Massachusetts Department of Transportation Technology Applications on the Callahan Tunnel Project

SMARTER WORK ZONES TECHNOLOGY APPLICATIONS CASE STUDY

The Every Day Counts Initiative (EDC-3) aims to accelerate the deployment of identified, but underutilized innovative practices that focus on reduced project delivery schedules, increased roadway safety, reduced congestion, and/or enhanced environmental sustainability. Smarter Work Zones (SWZ) is one of three EDC-3 initiatives focused on safety and mobility, and was developed to promote safe and operationally efficient work zones through *project coordination* and *technology application* strategies.

This case study focuses on technology applications for the Callahan Tunnel Rehabilitation Project deployed by the Massachusetts Department of Transportation (MassDOT). **Technology applications involve deployment of intelligent transportation systems (ITS) for dynamic management of work zone traffic impacts to improve motorist and worker safety and mitigate work zone-related congestion.**

Background

MassDOT conducted an accelerated construction project that closed the Callahan Tunnel in Boston from December 2013 to March 2014. This narrow, two-lane tunnel is a major commuter link carrying 30,000 vehicles per day outbound from Downtown Boston to Logan International Airport and East Boston, with 1,200 vehicles per hour during the morning peak hour and 2,300 vehicles per hour during the afternoon peak hour. Planning for a full tunnel closure on this project presented a significant challenge for MassDOT in trying to accommodate the displaced traffic during construction, especially during the afternoon peak hour. To address the challenge, MassDOT followed a systems engineering process, such as that outlined in the Federal Highway Administration's (FHWA's) *Work Zone ITS Implementation Guide* (FHWA-HOP-14-008), to successfully deploy smarter work zone technology, as presented in this case study.

Assessment of Needs

Due to the impact of a full tunnel closure on a major transportation link, MassDOT conducted a large-scale coordination effort with partner agencies to develop the transportation management plan (TMP) for the project. These partner agencies included the Massachusetts Port Authority (Logan Airport and Maritime Port), the Massachusetts Bay Transit Authority (MBTA) (transit services), City of Boston Transportation Department (local roadway network), law enforcement, and first responders.

In planning for the Callahan Tunnel Rehabilitation Project work zone, MassDOT first identified a need for real-time traffic condition information internally, as well as for

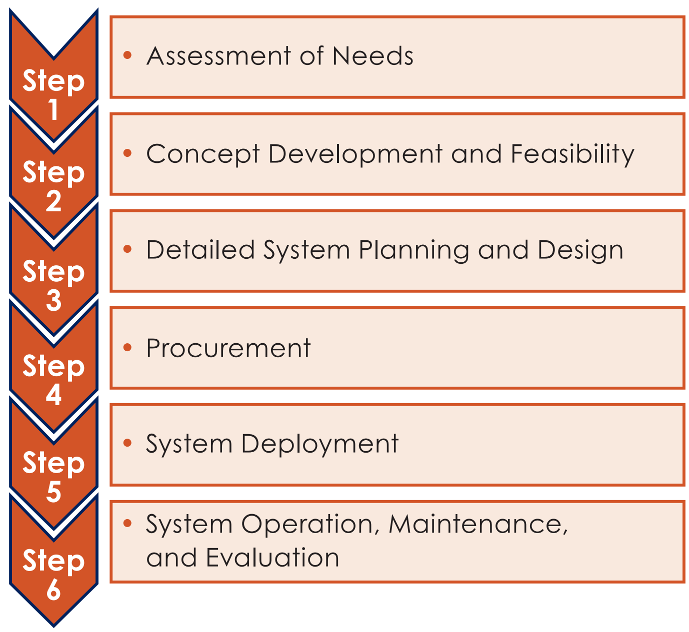

Figure 1: The Work Zone ITS Implementation Guide six-step process. *Source: Battelle*

stakeholders and motorists, to manage delays on routes that already experience recurring congestion in order to achieve several system goals:

- *Mobility* – minimize congestion by monitoring queues and managing delays, through queue management, providing route guidance with travel/delay times and encouraging traffic diversion to alternate routes with available capacity
- *Safety* – minimize the frequency and severity of traffic-related incidents, injuries and fatalities on the alternate routes
- *Performance Measurement* – collect operations data to develop performance reports, allocate enforcement patrols, refine allowable working hours, and evaluate throughput capacity

Concept Development

In response to the needs identified as part of Step 1 in the work zone ITS implementation process, MassDOT developed a comprehensive concept of operations that envisioned an ITS application to provide real-time conditions and traveler information to motorists to improve their route selection decisions. Unlike traditional construction projects that establish a set detour route, MassDOT identified three alternate routes to navigate travelers to areas served by the Callahan Tunnel, including East Boston and Logan Airport. Figure 2 shows an overview of the alternate routes for southbound traffic.

