERVIEW OF INNOVATION

The eSTORM web- and phone-based application collects, in one place, the necessary field data, device operational status, generator deployment, cabinet flooding, and downed structures events for ITS and traffic signals devices following a hurricane or thunderstorm. The application works offline, collecting information and pictures even if there is no cellular coverage. This data is uploaded automatically once internet service is available. Collected information is displayed in a dashboard for a quick real-time snapshot of the work that is done by the field staff. This allows for resource planning and allocation to expedite the recovery efforts.

The application, built on ArcGIS, was conceptualized in FDOT District 3 during Hurricane Sally in 2020 and converted into a statewide application in the 2021. Recently, the application was used during Hurricane Ian in September 2022.

The application has been pioneered in the State of Florida and has usability across the nation for any emergency management scenarios when the knowledge of device operational status is critical to safe and efficient traffic movement. The application is portable and scalable and can connect with arterial and freeway management software for a direct connection to extract operational status remotely.

BENEFITS

eSTORM allows FDOT to allocate its resources efficiently and expedite recovery efforts to make Florida roadways safe and traversable again.

FIND OUT MORE . . .

Website link:

eSTORM Article:

<https://bit.ly/56934FL578>

TIM Website:

www.fdot.gov/emergencymanagement

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Hurricane, estorm, situational awareness, emergency management, GIS, planning, freight/goods movement, technology, asset management, emergency response/relief, operations

Internally Cured Concrete in Florida's Concrete Bridge Decks and Rigid Pavements

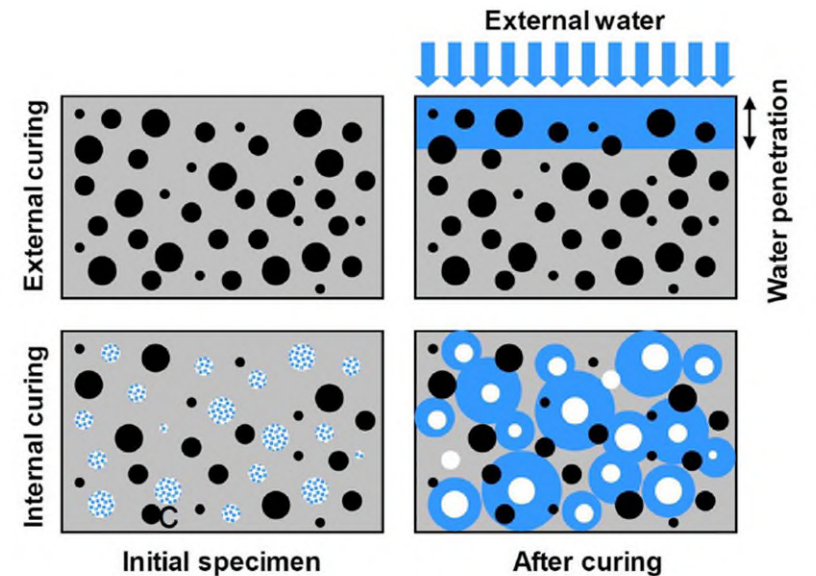


OVERVIEW OF INNOVATION

Typically, high-strength concrete used in bridge decks and rigid pavements has very high early-age shrinkage, which often leads to cracking. Cracks can greatly decrease the structural service life, causing decks or pavements to prematurely fail.

The innovative approach of internal curing concrete was investigated by the Florida Department of Transportation (FDOT) in partnership with the University of Florida. The resulting research concluded that resistance to shrinkage cracking was substantially higher for Internally Cured Concrete (ICC) than for standard high-strength concrete. Additionally, permeability of the ICC was reduced/improved compared to standard high-strength concrete.

As a result of its research, FDOT developed and implemented standard specifications for ICC and currently allows its use in bridge decks and rigid pavements.



BENEFITS

Durability (Reduced Cracking and Permeability), Reduced cracking due to reduced early-age shrinkage, Improved hydration – no self-desiccation, denser interfacial transition zone, Reduced permeability – less ingress of chlorides, etc., Reduced slab curling and warping

Structural Endurance (Reduced Cracking & Fatigue), Small reduction in weight, Lower elastic modulus, Lower coefficient of thermal expansion, Small increase in strength

FIND OUT MORE . . .

Mitigation of Cracking in Florida Structural Concrete
[Summary](#) | [Final Report](#)

Internally Cured Concrete for Pavement and Bridge Deck Applications
[Summary](#) | [Final Report](#)

FDOT State Materials Office

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Keywords:

internally cured concrete, lightweight aggregate, bridge deck, pavement slab, coefficient of thermal expansion, modulus of elasticity, shrinkage cracking, restrained shrinkage, sustainability, pavement, structures, materials

Flood Resiliency Analysis Tool



OVERVIEW OF INNOVATION

A methodological framework helps Iowa DOT identify the roads most vulnerable to extreme flood events and prioritize the state's investments.

As severe floods in Iowa become more frequent, catastrophic, and costly, understanding the risks to the state's infrastructure and preparing for changing conditions can make a big difference in how quickly the state recovers from potential disruptions.

In 2021, the Iowa DOT asked its Resiliency Working Group to develop a flood resiliency methodology that could be integrated into the agency's decision-making process and long-range planning activities. The group conducted a review of the state's primary highway system, identifying the corridors at greatest risk of extreme flooding and developing a methodology to objectively determine where mitigation efforts and investments would be most beneficial.

By considering seven weighted factors, Iowa DOT engineers can give each of the state's key highway segments a composite score up to 100. The higher the score, the greater the corridor's resiliency in the event of a 100-year flood.



Source: Iowa DOT

BENEFITS

Understanding the risks to the state's highways can help Iowa DOT plan for and invest in appropriate mitigation measures that minimize transportation-related disruptions in the event of a severe flood.

The metrics and framework used in Iowa's resiliency analysis tool can be easily replicated or adapted by other transportation agencies.

FIND OUT MORE . . .

Iowa DOT Resiliency Working Group
<https://iowadot.gov/sustainabilityandresiliency/Up-Close-Resiliency-Working-Group#53947672-i-classfa-fa-map-aria-hiddentruei-our-strategies>

Iowa DOT Resiliency Working Group

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Planning, Structures, Asset Management,
Emergency Response, Emergency Relief,
Stormwater Management

Tailgate Mounted Spreader Box



OVERVIEW OF INNOVATION

A custom-built chute mounted to the rear of a box spreader makes applying replacement gravel to rutted highway shoulders easier, safer, and more cost-effective.

Replacing aggregates and smoothing highway shoulders is routine work for Iowa's highway maintenance crews. The job has typically required multiple vehicles in tandem: one dedicated to depositing the rock, another close behind to spread and grade the material in place and a third to sweep the pavement. The process can be slow-moving and labor-intensive.

