2019

Accessible Automated Vehicle Demonstrations

USDOT Automated Driving System Demonstration Grant

SANTA CLARA VALLEY TRANSPORTATION AUTHORITY (VTA)

MARCH 21, 2019

PART 1, PROJECT NARRATIVE AND TECHNICAL APPROACH

Part 1. Project Narrative and Technical Approach

1.A. Introduction

Cover Letter

March 19, 2019

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

Subject: Cover Letter, Part 1: Project Narrative and Technical Approach for Santa Clara VTA Accessible Automated Vehicle Demonstrations

Dear Ms. Tarpgaard,

This important and innovative set of demonstrations, as part of a joint proposal led by Santa Clara Valley Transportation Authority (VTA) and supported by the Veterans Administration Palo Alto Health Care System (VAPAHCS), Prospect Silicon Valley, UC Berkeley, California Department of Transportation (Caltrans), and other partners, will yield an essential demonstration of safe, automated transit services and address a critical need to improve accessibility for all.

In our conversations with paratransit and VA clients and in our operational experience, vehicles and services more tailored to accessible mobility needs and time tables would provide expanded freedom to disabled and senior customers. We believe that smaller, 6 to 12 passenger, automated, accessible, zero emissions vehicles, operating on-demand along semi-fixed routes, will provide our customers with greater flexibility and better service. This will in turn increase our paratransit customer satisfaction, improve access to jobs and transit, and increase our core ridership.

Following the VTA Strategic Plan, we are fostering creativity by encouraging the automotive industry to develop automated, accessible solutions to serve a public need. VTA, with the support of its partners, is taking a leadership role in developing requirements and coordinating with automated vehicle developers, accessibility researchers, and accessible vehicle equipment providers to demonstrate Level 4 Automated Accessible Vehicles (AAVs).

Demonstration 1: Accessible Automated Vehicles AAV
The first demonstration is to provide automated accessible transportation services in the Cities of Palo Alto and Mountain View, California for veterans, their families, and VA staff. The AAVs would serve the VAPAHCS hospital campus, Stanford Medical Center in Palo Alto, the Palo Alto Transit Center, and the Mountain View Transit Center, and multiple stops in downtown Palo Alto including along the Caltrans Connected Vehicle Corridor along El Camino Real (State Route 82). Most veterans and staff live outside the Palo Alto and Mountain View area and are coming from underserved areas of the San Francisco Bay Area. Along with the high cost of housing and significant roadway congestion in the region, we lack affordable, convenient, accessible last-mile solutions.

The AAV demonstration project is subdivided into Phases 1 through 4. Phase 1 is funded through the regional Metropolitan Transportation Commission (MTC) using FHWA grant funds, VTA match and Prospect SV in-kind match to research technology options, engage industry through a Request for Information to identify automated vehicle developers and accessibility solution providers, and to build a first-generation AAV that will be tested at Prospect Silicon Valley in a controlled setting. Phase 2 is also funded through the FHWA grant and VTA Match to perform a limited demonstration at the VAPAHCS hospital campus with a select group of staff and patients. At this time VTA and ProspectSV have issued a Request for Information (RFI) around developing the AAV and Phase 1 and 2 operation. VTA received 17 proposals in February 2019. The evaluation team is working with the respondents in selecting the optimum and best-case solutions. Phase 3, to be funded through the ADS grant program, would enable us to enhance and build additional AAVs with industry partners that have expanded customer interaction and use an end-to-end trip management system. We would instrument these vehicles to provide near-real time data to USDOT and test them in operation at the VAPAHCS hospital. Phase 4, also to be funded through this request, would expand passenger-carrying operations of the fleet to the additional off-campus locations listed above. VTA and Prospect Silicon Valley will lead the AAV demonstration.

Demonstration 2: Safety Data Management and Assessment
The second proposed demonstration is focused on collecting additional road-based safety data over a broader geographic area using a specially-equipped Level 3/4 vehicle operated by Valeo North America Inc. Valeo will operate its vehicles across VTA's service area in Santa Clara County, including in the Demonstration 1 service area.

The second demonstration project consists of five tasks. Task 1 is Experimental Design and DSRC-based transit signal priority for the AAVs and Level 3/4 vehicles along El Camino Real (SR 82); Task 2 is data acquisition system selection, installation and verification, and propose and implement scenarios for evaluating safety of connected vs non-connected AVs; Task 3 is data collection, storage, and management; Task 4 is data analysis and performance assessment; and Task 5 is reporting and recommendations. UC Berkeley PATH will lead this demonstration and also perform all data collection tasks for the first AAV demonstration Phases 3 and 4.

Budget Overview
VTA will have overall grant management and project management responsibility, with detailed project coordination duties being assigned to Demonstration 1 with ProspectSV and Demonstration 2, UC Berkeley.

Demonstration 1 Phases 1 and 2 are already funded with a combination of FHWA funds totaling $845,000, and $413,000 in match and in-kind contributions for a total project budget of $1,258,000.

This request is to fund both Demonstration 1 AAV Phases 3 and 4 and Demonstration 2 Safety Data Management and Assessment. The following numbers highlight the total project budget and how the funding would break down and be applied to the two demonstrations:
US DOT request $6,930,461 Match and in-kind $1,312,134 Total project budget $8,242,594

Demonstration 1: Accessible Automated Vehicles Budget
US DOT funding $4,699,205 Match & in-kind $825,064 Total Demo 1 $5,354,000

Demonstration 2: Safety Data Management and Assessment Budget
US DOT funding $2,294,749 Match & in-kind $423,577 Total Demo 2 $2,718,326

Conclusion:
VTA is a unique organization. We have wide-ranging authority across Santa Clara County, including transit development and operations, congestion management, regional funding, highway design and construction, real estate and transit-oriented development, and bicycle and pedestrian planning. As a truly multimodal transportation agency we have the initiative, motivation, and experience to undertake this essential work. Supported by the VAPAHCS, Prospect Silicon Valley, UC Berkeley, Valeo North America Inc., Caltrans, and our local host cities, we bring an exceptionally strong team to tackle a challenge we have already started to address providing accessible, automated mobility for all. With the ADS Demonstration Grant, we look forward to producing innovative, transferable, and implementable solutions that can be applied across the United States. The team has the technical expertise, demonstrated experience, and organizational network to effectively advance the tasks demanded for the proposed demonstration projects to ensure success.

