CFAVP

PROJECT DELTA

FDOT

2019 FDOT ADS DEMONSTRATION GRANT APPLICATION

UNITED STATES DEPARTMENT OF TRANSPORTATION

NOTICE OF FUNDING OPPORTUNITY NUMBER 693JJ319NF00001

Mrs. Elaine Chao – Secretary
United States Department of Transportation
1200 New Jersey Ave, SE, Washington, DC 20590
RE: Automated Driving System Demonstration Grants – Project Delta Demonstration

Dear Secretary Chao:

The *Project Delta Demonstration* is a bold and collaborative approach to advance the effectiveness, application, and public trust of Automated Driving Systems (ADS). The Project Delta Demonstration will show how collaboration with industry can result in more competition through lower barriers to entry, efficient and responsive communication between vehicles, drivers, and infrastructure, and ultimately, safer and more robust ADS technologies. The Demonstration, led by the Florida Department of Transportation (FDOT) District Five on behalf of the Central Florida Automated Vehicle Partnership (CFAVP), consists of the following components:

1) Interoperability Standardization: Interoperability between DSRC and 5G communications will ensure public investments are future-proof. Standardizing baseline functionality between roadside units (RSUs) and onboard units (OBUs) will protect travelers and save money.
2) Human-Machine Interface (HMI) Standardization: Manufacturers are developing user interface systems in siloes. Developing uniform HMI standards will foster consistency for driver expectancy, reduce development costs, encourage innovation, and improve safety.
3) Automated MAP message generation: Automated MAP message generation will replace a rigid and overly complex function with one that is flexible and less time-consuming to support the frequent changes to Florida's expanding infrastructure. It will also allow for scaling and more direct communication between roadbuilders and users.
4) Electromagnetic Interference (EMI): ADS vehicles require uninterrupted communications and sensor functionality. Examining impacts from lightning and other EMI sources will expand the knowledge base for the industry, advance the state of practice, and improve safety.
5) Cybersecurity: By conducting a series of ethical hacks on the FDOT District Five network, vulnerabilities and deficiencies in the system can be identified and corrections made. These updates will be documented, with the resulting costs, scopes, best practices, and processes made available as guidance documentation for USDOT and other public agencies.

Public Benefiting Approach: The Project Delta Demonstration is designed to benefit the public. The bold vision and critical focus areas of Project Delta will not be addressed by an individual business, DOT, or research institution. Items such as *interoperability* and *HMI standardization* do not contribute to the bottom line of ADS device manufacturers and do not get developed. The complex process to deploy a *MAP message* onto RSUs highlights a market failure to address an issue that must be automated to scale ADS use. Evaluations of *EMI* and *cybersecurity* are rarely performed because they require access to public infrastructure and do not turn a profit.

Project Partners: The FDOT will be the agency that enters into the agreement with the USDOT and delivers the Project Delta Demonstration. Key partners include:

- Industry: **Cisco** will assist with Interoperability Standardization; **ESRI** will help create a unified complete automated MAP message generation methodology; and **Connected Wise, LLC** will create MAP messaging for rural, unequipped intersections.
- Academic: **Florida Polytechnic University** will develop the Mobile EM Lab to evaluate potential EMI sources in real-world settings; the **University of Central Florida**, with with the **University of Michigan Transportation Research Institute**, will lead the HMI program; and the **University of Florida** will help develop automated MAP messages for dynamic scenarios.
- Agencies: The **City of Orlando, Orange County, Sumter County,** and the **University of Central Florida** will facilitate and support deployments within their jurisdictions.
- Consultants: A **consulting firm** will be selected through the FDOT bidding process to fulfill the proposed work efforts of the Project Delta Demonstration.

Collaboration: The public/private/academic partnership of the Project Delta Demonstration and the support of the CFAVP is necessary to fuse the skills and resources needed to achieve the project goals. The team has a history of working together to advance technology and automation in Florida. FDOT—experienced in managing diverse teams and delivering complex projects—will provide the leadership to administer the project and maximize value to USDOT and the public.

Application/Scalability: The Project Delta Demonstration is designed with broad application and scalability in mind. The diverse geographic areas and demographics within Central Florida will enable deployments in urban, suburban, and rural environments. A closed-environment facility will be used to test systems for safety compliance. Open-road testing locations that represent suburban, urban, and rural environments will then be used to evaluate real-world conditions.

Project Request/Compliance: FDOT is requesting a grant of $6,795,000. The Project Delta Demonstration will comply with *Buy American* requirements and with Federal standards in managing and distributing funds from this grant. FDOT is committed to sharing project data with USDOT, industry, and the public while protecting data rights. This commitment to collaboration and transparency will be fulfilled through *SunStore*, FDOT's data management platform.

Project Benefit: Interoperability, HMI, automated MAP messages, electromagnetic interference, and cybersecurity are risks that must be tackled on the path to vehicular automation. Results of the Project Delta Demonstration – actionable data, standards, and guidance documentation – will be publicly accessible and easily transferable. The Demonstration will benefit public, private, and academic entities by addressing key needs, contributing data and standardization, and serving as a model for effective open source development. The outcomes will have immediate and long-term safety benefits in the development and deployment of ADS technology.

Sincerely,

Michael Shannon, PE
District Secretary | FDOT District Five

SUMMARY TABLE	
Project Name/Title	CFAVP Project Delta Demonstration
Eligible Entity Applying to Receive Federal Funding	Florida Department of Transportation 605 Suwannee St Tallahassee, FL 32399
Point of Contact	Jeremy Dilmore FDOT District Five TSMO Program Engineer Jeremy.Dilmore@dot.state.fl.us (386) 943-5360
Proposed Location (State(s) and Municipalities) for the Demonstration	Auburndale, FL (SunTrax) Orlando, FL (UCF Campus) Orlando, FL (Pine Hills) Wildwood, FL (US 301) Bushnell, FL (CR 476)
Proposed Technologies for the Demonstration	Level 3+ Autonomous Vehicle Connected Vehicle ITS Network Security Human-Machine Interface ADS Sensors / Communications Automated MAP Message Application MAP Message Sign
Proposed Duration of the Demonstration	10/1/2019 - 7/1/2022
Federal Funding Amount Requested	$6,795,000.00
Non-Federal Cost Share Amount Proposed	$0.00
Total Project Cost	$6,795,000.00

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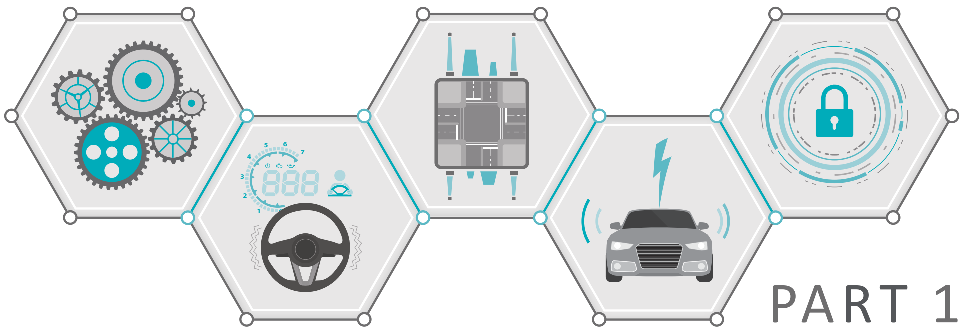


PART 1

PROJECT NARRATIVE | TECHNICAL APPROACH

1 EXECUTIVE SUMMARY

Through existing efforts within the Central Florida region, as well as coordination with manufacturers and our public agency counterparts, the Central Florida Automated Vehicle Partnership (CFAVP) has determined there are areas where the marketplace is not providing the proper incentive structure to continue to fully advance the communications infrastructure space. Additionally, more information is needed for the full marketplace in a number of key elements associated with ADS technologies. CFAVP is pleased to offer the Project Delta Demonstration to aid in moving the marketplace forward by addressing specific focused issues learned through implementation, and utilizing our collective assets and knowledge as a team.

As part of Project Delta, exhibitions will take place utilizing the state-of-the-art SunTrax testing facility for connected and autonomous vehicles will be used for closed-environment testing. SunTrax will provide a 2.25-mile oval track capable of high speeds for testing ADS-enabled vehicles. Once the team is confident of performance, demonstrations will be brought onto properly equipped roads. The University of Central Florida (UCF) main campus and State Road (SR) 50 in the Pine Hills community are in the process of deploying advanced road-side units (RSU) as part of the Connecting East Orlando Communities Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) grant project. Additionally, some intersections will be outfitted with LiDAR, Computer Vision, and WiFi as part of the grant award. The Project Delta exhibitions proposed at UCF and Pine Hills will leverage these technologies to demonstrate advancements made by our efforts. The facilities proposed represent suburban and urban conditions with advanced technology, but it is unrealistic for many areas to discuss infrastructure costs at scale. Therefore in Sumter County, a rural county in Central Florida, local roadways that are instrumented, along with an instrumented principle arterial, will be leveraged to demonstrate conditions more likely to be experienced in rural areas of the country. These four locations provide the foundation for the Project Delta Demonstration: a closed-environment facility where systems can be adequately tested for safety compliance, and open-road testing locations that represent suburban, urban, and rural environments common throughout Central Florida and the Nation as a whole.