A box spreader modified with a tailgate chute places a consistent quantity of aggregate in a targeted location along a road's shoulder without the need for a separate motor grader and broom. As a result, ruts can be filled in a single pass to save time and money and increase safety for workers and travelers alike.

Each tailgate spreader box costs \$310 in materials and can be installed in 30 minutes.



Source: Washington County Secondary Roads Department

BENEFITS

This innovation makes it possible for one person to perform a task that had previously required multiple people and a variety of equipment to accomplish.

The spreaders directly apply a consistent amount of gravel to the shoulder, ensuring ruts can be addressed in a single pass.

Filling ruts quickly saves time and labor costs and improves safety by reducing workers' exposure to traffic.

FIND OUT MORE . . .

Washington County Road Maintenance
<https://washingtoncounty.iowa.gov/184/Road-Maintenance>

Washington County Secondary Roads Department

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Maintenance, Safety, Asset Management



Heated Hot Mix Splitting Table

OVERVIEW OF INNOVATION

When testing a cylindrical cut of hot mix, two samples must be split from opposite sides of the mix. On a stationary table, this process can be cumbersome because the hot mix must be manually rotated, or the technician must maneuver to reach the other side of the cut. Aside from making the process more difficult, using a stationary table also increases the likelihood that the cut is segregated during the splitting process.

To address these issues, ITD employees created a hot mix splitting table that rotates to allow for greater accuracy and ease of use. This not only saves a considerable amount of time, but it increases the likelihood that the splitting process is homogeneous.



Source: The Idaho Transportation Department

BENEFITS

The Heated Hot Mix Splitting Table reduces the time and effort it takes to split hot mix samples.

FIND OUT MORE . . .

N/A

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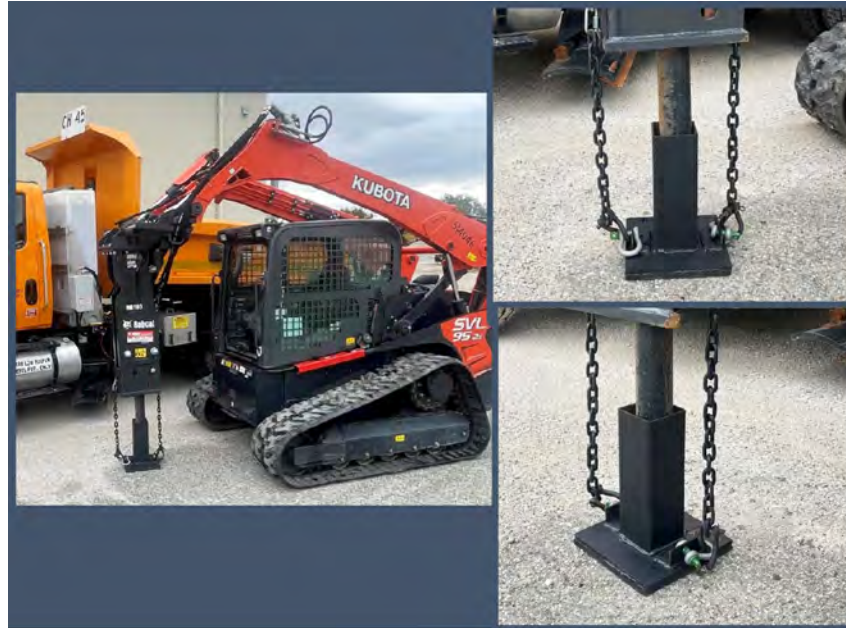
Testing, Hot Mix, Efficiency, Pavement, Quality,
Time-Savings

Tamp Plate

OVERVIEW OF INNOVATION

After disturbing road underlayment for a full-depth patch, achieving optimal compaction may be difficult. The width of the patch is often too narrow to allow the rolling compactor to be useful, and jumping jack tamps provide just 325 foot-pounds of force, making them less than ideal for the job at hand. When compaction is insufficient, the patch may sink and require further repairs.

A new tamp was developed that freely and safely attaches to the end of the skid steer breaker, transforming it into a 12-inch by 12-inch plate compactor. Harnessing up to 1,500 foot-pounds of force, the tamp plate was created by combining two plates with nuts, bolts, welded D rings, chains and a locking chain link. With the chains cut to length and connected via the locking link, the compactor safely attaches to the machine and moves up and down without restriction. The breaker tip compresses as if it were going through concrete, but the plate absorbs the force and distributes it evenly to the ground, causing more than enough compaction to ensure proper ground preparation for repairs.



Illinois Department of Transportation

BENEFITS

The compaction provided by the new tamp plate improves performance of a patch. The tamp plate quickly and easily attaches to the skid steer through chains with locking links. Building the tamp plate takes less than one day and can be easily replicated by other yards with minimal expense.

FIND OUT MORE . . .

Illinois Department of Transportation

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Keywords – tamp plate, patching, compaction

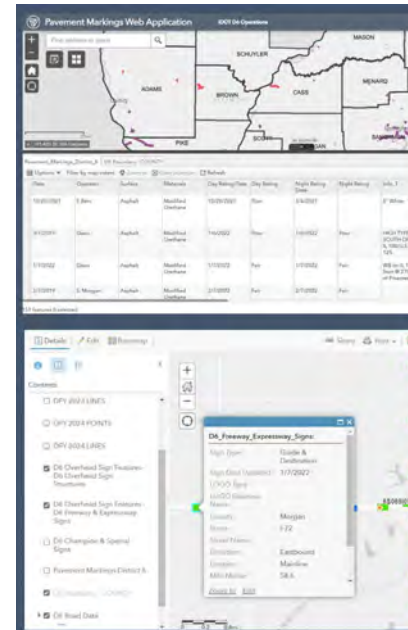
Tracking and Programming Maps



OVERVIEW OF INNOVATION

Decisions regarding when or where high-type pavement marking required restriping relied on past plan sets and technician memory, while hard-copy binders were used to track interstate, overhead, championship and special town name signs. Neither of these systems was reliable or efficient, and pavement markings became unnecessarily deficient throughout the district as a result.

A new system was developed using GIS technology to create a complete inventory of all high-type pavement markings maintained throughout the district, along with an up-to-date evaluation of each. The inventory can be easily filtered to provide a list of all road sections in need of restriping throughout the district. The system also provides a mapped inventory of all interstate and specialty signs, allowing for mobile access while decreasing time and manpower used to approve installation and repairs.