Sincerely,

Nuria I. Fernandez
General Manager and CEO
Santa Clara Valley Transportation Authority

Summary Table

Project Name/Title	**Accessible Automated Vehicle Demonstrations**
Eligible Entity Applying to Receive Federal Funding (Prime Applicant's Legal Name and Address)	Santa Clara Valley Transportation Authority 3331 North First Street, San Jose, CA 95134
Point of Contact (Name/Title; Email; Phone Number)	Gary Miskell, Chief Information and Innovation Officer; Gary.Miskell@vta.org; 408-321-7014
Proposed Location (State(s) and Municipalities) for the Demonstration	Cities of Palo Alto, Mountain View, and San Jose, California
Proposed Technologies for the Demonstration (briefly list)	Accessible Human-Machine Interfaces for Vision, Hearing, Mobility, and Cognitive Disabilities; Level 3/4 Automated Driving and Data Collection; Connected Vehicle Equipment and Infrastructure
Proposed duration of the Demonstration (period of performance)	36 months
Federal Funding Amount Requested	$ 6,930,461
Non-Federal Cost Share Amount Proposed, if applicable	$ 1,312,134
Total Project Cost (Federal Share + Non-Federal Cost Share, if applicable)	$ 8,242,594

Table of Contents

Tables

Figures

1.B. Project Narrative and Technical Approach

1.B.1. Executive Summary

1.B.1.a. Vision, Goals and Objectives

Vision. Santa Clara Valley Transportation Authority (VTA)'s vision is to work with public and private partners to develop the next generation of Accessible Automated Vehicle (AAV)-based mobility solutions to provide a new class of end-to-end transportation for people with disabilities. As the public transit operator for Santa Clara County, California, VTA recognizes that our region, like many others in the United States, lacks public or private mobility services that are simultaneously affordable, convenient, and accessible. Our customers who need accessible services – those with hearing, vision, mobility, and cognitive disabilities, including veterans and the elderly – are disproportionately impacted by expensive, inconvenient, or non-accessible transportation, limiting their access to jobs and activities for daily living – trips that many other Americans are able to take for granted.

VTA believes that AAVs are the key to providing a new paradigm of mobility for our customers. We define the ideal AAV as a highly automated (SAE Level 4), connected, electric, multi-passenger vehicle that can operate on-demand, on fixed or flexible routes, up to high speed in mixed traffic, much as a conventional paratransit vehicle would.

Located in the heart of Silicon Valley, we are in the midst of hundreds of companies developing technologies that can help us achieve our goal. Yet, in the context of intense commercial competition, primary technology development, and product focus, we need to better articulate the value of applying their technology to help solve broader societal issues that we as a community service provider face daily. And many aspects of our envisioned new mobility system need to be better defined and understood. We need practical, advanced demonstrations to generate significant learnings for all stakeholders and to prepare public and private mobility providers to deploy future AAVs across the United States.

Goals. VTA seeks to pursue the following goals:

1. Understand the safety implications of SAE Level 3 and Level 4 Automated Driving System (ADS) capability on urban and suburban streets and arterials in mixed traffic;
2. Understand the potential mid-term and long-term economic implications for transit and paratransit operators related to scaled-up Level 4 AAV operations in terms of capital and operating costs;
3. Understand the energy implications of ADS and in-vehicle edge computing platforms related to electric vehicle drivetrains and charging infrastructure requirements;
4. Demonstrate an end-to-end passenger mobility solution consisting of trip planning, booking, payment, and trip and vehicle tracking for passengers and caregivers, to provide a higher quality service for an underserved population;

5. Demonstrate interoperation of Level 3 and Level 4 ADS and AAV vehicles with Connected Vehicle infrastructure to assess how connected vehicle technology can benefit safe driving, transit signal priority, and congestion management of AVs;
6. Demonstrate safe and efficient management of curb space in various contexts including hospital campuses, urban districts, bus stops, and transit centers;
7. Develop, test, and demonstrate a data analytics platform that can house both public and private data to track impact to road safety, plan for future roadway improvements, and inform public policy; and
8. Transfer the knowledge gained from the demonstrations to inform new and ongoing activities to advance the deployment of AAVs into service across the United States.

Objectives. VTA will accomplish the following objectives:

- Leverage Federal Transit Administration grant funding awarded through the Metropolitan Transportation Commission to develop the first prototype AAV for testing at Prospect Silicon Valley and the Veterans Administration Palo Alto Health Care System (VAPAHCS) hospital campus;
- Develop, test, and demonstrate several Automated Accessible Vehicles (AAVs) that are highly automated (Level 4), connected, electric, and shared and can operate at moderate speeds (35-45 mph) that are designed to serve people with hearing, vision, mobility, and/or cognitive disabilities by deploying accessibility equipment and software systems in the vehicles;
- Deploy a last-mile, on-demand, semi-fixed route mobility service using the AAVs to connect the VAPAHCS hospital campus with other community destinations, including the Stanford Medical Center, downtown Palo Alto, and to connect to two major transit centers;
- Outfit the AAVs and additional vehicles to collect vehicle dynamics and interactions with other road users, including Vulnerable Road Users;
- Apply an operation, equipment, and staffing plan and track the use of all equipment and staff against the plan to identify implications for future AAV operations;
- Integrate an end-to-end passenger mobility solution consisting of trip planning, booking, payment, trip and vehicle tracking for passengers and caregivers, and localized wayfinding in combination with the AAV demonstration;
- Deploy vehicles outfitted with DSRC communications equipment to communicate with the Caltrans SR-82 Connected Vehicle Testbed to assess how connected vehicle technology can benefit safe driving, transit signal priority, and congestion management of AVs;
- Test curb management of AAVs at the VAPAHCS, Stanford Medical Center, downtown Palo Alto, bus stops along El Camino Real, and at the Palo Alto and Mountain View transit centers;
- Create a data analytics platform that can house both public and private data to track impact to road safety, plan for future roadway improvements, and inform public policy; and

- Produce a comprehensive knowledge transfer program to disseminate data and lessons learned in relevant local and national forums.

1.B.1.b. Key Partners, Stakeholders, Team Members, and Other Participants

VTA has assembled a wide range of partners, stakeholders, team members, and other participants to ensure that the Accessible Automated Vehicle Demonstrations address our project goals holistically, including the broad sharing of knowledge gained through the demonstrations.