In addition to using work zone ITS to address expected traffic impacts, MassDOT conducted other early action items, including:

- Removing a median barrier to realign the through travel lanes on Route 1A and provide increased queue storage for a congested off-ramp along a key alternate route.
- Evaluating existing operations at 25 signalized intersections, upgrading equipment, and implementing new timing plans to improve traffic progression along the alternate routes.

Figure 2: Alternate Routes for Callahan Tunnel Closure from the north. *Source: MassDOT*

System Design, Procurement, and Deployment

MassDOT has hired a consultant to provide work zone safety support, and leveraged that contract for writing the ITS specifications on this project.[1] The traffic monitoring and management component designed for the Callahan Tunnel Project technology system included the following ITS equipment and technology:

- 15 portable cameras,
- 6 portable camera/changeable message sign (CMS) combination units,
- 5 portable CMS (PCMS), and
- Probe Sensor (Vehicular) Data from the alternate routes.

While some field sensors were used for data collection purposes, probe data was needed for comprehensive travel time information on the network, since too many sensors would be required for that purpose.

MassDOT procured all ITS equipment as a single item lump sum bid in the larger construction contract. As a part of this contract item, the contractor also acquired probe data from a private sector provider. The cost for this ITS equipment and technology was $950,000, which represents five percent of the full contract value. While costs will vary for every contract, equipment mobilization and calibration can require significant resources and represent a lower proportion of the cost when spread out over a longer duration than this four-month project. Because this project occurred during the winter months, maintenance costs may also make this value higher.

In general, the costs of these types of ITS equipment fluctuate based on various factors like project duration and location, equipment quantities, specific data needs, web or software integration, and integration with outside data. Specifically, MassDOT noted unit monthly costs to be in the range of:

- Portable camera with trailer: $1,000-$1,300
- PCMS, solar with remote operation: $500-$750
- Queue Sensor Trailer with lane-by-lane data capture: System Operation with unlimited data plan: $2,500 - $3,500/month

The contractor deployed the system five weeks prior to the closure and followed a standard testing plan that MassDOT requires for all ITS deployments. Following calibration and verification of the system by the contractor, MassDOT took control of the system three weeks prior to the closure and conducted further validation checks and began posting information about the pending closure on the PCMS.

Messaging in the work zone ITS coverage area was driven by "delay threshold" logic fed by the travel times along the alternate routes, as determined from the probe vehicle data. The system was calibrated using free-flow travel time conditions as the baseline for message selection. As traffic congestion increased and average speeds dropped, the travel time thresholds triggered a corresponding message on strategically placed PCMS that suggested the best route option for motorists. Figure 3 shows the series of escalating two-phase messages that were displayed on a specific PCMS when travel times derived from sensors on one route

