Automated Driving Systems Demonstration Grant Application

Connected and Automated Safety Systems Commons Approach to Decentralized Data Environments (CASSCADDE)

Part 1: Project Narrative and Technical Approach

March 21, 2019

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March 21st, 2019

The Honorable Elaine Chao
Secretary
U.S. Department of Transportation
1200 New Jersey Ave, SE
Washington, DC 20590

Re: Automated Driving System Demonstration Project

Connected and Automated Safety Systems Commons Approach to Decentralized Data Environments (CASSCADDE)

Honorable Secretary Chao:

The City of Austin, in partnership with Capital Metropolitan Transportation Authority and the non-profit IOTA Foundation, are pleased to present this application for funding for the United States Department of Transportation's (USDOT) Automated Driving Systems (ADS) Demonstration discretionary grants program. The City proposes to demonstrate an automated shuttle operating a Level 4 ADS in an urban environment, collect data relevant to the safety of ADS, and collaboratively build and evaluate an Open Data Commons, to be known henceforth as the CASSCADDE Project.

The Project will validate the exchanges of data that can support the safe, secure, efficient and interoperable integration of ADS into our Nation's on-road transportation system. The candidate system architecture, a decentralized open data commons, would potentially accelerate the work of USDOT regarding ADS, including the development of voluntary consensus standards that can support national and global interoperability of ADS.

Austin is also a member of a multi-city USDOT ADS City Cohort that includes Austin, Detroit, Kansas City, Omaha, South Bend, and Washington, D.C. All cities in the Cohort are committed to coordinating project activities, especially around data and sharing. All cities in the Cohort are committed to collaborating on common data terminologies, frameworks, protocols, a community of practice, and most importantly, the development of an Open Data Commons that would be leveraged by all Cohort cities.

Lastly, ADS has the potential to greatly impact the lives of transportation-challenged populations by removing barriers to access. Our approach is inclusive of all ages and all abilities with focused, measurable outcomes for older adults and those with disabilities.

These unique elements to our approach will ensure that a significant and validated set of data is collected and analyzed for the purpose of providing information pertaining to the risks, opportunities, and insights relevant for USDOT safety and rulemaking priorities regarding the integration and operation of ADS in the Nation.

Sincerely,

Robert J. Spillar, P.E.
Director
Austin Transportation Department

Summary Table

Project Name	Connected and Automated Safety Systems Commons Approach to Data Environments (CASSCADDE)
Entity Applying	City of Austin P. O. Box 1088 Austin, Texas 78767
Primary Contact	Jason JonMichael Assistant Director, Smart Mobility Austin Transportation Department D: (512) 974-7028 E: Jason.JonMichael@austintexas.gov
Location(s) of Demonstration	Austin, Texas
Technologies for the Demonstration	Automated driving systems (shuttles) operating in an urban corridor
Duration of Demonstration	Planning: 1 year Demonstration: 3 years Evaluation: 3 years
Total Project Cost	$13,285,300
Non-Federal Match	$6,368,929 (Excludes Capital Expenditures)
ADS Grant Ask	$6,916,371

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Project Narrative and Technical Approach

1. Executive Summary

The City of Austin (CoA) and its local, regional, and national partners present our project vision for the United States Department of Transportation's (USDOT) Automated Driving Systems (ADS) Demonstration discretionary grants program.

The City understands and is in alignment with USDOT's strategic purpose and mission regarding safety of our Nation's on-road transportation system. While automation offers the potential to improve on-road safety and accessibility for all, only anecdotal accounts of safety exist today. Specific to ADS, we believe the objectives and deliverables of our project, Connected and Automated Safety Systems Commons Approach to Data Environments (CASSCADDE), offers our public and private transportation communities of practice the following:

a) Safety – guidance, lessons learned, and reference implementation documentation of the planning, engineering, testing and operations of ADS demonstrations in geographically and technically diverse environs.
b) Data – measurable outcomes through rigorous evaluation that level-set artifacts of anecdotal accounts of ADS safety within the marketplace; analyze the risks, opportunities and insights relevant for future rulemaking; and demonstrate innovative scalable systems architectures that are open and decentralized with the highest capabilities of securing data, by providing a digital commons approach to data.
c) Collaboration and Scaling – commitment to openly develop and share the intellectual property delivered as part of this project, including an additional five years of data sharing and collaboration on the Open Data Commons. Accelerate collaboration and scaling of best practices and reference implementations through the multi-city USDOT ADS City Cohort (Cohort).