Project Lead

- VTA – oversee the development of the AAV; identification of field support resources for the L4 AAVs in the field; vehicle tracking and support software; field support work plan and route instructions; customer support instructions; emergency response management; Control Center operations; define operating model for transit/cities/AV service providers;

Key Partners

- Veterans Administration VA Palo Alto Health Care System (VAPAHCS) – host campus for early AAV deployment; will recruit and engage user test population; will facilitate testing of accessibility-focused applications;
- Prospect Silicon Valley – task management and coordination, technology identification, unit test site host and knowledge transfer partner;
- UC Berkeley Partners for Advanced Transportation Technology (PATH) – Data management plan and platform; AV safety assessment; integration of AVs with DSRC infrastructure;
- California Department of Transportation (Caltrans) – owns and maintains the Connected Vehicle Testbed along SR-82 (El Camino Real) in Palo Alto; investing in the expansion of the Testbed to include more intersections equipped with DSRC communications equipment;
- Valeo North America, Inc. – will collect safety data and interact with the Connected Vehicle Testbed in the cities of Palo Alto and Mountain View, using a Level 4 vehicle operated by Valeo;

Stakeholders

- Metropolitan Transportation Commission – the Bay Area region's Metropolitan Planning Organization, manages grants including the AAV Phase 1-2 grant;
- City of Palo Alto – host city for AAV Phase 4 operations;
- City of Mountain View – host city for AAV Phase 4 operations;
- Peninsula Corridor Joint Powers Board (Caltrain) – host commuter rail operator for AAV Phase 4 transit station interaction and curb management investigation;

- Stanford University / Stanford Medical Center – host campus for AAV Phase 4 operations;
- Disabled American Veterans
- Disability Rights Education and Defense Fund (DREDF)
- United Spinal association
- Paralyzed Veterans of America
- National Federation of the Blind
- AAPD American Association of People with Disabilities

Team Members

- LG Electronics America R&D Center – will make available their ADS simulator to support safety assessment and HMI technology for AAV in-vehicle HMI accessibility;
- Mineta Transportation Institute – will develop ADA policy analysis and guidance based on user-centric AAV experiments and demonstrations;

Other Participants

- Intel Corporation – the Intel R&D team will support VTA's additional research using VTA's Intel Mobileye AV technology;
- UC Santa Cruz / IBM – will test Bluetooth iBeacon-based pedestrian wayfinding system at VAPAHCS;
- Vehicle manufacturer – candidates identified, to be procured through AAV Phase 1-2 process;
- AAV ADS hardware and software supplier – candidates identified, to be procured through AAV Phase 1-2 process;
- AAV service operator – candidates identified, to be procured through AAV Phase 1-2 process;
- Curbside management solution – candidates identified, to be procured through ADS grant follow-up process;
- TSP provider – candidates identified, to be procured through ADS grant follow-up process;
- End-to-end trip planning / booking / payment software – candidates identified, to be procured through ADS grant follow-up process;
- Communications equipment (vehicle) (DSRC/cellular) – candidates to be identified and procured through ADS grant follow-up process;
- Communications equipment (infrastructure) (DSRC/cellular) – to be procured separately by Caltrans.

1.B.1.c. Issues and Challenges to be Addressed

VTA seeks to develop and deploy prototype AAVs that simultaneously addresses two primary issues. Each of these topics is substantial and has many challenges, yet to fully realize VTA's vision, both major issues need to be addressed together in the same vehicle system.

1. The AAV needs to have Level 4 ADS capability in order to safely navigate on city streets in mixed traffic, at moderately high speeds (at least 35 mph). AAVs need to be able to operate safely with all other road users, including other vehicles, cyclists, and pedestrians. Further, in public transit operation, the AAV needs to interact safely with passengers at each stop location. Issues include:
    a. The readiness of driving algorithms to operate safely in mixed traffic;
    b. The economic implications for transit and paratransit operators;
    c. The energy implications of ADS and in-vehicle edge computing platforms related to electric vehicle drivetrains and charging infrastructure;
    d. The benefits of Connected Vehicle infrastructure for the AAV use case;
    e. The interaction and management of curb space for AAVs;
    f. Data analytics platforms that can track impact to road safety, plan for future roadway improvements, and inform public policy;
2. The AAV must be designed to be accessible by passengers with vison, hearing, mobility, and/or cognitive disabilities. This includes a vehicle form factor that accommodates wheelchairs, as well as Human-Machine Interface equipment and software systems to recognize passenger disabilities and offer appropriate adaptations, for example automatically deploying a ramp for a person in a wheelchair, speaking to someone who is blind, or providing visual cues to a deaf passenger. End-to-end trip management is essential for some passengers and caregivers to ensure that trips are completed safely. A comprehensive system like this does not yet exist and we seek to leverage ATTRI program research and work with industry to field a demonstration system.

1.B.1.d. Geographic Area or Jurisdiction of Demonstration

The various demonstrations will occur throughout VTA's service area in Santa Clara County, as follows:

Demonstration 1: Accessible Automated Vehicles

- Testing at Prospect Silicon Valley, 1608 Las Plumas Ave, San Jose, CA 95133.
- Testing and demonstration on VAPAHCS Hospital Campus, 3801 Miranda Ave, Palo Alto, CA 94304. This campus offers a complete on-site loop road system, surface and structured parking, and multiple hospital and support buildings.

Figure 1: VAPAHCS Hospital

- Testing and demonstration on city streets in Palo Alto, connecting from the VAPAHCS Hospital Campus to the following destinations:
    - Stanford Medical Center,
    - Caltrain Palo Alto Station, 95 University Ave, Palo Alto, CA 94301
    - Caltrain California Ave Station, 101 California Ave, Palo Alto, CA 94306
    - Bus stops along SR-82 El Camino Real in Palo Alto, connecting to VTA bus lines 22 and 522 (Rapid), along the Caltrans Connected Vehicle Testbed
- Testing and demonstration on city streets in Mountain View, connecting to the Mountain View Transit Center, including Caltrain, VTA Light Rail line 902, and 34, 35, 52 bus lines; 600 W Evelyn Ave, Mountain View, CA 94041

Figure 2: Mountain View Transit Center, with shuttles, buses, light rail, and Caltrain commuter rail services.

Demonstration 2: Safety Data Management and Assessment:

- In addition to safety data collection by the AAVs, data collection will be performed by partner Valeo within VTA's service area in Santa Clara County, including but not limited to the Connected Vehicle Testbed located along El Camino Real (SR-82).

