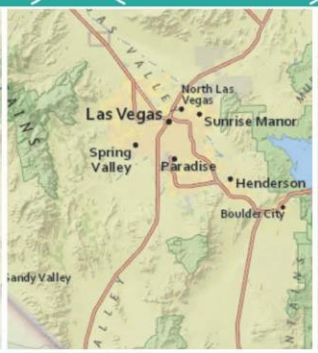
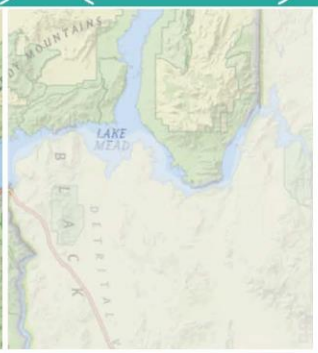
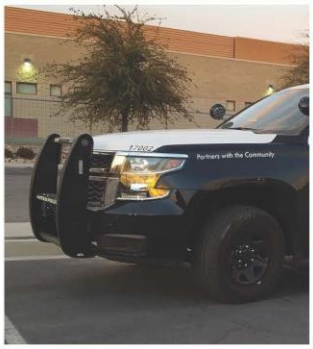
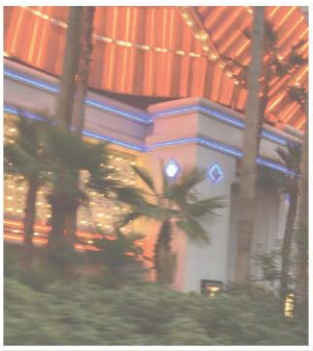
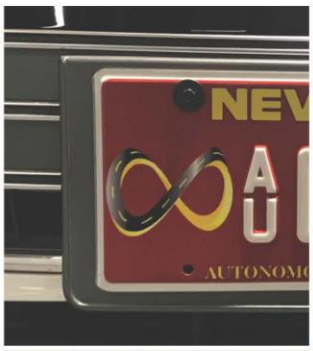


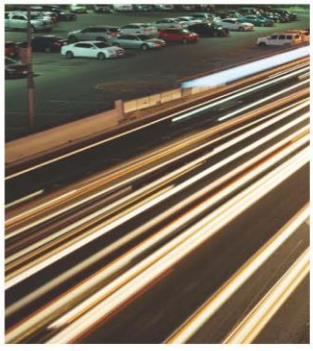


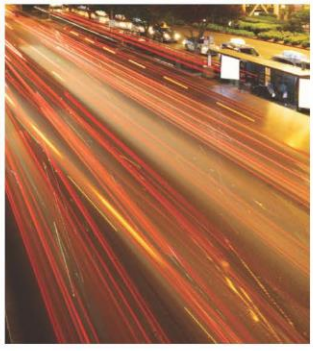
Navigate











Submitted by: Regional Transportation Commission of Southern Nevada

Submitted to: U.S. Department of Transportation

Notice of Funding Opportunity (NOFO) Number 693JJ319NF00001

"Automated Driving System Demonstration Grants"

Application Due Date: 3/21/2019

RTC

Regional Transportation
Commission of
Southern Nevada

600 S. Grand Central Pkwy., Suite 350, Las Vegas, NV 89106-4512

March 21, 2019

Attn: Sarah Tarpgaard, HCFA-32
U.S. Department of Transportation (USDOT)
Federal Highway Administration (FHWA)
1200 New Jersey Avenue, SE; Mail Drop: E62-204
Washington DC 20590

Subject: Notice of Funding Opportunity (NOFO) Number 693JJ319NF00001 "Automated Driving System Demonstration Grants"

Dear Ms. Tarpgaard,

The Regional Transportation Commission of Southern Nevada (RTC) is excited to submit the Nevada Autonomous Vehicles Information Gathering and Technology Ecosystem (NAVIGaTE) Program for consideration for an Automated Driving Systems (ADS) Demonstration Grant.

Navigate

Nav·i·gate – *verb* –
1. to plan and direct the route of transportation, especially by using instruments or maps.

Navigating is about using tools that make data available in a way that provides insight about an intended direction. The NAVIGaTE program was conceptualized to be a tool to provide data, insight, and direction to advance the deployment of ADS on the nation's roads.

The NAVIGaTE Program has two complementary parts. The first part is the development, testing, and deployment of ADS technology to detect and direct an autonomous vehicle (AV) to properly respond to emergency motor vehicles (EmV). To achieve this, our partner, Aptiv, will develop the ADS to include sensors and algorithms that can detect EmVs, other vehicles, people, and roadway characteristics. This data will be processed to train the vehicle with actions the AV should take to properly and safely navigate the situation.

The second part is the implementation of an open-source data platform. This platform will be adapted from another data platform that our partner, Pillar, developed. The open-source platform will collect data from Aptiv and from other projects advancing ADS in Southern Nevada, such as the GoMed project, which will use low-speed AV shuttles to transport employees and patients around the Las Vegas Medical District. The regional data platform will also be serving up data from various agencies, including public safety within the city and the county. This data will be publicly available to agencies in Nevada and around the nation for analysis.

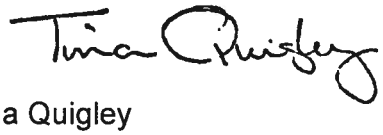
Sarah Tarpgaard
March 21, 2019

To support agencies as they gain insights from the data, we are partnering with the University of Nevada, Las Vegas (UNLV), to facilitate data collection, provide research direction, and ultimately navigate the development of other ADS. The NAVIGaTE Program is the next strategic step in development and advancement of ADS in Southern Nevada and nationwide. The technology and data from our program will be critical to ensuring the safety of AVs and preparing agencies for making data-driven, informed decisions as transportation systems transform. The Southern Nevada region is bold and innovative—we pioneered AV shuttle pilots, worked with Waycare using Artificial Intelligence (AI) to minimize traffic incidents, and launched early deployment of signal phase and timing (SPaT) information with Traffic Technology Service (TTS) and Audi. Our region is highly sought after for a variety of demonstration programs especially in the space of ADS and intelligent transportation systems (ITS). We are proud of the innovation happening all throughout the region in various corridors and communities.

The RTC is the only agency that has transit, metropolitan planning organization (MPO), traffic management, and implementation of regional plan (Southern Nevada Strong) all under one roof. This makes us a unique "one-stop shop" for innovators to pilot technology. By choosing the RTC for this Grant, USDOT will receive a significant benefit from the publicly available data, such as interaction scenes between ADS and EmVs, and the resulting insights from this program. In this dynamic Southern Nevada environment, we will facilitate knowledge sharing across industries, coordinate between key agencies, both public and private, increase data transparency and accessibility, and support an improved understanding of the necessary elements of safe ADS transportation solutions on public roads. NAVIGaTE will reveal the challenges, innovative solutions, and forward-thinking standards necessary for critical transportation elements such as emergency vehicles and infrastructure not just in the Southern Nevada but also nationwide.

As a result of our experience and infrastructure in the region, the RTC knows what it will take, and is committed to make the NAVIGaTE Program successful. In conjunction with our agency and industry partners, we request that you select RTC's NAVIGaTE Program for an ADS Demonstration Grant.

Sincerely,



Tina Quigley
Chief Executive Officer
RTC

Part 1 – Project Narrative and Technical Approach

a. Introduction

Summary Table

Part 1 Summary Table	
Project Name/Title	NAVIGaTE
Eligible Entity Applying to Receive Federal Funding (Prime Applicant's Legal Name and Address)	Regional Transportation Commission of Southern Nevada 600 S. Grand Central Parkway, Suite 350, Las Vegas, NV 89106
Point of Contact (Name/Title; Email; Phone Number)	Jodie Bare, Director Advanced Mobility & Innovation BareJ@rtcsnv.com 702-676-1801
Proposed Location (State(s) and Municipalities) for the Demonstration	Las Vegas, Nevada
Proposed Technologies for the Demonstration (briefly list)	Level 4 AVs, with two safety operators
Proposed duration of the Demonstration (period of performance)	4 years
Federal Funding Amount Requested	$8,892,000
Non-Federal Cost Share Amount Proposed, if applicable	65% Federal funding - $8,892,000 35% Non-Federal funding match - $4,788,000
Total Project Cost (Federal Share + Non-Federal Cost Share, if applicable)	$13,680,000

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b) Project Narrative and Technical Approach

1. Executive Summary

The NAVIGaTE program entails:

Training ADS to safely interact with EmVs by demonstrating:

- **Detection:** Reliable and cost-effective ways for an ADS to recognize, localize, and differentiate multiple types of EmVs.
- **Handling:** Preferred actions for an ADS to take in response to the detection of an EmV.