Illinois Department of Transportation

BENEFITS

The new system uses GIS to show striping sections throughout the district. Colors are used to indicate striping conditions. Sign information is filterable by type of sign, and colors and shapes indicate specifics of sign build and purpose. System information is clear, concise and readily accessible.

FIND OUT MORE . . .

Illinois Department of Transportation

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Keywords – pavement marking, asset inventory, asset mapping

Development of a Rural Primary Road System (RPRS)

OVERVIEW OF INNOVATION

THE PROBLEM:

The disparity between identified capital improvement needs and available financial resources was and is a significant issue. Transportation infrastructure was stretching a limited budget beyond its capacity to do most things well. Due to changes in the agriculture industry, many of our structures had become obsolete. We needed to document a method to prioritize expenditures.

THE SOLUTION:

"We developed a road system inside the current system called the Rural Primary Road System that identified areas of high traffic and agricultural use to focus available funding. Road upgrades are based primarily on traffic volumes and correlations between maintainability and soil conditions. "



BENEFITS

The identified Rural Primary Roads will receive higher priority when it comes to investing the County's limited available funds to upgrade road surfaces and drainage structures and repair/rehabilitate/replace facilities and still allow adequate access to property.

FIND OUT MORE . . .

KUTC BABM Winner, YouTube
<https://www.youtube.com/watch?v=Ob1h8zV9tHk>

KUTC 2022 Autumn LTAP Newsletter
<https://kutc.ku.edu/sites/kutc/files/documents/2022%20Autumn%20LTAP%20Newsletter.pdf>

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Planning, Maintenance, Asset Management,
Finance/Funding

Culvert Banding Tool



OVERVIEW OF INNOVATION

This banding tool is designed to join culvert collars when the coupler bolts are too short to reach. This tool saves time over the traditional method of winding nuts on threaded rod to reach the coupler bolts. Multiple tools recommended for easiest banding.



Photo by MaineDOT

BENEFITS

This tool makes fast work of banding two culvert sections together in the field, saving both time and physical muscling of sections to join.

FIND OUT MORE . . .

Measurement drawing and additional photos available to facilitate replication. Contact MaineDOTInnovates@maine.gov.

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Maintenance, Construction

Harris Inspection Tool (aka HIT Rod)



OVERVIEW OF INNOVATION

MaineDOT Bridge Inspection team leaders and twin brothers Scott and Steve Harris have invented a variation of a selfie stick to enable a phone camera to visually inspect bridge elements that otherwise would require expensive equipment and often traffic control.

The telescoping HIT Rod consists of a 20' telescoping pole with an attached adjustable phone cradle on top. The iPhone's camera is remotely controlled by an Apple watch. MaineDOT Inspection Teams use iPhones and Apple watches, but other phone brands and compatible pairings may work.

The iPhone's camera is activated from the Apple watch via Bluetooth and the preview is actively cloned to the watch display. The iPhone is then moved into position via the HIT rod and the iPhone's picture is snapped remotely from a button on the watch. The Apple watch can also remotely adjust the iPhone Zoom, Flash, Timer, and other functions.

All MaineDOT Team Leaders are issued iPhones by MaineDOT. The additional cost of the HIT Rod for each inspection team is approximately \$800 – the cost of the Apple watch, telescoping pole and phone holder.

The HIT Rod is only used in areas where visual inspections are deemed appropriate by MaineDOT. The use of the HIT Rod often identifies areas requiring advanced inspection techniques.



Photo by MaineDOT

BENEFITS

Up to \$5000/inspection is saved by using the HIT Rod rather than paying for heavy equipment and/or traffic control. Few innovations have this strong a return on investment.

FIND OUT MORE . . .

Demonstration video is posted on MaineDOT Sharepoint site. Contact MaineDOTInnovates@maine.gov for access credentials to view.

Steve Harris

Bridge Inspection Team Leader

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Maintenance, Technology, Safety, Structures

Contracting Risk Management Best Practices



OVERVIEW OF INNOVATION

Incorporating best practices from transportation agencies across the country, the Michigan Department of Transportation's (MDOT) Innovative Contracting program developed a new set of customized tools, documents and other resources in one user-friendly workbook to help identify, document, and manage risks more effectively.

Thoroughly assessing and managing risk is critical for keeping construction projects on time and within budget.

Risk management (RM) is a project planning and control function that includes proactive efforts to identify, mitigate, and control risk throughout the project delivery process.

MDOT has been successfully applying RM on innovative contracting methods and was looking to formalize and build upon its current guidance.

To make its entire RM process more streamlined and efficient, MDOT sought to evaluate the best practices nationwide and use the information to develop new tools, templates, training documents, and customized guidance.

The insight guided the department during the development of a new and improved set of customized tools, documents and guidance to ensure MDOT's construction projects are on track to save time and money.

BENEFITS

MDOT is better able to identify and manage project risks with a new RM toolbox, consisting of a variety of easy-to-use applications, templates and procedural guidance.

FIND OUT MORE . . .

Research Spotlight Brief:

<https://www.Michigan.gov/MDOT/-/Media/Project/Websites/MDOT/Programs/Research-Administration/Research-Spotlights/SPR-1711-Spotlight.pdf>

Final Report:

<https://www.Michigan.gov/MDOT/-/Media/Project/Websites/MDOT/Programs/Research-Administration/Final-Reports/SPR-1711-Report.pdf>

Risk Management Workbook:

https://www.Michigan.gov/mdot/-/media/Project/Websites/MDOT/Business/Contractors/Innovative-Contracting/Risk-Management-Template_MDOT-Risk-Management-Workbook_r1.xlsx

Michigan Department of Transportation

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Tools, Best practice, Risk Management

BridgeWatch: Public Safety Through Real-time Structure Monitoring



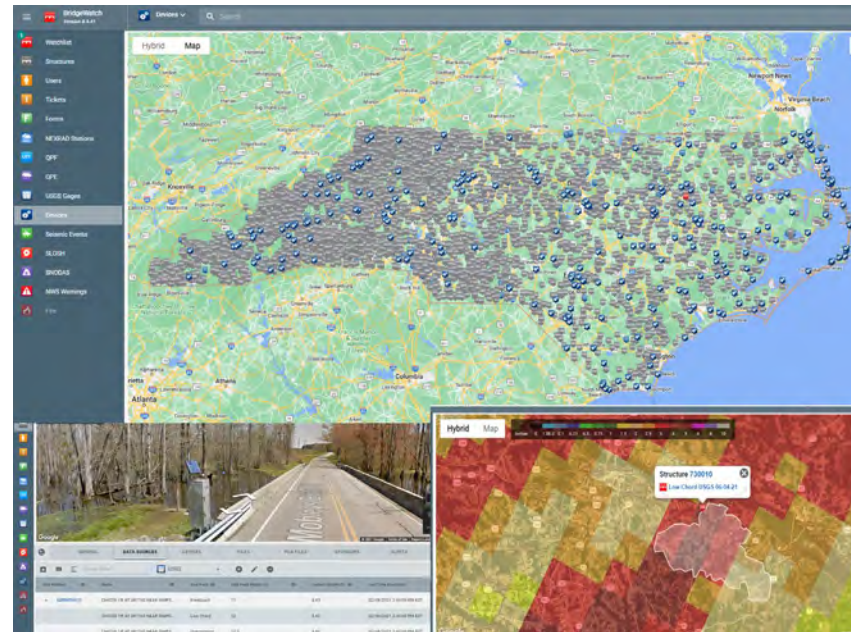
OVERVIEW OF INNOVATION

BridgeWatch empowers bridge management to predict, identify, prepare for, and record potentially destructive environmental events by proactively monitoring, in real-time, bridge infrastructure.