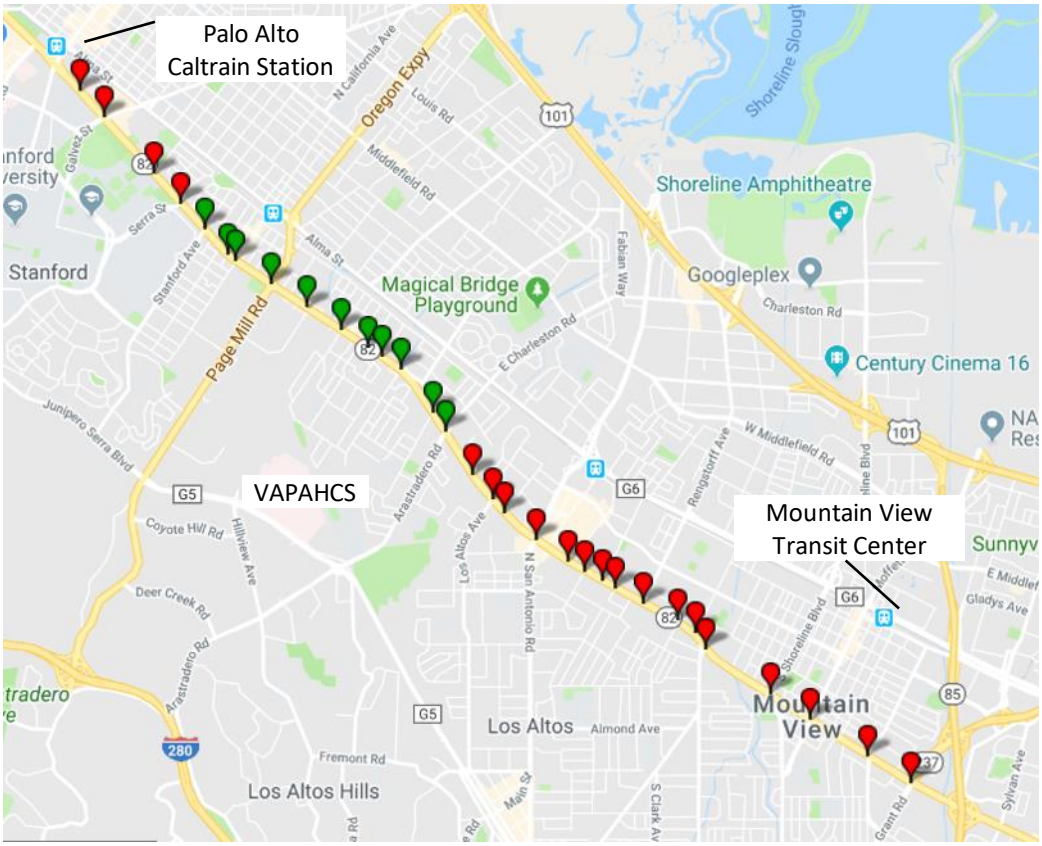

Figure 3: Demonstration Locations Including Caltrans Connected Vehicle Testbed (current intersections in green, planned in red)

1.B.1.e. Proposed Period of Performance

The proposed period of performance is 3 years duration starting October 1, 2019 and ending September 30, 2022.

1.B.2. Goals

Describe how your proposed demonstration aligns with and/or satisfies the Goals contained in NOFO Section A:

1.B.2.a. Safety

As a transit and paratransit operator, safety is paramount for VTA. VTA is entrusted with the safe operation of its vehicles on roadways, as well as safe mobility services for its passengers. The proposed project will demonstrate a staged approach to the safe operation of transit-focused Level 4 AAVs on public streets as we start with testing focused on geographically limited sites (Prospect Silicon Valley and VAPAHCS) and progress to increasingly complex contexts. The various contexts to be tested and demonstrated include:

- Campus circulation in parking lots and low-speed access roads;
- Travel along several defined local residential and commercial streets in mixed traffic;
- Travel along two moderate-speed arterial corridors in mixed traffic;
- Navigation within two transit centers with bus traffic; and
- Curbside pick-up and drop-off at designated stops in campuses, bus stops, and transit centers.

Our initial ADS operations will include a mix of safety drivers/attendants on board vehicles as well as remote monitoring operators who can manage vehicle operations in real time and intervene if necessary.

Of equal importance in this demonstration is the focus on passenger safety, especially for passengers with disabilities. Our AAV demonstration is user-centric and includes many applications envisioned to ensure passenger safety, including end-to-end passenger trip management, a focus on safe curbside interaction, human-machine on-board interaction, and localized wayfinding using iBeacon technology.

1.B.2.b. Data for Safety Analysis and Rulemaking

The proposed project will provide rich data sets from automated vehicles and the infrastructure that will be shared and used in safety analysis and to inform USDOT AV policy and rulemaking. To maximize the quality of data to be captured, our team will adopt several approaches that are unique and comprehensive.

First, we will ensure the diversity of the operational conditions from the following aspects:

- Diversity in driving environment; where we include ample daily data in urban setting, congested and free-flow, local streets, arterial and freeway driving environment;

- Diversity in vehicle operation; for example, a mix of paratransit AVs and personal-use AVs;
- Diversified selection in high-risk cases; where ADS interact with regular traffic and other road users frequently; and
- Diversity in time of the day, weather and lighting conditions.

Secondly, due to the relatively small number of vehicles involved in the proposed demonstration and in order to investigate the distribution and intensity of intended vehicle interaction scenarios, we plan to select a set of strategic locations for data collection. These locations will include intersections, junctions, passenger pickup and drop-off areas, and the Connected Vehicle Testbed corridor along El Camino Real in Palo Alto. These strategic locations offer the most dynamic and challenging operational scenarios and conditions that will provide the most valuable data sets.

Thirdly, the VTA team will work with all project partners to establish a database structure and schema that will support a robust operational safety analysis. The data elements chosen for capture will be based on the safety metrics identified in our technical approach section below. Our Data Management Plan presents a more detailed description of data elements that we expect to capture and deliver in this project and our approaches to data access and data storage. In short, we will ensure the quality of data and address the challenges and risks associated with maintaining the database; providing smooth and robust data downloading, storage, and archiving processes; protecting the privacy of data; and facilitate reliable and robust access to the database.

1.B.2.c. Collaboration

VTA is taking a leadership role in the public transit industry to develop the technical requirements for an Accessible Automated Vehicle, with the goal of developing a vehicle prototype that is capable of performing service in public and private environments. We identified a need for better AAV-type solutions in 2016 and since then have closely engaged our passenger customers, civic partners in our service area, human services partners, and advocacy stakeholders to help us create a demonstration that will serve a significant population with underserved needs. More recently, in preparation for implementing our locally-awarded grant project, we engaged more than 140 technology developers representing ADS, human-machine interface, and vehicle manufacturers through a Request for Information and received 17 responses to date. Our team of core partners is also diverse, consisting of our local Veterans Administration hospital; Prospect Silicon Valley, a technology-oriented non-profit organization; UC Berkeley PATH, a premier ADS academic institution; and Caltrans, our state department of transportation who has been very active in supporting and creating ADS and Connected Vehicle applications.