In order to address issues involving AV technology and accelerate the safe, efficient and secure interoperable integration of ADS into our Nation's on-road transportation system, the City of Austin proposes an in-project scaling concept that was employed during CoA's involvement in another USDOT project: the Vehicle-to-Infrastructure Connected Vehicle Reference Implementation Architecture, now known as the V2X Hub. In that project, a candidate reference implementation architecture was developed by one team, then scaled, tested and evaluated by another in a geographically and technically different environment. The City of Austin proposes employing the same approach on this project. Once the Open Data Commons is tested with ADS data from Austin, the project will develop a candidate reference implementation set for Omaha and South Bend, two of the USDOT ADS Cohort cities. These city partners are committed to adopting, scaling, and evaluating the CASSCADDE project (the Project) approach for data commons.

In addition to the Austin-Omaha-South Bend scaling team, three other cities within the Cohort, Detroit, Kansas City, and Washington, D.C., are committed to coordinating project activities, especially around data and sharing. The Cohort are committed to collaborating on common data terminologies, frameworks, protocols, a community of practice, and most importantly, the development of an Open Data Commons that would be leveraged by all Cohort cities.

Austin is a hot-spot for automated vehicles (AV) companies, both as a deployment market and job market. Several AV companies are currently planning commercialized AV fleet services of different types that could launch during the period of performance of this project. Furthermore, agency partners are in the midst of launching similar services. The City of Austin proposes to initially demonstrate, test and collect data on an automated shuttle operating a Level 4 ADS in the downtown Austin urban environment along the 3rd Street corridor adjacent to a Capital Metropolitan Transportation Authority (CMTA) rail line. Future ADS deployments in Austin will also be candidates for the CASSCADDE project.

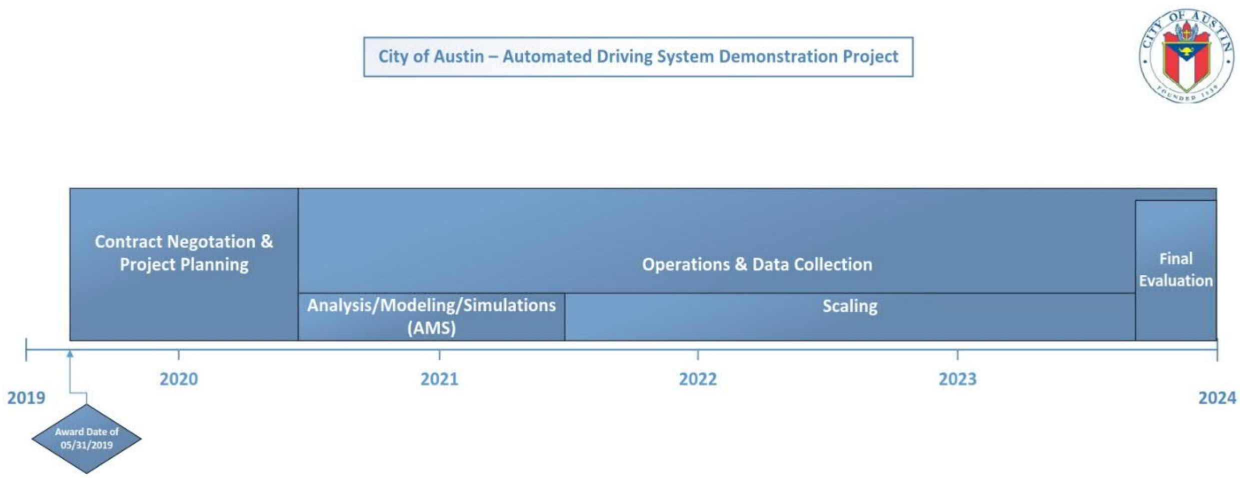
Additional use case demonstrations for scaling have been identified across the City of Austin (CoA) and include urban locations at the Texas School for the Blind and Visually Impaired (TSBVI), and the Austin Bergstrom International Airport (ABIA) and the Domain entertainment district to the Austin FC Soccer Stadium, to be completed I 2021 .

Lastly, ADS has the potential to greatly impact the lives of transportation-challenged populations by removing barriers to access. Our approach is inclusive of all ages and all abilities with focused, measurable outcomes for older adults and those with disabilities. In addition to TSBVI, the CoA plans to engage other local partners and community based organizations such as the Mayor's Commission on Seniors, ADAPT Texas, the Texas School for the Deaf, and others.

