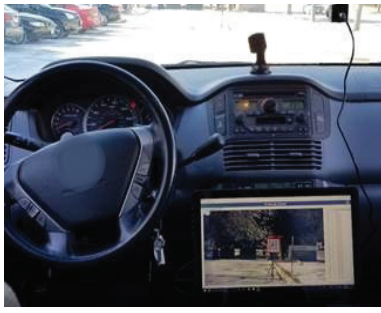
DelDOT



U.S. Department of Transportation

Part I
Narrative and Technical Approach

Automated Driving System Demonstration Grants
NOFO #693JJ319NF00001

March 21, 2019

STATE OF DELAWARE
DEPARTMENT OF TRANSPORTATION
800 BAY ROAD
P.O. BOX 778
DOVER, DELAWARE 19903

JENNIFER COHAN
SECRETARY

March 18, 2019

Federal Highway Administration
Office of Acquisition and Grants Management
1200 New Jersey Avenue, SE
Washington, DC 20590
Location: E66-101

Dear USDOT ADS Demonstration Grant Selection Committee:

I am pleased to provide Delaware Department of Transportation's (DelDOT's) proposal for the Automated Driving System (ADS) Demonstration Grant. Our team has put together a program plan, spanning approximately three (3) years, to implement a three-phase ADS technology demonstration deployment with the goals of improving safety and enhancing mobility using artificial intelligence, machine learning and advanced technology.

Incorporating Connected and Autonomous technology supports the National Safety Council's Road to Zero mission, which lays out strategies to end roadway fatalities and serious injuries by 2050. Motor vehicle crashes remain a leading cause of accidental death in the United States with the major factor in over 90 percent of all fatal crashes being human error [1]. It is anticipated that progressing towards fully automated vehicles and investing in the safe implementation of technology, will increase overall roadway safety.

DelDOT is already investing in autonomous and intelligent technology, proving ourselves to be a leader in innovation and implementation. Delaware is providing a large-scale variation of environments to evaluate ADS. By using this grant, DelDOT will have the ability to set the stage for ADS deployment, addressing challenges such as data collection and sharing, monitoring safe implementation of a mixed fleet, and implementation of policy. Deploying the most up-to-date autonomous and intelligent technology will provide motorists and road users with a reliable and safe transportation system. The funds provided by the grant will allow DelDOT to safely test ADS, implement technology, and evaluate the impacts these systems will have in real world situations on a statewide level.

[1] US DOT "Preparing for the Future of Transportation: Automated Vehicle 3.0", October 4, 2018

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Our project team is requesting $3,135,085.93 from this grant opportunity. This request would leverage our current ADS Shuttle Pilot Deployment projects along with multiple ongoing Intelligent Transportation Projects including investing in Artificial Intelligence (AI) and Machine Learning (ML) throughout the state of Delaware.

This project will fund the integration of automated driving systems into Delaware's on-road transportation system, ensure significant data gathering and sharing of project data from the USDOT and the public in near real-time, demonstrate significant commitment to leveraging the demonstration data and results for safety, improved mobility and environment, and work with local governments as well as universities and private partners (vendors) to create collaborative environments that harness the collective expertise, ingenuity and knowledge of multiple stakeholders. Our team will use the funding specifically for the following initiatives:

1. Leverage on-going ADS programs into the existing transportation infrastructure through demonstrations such as the ADS Shuttle deployment, Dilemma Zone implementation, Connected Vehicle Weather Responsive Traffic Management (CV-WRTM) program, AI software development.
2. Safely integrate emerging connected and autonomous vehicle technology into our existing statewide multimodal Integrated Transportation Management System (ITMS).
3. Further develop and implement a model for data collection and sharing of ADS shuttle data with USDOT, other states, academia, and others for safety analysis and rulemaking; foster collaborations among different agencies and stakeholders for adoption and deployment of ADS.
4. Address challenges in technology deployment such as the implementation of policy and provision of service.

Delaware is already investing in a multitude of forward thinking and innovative projects. Our proposal outlines our capabilities and experience, which includes the Advisory Council on Connected and Autonomous Vehicles, with innovative research and implementation of many emerging technology programs such as the Dilemma Zone Detection/Warning System, participation in the Signal Phase and Timing (SPaT) Challenge (which deploys DSRC equipment to enable Vehicle-to-Infrastructure (V2I) communication), and the deployment of mobile road weather information sensors onto DelDOT fleet vehicles through the FHWA "Connected Vehicle Enabled Weather Responsive Traffic Management" (CV-WRTM) program.

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JENNIFER COHAN
SECRETARY

We anticipate that the ADS Demonstration Program will enhance safety, improve mobility, and provide the data and experience necessary for deployment on a larger scale. As program manager, I am pleased to present our ADS Demonstration Grant Application.

Thank you for your consideration.

Sincerely,

Gene S. Donaldson

TMC Operations Manager

Delaware Department of Transportation

Summary Table	
Project Name/Title	Autonomous Driving System Demonstration
Eligible Entity Applying to Receive Federal Funding (Prime Applicant's Legal Name and Address)	Delaware Department of Transportation (DelDOT) 800 S Bay Road, Dover, DE
Point of Contact (Name/Title; Email; Phone Number)	Gene Donaldson, TMC Operations Manager (302) 659-4601 Gene.Donaldson@Delaware.gov
Proposed Location (State(s) and Municipalities) for the Demonstration	Delaware, statewide
Proposed Technologies for the Demonstration (briefly list)	Autonomous Shuttles Advanced communication technologies (e.g. Dedicated Short Range Communication (DSRC), 5G as available) Connected Vehicle-enabled Road Weather Sensors Computerized Signal System Artificial Intelligence and Machine Learning Web-based data server and
Proposed duration of the Demonstration (period of performance)	3 years
Federal Funding Amount Requested	$3,135,085.93
Non-Federal Cost Share Amount Proposed, if applicable	$810,000.00
Total Project Cost (Federal Share + Non-Federal Cost Share, if applicable)	$3,945,085.93

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1 EXECUTIVE SUMMARY AND PROGRAM OVERVIEW

1.1 Introduction

Incorporating Connected and Autonomous technology supports the National Safety Council's Road to Zero mission, which lays out strategies to end roadway fatalities and serious injuries by 2050. Motor vehicle crashes remain a leading cause of accidental death in the United States and the major factor in over 90 percent of all motor vehicle crashes is human error. [1] It is anticipated that progressing towards fully automated vehicles and investing in the safe implementation of technology, will increase overall transportation system safety, efficiency, and mobility.

Automated Driving Systems (ADS) have the potential to improve quality of life and enhance mobility and independence for millions of Americans, especially older Americans and people with disabilities. Most importantly, it has the potential to improve safety by reducing crashes caused by human error (impaired or distracted drivers) and saving lives. Safely integrating ADS into the nation's transportation system, however, requires careful design and upgrade of roadways and infrastructure, extensive testing, evaluation and improvement of ADS technology both in controlled environments and on public roads. Broad collaboration and coordination among different agencies and stakeholders for pilot ADS will lead to the eventual full deployment of ADS on public roadways and would serve transportation needs.

In response to the USDOT Automated Driving System (ADS) Demonstration Grant, Delaware Department of Transportation (DelDOT), in collaboration with Jacobs Engineering Group (Jacobs) and Intelligent Automation, Inc. (IAI), is proposing a three-phase Automated Driving System (ADS) technology demonstration deployment program to span approximately three (3) years. The total funding requested under this program is $3,135,085.93.

This deployment program **leverages DelDOT's investments in ADS and Artificial Intelligence (AI) through on-going ADS Shuttle Pilot Deployment projects, along with multiple Intelligent Transportation System (ITS) Projects** throughout the state of Delaware. Two ADS Shuttles from EasyMile (EZ10) are currently being procured and deployed, and two Olli shuttles from Local Motors will be made available through participation in the Olli Challenge. **These low-speed, Society of Automotive Engineering (SAE) Automation Level 3 (Olli) and Level 4 (EZ10) shuttles will be used as matching resources for this effort.** DelDOT has not yet finalized the details of shuttle deployment with Local Motors, so efforts/projects within this proposal will be focused around the state procured EasyMile EZ10 shuttles.

Goal: The goal of the proposed project is to demonstrate ADS vehicle technology, incorporate ADS transit vehicles into the Delaware Transit Corporation's (DTC) First State fully integrated transit system (which is an operating division of DelDOT), integrate with DelDOT's Integrated Transportation Management System (ITMS), and continue to support research initiatives at public and private institutions.

Benefit: The benefit of investing in the ADS shuttles and the associated technology in Delaware will be the safe implementation of technology which will increase overall transportation system safety.