The components of the CFAVP Project Delta Demonstration are intended to provide much-needed guidance and standardization documentation relating to key elements necessary for ADS operations. The CFAVP is proposing the following five components as part of the CFAVP Project Delta Demonstration: 1) Interoperability Standardization; 2) Human-Machine Interface (HMI) Standardization; 3) Automated MAP Message Generation; 4) Electromagnetic Interference; and 5) Cybersecurity.

1.1 INTEROPERABILITY STANDARDIZATION

Debates still continue on the right platform for communication. Vendors race towards developing products for an emerging marketplace. How will it all work together? ***Will*** it all work together? Interoperability spans many fronts. The CFAVP believes some of these interoperability concerns can be addressed in the *architecture* of the system, but other areas require more guidance to industry to ensure implementation will not be vendor-specific. Further, obtaining interoperability can unlock the power of private industry to innovate and deliver better products by maintaining a competitive environment, all while keeping minimum specifications in place to ensure safe operations and protect the public interest.

The proposed **Interoperability Standardization** component will focus on lowering barriers to interoperability and providing baseline standards for manufacturers to follow. Using existing hardware, the CFAVP will collect and analyze the format of the data packets generated by each vendor's CV units, and post a comparison matrix to a publicly available website for manufacturers to determine what translation is needed for their hardware to communicate with other manufacturers' hardware. That packet data will likewise be used by FDOT to provide an official interpretation of standards for the state of Florida. These interpretations will be shared with industry and become the standard that all hardware products must meet to be eligible for sale in the state.

Exhibitions will be held at the SunTrax testing facility, Sumter County, Pine Hills, and the UCF campus to validate receipt of the communication by a connected vehicle, and the vehicle's ability to act appropriately to the information received.

1.2 HUMAN-MACHINE INTERFACE STANDARDIZATION

A key communication process that has taken place since the advent of the automobile is how vehicles communicate information and alerts to their users. For years, this communication had been confined to the driver's dashboard with its speedometer, check engine light, and other similar features. These messages and alerts from the vehicle to the user have been standardized over the years, to the point where they are largely interchangeable from one brand to another and are easily understood by the driver.

In recent years, many ADAS features such as lane-assist, adaptive cruise control, and collision avoidance now come standard in new vehicles. While these systems, and more advanced Level 3+ automation systems, are helpful for users, their warning messages also become far more important. These alerts now carry critical information that a user must be able to act on immediately for the vehicle to continue operating safely.

For this reason, more information and advances are needed in relation to this communication between vehicle and human, often referred to as the Human-Machine Interface (HMI). Humans have their own "driving language," and ADS vehicles need to be able to communicate effectively with that language, both to users inside the vehicle and to external third parties, such as pedestrians, bicyclists, and other motorists. If the HMI is not properly considered and developed, the safety of travelers and the effectiveness of the ADS vehicle may be compromised. Improving data-sharing and safety oversight regarding the HMI component of ADS will improve the quality of experience for drivers.

The **Human-Machine Interface** program will use simulations at UCF and the University of Michigan Transportation Research Institute (UMTRI). Researchers, building upon previous HMI research (DOT HS 812 207 – Crash Warning Interface Metrics), will develop a basis of knowledge associated with HMI to elicit the correct response from drivers. By conducting this research through the university system, the tests conducted within these simulators will be recorded within a "best practices" guidance document. The tests and guidance documentation will inform manufacturer decision-making and prepare the public sector for ADS development and deployment.

Building upon the knowledge and results obtained from the simulations, a connected vehicle will be deployed at the SunTrax testing facility. The CFAVP will validate the results of the simulations at UCF and UMTRI within the closed-environment facility through cellphone-and vehicle-based HMI outputs that are derived from artificial obstructions placed along the roadway. Once the HMI communication and vehicle operations are validated at SunTrax, exhibitions will be conducted at properly equipped intersections in Pine Hills, Sumter County, and within the UCF campus.

1.3 AUTOMATED MAP MESSAGE GENERATION

Highly autonomous vehicles rely on an array of advanced sensor and communication devices. A key component of this communication is obtaining the correct roadway and intersection geometry for ADS vehicles to navigate safely and effectively. While private companies gather information on most areas, public agencies are responsible for construction and maintenance activities that can modify geometrywith limited advance notice. MAP messages in these conditions merged with private sector data sources will be critical for ADS vehicles to operate as intended. However, MAP messages currently require a complex process to prepare and update to RSUs. As ADS technologies mature and see deployments on public roadways, these MAP messages will need to produce accurate data in near-real time to keep connected and autonomous vehicles operating safely and effectively. This will be difficult under the current manual process.

The proposed **Automated MAP Message Generation** program will research, demonstrate, and test methods by which public agencies can generate this vital information in an automated process. The MAP message will be developed using drone video and computer vision, processing analysis, trajectory analysis, and software development. Real-time geometry and travel patterns will be collected and analyzed, and then the geocoded data will be uploaded to a web service where the MAP message can be created automatically. The automated MAP message will then be distributed to a connected vehicle to demonstrate receipt of and response to that message in closed-environment testing at the SunTrax facility. Once safe vehicle operations have been observed, demonstrations will progress to open road testing, with exhibitions planned for Sumter County, the community of Pine Hills, and the UCF main campus.

Autonomous connected vehicles will likely use maps generated from third parties. To demonstrate this capability, CFAVP is partnering with Cisco and Esri to merge their historical data with real-time data. At the conclusion of the Project Delta Demonstration, the automated MAP message generation application will be made available to USDOT and other agencies for public benefit.

In addition to the proposed work efforts with MAP messages and RSUs, the CFAVP also proposes a sub-component that will focus on examining and evaluating their MAP message sign and on-board machine vision device in a rural environment. The graphics displayed on the sign are encoded with a MAP message stored in a database. Given the comparatively high costs of deploying, operating, and maintaining RSUs and the underlying infrastructure (i.e., fiber optic cable), the CFAVP believes a low-cost alternative like this MAP message sign could advance the state of practice and better-prepare agencies for the arrival of ADS vehicles. The sign recognition system will generate MAP messages for three different V2I safety applications: **1)** Intersection Situation Data (ISD) Message for unsignalized intersections; **2)** Traveler Information Message (TIM) multiple work-zone configurations; and **3)** Personal Safety Message (PSM) for vulnerable road users.

1.4 ELECTROMAGNETIC INTERFERENCE TESTING

Rapid progress is being made in the core intelligence engines, which form the basis of ADS technology. While these technologies greatly improve autonomous operations and communications, it is unclear how ADS sensor systems and vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications will be affected by electromagnetic interference (EMI) noise generation sources such as weather and man-made devices (e.g., transmission lines). Considering the propensity for thunderstorms in the Southeast and other parts of the United States, it is imperative that we determine how electromagnetic interference might impact various ADS technologies.

As part of the **Electromagnetic Interference Testing** program, Florida Polytechnic University's *Advance Mobility Institute (AMI)* will design and build a mobile measurement laboratory that can evaluate the potential impacts of weather and man-made sources of EM noise on ADS sensor and communications equipment, and also assess the impact of ADS technologies on the environment. The Mobile EM Lab will include video recording so that impacts to equipment and/or environment can be recorded and reviewed in a traditional lab or simulation environment.

The Mobile EM Lab will conduct field reviews in real-world environments around the Central Florida region to understand these impacts in a variety of settings and scenarios. In addition to traveling around the Central Florida area, the Mobile EM Lab will target field tests at locations with heightened levels of EMI, including tunnels, utility transmission lines, and near airports. With the weather measurement equipment on-board, the Mobile EM Lab will also examine impacts of heavy rain and thunderstorms on AV sensors and communication.

The Mobile EM Lab will be developed as an open-source project, with its design plans made available for other entities to use for their own testing purposes. The Electromagnetic Interference component will include recommendations on improving EMI resistance for ADS equipment and infrastructure.

1.5 CYBERSECURITY

Automated driving systems will be supported by the surrounding communications infrastructure deployed by transportation agencies. The private sector will take the necessary steps to ensure their systems are secure from external cyber threats. USDOT and private industry are engaged in developing the Security Credential Management System (SCMS), which protects the security of the connection between RSU and OBU. Consequently, the public sector must develop similar protections for its roadside equipment and underlying network.

The proposed **Cybersecurity** component will include a white hat penetration test of the existing FDOT District Five ITS network. The Department previously received feedback from experts on how to improve its network security. With those low-technology best practices in place, the Project Delta Consultant will conduct a penetration test on the network to further ascertain vulnerabilities and other issues within the system. This will be an iterative process, whereby the Consultant provides feedback and recommendations based on the penetration test, and FDOT implements those recommendations. Upon implementation, several rounds of validation tests will be conducted to assess the implementation and identify additional vulnerabilities. This agile development approach will result in a step-by-step process that can be replicated by other public agencies. Following a series of tests and improvements on network security, FDOT will host a white hat "hack-a-thon" for cybersecurity students in the region. Participants will conduct their own penetration tests to try to gain access to the network and report any vulnerabilities, providing a demonstration, as well as an opportunity to attract students to the field.