The project director, Robert Spillar, is the Director of the City of Austin's Transportation Department (ATD). In January of 2018, ATD proactively made organizational and resource allocation changes in order to be better prepared for near-term and future disruptions in the transportation landscape. The project will be managed by Jason JonMichael, Assistant Director. Jason oversees the Smart Mobility Division, IT, and the Parking Enterprise Division which manages all parking, curb access, ground transportation, key infrastructure elements to ADS. Todd Hemingson, Vice President of Austin's regional transit agency, (CMTA) will join Robert and Jason to round out the executive management team. Other key partners in this demonstration include the IOTA Foundation, AECOM, and the Smart Cities Lab.

The period of performance for the demonstration is four years, which includes 12 months of: planning, testing and development, initial technology validation; and three years of demonstration execution, scaling, data gathering, analysis, and evaluation. The data from the demonstration will be available to the USDOT for five years following the demonstration.

Figure 1: Project Schedule and Timelines



The Project will validate the exchanges of data that can support the safe, secure, efficient and interoperable integration of ADS into our Nation's on-road transportation system. The candidate system architecture, a decentralized open data commons, would potentially accelerate the work of USDOT regarding ADS, including the development of voluntary consensus standards that can support national and global interoperability of ADS.

These unique elements to our approach will help ensure that a significant and validated set of data is collected and analyzed for the purposes of providing information pertaining to the risks, opportunities, and insights relevant for USDOT safety and rulemaking priorities regarding the integration and operation of ADS in the Nation.

2. Goals

The objectives and approach to the Project demonstration align directly with the USDOT's three overarching goals of the ADS Demonstration Program – Safety, Data, and Collaboration. The Project will test and validate the proposed methodology of collecting data and evaluating the safety of automated driving systems. The project and management approaches enable accelerating the timeline USDOT would receive meaningful and actionable outcomes from projects awarded as part of the ADS Demonstration Program as a whole.

2a. Safety

The primary purpose of the demonstration is to identify challenges regarding the safe integration of ADS into the nation's on-road transportation networks through the collection and analysis of data, collaboration, and the sharing of data through a trusted third-party data commons.

The Project will address safety from a number of perspectives; it will encourage the use of multiple transportation modes, serving to connect a popular commuter rail line with downtown attractions, as well as other transportation modes such as car-share, docked bicycles, and dockless bicycles and scooters. The Project will have a governing effect on local traffic, as the shuttles will be limited to 25km/h - 40km/h (~15-25mph) and the roadway is single lane in each direction. Vehicle movements with the highest risk will be in the traversing of intersections and completing turning movements at the termini of the route.

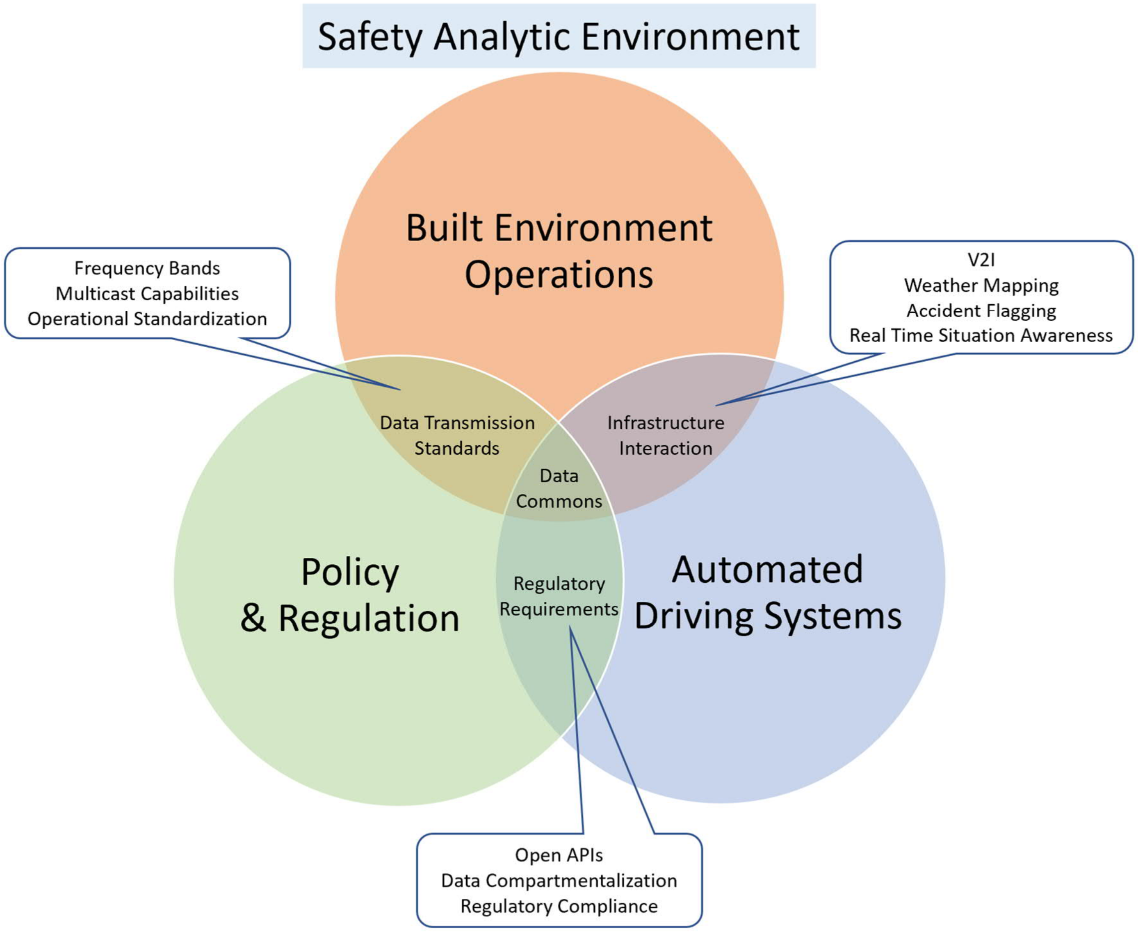
A second aspect of the demonstration technology is in its interaction with other users of the corridor, including vehicles, pedestrians, bicyclists, and those on scooters. In addition to traditional interfaces to display intentions, such as brake lights and indicators, shuttles will be able to communicate with connected vehicles, as well as equipped infrastructure. Connected vehicle applications exist specifically to enhance safety, and to the extent possible, will be used and evaluated as to their applicability to ADS.