BridgeWatch collects and processes real-time data at regular intervals from meteorologic, hydrologic, and oceanographic sources, gauges, and other sensing devices. Data comparisons are then performed with internal NCDOT bridge parameters such as flood impact (floodwaters reaching structure levels) or roadway overtopping. NCDOT officials and Emergency managers can customize alerts, when appropriate, via any electronic medium (cell phones, email, application dashboard, etc.) when bridges are experiencing a dangerous or critical condition.

Officials are notified as sensors in the field detect water levels or high rainfall intensity levels that could indicate that the roadway is overtopped either at the bridge or bridge approaches based on elevation or design data. This valuable information can be used for road closure, emergency response, and post-event inspection prioritization.

In addition, BridgeWatch can also be utilized as a hands-on training and scenario tool for emergency evacuation or security drills with event simulation capabilities.



Source: BridgeWatch

BENEFITS

The benefits of using BridgeWatch include improved monitoring and awareness of structures impacted during major storm events.

In the past 3 years, the North Carolina DOT has piloted BridgeWatch and integrated it into its storm response. Structures management uses BridgeWatch alerted structures to aid in identification of critical structures to inspect post-storm.

FIND OUT MORE . . .

NCDOT BridgeWatch Website (Login Required) [BridgeWatch v8.4.41 from USEngineeringSolutions](#)

Hydraulics Storm Tools Website [NCDOT - Hydraulics & EM Flood Warning Tools - Home \(sharepoint.com\)](#)

US Engineering Solutions Website (BridgeWatch) <https://usengineeringsolutions.com/bridge-watch/>

NCDOT Hydraulics Unit

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Structure Management, Flood Warning, Emergency Response, Situational Awareness, Roadway Flooding, Hydraulics, Operations,

T-SURGE



OVERVIEW OF INNOVATION

Expanding on the FIMAN-T (Flood Inundation Mapping and Alert Network for Transportation) system, T-Surge helps NCDOT identify potentially-impacted roadways and assets during a storm surge event.

Rather than relying on gauge-based data like the rest of the FIMAN-T network, this dashboard uses data from RENCI (Renaissance Computing Institute at The University of North Carolina), which models storm surge for the entire North Carolina coastline based on National Hurricane Center official advisories.

T-Surge automatically downloads maximum water elevation and wave height rasters as soon as they are available. This data runs through a model that maps predicted flood inundation extents and depths, and uses lidar-derived roadway elevations to estimate flooding along roadways. The roadway inundation is then viewable on the interactive dashboard application that allows users to view mapping, filter roads by type and depth of flooding, and view summaries of predicted impacts.

T-Surge provides visualization and metrics for roadway inundation from forecasted hurricane and tropical storm surges. The dashboard application maps predicted flood and roadway impacts for the entire North Carolina coastline. This information allows emergency managers and first responders to reach critical destinations, like hospitals, while avoiding potential roadway flooding.

BENEFITS

- Easily identify areas and roadways forecasted to be impacted by flooding during a storm event
- Provides summary reports and navigable tables for predicted roadway inundation to aid in quick decision-making
- Expands coverage to include all coastal areas

FIND OUT MORE . . .

[T-Surge Dashboard](#) (beta version – open to NCDOT staff)

NCDOT Hydraulics Unit

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Emergency Response/ Relief, Technology,
Roadway Flooding, Inundation Mapping,
Hurricane Preparedness

New Hampshire DOT incorporates a culvert diffuser in a pipe rehabilitation project in Exeter, New Hampshire.

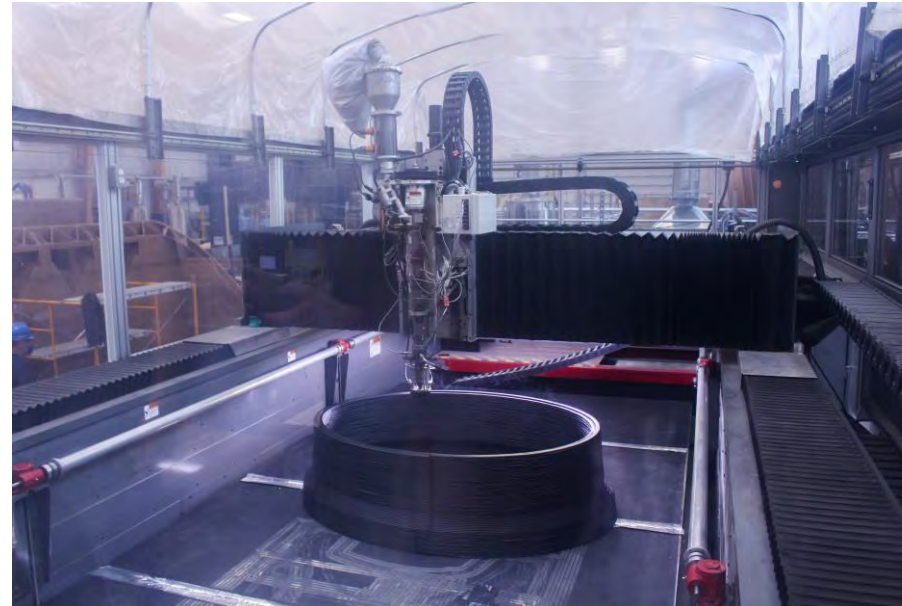


OVERVIEW OF INNOVATION

Building on a Maine DOT research project, State Transportation Innovation Council (STIC) funding provided for the inclusion of a culvert diffuser in a NHDOT project.

State DOTs have a need for increasing the capacity of existing culverts through deep embankments with high traffic and difficult access. Recent research by Maine DOT, has demonstrated the effectiveness of installing a culvert diffuser at the outlet, increasing the culvert capacity and lowering the outlet velocity.

