Signal Phase and Timing (SPaT): US 1 and MD 175
Howard County, Maryland

FORM 442: QUESTION 7
PURPOSE OF EXPERIMENT
2021

MARYLAND DEPARTMENT OF TRANSPORTATION

STATE HIGHWAY ADMINISTRATION

Background

Intelligent Transportation Systems (ITS) and connected and automated vehicle (CAV) technologies are rapidly developing in the transportation industry, making it imperative for infrastructure owners and operators (IOOs) to stay up to date with these emerging technologies. In preparation for vehicle-to infrastructure (V2I), infrastructure to vehicle (I2V), and generally vehicle to everything (V2X) connectivity on our roadways, the Maryland Department of Transportation State Highway Administration (MDOT SHA) is pursuing a variety of CAV initiatives throughout the state, including the deployment of a detection and notification strategy to warn drivers via connected vehicle (CV) communication of a vulnerable user in the roadway, performing planning and engineering for queue around curve warnings, and specifically for this report, participation in the national effort to meet the Signal Phase and Timing (SPaT) Challenge. MDOT SHA is taking the systems engineering approach to prepare for the deployment of wireless communication via Cellular Vehicle to Everything (C-V2X) and Dedicated Short Range Communication (DSRC) for this project.

Goals and Objectives

MDOT SHA's primary objective is to deploy roadside equipment at 20 intersections and onboard 5 vehicles to communicate the Signal Phase and Timing messaging of the traffic signal controller. The roadside unit (RSU) will serve as supporting infrastructure for CV applications, allowing vehicles nearing an intersection to gain situational awareness of signal phase and timing via a DSRC and C-V2X-compatible onboard units (OBU). The goal of this specific deployment is to promote safety, with the larger ambition of working toward state-wide integration of CV technologies. Deployment of RSUs and other ITS equipment will provide support to many of Maryland's ongoing CAV initiatives.
As connected data becomes more abundant through deployments similar to this one, it may be possible to incorporate this data into traffic management as a whole to provide travelers with a safe and efficient system. MDOT SHA will continue to work to overcome hurdles, encourage private investment, and coordinate with public agencies in the realm of ITS and CAV testing and deployment.

System Boundary

This proposed SPaT project, which will in part serve as a pilot deployment to gauge the effectiveness of ITS messaging systems, will be comprised of users including individuals and systems that interact either directly or indirectly. The direct interaction will be primarily comprised of systems including the traffic signal controller, RSU and OBU. Motorists are identified as indirect users. These are the users that will benefit from the generated broadcasts or notifications but will not interact directly with the SPaT System. They instead interact with a C-V2X or DSRC-compatible OBU with a Human Machine Interface (HMI) that is frequently a tablet or smart phone.

Deployment Area

The SPaT project will deploy state-of-the-art Connected Vehicle Technology at twenty (20) specified locations on US 1, MD 175 and MD 108. The locations will have secure backhaul communications capability via fiber and/or wireless to the MDOT SHA network in order to receive Security Credential Management System (SCMS) updates and for administration. The locations are show below in Figure 1 depicting the US 1 Corridor with 14 intersections, MD 175 with 4 intersections and MD 108 with 2 intersections.