[1] US DOT "Preparing for the Future of Transportation: Automated Vehicle 3.0", October 4, 2018

Granted funds will be used to conduct various demonstration projects and technologies throughout the state of Delaware to further enhance and develop the state's data management strategy, successfully enhancing and integrating ADS data into the existing ITMS.

These technologies are described in more detail in Section 5 and include the following:

1. Develop machine vision algorithms to monitor and record incidents.
2. Develop and deploy machine vision capabilities on ADS vehicles to read traffic signals and traffic signs in order to validate compliance.
3. Deploy Vehicle-to-Infrastructure (V2I) communication equipment into the ADS demo Shuttles, collect vehicle Basic Safety Message (BSM) data, and communicate TMC warnings and travel advisory information to and from ADS shuttles.
4. Deploy vehicle Controller Area Network (CAN) bus data logger and accelerometers to the ADS shuttle vehicles to record vehicle operation and maneuver dynamics data.
5. Procure and install video cameras inside the ADS shuttle and streaming near real-time video data.
6. Equip the ADS Shuttles with wireless weather and road surface friction sensors to collect road weather data.
7. Enhance and integrate the existing data servers to incorporate ADS shuttle data into the existing ITMS data and share with USDOT and/or other stakeholders.

Integrated transportation management is DelDOT's unique way of doing business. DelDOT has long been integrating advanced technology, infrastructure and people to achieve mobility, safety and security goals[2]. This proposed ADS Demonstration deployment program leverages multiple ongoing Intelligent Transportation Systems (ITS) projects and over twenty years of capital investments in ITS and transportation management operations, policies, and procedures.

- DelDOT published its initial Integrated Transportation Management Strategic Plan in 1997, with the vision to reduce congestion and delay, improve safety, reduce operating costs and improve system performance. In 2017, DelDOT released an updated Integrated Transportation Management Strategic Plan focusing on maintaining what we have, finishing what we started and integrating new opportunities.

- **DelDOT has made a significant investment in Artificial Intelligence (AI) and Machine Learning (ML) at DelDOT's TMC** over the past four years with the goal of collecting and analyzing transportation system data as well as automate the system management and operation decision making process. DelDOT continuously collects traffic data to monitor the dynamic nature of travel conditions and proactively manages the transportation system through the 24-hour statewide TMC.

- DelDOT will continue to **leverage existing investments** such as the AV Shuttle Implementation Program, Governor's Advisory Council on Connected and Automated

[2] https://deldot.gov/Publications/reports/ITMS/pdfs/2017_Delaware_ITMS_Strategic_Plan.pdf

Vehicles, CV-WRTM, Dilemma Zone Detection/Warning System, and SPaT Deployment Challenge.

- DelDOT is a multimodal transportation agency that owns and operates over 90% of the roads, along with a statewide computerized signal system, and a fully integrated statewide transit system. Delaware Transit Corporation (DTC), an operating division of DelDOT, is the transit provider for the state of Delaware.
- **DelDOT has a robust fiber/wireless telecommunications system.** The State of Delaware has continuously made investments in its telecommunications and information technology (IT) systems over the last 20 years, including the state-owned fiber network that connects to neighboring states, its wireless network, and information systems. Delaware's state-owned network provides sufficient bandwidth and reliability to function at peak performance even in the worst conditions.
- **DelDOT has established and continues to foster a culture of innovation**. Delaware Secretary of Transportation, Jennifer Cohan, has made customer service and innovation the focus of her tenure. She has promoted innovation in all divisions of DelDOT, including work done through the Connected and Autonomous Vehicle (CAV) program and the annual Innovation Fair.
- **Delaware is fostering private telecommunication growth with recent legislation.** House Bill 189 of the 149th General Assembly of the State of Delaware supports the "Advanced Wireless Infrastructure Investment Act." This Section of Delaware Code created a mechanism to allow wireless service providers to place qualifying wireless small cell facilities and support structures within the State's right of way, as well as being attached directly to state maintained infrastructure at no leased cost.

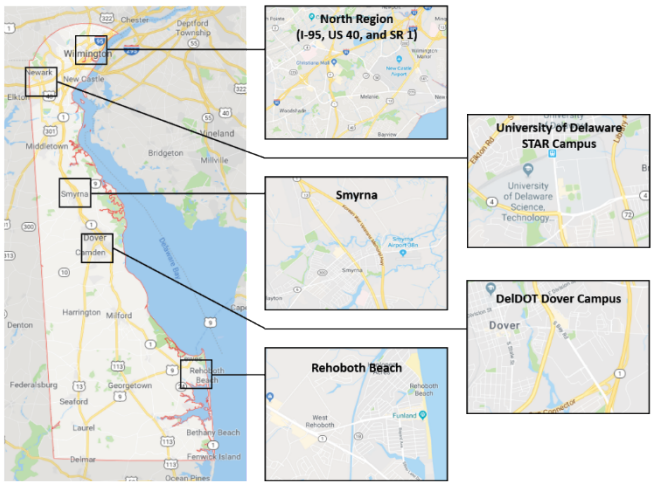


Figure 1: DelDOT CAV demonstration Site Locations

The below table details each demonstration activity as well as the applicable NOFO requirement and how each proposed demonstration satisfies the requirement.

Requirement	Proposed Demonstration	How does it satisfy Requirement	Associated Challenges
a. Demonstration must focus on ADS technology (preference SAE Level 3 or greater)	ADS Shuttle Implementation Program	ADS Shuttles that DelDOT is procuring are L3/4 automation.	Low-speed, low capacity nature of automated shuttle may have unforeseen limitations
b. Include a Physical Demonstration	Potential locations for ADS shuttle deployment include the DelDOT Campus and surrounding public street networks in Dover, DE and a planned location at the University of Delaware, Newark, DE.	ADS Shuttles are being procured now and will be deployed for testing. Existing multi-year executed contract to purchase L3 or greater ADS shuttles	Physical vehicle deployment Level of public acceptance for ADS shuttle vehicles Operations and maintenance
c. Include gathering and sharing of all relevant data in near real-time	ADS shuttle vehicles will be instrumented with multiple types of sensors to collect and analyze vehicle operation and safety performance data.	Delaware's existing real-time Transportation Management System. Build the interface required for the ADS technology to collect store and share real-time and historical data to USDOT and to existing public extranet.	Data storage (especially raw sensor data such as CAN bus data, video clips, BSM data etc.) and processing algorithms development and integrative software development.
d. Include input/output user interfaces on ADS and related applications.	The proposed ADS Shuttle includes an OBU and a built-in touch screen display inside the vehicle that will provide a visual/audible user interface and the	Through connection to the V2I-enabled OBU, the touch screen display will provide a means for user interaction by displaying route information, allowing users to request stops,	Supporting multiple languages, and haptics warning to individuals and persons with accessibility challenges including

Requirement	Proposed Demonstration	How does it satisfy Requirement	Associated Challenges
	ability to access the DelDOT app.	and supporting audible and visual access.	remaining compliance with the latest ADA requirements. Determine shuttle integration into long term transit operations.
e. Each demonstration must be scalable to be applicable across the Nation and include outreach with other jurisdictions and the general public.	The ADS demonstration will be on public roadways with mixed traffic, multiple routes serving a wide range of municipalities including urban, rural and suburban communities.	The demo routes include public roadways as well as signalized corridors with mixed traffic, along multiple varied routes. ADS shuttle data is shared with the public and stakeholders. Outreach and user education programs including public demonstrations will occur.	The lengths of routes are limited to under ten miles; the shuttles are low-speed. New route development process

Table 1: Program Fulfillment of NOFO Requirements

Delaware's culture of innovation and investment makes us an ideal candidate for investment in continued ADS demonstration deployment applications. DelDOT will continue to be a leader when it comes to transportation systems, operations and management (TSMO).