A pipe rehabilitation at Rocky Hill Brook under NH 85 in Exeter, New Hampshire, was needed for NHDOT Project 43254. The NHDOT Highway Design Specialty Section developed an alternative solution for a 42-inch corrugated metal pipe (CMP) liner that incorporated a 15 foot long by 5.83 foot wide, 3D printed diffuser at the outlet.



3D printing of the culvert diffuser at the University of Maine in Orono, ME
Source: TIDC

BENEFITS

The installation of the diffuser at the outlet of the culvert provided an estimated 40 percent increase in outlet capacity. The innovative method of 3D printing was used in manufacturing the outlet diffuser at the Advanced Structures and Composites Center and Transportation Infrastructure Durability Center (TIDC) at the University of Maine, Orono, Maine.

FIND OUT MORE . . .

NHDOT Contact:

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Project Partners:

Maine DOT
Alexander W. Mann

Outlet Diffusers to Increase Culvert Capacity (Technical Report 14-17)

<https://rosap.ntl.bts.gov/view/dot/31351>

Transportation Infrastructure Durability Center (TIDC), University of Maine

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culvert diffuser, 3D printing

Improving a road-stream crossing in northern New Hampshire benefits Eastern brook trout and mammals



OVERVIEW OF INNOVATION

New Hampshire DOT partners with The Nature Conservancy to improve wildlife connectivity across US 3 in Stratford, NH

Habitat fragmentation threatens the long-term sustainability of healthy wildlife populations. In 2009, New Hampshire Department of Transportation (NHDOT) and The Nature Conservancy (TNC) began addressing landscape connectivity across northern Vermont and New Hampshire. This project helped restore aquatic connectivity in the Connecticut River Valley by replacing a deteriorated culvert in a high priority site for Eastern brook trout and multiple mammal species that reside in the area.

The bottom of the culvert was specifically designed to provide for aquatic passage through a low flow channel and for mammal passage via a wildlife shelf. The project is part of the Staying Connected Initiative (SCI) that spans from the Tug Hill Plateau west of the Adirondacks, across Vermont, northern New Hampshire and Maine, and into the Canadian Maritimes.



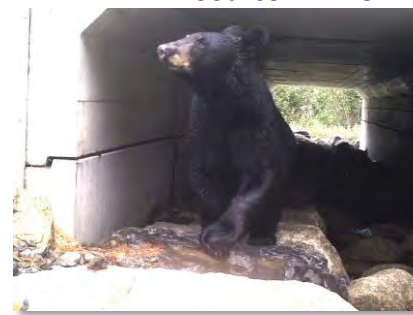
Source: NHDOT



Source: NHDOT



Source: TNC



Source: TNC

BENEFITS

Six months of wildlife camera trap monitoring at the crossing indicated that the culvert is regularly used by small mammals to cross under US 3. It is anticipated that more wildlife will use the improved culvert rather than crossing at the roadway surface, enhancing safe passage for aquatic and terrestrial species and safety for drivers.

FIND OUT MORE . . .

NHDOT Contact:

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Asst. District Engineer

NHDOT Maintenance District 1

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Project Partners:

- *New Hampshire DOT*
- *The Nature Conservancy (TNC)*
- *New Hampshire Fish & Game*
- *National Fish & Wildlife Foundation*

wildlife crossing, culverts, landscape, aquatic, terrestrial, connectivity, sustainability, environment, structures, stormwater management

Bicycle-Friendly Resurfacing in Mercer County



OVERVIEW OF INNOVATION

Mercer County's Bicycle Friendly Resurfacing Program integrates bicycle facilities into resurfacing projects and ensures that bicycle facilities are considered during routine road maintenance, reconstruction, construction, and land development reviews to create a network in alignment with the County's Complete Streets Policy.

The Mercer County Bicycle Master Plan describes factors for analysis of County Roads such as cartway width, environmental constraints, crashes records involving bicycles, network connectivity, Level of Traffic Stress (LTS), Annual Average Daily Traffic, truck volumes, existing bus routes, existing and proposed speed limits, bicycle travel demand modeling and 8-80 Design.

Some routes require simple striping and others will require more intensive work such as road widening or intersection redesign that may involve drainage or right-of-way issues for example. The County prioritizes roadways that are in need of repaving, and only need additions of epoxy paint or thermoplastic and signage to define the bicycle facility, and continues to plan for more complicated segments.

BENEFITS

Bicycle infrastructure is integrated into the repaving program to conduct all work at one time which increases efficiency and cost savings.

The addition of bicycle infrastructure increases safety for all road users.

The integration of bicycle facilities into resurfacing projects advances a multimodal network in alignment with the County's Complete Streets Policy.

FIND OUT MORE . . .

2020 Mercer County Bicycle Plan Element
<http://www.mercercounty.org/departments/planning/2019-bicycle-master-plan>

NJ STIC Innovation Spotlight: Bicycle-Friendly Resurfacing Program
<https://www.njdottechtransfer.net/bike-friendly-resurfacing>

FHWA's Incorporating On-Road Bicycle Networks into Resurfacing Projects
https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/resurfacing/

Mercer County Planning Department

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Safety, Planning, Pavement, Maintenance

Ultra High Performance Concrete for Bridge Repair



OVERVIEW OF INNOVATION

An NJDOT pilot project demonstrated that UHPC overlay will provide durable bridge decks that will extend the service life of the structures. Additionally, the project showed that UHPC overlay construction methods can minimize traffic interruptions and shorten the total construction time.

NJDOT installed three UHPC bridge deck overlays as pilot projects. One of these projects, completed on a bridge spanning the Newark Turnpike, included both a UHPC bridge deck overlay and field-cast UHPC joint headers.

This curved 3-span bridge, originally built in 1979, feeds nearly 30,000 vehicles per day from the New Jersey Turnpike onto I-280. The heavy traffic and the impact of de-icing salts resulted in corrosion of the reinforcing steel in the existing bridge deck, as well as the deterioration of all abutment and pier expansion joints.

Prior to installation of the UHPC overlay and field cast UHPC headers, the existing asphalt overlay and deteriorated expansion joints were removed. A new UHPC header expansion joint solution was installed, and after installation the finished UHPC overlay was covered with asphalt.

The resulting 340-foot UHPC overlay is currently the longest continuous overlay installation in North America.



Source: New Jersey Department of Transportation

BENEFITS

UHPC bridge overlays offer superior bond strength, compressive strength, lower permeability, more resistance to freeze thaw-damage, good abrasion resistance, and rapid cure times, among other benefits.

Increases safety and efficiency due to fewer days required for construction, and less impact on the traveling public due to traffic interruptions.

