

Request for Research Funding for FY 2019-2020

Requesting Office	State Traffic Engineering Office	Priority High	4 of 8
Proposed Title	Assessment of the Infrastructure Readiness for Connected Vehicle-to Infrastructure Applications on Arterial Streets		
Justification	<p>An important component of connected and automated vehicle (CAV)-based applications is the infrastructure support of these applications. A critical infrastructure element is the traffic signal controller and the associated equipment that allow when combined with other devices the delivery of the needed functionality of CAV vehicle-to-infrastructure (V2I) applications. Most existing signal controllers are not CAV-ready and thus agencies need to determine their options as they approach the deployments of vehicle-to-infrastructure (V2I) applications. Signal controller vendors have started to produce CV processors to provide the required functionalities V2I applications. However, not all of these processes can support all V2I applications. In addition, the performance of the resulting applications when applied with the controllers and the impact on traffic have not been adequately tested,</p> <p>When considering V2I applications, it is recognized that some of the required infrastructure functionalities will be provided by the roadside units (RSUs) depending on the specific application. Others will be provided by the signal controller processors. It may be possible to also have the CV processor as a standalone “V2I Hub.” Signal control agencies need information regarding the capabilities of infrastructure technology alternatives to support various mobility and safety V2I applications and guidance of the best configurations for the applications.</p> <p>The research team will coordinate and work closely with the FDOT project manager and Traffic Engineering Research Laboratory (TERL) on all tasks of the project. It is expected that TERL will determine if the selected controller for the test will be CV ready. It is anticipated that TERL will take the lead in assessing the controller readiness for CV. This project will then:</p> <p>1) Review the state of practice associated with utilizing signal controllers to support V2I-based applications through detailed interviews with the agencies that implemented such applications, interview with signal controller and RSU manufactures, and review of existing presentations and publications on the subject. A deliverable will be provided 45 days after the kick-off meeting. This deliverable will be updated at least twice through the life-cycle of the project.2) The project team develop an evaluation plan to test selected V2I applications using hardware-in-the-loop simulation and also a real-world test. TERL will be involved every step of the way with the test plans to ensure each controller used is configured, tested and evaluated correctly. The research team will select three applications for testing in coordination with the FDOT. The type controller (and RSU) utilized for testing will be selected based on Task 1 results and past experience to ensure that they allow the testing of the selected applications. Examples of three high priority applications that may be selected are adaptive signal control with CV, freight signal priority, and pedestrian on crosswalk applications. It should be mentioned that the first two applications have been developed as part of the MMITSS system. This system was tested with Econolite and McCain controllers with only Econolite controller implementation tested in the field.</p> <p>3) Develop a hardware-in-the-loop simulation environment were a controller will be interfaced with a computer that hosts the VISSIM simulation model. A Controller Interface Device (CID) will be used to provide communication of virtual traffic detector data from the simulation to the controller and signal timing parameters from the controller to the simulation. An On-Board Unit (OBU) will also be interfaced with the VISSIM simulation through a cable connected to the computer to get the virtual vehicle messages from the vehicles and communicate SPAT messages to the simulation. A road-side unit (RSU) will be interfaced with the OBU and controller. This will provide an environment that allows testing applications that reside on the RSU and/or the controller CV processor.</p> <p>4) Based on the findings from Task 4, the research team will work with the FDOT on testing the applications in the field using the evaluation plan developed in Task 3 above. The field test will be done at TERL or SunTrax infield (if it is developed in time) using only one brand of controller in this phase. TERL will be involved in every step of the test.</p>		