1.2 Vision Goals and Objectives

The current ADS shuttle program is a key component of Delaware's overall CAV program and is supported by Delaware's Advisory Council on CAV, which supports statewide goals as established under Executive Order 14. **By leveraging DelDOT's existing ITMS and ongoing CAV projects, as outlined in the table below, this grant will support further study to aid in the next steps of ADS implementation and policy development.**

CAV Related Project	Description	Status
Artificial Intelligence Transportation Operations and	Creating a fully predictive and adaptive transportation system based on AI and machine learning.	DelDOT is integrating software into TMC operations. The AI

Management System (AI-TOMS) (USDOT contract #: DTRT5716C10004; and 6913G618P80011)	The software collects data from network-wide traffic sensors and signal controllers, detects and predicts traffic incidents, and recommends plans to mitigate congestion.	software can detect traffic anomalies and determine the cause and location of the event using machine learning algorithms.
Connected Vehicle Enabled Weather Responsive Traffic Management (CV-WRTM)	Equipping DelDOT fleet vehicles and a transit vehicle with mobile road weather information sensors that communicate via cellular modems to collect mobile data to supplement and enhance the existing fixed weather sensor data.	Mobile sensors have been installed on DelDOT fleet vehicles and are currently collecting winter weather data. Final report is expected to be submitted to USDOT Summer 2019.
Dilemma Zone Detection/Warning System (USDOT contract #: DTRT57-10-C-10073)	Utilizing high-definition radar detectors and DSRC equipment to provide Dilemma Zone detection and protection by providing warning messages to motorists as they approach an intersection and extending green phases as conditions warrant.	System has been implemented and is operating successfully. Opportunities to equip other intersections are being investigated.
Signal Phase and Timing (SPaT) Deployment Challenge	Participating in AASHTO's challenge to equip at least 20 signalized intersections in at least one corridor with DSRC Road Side Equipment and broadcast SPaT information by January 2020. DelDOT is beginning with intersections along Route 13 in Smyrna, as well as intersections in Dover, and further south near Delaware's beach resorts.	Roadside Units have been installed along Route 13 in Smyrna, DE. Design is progressing for installation in Dover and the Beach area.
ADS Shuttle Implementation Program	Deployment of ADS Shuttles throughout Delaware. Phase 1 - Testing technology and safety applications.	DelDOT has a contract mechanism in place for the procurement of unlimited shuttles.

	Phase 2 - Includes limited deployment in campus environments and performance evaluations. Phase 3 - Ultimate deployment of shuttles on state roadways that service transit customers.	
Governor's Advisory Council on Connected and Automated Vehicles	Council developed recommendations for innovative tools and strategies that can be used to prepare Delaware's transportation network for connected and autonomous vehicles.	Activities and recommendations were provided to the Governor and General Assembly in July 2018.

Table 2: CAV Projects

Many of these programs support the state's implementation of ADS Shuttle deployment. Currently, DelDOT is in the process of procuring two shuttles to test and deploy in various environments around the state including DelDOT's Dover campus and University of Delaware's STAR campus. These campus locations will initially provide a test bed for the shuttles before their operation is expanded to the surrounding public street networks.

1.3 Key Partners and Stakeholders

DelDOT has assembled a team of transportation professionals, civil engineers, computer scientists and AI/ML experts for this effort. The team will be working side by side with the program management and DelDOT TMC staff that are already committed to DelDOT's ADS Shuttle Program as well as many of the initiatives listed above. The current shuttle program has developed a proposed location for the shuttle, procured two (2) ADS Shuttles, and is currently in the process of developing policies and procedures to safely and effectively test and integrate ADS technology into Delaware's multimodal transportation system.

1.3.1 Delaware Department of Transportation (DelDOT)

Delaware believes in technology investment as a path towards enhanced mobility and safety. The state has already made investments into AI, ML, and CAV technology implementation. DelDOT is leading this ADS demonstration grant initiative and will provide the program management, support, and guidance for all aspects of the program (e.g., policy, technical, financial). DelDOT team members will be responsible for arranging various resources with their support team which includes Jacobs and IAI whom DelDOT has pre-existing contractual relationship with.

DelDOT employs a team of highly qualified management and technology deployment professionals who are currently collaborating to successfully deliver innovative transportation solutions in Delaware. Gene Donaldson will continue to lead the effort as Program Manager. Mr. Donaldson is extremely qualified for this role, having extensive experience with technology deployments through his forty plus year career in transportation operations and ITS. Mr. Donaldson will be assisted by transportation planners and engineers from Jacobs, as well as a team of technical software and innovation experts from IAI to successfully accomplish the goals

of the ADS program. Jeffrey Van Horn, PE, in his capacity as the current TMC Program Manager, will assist Mr. Donaldson in quality control and innovative leadership.

1.3.2 Jacobs Engineering Group Inc. (Jacobs)

Jacobs is one of the largest and most diverse providers of technical, professional and construction services, including all aspects of architecture, engineering and construction, operations and maintenance, as well as scientific and specialty consulting. Jacobs' 77,000 employees in 400+ locations around the world serve a broad range of companies and organizations, including industrial, commercial, and government clients across multiple markets and geographies. Jacobs has been providing planning, engineering, and consulting services for DelDOT and the TMC for the past 15+ years and has supported DelDOT federal grant initiatives for the past 12 years. Jacobs is committed to providing Program Management support to Gene Donaldson and Jeffrey Van Horn for the duration of the ADS demonstration grant program and transportation engineering support as needed during the program.

1.3.3 Intelligent Automation, Inc. (IAI)

IAI is a world class research and development firm that has been in business for more than 30 years with more than 170+ full-time professional employees. More than 70 IAI employees have Ph.D. degrees, and most of the others have Masters Degrees. IAI has a dedicated transportation technology team with expertise in integrating AI into transportation systems leveraging advanced knowledge of traffic engineering, system detection, signal processing, software development, and communications. IAI has deployed AI systems and performed multiple evaluations of several autonomous and CV integrations throughout Delaware.

1.4 Issues and Challenges

The adoption and deployment of ADS comes with unique challenges such as data collection and sharing, monitoring safe implementation of a mixed fleet, and implementation of policy. DelDOT has procured ADS shuttles and as we work to implement the shuttle program, we are continuing to integrate and test on-board technology in our other CAV programs. **Data management under this program, in the form of collecting and sharing the ADS shuttle data,** will incorporate CAV data into the existing ITMS data management system. As our program grows, we will continue to revise **policies and procedures to incorporate ADS and CAV data into our existing ITMS**.

Delaware has seen an increase in population of 21 percent between 2000 and 2015, and a resulting 16 percent increase in vehicle traffic. In addition to deploying the technologically advanced shuttles, additional connected and autonomous vehicle technologies continue to be integrated into DelDOT's ITMS.

Some of the specific issues and challenges to be addressed include, varied transportation needs at the initial proposed ADS Shuttle locations, development of policy and procedures for emerging ADS data technologies and refinement of a data management plan. This plan would outline the collection, storage, optimization, and dissemination of data for research and transportation management purposes. Additionally, optimization of ADS safety and efficiency based on weather conditions and interaction with traffic control devices such as traffic signals, signing, and pavement markings will be investigated.

Challenge	Technology Demonstration Solution
Analyzing ADS shuttle data and developing sharing and collection procedures to support ADS.	Collect multiple sources of real-time ADS vehicle operation data for safety analysis and rulemaking. The data collected will also provide feedback to ADS for enhanced performance.
Safely integrating ADS into the existing transportation system, including considering the transition period, or conditions of autonomous and manually driven vehicles sharing the roadway.	Utilize Vehicle to Infrastructure (V2I) and Vehicle to Vehicle (V2V) communications to exchange safety and operational information (BSM, SPaT/MAP, ITMS/TMC information, etc.). Use machine vision to evaluate compliance of ADS with traffic signal and traffic signing.
Refining **existing data management plan,** including communication and data collection for research and transportation management purposes.	Develop an enhanced web-based data management software tool to collect, analyze, and share data with US DOT and interested parties for ADS safety and operation analysis. Data privacy, management, security and user experience will be considered.
Optimizing ADS safety and efficiency based on weather conditions and interaction with traffic control devices such as signals and signage.	CV-WRTM data will be collected both from ADS as well as from DelDOT vehicles to generate high resolution digital maps of road weather condition for ADS safety and efficiency. DSRC and machine vision systems will interact with traffic control devices for improved ADS safety and mobility.

Table 3: Challenges and Related Technology Demonstrations Solutions

This ADS Demonstration Program will successfully address these issues and challenges by integrating and deploying the following technologies:

1. **Collect and analyze vehicle dynamics data for safety and fuel efficiency analysis via the existing CAN bus data**. DelDOT will collect and analyze ADS vehicle CAN bus data with Global Positioning System (GPS) and accelerometer data to assess the ADS vehicle operation and maneuver dynamics (location, speed, time of drive/stop, braking status, vehicle acceleration). Other CAN bus data (operation mileages, fuel economy, battery level etc.), along with data from the vehicle fleet management software, can be used for vehicle maintenance and operation performance assessment. All data collected is important in ensuring the ADS vehicle safety and operation efficiency.
2. **Video data collection and real-time video analytics for vehicle operation monitoring, object detection and event recording, and compliance validation.** DelDOT will collect video data from cameras installed on the ADS Shuttle (front and back) and utilize machine vision algorithms to monitor safe shuttle operation. In addition, DelDOT will deploy machine vision

capabilities on-board the vehicle for reading traffic signals and traffic signs to validate the compliance of vehicle maneuvers.