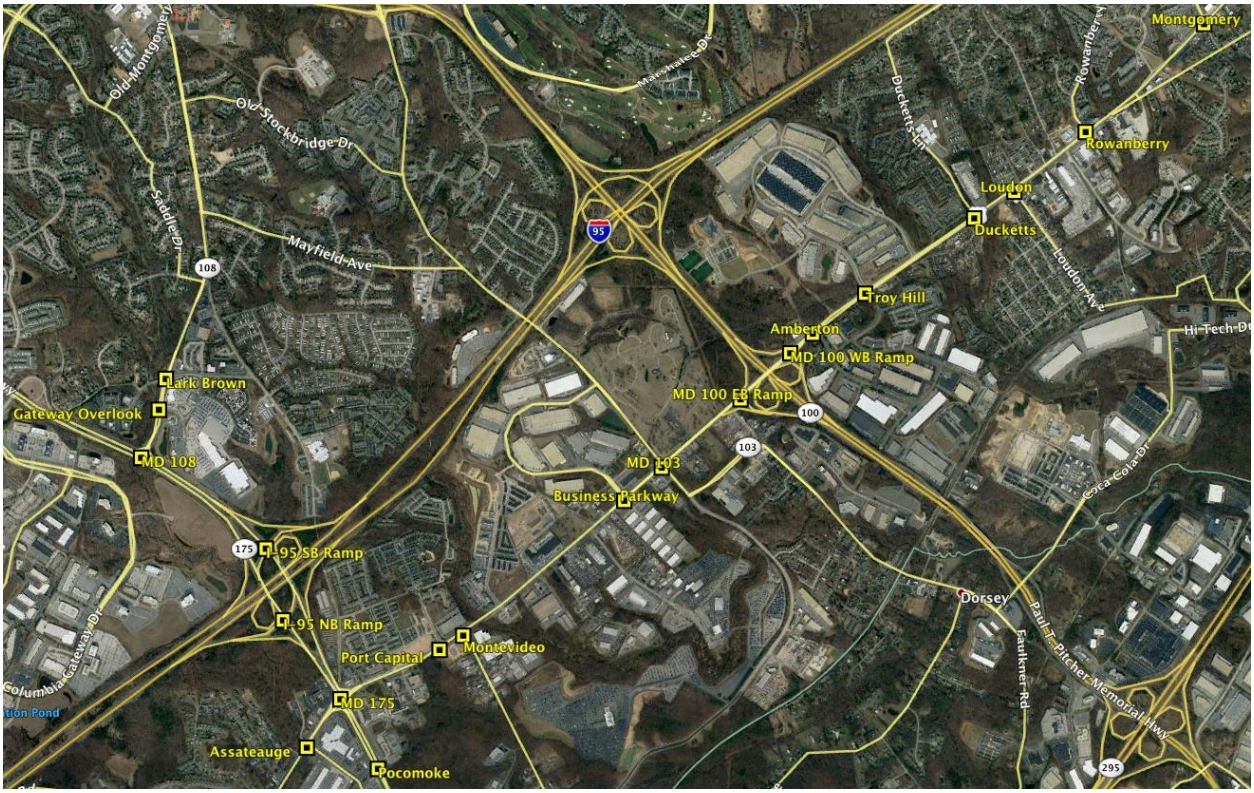

Figure 1: MDOT SHA SPaT Deployment Locations

Contribution to Broader Stakeholder Groups

Stakeholders include the agencies and groups responsible for controlling, operating and maintaining the equipment and systems, as well as travelers who will benefit from the CV applications. MDOT SHA is responsible for the installation, integration, operations and maintenance of the system, and will be the main stakeholder; however this program has a reasonable promise of contribution to the development, extension, and expansion or utilization of the radio art for future C-V2X deployments.

MDOT SHA Agency fleet vehicles (5) are to be equipped with OBUs for the SPaT project testing and ongoing use thereafter. However, this does not preclude other vehicles from receiving the CV messaging and receiving benefit from the project. The primary requirements for additional stakeholder participation are to conform to CV messaging constructs and valid SCMS credentials. This will allow compliant Original Equipment Manufacturers (OEM) vehicles, agencies, academia and other OBUs to communicate with the project CV infrastructure and receive the SPaT messaging.

Use of the Signal Phase and Timing (SPaT) Messaging System

For a visual representation of how the SPaT system is to be used, see the following Figure 2, which displays a Use Case / Messaging Diagram. This diagram depicts the user(s) of the system and displays how they communicate/interact within the CV ecosystem. For example, the diagram shows that the vehicle communicates via wireless technologies (C-V2X or DSRC) to the RSU that is located on a mast arm at the intersection.
will be impacted by the pedestrian I2V system. For example, the diagram shows that the pedestrian I2V system will use the detection of a vulnerable user to notify an in-vehicle OBU or similar system.