2b. Data for Safety Analysis and Rulemaking

Regulations from a number of federal agencies govern the safety of vehicle systems on the nation's roadways; however, ADS pose additional challenges for regulators as the decision-making algorithms of vehicle systems often cannot be queried to determine a causal chain of events that leads to a failure in safety. Progress is being made as original equipment manufacturers (OEMs) are implementing data recording techniques to capture the various internal data streams prior to an event of interest.

The Project refers to the physical environment and the related measurable transportation operations data within it as the safety analytic environment. The data generated, analyzed, and evaluated as part of the Project will deliver measurable outcomes through rigorous simulation, testing, and evaluation. One of the purposes of analyzing and evaluating the data is to level-set existing artifacts of anecdotal accounts of ADS safety within the marketplace. Identification of which metrics within the safety analytic environs characterize safety risk will be based on creation of baselines using historical and pre-event data.

Figure 2: Safety Analytic Environment: CASSCADDE Project



Adding to the data commons, all data within the safety analytic environment will enable analysis focused on human safety and usability in and around ADS operations, including human driven equivalents. By leveraging all available data to analyze the safety risks, opportunities, insights, and alternatives will make the Project become relevant for USDOT safety analysis and future rulemaking.

The Project will demonstrate an innovative and scalable systems architecture by providing a digital commons approach that is open and decentralized with the highest capabilities of securing data. This commons approach allows all participants of the commons to analyze larger data sets, analyze and evaluate data that is not being captured in their project, and share more meaningful, actionable lessons learned so that, as a community of practice, future iterations of the candidate reference implementation architectures, protocols, etc. and accelerate at pace that meets or exceeds USDOT's needs.

The Project will generate a wealth of information on vehicle performance, its interaction within the environment, and user behaviors and interactions. As additional deployment scenarios are implemented through the scaling partner network, the breadth and diversity of data will increase significantly, providing more support in the rulemaking process.

2c. Collaboration

The deployment, demonstration, and evaluation of the Project represents years of close collaboration by the project partners. The coordination of the project team was fostered by the Smart Mobility Division of the ATD, which works closely with the CMTA to provide multiple modes of transit to the population of the Greater Austin metropolitan area. CMTA and the CoA frequently partner on Smart Mobility initiatives such as the development of the Smart Mobility Roadmap and similar stakeholder events.

The Project will comprise multiple levels of collaboration at the local, regional/state, and national levels.

a) Local: CMTA, TSBVI, ABIA, local community-based organizations.
b) Regional/State: The Project supports the Texas Innovation Alliance proposal and supports collaboration on common approaches to data management statewide.
c) National: The Project is committed to sharing and scaling through its participation in the Smart Cities Lab USDOT ADS City Cohort. The Cohort has agreed to share and collaborate on a common data framework, as outlined in: the data management plan; data sharing agreements; a common ADS lexicon across projects; an ADS community of practice—where cities commit to share progress on the various ADS projects and developing best practices; and an ADS Advisory Council comprised of organizations willing to provide technical advice to the cities related to: Robotics/Artificial Intelligence, Safety, Mobility, and Data.