3. **Advanced communication systems supporting ADS safety and mobility.** DelDOT will deploy DSRC and cellular based communication equipment into the ADS Shuttles. It is expected the On-board Unit (OBU) deployed on the ADS will easily migrate to 5G when the network becomes available. DelDOT will collect vehicle BSM data and communicate TMC warnings and travel advisory information to the shuttle. The ADS Shuttle can interact with signalized intersections to receive SPaT and MAP data to optimize its navigation across the intersection and may implement Dilemma Zone protection or Transit Signal Priority approach via DSRC for improved operation safety and quality of services.
4. **Weather and road surface condition data for safety and operation optimization building on the existing CV-WRTM project.** DelDOT will leverage the on-going program with CV-WRTM and deploy wireless weather and road surface condition sensors to collect road weather data from the ADS Shuttles. The collected data can be used for safety event (e.g. loss of control, collision) reasoning and use of AI/ML to analyze road weather sensor data for optimization of vehicle operations.
5. **Enhance and develop web-based data management software for data collection, analysis and sharing.** DelDOT will develop a web-based data management software to manage the ADS data collection, analysis and sharing with US DOT and other interested parties and stakeholders. The data management software will facilitate the visualization, query, and analysis of ADS vehicle operation and safety performance, and generate customizable reports to interested parties. The data server will be integrated into the existing ITMS/TMC data management system.

1.5 Geographic Area(s) or jurisdiction of demonstration(s)

DelDOT will deploy advanced technologies statewide. Each deployment area under consideration provides a variety of attributes that will enhance ADS testing, integration and evaluation by introducing ADS Shuttles to various environments and populations. Beginning at DelDOT's Dover location, **the shuttles, equipped with sensors and communication devices, will use artificial intelligence and machine vision to learn behaviors** on a controlled test bed before extending operations to other areas in Dover, and eventually other areas in the state. The goal of large-range deployment of ADS Shuttles is to address challenges that are unique to the varying locations.

The first site for ADS Shuttle deployment will be on **DelDOT's Dover location**. Once the ADS Shuttle operation is vetted and integrated and has gained increased exposure to a broad array of transportation professionals (Phase 1), the program will then extend to other areas of Dover for field trials and service to DelDOT personnel, as well as public users. The University of Delaware STAR Campus in Newark, DE will also provide an excellent test bed for the ADS Shuttles. The DelDOT Dover and University of Delaware campus settings provide controlled testing environments to deploy and evaluate shuttle operations for initial technology integrating and testing, while also engaging Delaware's transportation professionals, as well as students, researchers, and visitors, to promote the deployment of ADS.

In Phase 2, ADS Shuttles will begin operating on an expanded street network adjacent to the DelDOT Campus in Dover. This area (US Route 13 Corridor) is in the process of undergoing a traffic signal

upgrade that will include DSRC for SPaT and other V2I initiatives. In Phase 3, ADS Shuttle operations will expand beyond the area immediately surrounding the DelDOT campus within Dover and potentially (though the Department's purchase of additional vehicles) in the following areas:

- **US 13 in Smyrna, DE** is DelDOT's existing focus area for demonstrating advanced communication technologies (e.g. DSRC) as part of the SPaT Challenge. RSUs that provide the connectivity and support needed to ensure safe ADS deployment are already installed and currently operating on this roadway.
- **Interstate 95, US 40, and SR 1 in New Castle County**. This area provides a more urban environment to test and deploy ADS and connected technologies and is currently the site of an AI based decision support system pilot project being deployed in conjunction with US DOT.
- **Route 1/Delaware Beach Corridor** is another area being considered for demonstration. The Delaware beaches attract high numbers of tourists every year, which would bring attention to this advanced transportation technology and promote its deployment. There are high numbers of elderly communities that live in the beach area all year round, making an ADS Shuttle an excellent mitigation method for limited mobility issues as well as challenges associated with first mile/last miles.

1.6 Proposed Period of Performance – Deployment Plan

The **ADS Demonstration** program builds on DelDOT's ongoing investments and will **continue to invest in machine learning, artificial intelligence, and CAV technologie**s at the TMC as well as ITS technologies in the field. The software and equipment deployed through the **ADS Demonstration** program will be integrated with existing ITMS/TMC infrastructure and become a normal part of TMC operations.

The project team is proposing a multi-phased approach with the ultimate goal to address the integration of the ADS shuttle into the State of Delaware's transportation network. A successful ADS shuttle would offer significant public benefits by offering a safe and simple way to transverse heavily traveled campuses and local routes. At the University of Delaware STAR campus in Newark, DE, this location could provide enormous information sharing opportunities due to its proximity to university research institutions as well as provide a controlled place for testing. In addition, the City of Dover DelDOT location would serve a variety of populations with the eventual integration onto public roads.

Implementation will be rolled out in a Phased Approach for each year. Phase 1 will be installation and integration, Phase 2 will be the evaluation and analysis period and Phase 3 will be the public road deployment period and will focus on last mile delivery of people to their ultimate destinations.

Phase 1 (Year 1): *Installation & Integration*

The first phase will include the procurement and installation of DSRC equipment into Delaware's transportation infrastructure as well as the ADS Shuttles for full integration and communication between ADS vehicles and the system. Software development and ADS integration of the automation technology will also begin during this phase. The following tasks will fall under Phase 1:

- Procurement and installation of the following on the ADS shuttles:
  - RSUs
  - OBU installation
  - GPS and DSRC antennas on board units (OBUs)
  - CAN bus data loggers
  - Exterior facing cameras
  - Wireless weather sensors
- Instrumentation and data collection on AV shuttles in campus test environment
- System testing and initial software development
- Enable sensor data collection and communication with the ADS Shuttles for deployment under controlled environments at both City of Dover (DelDOT) and Newark DE (University of Delaware) locations.
- Develop Concept of Operations (ConOps) and Requirements for public road testing.
- Data collection from devices installed on shuttles will be archived and shared via the web-based data server and DelDOT TMC extranet server to US DOT and the public.

Phase 2 (Year 2): *Evaluation & Analysis*

The second phase will involve data collection and evaluation of the shuttle's vehicle sensor technology and its V2I/V2V capabilities. Additionally, enhanced testing and engagement with stakeholders will occur. Software development will continue and be supplemented by the introduction of AI algorithms. The following tasks will fall under Phase 2:

- Implementation and Evaluation of V2I/V2V Operation
  - Shuttles will interact with signalized intersections equipped with RSUs to receive SPaT data and MAP messages to obtain relevant performance information;
  - Shuttles will interact with other vehicles equipped with OBUs and DSRC technology;
  - Deployment of Dilemma Zone Detection/Warning System at additional intersections to overlap with ADS Shuttle routes.
  - Transit Signal Priority via DSRC during heavy traffic conditions.
- Begin to test vehicle sensor technology on public roads in area of DelDOT Dover Campus.
- Expansion of RSUs on public roads in Dover – Locations to be determined during ConOps in Phase 1.
- Data collection and analysis.
- AI software development.
- Engagement with DTC on Shuttle operations and maintenance.
- Engagement with DelDOT employees who are using the shuttle.
- Develop deployment plan and routes for public pilot(s) to be introduced in Phase 3.

- Data collection from devices installed on shuttles will be archived and shared via the web-based data server and DelDOT TMC extranet server to US DOT and the public.

Phase 3 (Year 3): ***Advanced Road Network Deployment***

The third and final phase will include full deployment onto public roads extending throughout Dover and eventually throughout the state of Delaware to serve the need for operation and services to the public. Tasks that fall under Phase 3 could include:

- Deployment and testing of technology during normal traffic conditions on public roads.
- Data collection from devices installed on shuttles will be archived and shared via the web-based data server and DelDOT TMC extranet server to US DOT and the public.
- Reasoning, analysis, and evaluation of overall system to be provided, including overall operation and social benefits and performance in safety, mobility and economic benefit.
- Implementation of shuttles in full-time Transit Operation.
- Public outreach for feedback from transit customers.

2 GOALS

Safety technologies are rapidly advancing - continued integration of artificial intelligence as well as open collaboration with departments of transportation and research centers will continue to decrease the number of incidents that occur on the existing transportation infrastructure. This project will test the safe integration of automated driving systems into Delaware's on-road transportation system and ensure significant data gathering and sharing of project data with USDOT and the public in near real-time. Additionally, the project will demonstrate significant commitment to leveraging the demonstration data and results for safety, improved mobility and environment, and work with local governments as well as universities and private partners (vendors) to create collaborative environments that harness the collective expertise, ingenuity, and knowledge of multiple stakeholders.