CFAVP will document key findings into a best practice guidance document, to include priority network vulnerabilities, recommended solutions, costs associated with implementing solutions, time associated with implementing solutions, and Scope of Services including training.

1.6 ENTITIES ENTERING AGREEMENT

FDOT will be the agency that enters into the agreement with the USDOT and delivers the CFAVP Project Delta Demonstration. FDOT is an executive agency, meaning it reports directly to the Governor. The Department is decentralized in accordance with legislative mandates. Each District is managed by a District Secretary, and has major divisions for Administration, Planning, Production, and Operations.

The proposed CFAVP Project Delta Demonstration will include a variety of local, regional, and state transportation agencies, as well as prominent academic institutions. These entities are identified below as **key partners** or **testing partners**. Key partners will be responsible for carrying out the administrative and technical components of the proposed program, while testing partners will facilitate and support physical exhibitions on their facilities.

1.6.1 KEY PARTNERS

Cisco Systems, Inc. (Cisco) will assist CFAVP with Interoperability Standardization. Through testing efforts at the Seminole County Test Lab, CFAVP has seen the benefit of Cisco's expertise in protocol translation to create interoperability. Their functionality will be shown via the exhibits, but their model will also put pressure on others to conform to interpretations of existing standards.

Connected Wise, LLC has shown through their efforts with USDOT's SBIR program that they can bring MAP messaging to rural, unequipped intersections. Further enhancements to this system by connecting them to an automated back office will be demonstrated in a rural context. This system is expected to be highly beneficial to rural areas that may lack the funds to deploy RSUs or the underlying power and fiber optic cable infrastructure necessary to use RSUs.

After discussing the dynamic MAP data needs with Cisco, CFAVP learned that Cisco was working with **Esri** on the same problem for static conditions. Partnership with the two companies will allow for a unified, complete automated MAP message generation methodology.

The *Advanced Mobility Institute (AMI)* will develop a mobile testing apparatus, the Mobile EM Lab, to evaluate potential electromagnetic interference sources in real-world settings. The AMI will conduct electromagnetic interference testing in a real-world scenario at SunTrax and conduct field tests throughout the Central Florida region, with a heavy emphasis on areas likely to have increased levels of EMI. The mission of the AMI is to coordinate research and partnerships in the burgeoning industry of autonomous vehicles, as well as stimulate economic development.

UCF will lead the proposed Human-Machine Interface program, in cooperation with the **University of Michigan Transportation Research Institute (UMTRI)**. The UCF campus will also be an integral deployment location for the other efforts proposed in the CFAVP Project Delta Demonstration.

UF will play a key role in developing an automated MAP message for dynamic scenarios such as work zones. UF will develop and test computer vision techniques that can track vehicle movements and changes in movement patterns, to be incorporated into an automated MAP message generation application.

The CFAVP has been in contact with industry experts and has determined that multiple consulting firms will be able to provide not just expertise, but also a Level 3+ ADS-enabled vehicle. To support the key partners, a **consulting firm** will be selected through the FDOT bidding process to fulfill the proposed work efforts of the Project Delta Demonstration, including but not limited to:

- As part of the ***Interoperability Standardization*** component, the Consultant will capture packet data for industry use, support FDOT in developing state standards for interoperability, and document the project results, findings, and best practices via *www.cflsmartroads.com/projects/CVAV_D5_Testing.html*.
- For the ***Automated MAP Message Generation*** component, the Consultant will build the API, webservice, and mechanism that leverages the video algorithm developed by UF, the tool built by ESRI, and ensure seamless delivery via Cisco's harmonization of the datasets.
- For the ***Cybersecurity*** component, the consultant will fulfill the role of cybersecurity white hat hacker. The Consultant will conduct a series of penetration and validation tests on the CFAVP interconnected networks and provide security recommendations. Based on the results of the penetration and validation tests, the cybersecurity firm will work with CFAVP to develop best practices and guidance documentation for the benefit of other transportation agencies.
- The Consultant will support the Project Delta Demonstration by providing staffing for ADS exhibitions, including providing the ADS-enabled vehicle for the various exhibitions proposed for the program.

1.6.2 TESTING PARTNERS

The following partner agencies will facilitate and support deployments within their respective jurisdictions: City of Orlando, Orange County, Sumter County, and University of Central Florida.

1.7 PROGRAM LOCATION

The exhibitions proposed in the CFAVP Project Delta Demonstration will leverage the range of diverse geographic areas and demographics within the Central Florida region. Urban, suburban, and rural environments will all be captured in the various deployments.

1.7.1 URBAN ENVIRONMENT

The Interoperability, Human-Machine Interface, and Automated MAP Message Generation components will be deployed in Pine Hills, a community within the Greater Orlando area. This area is representative of an urban environment, with its high traffic volumes, heavy bicycle/pedestrian movements, and multiple transit routes. This community also exhibits a larger proportion of transportation-disadvantaged demographics than Orange County and the State of Florida. According to the American Community Survey 2013-2017 5-Year Estimate, approximately 8.5% of Pine Hills *households have no vehicle available*, compared to 6.4% for the County and 6.7% for the State. Similarly, approximately 7.5% of Pine Hills *workers 16 and older traveled to work via public transportation or walking*, compared to 3.8% for Orange County and 3.3% for Florida. While the State of Florida has a higher *proportion of individuals 5 years and older with ambulatory difficulty* (7.7%), the Pine Hills percentage (6.9%) is higher than the Orange County percentage (5.5%).

The proposed exhibitions will leverage existing connected vehicle infrastructure from the Connecting East Orlando Communities ATCMTD grant project.

1.7.2 SUBURBAN ENVIRONMENT

UCF's main campus will serve as a deployment location for the Interoperability, Human-Machine Interface, and Automated MAP Message Generation Demonstration components. The Greater Orlando area is characterized by suburban communities surrounding the downtown Orlando central business district. The proposed exhibitions will leverage existing connected vehicle infrastructure from the *Connecting East Orlando Communities* ATCMTD grant project.

1.7.3 RURAL ENVIRONMENT

The Interoperability, Human-Machine Interface, and Automated MAP Message Generation components will be deployed in Sumter County, along a roadway previously outfitted with RSUs.

Additionally, part of the MAP message component will include demonstrating the use case of the V2I MAP message ***sign***, a low-cost alternative for rural areas that may not be able to invest heavily in RSU deployments along all their facilities. The ADS vehicle will be evaluated for how it interacts with and responds to the MAP Message sign in various scenarios, including at an intersection, multiple work zone configurations, and a school crossing.

1.8 VISION, GOALS, AND OBJECTIVES

1.8.1 VISION

To be a smart region served by a fatality-free transportation system that is interoperable, secure, and agnostic to communication protocol, leveraging the latest in technology. To achieve this, CFAVP has identified several strategic goals.

1.8.2 GOAL 1 – CREATE A COMPETITIVE AND EFFECTIVE MARKETPLACE

Create and maintain a competitive marketplace within the Connected Vehicle arena that is independent of communication protocols.

Key partners: Cisco and Project Delta's Consultant

Current situation – Autonomous vehicle technology needs information from other vehicles to supplement what its sensors can see (e.g., being able to look around corners of intersections). Additionally, un-instrumented vehicles that have been traditionally measured by infrastructure need to be able to share data to have a complete view of the roadway. This information needs to be consistent in format to be usable. Through previous work interoperability testing, the CFAVP has identified limitations in the interoperability observed.

Through receipt of the ATCMTD grant and previous investments, **the team has already begun this process of creating a marketplace that is competitive. The region has over 700 miles of publicly owned fiber optic network. This allows for an architecture that centralizes processing, allowing for low-latency, high-bandwidth communication** to the edge (WiFi, LiDAR, Computer Vision, and DSRC) and internet (messaging that replicates forthcoming 5G cellular communications). Additionally, the team is using the ATCMTD grant to develop a public-sector application that transforms a cellphone into an OBU emulator. Research from our university partners will resolve the location-accuracy issues that plague current private sector applications. Also, using progressive web application technology allows for the same architecture integration, forcing vendors to compete on software. Unfortunately, **through the team's testing it was determined that DSRC standards are not being uniformly implemented, preventing V2V and V2I communication.** Variation in the interface with controllers, which is not governed, has produced variances that the connected vehicle industry must react to; however, lack of familiarity with other hardware has led to gaps in performance. Additionally, Basic Safety Message (BSM) variation from OBUs has led to non-performance associated with autonomous connected vehicle applications in the Seminole County Interoperability Test Lab. The SAE standards are being interpreted differently and the interface to controllers has not been established.