CMTA will be leasing the automated shuttles to be used in the demonstration, given its vested interest in providing additional modes of transportation to connect with the MetroRail Downtown Station, which is adjacent to the Austin Convention Center.

The IOTA Foundation has also worked in partnership with the CoA since early summer 2018 to understand the processes through which data generated by ADS can be captured, validated, cleansed, and shared with stakeholders, while meeting the security and privacy needs of the private sector ADS partners. The IOTA Foundation will be developing an open source decentralized data framework and architecture to enable the collaboration and data sharing among partnering cities and organizations in a cost-effective scalable data commons that allows for replicable integration of successful candidate reference architectures, protocols, etc., both nationally and globally.

It is a key objective of the Project will lead to subsequent launches of ADS in Austin as well as other cities. The IOTA Foundation will architect an Open Digital Commons that can accept near real-time data and batch data from multiple automated driving systems which can then be securely and permissively accessed by the USDOT, the Cohort, and others. The Cohort will leverage a set of candidate reference architectures, developed as part of the Project, to implement similar AV projects and begin to stream data to the digital commons. The successful deployment of the Project will validate that ADS can be measured with respect to operational safety outcomes. The candidate system architectures are thereby tested and validated by a geographically and technologically diverse scaling team.

For instance, the successful demonstration along the 3rd Street route could lead to the deployment and safety analysis of automated shuttles at ABIA and future locations. Subsequent deployments of automated shuttles using the CASSCADDE Open Digital Commons in Kansas City, Detroit and Washington, D.C., who are collaborative partners of the Cohort.

3. Focus Area Alignment

The proposed demonstration aligns with the discretionary grant program's focus areas and are described below.

3a. Significant Public Benefit

The demonstration will measure the public benefit consistent with AV 3.0 – the safe, reliable, and cost-effective integration of automation into the nation's surface transportation systems. The safe interoperable integration of ADS into the transportation systems will provide enhanced accessibility for all populations, including those who are aging and those with diverse disabilities. This demonstration will provide opportunity for: the provision of social equity; cooperative automation and connectivity; and assurances of cybersecurity and privacy in regard to the collection, evaluation, and storage of data used to measure the operational safety of ADS.

The Project will also generate a basket of traditional economic benefits to the users of the demonstration corridor. These benefits will include: the avoidance of accidents through the reduction of human error and of vehicle miles traveled; efficiency gains by other users of the demonstration corridor due to congestion alleviation related to fewer single occupancy vehicles on the road; and emissions reduction through the removal/replacement of internal combustion engine vehicles by the automated electric shuttles. While likely to be relatively nominal in the project corridor during the demonstration period given its size and average daily traffic (ADT), the demonstration technology's potential to generate significant public benefit grows significantly at scale - use cases where there are more automated shuttles operating in broader, more complex environs that embody various characteristics, such as the ratio of densities of vehicles, pedestrians, and other vulnerable road users in the safety analytic environment.

3b. Addressing Market Failure and Other Compelling Public Needs

Currently, there is a lack of data from ADS OEMs due to the polarizing institutional barriers set between the public sector, university researchers, and the private sector OEMs and Tier 1 suppliers of ADS technologies. The Project addresses this market failure by employing a project approach that utilizes an existing third party, the IOTA Foundation, which already has trust relationships with several global OEMs – creating a trust gateway for USDOT and others to access and analyze data in a secure way that protects the private sector's intellectual property and privacy of their customers.

Another area of market failure in ADS is with regard to the complexities of providing ADA accessibility and compliance. The Project addresses these complexities by way of direct inclusion of ADA requirements in the data schema and evaluation of the data by CMTA, TSBVI, and other state and community based organizations in this space.

3c. Economic Vitality

The gradual introduction of ADS into the nation's transportation system has the potential to increase productivity, facilitate more efficient freight movement, and to stimulate job growth in emerging, knowledge-driven sectors. However, the impact on economic vitality of the demonstration corridor and surrounding area as a result of the Project itself is likely to be nominal. The corridor is not characterized by vehicular congestion nor by heavy freight movement. The demonstration may contribute to a small increase in investment attractiveness (and by association an increase in property values) along the corridor given its enhanced mobility relative to all other parts of the Downtown business district of Austin in which ADS is not operating. One additional benefit in demonstrating that the technology is viable and safe within an urban setting, is the establishment of a guidebook for how future ADS use cases can be deployed and evaluated. With this guidebook and demonstration, there is significant potential for fostering greater economic vitality. In future scaled use cases, particularly those in more active, complex, and congested systems, the technology to be demonstrated could contribute to system wide efficiency gains. In addition to increases in productivity, the alleviation of recurring congestion through mode-shift to an increasing cohort of more efficient ADS could improve freight efficiency and productivity through reduced travel times.

