Request for Research Funding for FY 2021-2022			
Requesting Office	State Traffic Engineering and Operations	**Priority**	14 of 15
Proposed Title	Evaluation of CARMA for I-STREET Testbed Implementation		
Justification	Technology is changing at a rapid pace and transportation departments across the country are leveraging the latest applications to improve the safety and mobility of the traveling public. CARMA (Cooperative Automation Research Mobility Applications) is a United States Department of Transportation (USDOT) program developed by the Federal Highway Administration (FHWA) to advance research and development of Cooperative Driving Automation (CDA) with the objective of accelerating market readiness and deployment. CDA enables automated vehicles (AVs) to communicate between vehicles, infrastructure devices, and road users such as pedestrians and cyclists[1]. This project will be the first implementation of CARMA in a transit use case. CARMA encourages the development of CDA, which supports and enables automated vehicles to cooperate through communication between vehicles, infrastructure devices, and other road users such as pedestrians and bicyclists. CDA has the potential to improve transportation efficiency, facilitate freight movement, increase productivity, and save billions of dollars by reducing the number of roadway facilities. Most importantly, CDA has the potential to reduce crashes caused by human error and save lives[2]. Through the CARMA Platform FHWA is encouraging collaborations from academia and the industry. The CARMA roadmap[3] features transit applications. A CARMA enabled transit vehicle equipped with a selection of sensors compatible with CARMA could provide shared vision with other road users and has the potential to solve blind spot related crashes. A number of transit related applications like pre-emption and transit signal priority could also be tested with the vehicle. This project will leverage some of the equipment procured from previous projects. For example, the Florida Department of Transportation (FDOT) along with the University of Florida (UF) and the City of Gainesville (CoG) as a part of the I-STREET program has equipped 10 transit buses with the Mobileye Advanced Driver Assistance Systems (ADAS) system which includes four cameras - two interior-mounted smart sensor cameras and two exterior housed smart sensor cameras. Mobileye is one of the primary equipment vendors recommended by the FHWA CARMA team for implementation. In addition, the UF team will collaborate with the University of South Florida (USF) team who have already implemented CARMA in passenger cars and will assist the UF team in extending the CARMA application to transit buses. FHWA has made significant investments in the CARMA platform and is looking to collaborate with state DOTs and academia to test and develop various applications. Its roadmap for CARMA features transit applications. FDOT having made its own investments in transit applications in Gainesville, FL, has the opportunity to develop the first "CARMA enabled" transit vehicle that has the potential to improve safety and mobility. A detailed evaluation of CARMA hardware suite requirements and other CARMA compatible sensors for specific use cases would be the first step for FDOT towards a CARMA enabled transit vehicle. **Project Objectives** For a comprehensive application of CARMA on the I-STREET testbed, the project is proposed in 2 phases – Evaluation (Phase-I) and Implementation (Phase-II). This proposal is for Phase-I where we are evaluating the needs, benefit, and application of CARMA. Upon successful completion of Phase-I, a Phase-II plan will be submitted for FDOT for consideration. This research project will evaluate the CARMA ecosystem for transit applications. More specifically, the project has the following objectives: 1. Explore the CARMA collaboration ecosystem and its applicability to I-STREET testbed 2. Setup a stakeholder alliance with FHWA, FDOT and CoG 3. Evaluate CARMA Hardware Suite and 4. Develop use cases for testing and evaluation		

[1] https://highways.dot.gov/research/operations/CARMA-Collaborative
[2] FDOT (2019), CARMA White paper
[3] https://usdot-carma.atlassian.net/wiki/spaces/CET/pages/745111786/CARMA+Ecosystem+Roadmap