A Regional Data Management Platform (RDMP) that helps ADS developers, researchers, and agencies translate data produced from the EmV demonstration and other activities into actionable insights that advance ADS nationwide. The RDMP is the foundation for a broader Souther Nevada smart communities regional data platform.

Benefits of these demonstrations (and solutions behind them) include:

- Knowledge sharing across industries, regions, and technologies to **accelerate learning and innovation.**
- Agency coordination (regional and national; public and private) to **support regional and national applications.**
- Data transparency/accessibility and a mechanism to develop **solutions that solve real-world problems.**
- Thorough understanding of requirements and technological solutions for **safe operation of fully driverless ADS on public roads.**
- Establish framework for holistic regional **smart communities data sharing.**

ADS offer an opportunity to reduce the thousands of premature deaths and millions of injuries that occur on our roads every year, more than 90% of which relate to poor human driving choices. In addition to interacting with traditional vehicles, they are interacting with EmVs such as fire trucks, police vehicles, and ambulances. Because of the life-threatening consequences of delayed or unsafe EmV passage, there is a critical need to develop the AI to detect EmVs and autonomous technologies to ensure that ADS interact safely with EmVs.

This proposal aims to further develop the technology and begin to resolve a real-life challenge experienced every day by emergency responders. The proposal involving EmV and ADS interaction (**Figure 1-1**) will specifically research ways ADS can detect EmVs, appropriate ADS responses to the detection of an EmV, and ways that EmV operators can access ADS when pulled over or involved in a crash. Little research has been completed to date on the requirements for ADS to safely interact with EmVs on public roads, on the desired functionalities by first responders, and on how to make these functionalities available to ADS operators without compromising the vehicle.

ADS and EmV interactions yield data in amounts unimaginable even a few years ago, offering opportunities for study, analysis, and insights that are invaluable to ADS developers, researchers, and agencies. Understanding the vast opportunities made possible by the data, this program also proposes to develop a RDMP that will act as an aggregator for data from this demonstration as well as other ADS activities under way or planned in Southern Nevada. **Table 1-1** provides an overview of our executive summary for the NAVIGaTE program.

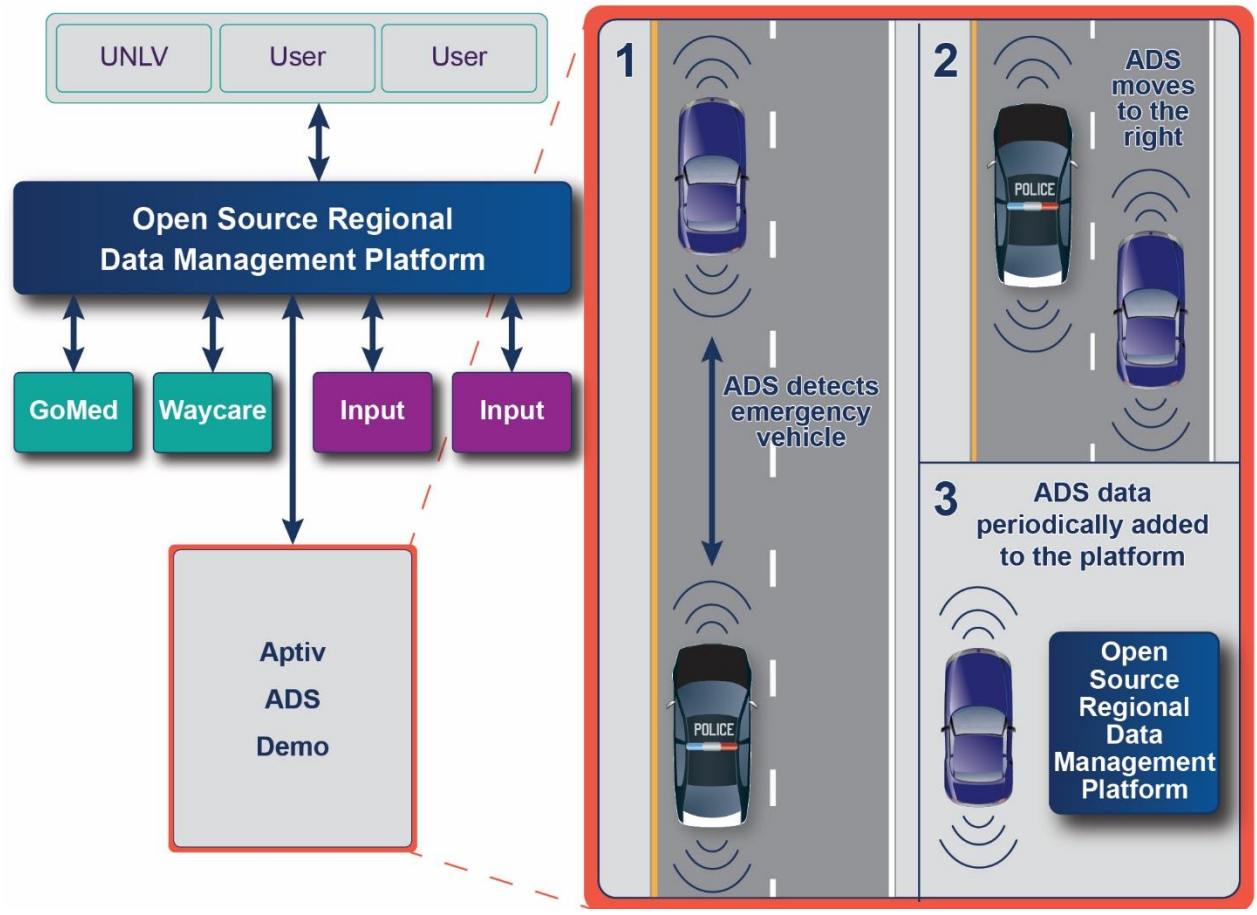

Figure 1-1. Proposed Demonstration: RDMP Data Flow and ADS-EmV Detection and Handling

The context:

The Southern Nevada region's Smart Communities Vision has four data focus areas:

- Safety using data analytics to inform decisions and support first responders.
- Inclusivity of data sharing with a broad, diverse user base.
- Data accessibility and user friendliness.
- The efficient leveraging of existing infrastructure.

This strategy will advance mobility in the region and help people connect to opportunities, services and resources. This vision affirms that, as a region, we believe that **data is at the core of all things "smart.**" We must know the data we have, remove the data silos, understand the data we need, and make the data available to provide meaningful, holistic insights about our region.

Aptiv has provided more than 35,000 rides across the Las Vegas Strip and downtown Las Vegas using a solution that is agnostic to both original equipment manufacturer and infrastructure. Aptiv is committed to both the science of AI and machine learning rule-based robotics and to applying it to the advancement of ADS as part of this Grant.

The RTC's GoMed project was recently selected for a BUILD Grant and includes pedestrian detection capabilities that will lead to dynamic traffic signal controls. These deployments will be dependent on data inputs and outputs, which will be a valuable source for the RDMP.

Table 1-1. Executive Summary Overview	
a. Vision, goals, and objectives **Page 5**	› Unlock key insights for safer transportation and ADS use › Successful ADS detection and interaction with EmVs › Develop an open-source repository for ADS-related data › Answer questions from Advance Notice of Proposed Rulemaking Pilot Program for Collaborative Research on Motor Vehicles with High or Full Driving Automation (ANPRM)
b. Key partners, stakeholders, team members, and others proposed to participate **Page 8**	› **RTC** - Program Lead › **Aptiv** - ADS Developer › **Atkins** - Program Management › **Pillar Technology** (part of Accenture Industry X.0) - Data Platform Development › UNLV Transportation Research Center - Research Support › Local cities' public safety and IT departments
c. Issues, challenges, technologies, and performance improvements **Page 10**	› Several types of issues with various ADS-EmV interactions to address and reaching consensus with stakeholders › Challenges to collect the right kinds and amounts of data; manage accessibility › Train ADS for fully driverless technologies; create open-source data platform › Reduce obstacles facing emergency responders; provide financially sustainable platform as a passport to additional improvements
d. Area of demonstration **Page 11**	› Phase 1: Virtual simulation testing › Phase 2: Off-street testing at Aptiv test track (North Las Vegas) or City of Las Vegas' 5-acre test track at West Service Center
e. Proposed period of performance **Page 11**	› 4 years (Setup: 1 year; implementation: 2 years; demonstration and summary: 1 year). See Figure 1-5 for schedule.

The various initiatives throughout the Las Vegas Valley require collaboration across multiple sectors (private, public, and academic) and public agencies**.** The Smart Communities Vision has been adopted by all six Southern Nevada jurisdictions (Clark County and the Cities of Las Vegas, Mesquite, Henderson, Boulder City, and North Las Vegas) as well as several other agencies (RTC, Las Vegas Valley Water District, Nevada Department of Transportation [NDOT], McCarran International Airport, and Southern Nevada Health District). The GoMed project is being executed in full partnership with the City of Las Vegas and Las Vegas Medical District. The private sector also engages regularly in our conversations and participates in our quarterly Smart Communities meetings.