These funds would support the following goals and programs:

- Leverage on-going ADS programs into the existing transportation infrastructure through demonstrations such as the ADS Shuttle deployment, Dilemma Zone implementation, Connected Vehicle Weather Responsive Traffic Management (CV-WRTM) program, AI software development.
- Safely integrate emerging connected and autonomous vehicle technology into our existing statewide multimodal Integrated Transportation Management System (ITMS).
- Further develop and implement a model for data collection and sharing of ADS shuttle data with USDOT, other states, academia, and others for safety analysis and rulemaking; foster collaborations among different agencies and stakeholders for adoption and deployment of ADS.
- Address challenges in technology deployment such as the implementation of policy and provision of service.

3 FOCUS AREAS

3.1. Significant Public Benefit – Safety & Mobility

The operation of an ADS shuttle on the DelDOT campus in Dover, DE has the potential to provide significant safety and mobility benefits to riders. Pedestrians crossing roads and major highways, like Route 13, may put themselves in danger. ADS Shuttles could easily transport passengers at low speeds from one point to another, providing a potential tool to increase safety for pedestrians on busy roads. DelDOT employees could avoid dangerously crossing streets and intersections to get from one building to another.

In addition to safety, mobility is enhanced with ADS Shuttles: employees will be able to travel around the campus more quickly than by walking and employees with disabilities or limited mobility will be offered the opportunity to ride on the shuttles for quick and easy access to the campus. ADS technology can advance on-demand service, which has the potential to provide increased mobility for passengers such as the elderly community or people with disabilities with limited mobility who need to get from one point to another. Fourteen percent (14%) of Dover's population is over the age of 65, and there are many elderly communities, assisted living developments, and nursing homes in close vicinity to the DelDOT Dover campus that can benefit from a dedicated, ADS Shuttle.

At University of Delaware STAR campus, ADS shuttles have the potential to provide a last-mile connection between a new regional rail station, offices, a laboratory, and classroom facilities within the campus for daily commuters. In addition, the ADS shuttles will provide an intra-campus mode of transit for students, faculty, and employees.

3.2. Economic Equity & Public Engagement

The variety of DelDOT's departments that are housed on the City of Dover campus makes a shuttle demonstration a great opportunity for public education and engagement. The employees who are tasked with planning, engineering, constructing, and maintaining the roads throughout Delaware are available and able to see the results of an ADS Shuttle demo right outside their office window and experience the shuttles first hand. This also lends itself to a major opportunity to gain exposure to legislators who often visit the DelDOT campus. If they are able to witness the benefits of an ADS Shuttle firsthand, they will be more inclined to support policy that encourages the development of CAV and ITS technologies.

3.3. Addressing Market Failure and Other Compelling Public Needs

This sort of advanced deployment can attract attention from state employees who can increase Delaware's role in developing CAV technologies, and can also attract companies and businesses who want to test similar technologies in a real world, campus setting. Hosting tech companies to test their devices and tools can help to promote the economy in Delaware, as well as the nation. Eventually, after successful testing and deployment on DelDOT's campus, the goal would be to extend service to other areas throughout Dover such as annual events like Firefly Music Festival and NASCAR races to engage the public, which is a great way to get more groups interested in autonomous vehicle technologies.

3.4. Complexity of Technology

This project will serve as a means for DelDOT to develop extensive research into state-of-the-art transportation technologies and communication devices. The ADS Shuttles will operate at a Level 3/4 automation to demonstrate advanced autonomous technology. In addition to deploying the technologically advanced shuttles, the campus will be equipped with various other connected and autonomous vehicle technologies that are integrated into the TMC to create a full test bed for transportation devices beyond automated vehicles.

DelDOT is currently working with IAI to develop an AI Software Tool to be integrated into their TMC operations as a way to predict and react to traffic incidents and events. During deployment of the shuttles, their operations data can be used in accordance with the tool to further advance the use of AI and machine learning. As these initiatives develop, DelDOT will continually use the ADS Shuttles as a research demonstration tool to test interoperability and to validate how they interact with each other, how they interact with connected infrastructure, and how they integrate into the existing traffic management system.

3.5. Research/University Collaboration

As DelDOT advances in research they will engage with universities and colleges in Delaware to provide students with an opportunity to get involved in the development of these future technologies. As previously stated, the University of Delaware STAR campus is currently designated as an ADS shuttle test site, and DelDOT has been coordinating with the University through the ADS shuttle procurement process. The University also has a facility on-site at the DelDOT Dover Campus. Delaware State University is located just a few miles north of DelDOT's campus, in Dover, and can also connect with DelDOT to aid in research and development. Delaware Technical Community College has a campus in Dover as well, and will be provided an opportunity to get involved, as it will be crucial to involve technical trades in the development of this technology.

3.6. Diversity of Projects

Although DelDOT's Dover campus will be the first site for testing and deployment of the ADS Shuttles, future deployments are being considered in various areas throughout Delaware. The University of Delaware and other universities in the state, could be a potential research partner throughout testing and implementation, and their STAR Campus provides a potentially useful and safe area for deployment. Additionally, as noted in Section 1.5, DelDOT has CAV testbeds located throughout the state that provide varying challenges and opportunities for ADS deployment.

3.7. Transportation Challenged Populations

Deployment of ADS Shuttles within the campus environment will allow for intra-campus trips, that had been facilitated by dangerously crossing parking lots and access roads can be facilitated by the ADS shuttle, providing a safer, faster, and more comfortable user experience. The areas noted for public road deployments (especially City of Dover and Delaware Beach area) contain a high percentage of low income (Dover) and elderly (Beaches) populations who do not have access to the use of personal vehicles.

3.8. Prototypes

The ADS shuttles procured have been widely deployed in both the US and abroad in a testing and campus environment. EasyMile, within their proposal to DelDOT, indicated that they have received all required waivers from USDOT as well as other state and local agencies for operation on public roads. DelDOT will coordinate closely with USDOT during the project to ensure that all applicable federal safety standards are met and that the public is not put at unnecessary risk.

4 REQUIREMENTS

The ADS Shuttle demonstration will focus on the research and development of automation and ADS technology (per the SAE definitions) with Level 3/4 automation technologies. It is expected that the procured shuttles will achieve fully self-driving for the predetermined routes, and the onboard conductor will serve mainly as a gatekeeper for helping the public riders.

The demo will involve a minimum of two (2) vehicles running physically in Delaware and will gather and share all the relevant and required data with the USDOT throughout the project, in near real time. The data will be accessible to USDOT throughout the entire duration of the project and can be stored if needed to support future research. The ADS Shuttle (EZ10) has an on-board computer that allows users with varied abilities to input a destination or communicate route information (via touch screen selection, voice command, etc.) and to access information generated by the ADS over display or synthesized voice.

A table outlining each requirement and how each proposed demonstration satisfies the requirement along with the possible associated challenges can be referenced on Page 5 of the introduction on *Table 1: Program Fulfillment of NOFO Requirements.*

5 APPROACH

5.1 Technical Approach

The technical approaches to implement and evaluate the demonstration are elaborated below. DelDOT and the participating team members will work closely together to deploy the following sensing and communication technologies that integrate with ADS shuttle vehicles for data collection and safe operation of ADS Shuttles at the testing and deployment sites.