1.B.3. Focus Areas

Describe how your proposed demonstration aligns with and/or satisfies the Focus Areas contained in NOFO Section A:

1.B.3.a. Significant Public Benefits

VTA is proposing a significant, larger-scale project that will result in substantial benefit to the public, particularly to our focus demographic of people with hearing, vision, mobility, and cognitive disabilities. The proportion of the population with disabilities is growing, as a greater proportion of the U.S. population is aging. The development of an AAV that can augment or replace paratransit vehicles, and/or augment fixed-route service particularly in lower-density suburban areas, will allow public and private transit operators to provide more convenient and cost-effective service and improve access to fixed-route transit.

1.B.3.b. Addressing Market Failure and Other Compelling Public Needs

Located in the heart of Silicon Valley, we are in the midst of hundreds of companies developing technologies that can help us achieve our goal. However, there is intense pressure and competition for companies to be first to market, first to scale, to raise capital to fund their next stage of growth. Therefore, technology development and product development are key. In the automated mobility space, companies are targeting personally owned automobiles as the primary target market. Mobility for people with disabilities is considered by industry to be a niche market with magnitudes less market potential. While some companies have expressed interest and support in the topic, it is generally not at the forefront of industry technology roadmaps. As characterized in the NOFO, we consider this to be a profound failure of the market. The proposed AAV development will provide a strong mechanism and incentive to encourage many facets of the technology and mobility industry to join forces to create user-centric vehicle and software systems to provide new mobility solutions for our target market.

1.B.3.c. Economic Vitality

VTA supports the development of domestic industry and domestic Intellectual Property that can be applied to solve the needs we have identified and that are scalable across the country. VTA has taken care to choose partners with significant economic and financial interests focused on the U.S. As AAVs eventually scale across the U.S., transport operators will need to tap into a well-developed industry that can supply the necessary equipment, systems, and services. This new mobility industry reaches beyond the traditional transit industry to include new safety, mobility, human interface, and end-to-end management technologies. VTA is committed to working with industry to develop these new capabilities or help apply existing technology toward new use cases. Already, we are engaging varied industry segments and academic disciplines to collaborate toward the development of AAVs and supporting technologies.

1.B.3.d. Complexity of Technology

The focus of our proposed demonstration projects is on developing a Level 4 Accessible Automated Vehicle. This is a very complex undertaking, as it involves not only integration with ADS hardware and software, vehicles, V2X communications, and electric powertrain, but also the human services side with end-to-end trip management, human-machine interfaces that can adapt and serve people with disabilities, and a high level of care at curbside interactions. VTA believes that we have packaged an extraordinary combination of technologies necessary to field vehicles, even if only in demonstration form, that can serve our defined use case properly. Further, we are augmenting our road- and vehicle-based data collection and management with Level 3/4 vehicle fleets deployed elsewhere in VTA's service area. Our team, including our primary academic partner UC Berkeley PATH and our primary organizational partner Prospect Silicon Valley, bring expertise needed to help manage the plethora of data that will be collected and the technology integration required.

1.B.3.e. Diversity of Projects

With our proposed AAV demonstration project, VTA aims to address the needs of U.S. suburban communities who need to serve a growing population of people with disabilities who have a need for personalized public transportation. The community context we propose to serve is broadly applicable across the United States: suburban land use form with low to moderate density, ranging from residential single-family areas to retail, office, and industrial commercial areas to suburban downtowns; traversing a wide range of roadway types and operating speeds; across a range of jurisdictions including cities and county governments, state DOT, multiple transit agencies, federal (Veterans Administration). Further, we believe that we provide a strong framework for integrating a wide range of technology applications to focus on serving people with disabilities.

1.B.3.f. Transportation-challenged Populations

Our proposal to develop and demonstrate Accessible Automated Vehicles directly addresses the need to serve transportation-challenged populations, specifically people with hearing, vision, mobility, and cognitive disabilities. We propose to bring together many facets of industry to create and demonstrate these AAVs, which would be safe, user-centric, accessible, electric, connected, shared mobility vehicle and software solutions to serve our target population.

While our desired capabilities may seem ambitious, we are not starting from scratch. VTA has leveraged a regionally-administered grant to conduct a Request for Information that has generated 17 proposals offering vehicle platforms, Level 4 automated driving, operations and maintenance, HMI technology, and trip reservation software.

The ADS grant would help us develop a set of AAV vehicle with enhanced accessibility capability (the additional budget would allow for enhanced HMI system capability and integration) as well

as better understand safe automated driving, connected vehicle applications, curbside management and vehicle-passenger curbside interaction, and end-to-end trip management.

1.B.3.g. Prototypes

VTA is primarily proposing the use of pre-commercial equipment and software, and appreciates USDOT's flexibility. VTA will employ a comprehensive testing plan developed by industry experts to help safeguard that all fielded vehicles, equipment, and software are safe, including the use of remote monitoring and safety on-board attendants as necessary. All our primary industry partners are reputable, credible, companies with track records (and reputations). We have a process in place to vet startups and new technologies and will work with USDOT to continually monitor the performance of new systems. We have not yet selected a specific vehicle platform or vehicle type, as our RFI uncovered multiple options, including those that do and don't require exemptions.

1.B.4. Requirements

Describe how your proposed demonstration satisfies the Requirements contained in NOFO Section A:

1.B.4.a. Each demonstration must focus on the research and development of automation and ADS technology (per the SAE definitions), with a preference for demonstrating L3 or greater automation technologies.

VTA's proposed demonstrations focus on the research and development of ADS technology Level 3 and Level 4. Demonstration 1, involving our proposed AAVs, is ambitious. We aim to demonstrate the combination of Level 4 ADS safe driving technology along with automated, accessible, human-machine interface systems and equipment. This will require significant research and development along with our partners. We have also proposed a Level 3/4 demonstration, Demonstration 2, to help collect additional ADS and road safety data, which will add to the overall data pool requested by USDOT.

1.B.4.b. Each demonstration must include a physical demonstration.

Both proposed demonstrations will be physical demonstrations involving Level 3 and Level 4 vehicles in the cities of Palo Alto and Mountain View, California. Our Level 3/4 demonstration (Demonstration 2) will be used to collect data on city streets in and around the area to be used for our Level 4 demonstration (Demonstration 1). Demonstration 1 AAVs will be deployed at the VAPAHCS hospital campus and then on city streets in mixed traffic, connecting to community destinations including other medical centers, downtown Palo Alto, and two major transit stations.

1.B.4.c. Each demonstration must include the gathering and sharing of all relevant and required data with the USDOT throughout the project, in near real time. The Recipient must

ensure the appropriate data are accessible to USDOT and/or the public for a minimum of five years after the award period of performance expires.