3e. Complexity of Technology

The ADS to be demonstrated in the Project represent some of the most technologically advanced vehicles currently manufactured. They contain a variety of sensors to provide a 360-degree situational awareness of the vehicles' environment, as well as advanced artificial intelligence and machine learning algorithms to perform: the functions of real-time sensor fusion; path planning; global and relative localization; and object detection and avoidance. These shuttles also have the added ability to interact directly with passengers, as their primary operational design domain (ODD) is as a people mover. Additional sensors and algorithms will be dedicated to detecting the presence, movement, and boarding/deboarding intentions of people. The shuttles will likely still contain a "safety attendant" provided by the OEM and will also be monitored remotely at all times in case a manual takeover is required. However, the normal operation of the vehicle will be executed without direct human input or oversight, and its operation will be limited to a specific operational domain. These characteristics place the Society of Automotive Engineers (SAE) autonomy classification for this type of vehicle as a Level 4 automated vehicle. The planned interface with dedicated short-range communications (DSRC) equipment further increases the complexity of the overall system and will enable the exploration of more sophisticated and dynamic interactions and data analysis. Considering the eventual marketization of 5G cellular technologies and the subsequent introduction of CV2X, the Project will accommodate this connected vehicle technology, once market-ready. The use of a distributed, cryptographically secure data management system will break new ground in the deployment of ADS systems, demonstrating the practical applicability of a leading-edge technology for the secure transfer of data among devices without the need for a centralized certification authority. Additional technical elements to be employed by the COA include a Vision Zero program technician to analyze the safety data and lighting and curb access technology to facilitate safety at the ADS stops.

3f. Diversity of Projects

The Project is the first of several automated driving systems use cases to be demonstrated in the greater Austin Metropolitan Area, with future use cases to be scaled from the framework established in the demonstration. Additional use cases in different urban environment being considered for ABIA. Using the same common digital platform demonstrated in the Project, additional automated shuttle use cases are being considered in urban areas such as Detroit and Washington, D.C., and more rural applications in Omaha and South Bend, as a part of the Cohort.

3g. Transportation Challenged Population

The demonstrated technology would be helpful to several segments of the population that are transportation challenged including: those who are aging, those who are diversely disabled, and those who live in low-to-moderate income households. The elderly and those living on fixed incomes often rely on public transit for their transportation. The Project would provide social equity by offering affordable mobility options, including an extension of transit services. The demonstration would move people from the Downtown MetroRail Station through the city core, allowing passengers to access additional services and amenities in the area. While the existing prototypes are not ADA enabled, each of the OEMs are able to equip their automated shuttles with wheelchair accessibility to provide better service to disabled users. Furthermore, technology solutions can be applied to address ADA accessibility through applications of universal design.

Opportunities to partner with the community using this technology include:

- Texas School for the Blind and Visually Impaired (TSVBI): A special public school through which students who are blind, deaf-blind, or visually impaired, including those with additional disabilities, receive services. This partnership would provide better understanding of transportation solutions to increase access for the blind and visually impaired.
- Housing Authority of the City of Austin (HACA) and Austin Pathways: A mobility ambassador program to highlight the transportation needs of those living in public housing and find workable solutions. The partnership would provide improved access to services, points of interest, and employment for residents.

- Central Health and the Community Care Collaborative: A collaborative entity which partners with various private sector entities to offer transportation to and from non-emergency medical appointments for low-to-moderate income populations. The partnership would provide additional transportation options for medical trips.

3h. Prototypes

The proposed demonstration will utilize automated shuttles enabled with an ADS that meets SAE level 4. The vehicles capable of communicating with other devices, and interacting with passengers, within a limited operational domain. These types of systems have been used in a number of use cases domestically and globally; however, they are in essence still considered prototype ADS. The combination of the prototype with a limited and pre-engineered operational domain (3rd Street) will yield a higher safety outcome and limit unwanted project complexities that may come with a larger route-based domain or non-route based operational area.

4. Demonstration Requirements

The below table summarizes the requirements stated in the notice of funding opportunity, and how the proposed demonstration addresses each of these.