1 These specifications are available at: https://www.workzonesafety.org/swz/technology_application/tech_specs

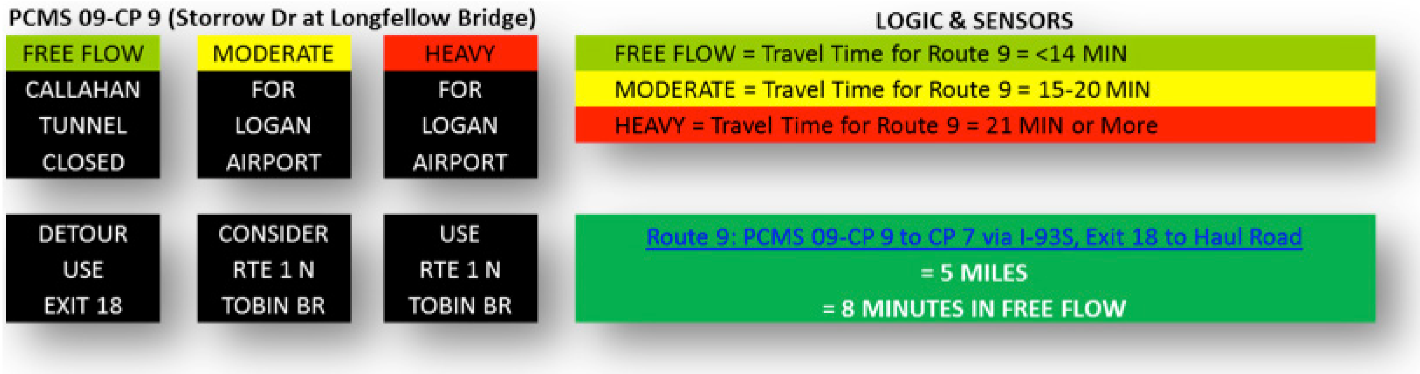

Figure 3: Example of logic for PCMS messaging corresponding to route-specific travel time sensor data. *Source: MassDOT*

indicated free flow, moderate, or heavy traffic conditions. For example, travel times less than 14 minutes for this 5-mile route were designated as free flow traffic conditions and corresponded to a two-phase PCMS message saying "CALLAHAN TUNNEL CLOSED; DETOUR USE EXIT 18."

System Operations and Maintenance

In order to manage the day-to-day operations during construction, MassDOT used a System Dashboard to provide a quick "snapshot" of traffic conditions via a map view. Color codes on the map reflected the current traffic conditions with green representing approximately posted speeds, yellow representing moderate traffic with some delays, and red conditions signifying very heavy traffic.

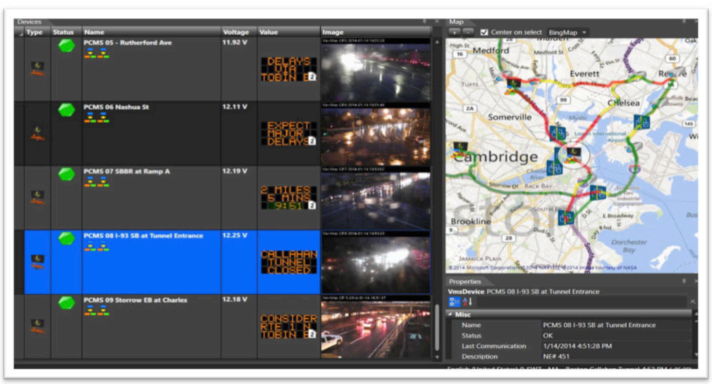

Figure 4: Screenshot of the System Dashboard. *Source: MassDOT*

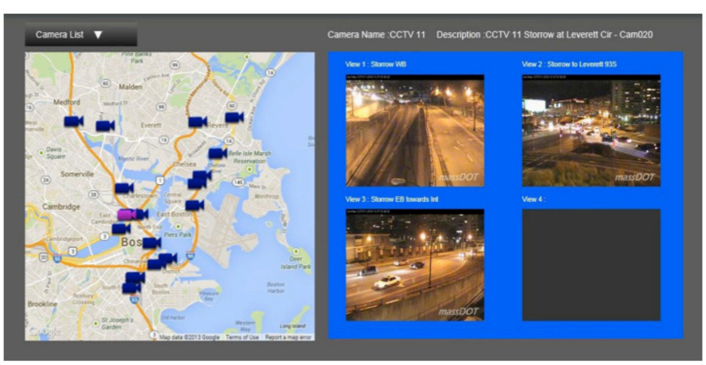

Figure 5: The Work Zone ITS Vendor Developed a Website of the Traffic Camera images for Partner Agencies. *Source: MassDOT*

The System Dashboard also displayed the current conditions occurring at the portable cameras, PCMS, and combination units. This included the equipment status, displayed message, and real-time camera image. In this way, operations personnel could access real-time camera images for individual locations and view the corresponding message on the portable boards to ensure that it correlated to the conditions displayed on the map view. Additionally, the work zone ITS vendor created a dedicated website that provided easy access to the 21 cameras that were strategically placed around metropolitan Boston. This allowed MassDOT's partner agencies to have access to the project cameras to monitor conditions and react as necessary to better manage operations of their networks and equipment.