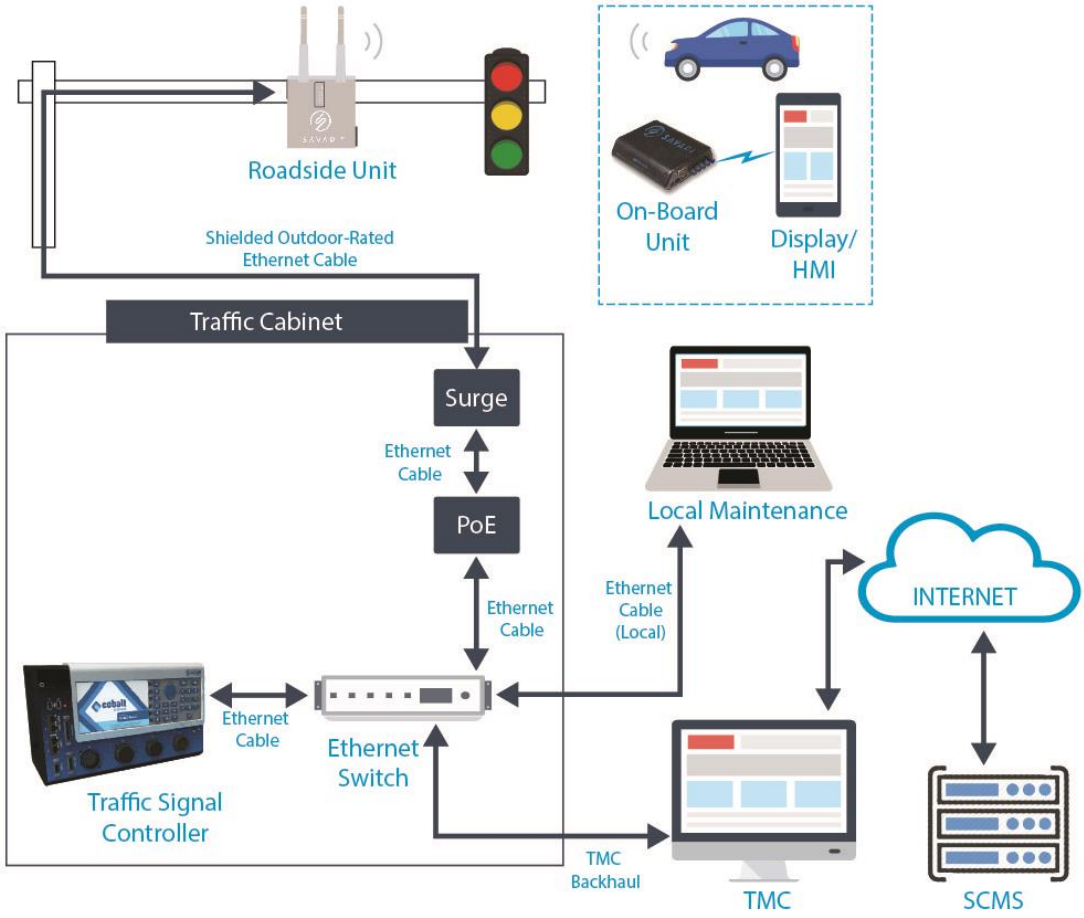

Figure 2: Signal Phase and Timing (SPaT) Messaging Diagram

Signal Phase and Timing (SPaT) Operational Scenario

The following scenario describes how the SPaT System will communicate under ***normal conditions***. The following conditions must be in place before the scenario starts:

The Vehicle System:
• Is approaching the CV equipped intersection and in-range of the radio (C-V2X or DSRC),
• Continuously knows its current position, and
• Is configured to receive messages, including supporting standard message security features

The SPaT (I2V) System:
• Is configured and broadcasting a proper MAP message,
• Is configured and broadcasting a proper SPaT message describing the current phase at the signalized intersection, together with the residual time of the phase, for every lane (hence every approach and movement) of the intersection.
• It supports standard message security features.

Sequence of Events:

1. The Vehicle System broadcasts location and secure messaging credentials.
2. The SPaT I2V system validates the security credentials and decodes the message.
3. The SPaT I2V system transmits the MAP message and SPaT message to the Vehicle System (updated as frequently as 100 milliseconds).
4. The Vehicle System receives the message and validates the security credentials.
5. The Vehicle System decodes the message and conveys the information to the driver.

Next Steps

As our roadways advance in connectivity, MDOT SHA will investigate impacts and deploy CV technologies on Maryland's transportation network to increase safety, improve efficiency and enhance mobility for travelers. Following the systems engineering process, testing and verification will occur, followed by system validation. This will involve analysis of data to evaluate performance measures and checks of the system to verify its successful operation.

Coordination will continue between stakeholders described in this document as well as with local and regional state agencies, organizations, and the public. Continued investments will be made in the future of transportation to enhance traffic management and provide a connected, safe infrastructure network.

MDOT SHA will continue to stay at the forefront of emerging technologies in transportation by investigating the impacts of DSRC and CVs and preparing for the predicted deployment of AVs on the roadways. MDOT SHA will be able to leverage lessons learned from the deployment of the Signal Phase and Timing (SPaT) I2V deployment outlined in this Purpose of Experiment document as well as ongoing CAV initiatives throughout the state to prepare for future installments of CAV technologies and V2I, V2V and V2X applications.