FIND OUT MORE . . .

NJ STIC, UHPC for Bridge Preservation and Repair in NJ

<https://www.njdottechtransfer.net/UHPC-bridge>

Design, Construction, and Evaluation of UHPC Bridge Deck Overlays for NJDOT - Presentation

<https://www.njdottechtransfer.net/UHPC-presentation>

New Jersey Department of Transportation

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Structures, Construction, Pavement, Materials

Bridge Upcycling



OVERVIEW OF INNOVATION

“Upcycling is the act of taking something no longer in use and giving it a second life and new function.” - Habitat for Humanity.

The innovative Ohio County Engineer’s Bridge Upcycling program is the state LTAP Center’s top Local Public Agency success story.

The Ohio Department of Transportation partnered with the County Engineers Association of Ohio to upcycle steel beams leftover from bridge projects that were demolished or rehabilitated.

Reusing this existing product helps stretch financial resources and reduces potentially unsafe bridge rating conditions.

Two Ohio counties, Defiance and Muskingum, have successfully used upcycled steel beams on several projects.

"It's a benefit to our county, a benefit to our community, and we're not scrapping valuable products," said Muskingum County Engineer Mark Eicher.

Defiance County Engineer Warren Schlatter praised the program's cost savings benefits and is confident that the bridge is just as safe and just as strong as if they had used new steel.

"So, in the end the capacity of the bridge is not of concern. These are rock solid bridges," he said.



Upcycled bridge beams ready for a local construction project. - The Toledo Blade newspaper

BENEFITS

Upcycling reuses steel bridge beams that previously had been discarded.

Saves costs by reducing the need to fabricate new material.

Enables additional bridge reconstruction and enhances motorist safety.

FIND OUT MORE . . .

<https://youtu.be/r5AyX5uDH8U>

Muskingum County Engineer

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Sustainability, Planning, Structures,
Construction, Materials, Asset
Management

Catch Basin Trailer



OVERVIEW OF INNOVATION

Outfitting an available trailer with equipment and materials needed to replace or repair catch basins has improved service, increased efficiency, and reduced costs associated with this ongoing Violet Township, Ohio work.

Before implementing the trailer's use each catch basin took hours to repair. Preparing the materials and equipment would take at least an hour alone.

Its use also reduced the number of people and equipment that were needed for the work.

Using the trailer freed two employees that could be deployed for other work.

An additional benefit includes if a basin is observed in the field and needs repaired the only requirement now is hitching the trailer and returning to complete the needed work eliminating time consuming prep.



Outfitted trailer ready for catch basin repair project - Violet Township, Pickerington, Ohio

BENEFITS

Reduces set up and break down time.

Saves taxpayer funding.

FIND OUT MORE . . .

[Welcome to Violet Township, OH](#)

Violet Township

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Operations, structures, maintenance

Drone Bridge Inspection



OVERVIEW OF INNOVATION

The Ohio Department of Transportation's (ODOT) expansion of Unmanned Aircraft System (UAS) bridge inspections allowed the department to reduce costs and time associated with essential structure examinations.

ODOT used State Transportation Innovative Council (STIC) funding to purchase equipment and software for new and existing pilots.

A total of eight Skydio 2 UAS and one Skydio X2E were purchased using STIC and ODOT funding. Initially UAS's were mainly used as a supplement for snooper truck inspections. However, the department is moving toward drone use for other services as well.

This migration to using UAS for bridge inspection has significant cost savings. A UAS inspection can be carried out by one or two bridge specialists, without any need for traffic management personnel or equipment. The use of drones for bridge inspections has saved the department over \$1.6 million.

The use of a drone to conduct bridge inspections eliminates the need for lane closures that can cause traffic delays and safety hazards that existed previously with snooper or bucket truck use.

Expanded drone bridge inspections were particularly beneficial during the height of COVID-19 because a minimal number of inspectors could complete this important task while social distancing.



Drone Bridge Inspection of the Jeremiah Morrow Bridge, Warren County, Ohio - Ohio Department of Transportation

BENEFITS

UAS inspection requires fewer people, less time, and reduces costs as compared to using a snooper truck.

Less travel disruption to motorists.

Improved safety conditions.

FIND OUT MORE . . .

[DriveOhio | Ohio.gov](https://www.driveohio.com)

[About UAS | Ohio Unmanned Aircraft Systems Center](#)

ODOT Office of Unmanned Aircraft Systems

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Safety, Operations, Structures, Technology,
Asset Management

Hybrid EDC Training: Success Stories of Next Generation TIM & Microsurfacing Using Drones in Puerto Rico



OVERVIEW OF INNOVATION

The Puerto Rico LTAP has adapted its training program to address a combination of strategic virtual webinars, field demonstration of EDC proven initiatives combined with UAS (unmanned aerial systems), and in-person seminars to be able to open the educational spread to all of our stakeholders. Vital elements for the success of the hybrid EDC trainings in Puerto Rico includes:

- Webinar to present the practical uses of UAS in the transportation area.
- Field Demonstration with different types of drones used for Traffic Incident Management.
- Hands-on practice on flying a UAS.
- Assistance in taking *The Recreational UAS Safety Test* (TRUST) Certificate.
- Includes a bilingual translation of pertinent technical information when a SME (subject matter expert) from State and Federal agencies from Puerto Rico and the US are in the same technical session.
- Use of mentimeter with strategic poll questions to know the diversity of our participants and promote active participation in the hybrid training.



Sources/Credits: Puerto Rico LTAP-T², FHWA, PRHTA & NICR

BENEFITS

A 100% increase in participation in virtual events.

Improve adult learning with one-to-one technical assistance in using apps; train-the-trainer with field demos and technical assistance in the process for UAS recreational license exam.

Raise safety awareness in work zones for all users.

The learning process of EDC initiatives and emerging technologies is fun and exciting for participants of all ages, and is cost effective.

FIND OUT MORE . . .

PRLTAP Website

<https://www.prltap.org>

PRLTAP Webinars Recordings

<https://www.gotostage.com/channel/prltap>

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Technology Transfer, Continuing Education, TIM, EDC, Traffic Incident Management

Develop a DOT Specific UAS Simulator and Flight Proficiency Exam



OVERVIEW OF INNOVATION

Most state DOT Unmanned Aircraft Systems (UAS) commercial operations are governed by CFR 14 Part 107. This regulation requires pilots pass a knowledge test but does not require a demonstration of minimum flight proficiency to operate in the national airspace. This project addresses this limitation by developing a computer-based flight proficiency simulator based on the National Institute of Standards and Technology (NIST) Basic Maneuvering Test (BMT). The simulator realistically recreates environmental conditions, UAS physics, stick control and field conditions of the BMT. A “drone rodeo” was hosted to evaluate if the simulator BMT performance data is simulator to traditional in-person methods. Twenty-four Part 107 pilots completed the BMT in-person and with the simulator. At 95% confidences, the pilots scores at times were statistically the same. The significant percentage of the SCDOT pilots completed the BMT under proctored conditions. Based on their performance and similar nationally recognized organization’s certifications, the research team recommends that the SCDOT require a minimum score of 80% on the BMT with a maximum duration of 5 minutes per maneuver before flight privileges are granted. In addition to the NIST scenarios develop, a bridge inspection scenario was developed to support this common use for UAS.