NAVIGaTE will become an integral part of these initiatives supporting the transportation innovation taking place in the Las Vegas Valley. The RDMP can be scaled for broader use across the other aspects of these programs. **The region is well-positioned to use the ADS Grant to unlock and extend our Smart Communities Vision while also helping to advance ADS on a federal level.** We have the vision, the regional collaboration, the multi-sector engagement, and the ADS deployments to learn from and continue advancing the technology. **Figure 1-2** shows our key collaborators.

This highly collaborative environment enables thorough technical problem assessment and solution creation for ADS' interaction with a critical public

service of first responders and emergency vehicles. Emergency services are a public priority, yet emergency responders face important challenges when dealing with traditional vehicles. When lights and sirens are on, drivers are required to move out of the way to clear the lane for the EmV to be able to pass freely. Having a clear lane can be a matter of life or death, where seconds count. Moreover, human drivers often unknowingly threaten safety of emergency responders who may be attending an emergency in a dangerous situation. ADS currently have limited ability to identify and interact with EmVs, relying on measures such as the safety driver to manage encounters with an active EmV. Data and new technologies will help save lives and remove the issues that limit a traditional driver's ability to respond as needed.

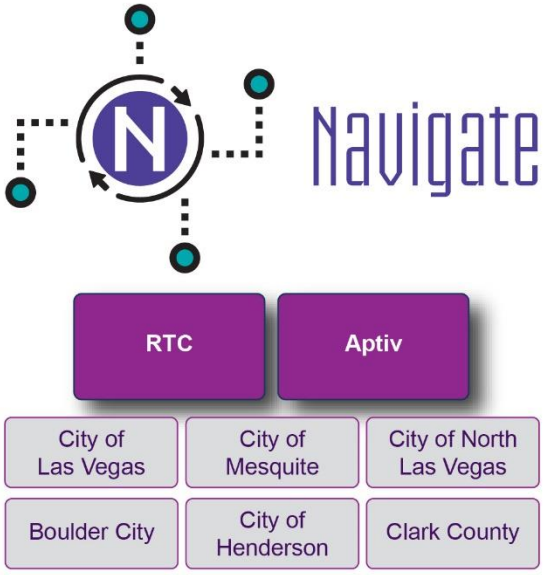

Figure 1-2. Team Collaborators

Table 1-2 summarizes how NAVIGaTE aligns with the Goals and the Focus Areas of the Technical Merit Criteria of the Notice of Funding Opportunity (NOFO).

Table 1-2. Technical Merit Criteria	
Goals	**Project Outcomes**
Safety	EmV interaction with traditional vehicles is already challenging, with delays often being a life-or-death matter. Appropriate responses by ADS are critical and may improve response times, thus saving lives and improving public safety.
Data for Safety Analysis and Rulemaking	The proposal responds to questions 9 and 15 of the Advance Notice of Proposed Rulemaking Pilot Program for Collaborative Research on Motor Vehicles with High or Full Driving Automation (ANPRM). Please refer to Section 2.B.
Collaboration	Entities involved with this program include: RTC, Atkins, Aptiv, City of Las Vegas, City of Las Vegas Public Safety (Marshals), and Pillar Technology, and NDOT.
Focus Areas	**Project Outcomes**
Significant Public Benefit(s)	This demonstration addresses the critical need for safe interaction of ADS and EmVs. The results of the demonstration have national importance and the data provided will benefit the broader research community.

Table 1-2. Technical Merit Criteria	
Addressing Market Failure and Other Compelling Public Needs	This demonstration will result in data and research that will be publicly available and can be used to help develop national standards. It addresses market failures because market forces may otherwise limit such data sharing.
Economic Vitality	This demonstration supports the regional focus on developing high-tech jobs and an educated workforce. The RTC will comply with the Buy American Act as implemented under 48 CFR Subparts 25.1925.2
Complexity of Technology	Aptiv vehicles are Society of Automotive Engineers (SAE) level 4 AVs with safety drivers and operators.
Diversity of Projects	This demonstration has implications for all road users (urban, rural, and suburban) and serves a public safety function. Data from other projects, including GoMed, will be incorporated into the RDMP.
Transportation-challenged Populations	This demonstration addresses a need found by all users of emergency services. While not specifically addressing older adults and individuals with disabilities, the ADS-EmV demonstration will provide insights that will positively impact any person who is traveling on a roadway in an EmV.
Prototypes	This demonstration addresses the critical need for safe interaction of ADS and EmVs. The results of the demonstration have national implications.

Sections 3 and 4 provide detail about how this proposal satisfies the Goals and Focus Areas. Section 5 discusses how NAVIGaTE satisfies the Demonstration Requirements.

a. Vision, goals, and objectives

Data analyzed from diverse situations and technologies can unlock key insights for safer transportation. Therefore, data is at the core of this program, along with insight it can provide, and power of that insight when it is applied.

There are two components to this program. The first is the development and deployment of ADS technology that will enable vehicles with Aptiv's autonomous driving features to use a variety of inputs (visual, audible, and connected vehicle) to identify an approaching EmV responding to an incident. Identifying the approaching EmV is a prerequisite to trigger the ADS to maneuver to let the EmV pass unencumbered, as required by law. Current ADS rely on safety operators to recognize the approaching EmV to take control of the AV and maneuver as appropriate. The capability to detect EmVs and appropriately handle the interaction is critical for Level 3 ADS and higher.

The second component of the program is the development of the RDMP to aggregate the data that is collected to support the advancement of ADS in Southern Nevada. This data will be used to support the reporting required for the ADS Grant, sharing amongst agencies and institutions working to advance ADS and for future sharing among industry and others working to develop ADS.

The RDMP will be an open-source repository for data associated with ADS. The framework for this data platform will build on an existing open-source platform. The program will use an Agile process and use the data management framework from Pillar's previous

open-source platform. The first thin slice of the platform will be a repository for ADS information from the GoMed ADS shuttles and information from Aptiv and agencies regarding the pilot on interactions between ADS and EmVs. We anticipate that the GoMed data will provide one input to the Aptiv ADS.

The framework for this data platform can scale in the future to provide a broader open-source data resource assisting Smart Cities with their efforts to address their transportation challenges. We also anticipate the data platform will assist with the development of the technologies. Examples include the sharing of sensor data around EmV interactions to aid the development of detection algorithms and develop a better understanding of where EmVs are; what kind of delays they experience (due to traditional cars); and the frequency, location, and type of their interactions with ADS. The RTC and the Jacksonville Transportation Authority (JTA) are collaborating on how to incorporate transformative technologies within the industry addressing innovation, efficiency, safety, and accessibility. If selected, RTC and JTA will be able to share best practices of the ADS projects.

We anticipate the data platform will support the following high-level vision:

- **Seamless Computing**. The open-source nature and cloud computing capabilities of the RDMP will reduce run costs, allow for cloud agnosticism, and eliminate geographic boundaries.
- **Financial Sustainability**. As public and private entities look to monetize features and data stored in the RDMP at scale, these groups will fund the financial sustainability of the solution via micropayments.
- **Open-Source Scalability**. The RDMP will build upon the success of the open-source movement, leveraging best-of-breed open-source projects to provide core functionality and release its own unique components back to the community, allowing other communities to easily leverage Southern Nevada's successes.

Other objectives of this proposal include:

Answers. NAVIGaTE will help answer some of the Advance Notice of Proposed Rulemaking Pilot Program for Collaborative Research on Motor Vehicles with High or Full Driving Automation (ANPRM) questions established by USDOT and the RTC, as described in Section 2.b. The learnings from the ADS Grant outcomes can help inform the minimal data elements needed from ADS manufacturers and other relevant agencies to ensure ADS react appropriately to EmVs and emergency personnel. Insights from this research may also help develop standards around ADS and EmV interaction.

Data sharing. The USDOT BUILD Grant funds the deployment of four ADS shuttles for GoMed. We will make relevant data from this project available on the RDMP. Examples of this data could include:

- Ridership
- ADS performance safety learning
- Pedestrian detection impact
- Smart transit shelter impact
- Pedestrian detection data to train ADS via a machine learning pipeline

Data from interactions of the GoMed shuttles with EmVs may provide an additional data source that Aptiv can use to support the demonstration proposed in this application.

Performance Metrics. ADS-EmV interaction technologies remain relatively immature and consequently so are the performance metrics to evaluate these technologies. This program will provide a key data set to measure the performance of EmV detection technologies for ADS. NAVIGaTE will also reveal key ADS-EMV interaction scenarios to measure the performance of EmV handling technologies for ADS. We will identify specific metrics and measures of success and progress during the initial research phase.

