Applying Emerging Technologies to the Arizona DOT Traveler Information Program

By Arizona Department of Transportation

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Benefits Statement

ADOT's Vehicle-to-Everything (V2X) technology saves lives by issuing real-time warnings, reduces congestion to save time, and cuts costs by minimizing infrastructure needs. This scalable approach fosters collaboration among agencies, potentially reducing expenses and improving traffic management efficiency.

In this case study you will learn:

1. How V2X technology is used for road safety in Arizona, including back-of-queue and curve speed warnings.
2. How V2X analyzes probe data, implementing measures to address congestion and accidents on Phoenix Metro highways.
3. How traveler notifications were tested and validated, and how they can potentially expand this solution to other states and telecom providers.

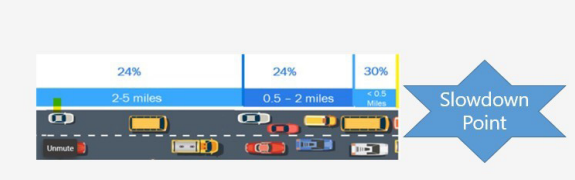
Case Study #171

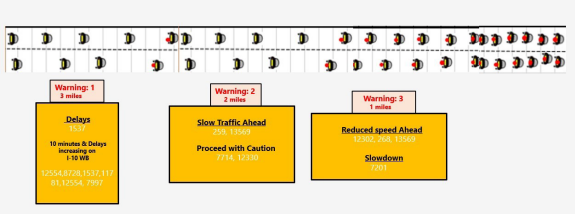
Version Number: 1

BACKGROUND

Traffic volumes are increasing as more people move to Arizona. Fatalities and crashes are trending higher. In some situations, speed differentials from non-recurring incidents, congestion, or work zones can cause crashes into the back-of-queue. The Arizona Department of Transportation's (ADOT) current traffic communication methodology includes Dynamic Messaging Signs (DMS), static signs, or apps such as AZ511. DMS and static signs can only be used in fixed locations. No apps currently broadcast traveler information like back-of-queue warnings or curve speed warnings. ADOT also prioritized minimizing roadway hardware investment as part of an enhanced Traveler Information Message (TIM) program to minimize demands on financial and state maintenance resources.

Based on the conditions previously described, the TSMO Division embarked on identifying a solution that provides timely and accurate information regarding roadway conditions while minimizing costs. This solution utilizes Vehicle-to-Everything (V2X) technology to disseminate safety notifications through a cell phone app and a cloud-based edge computer that compliments existing methods.

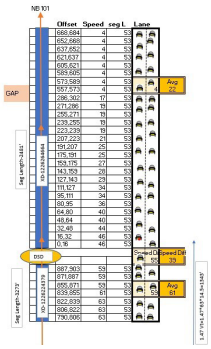




TSMO PLANNING, STRATEGIES AND DEPLOYMENT

The TSMO Division faces challenges to keep drivers safe and congestion at a minimum on its roadways. During congestion, drivers experience sudden condition changes as they pass from free-flow speeds to congested, standstill or low speed states. Secondary collisions in the queue and shockwaves are significant concerns.

Within the Phoenix Metro, four to six-lane highways like I-10, I-17, and State Route (SR) 51 lead to, through, and around Phoenix with multiple curves, merge points, on-ramps, and off-ramps. Inductive loop detectors are a mile apart, which made lane-by-lane micro-analysis difficult.

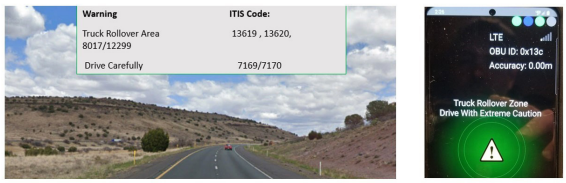


By conducting a study of probe data where we identified significant speed differentials within roadway segments. Probe subsegment speed data was collected at 53 foot intervals for each segment below near the interchange of SR 101 and SR 202 to solve this problem as shown in Figure1 (Subsegment Speed Differential analysis at 53 feet roadway segment).

The study examined several locations where large speed differentials and queuing occur, like SR 101 and US 60 as well as SR 101 and SR 202. The study also included how the congestion/queue impacts driving behavior. We piloted four use cases: Basic communications between the TSMO Division and cell phone service provider, BOQ warning, Curve Speed Warning (CSW), Work Zone Warnings as described below.

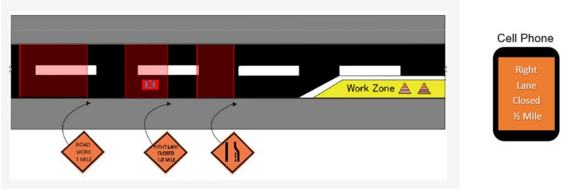
Curve Speed Warning: Studies show the vast majority of truck rollovers result primarily

from driver error. The most common driver errors are: excessive speed on curved roads, misjudging the sharpness of a turn and truck driver fatigue, impairment, or distraction To alert the driver, as shown in Figure2 we deliver a warning message dynamically to a smartphone application for drivers approaching a curve.