As explained in our Data Management Plan, the VTA team expects to collect several categories of data:

1. Raw data and processed variables of data sets on test vehicles;
2. Vehicle-based raw data from additionally installed DAS, beyond those that are available from the ADS platform;
3. Infrastructure-based data including but not limited to SPaT and map data;
4. External data sources, such as weather and traffic data, that are relevant to the assessment of test conditions and should be captured for the evaluation of test results;
5. Trip summaries for test vehicles;
6. Data log, including data quality measures and data history, such as periods of recording, incidents of data missing, video and image issues, etc.

Our team expects that all data elements will be made accessible, after working with USDOT to protect privacy and distill the raw data down to those that are useful for the assessment of safety performance as the primary goal of this project. Due to the large amounts of data to be collected and shared, our team plans to capture daily downloads of vehicle data and share them with USDOT. Additionally, our team intends to make the appropriate data accessible to USDOT according to the terms of the NOFO.

1.B.4.d. Each demonstration must include input/output user interfaces on the ADS and related applications that are accessible and allow users with varied abilities to input a new destination or communicate route information and to access information generated by the ADS.

VTA embraces the Universal Design principles for application in our Accessible Automated Vehicle demonstration. The AAVs will be especially designed to incorporate Human-Machine Interface systems and equipment to be accessible to passengers with hearing, vision, mobility, and cognitive disabilities. The demonstration will include an end-to-end trip management system, smart kiosks at stop locations, and on-board HMI systems for communication.

1.B.4.e. Each demonstration must address how the demonstration can be scaled to be applicable across the Nation to similar types of road environments, and include an outreach task to share demonstration status, results, and lessons learned with other jurisdictions and the public, in furtherance of technical exchange and knowledge transfer.

VTA is committed to sharing our experience widely, not just with our many partners and stakeholders, but also nationally to aid our fellow transit agencies and their many stakeholders to make AAVs a reality across the United States. With the aid of Prospect Silicon Valley, which is highly experienced in engaging industry to gain and share knowledge, we have proposed

numerous knowledge transfer activities including a workshop series to match the breadth of topics we are addressing through the demonstrations. Additionally, we look forward to providing updates and continuing our learning at conferences and industry gatherings, including those put on by USDOT specifically for the ADS program.

1.B.5. Approach

1.B.5.a. Technical Approach

VTA proposes two demonstration projects to meet its vision, goals, and objectives. Demonstration 1 is focused on developing, testing, and deploying several L4 Accessible Automated Vehicles on city streets in mixed traffic. Demonstration 2 is focused on collecting ADS data and assessing safety of the AAVs as well as from additional L3/L4 partner vehicles.

Demonstration 1 Approach: Accessible Automated Vehicles

The AAV demonstration project is subdivided into Phases 1 through 4. Phase 1 is funded through a regional Metropolitan Transportation Commission (MTC) grant to research technology options, engage industry through a Request for Information to identify automated vehicle developers and accessibility solution providers, and to build a first-generation AAV that will be tested at Prospect Silicon Valley in a controlled setting. Phase 2 is also funded through the MTC grant to perform a limited demonstration at the VAPAHCS hospital campus with a select group of staff and patients. Phase 3, to be funded through the ADS grant program, would enable us to enhance and build additional AAVs with industry partners that have expanded customer interaction and use an end-to-end trip management system. We would instrument these vehicles to provide near-real time data to USDOT and test them in operation at the VAPAHCS hospital (see activities in Demonstration 2 below that will be applied to the AAV fleet). Phase 4, also to be funded through this request, would expand passenger-carrying operations of the fleet to the additional off-campus locations listed above. VTA and Prospect Silicon Valley will lead the AAV demonstration.

Demonstration 1, Phases 1 and 2 Activities

VTA began Phase 1 in summer 2018 with market outreach to identify and talk to potential suppliers of ADS technology, HMI accessibility technology, and accessible vehicle manufacturers. Subsequently, VTA with the assistance of Prospect Silicon Valley refined its Phase 1 / Phase 2 AAV concept and developed a Request for Information detailing desired functionality. VTA distributed the RFI via its website and direct notification to more than 140 recipients, and held a Question and Answer session that generated more than 30 insightful questions that VTA answered. VTA, Prospect Silicon Valley, and MTC are currently reviewing the 17 RFI responses received to date. The RFI responses collectively span all of the desired functionality. Next steps include engaging responders with follow-up conversations, creating partnering opportunities, and eventually, selection of partners to provide the various vehicular, ADS, accessible, and other software systems to create a first-generation prototype AAV.

Prospect Silicon Valley, working with VTA, will work with the identified suppliers to test the prototype AAV at the Prospect Silicon Valley site to validate basic ADS functions as well as accessibility functionality. Prospect Silicon Valley will coordinate user testing with VAPAHCS, San Jose State University, the Mineta Transportation Institute, and community-based accessibility stakeholder groups. Mineta Transportation Institute will begin documenting, through conversations with the stakeholder groups, more specific feedback about accessibility functionality and compare the feedback with current ADA guidelines for transit vehicles.

Upon validation of the AAV at Prospect Silicon Valley, VTA will move the AAV to the VAPAHCS hospital campus for further development and testing. VTA and Prospect Silicon Valley will work with the VAPAHCS staff and research team to identify stops and routes on campus, and work with the vehicle operator to localize the AAV for automated driving on the campus. VAPAHCS will supply a participant pool of patients and staff who will test the AAV during the demonstration period and provide additional feedback on accessibility functionality through surveys, interviews, and focus groups. Prospect Silicon Valley will synthesize the user experience feedback and report back to vehicle provider(s) to inform future phases and iterations of AAV development.

Demonstration 1, Phase 3 and 4 Approach

VTA will utilize any awarded ADS grant funds to commence Phase 3 of the AAV demonstration. This includes increasing the number of AAVs, enhancing their capability beyond the initial prototype developed in Phases 1 and 2, integration of data collection capability with the UC Berkeley/USDOT defined system, testing and deploying the enhanced AAVs at the VAPHCS, and initial investigation and development of additional topics necessary for the safe and efficient deployment of the AAVs onto city streets. Phase 4 of the AAV demonstration will involve expanding operations onto city streets and service to local destinations.