Table 1: ADS Demonstration Grant Requirements: CASSCADDE Project

	ADS Demonstration Grant Requirement	CASSCADDE Project	Reference
4a	Technology is to be Level 3 or above.	The Project will include automated shuttles that do not require a driver but are limited in their operational design domain. This type of system is classified by SAE as Level 4 automation.	Section 3.e
4b	The candidate project must include a physical demonstration.	The demonstration will take place along a 1.5-mile fixed route, on surface streets, within the central business district of Austin, Texas.	Section 5.c
4c	The demonstration must entail the production, capture, storage, and sharing of data, and that the data be shared for 5 years.	The automated driving systems of the Project will generate multifaceted data during its operation while also capturing data in its communications with other connected vehicles and infrastructure. All data will be conveyed to a trusted third-party data management provider, the IOTA Foundation, who will in turn validate, cleanse, and secure the data in a decentralized data commons. The data generated by the demonstration will be available for sharing by approved stakeholders, including the USDOT for 5 years after the completion of the demonstration.	Section 5.c and 5.e
4d	The demonstration must include multiple mechanisms to enable passengers to interact directly with the vehicles, using a variety	The automated shuttles will be equipped with an ADA compliant onboard touchscreen, voice activated options, audio cues, and traditional methodologies to interact with the vehicle, a number of emergency stop buttons, as well as external facing lights and video signs.	Section 5.c

	of input/output user interfaces.		
4e	The demonstration must have the ability to be scale to other analogous locations/environments.	The Project will provide the USDOT with a candidate reference architecture, framework, taxonomy and protocols in an open digital commons. The USDOT ADS City Cohort helps accelerate scaling of best practices, common architectures and enable a higher level of participation and collaboration with all parties.	Section 5.e
4f	The ADS demonstration project will include an outreach task to share the findings of the demonstration so as to facilitate technical exchange and knowledge transfer.	The development of the Project has been rooted in collaboration and knowledge sharing between the City of Austin, its project partners, and various other public sector and industry partners within the fields of automation and smart mobility. The project team will provide regular updates to stakeholders, and present the findings and lessons learned from the demonstration at industry conferences at the request of USDOT throughout the Project and beyond. As deemed appropriate by the USDOT, the project team may choose to provide information to its industry and agency cohorts about the demonstration through its open digital data commons or through other initiatives, such as Cooperative Automation Research Mobility Application (CARMA).	Section 2.c

5. Technical Approach

The demonstration will be conducted in Austin, Texas, which has integrated connected and automated driving system technologies into its transportation networks. In partnership with the local transit agency, CMTA, the City will be deploying a pilot demonstration of low-speed all-electric shuttles equipped with automated driving systems along a fixed route, providing service between the City's convention center and commuter rail system and the City's central business district. Downtown environments often contain non-conforming traffic and pedestrian behavior such as: pedestrians, scooters, or bikes crossing mid-street, and temporarily double-parked vehicles that are loading or unloading. However, the selected demonstration corridor is a relatively low-traffic street, providing a unique environment for testing specific use-cases of the ADS.

5a. Technology to be Demonstrated

The demonstration will use low-speed, electric ADS from two different suppliers, Easy Mile and Navya, within a use case of a circulator service along a programmed 1.5-mile route. The AV shuttle systems currently available have a carrying capacity of between six and fifteen passengers, with a mixture of seated and standing positions, and are required to travel at speeds of 25 to 40 kmh. The specific shuttles selected for this demonstration from Easy Mile and Navya will hold eight and twelve passengers, respectively, and have basic obstacle detection and avoidance capabilities which, along with specific modes of operation (behavior modes), are well-suited to their specified operational design domain. The demonstration route will provide a more controlled environment, ensuring a more uniform experience for passengers, and better data quality for evaluating operational effectiveness and safety.

5b. Onboard Systems

The shuttle technology suppliers EasyMile and Navya both use similar technologies for perception of their environment, route planning and execution, and passenger interaction. Specifically, a combination of light detection and ranging (LiDAR) sensors and cameras are used for object detection, classification, and tracking, which may also be combined with RADAR or ultrasonic sensors. Wheel speed sensors (encoders) monitor the motion of all four wheels as part of their relative localization system, along with an inertial measurement unit (IMU) that enables the relative returns of sensor data to be transformed into a global vehicle coordinate system. The vehicles need to perform this transformation for each sensor in real-time in order to properly identify the location and movement of objects in the environment by subtracting the motion of the vehicle itself ('ego motion'). Lastly, the vehicles will use a global positioning system (GPS) with real-time kinematic corrections as part of an absolute localization subsystem. The vehicle systems have the ability to execute path planning along pre-mapped routes in a fixed mode. In a fixed-mode of operation, the shuttle will stop at all stops along the route regardless of occupancy within the vehicle or the presence of waiting passengers at the stop.