Advance the state of the practice. This program builds on work being done, on the data management side and the ADS technology side to facilitate rapid progress.

Collaboration. NAVIGaTE will leverage and further foster a regional culture of collaboration and innovation. The region has demonstrated a dedication to collaboration through the adopted Southern Nevada Smart Community Vision; the RTC's Freeway and Arterial System of Transportation (FAST) Mobility Roadmap; and projects such as GoMed and the autonomous shuttle program deployed by Navya, Keolis, AAA, and the City of Las Vegas.

The Proposed ADS Demonstration

The team will take a "thin slice" approach to these demonstrations. This approach is adapted from the Agile approach to project development. We will focus on small, well defined aspects of the NAVIGaTE program development components. This approach will keep the team focused on desired outcomes, resulting in better program deliverables.

This approach to developing software is particularly appropriate to this project because the questions being answered during these demonstrations are a smaller (thinner) subset of the overall challenge of ADS-EmV interaction. Maintaining that thin-slice or narrow focus, both during the ADS demonstration and the development of the RDPM, means the team can develop the most complete responses rather than being distracted by the entire universe of issues surrounding ADS-EmV interaction. During the Grant performance period, we will demonstrate the early value of a RDMP and will build the platform to support the research and analysis of EmV detection and response.

By understanding the issues, defining the need, and refining the simulation and subsequent test track interactions, this demonstration will answer two questions fundamental to ADS-EmV interactions. **(Figure 1-1)**:

- **DETECTION**: What are the most reliable and cost-effective ways for an ADS to recognize, localize, and differentiate multiple types of EmVs among other traffic in different situations?
- **HANDLING**: What are preferred actions for an ADS to take in response to the detection of an EmV?

Aptiv will refine methods for detecting and classifying EmVs, using light detection and ranging (LiDAR), radar, vision, and/or audio sensors. We will also include a wide range of scenarios of ADS and EmV interactions to develop EmV handling technologies.

We believe that the breadth of data on the RDMP can reveal even greater insights regarding EmV interactions with traffic and opportunities for improvements. Derivatives of our learning will be shared with the USDOT Data Hub and Secure Data Commons.

The benefits of the Aptiv demonstration include data collection and data sharing as well as AI technology development to ultimately reduce the risk to emergency responders in the field and to increase the safety and efficiency of their efforts to reach emergency situations.

The benefits of the RDMP demonstration include the ability to facilitate data sharing, support research, and provide insights related to the interaction of EmVs with a variety of AVs and connected vehicle technologies.

b. Key partners, stakeholders, team members, and others proposed to participate

The partners in this program each offer specific and complementary strengths to support the proposed research and development. Many of the participants are already collaborating on ADS projects or are planning for collaborative projects related to intelligent transportation systems (ITS) and ADS. Part 2 provides details about the roles they will play on this program.

RTC - Program Lead

The RTC is a regional entity that oversees public transportation, traffic management, roadway design and construction funding, transportation planning, and regional planning efforts known as Southern Nevada Strong. As the population continues to increase daily, so does congestion.

The RTC identifies transportation challenges and implements both short- and long-term solutions while promoting sustainability, air quality improvement, enhanced mobility, and quality of life in the region. RTC is the administrator FAST. NDOT and the RTC became funding partners, contributing to the operations and management of FAST which is the collocation of freeway and arterial monitoring and operations.

Aptiv - ADS Developer

Aptiv (formerly Delphi Automotive Systems) is a global technology company that develops safer, greener, and more connected solutions enabling the future of mobility. Aptiv is one of the leaders in the ADS space and draws on decades of experience developing increasingly automated systems as a tier 1 automotive supplier. Following the acquisition of two promising self-driving car startups (Carnegie-Mellon spinoff Ottomatika in 2015 and Massachusetts Institute of Techology [MIT] spinoff nuTonomy in 2017), it rolled out a large-scale ADS testing operation in Las Vegas in 2018. Aptiv has provided more than 35,000 autonomous rides with partner Lyft in Las Vegas.

Besides its leading self-driving technology, Aptiv's Mobility and Services group has expertise in data management and telematics through the acquisition of nuTonomy and its data pipeline. Aptiv's self-driving vehicles rely on a comprehensive sensor suite that generates terabytes of data daily, which the company uses to train its perception algorithms and improve its overall performance. In 2018, Aptiv launched the nuScenes effort to make annotated sensor data freely available to academics across the globe to aid in the training and validation of perception methods and algorithms.

Atkins - Program Management

As a global expert in implementing programs that integrate technology and infrastructure, Atkins is pioneering intelligent mobility solutions worldwide. Atkins' intelligent mobility group is

comprised of leadership and technology experts who have delivered ADS projects from research and development through design, implementation, and operation. Atkins recently collaborated with five Nevada agencies to organize and host Nevada's GO-NV Summit, which brought together industry leaders and transportation technology experts. The focus was on achieving statewide benefits and gaining an understanding of mobility changes taking place across the globe to help rapidly advance capabilities for Nevada's residents and 42 million annual visitors.

Atkins recognizes the need for creativity and innovation when championing projects. For the North Avenue Smart Corridor located in Atlanta, Georgia, Atkins deployed smart technologies and used intelligent mobility to provide actionable information to fundamentally transform transportation; to date, the route has seen an accident reduction of 25 percent. Atkins and the RTC have a successful relationship working together on such similar projects as the FAST Mobility Roadmap, which is a 5-year actionable plan that will thoughtfully guide efforts to improve safe, efficient, reliable, and sustainable multimodal mobility through implementation of intelligent mobility strategies.

City of Las Vegas Fire & Rescue

Las Vegas Fire & Rescue Department (LVFRD) supports this program in order to develop technologies to further improve LVFRD's emergency response times and safety of the responding personnel. LVFRD provides all fire suppression, prevention, and education programs in the city as well as paramedic emergency medical services to the residents and visitors of the Las Vegas community. The department also has a bomb squad, hazardous materials team, and technical rescue team that provides services for the city and the rest of Clark County.

City of Las Vegas Public Safety (Marshals)

Providing the public with law enforcement and detention services, this department manages the City's jail and includes emergency responders and deputy city marshals who provide public safety at City parks and facilities as well as animal control services.

Pillar Technology - Data Platform Development

Pillar Technology (part of Accenture Industry X.0) has been solving complex business problems through technology for more than 20 years. From the ADS to mobile wellness to precision farming, Pillar has partnered with leading Fortune 500 organizations to accelerate some of the most transformative innovations of the 21st century. As a part of Accenture's Industry X.0, Pillar brings end-to-end capabilities for strategy, design, software development, and hardware engineering.

In early 2018, Pillar was selected to begin development on the Smart Columbus Operating System, the data framework at the heart of Columbus, Ohio's Smart City initiative. This open-source solution will form the foundation of NAVIGaTE's RDMP proposed in this application, and the Pillar team developing it will act as a source of Smart City data expertise.

UNLV Transportation Research Center - Research Support

The Transportation Research Center (TRC) is a multidisciplinary center for research in planning, operations, and management of sustainable transportation systems in rapidly growing

urban areas. It promotes and conducts transportation research, education, and outreach for the safe, secure, and efficient movement of people and goods in collaboration with sponsors from federal, state, and local government agencies as well as from the private sector.

c. Issues, challenges, technologies, and performance improvements

The following is a discussion of the initial issues and challenges and any quantifiable performance improvements identified for each aspect of the proposed demonstrations. These and others identified during the first phase of the program will be solved for in the proposed use cases.

ADS

In talking with emergency responders, they brought up several concerns about their interactions with ADS:

- An ADS encounters an EmV responding to a call and needs to yield or pull over to let it pass.
- An EmV is stationary in a lane or on the shoulder in response to an incident, and the law requires moving traffic to ensure that there is a separation distance of at least one lane ("move over law").
- An ADS is being pulled over by an EmV or traffic officer.

Each of these situations highlight the need for ADS-EmV interaction technologies that will benefit the safety of EmV personnel, other road users, and ADS passengers. By potentially allowing more efficient ADS-EmV interactions, such technologies can help reduce emergency response times and therefore improve crash survival rates. Currently, ADS being tested in Las Vegas and elsewhere largely rely on safety operators to identify and appropriately respond to EmVs. However, in a driverless ADS future, the ADS software will need to perform these tasks autonomously. Capabilities for ADS-EmV interaction currently are at the cutting edge of self-driving car technologies. The data sharing use case we propose will advance the development of ADS-EmV interaction technologies by making available data to train, test, and evaluate such technologies.