Issues and Challenges #1 – Vendor business models often rely upon selling maintenance and support services after a hardware purchase is made. Once hardware is purchased, especially in bulk, competition is reduced and performance can suffer. Maintaining interoperability establishes a baseline that all products/services must meet, resulting in market forces requiring a high level of performance from vendors.

Issues and Challenges #2 – There are many barriers for vendors to understand if their devices are truly interoperable. Not the least of which is equipment costs and availability.

Objective #1 – Remove barriers to interoperability. Many manufacturers that have worked with CFAVP are unfamiliar with competitor OBUs and RSUs. They are unaware of how standards are being interpreted by others. As part of Project Delta, CFAVP will leverage previous hardware investments by capturing packets and posting the information on *www.CFLSmartRoads.com*. Giving industry vendors access to the packets will help them understand what translation is needed.

Objective #2 – Direct industry towards standardization within the SAE Standards. With the packet information, CFAVP will work with FDOT on an official interpretation of standards for the state. This is something the Traffic Engineering Research Laboratory (TERL) has done routinely with NTCIP. These interpretations are shared with industry and become the minimum standard to be eligible to sell in Florida. Given the size of the Florida market, the industry finds a way to meet these interpretations and, hence, create interoperability.

Objective #3 – Work with industry to interpret SAE standards around progressively more complex applications using standardized packets (Basic Safety Message One and Two to Signal Phasing and Timing to Personnel Safety Message to Road Side Alert to Common Safety Request to Intersection Collision Avoidance), providing a development path as we progress down the standards. Perform testing end-to-end on sample applications to demonstrate interoperability and report via *www.CFLSmartRoads.com* the outcome.

Exhibition #1 – At SunTrax lab, V2I communication using cellular and DSRC methods will be demonstrated passing SPaT and MAP messages.

Exhibition #2 – At SunTrax lab, Vehicle-to-Pedestrian (V2P) communication using cellular will be demonstrated passing PSMs and TAMs.

Exhibition #3 – In Sumter County Vehicle to infrastructure communication using cellular and DSRC methods will be demonstrated passing SPaT and MAP messages.

Exhibition #4 – In Sumter County Vehicle to infrastructure communication using cellular and DSRC methods will be demonstrated passing MAP messages coded to Message Signs for uninstrumented locations.

Exhibition #5 – In Pine Hills Vehicle to infrastructure communication using cellular and DSRC methods will be demonstrated passing SPaT and MAP messages.

Exhibition #6 – At UCF Vehicle to infrastructure communication using cellular and DSRC methods will be demonstrated passing SPaT and MAP messages.

Exhibition #7 – At UCF V2P communication using cellular will be demonstrated passing PSMs and TAMs.

1.8.3 GOAL 2 – CREATE A STANDARDS DOCUMENT FOR ADS HMI

Create the "MUTCD" of ADS Human-Machine Interface.

Key partners: UCF, UMTRI, and the Professional Services Consultant

Current Situation - Through receipt of the Connected Vehicle Pilot, Tampa Hillsborough Expressway Authority (THEA) deployed approximately 1,000 OBUs. During the effort, they were presented with the challenge of how to get drivers to react correctly to warning messages. With information spread out and difficult to acquire, they used their best judgment and past messaging standards to convey information to users with brief, familiar messages. OEMs are going to be presented with the same challenges and are creating different solutions. Currently, difficulty with activating cruise control across different vehicle models is an inconvenience. Those extra seconds may be more impactful in response to warning messages for safety systems.

Issues and Challenges #1 – The crash avoidance HMI documentation is spread across many studies and has not been compiled into one source document that is readily available for practitioners.

Issues and Challenges #2 – The goal of many of the studies is to prove a value of the HMI but not to optimize the HMI, leaving a gap to be filled.

Objective #1 – Create common information, building off previous research. Using the vehicle simulators at UCF and UMTRI, different in-vehicle messages will be tested, and the results will be published for public consumption. The messaging will be comprised of auditory, visual, and haptic feedback.

Objective #2 – Understand transferability of platforms. As with backup cameras, in-vehicle messaging via an OBU could come from an in-mirror, an in-dash, or a heads-up display. Further, a cellphone could be the first deployment means. The effectiveness of these different platforms and any special considerations needed to achieve the appropriate action will be published for public consumption.

Exhibition #1 – At SunTrax lab, vehicle-based HMI will be demonstrated; user feedback will be gathered; validation of simulated environment research will be conducted.

Exhibition #2 – At SunTrax lab, cellphone-based HMI will be demonstrated with a mocked-up pedestrian and vehicle near-miss using two rounds: one with virtual vehicle and one with a virtual pedestrian.

Exhibition #3 – A construction lane closure will be simulated in Sumter County. Vehicle-based HMI will be demonstrated; user feedback will be gathered; validation of simulated environment research will be conducted.

Exhibition #4 – A construction lane closure will be identified via V2I MAP Message Sign in Sumter County. Vehicle-based HMI will be demonstrated; user feedback will be gathered; validation of simulated environment research will be conducted.

Exhibition #5 – The autonomous connected vehicle will be demonstrated on SR 50 in Pine Hills. Vehicle-based HMI will be demonstrated; user feedback will be gathered; validation of simulated environment research will be conducted.

Exhibition #6 – The autonomous connected vehicle will be demonstrated at UCF. Vehicle-based HMI will be demonstrated; user feedback will be gathered; validation of simulated environment research will be conducted.

Exhibition #7 – An autonomous connected vehicle will be deployed on the UCF campus at a properly instrumented signalized intersection. A "Car vs. Pedestrian" scenario will be simulated. Vehicle- and cellphone-based HMI will be demonstrated; user feedback will be gathered; validation of simulated environment research will be done.

1.8.4 GOAL 3 – AUTOMATED MAP MESSAGE GENERATION

Allow agencies to share information about roadway changes quickly and easily, updating OEM maps and broadcasting MAP updates.

Key Partners: UF, Professional Services Consultant, Cisco, Esri, and Connected Wise

Current situation – The largest FDOT project ever is the I-4 Ultimate Project in Central Florida. The project has over 200 maintenance of traffic (MOT) shifts as the consultant attempts to maintain traffic while economically constructing the project in a timely fashion. The shifts have been moving faster than current mapping services can keep up with the changes. Gore points are moved thousands of feet, sometimes miles away. Construction Engineering and Inspection (CEI) personnel are realizing the benefits of drone technology and its potential to locate objects and traffic changes on the fly, without risks to employees on-site.

The I-4 Ultimate Project is just one example of traffic conditions changing at a faster rate than the manual MAP message can be updated. The I-75 FRAME project has over 120 RSUs to be deployed in Alachua, Marion, and Sumter counties. One year after construction is complete, a roadway resurfacing effort will conflict with three RSU locations. In order to create and deploy the necessary MAP messages for the three conflicting I-75 FRAME RSU locations, there had to be weeks of specialized training for personnel. Still, the cost of sharing the MOT and associated downtime waiting for shift information to be provided and updated to the RSU may lead to the RSU being turned off during the construction period.

Frequently changing MOT shifts are currently an issue in road construction projects, but they are typically not a significant impact as nearly all vehicles on the road today are operated by human drivers who do not need MAP messages to function effectively. This will become a far more serious issue once ADS-enabled vehicles are more commonly operating on roadways and not receiving information relating to upcoming lane shifts or closures. An automated MAP message, using drone technology and computer vision, can dramatically improve the rate at which public agencies can provide necessary information, consequently improving safety on public roadways.

Parallel to the issue of MAP message automation, it may not be feasible for rural jurisdictions to invest heavily in RSU deployments where the fiber optic infrastructure is not present and/or the costs associated with RSUs may be too high. How can the benefits of MAP messages for ADS vehicles be captured by these rural jurisdictions?

Issues and Challenges #1 – There is no efficient and unified means by which road agencies can let the mapping industry know there are changes coming to their systems. This issue becomes even more important with ADS deployments.

Issues and Challenges #2 – Building and uploading the MAP message is complex.

Objective #1 – Standardize the MAP message – see Goal #1.

Objective #2 – Coordinate with Consultant to develop an API for ADS vehicle and evaluate the ability to receive the MAP message with various DSRC units from one or more vendors.

Objective #3 – Develop methodology and process for utilizing Computer Vision and Drone Technology for the development of a MAP message application. Establish the application as a web service so that geocoded video can be uploaded for MAP message generation. Allow the web service to receive confirmation on MAP message accuracy and provide option to push uploads to RSUs and connected vehicle.

Objective #4 – Evaluate the smart vision system and V2I MAP Message sign developed for rural environments that do not have access to RSUs and their underlying infrastructure.

Exhibition #1 – Capture aerial imagery using drone flyovers. Develop MAP messages for known intersections at UCF, Sumter County, and Pine Hills, showing the ability to perform in suburban, rural, and urban environments without construction. Connections to the ESRI back office will also be validated.

Exhibition #2 – At SunTrax lab, mock up an intersection reconfiguration using cones and update the MAP message, demonstrating the time between data collection and dissemination to infrastructure.