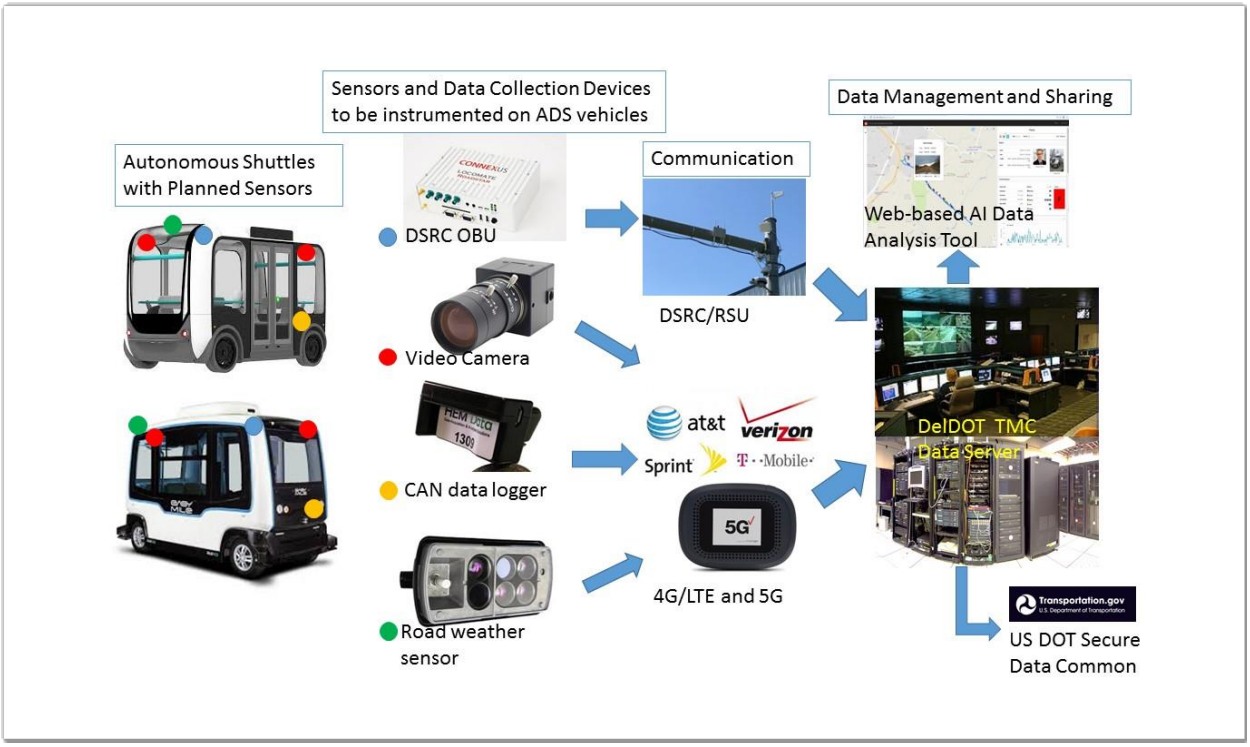


Figure 2: ADS System Integration Diagram

5.1.1 DelDOT Signal Phase and Timing (SPaT) challenge project - Advancing communication systems supporting safety and mobility

DelDOT will leverage the SPaT challenge project, to deploy DSRC communication equipment into the ADS Shuttles, collect vehicle BSM data, and communicate TMC warnings and travel advisory information to the shuttle.

As part of DelDOT's participation in the SPaT Challenge, RSUs are being installed with a goal of having 31 operational units by summer 2019. Installations are occurring at intersections throughout Smyrna, Dover, and the beach corridors. Figure 2 shows deployed RSUs on a traffic signal and on a steel pole, both at the Dilemma Zone intersection in Ellendale, DE.

Along with RSU installation DelDOT is also instrumenting multiple DelDOT vehicles with OBUs that communicate with RSUs when they are within 1000 feet. The OBUs can receive SPaT and MAP data broadcasted by the RSUs for safety and fuel efficiency operations (e.g. Green countdowns, economic driving speed approaching an intersection, etc.). Alternatively, vehicle BSM data can also be collected by the RSUs for traffic management applications (via tracking vehicle location, speed, brake status etc.).

Figure 3: (a) Siemens RSU installed and tested at the DelDOT campus (DelDOT Signal Shop); (b) Siemens RSU installed on public roads in Delaware

Figure 4: Lear OBU unit instrumented inside a passenger car for testing red light violation warning application (a) setup inside the vehicle, (b) example warning message displayed with sound alert

5.1.2 Applying Safety, Fuel Efficiency and Maintenance Reporting technology to the ADS Shuttle with CAN bus data and Vendor provided data

In this effort, CAN bus data logger and accelerometers will be installed into the ADS Shuttles to record vehicle operation and maneuver dynamics data including location, speed, odometer mileages, time of drive/stop, braking status, battery level etc. Some of the data is also available from the ADS Shuttle fleet management software provided by the vendor. This data will be used for vehicle safety monitoring and operation performance assessment.

Figure 5 shows the schematic of the E-TRIP system for tactical vehicle driving performance monitoring, where an environmentally hardened Commercial Off the Shelf (COTS) CAN data logger (for SAE J1939/J1708/1587 network) plugs into a vehicle data port with a split-port cable and collects CAN data, GPS and 3-axial accelerometer data, transfers the data to a rugged Android tablet. This device then uploads the trip data to a web-based data server for vehicle operation performance assessment (e.g. training effectiveness, operation safety, fuel efficiency) and vehicle maintenance/conditions tracking. The archived data can then be shared with Marine Corps Training Information Management System for driver performance analysis and Transportation Capacity Planning Tool for enhanced tactical vehicle dispatch process. Figure 5 shows an example trip record data where risky driving events are marked clearly on the map with the overall operation performance showing in the dashboard.

Figure 5: E-TRIP System for Vehicle Operation Performance Assessment and Vehicle Condition Monitoring

In this project, a similar system will be deployed onto the ADS Shuttles for operation performance assessment and vehicle maintenance condition to monitor safe vehicle operation. Specifically, risky driving events such as hard braking, erratic acceleration, engine idling, sharp turning at high speed, and vehicle swerving, will be examined with a scoring mechanism for assessing the vehicle operations. Other information such as tire pressure, mileage, fluid level, battery charge status will also be recorded and reported for vehicle condition monitoring and maintenance scheduling.

In the first phase, a similar E-TRIP sensor hardware and software will be developed and customized for ADS vehicles. Since the ADS vehicle may use a different CAN protocol, or some CAN messages may or may not exist on the CAN bus, customization of the CAN data logging will be needed. Once the system is integrated with the ADS Shuttle vehicle, initial tests will be conducted on one or both of the demonstration areas within the first year.

In the second phase, as the vehicle is moved to public roads for testing, E-TRIP data will be collected and analyzed for that environment. The time stamped and location specific vehicle data will be used to improve the ADS Shuttle operations and safety.

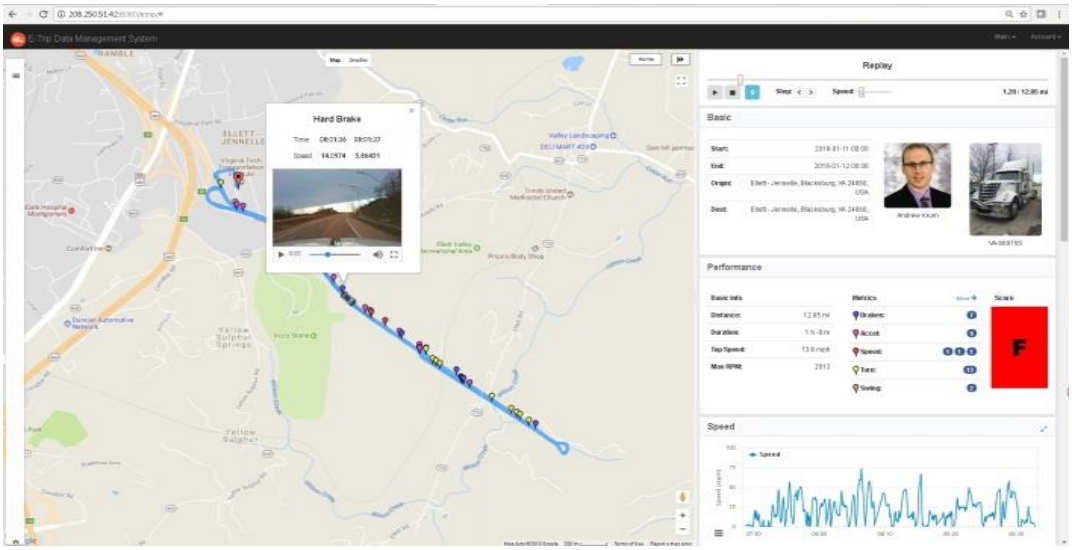


Figure 6: E-TRIP Data Server Web Interface showing the recorded trip data with risky events marked on the map and operation score at the performance dashboard

For the third phase, as the vehicles will serve the public transportation need in Dover, real service data will be collected and analyzed for vehicle operation performance and maintenance condition monitoring.

5.1.3 Video data recording and machine vision algorithms to monitor and record vehicle operation incidents

In this effort, video cameras will be installed inside the ADS Shuttle vehicles and will record/stream roadway video data. Machine vision algorithms will be developed to safely monitor incidents. In addition, machine vision capabilities will be deployed on-board the vehicle for reading traffic signals and signs for validating the compliance of the vehicle maneuvers with traffic laws.