We propose the development of two limited prototype technologies to address specific aspects of EmV detection and EmV handling by ADS.

NAVIGaTE's performance improvements can include:

- Stakeholder consensus on the required technologies and desired ADS maneuvers in ADS-EmV interaction situations.
- Availability of data, metrics, and methods to evaluate ADS-EmV detection and handling technologies.
- More accurate and reliable EmV detection and handling technologies for ADS, paving the way for widespread deployment of this life-saving technology and its other benefits.
- Potential improvements in emergency response times.

Regional Data Management Platform

Once we collect the data from Aptiv's work and learn insights from the deployment of the technologies, we need to be able to effectively share this information. The nature of our solution addresses a fundamental challenge in the collection of non-proprietary information from ADS and EmVs and the aggregation of it in an open-source, shared data environment. The RDMP will control the

kinds of data being collected and shared to allow open sharing of data between partners in a manner that benefits the advancement of the technology. In this way, an open-source solution offers greater capabilities than a proprietary data platform.

The RDMP will be a centralized repository of ADS-related data points. Depending on the operational needs and technological possibilities identified during the first phase of the Grant, we may use the data to orchestrate bi-directional communication between EmVs, ADS, and infrastructure (dedicated short-range communications [DSRC]).

The platform is open-source and will not handle sensitive intellectual property; the provider of data into the system will have discretion over whether to share data with the platform, and the parties will mutually agree on a license for use of the data that places reasonable restrictions on the misuse of that data. With its open source architecture, the RDMP can be scaled to include other Smart Communities' data sharing needs in the future.

d. Area of demonstration

The technology demonstrations will take place in two main phases, allowing for testing of the interaction between ADS and EmVs. The first phase will include simulation testing by the Aptiv team. The second phase will include off-street testing to validate the vehicle operations and the integration between the ADS (with safety operators), the roadside, and the EmVs. The off-site testing to validate EmV interaction prototype technologies will be conducted at the Aptiv test track located in North Las Vegas or the **City of Las Vegas' 5-acre test track at West Service Center**.

Figure 1-3 illustrates Aptiv's test track located in North Las Vegas.

Figure 1-3. Aptiv Test Track Area

e. Period of performance and schedule

NAVIGaTE's period of performance is anticipated to be 4 years, with 1 year for set-up, 2 years for implementation, and 1 year for demonstration and summary. **Figure 1-4** shows the schedule, and Part 6 provides more details about each of the activities in the figure. We will meet the milestones identified in the NOFO to the schedule and timing described in the NOFO.

2. Goals

This program is an important part of the regional effort to collect, analyze, and use data as noted in the Southern Nevada Smart Community Vision. It aligns with the goals of this NOFO in the following ways.

a. Safety

Interactions between EmVs and other traffic are critical for the safety of

Major activity		Months to complete						
		12	18	24	30	36	42	48
Project Management	Program management							
	Data governance							
Demonstration	Develop a research paper of existing EmV technologies							
	Organize a roundtable with Aptiv ADS safety drivers involved in EmV interactions							
	Organize and convene roundtable discussion with EmV operators							
	Generate, document, and publish EmV detection scenes dataset							
	Generate, document, and publish EmV handling scenarios							
	Develop and test one EmV detection technology proof-of-concept							
	Prototype one EmV detection technology							
	Develop and test one EmV handling technology proof-of-concept							
	Prototype one EmV handling technology							
	Publish and present findings (1 or more papers on each technology and data sharing use case)							
Platform	Set up architecture for the platform							
	Sustainability (operations and maintenance)							

Figure 1-4. Schedule

emergency personnel and other traffic users. For example, in a recent conversation with the team, a LVFRD captain described in vivid detail how other road users failed to clear an intersection for a ladder truck that was responding to a fire. The ensuing chaos resulted in one vehicle crashing into the ladder truck and the need to dispatch a second fire truck to respond to the fire emergency, causing a significantly delayed response and costly damage to the fire truck. The U.S. Fire Administration reports that “sixteen percent of on-duty firefighter fatalities occur each year while responding to or returning from incidents, with the majority of fatalities resulting from vehicle crashes” and that “vehicle collision is the second leading cause of firefighter fatalities.”

By providing data and developing technologies for interactions between ADS and EmVs, NAVIGaTE will contribute to the safety of emergency responders and traffic users at large. With the technological opportunities available to ADS, including advanced detection, optimized maneuvers, and connected vehicle technologies, we believe that an ADS future can offer greater safety of EmV operators and faster response times. Furthermore, by advancing the development of ADS technologies, the proposed research will facilitate the introduction of fully driverless ADS on our roadways to ultimately eliminate crashes associated with human driving choices.

b. Data for Safety Analysis and Rulemaking

This proposed program responds to Questions 9 and 15 of USDOT's ANPRM as described below.

Question 9: *What type and amount of data should participants be expected to share with National Highway Traffic Safety Administration [NHTSA] and/or with the public for the safe testing of vehicles with high and full driving automation and how frequently should the sharing occur?*

We anticipate that this program will result in a better understanding of metrics that can help evaluate the safe interaction of ADS with EmVs. Potential metrics that the program may consider include:

- Recall and accuracy of EmV classification, as a function of distance, among available ADS-EmV encounter scenes.
- Precision or accuracy of EmV localization, as a function of distance, among available ADS-EmV encounter scenes.
- Percent of ADS-EmV encounters in which ADS identifies an appropriate maneuver (e.g., law-compliant, or safe, or some combination thereof).
- Percentage of defined EmV handling scenarios successfully performed in simulation or closed course.

Data required to compute these metrics would include:

- Retroactive annotated data from ADS-EmV encounter scenes.
- Scenarios of desired ADS responses to EmV encounters.

Question 15: *What value would there be in NHTSA's obtaining one or more of the following potential categories of data from the participants in the pilot program? Are there other categories of data that should be considered? How should these categories of data be defined?*

Responses can be found below to the sections of Q15 that are relevant to this proposal. Sections a, b, c, g, j, l, n, and o are not addressed in this discussion**.**

d. Sensor data from each crash or near miss (e.g., raw sensor data, perception system output, and control action).

While the program will not focus on crash or near-miss scenes, it will help NHTSA consider the nature and value of raw and retroactive annotated sensor data related to ADS-EmV encounter scenes. In addition to camera data, which numerous other datasets include, the proposed framework provides insights into data from radar and LiDAR sensors. Moreover, the focus on EmV encounter scenes may further provide insights into the potential application of audio data, vehicle-to-vehicle data, and vehicle-to infrastructure data for safety-critical situations.

e. Mobility performance impacts of vehicles with high and full driving automation, including string stability of multiple consecutive ADS vehicles and the effects of ADS on vehicle spacing, which could ultimately impact flow safety, and public acceptance.

The proposed research will yield insights into the potential effects of ADS on EmV flow and response times, which impacts overall traffic safety and public acceptance.

f. Difficult scenarios (e.g., scenarios in which the system gave control back to an operator or transitioned to its safe state by, for example, disabling itself to a slow speed or stopped position).

The proposed research will help define what constitutes difficult ADS-EmV

interaction scenarios and desirable responses by multiple stakeholders. This will help NHTSA evaluate the value of collecting data on ADS-EmV interactions and handling.

h. Metrics that the manufacturer is tracking to identify and respond to progress (e.g., miles without a crash and software updates that increase the operating domain).

The proposed research will help identify and/or develop metrics for the assessment of ADS-EmV interaction capabilities.

i. Information related to community, driver and pedestrian awareness, behavior, concerns and acceptance related to vehicles with high and full driving automation operation. For example, if vehicles with high and full driving automation operated only in limited defined geographic areas, might that affect the routing choices of vehicles without high and full driving automation? For another example, if vehicles with high and full driving automation are programmed to cede right of way to avoid collision with other vehicles and with pedestrians and cyclists, might some drivers of vehicles without such automation, pedestrians and cyclists take advantage of this fact and force vehicles with high and full driving automation to yield to them?

The proposed research includes stakeholder engagements that will consider questions like:

- How may ADS impact the ability of EmVs to rapidly respond to emergencies?
- Are there opportunities to improve EmV response times in a future with ADS relative to only human drivers?
- What opportunities exist for ADS to reroute in the event of proximity to an EmV?
- What concerns do EmV operators and law enforcement officials have about the impact of ADS on their operations?

k. Data from "control groups" that could serve as a useful baseline against which to compare the outcomes of the vehicle participating in the pilot program.

In developing performance metrics for ADS-EmV interaction technologies, this research will consider human performance as a potential benchmark. Possible relevant human driver data may include the percent of human drivers that do not detect an EmV approaching from behind or the percent that does not respond appropriately. We expect that this work may identify gaps in such human data that could guide future human driver data collection efforts.

m. Given estimates that vehicles with high and full driving automation would generate terabytes of data per vehicle per day, how should the need for data be appropriately balanced with the burden on manufacturers of providing it and the ability of the Agency to absorb and use it effectively?