Exhibition #3 – A construction lane closure will be simulated in Sumter County. Information will be gathered by automated MAP generation methods and shared to an autonomous connected vehicle.

Exhibition #4 – A construction lane closure will be identified via V2I MAP Message Sign in Sumter County. Evaluate the autonomous connected vehicle's receipt of MAP message via sign and its response.

Exhibition #5 – The autonomous connected vehicle will be demonstrated on SR 50 in Pine Hills. A construction lane closure will be simulated to examine how the vehicle responds in an urban setting. Information will be gathered by automated MAP generation methods and shared to an autonomous connected vehicle.

Exhibition #6 – The autonomous connected vehicle will be demonstrated at UCF. A construction lane closure will be simulated to examine how the vehicle responds in a suburban setting. Information will be gathered by automated MAP generation methods and shared to an autonomous connected vehicle.

1.8.5 GOAL 4 – UNDERSTAND THE IMPACTS OF ELECTROMAGNETIC INTERFERENCE ON ADS

Understand the risks and impacts associated with electromagnetic interference to ADS communications and operations.

Key Partners: AMI

Current Situation – Automated vehicles depend on electromagnetic signals for their sensor functionality. The impact of EMI sources from natural events such as lightning is not well understood for the core AV sensor systems nor for the V2V and V2I communication systems. In order for the technology to advance responsibly, additional data is needed relating to the potential impacts that natural and man-made EMI sources may have on ADS operations.

Issues and Challenges #1 – There is a general lack of understanding regarding the risks and impacts associated with EMI sources on the sensory and communication systems used in ADS vehicles.

Objective #1 – Evaluate the risks and impacts of EMI from lightning and other sources in closed and open environments. Examine methods and test methods for fortifying hardware equipment to withstand EMI.

Exhibition #1 – Demonstrate mobile laboratory can operate safely and effectively prior to field work.

Exhibition #2 – Conduct field tests with the Mobile EM Lab. Testing will focus on locations that experience heightened levels of EMI. The Mobile EM Lab will drive near an airport to assess its potential effects on ADS technologies. The Mobile EM Lab will also drive through a tunnel to examine how communications equipment functions. Finally, the Mobile EM Lab will be deployed during adverse weather conditions to assess the impacts on radar, LiDAR, and other ADS technologies.

1.8.6. GOAL 5 – DEVELOP GUIDANCE DOCUMENTATION FOR CYBERSECURITY

Assess existing FDOT cyber network in an escalating series of targeted "white hat hacks." Develop guidance materials based on results.

Key Partners: FDOT, Local Agency IT Departments, and Professional Services Consultant

Current situation – Private industry will get cybersecurity right, as the cost of not doing so is high. On the public side, however, more needs to be done if these systems are to be interoperable. The Central Florida region has undergone an evaluation of its network and developed principles for each of the agencies to follow to minimize the risk of cyberattacks. These standards are based on general best practices and only involve low levels of technology sophistication. Generally, no new hardware has been purchased other than locks.

The importance of cybersecurity will only increase as transportation gives rise to connected and autonomous vehicles. Agencies must prepare their systems for malicious attacks on their network, but guidance on this topic is relatively limited.

Issues and Challenges #1 – There is no standard that plainly speaks to traffic signal systems and ITS on how vulnerable an agency is and what standard the agency should meet to be ready for the future.

Issues and Challenges #2 – Current agency equipment procurement processes typically do not involve cybersecurity experts; as a result, agencies do not understand the areas of risk on their systems.

Issues and Challenges #3 – Budgets are limited and generally come along with capital purchases and require budgeting and scopes that are well-defined to get something done. This does not allow for agencies to adequately investigate their cybersecurity vulnerabilities.

Issues and Challenges #4 – A knowledgeable owner needs to know what they are buying and be certain that the agency got what it paid for prior to paying the invoice.

Objective #1 – Hire a white hat hacker to conduct a penetration test on the FDOT District Five's network. Document vulnerabilities and receive recommendations on closing the gaps. As part of process, FDOT will conduct a risk assessment and develop a risk treatment process to guide the white hat hacker.

Objective #2 – Implement changes with agency staff and consultants based on cybersecurity recommendations provided by the white hat hacker. Document costs and time for efforts.

Objective #3 – Conduct validation tests to assess efficacy of recommended improvements. Document costs, miscommunications, processes, and effects to share with other agencies.

Exhibition #1 – Host a "Hack-a-thon" event at UCF for cybersecurity students from around the Central Florida region. Examine how secure the FDOT network performs, considering the penetration and validation tests conducted, and the recommended improvements undertaken as part of the Cybersecurity component.

The purpose of this exhibition will be to bring awareness to the industry as a career, as well as to see the progress made on the network's security measures.

TABLE 1: VISION, GOALS, AND OBJECTIVES

VISION

To be a smart region served by a fatality-free transportation system that is interoperable, secure, and agnostic to communication protocol, leveraging the latest in technology.

To achieve this, CFAVP has identified several strategic goals.

GOALS	OBJECTIVES
1 - Create and maintain a competitive marketplace within the Connected Vehicle arena that is independent of communication protocols	Remove barriers to interoperability
	Direct industry toward standardization of hardware and software
	Work with industry to perform definitions around progressively more complex applications using standardized packets, providing a development path. Report on functionality of application
2 - Create the "MUTCD" of ADS Human-Machine Interface	Using vehicle simulators, create common information building off previous research
	Understand transferability and effectiveness of platforms (i.e., rear-view mirror, heads-up display, or an in-dash display)
3 - Allow agencies to share information about roadway changes quickly and easily, updating OEM maps and broadcasting MAP updates	Standardize the MAP message
	Work with Consultant to develop an API for ADS vehicle. Evaluate the ability to receive MAP message with various DSRC units
	Develop methodology and process for utilizing Computer Vision and Drone Technology for the development of a MAP message application
	Evaluate the smart vision system and V2I MAP Message sign developed for rural environments that do not have access to RSUs and their underlying infrastructure
4 - Understand the risks and impacts associated with electromagnetic interference to ADS communications and operations	Evaluate the risks and impacts of EMI from lightning and other sources in closed and open environments. Examine methods and test methods for fortifying hardware equipment to withstand EMI
5 - Assess existing FDOT cyber network in an escalating series of targeted "white hat hacks." Develop guidance materials based on results	Conduct a "white hat hack" to test network for vulnerabilities. Document vulnerabilities and appropriate recommendations for closing the gaps
	Implement changes with agency and consultant staff. Document costs and time associated with efforts
	Conduct validation tests to assess efficacy of recommended improvements. Document costs, miscommunications, processes, and effects

1.9. ANTICIPATED DELIVERABLES

In addition to the deliverables required for each ADS Demonstration Grant awardee, the CFAVP anticipates several additional deliverables specific to the proposed program. The anticipated deliverables are noted in Table 2.

TABLE 2: ANTICIPATED DELIVERABLES

PROJECT DELTA DEMONSTRATION COMPONENT	ANTICIPATED DELIVERABLES
Interoperability Standardization	Packet Data for Industry Use
	FDOT Interpretation of Standards for Interoperability
Human - Machine Interface	Test Construction
	Test Results
	Recommendation of HMI
Automated MAP Message Generation	Automated MAP Message Generation Application
	Guidance Document- MAP Message Automation and MAP Message Sign Use
Electromagnetic Interference	AMI Mobile EM Lab- design and construction of apparatus; will be open-sourced for external use
	Data of EM Activity in Florida
	Technical Memorandum- Mobile EM Lab design; Driving Data; Recommendations
Cybersecurity	Scope of Services Template for Network System Hardening
	Budget Estimate for Network System Hardening

2 ADS DEMONSTRATION GOALS

2.1 SAFETY

At the heart of ADS implementation is public safety. The CFAVP Project Delta Demonstration addresses safety in several ways. First, interoperability ensures that V2X communications work across platforms. In other words, a driver does not have to worry if their car communicates properly with their local agency's traffic signal or RSU manufacturer. The safety applications simply work, meaning everyone benefits.

Second, interoperability allows for competition and does not allow industry to get complacent. The competition will create better applications, and the best application could be applied regardless of past infrastructure investments.

Third, ADS vehicles only provide safety benefits if the reaction from the driver meets the expectation of the alert. Common alerts across vendors prevent learning curves on actions that hopefully are not too common. Conversely, if safety alerts are not properly standardized, reaction times could suffer due to unfamiliarity, potentially leading to tragic consequences. Creating a common base of information that is openly shared will help move the industry in the right direction.

Fourth, many applications and certainly autonomous connected vehicles rely upon accurate maps. Improving the work flow by making maps more timely, accurate, and available will serve to keep applications functioning and areas accessible by autonomous vehicles.

Fifth, important environmental consideration will ensure that sensor development will take EMI edge cases into consideration, making certain that local weather will not limit the performance of ADS technology. This will allow the safety benefits from ADS systems to be useful even in severe weather.

Sixth, cybersecurity indirectly benefits safety by preventing bad actors from damaging safety systems, keeping them operating.