The afternoon peak hours proved to be a significant challenge for MassDOT. This had been anticipated in the initial assessment of needs, but the deployed ITS helped alleviate congestion impacts. Using real-time data allowed the time-of-day temporary traffic control plans specifically developed for this project to be implemented in order to facilitate a reduction in the queue length and to prevent gridlock conditions.

Winter weather conditions were the primary source of maintenance issues, but the contractor was very proactive and responsive about keeping the system operational. Specifically, rain and snow would occasionally cause cameras to freeze up or obstruct the view from the cameras.

System Evaluation

At the end of the project, MassDOT evaluated the effectiveness of the system at minimizing impacts to alternate routes and identified a number of positive findings. Qualitative results indicated that there were no gridlock conditions in the network and partner agencies including the MBTA, Massachusetts Port Authority, and the City of Boston Transportation Department were able to successfully manage their systems without major traffic issues caused by the closure of the Callahan Tunnel. The real-time travel time system generated significant positive feedback from travelers and very few complaints. Travelers had the benefit of enhanced, real-time information to inform them of congestion levels and expected travel times, and to guide them to the best alternate route which reduced overall driver frustration. Travelers were also alerted to stopped traffic at the end of queues which helped to prevent incidents.

The work zone ITS was successful for the following reasons:

- The system was able to effectively distribute traffic across the network, thus preventing specific links from being overloaded.
- The technology enabled better management of traffic and public expectations, which allowed MassDOT's District Construction Engineering staff more time to concentrate on the primary job of addressing construction activities.
- Sharing access to the work zone ITS system with other state and local transportation agencies in the Boston area allowed MassDOT to better manage their network.
- While MassDOT generally shares available traveler information with other agencies, the video sharing webpage was an add-on after the initial concept of operations was developed that Massachusetts Port Authority and the City of Boston Transportation Department in particular found to be extremely beneficial.
- In general, the ability to share information is a benefit of work zone technology applications that can broaden the support for investing in ITS among a variety of stakeholders. Sharing the system also created a sense of partnership on this aggressive construction project.

Conclusions

This case study illustrates one example of work zone technology applications. As demonstrated by this example, agencies should follow a systems engineering process that identifies the appropriate strategy to design and implement, and then monitor and evaluate that deployment to gather lessons learned for future deployments.

Several specific lessons learned from MassDOT's experiences on this technology application include:

- The expected project impact on traffic operations should drive the agency's needs and goals for mitigating impacts to traffic operations.
- In addressing identified project needs, the use of portable ITS technology can be a valuable component of traffic operations management to be considered in developing the TMP.
- Development of a concept of operations early in the design process verifies that the mitigation strategy will address agency and stakeholder needs, and provides a clear understanding of the project requirements necessary to conduct a detailed system design.
- Detailed performance specifications are an absolute necessity for work zone ITS. Clearly specify what equipment is desired, how the system should operate and what data information are required in deliverables. These specifications are driven by the system requirements, which are derived from the concept of operations.
- Having a qualified technician in the field to quickly address maintenance concerns to keep the ITS operational is extremely beneficial.
- Capture the data collected through the work zone ITS and generate performance measures in an evaluation that demonstrates the benefit of data-driven work zone technology applications to agency leadership, stakeholders, and the public at-large, and informs improvements to future system deployments.

Additional resources on SWZ project coordination strategies can be found at: https://www.workzonesafety.org/swz/technology_application

For additional information, please contact:

Neil Boudreau
Massachusetts DOT State Traffic Engineer
857-368-9655
Neil.Boudreau@state.ma.us

Todd Peterson
FHWA Office of Operations
202-366-1988
Todd.Peterson@dot.gov

Jawad Paracha
FHWA Office of Operations
202-366-4628
Jawad.Paracha@dot.gov

Every Day Counts (EDC), a State-based initiative of FHWA's Center for Accelerating Innovation, works with State, local and private sector partners to encourage the adoption of proven technologies and innovations aimed at shortening and enhancing project delivery.

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