Sponsored by the FHWA (SBIR Contract # 6913G618P800106), IAI has been developing an on-board vehicle machine vision system, with standard resolution imaging, can identify and interpret traffic signal conditions and roadside signs. Figure 7 shows the prototype machine vision-based barcode reading system for roadside signage. The green light shown at the top of Figure 8 is an example of machine vision reading traffic signal condition at an intersection in Delaware.

IAI has developed a high fidelity, cloud-based video processing and exploitation tool called PixL (see Figure 9) that significantly reduces the time for analysis and delivery of actionable intelligence. The tool offers an easy-to-use interface and workflows for analyzing video data from online, security, and surveillance feeds. It has the ability to process full-motion video datasets as well as the following capabilities:

- Automatically generates relevant video annotation.
- Provides alerts to users based on specific detection criteria (e.g. vehicles, pedestrians, etc.).
- Allows the analysts to view the alerts, query collected data, and investigate the data.
- Exports the results into a file for reporting purposes.

Figure 7: Prototype machine vision system for CAVs with a dash cam attached to the vehicle windshield for real-time barcode signage reading.

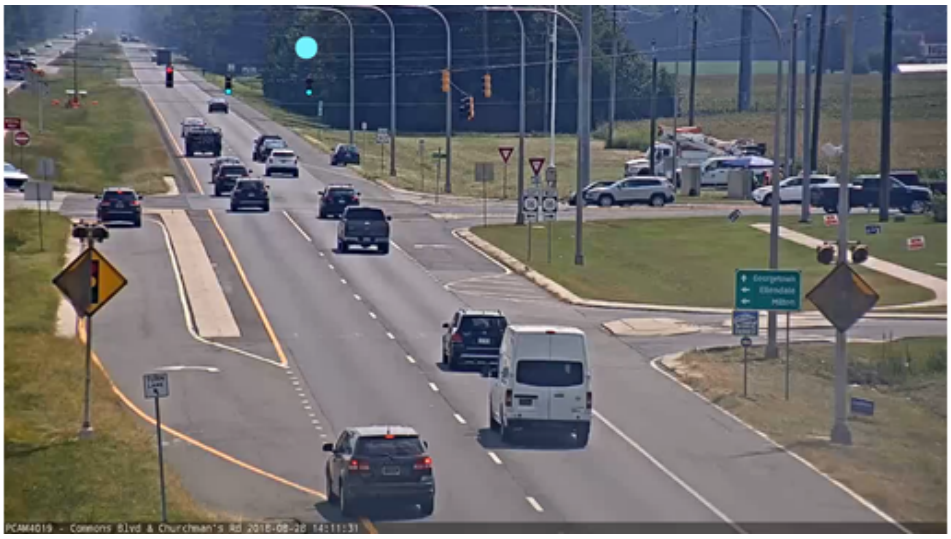


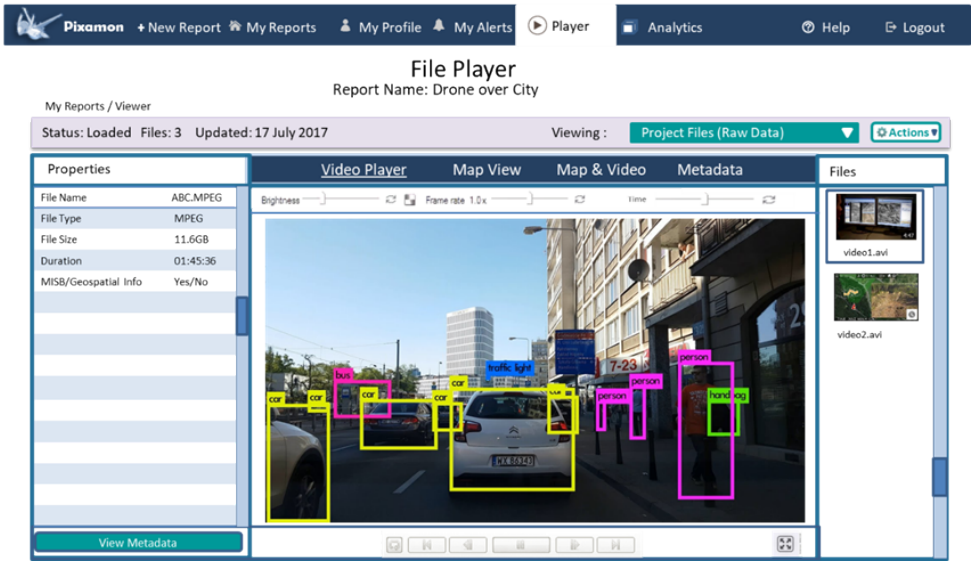
Figure 8: Machine vision algorithm for traffic signal light detection and status reading

Currently the software can track vehicles as they enter and leave the frame. Occupancy can also be measured by defining a trigger bounding box where the presence of vehicles can be detected inside the bounding box for calculating the ratio between the trigger on and off status. Speed estimation can also be collected based on the video/camera setup (focal length, viewing angle etc.).

DelDOT will leverage these technologies and deploy a real-time machine vision system inside the ADS Shuttle vehicles as well as on the web data server. In particular, in the first year, the proper video cameras and hardware/software will be identified and installed on the ADS Shuttles. When a risky maneuver event happens, such as a hard brake or sharp turn, the recorded video will be automatically processed to detect what object caused the event. This data will be accumulated and

used to provide statistics on the events affecting operational safety. In addition, DelDOT will also deploy the machine vision algorithms for traffic signal status detection and roadside signage reading for verification of the vehicle operational compliance with traffic laws.

During the second year, these functions will be tested and improved on more public roads in Dover for system adjustment and ruggedization. In the third year, when the ADS Shuttle is deployed to service the public, a large amount of operation data will be gathered and analyzed for operational safety and efficiency performances.



Dynamic Dashboard	Object Recognition	Object Detection and Tracking
A web-based visualization and analytics dashboard allowing for easy access anytime, anywhere, on any device.	Analytics based on state-of-the-art convolutional neural networks and deep residual learning.	Deep learning-based analytics for detection of multiple object classes and prediction of the positions of bounding boxes.
Scalable Pipeline	**Interactive Video Player**	**On-Premise Install**
A scalable data ingest pipeline, data store, and workflow manager for management of the entire video intelligence cycle.	Embedded video player that can zoom, pan, and change hue and saturation.	On-premise install, behind your corporate firewall, for analytics on proprietary data sets and data feeds.

Figure 9: Deep Learning based Video Analytics Tool PixL for real-time object detection and tracking

5.1.4 Connected Vehicle Enabled Weather Responsive Traffic Management (CV-WRTM) - Weather and road surface condition data for safety and optimized operations

The team will leverage DelDOT's on-going CV-WRTM program with FHWA by equipping the ADS Shuttles with wireless weather and road surface friction sensors to collect road weather data in advance of, and during, weather incidents. AI software will be used in the analysis of the road weather data to optimize vehicle operations, as well as provide situational awareness that ensures

safe operation of the shuttles. DelDOT has procured and as currently deploying eight (8) Mobile Advanced Road Weather Information Sensors (MARWIS) that connect to the TMC. The goal of this effort is to improve safety by decreasing crashes due to weather incidents and enhance mobility and traffic flow by collecting real-time roadway weather condition data.

Additional agency fleet vehicles as well as traditional transit vehicles are being outfitted with road weather sensors. DelDOT is collecting and analyzing the data and evaluating the functionality and operation of the sensors. Figure 10 shows a DelDOT vehicle equipped with the mobile weather sensor and the MARWIS data display from the user interface.