	5) Research on current controller capabilities, the newly developed RSU specifications and revised 671 specs, or similar specification language from around the nation. Propose to FDOT on where the gaps are and steps to take for moving towards CAV readiness.		
Impact	Agencies have just started considering the implementations of CAV-based applications to improve the mobility, reliability, safety, and environmental impacts of their systems. There are a lot of uncertainties and risks associated with these new applications that impact the probability of their success and discourage agencies that may consider implementing them. This project will provide information and guidance that will reduce the risks and uncertainties and thus contribute to the success of CAV V2I-based applications.		
Affected Offices	FDOT Traffic Engineering and Operations Office, Traffic Engineering Research Laboratory (TERL), District Traffic Operations Offices		
Existing Work	<p>Zink, G. and A. Polinori, "V2I Hub Deployment Guide," Produced for the Federal Highway Administration Report No. FHWA-JPO-18-644, July 2018.</p> <p>Ma et al. "Hardware-In-The-Loop Testing of Connected and Automated Vehicle Applications: A Use Case For Queue-Aware Signalized 2 Intersection Approach And Departure," Presented at the Transportation Research Board annual meeting, Washington, D.C., January, 2018.</p> <p>An Overview of USDOT Connected Vehicle Roadside Unit Research Activities Produced for the Federal Highway Administration Report No. FHWA-JPO-17-433, May 2017.</p> <p>Khoshmagham, Shayan, "Real Time Performance Observation and Measurement in a Connected Vehicle Environment," Ph.D. Dissertation, University of Arizona, 2016.</p> <p>Leonard, B., "Installing DSRC Systems for Vehicle to Infrastructure Applications," Presented at the Rural Transportation Technology Implementer Forum, Accessed 2018.</p>		
Keywords Used In Existing Work Search (Cannot leave blank)	Signal controller, vehicle-to-infrastructure, V2I hub, connected automated vehicles, roadside units		
Related Contracts (Give contract numbers)	None.		
Funding Request	\$200,000	Anticipated Duration	15 months
Project Manager	Derek Vollmer	Contracting Method	Direct contract with Florida International University (Dr. Mohammed Hadi)
Urgency	1	The results will support the FDOT Central Office and Districts in the design, procurement, and implementation of CV-based applications. The research is needed immediately to address identified risks and the unknowns associated with the applications and the associated technologies, standards, and products that are still gaining maturity.	
Implementability	1	The research team will work closely with the FDOT TERL on providing state-of-the-practice reviews that will provide an immediate input to support the FDOT in its procurement of CV-based solutions. The research team will work closely with TERL to develop and implement test plans that will be used to test traffic controller and associate device readiness for CV-based applications and the benefits of these applications under various conditions. This will also provide important inputs to support updates to the FDOT Standard Specifications.	
Project Benefits (Succinct, complete explanation) Significant benefits are expected with the implementations of signalized intersection V2I-based applications. An on-going FDOT research project (BDV29 TWO 977-41) identified what is known about the benefits of V2I applications. Table 1			

presents a subset of the estimated benefits, which are related to signalized intersection operations. A return on investment analysis is currently being conducted for a typical congested arterial in Miami.

Project Benefits (Select all that apply and explain)	Quantifiable Benefits (units, dollars, etc...if applicable)	Methodology or Data Sources Used to Determine Quantifiable Benefits. If not applicable, please give justification of project benefits
<input type="checkbox"/> Materials Enhancement		
<input type="checkbox"/> Materials Savings		
<input type="checkbox"/> Time Savings		A methodology developed as part of an on-going research project (BDV29 TWO 977-41) to calculate the mobility benefits on urban arterials.
<input type="checkbox"/> Lives Saved/Injuries Prevented		A methodology developed as part of an on-going research project (BDV29 TWO 977-41) to calculate the safety benefits on urban arterials.
<input type="checkbox"/> Other (Explain)		

*Comments should explain and support urgency, financial benefit, and implementability scores

Table 1 Summary of Mobility and Safety Impacts of Existing and CV-Based Solutions to Address Arterial Management Needs

Function	Existing Solutions	CV-Based Solutions
Provision of Signal Control to Accommodate Varying Conditions		
Adaptive signals	5% for saturated conditions and 10% for undersaturated conditions over time-of-day control	25%, 50%, and 75% CV market penetrations result in 15%, 20%, and 25% improvement for undersaturated conditions and 5%-10% for saturated conditions
Transit Signal Priority	5%-15% decrease in bus travel time with 0-10% increase in cross street delay depending on the degree of saturation.	15% to 25% decrease in bus travel time with 0-10% increase in cross street delay depending on degree of saturation
Freight Signal Priority	5% to 15% decrease in truck travel time with 0 to 10% increase in cross street delay depending on degree of saturation.	15% to 25% decrease in truck travel time with 0-10% increase in cross street delay depending on degree of saturation
Pedestrian Control	NA	TBD
Emergency Vehicle Preemption	15-45 seconds per intersection and 10% reduction in probability	TBD

Function	Existing Solutions	CV-Based Solutions
	of death for each one-minute faster response	
Speed Adjustment to Support Arrival on Green		
Green Light Optimal Speed Advisory (GLOSA)	NA	5% improvement in fuel consumption and delay
Glide Path (Involving Partial Automation)	NA	15% improvement in fuel consumption and delay
Support of Signalized Intersection Safety		
Permissive Left Turn and Right Turn on Red Support	TBD	With 100% CV market penetration, 25% of intersection crashes and 45% of intersection and injury fatality
Red Light Violation and Rear-End Collision Reduction	Red light camera benefits include 11% reduction in angle crashes and 16% reduction in rear-end crashes	With 100% CV market penetration, 25% of intersection crashes and 45% of intersection and injury fatality
Reduce Pedestrian on Crosswalk Crashes	25-75% reduction in pedestrians on crosswalk crashes with 100% market penetration	50%-100% reduction in pedestrians on crosswalk crashes with 100% market penetration
Support of Visually Impaired Pedestrian in Crossing the Street	Accessible pedestrian signal is expected to reduce visually impaired accidents significantly	Expected to reduce visually impaired accidents more than the accessible pedestrian signal