2.2 DATA FOR SAFETY ANALYSIS AND RULEMAKING

In terms of providing data for safety analysis and rulemaking, existing CFAVP activities provides stored data through the SunStore data portal available at *http://sunstore.cflsmartroads.com*. This data is available for researchers and the general public as part of the ATCMTD grant. Any new datasets derived from the Project Delta Demonstration will be made available through this same web portal. FDOT will negotiate and sign a mutually agreeable data-sharing agreement with USDOT ensuring data accessibility for at least five years after the performance period.

For rulemaking consideration, the Project Delta Demonstration will deliver some specific information and documentation. CFAVP is not asking for rulemaking with respect to these areas, but is making data available that may be used to inform rulemaking. Information to be made available as a result of the CFAVP Project Delta Demonstration includes: FDOT interpretation of interoperability standards; Human-Machine Interface impacts; automated MAP Message Generation application; process documentation; electromagnetic interference impacts on ADS technology and recommendations for reinforcement of systems; and cybersecurity standards and guidance, lessons learned, implementation costs, and schedule for public agencies.

2.3 COLLABORATION

The CFAVP Project Delta Demonstration intends to use the combined capabilities, industry knowledge, and public authority of a wide variety of entities, including local, regional, and state governmental transportation agencies, as well as academic institutions and private industry experts and vendors. As one of the stated goals of the initiative, collaboration will be a key component in carrying out the program. One of the goals of this program is to improve the coordination and collaboration between public agency and private vendor by making standardization and guidance documentation available for both sectors.

The Central Florida Transportation Systems Management and Operations (TSMO) Consortium, comprised of local, regional, and state transportation agency planners, engineers, and technologists will be a great resource for the CFAVP partners. As part of the bi-monthly meetings, FDOT and partner agencies will be able to share project details to and obtain valuable feedback from industry experts. The CFAVP will leverage this resource on a consistent basis to ensure the Project Delta Demonstration is being conducted in a way that makes sense to local agencies who are directly responsible for preparing their agencies and communities for the advent of ADS technologies. For more information, see Part II – Management Approach.

3 FOCUS AREAS

3.1 SIGNIFICANT PUBLIC BENEFIT

The significant public benefits provided by the Project Delta Demonstration stem from the program's broad impact. While the effect on any single individual cannot be directly pointed to, the advancement of the state of practice is clear. The components under the proposed program are designed to provide the needed guidance on several critical-path components in the advancement of ADS technologies. **The results of the program – actionable data, guidance documentation, and standardization – will be inherently portable and scalable to other regions of the Nation, assisting both public and private sector entities.**

Interoperability – A properly managed marketplace will yield optimal safety results. Interoperability between DSRC and 5G cellular communications will ensure investments made are carried forward no matter which communication technology prevails. Similarly, establishing a baseline standard of functionality between RSUs and OBUs will protect travelers as well as public investments.

Human-Machine Interface – Presently, manufacturers are developing user interface systems with little guidance, leading to widely different methods and platforms for communicating a given issue to the human driver. This is problematic given the need for timely and appropriate responses from drivers in the event of an emergency. Developing uniform HMI standards will meet driver expectancy and improve safety, just as the MUTCD has done for signage.

Automated MAP Message Generation – Automated MAP message generation will remove a specialist function that is unsustainable and siloed, and will allow for scaling and more direct communication between roadbuilders and users. As automation is expected to improve safety for vehicles, automating MAP messages will ensure ADS vehicles obtain the correct information in a timely fashion, ensuring their safe and efficient operation. Similarly, the MAP message sign may offer great benefit to rural areas that cannot afford to deploy RSUs along every roadway.

Electromagnetic Interference – Fully realized ADS technologies will require uninterrupted communications and sensor functionality. Evaluating electromagnetic interference and protecting against this potential issue will build out the knowledge base for the industry and advance the state of practice.

Cybersecurity – The guidance resulting from this Cybersecurity effort will bring more transparent and understandable solutions to an issue that is talked about with concern from the public, but in varies at the agency level. For the purposes of public safety, a more intentional process for advancing cybersecurity is necessary. By conducting a series of ethical hacks on the FDOT District Five network, we can ascertain vulnerabilities and deficiencies in the system and make corrections. These updates will be documented, with the resulting costs, scopes, best practices, and processes made available as guidance documentation for USDOT and other public agencies to examine their own networks.

3.2 ADDRESSING MARKET FAILURES

Interoperability - In a separate project, FDOT is actively testing numerous RSU and OBU models to determine how they function compared to the manufacturer's assertions, and to determine their interoperability with one another. The goal of this effort is to obtain empirical results on the real-world effectiveness of various hardware devices, so that the Department and other transportation agencies can make more-informed investments. Thus far, the testing has resulted in a wide range of compatibility and effectiveness between the various RSUs and OBUs. This raises significant concerns regarding public investments in ITS communication devices. If a public agency cannot conduct the extensive testing and research to determine compatibility between RSUs and OBUs, investments may be made on incompatible or ineffective equipment.

Stemming from the lack of interoperability between manufacturers' hardware/software is the potential "vendor lock" that public agencies may be forced into through their investments in particular models. Under the burden of vendor lock, public agencies cannot feasibly change vendors due to the investments previously made in the vendor's products. Vendors may take advantage of this predicament either by increasing prices or reducing quality and/or customer support at existing prices. Developing interoperability standards will ensure all RSU and OBU devices, and their software, are built to minimum specifications, reducing or eliminating this potential hardship on public agencies, freeing up funds for those products that best suit the needs of a given agency.

Vendors seeking an interoperable product also run into challenges as CFAVP's experience shows that vendors do not typically own each other's products or the products many are trying to integrate into. By making information readily available, this Project Delta Demonstration component will remove barriers to entry for many private sector vendors. Changing the business model and commoditizing hardware features will create a more efficient marketplace and better products.

Human-Machine Interface - CFAVP members have assisted private industry in the development of HMI for some OEMs. Additionally, investments have been made and carried out in HMI research, but the information is spread out, making data gathering costly and time consuming. Without easy access to information, decisions will be made with less information. The lack of standardization creates a marketplace that is unlikely to converge on a best practice. The likely result is implementations that require a learning curve from drivers. Given the rarity and split-second nature of emergency situations and HMI alerts, bringing research into the public domain can help converge interfaces to agreed-upon best practices. Combining the information and filling in the gaps will provide a resource for industry.

Automated MAP Message Generation - The CFAVP has identified the need for automated MAP messages that update in near-real time, merged with existing datasets in order to maintain accurate data for connected and autonomous vehicles. While this lack of MAP message automation is less obtrusive in the present, ADS vehicles will require accurate and timely information in near real-time to operate safely and effectively in SAE Level 3+ automation. Considering public agencies are the only entities that will know when, where, and how traffic shifts are going to occur, public agencies should lead the effort on MAP message generation.

Electromagnetic Interference - Edge cases abound within the ADS space. In Florida, the presence and persistence of thunderstorms during peak travel times makes electromagnetic interference testing a critical issue. Similarly, man-made sources of EMI, such as transmission lines, are commonplace along transportation infrastructure, and may pose a danger to ADS communications and sensors.

Cybersecurity - The marketplace for cybersecurity in the transportation space lacks a client that knows what to buy and a vendor that knows how to serve the market. This Project Delta Demonstration component seeks to take on these issues by informing the client side with an implementation experience, scope, and budget. Also, the iterative nature of implementation will help to inform the industry on the transportation marketplace.

3.3 ECONOMIC VITALITY

3.3.1 ADVANCING DOMESTIC INDUSTRY

The work proposed for the Project Delta Demonstration is primarily labor-driven, directly benefitting the American workforce. The program will increase investment in a high technology industry. Further, Project Delta will enhance the marketplace in the United States by addressing key market conditions within a growing industry.

3.3.2 HARDWARE PROCUREMENT

There are two components of the Project Delta Demonstration that will require hardware procurement. The *Electromagnetic Interference* component proposes the design and construction of a mobile measurement apparatus that can be installed on a standard truck, and used to measure radio frequency interference from a variety of sources in the field. The CFAVP commits to sourcing the development of this mobile laboratory with *Buy American*-compliant components.

The *Automated MAP Message* component will include the evaluation of MAP message **signs** that can be used in rural areas with limited resources. The manufacture of these signs will be compliant with *Buy American* standards.

For these components and all other elements of the Project Delta Demonstration, the CFAVP takes no exception with the standards outlined in the *Buy American* requirements.

3.4 COMPLEXITY OF TECHNOLOGY

The exhibitions outlined in Project Delta will include SAE Level 3 and higher automation. The highest levels of automation will be explored during the exhibitions for the Interoperability, Human-Machine Interface, and Automated MAP Message Generation components. In these exercises, infrastructure will communicate simulated and actual vehicle locations, as well as simulated lane closures. The exhibitions will examine how the ADS-equipped vehicle responds to these dynamic obstructions.

While the work efforts relating to Electromagnetic Interference and Cybersecurity will not physically demonstrate Level 3 or higher automation, these components will contribute significantly to advancing the state of practice for ADS technologies overall, and improving vehicle operations at every level of automation.