Phase 3: AAV Expansion, Enhancement, and User Testing

- VTA will procure additional AAVs to a total fleet of 3-5 vehicles, in order to provide desired service between the various community destinations identified;
- VTA will procure additional HMI accessibility equipment and software systems and work with partners to enhance the accessibility functionality of the AAVs;
    - Specific technologies are currently being reviewed during Phase 1;
    - The ideal accessibility functionality is envisioned to include:
        - Be able to recognize and anticipate passenger needs and disabilities and customize interactions accordingly
        - Navigation assistance to pick up point/stop identification
        - Vehicle arrival announcements/warnings of approach
        - Guidance with boarding and finding a seat/space onboard
        - Wheelchair securement, if needed (prefer non-assisted securement)
        - Customized en route information, announcements, interaction, in multiple languages

    - Deboarding guidance and assistance
    - Navigation assistance to final destination, and/or notification to caregiver of arrival
    - Facial recognition (ability to confirm identity of person boarding and adjust interactions with the customer according to their profile)
    - Care giver / monitoring option
- Prospect Silicon Valley will assist VTA with procuring and working with industry to develop an end-to-end passenger trip management system for integration with the AAVs; this may be a single web/mobile-based solution or it may need to be a deep-linked solution involving multiple integrated applications for multimodal trip planning, routing, and payment;
- Prospect Silicon Valley will help VTA formalize its User Experience Working Group to engage representatives from stakeholder organizations representing the interests of transportation-challenged populations, such as the National Aging and Disability Transportation Center (NADTC), Disabled American Veterans, and National Federation for the Blind, etc. for the purpose of generating localized project guidance, feedback, and advice and recruiting participants for static testing;
- Prospect Silicon Valley will coordinate static user testing of accessibility features at the Prospect Silicon Valley site by the User Experience Working Group stakeholder groups;
- Prospect Silicon Valley will coordinate testing of accessibility features with patients and staff at the VAPAHCS hospital campus;
- Prospect Silicon Valley will convene an Industry Technical Advisory Group, including private sector representatives who are in the advanced mobility industry, ranging from large corporations to startups, who are not participating on the project team but have insights to share regarding innovations in the market, technical feasibility, and other implementation issues;
- UC Berkeley PATH will establish the data collection and safety assessment system, and will coordinate the sharing of data from the AAV ADS provider to the data collection system (see below under Demonstration 2);

Phase 3: AAV Site Preparation

- Prospect Silicon Valley will coordinate with partners/stakeholders to define specific community stop locations in the Stanford Medical Center, downtown Palo Alto, El Camino Real, Palo Alto Caltrain station, and Mountain View Transit Center;
- VTA, working with Prospect Silicon Valley and the host cities, will develop routes to connect the community stop locations;
- VTA will develop a field support work plan for the expansion of service to include community stop locations and routes;
- Prospect Silicon Valley will coordinate with UC Santa Cruz to investigate application of their iBeacon-based wayfinding technology to specific stop locations to facilitate curbside identification and passenger-vehicle interaction;

- Prospect Silicon Valley will coordinate AAV electric vehicle infrastructure planning and implementation to allow EV charging to take place as needed at stop locations or along routes;
- Prospect Silicon Valley will convene a Public Agency/Academia Working Group to provide advice on the overall transportation system, traffic management, curbside management, transit ridership and social equity issues expected from an AAV deployment;
    - The group will specifically address procedures and technologies to define and manage vehicular curbside access at stop locations;

Phase 4: Preparation and Operations

- VTA will train control center staff, paratransit call center staff, and customer support staff with specific instructions for the AAV deployment;
- VTA will deploy and evaluate field support resources to service AAVs in the field;
- VTA will develop emergency response procedures for the AAV deployment;
- VTA will integrate the VTA support system with the AAV operator's support system;
- Prospect Silicon Valley will coordinate the demonstration of selected relevant curbside management technologies or systems to be procured through the ADS grant;
- Prospect Silicon Valley will coordinate with UC Berkeley PATH, Caltrans, and Valeo North America Inc. for a study of the integration of connected vehicle equipment and use of the Caltrans Connected Vehicle Testbed corridor to test CV intersection safety applications for vehicles, Vulnerable Road Users, and pedestrians including Demonstration 1 passengers with disabilities;
    - Define software architecture and specification to integrate V2X communication into the Valeo platform;
    - Development of software allowing the Valeo vehicle to communicate with DSRC Roadside Unit (RSU) and to process the data to provide useful additional information to the vehicle perception layer;
    - Modify the decision layer to act on the additional information provided by the infrastructure;
    - Integrate components on Valeo vehicle; and
    - Validate system along El Camino Real (SR 82).

Demonstration 2 Approach: Safety Data Management and Assessment

The second proposed demonstration is focused on collecting road-based safety data over a broader geographic area using a combination of AAVs and additional vehicles. Project partner Valeo North America Inc. will use one of its L3/L4 Automated Driving development platforms, called Drive4U®. Drive4U® vehicle is equipped exclusively with ultrasonic sensors, cameras, laser scanners and radars already series produced by Valeo, and artificial intelligence, giving it a full-fledged digital brain. The technology is able to manage all the information collected by the sensors and learn from the complex scenarios it encounters in the city. The vehicle can already handle a wide variety of driving situations in urban environments, including undivided roads, intersections, traffic lights, tunnels and streets with no markings as well as cyclists and pedestrians.

Figure 4: Valeo Drive 4U

In addition, VTA is actively discussing with Intel Corporation's AV R&D Center in Silicon Valley to leverage the installation this month of more than 200 commercially-procured Intel Mobileye Connect6 ADAS units into VTA's paratransit fleet. All of the new Connect6 hardware is in hand. The VTA team has been discussing potential use of this installation for safety data collection, but cannot commit to a specific integration yet. Demonstration 2 has been designed to provide a robust framework for data collection and assessment and can accommodate the proposed AAV fleet and Valeo L3/4 vehicle as well as additional vehicles.

Demonstration 2 consists of five tasks. Task 1 is Experimental Design and DSRC-based transit signal priority for the AAVs and Level 3/4 vehicles along El Camino Real (SR 82); Task 2 is data acquisition system selection, installation and verification, and propose and implement scenarios for evaluating safety of connected vs non-connected AVs; Task 3 is data collection, storage, and management; Task 4 is data analysis and performance assessment; and Task 5 is Reporting and Recommendations. UC Berkeley PATH will lead this demonstration, working with VTA and Valeo North America Inc. and also perform all data collection tasks for Demonstration 1, Phases 3 and 4 using the approach below. More detailed descriptions of the technical contents for Tasks 1-5 below are provided in Part 3, Data Management Plan. An abbreviated list of items is given here to highlight tasks and sub-tasks.

Task 1: Experimental Design

- Define data requirements and data elements;
- Define relevant measures of performance for assessing interactions of AVs with other road users;
- Define data collection configurations for assessing safety implications of AVs interacting with all other road users (what measurements needed, what data sampling rates, what supplementary sensors beyond those installed on vehicles by their developers);
- Design experiments to assess performance of AVs in protected environment before advancing to general public roads;
- Define experiments and scenarios relevant for this study for evaluating safety of connected vs non-connected AVs; and
- Prepare and seek human subject participation approval from Internal Research Board (IRB).