The data platform demonstration will provide an example of data subsets that can be appropriately shared with a clear purpose. It will provide a blueprint for event-based data collection that NHTSA can consider as it evaluates data retention and sharing guidelines for ADS manufacturers.

c. Collaboration

Led by the RTC, local public agencies and safety agencies, research institutions such as UNLV, and public advocacy groups, this demonstration will continue to broaden opportunities to expand the

knowledge and insight around ADS in Southern Nevada and will deepen the commitment to incorporating the technologies to improve public safety and reap the benefits of ADS. By partnering with Aptiv, the program will enhance the collaboration on ADS technologies between the public and private sectors in the region.

Early engagement with partners and local public agencies will lay the foundation for the research, giving researchers insights into the real challenges that emergency responders face as well as a broad understanding of the data available that may inform machine learning and the development of the RDMP. Subsequent events will allow discussion and iterative review of the effort to either affirm or modify the direction of the research.

3. Focus Areas

a. Significant Public Benefit(s)

This demonstration will provide data and evaluation to support safer interaction of EmVs with connected vehicles and AVs which has national applications and addresses a serious public safety issue. The NAVIGaTE program will help accelerate the broader development of ADS nationwide and make vehicles better able to respond to EmVs and other roadway interactions. We aim to enhance travelers' safety with information sharing and enable a data-sharing culture.

b. Addressing Market Failure and Other Compelling Public Needs

There is a critical need to develop the technology to safely interact with EmVs. Private companies typically perform research and development, with limited opportunity to share data and build on the technology. By funding this demonstration, there is an opportunity to properly define the challenge and lay the foundation for development of a national standard. This program provides the opportunity to build a data set as part of the RDMP that advances the state of the practice and allows for research and development by the widest possible audience, for the public, and not limited to a single company.

c. Economic Vitality

The State of Nevada and the Las Vegas region were hit very hard by the great recession because the economy was largely based on tourism and entertainment. As a result, the State formed the Governor's Office of Economic Development (GOED) to promote a more robust and diverse economy. One focus area of GOED is the development of new innovative business in the state. This effort has helped the state become a leader in the development of ADS technology, which subsequently has created new companies and jobs in Nevada. This Grant will result in the creation and retention of mid- to high-paying jobs, such as engineers, computer scientists, safety engineers, data scientists, systems engineers, operators, and mechanics in the Las Vegas region, which will further diversify and bolster the region's economy. The RTC will ensure compliance with the Buy American Act as implemented at 48 C.F.R. Subparts 25.125.2. No grant funds are anticipated to be spent on motor vehicles.

d. Complexity of Technology

Aptiv technology is SAE level 4 automation with safety operators. Aptiv's automated mobility team includes leaders in the field of autonomous driving that contributed significantly to ADS technology since participating in the 2007 Defense Advanced Research Projects

Agency (DARPA) grand challenge and conducting the first coast-to-coast autonomous drive in 2015. Aptiv's ADS involve substantial complexity in that they tackle all driving tasks including mapping, localization, perception, planning, and control.

e. Diversity of Projects

This demonstration has implications for all road users (urban, rural, and suburban) and serves a public safety function. Data from other projects, including GoMed, will be incorporated into the RDMP.

f. Transportation-challenged Populations

This demonstration addresses a need found by all users of emergency services. While not specifically addressing older adults and individuals with disabilities, the ADS-EmV demonstration will provide insights that will positively impact any person who is traveling on a roadway in an EmV. The inclusion of GoMed data is anticipated to allow insights into issues the transportation-challenged population faces.

g. Prototypes

We will develop two proposed ADS-EmV interaction technology demonstrations to limited prototype states, as described in Section 4.b. Aptiv uses a rigorous process for the safe demonstration of new technologies. They implement stage gates at simulation, closed-course testing, and public road release testing with safety operators before releasing a new feature for more extensive endurance testing or commercial deployment, which will continue to involve safety operators until full validation and certification for driverless operation. Aptiv's process has delivered more than 35,000 autonomous rides on its commercial road release and has an excellent safety record.

For this Grant, we will follow all applicable safety standards and internal safety processes to develop the new technologies to the closed course testing stage gate. For the EmV detection technology, simulation and closed-course testing will focus on robustness, accuracy, and reliability. For the EmV handling technology, simulation and closed-course testing will focus on safety and reliability. Testing of the technologies in simulation and closed course does not involve any risk to the public and minimal risk to testing crews. Depending on the close-course testing results, public road releases may include the prototype technologies as features for a public road release if warranted and according to Aptiv's rigorous process.

4. Demonstration Requirements

This section describes how the proposed demonstration satisfies the requirements contained in NOFO Section A, listed below.

a. Research and development of automation and ADS technology

Aptiv's SAE level 4 vehicles are capable of highway and surface street driving and can handle a variety of situations. Currently, there are always two vehicle operators behind the wheel to ensure vehicles stay within Aptiv's geo-fenced operating area in the event of any rare edge cases that are still undergoing testing. NAVIGaTE's research will significantly contribute to the development of ADS technology capable of driverless operation by developing EmV detection and handling technologies to limited prototype state and by providing data to support the development of such technologies.

b. Physical demonstration

The physical demonstration proposed covers two areas, taking advantage of work already happening in Las Vegas. The first will be the physical demonstration of ADS interacting with EmVs and the second will be the use of the RDMP that creates the clearinghouse for data access.

Demonstration 1

During this demonstration, we will collect data to "teach" the Aptiv cars how to handle EmVs. Aptiv cars will then apply what they learned. To do this, the team will create actual scenarios and use the data to shape the ADS ability to handle the situation.

Demonstration 2

The RDMP will provide a data fabric for the integration of many systems and services. It provides a space for data created by government organizations, public partners, private entities, and individual citizens in a single, logical system. The RDMP will feature simple, powerful interfaces to enable researchers and city stakeholders to browse, search, and apply the data necessary to advance engagement on issues like transit, economics, healthcare, and, in our case, the interaction of safety and smart mobility. Developers and innovators can take advantage of the solution's public Application Programming Interface (API), a robust middleware environment, and a self-sustaining micropayment model to consume and turn this data into rich, transformational experiences.

c. Data gathering, sharing, and accessibility

Each of the proposed demonstrations will include the gathering and sharing of all relevant and required data with the USDOT throughout the project, as agreed to upon award. Data demonstrating safety performance would include conventional data regarding safety incidents, operational data, exposure measures, and measures of vehicle data that may indicate potential safety problems. As data collected for the ADS demonstration may not address safety performance, not all data points listed above may be available; however, the team commits to regular data sharing of the ADS-EmV data. The RTC will ensure the appropriate data are accessible to USDOT and/or the public for a minimum of 5 years after the award period of performance expires.

d. Input/output user interfaces

The proposed demonstration will include a user interface (UI) on board the ADS. Aptiv's ADS are in a commercial pilot in Las Vegas that allows users to select pick-up and drop-off locations through the app of Aptiv's ride-sharing partner, Lyft. The UI will provide the ADS rider with a graphical presentation of what the ADS "sees" and thus the resulting ADS behaviors. Additionally, the UI will provide the rider the ability to monitor and affect the route.

The roundtable discussions with EmV and ADS safety operators personnel may yield a recommendation for a UI within the EmV. The UI may provide the EmV personnel with a variety of information and control including status of local ADS vehicles, location of ADS vehicle relative to planned route, ability to request specific or general behaviors from certain ADS vehicles, ability to monitor status of requested behaviors, and ability to disengage requested behaviors. We will use roundtable discussions to guide the UI functionality and design.

e. Scalability of demonstration and outreach

We will make the insights from the roundtables and the technology demonstrations publicly available for the broader ADS research community to build on. These insights will include valuable lessons learned and ways to measure the performance of ADS-EmV interaction technologies. The technology demonstrations focus on developing prototype technologies that Aptiv can integrate into its fleet in Las Vegas and beyond.

A successful EmV detection method would scale to production vehicles in Las Vegas without additional development or training data. We anticipate that the methodological approach for detection (e.g., algorithms, types of sensor input) will scale directly to other locations. Tailoring of the technology to other areas may involve the need for additional training data to account for any unique EmV aspects that may critically affect detection.

For the EmV handling technology, the set of required maneuvers for safe EmV handling scales directly to ADS anywhere. The implementation of these maneuvers in the ADS planner, and any interfaces between the ADS and the EmV would scale to production vehicles in any location, with possible adjustments to account for local rules of the road and regulations. To the extent that the technology relies on map annotations (e.g., for safe stopping locations), such annotations would need to be developed for any new locations.