3.5 DIVERSITY OF PROJECTS

The Project Delta Demonstration includes work in rural areas of Sumter County, the suburban environment of the UCF campus and surrounding area, and the urban setting of Pine Hills. Walking, biking, transit, and driving are all modes of transportation represented in these areas. Freight traffic is also featured, particularly in Sumter County.

3.6 TRANSPORTATION - CHALLENGED POPULATIONS

No new publicly available transportation services are directly being deployed as part of this effort. In place of location-specific services, Project Delta Demonstration is engaging with more technical topics that will potentially support future ADS deployments around the Nation. While there are no physical infrastructure components or ADS vehicle design elements proposed by the Project Delta Demonstration, the HMI component will evaluate potential auditory, visual, and haptic feedback for effectiveness in communicating to individuals with disabilities.

3.7 PROTOTYPES

3.7.1 AUTOMATED MAP MESSAGE GENERATION APPLICATION

As part of the Project Delta Demonstration, the automated MAP message generation application will provide a much-needed advancement in V2I communications. The prototype will be in the public domain and will be transferable as a result, with minimal costs. This prototype will have far-reaching impacts on the safe and efficient operation of ADS vehicles by sending near real-time, accurate roadway geometry to vehicles. Automating this element of V2I communications will greatly improve upon the existing model, which currently requires a labor-intensive process to create a new MAP message. The application will generate a near real-time MAP message based on drone video and machine vision, and then upload the MAP message into an RSU. Not only will an automated MAP message application improve efficiency; it will also ensure ADS vehicles operate safely in dynamically changing conditions.

3.7.2 MAP MESSAGE SIGN

In addition to the *automated* MAP message application, the CFAVP Project Delta Demonstration will also evaluate the potential benefits of a MAP message *sign*, which will provide similar geometric information to an ADS vehicle without the need for an RSU. Currently, many rural areas cannot afford to deploy RSUs on all their minor facilities. This will be problematic for ADS vehicles when traveling along roadways that are not functioning as expected due to a work zone, a lane closure, or other dynamic conditions. A MAP Message sign is a low-cost alternative that still ensures an ADS vehicle can operate safely and efficiently in altered travel conditions.

4 REQUIREMENTS

4.1 FOCUS ON ADS

The five focus areas of interoperability, human-machine interface, automated map message generation, electromagnetic interference, and cybersecurity have clear effects on ADS technology, and all represent risks that must be tackled on the path to making cooperative automation a functional system. These focus areas will support and enhance Level 3 and higher automation.

4.2 DEMONSTRATION

The efforts of interoperability, human-machine interface, automated MAP message generation, and electromagnetic interference will include physical exhibitions that demonstrate the capabilities of Level 3+ automation and also examine opportunities to improve automation as well as resistance to external factors such as lightning. Testing will be progressive, from a closed environment to the open road across different environmental conditions. The exhibitions are meant to be both practical and safe in their increasing complexity, as well as comprehensive in the areas of deployment, as to resonate with a broader audience. For cybersecurity, the exhibition will be a physical deployment as much as is practical.

4.3 DATA EXCHANGE

CFAVP will go above and beyond in providing data to USDOT. Data is already made available for many of our efforts via the portal located at *SunStore.CFLSmartRoads.com*. CFAVP work already accomplished in determining interoperability can be found at *www.cflsmartroads.com/projects/CVAV_D5_Testing.html*. We are enthusiastic members of the ATCMTD Cohort. We are committed to be as transparent as possible with the data we collect and lessons we learn. Florida Statutes create an environment where government work takes place "in the sunshine" and many of the record retention requirements meet or exceed the ADS Demonstration Grant requirements. FDOT will negotiate and sign a mutually agreeable data-sharing agreement with USDOT ensuring data accessibility for at least five years after the performance period.

CFAVP will work with its Consultant on sharing as much data as they can while still being sensitive to their leadership role in a competitive marketplace. Their role is focused on exhibition, precisely to keep as much data in the public sphere as possible while still meeting the objectives of the ADS Grant program. **For more information relating to FDOT's Data Management program and proposed data-sharing, see Part III – Draft Data Management Plan.**

4.4 USER INTERFACE

As part of the HMI component, extensive testing and evaluation of input/output user interfaces (UI) will be conducted to provide guidance and standardization material to the industry, similar to the Manual on Uniform Traffic Control Devices. The HMI exhibitions will examine how ADS vehicles communicate with various types of users, including the elderly and individuals with disabilities.

For the other elements under the Project Delta Demonstration, such as Interoperability Standardization and Automated MAP Messaging, the UI will play a secondary role in the exhibition.

4.5 SCALABILITY

The proposed exhibitions in the Project Delta Demonstration were designed with scalability in mind. As the Demonstration components are focused on broader technological elements, there are no planned localized ADS services for the Project Delta Demonstration. Instead, smaller exhibitions will be conducted, with the end goal of providing data and documentation to USDOT and the industry. The anticipated deliverables (see Section 1.9) proposed for the Project Delta Demonstration will be immediately beneficial to transportation agencies and decision-makers across the United States and will not be confined to the Central Florida region.

4.6 AGENCY OUTREACH

Since 2014, FDOT District Five has hosted the bi-monthly TSMO Consortium meeting which is attended by transportation planners and engineers representing the nine counties and five metropolitan/transportation planning organizations (MPO/TPO) within the District's jurisdiction. The TSM&O Consortium meeting includes discussions relating to the state of practice, existing and planned projects, lessons learned, and challenges facing agencies. This meeting has been a great resource for local, regional, and state agencies to maintain effective communication and a collaborative spirit, and will be used by the CFAVP to share the status, lessons learned, and best practices relating to ***Project Delta Demonstration***.

In addition to the TSMO Consortium, the Regional Working Group meeting, which is attended by transportation technologists, is also held every other month. While the TSM&O Consortium generally provides planning-level information and guidance to participants, the Regional Working Group Meeting is intended to provide technical insights relating to ITS for local transportation and traffic engineers. When appropriate, information pertaining to the proposed CFAVP Project Delta Demonstration will also be shared at this meeting.

5 APPROACH

5.1 IMPLEMENT AND EVALUATE THE DEMONSTRATION

5.1.1 METHODOLOGY

The CFAVP Project Delta Demonstration is comprised of five major components. Each component will be structured in a manner similar to research efforts conducted at academic institutions. Generally, the process will include the following elements: construct a hypothesis, construct test(s) with the purpose to affirm/reject hypothesis, gather data, conduct test(s), and determine if the hypothesis be rejected.

Each exhibition will be constructed with the goal of establishing **reasonable, repeatable, and reproducible** test procedures. The processes and costs associated with each exhibition will be documented and provided in the interest of supporting ADS rulemaking.

5.1.2 IMPLEMENTATION

Exhibitions will be conducted to affirm or reject the hypotheses developed at the outset of each component. In addition to the exhibitions shown below, the Interoperability Standardization, HMI, and Automated MAP Message components will also include simulation and modeling efforts prior to closed-environment testing.

The program manager, FDOT, is experienced in managing complex projects and will deliver the Project Delta Demonstration with the same level of efficiency.

Pre-Deployment Exhibitions

Goal 3 Exhibition #1 – Capture aerial imagery using drone flyovers. Develop MAP messages for known intersections at UCF, Sumter County, and Pine Hills, showing the ability to perform in suburban, rural, and urban environments without construction. Connections to the ESRI back office will also be validated.

Closed Environment Exhibition at SunTrax

Goal 1 Exhibition #1 & Goal 2 Exhibition #1 – At SunTrax lab, the CFAVP will show the message types are consistently being passed to an autonomous connected vehicle correctly. Verify receipt and interpretation of the message. Vehicle-based HMI will be demonstrated; user feedback will be gathered; validation of simulated environment research will be conducted.

Goal 1 Exhibition #2 – At SunTrax lab, a virtual stopped vehicle will be created and messaged to an autonomous connected vehicle. Its ability to respond to the “stopped vehicle” will be demonstrated on the closed facility using cellular and DSRC messaging.

Goal 2 Exhibition #2 – At SunTrax lab, cellphone based HMI will be demonstrated with a mocked-up pedestrian and vehicle near-miss using two rounds. One with virtual vehicle and one with a virtual pedestrian.

Goal 3 Exhibition #2 – At SunTrax lab, mock up an intersection reconfiguration using cones and update the MAP message, demonstrating the time between data collection and dissemination to infrastructure.

Goal 4 Exhibition #1 – Demonstrate Mobile EM Laboratory can operate safely and effectively prior to field work.

Open Road Exhibition at Sumter County Facility

Goal 1 Exhibition #3, Goal 2 Exhibition #3, & Goal 3 Exhibition #3 – A construction lane closure will be simulated. Information will be gathered by automated MAP generation methods and shared to an autonomous connected vehicle. Vehicle-based HMI will be demonstrated; user feedback will be gathered; validation of simulated environment research will be conducted.