Source: Clemson University

BENEFITS

Drone flight proficiency is a skill that requires continual practice. The simulator developed in this project provides a convenient way to practice, teach and assess UAS flight skills. This software is available at no cost to all state DOTs.

To date, 24 state DOTs have requested licenses and made this simulator an important part of their drone program.

FIND OUT MORE . . .

Little Arm Studio:

<https://www.zephyr-sim.com/>

Clemson University – Department of Construction, Development, and Planning:

<http://www.clemson.edu/degrees/construction-science-and-management>

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Joe Burgett (Clemson University)

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UAS, UAV, Drone, Simulator

Strategic Deployment of Drone Technology and Software to Support SCDOT Operations



OVERVIEW OF INNOVATION

A recent FHWA publication found that all 50 state DOT's are using Unmanned Aircraft Systems (UAS), commonly referred to as "drones," in some capacity. As the cost of UAS equipment can be relatively low, the greatest challenge limiting the benefit that this technology can provide is the lack of education and training. By partnering with Clemson University, this project aggressively addressed this challenge and made meaningful drone deployment a viable option for employees across the SCDOT. The project leveraged Clemson University's nationally recognized School of Construction Management to develop a drone training program tailored to the SCDOT's needs. The course was structured so Clemson students and SCDOT employees could work shoulder-to-shoulder as they learned leading edge drone workflows. The program participants came from a wide range of SCDOT offices including (among others) Construction, Communications, IT Services, Preconstruction Engineering, Planning, Traffic Engineering, Survey and Maintenance. Through its professional studies program, Clemson University has made this course available fully online to any state DOT.



Source: Clemson University

BENEFITS

This project created an in-person and online drone course for SCDOT employees. During the class, students earn their FAA Part 107 drone license, flight skills (in-person and with a simulator), and how to create 3D maps/models with drone data. It is an excellent way for employees to gain the skills and knowledge to operate a UAS to benefit their department.

The course is available online for all state DOT employees.

FIND OUT MORE . . .

Overview video of the course:
<https://www.youtube.com/watch?v=YlkoQl64D3w>

Clemson University – Department of Construction, Development, and Planning:
<http://www.clemson.edu/degrees/construction-science-and-management>

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UAS, UAV, Drone, Class, Course, Professional Development

Perform Feasibility Study on Use of Innovative Tools and Techniques to Accelerate Pavement Construction



OVERVIEW OF INNOVATION

2022 Sweet Sixteen Winner

The goal of accelerated construction is to minimize construction zone impacts to the driving public. This research project investigated techniques to evaluate the pavement condition, rehabilitation options and estimate pavement construction traffic impacts before letting.

There is potential for significant time and money savings when the existing pavement, proposed pavement design, and traffic control scenarios are evaluated and optimized.

A novel construction schedule/cost/traffic integration approach was implemented to help TxDOT make the most informed decisions regarding balanced trade-offs to lessen traffic disruption to the traveling public while minimizing construction time and road user cost.

The researchers prepared and presented training materials and guidance to include methodology, testing procedures, and other tools used in the selection and design of pavement for candidate projects.



Source: TxDOT Project 0-6985

BENEFITS

Value to TxDOT: Leads to routinely selecting pavement design strategies that are fast to construct to achieve statewide goals.

Savings for TxDOT: The ROI to TxDOT is expected to be \$150.13 for every dollar spent on this research project.

FIND OUT MORE . . .

Project Web Link: [TxDOT Research Library: Project No. 0-6985](#) – Use of Innovative Tools & Techniques to Accelerate Pavement Construction

Video: <https://youtu.be/ENl4t82yf1w>

Texas STIC Website: <http://txstic.org/>

Contact Info:

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Darlene Goehl, Principal Investigator, Texas Transportation Institute

Keywords: Pavement, Design, Construction

Aerial Images Used to Conduct Pavement Inspections

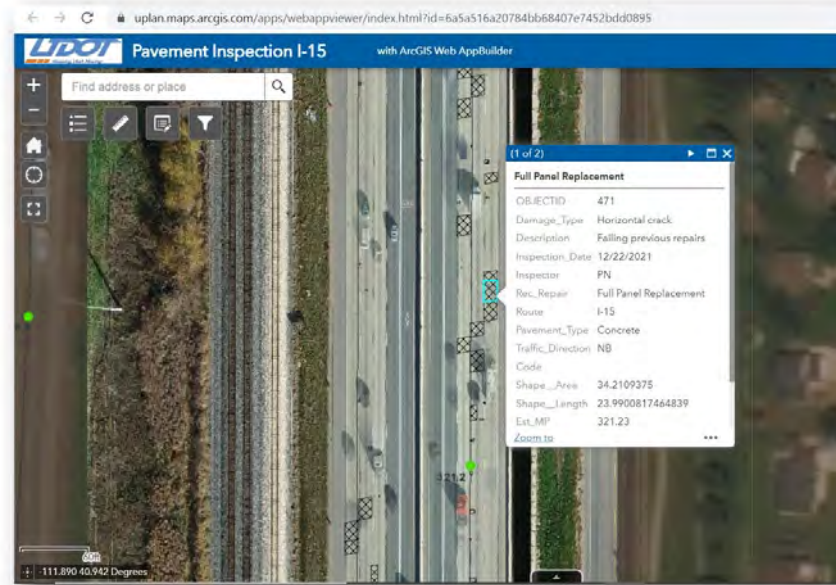


OVERVIEW OF INNOVATION

The aerial images are used to create a dynamic GIS map with embedded feature layers to mark the necessary repairs.

This new method of conducting pavement inspections results in improved efficiency, safety, and accuracy of inspections. The UAS pilot can collect images of the area in need of repair from a safe distance, and the inspection completed on a computer in the office. The location of the repairs and damage area measurements are marked with greater accuracy, leading to better project cost estimates. This in turn decreases the number of change orders made during construction.

The Central Design and GIS teams are taking the next steps to improve this new process by developing a machine learning program that will analyze photos taken by a UAS and automatically identify cracks and potholes to create a database for further processing.