Though the RDMP is regional in name, its scalability will expand beyond the region. The platform will bring the following characteristics to support scalability:

- **Agnostic cloud computing**. Using a cloud-based storage platform will allow users to access the platform in different locations, including through other cloud providers or private clouds installed in data centers.
- **Open-source accessibility**. As emerging smart cities seek to extend and improve the open-source platform, the resulting network effects will return to Las Vegas functionality worth far more than its initial investment.

Finally, stakeholder engagement is important for the development of the EmV detection and handling, as well as the RDMP. For the EmV detection and handling it is important to understand the challenges and desired outcomes of emergency service providers. We will engage them through a series of workshops to understand these challenges and outcomes.

We will develop conceptual approaches to address the challenges and validate with the stakeholders to ensure we will achieve the desired outcomes. Then we will work with the stakeholders to test, calibrate, and adjust EmV detection and handling in simulation and closed course settings.

For the RDMP, we will engage program stakeholders to understand components that will make the platform usable to them to advance ADS, including validation of the approaches to effectively share data through the platform.

We will share knowledge and data obtained from the development of the EmV detection and handling technology through the data platform and through outreach materials, such as websites, white papers, and presentations, that share the knowledge and lessons learned from this program.

5. Approach

This section describes the approach we will take for this program, both for the ADS demonstration and for the RDMP.

a. Technical approach

ADS Demonstration

The ADS demonstration aims to further the development of technologies to improve ADS-EmV interactions. This includes:

1. A comprehensive assessment of existing technologies and key gaps.
2. Generation of data that will aid in the development of new technologies for EmV detection and handling.
3. Concepts that demonstrate and evaluate ADS-EmV technologies.

The assessment of existing technologies will be broad in scope and draw from expertise from EmV operators and other stakeholders in Southern Nevada. We will focus the work on data generation on specific aspects of ADS-EmV interactions (i.e., one EmV detection aspect and one EmV handling aspect).

Similarly, the technological concept development will focus on one technological concept for the ADS to detect EmVs and one for the ADS to handle an EmV responding to a call unrelated to the ADS. The assessment of gaps in existing technologies will help inform the details of the subsequent two items. The following sections describe the planned activities for this ADS demonstration.

1. Literature review

This activity will survey the landscape of existing ADS-EmV interaction technologies and summarize the literature. The scope of the review is expansive and can include all of the four main areas of ADS-EmV interaction situations (see section 1c). We anticipate that this activity will occur during the first 3 months of the Grant and will result in a report that will provide a starting point for further research in the context of this Grant or the research community at large.

2. Aptiv roundtable

Aptiv has provided more than 35,000 autonomous rides with partner Lyft in Las Vegas, always with two safety operators present in the ADS. As a result, our safety operators have accumulated valuable experience in ADS-EmV interaction situations. This activity involves a roundtable with Aptiv's safety operators to leverage this in-house experience.

As with the previous activity, this activity is broad in scope in that it will consider all four types of ADS-EmV interaction situations above plus any new types of interactions identified during the roundtable. We anticipate that this activity will occur early in the program and that the perspective from the ADS operators will help scope and frame the roundtable with EmV operators. The deliverable for this activity is a report or presentation will compile the insights from the roundtable.

3. EmV and other stakeholders roundtable

This activity aims to collect information from a wide range of stakeholders in future ADS-EmV interactions in the Las Vegas metropolitan area. This includes EmV operators and personnel, law enforcement representatives, and the RTC.

Like the previous activities, the scope is broad and considers all ADS-EmV interaction situations. This activity promotes the exchange of ideas and alignment of any ongoing work in this area among different stakeholders. The

input of EmV personnel and safety operators is critical to designing practical solutions and will benefit long-term research in this area.

We anticipate that the roundtable will help answer the following questions:

- What technologies for EmV detection by ADS do EmV operators anticipate support for in the future (e.g., vehicle-to-vehicle communications, infrastructure-to-vehicle communications, modifications or harmonization of the appearance of EmVs, novel sirens, or flashing lights)?
- What methods would be practical for EmV personnel to access ADS?
- What are the preferred programmed maneuvers for the ADS in response to the detection of an EmV?
- What specific scenarios and edge cases would developers need to consider when designing and evaluating EmV handling technologies?

The key deliverable will be a report, which will provide insights that we expect will be a major contribution to the research community on ADS-EmV interactions.

The literature and roundtables will form the foundation for the technology concept development phase. We anticipate that it will yield a narrowed-down set of functions to further develop and assess. We expect to select leading concepts in each of the following two areas of ADS-EmV interaction: EmV detection and handling technologies.

4. EmV detection technologies

This activity aims to further the development and evaluation of technologies for an ADS to detect EmVs. It includes an initiative to share sensor data collected by Aptiv's ADS during encounters with EmVs as a specific use case of the data platform and the development and evaluation of an EmV detection technology.

The sensor data sharing initiative will leverage Aptiv's existing nuScenes initiative that is making 1,000, 20-second scenes available to the broader research community for the development and training of perception algorithms. As stated on its website, the final nuScenes dataset "will include approximately 1.4M camera images, 400k LiDAR sweeps, 1.3M RADAR sweeps and 1.1M object bounding boxes in 40k keyframes."

The nuScenes data set is the most comprehensive, large-scale dataset available from the entire sensor suite of road-released and autonomously operated ADS. As of February 2019, it had more than 1,000 registered users and almost 800 registered institutions, including more than 200 academic institutions.

We intend to collect, select, curate, and publish scenes involving different types of EmV detections (e.g., different vehicles, different visual or auditory warning signals, different directions). The EmV scenes will expand on annotations related to EmVs and audio or other sensors not currently included in the nuScenes data set. We expect that these data will be critical for the training and validation of safe, accurate, and reliable EmV detection algorithms for ADS.

The roundtables will help determine the types of EmV detection scenes and duration of each scene required to support the development and evaluation of EmV detection technologies. The main deliverable will be the publication on the RDMP of annotated relevant sensor data associated with up to five EmV detection scenes per month (starting sometime

during year two of the Grant and continuing throughout the 4-year Grant period), not to exceed 25% of all of the EmV encounters that Aptiv's ADS experience during this period.

The detection and evaluation of an EmV detection technology will focus on a specific aspect of EmV detection. For example, the project could focus on a type of EmV signal detection (e.g., siren detection or EmV lighting detection), a type of vehicle (e.g., ambulances or police car), a type of approach (e.g., from behind or in cross-traffic), a vehicle-to-vehicle communication method, or an EmV localization method.

Depending on the needs identified during the roundtable, the nature of the technology, and feasibility within the budget, we may expand the scope if warranted to consider a combination of aspects.

The testing of the technology will focus on demonstrating the robustness, accuracy, and reliability of EmV detection. This could involve machine learning approaches to be developed by Aptiv's machine learning research team. To compare and evaluate the success of machine learning models, Aptiv will develop metrics. The scene data will provide a key dataset for the off-line (i.e., simulation) evaluation of the EmV detection technology concept(s).

After reviewing the off-line test results, Aptiv will refine the concept. This is likely to involve improvement of the EmV detection algorithm. Then we will integrate the technology concept on Aptiv's ADS for further evaluation on a closed course proving ground in conjunction with the evaluation of EmV handling technology concepts. The main deliverable will be one EmV detection technology developed to the prototype state and evaluated as such.

The following list summarizes the key tasks related to the EmV detection effort:

- Review findings from the roundtables to define desired EmV detection functions.
- Brainstorm concepts for EmV detection technologies.
- Adapt existing nuScenes process to new vehicles, sensor set, and EmV detection application.
- Collect and annotate EmV scenes for training and validation of technologies.
- Prepare documentation and publish EmV scenes.
- Develop most promising concept for one aspect of EmV detection.
- Consider metrics to measure the performance of EmV detection technologies based on needs identified in roundtables.
- Test concept on EmV scenes dataset.
- Refine concept based upon test result.
- Integrate into vehicle prototype.
- Test at Aptiv proving ground as discussed in Part 1.d

5. EmV handling technologies

This activity aims to further the development and evaluation of technologies for ADS to handle EmVs for the first ADS-EmV interaction scenarios (i.e., yielding/ pulling over for an EmV responding to a call). It includes:

- An initiative to share canonical scenarios for EmV handling by ADS as a specific use case of the RDMP.
- The development and evaluation of an EmV handling technology.

The scenario sharing initiative will use lessons learned from the roundtable to develop key scenarios to structure thinking and help the evaluation of EmV

handling technologies for ADS. This work will leverage the publicly available OpenScenario data format to describe driving scenarios, which was specifically developed to advance ADS simulation and ADS evaluation standards.