Goal 1 Exhibition #4, Goal 2 Exhibition #4, & Goal 3 Exhibition #4 – A construction lane closure will be identified via V2I MAP Message Sign. Evaluate the autonomous connected vehicle's receipt of MAP message via sign and its response. Vehicle-based HMI will be demonstrated; user feedback will be gathered; validation of simulated environment research will be conducted.

Open Road Exhibition on SR 50 in Pine Hills

Goal 1 Exhibition #5, Goal 2 Exhibition #5, & Goal 3 Exhibition #5 – The autonomous connected vehicle will be demonstrated on SR 50 in Pine Hills. A construction lane closure will be simulated to examine how the vehicle responds in an urban setting. Information will be gathered by automated MAP generation methods and shared to an autonomous connected vehicle. Vehicle-based HMI will be demonstrated; user feedback will be gathered; validation of simulated environment research will be conducted.

Open Road Exhibition at UCF

Goal 1 Exhibition #6, Goal 2 Exhibition #6, & Goal 3 Exhibition #6 – The autonomous connected vehicle will be demonstrated at UCF. A construction lane closure will be simulated to examine how the vehicle responds in a suburban setting. Information will be gathered by automated MAP generation methods and shared to an autonomous connected vehicle. Vehicle-based HMI will be demonstrated; user feedback will be gathered; validation of simulated environment research will be done.

Goal 1 Exhibition #6, & Goal 2 Exhibition #7 – A autonomous connected vehicle will be deployed on the UCF campus at a properly instrumented signalized intersection. A "Car vs. Pedestrian" scenario will be simulated. Information will be gathered by instrumentation put in place by the ATCMTD grant resulting in Personnel Safety Messages and Traffic Advisory Messages and shared to an autonomous connected vehicle. Vehicle- and cellphone-based HMI will be demonstrated; user feedback will be gathered; validation of simulated environment research will be done.

Goal 5 Exhibition #1 – Host a "Hack-a-thon" event at UCF for cybersecurity students from around the Central Florida region. Examine how secure the FDOT network performs, considering the penetration and validation tests conducted, and the recommended improvements undertaken as part of the Cybersecurity component.

Field Testing for the Mobile EM Lab

Goal 4 Exhibition #2 – Conduct field tests with the Mobile EM Lab. Testing will focus on locations that experience heightened levels of EMI. The Mobile EM Lab will drive near an airport to assess its potential effects on ADS technologies. The Mobile EM Lab will also drive through a tunnel to examine how communications equipment functions. Finally, the Mobile EM Lab will be deployed during adverse weather conditions to assess the impacts on radar, LiDAR, and other ADS technologies.

5.1.3 EVALUATION

Each component includes a scheduled evaluation element following their exhibitions. The documentation for each component, identified in previous sections, will be developed and/or finalized during these evaluation periods. These evaluations will be a collaborative effort between the various CFAVP agencies and testing partners, to ensure all information and data is captured.

5.2 LEGAL, REGULATORY, ENVIRONMENTAL, OTHER

To the best of CFAVP's knowledge, the exhibitions do not require any exception to Florida Statute, Federal Motor Vehicle Safety Standards (FMVSS), Federal Motor Carrier Safety Regulations (FMCSR), or any other regulation. Additionally, for much of the proposed work effort, there is no hardware being purchased as part of the Demonstration. As part of the EMI component, a testing apparatus will be developed. The development of the apparatus will comply with Buy American requirements. Similarly, the construction of the V2I MAP message signs will comply with Buy American requirements. The remaining elements of the Project Delta Demonstration will not include hardware procurement, and should not require any exceptions to Buy American requirements.

5.3 COMMITMENT TO PROVIDE DATA AND PARTICIPATE IN SAFETY EVALUATIONS

As stated in Section 4.3 Data Exchange, the CFAVP is committed to sharing as much data as possible. This is not just a throwaway statement. Our actions support this approach. For more information relating to our proposed efforts to manage and share project data, see Part III – Data Management Plan.

The CFAVP goal is, at its core, to support safe operations. We believe our progressive approach to exhibitions is a best practice that will support advancements in the ADS space. Nothing will hit the streets without first being tested in a closed environment. We look forward to another set of eyes to ensure that our exhibitions protect the public interest.

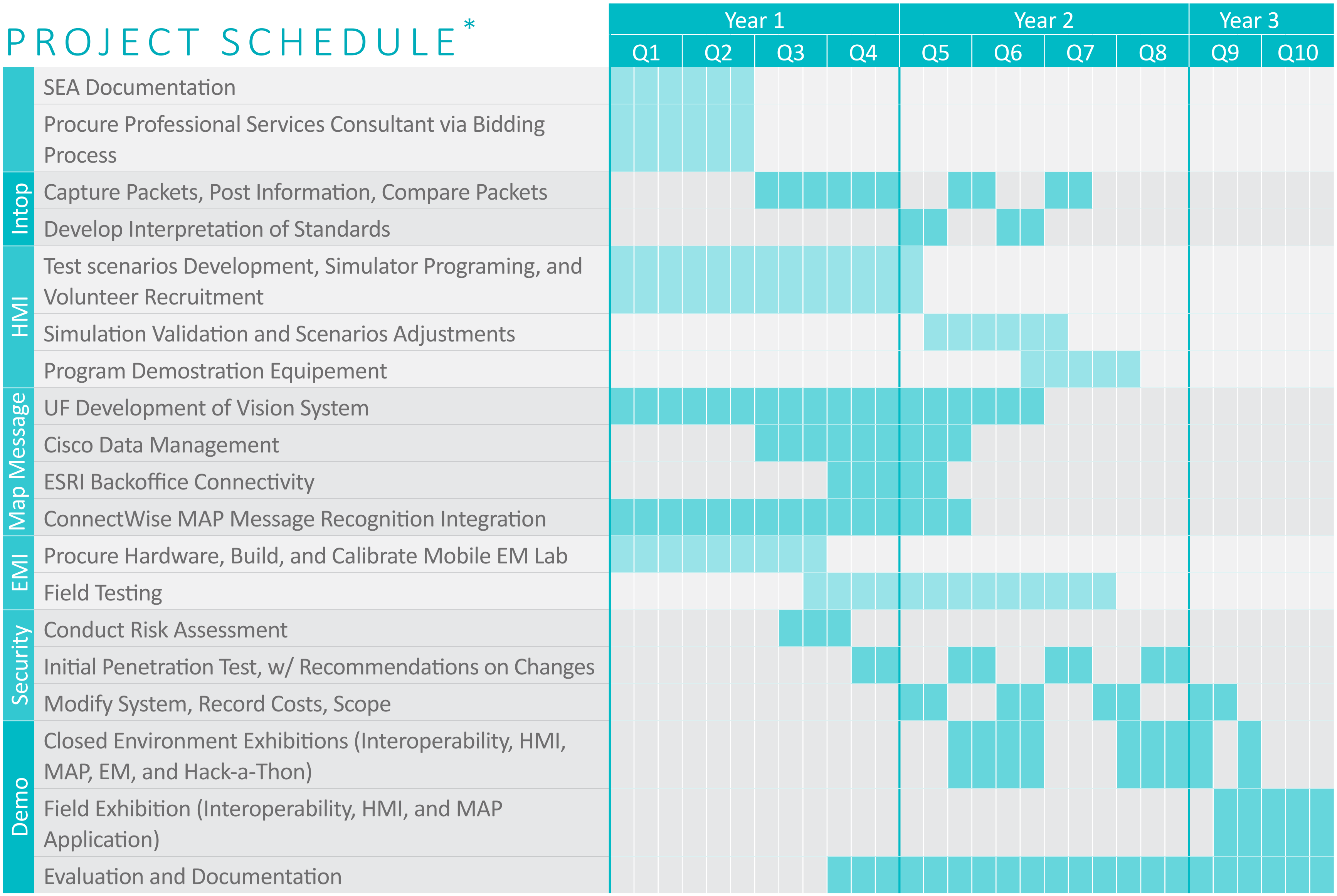
5.4 RISK IDENTIFICATION, MITIGATION, AND MANAGEMENT

Before exhibitions occur, a risk management plan will be developed consistent with the CFAVP Safety Plan and Systems Engineering best practices. The Safety Plan was a requirement established as part of the Automated Vehicle Proving Grounds (AVPG) designation. The Safety Plan incorporates local lessons learned and requirements with national best practices, and may be viewed at *www.cflsmartroads.com/projects/CVAV.html*. Risk Management Plan templates may be viewed at *www.fdot.gov/traffic/ITS/Projects-Deploy/SEMP.shtm*.

5.5 CONTRIBUTION AND MANAGEMENT OF NON-FEDERAL RESOURCES

Cost share is not proposed for the Project Delta Demonstration. **However, the Department will comply with all applicable Federal standards in managing and distributing federal funds awarded as a result of this ADS Demonstration Grant.**

PROJECT SCHEDULE*



*For a comprehensive schedule of the Project Delta Demonstration, please visit *http://www.cflsmartroads.com/projects/CVAV.html*