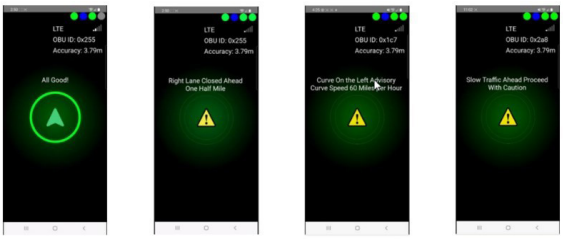


Work Zone Warning: This dynamically warns drivers of downstream work zones that sends a message to the user's smartphone using visual and audio cues. Figure3 illustrates the pilot test.

Back-of-Queue Warning: Studies show that 82% of secondary crashes occurred 15+ minutes after initial crash, 49% with 60+ minutes queues present. Figure4 shows the crash rate at 2-5 miles, 0.5-2 miles and .5 miles from initial crashes. Based on the study above, we deliver a warning message to a cell phone application for drivers approaching a congested area along a freeway which requires reduced speed. Figure5 and Figure6 shows a real-time BOQ warning Sequence on US-60. In addition the TSMO Division also received Basic Safety Messages (BSM) from the vehicle. The BSM provides accurate data to inform conditions where traffic alerts need to be sent.



The TSMO Division now had a practical solution to identify back-of-queue and other roadway conditions that could become a part of our TIM program. At this point, the TSMO Division engaged with the Maricopa Association of Governments (MAG) and their Emerging Technology Program. This program allows different technologies to be piloted with agencies like ADOT to determine their applicability to our operational needs. Figure7 are a few traveler notifications that were used in the pilot with the telecommunications provider's smartphone app.



No Warnings | Road Work Warning | Curve Speed Warning | Back of Queue Warning

COMMUNICATIONS PLANNING AND EXECUTION

The TSMO Division organization has communicated our efforts, progress and plans to various stakeholders including the Maricopa Association of Governments (MAG), Maricopa County Department of Transportation (MCDOT), Institute of Automated Mobility (IAM), Transportation Research Board (TRB), the Federal Highway Administration (FHWA) and regional Arizona universities. The project was presented at the Intelligent Transportation Society of Arizona (ITS Arizona) and the EDC 6 Crowdsourcing Conference. ADOT also participated in a peer exchange for the NCHRP 20-44(39) Implementation of Guidebook for Managing Data from Emerging Technologies by presenting a working CV solution in the cloud and will be published as a case study in late 2023.

This work is also critical to the DRIVE Arizona initiative: Digitizing Roadways with Innovative

V2X Ecosystems for a Safe and Inclusive Arizona Smart Grant provided by Strengthening Mobility and Revolutionizing Transportation (SMART) Grant Program. Additionally, the 5G telecommunications partner, in conjunction with ADOT's communication group created a public video and web site highlighting the project's viability.

OUTCOME, BENEFITS AND LEARNINGS

The TSMO Division used the MAG Emerging Technology Program to engage with a telecommunications provider to pilot a communications approach with driver's cell phones. This pilot required a number of tasks be implemented by the TSMO Division as well as the provider to meet the use case requirements explained above, This included identifying applicable programming languages, creating new software to ingest probe data and to interact with the ADOT Linear Referencing System (LRS). Additionally software was created to interact with the telecommunications provider's message broker so BSMs could be received and messages from the TSMO Division could be sent. The telecommunications company had to create software to ingest the messages sent from the TSMO Division and to provide a cell phone app that could receive them and manage audio messages to cell phone users. All of the use cases were successfully completed which made the next implementation steps viable.

The TSMO Division determined that we needed to be the TIM provider for all users to ingest this data. Additionally, we wanted to ensure that we had a solution that is scalable and could meet the demands of ever increasing traffic demands especially during peak periods on our system. With this in mind, we implemented the solution created during the pilot into our cloud environment so these demands could be met. The TIM messages could now be exposed through the AZ511 Application Programming Interface (API) so anyone subscribing to it can ingest these messages and use them for their own apps. Additionally, these messages can be received through the Arizona AZ511 app and improve driver awareness of roadway conditions.

The TSMO Division successfully tested and validated four traveler notification use cases: work zone warnings, curve speed warnings, dynamic back-of-queue (BOQ), and basic safety messages (BSM) see fig 4. Since the pilot was focused on a specific telecommunications provider, the TSMO Division needs to create a solution where any company or other end users can use this data and approach. The CV PFS is currently investigating ways to expand this solution with other states and telecom providers. In the interim, the TSMO Division is implementing the expanded TIM solution through AZ511.com to allow end-users to gain access to the TIM data. Another state DOT has independently expressed interest in implementing this solution. Additionally, this solution may be used as an integrated corridor management (ICM) solution that other jurisdictions can use in cases such as back-of-queue events and dynamic road work events.