We anticipate that the EmV handling scenarios will inform research into EmV handling technologies by the broader research community and will facilitate the development of standards related to the safe handling of EmVs by ADS. Two possible high-level examples of canonical scenarios may read as follows:

- Approach behind ADS of an EmV traveling in the same lane as the ADS on a two-way street with one lane in each direction.
- Approach from the left side by an EmV with ADS entering a four-way intersection.

It will involve the development of tools required to deliver the scenarios in OpenScenario and to modify existing digital infrastructure to share resources. The main deliverable will be the publication of 50 or more scenarios in the OpenScenario format involving EmV handling by an ADS.

The detection and evaluation of an EmV handling technology will focus on a specific aspect of EmV handling. For example, the project could focus on maneuvers (e.g., stopping or moving to right until EmV passed), an interface with the EmV (e.g., a mechanism for the EmV to remotely select an ADS maneuver), a mapping solution (e.g., identification and annotation of safe pull-over locations for the ADS), or a proactive technology for ADS to re-route based on real-time data on emergencies and/or EmV locations.

Depending on the needs identified during the roundtable, the nature of the technology, and feasibility within the budget, we may expand the scope to consider a combination of aspects. The testing of the technology will focus on demonstrating the safe and reliable performance of the EmV handling technology in selected scenarios, which may require the development of metrics to evaluate these technologies.

We anticipate that this will involve off-line testing in simulation based on the selected scenarios. After reviewing the off-line test results, we will refine the concept. Then we plan to integrate the technology concept on Aptiv's ADS for further evaluation on a closed course proving ground in conjunction with the evaluation of EmV handling technology concepts. The main deliverable will be one EmV detection technology developed and evaluated at the prototype stage.

The following summarizes the key tasks related to the EmV handling activity:

- Review findings from roundtable to define desired EmV handling functions.
- Brainstorm concepts for EmV handling technologies.
- Develop set of scenarios for EmV handling by ADS, based on roundtable findings, for validation of EmV handling technologies.
- Use OpenScenario or other scenario format to make EmV handling scenarios available on RDMP.
- Prepare documentation and publish EmV handling scenarios.
- Develop most promising concept for one aspect of EmV handling.
- Consider metrics to measure the performance of EmV handling technologies based on needs identified in roundtables.

- Test concept on EmV handling scenarios in simulation or closed course proving ground (possibly in conjunction with EmV detection concept technology).
- Refine concept based upon test results.
- Integrate into vehicle prototype.
- Test at Aptiv proving ground as discussed in Part 1.d.

6. Dissemination of findings

The last major activity will focus on the further dissemination of the insights derived from this research. We anticipate that in addition to the findings in the publishable manuscript and report mentioned under activities 1 (literature review) and 3 (stakeholder roundtable), insights will include evaluation of the two technological concepts, lessons learned from the two data platform use cases, and recommendations for further research and development of ADS-EmV interactions. Key deliverables are:

- Reports for:
  - Development and evaluation of EmV detection technology.
  - Development and evaluation of an EmV handling technology.
  - Lessons learned from the data platform use cases.
  - Key further research and development opportunities in the ADS-EmV interaction space.
- Presentation of findings at one or more leading conferences.

Regional Data Management Platform

To maximize efficiency, capitalize on collaboration, and leverage investments already made by the USDOT, we plan to port Pillar's previously completed similar operating system (OS) source code and use it as the foundation of our RDMP. This will allow us to deliver progress towards our initial value stories very quickly while still maintaining the flexibility to adjust as technical, user, and business needs change. It will also allow Southern Nevada to leverage learnings developed in other parts of the nation and vice-versa.

We are well-informed on the technical architecture and elements of Pillar's similar platform, and we believe that this technical approach will allow us to capitalize on progress already made while also allowing us to build customized solutions which address the specific needs of Las Vegas.

As we continue to build our RDMP, we will also contribute back to the open-source community so that it becomes easier for other cities to build on the benefits of our initiatives.

High-level proposed steps to form this foundation in Las Vegas include:

- Clone Pillar's previous similar OS code repository.
- Integrate with our cloud provider.
- Connect to all the necessary data sources required to accomplish the scope defined in this proposal.

Table 1-3 in this section outlines some of the challenges and relevant risk mitigation strategies associated with this approach.

b. Approach to addressing obstacles

Demonstrations are currently running or soon to be running so there are no anticipated, legal, regulatory, environmental, or other obstacles. This is another advantage of this program. The GoMed project will advertise for four AVs, and the contract will include the requirement to provide operational data and coordinate with the NAVIGaTE team on relevant data points.

i. Exemptions from regulations

We are not requesting and do not anticipate requesting any exemptions to federal regulations in connection with this program.

ii. Exceptions to Buy American Act or Domestic Vehicle Preferences

This program does not require any exceptions under the Buy American Act or an exception to the terms of the NOFO Clause at Section F, Paragraph 2.J. entitled BUY AMERICAN AND DOMESTIC VEHICLE PREFERENCES. It is understood that the clause: (1) requires compliance with the Buy American Act, 41 U.S.C. §§ 8301–8305, as implemented at 48 C.F.R. Subparts 25.1–25.2; and (2) requires that the recipient not expend Grant funds to purchase a motor vehicle unless the final assembly of that vehicle occurred in the United States.

c. Commitment to provide data and evaluate safety outcomes and effectiveness

RTC commits to providing data, to participate in the evaluation of the safety outcomes of proposed activities, and to note measures of effectiveness in other arenas, such as mobility.

d. Risk identification, mitigation, and management

Successful risk management on advanced technology programs begins with a detailed program management plan (PMP) and skilled program leadership. The RTC will ensure successful execution of the PMP, including ongoing operations. Furthermore, an audit and quality assurance/quality control (QA/QC) team member will support the RTC to ensure fiscal accountability, document control, and quality. Finally, the RTC will use and maintain a schedule management plan with USDOT with frequent reviews to ensure timely delivery of projects and to facilitate schedule recovery.

Table 1-3. Risk Management

Risk category	Risk identification	Risk level	Risk mitigation
User	User contributions to the open-source solution	Low	We will collaborate to select the most appropriate, usable open-source license, protect contributors with contributor license agreements (CLA), verify all licensing before allowing access, and continually test package and code quality.
User	Platform learning curve	Low	We will leverage the technical knowledge of other smart community teams and individuals who have a deep understanding of the data platform and related technologies. Our microservice-based architecture will allow us to quickly learn and identify focus areas.
Technical	Performance of new EmV technologies	Low	Initial Grant phase will comprehensively review and select appropriate prototype development targets.

Table 1-3. Risk Management			
Risk category	**Risk identification**	**Risk level**	**Risk mitigation**
Operational	Low volume of ADS-EmV encounter scenes	Low	If needed, ability to run ADS in manual mode near hospitals to ensure larger volume of encounters.
Schedule/ Costs	Schedule slips	Low	Our team will continually monitor the schedule and budget to minimize cost and time overruns.
Technical	Technical challenges with the RDMP	Med	Our close collaboration with the technical developers of the Columbus OS and its contributors will mitigate the technical risk of migration, setup, and operation.
Schedule	Development of prototype technologies takes 2+ years	Med	Ability to scope prototype technologies and continue into fourth Grant year as needed.

A key feature of this initial risk assessment is the "low" rating of operational risk. This research requires encounters with EmVs to develop the baseline and then testing. While we can orchestrate interactions with EmVs, the availability of random, organic interactions with EmVs can speed up the data collection. This effort builds on the successful and ongoing technology deployment and development efforts of the key stakeholders. Their experience in developing, refining, deploying, and managing technology projects is of great value in proactively addressing risks and ensuring all challenges are overcome without negative impact on the project schedule and budget.

Because of the work already happening in the region, RTC does not anticipate significant regulatory, legislative, or institutional deployment challenges in implementing these technologies. Aptiv has successfully launched a pilot deployment of AVs in a vibrant public street setting, and GoMed will provide transit services on public streets in the medical district.

Public perception of ADS capabilities

The public still has skepticism about the safety and capabilities of AVs requiring pilot demonstrations showcase successful and safe operation. RTC has actively improved perception of ADS within the region. A recent AAA survey found 96% of Las Vegas's ADS shuttle riders would recommend the experience to their friends, and riders of the ADS shuttle showed a greater than 25% improvement in ADS sentiment score. Ongoing engagement with the public on this research and AVs is critical to long-term comfort with the technology. Meetings with the public will be scheduled throughout the program to continue the foundations laid by the other work being done in the region.

e. Approach to contribute and manage Non-Federal resource (cost share)

The total program funding for NAVIGaTE is $13,680,000 with the ADS Grant request in the amount of $8,892,000. The RTC non-federal cost share is $4,788,0000 or 35% of the total cost. Additional details can be found in Part 6.