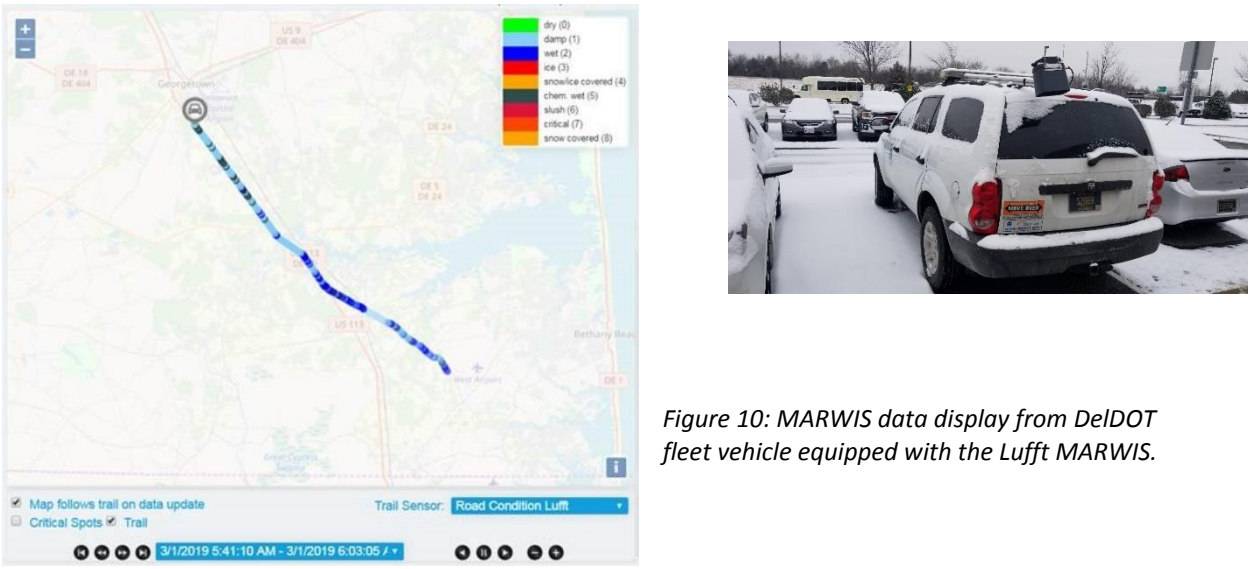


Figure 10: MARWIS data display from DelDOT fleet vehicle equipped with the Lufft MARWIS.

In the first phase, DelDOT will acquire and install the MARWIS on the ADS Shuttles and integrate the road weather data into ADS management system. Tests will be performed at the Dover DelDOT Campus to safely verify the functionality and accuracy of the sensor system. Such tests will be extended into the second and third phases as the project progresses. In the third phase, the system will collect and disseminate real-time operations data and weather/road surface condition information so that the ADS Shuttle operations can be optimized for improved safety and schedule adjustment in real time.

5.1.5 Develop a web-based data server and software interface to manage the ADS data and share the data with FHWA and other stakeholders

This effort will build the backend computer server software that collects and manages ADS vehicle and fleet operations data from various sources such as data from RSUs and OBUs, dynamics measurements from the CAN bus data logger, video camera data, and MARWIS units.

The team's extensive web software development and real time data sharing experience has been utilized for the ongoing Artificial Intelligence based Transportation Operation and Management System (**AI-TOMS)** project sponsored by FHWA and DelDOT. AI-TOMS is a web-based traffic management expert system tool with an interactive map developed to show the number of detectors experiencing "anomaly" and "congestions". The travel restriction and weather data is displayed on the status dashboard. The dash bar, on the top, provides situational awareness to

the user of the traffic status in real time. Video cameras can be shown on the left quarter of the interface at any time to display live traffic conditions. When an incident or congestion occurs in the network, the affected detectors will change their color/flash on the interactive map. Traffic detector data will be plotted on the right hand side of the screen with the location highlighted as a red square, shown in Figure 11.

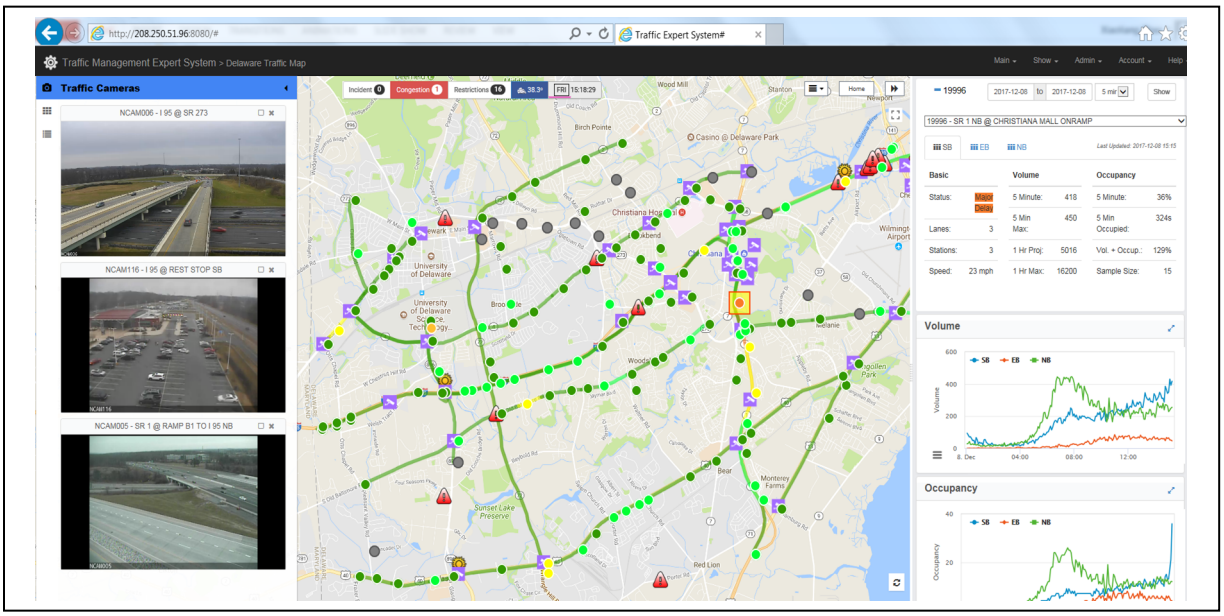


Figure 11: AI-TOMS DelDOT Website

DelDOT will develop the web-based interface for each source of data collected from the ADS Shuttle vehicles and test their functions in the first year. In the second year, integration of these data modules will be performed and synchronized so that data from multiple sources can be correlated to understand the full picture of the vehicle operation and safety concerns. For example, data from OBU BSM and CAN bus may show a sudden brake of the ADS Shuttle near a crash, accelerometer data will show a sudden change in vehicle dynamics, and video cameras may record that a bicyclist suddenly falls into the vehicle path due to slippery road surface. The road weather sensor reports that the road surface is wet and friction is low. With fusion of multiple data sources, a full picture of such safety critical events can be easily detected and reasoned.

For the third phase, the overall web-based software tool will be deployed to collect and analyze data from the ADS Shuttle vehicles. The collected data will be shared with USDOT and other interested parties in near real time, and a customized report will be provided at users' request. It is envisioned this ADS demonstration will produce extensive, high-quality ADS safety and operational data. This data can be useful to establish rule making and innovation research for the transportation community.

5.2 Exemption from the Federal Motor Vehicle Safety Standards (FMVSS) or Federal Motor Carrier Safety Regulations (FMCSR)

EasyMile's EZ10 shuttle does not currently comply with FMVSS. However, EasyMile has indicated to DelDOT that the EZ10 shuttle has received all required federal and state exemptions necessary

to operate the shuttles. DelDOT does not anticipate requiring any additional exemptions at this time.

5.3 Buy American Provisions

DelDOT does not anticipate utilizing any USDOT funds to purchase equipment assembled outside of the United States as part of this effort. EasyMile EZ10 shuttles are assembled outside of the United States but will be purchased utilizing Delaware State Funds.

5.4 Data Sharing

The proposed ADS demonstration program is focused specifically on ADS operational data collection and safety analysis of ADS deployment. DelDOT is committed to providing all collected ADS, roadside infrastructure, and video data (both raw and processed) to US DOT and interested parties with proper access authorizations either in near real-time streaming (e.g. BSM data, road weather conditions, video) or periodically (CAN data, edited video clips for presentations, aggregated/processed data).

In addition to safety, the mobility and efficiency aspect of the ADS will also be assessed. Some of the technologies that are geared toward improving mobility and fuel efficiency, such as V2I with signalized intersections, will be tested and evaluated.

5.5 Risk Identification, Mitigation and Management

The high complexity, limited-proof technology, and public perception as it relates to automated vehicles contribute considerable risk to this project. In addition to the required contents of the Project Management Plan (PMP) the project team will include a risk register that identifies each anticipated risk. The register will provide categorization of that risk (low, medium or high) based on the risk's likelihood of occurring and the impact on the project schedule and scope. Risk mitigation procedures and strategies for addressing risk events if/when they occur will also be considered. USDOT will be provided the opportunity to comments on/add risks to the register as part of the review of the PMP. An update of the risk register will be provided with each quarterly progress report.

5.6 Approach to contribute and manage Non-Federal resources (cost-share) proposed by the demonstration, implementation, and evaluation of ADS

DelDOT is proposing a minimum cost share match of $810,000, which is inclusive of the purchase of two (2) EasyMile EZ10 ADS Shuttles through DelDOT's procurement contract with EasyMile. DelDOT reserves the right to purchase additional ADS Shuttles with state funds during the life of this project to supplement proposed test beds and functionalities as proposed.