Task 2: Data acquisition system selection, installation and verification

- Coordinate and implement data acquisition system on demonstration vehicles;
- Develop data acquisition system (or select an available system);
- Install, integrate, and pre-demonstration test data acquisition; and
- Modify data collection if needed, after testing and verification.

Task 3: Data collection, storage, and management

- Select a sub-set of data acquisition for operation monitoring by cellular connection;
- Download daily vehicle-based data collection via physical removal and replacement of hard drives and transfer to data storage system;
- Develop data management system for collected data, archiving it in readily accessible form, and providing access for USDOT and other researchers; and
- Test and verify data collection, storage and management systems.

Task 4: Data Analysis and Performance Assessment

- Process, filter, and screen data;
- Define protocols for logging of incidents and events by onboard operators/chaperones;
- Develop data analytics tools to extract relevant information about vehicle interactions from the massive set of raw data and estimating the measures of performance and matching them up with onboard operator logs;
- Analyze AV performance data, specifically:
    - Identification of hazardous situations - incidents, near misses, violations;
    - Causality analysis of these hazardous situations and their classification;

    - Classification of unusual driving behavior - disengagements, deadlocks, inefficiencies.
- Develop data visualization tools to display relevant information about vehicle interactions; and
- Provide monthly and quarterly summary updates.

Task 5: Reporting and Recommendations

- Provide summary of data collection;
- Provide summary of data management;
- Report analysis of results to define situations that challenges encountered by the AV systems;
- Report how field data experience and performance evaluation reveal necessary ADS enhancements;
- Develop policy recommendations on integration of AVs into road traffic;
- Develop policy suggestions for a city aimed at minimization of hazards and inefficiencies at three levels:
    - Requirements for connected roadside sensing and signals where necessary;
    - Regulation adjustments, e.g. elimination of right turn on red and so forth;
    - Requirements for new street design - Vision Zero design;
- Develop recommendations for future data collection and implications for safety regulations;
- Propose and implement connected vehicle enhancements to improve safety and efficiency of AV operations. For example, implement DSRC-based transit signal priority for the Accessible AVs along El Camino Real (SR 82);
- Propose and implement scenarios for evaluating safety of connected vs non-connected AVs.

Knowledge Transfer

Throughout Demonstration 1 Phases 3 and 4, and Demonstration 2, the VTA team will engage in a broad and comprehensive knowledge transfer effort. Prospect Silicon Valley will lead this task to engage project partners and stakeholders involved in both demonstrations, including the User Experience Working Group, Industry Technical Advisory Group, and Public Agency/Academia Working Group, to ensure adequate distribution of lessons learned and knowledge gathered throughout project planning and implementation.

- Develop reports, white papers, best practice documents such as guides and policy reports, and training materials that documents experience from all project partners and communicate skills and resources learned;
- Organize quarterly knowledge transfer events such as workshops, roundtables, panel discussions, webinars, and presentations focused on relevant topics. Examples of topics may include but are not limited to the following:

- Road data collection system instrumentation and implementation
- Safety assessment set up and results
- Universal design principles applied to AAVs
- User testing of disability equipment and systems
- Integration of HMI equipment into AV vehicles
- Implications for ADA policy
- End-to-end trip management systems industry scan and implementation
- AV passenger interaction at curb side
- AV interaction with Vulnerable Road Users
- Traffic management and connected vehicle equipment and infrastructure
- Impact of AAV demonstration on paratransit convenience and last-mile access to high-quality transit
- Testing protocol and procedures
- Regulatory considerations for site-specific requirements

1.B.5.b. Approach to Address Obstacles

VTA will address obstacles encountered in this project by applying our approach to risk identification, mitigation, and management as described in Section 1.B.5.d below.

1.B.5.b.i. Exemption from Regulations

VTA is not requesting exemption from any of the regulations identified in NOFO Section F, 2. Governing Regulations.

1.B.5.b.ii. Exception to Buy American Act or NOFO Clause Section F, Paragraph 2.J

VTA acknowledges domestic vehicle preferences and is not requesting exceptions to the Buy American Act or NOFO Clause Section F, Paragraph 2.J.

1.B.5.c. Commitment to Data and Evaluation

As described in detail in our technical approach above, our team is fully committed to providing a complete set of safety data that will be used to evaluate the safety of automated vehicles. Some of the safety metrics that we will consider include number and severity of accidents, number of faults in the AV system, number of disengagements, variation of vehicle control, relative distance to other objects and number of emergency stops. In addition, we are committed to evaluating measures of effectiveness in other areas such as mobility (e.g. travel times, delay, throughput) and environmental impacts (e.g. fuel consumption, emissions). Finally, our team is committed to providing policy recommendations for agencies where AVs are deployed. The policy recommendations aim at minimizing safety hazards for all road users and inefficiencies of transportation infrastructure.

1.B.5.d. Approach to Risk Identification, Mitigation, and Management

The VTA team's approach for managing risks for the proposed project follows a methodical process by which the team identifies, scores, and ranks potential risks and their impacts. Every effort will be made to proactively identify risks throughout the project in order to develop and implement mitigation strategies before a risk is realized. A manager will be assigned to each risk at the time the risk is identified, and will have the responsibility of managing the risk throughout its life cycle. For example, one risk for this project might be that an ADS partner is unwilling to share a particular data set that is needed for the safety assessment. In this case, the risk would be assigned to our team's safety data lead (PATH) to manage throughout the term of the project.

The VTA Team will utilize the following basic 5-step process to manage risk:

- Identify the Risk
- Analyze the Risk
- Evaluate or Rank the Risk
- Treat the Risk
- Monitor and Review the Risk

All risks will be recorded and tracked in a risk register. The most likely and highest impact risks will be added to the project schedule to ensure the assigned risk managers take the necessary steps to implement the mitigation strategy at the appropriate time. Risk managers will provide status updates on their assigned risks during the recurring project team meetings, when the meeting includes the risk's planned timeframe.

1.B.5.e. Approach to Contribute Non-Federal Resources

VTA has worked internally and with its partners to secure significant, additional non-Federal resources to support the ADS demonstrations.

Highlighting VTA's commitment to the project, in its FY2020 budget, VTA has authorized $350,000 of VTA non-federal transit funds to contribute directly to this project.

Caltrans has funded the extension and expansion of the Connected Vehicle Testbed along El Camino Real and three years of support cost, totaling $600,000.

Valeo has committed to providing $353,000 in-kind contribution consisting of their vehicle, connectivity equipment, and data recorder and storage equipment.

The AAV vehicle providers have all agreed to provide between 20-50% of their cost as contribution to the demonstration project.