	The research project will include the following tasks: **Task 1: Literature Review and Roadmap for CARMA Implementation** During this task, the research team will study and report the state-of-art applications built with CARMA platform. In addition, other related CARMA collaborative tools like CARMA Cloud, CARMA Streets, and CARMA Messenger will be studied. A stakeholder alliance with FHWA, FDOT and CoG would be setup to develop a roadmap for implementation of CARMA in Gainesville, FL. This group will meet monthly to assess and update the roadmap. **Task 2: Evaluation of Hardware Capabilities** The research team will evaluate CARMA Hardware Suite and other third-party sensors and equipment alternatives that can be used in development of cooperative driving automation (CDA) applications for transit. An exhaustive list of hardware evaluated along with their technical specifications, performance, and their applicability in potential use cases will be provided. **Task 3: Development of Use Cases for Testing and Evaluation** Based on the hardware evaluated and their capabilities the research team will develop use cases for testing and evaluation. Research team coordinate with FHWA team to receive their inputs and ensure that the transit applications that would be developed in Q2 and Q3 of CARMA Roadmap for 2021 are sufficiently captured. Both operational and safety use cases will be developed. Potential use cases would use "shared vision" to reduce blind spots related crashes. For example, a transit bus at a right turn could detect the pedestrians through the Mobileye system and other sensors and alert the vehicles behind it. University of Florida (UF) in consultation with University of South Florida (USF) will prepare a list of use cases with the hardware suite each of them requires. This would enable the planning of the procurement of hardware suite for various budgets and applications. **Task 4: Framework for implementation of CARMA** Overview of the entire effort, a summary of monthly meeting with the stakeholders, hardware evaluation and use cases developed would be documented. A framework for implementation of CARMA for transit applications would be developed. A detailed Phase-II plan for implementation of CARMA will be submitted for FDOT for consideration.		
Impact	This project would prepare FDOT and CoG to implement a transit-based use case of the CARMA Platform in Florida. The implementation phase would result in safety and mobility benefits for both transit users and other road users where the system is implemented. This project would first enable UF to establish a stakeholder alliance with FHWA, FDOT and CoG to develop a roadmap for implementation of CARMA in Florida. Further, it will allow for an exhaustive evaluation CARMA Hardware Suite and other third-party sensors and equipment alternatives would be made along with their technical specifications, performance, and their applicability in potential use cases. A roadmap would be developed which will include use cases and hardware suite requirement that would enable the planning and procurement of hardware suite for CARMA implementation in Florida		
Affected Offices	Traffic Engineering and Operations Office, District 2 Traffic Operations Office, State Transit Office		
Existing Work	Currently there is no study focusing on the CARMA implementation for transit applications.		
Keywords Used In Existing Work Search **(Cannot leave blank)**	• CARMA transit use cases • Cooperative Driving Automation (CDA) for transit		
Related Contracts (Give contract numbers)	N/A		
Funding Request	$95,000	**Anticipated Duration**	10 months but interim results will be disseminated for immediate use by FDOT.
Project Manager	Raj Ponnaluri, PhD, PE, PTOE, PMP	**Contracting Method**	Direct contract with University of Florida (UF) – Dr. Lily Elefteriado

Urgency	1	The CARMA team features transit applications in their 2021 roadmap, this project would be timely to coordinate development of use cases with FHWA. With FHWA encouraging collaboration from academia and FDOT funded ADAS equipment already on transit busses in Gainesville, the outcome of this project can be immediately implemented as first of its kind "CARMA enabled" transit busses.
Implementability	1	The research results will be readily implementable. A framework for implementation of CARMA for transit applications would be developed for Phase-II and a detailed plan for immediate implementation of CARMA will be submitted for consideration.

Project Benefits (Succinct, complete explanation)

The research project will help in developing an implementation plan for CARMA in Florida. Potential use cases would be developed to leverage "shared vision" from connectivity to reduce blind spots related crashes. A list of use cases with the hardware requirements would enable the planning of the procurement of hardware suite for various budgets and applications of CARMA across Florida.

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**
○ Materials Enhancement		Transit busses in CoG are equipped with ADAS equipment. This equipment would be enhanced with CARMA application in Phase-II.
○ Materials Savings		The outcome of Phase-I would detail the use cases and hardware requirement that would enable efficient procurement of equipment for Phase-II CARMA implementation.
○ Time Savings		
○ Lives Saved/Injuries Prevented		"Shared-vision" using sensors from the CARMA suite has the potential to eliminate blind spots and reduce crash severity and crash frequency.
○ Other (Explain)		According to USDOT, AVs working together have the potential to: • Reduce fuel consumption at intersections by 20 percent. • Double the capacity of existing lanes. • Reduce overall fuel consumption by 10 percent. Source: https://highways.dot.gov/research/operations/Cooperative-Driving-Automation

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