Source: UDOT UPLAN

BENEFITS

Using aerial imagery is helping crews conduct inspections that are done more efficiently and with greater accuracy and safety.

FIND OUT MORE . . .

[Technical summary document](#)

Information from 2023 Innovation and Efficiency Report

[Aerial Images Used for Pavement Inspections](#)

For more information:

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Safety, Maintenance, Pavement, Asset Management

Innovative Design Technology for Ultra Long Span Precast, Prestressed Concrete Bridge Girders



OVERVIEW OF INNOVATION

Advanced design methodology coupled with state-of-the-art software enable design of ultra long and efficient concrete bridge girders, reducing project cost and improving on-site safety.

Extending the span length of precast concrete bridge girders beyond 200 feet in length presents unique challenges for design, fabrication, handling, and erection. An advanced design methodology cooperatively developed by the Washington State DOT and local precast concrete producers results in designs that support optimized fabrication and safe handling of precast concrete girders at the manufacturing facility, during transportation, and on-site.

State-of-the-art open-source software, named BridgeLink:PGSuper, has been collaboratively developed by the Washington State and Texas Departments of Transportation implementing this design technology. This software is used by DOT, local agency, and consulting engineers around the country and by international engineering organizations.

The technology for designing ultra long span girders has been successfully deployed in Washington State. The recently completed Wapato Way bridge over Interstate 5 in Fife, WA features 220 ft long girders weighing in excess of 220,000 lbs. each, spanning 10 traffic lanes, 4 shoulders, and the median in a single span. The median pier was eliminated reducing project cost and improving on-site safety by eliminating the dangerous work area between north and southbound highspeed traffic. The recently completed Interstate 5 bridge over the Puyallup River features a span of record setting 223 ft long girders.



Source: WSDOT

BENEFITS

The benefits of the BridgeLink:PGSuper software and its advanced design technology include:

- reduced design time
- technical solution for designing ultra long span precast, prestressed girder
- designs that support optimization of fabrication processes
- improved safety during manufacturing, transportation, and on-site construction activities

FIND OUT MORE . . .

WSDOT Bridge Software Tools
<https://wsdot.wa.gov/engineering-standards/design-topics/bridge-software-tools-downloads>

WSDOT Bridge Design Manual
<https://www.wsdot.wa.gov/publications/manuals/fulltext/M23-50/BDM.pdf>

Brice, R. 2009, *Design optimization for fabrication of pretensioned concrete bridge girders: An example problem*. PCI Journal, Fall 2009, V. 54, No. 4. pp 73-111

WSDOT Bridge and Structures Office

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Precast, Prestressed, Concrete, Girders, Bridges, Fabrication, Optimization, Safety, Design, Construction, Technology

Design Technology for Ultra High Performance Concrete (UHPC) Precast, Prestressed Bridge Girders



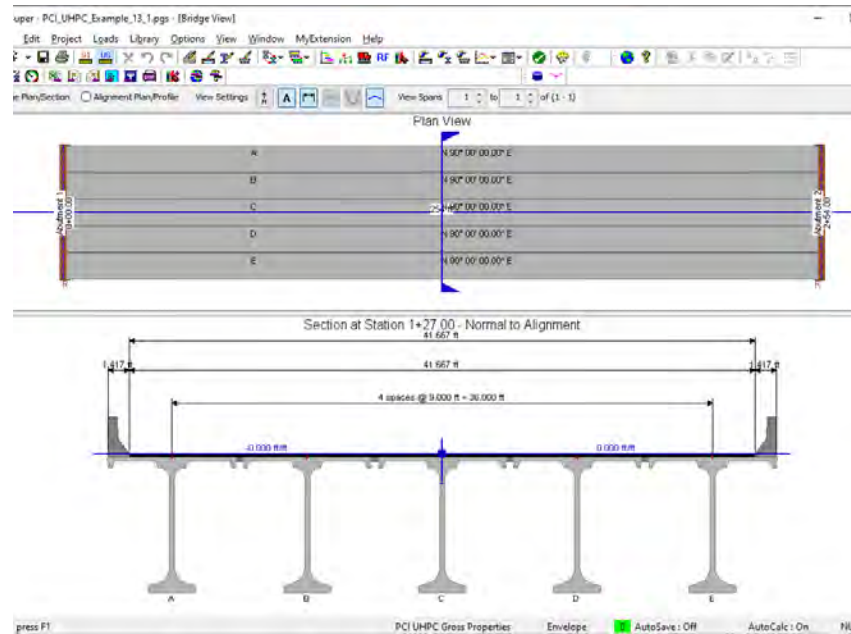
OVERVIEW OF INNOVATION

UHPC is an innovative concrete material gaining traction in the US infrastructure sector. The BridgeLink:PGSuper bridge design software has been updated to support design for precast, prestressed UHPC bridge girders.

UHPC is a fiber-reinforced composite cementitious material with unique properties that differ greatly from conventional concrete. UHPC provides superior durability and high tensile and compressive strengths compared to other classes of concrete. The Precast/Prestressed Concrete Institute (PCI) and the Federal Highway Administration (FHWA) have developed structural design guidance for precast, prestressed concrete bridge girders manufactured with UHPC. This guidance is being coalesced into AASHTO guide specifications.

Washington State and Texas Departments of Transportation collaboratively developed open-source bridge design software named BridgeLink:PGSuper. This software is used by DOT, local agency, and consulting engineers around the country and by international engineering organizations. The software has been recently updated to support design of precast, prestressed UHPC girders with both the PCI and FHWA structural design guidance.

Many US bridge engineers are unfamiliar with the use of UHPC in precast structural elements. The BridgeLink:PGSuper design technology reduces barriers for adopting UHPC solutions and provides engineers with an important tool that supports the implementation of UHPC in US infrastructure projects.



Source: WSDOT

BENEFITS

The benefits of the BridgeLink:PGSuper software and its UHPC design capabilities includes:

- supporting national implementation of UHPC bridge girders
- open-source software available to everyone for production design and research implementations
- educating design engineers on UHPC design requirements

FIND OUT MORE . . .

WSDOT Bridge Software Tools
<https://wsdot.wa.gov/engineering-standards/design-topics/bridge-software-tools-downloads>

Tadros, M., *Implementation of Ultra-High Performance Concrete in Long-Span Precast Pretensioned Elements for Concrete Buildings and Bridges, Phase II Report*, Sept. 15, 2021, Precast/Prestressed Concrete Institute

WSDOT Bridge and Structures Office

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Precast, Prestressed, Concrete, Girders, UHPC, Software, Structures, Design, Technology, Pavement