5c. ADS HMI and ADA Compatibility

Interaction with these vehicle systems will be enabled through a number of mechanisms, including: touch screens; voice activated options; internal-facing cameras and intercom systems; door open and close buttons; and emergency stop (e-stop) buttons for safety. Interactive touch and voice activated screens can be used to provide information to passengers regarding the technology of the shuttle, operational parameters such as battery usage and internal climate, and details of its operation such as its location along the planned path and the next scheduled stop. They can also be used as a two-way communication device with the shuttle. The internal-facing camera and intercom system will be used by support staff remotely monitoring the internal conditions of the shuttle. The e-stop button is provided as an emergency mechanism to immediately disrupt and preempt the behavior mode of the vehicle, and to execute a stop as quickly as is safely possible given that some passengers may be standing and unprepared for a sudden stop. Often, these buttons are also located on the exterior of the vehicle, and any trigger of an emergency stop – either from the physical button or via a mechanical, electrical, or software trigger – will be logged and collected as part of the shuttle's operational safety and data management plans. Ideally, a rolling buffer ('ring buffer') of all available data sources and vehicle state data will also be logged in the event of an emergency stop, vehicle collision, or other significant event. The duration of the ring buffer will be sized to capture all relevant sensor and state information.

These shuttles will also be accessible for passengers who are visually impaired or in wheelchairs, where a ramp is deployed to assist in boarding and exiting the shuttle. The ADS systems will not conflict with the physical accessibility of the hand controls, wheelchair ramps or lockdown systems. Additionally, COA has been successful in deploying mobility ambassadors to assist those who have diverse disabilities, including hearing, visual, mobility and developmental impairment.

5d. Fixed Connected Infrastructure

Additional technology that will be used in this demonstration include DSRC units for enabling CV applications that support ADS and edge computing devices that capture system data and transmit to the Project's secure data commons. This is discussed in detail within the data management plan. DSRC devices include roadside units (RSUs) that are already planned for six intersections along 3rd Street with a variety of applications. The devices will include the ability to broadcast signal phase and timing (SPaT) and MAP messages, as well as the ability to forward received messages. Additional applications may include the broadcast of transit signal priority (TSP). If the shuttles are not already outfitted with DSRC onboard units (OBUs), these will be installed by the project team using temporary and non-invasive techniques. The OBUs will enable the shuttles to, at a minimum, broadcast the J2735 basic safety message (BSM) but may also include the ability to broadcast the Signal Request Message (SRM) and receive from the RSU the Signal Status Message (SSM) within the TSP application. Additional CV applications, as described in the connected vehicle reference implementation architecture (CVRIA) that will be enabled include: Vehicle Turning Right in Front of Transit Vehicle, Stop Sign Gap Assist, Left Turn Assist, Pedestrian in Signalized Crosswalk Warning, and Transit Vehicle at Station/Stops Warning.

5e. Demonstration Location

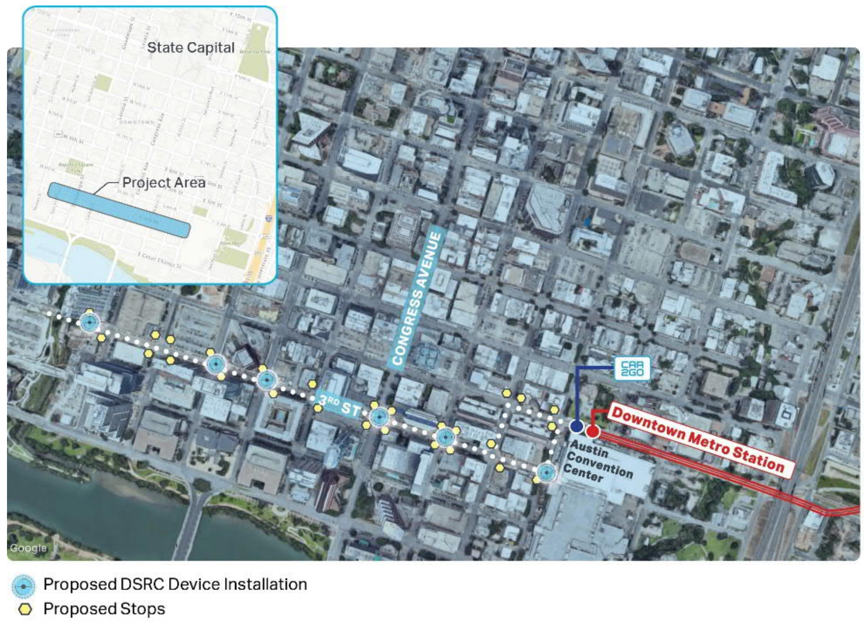


Figure 3: Location of CASSCADDE Project

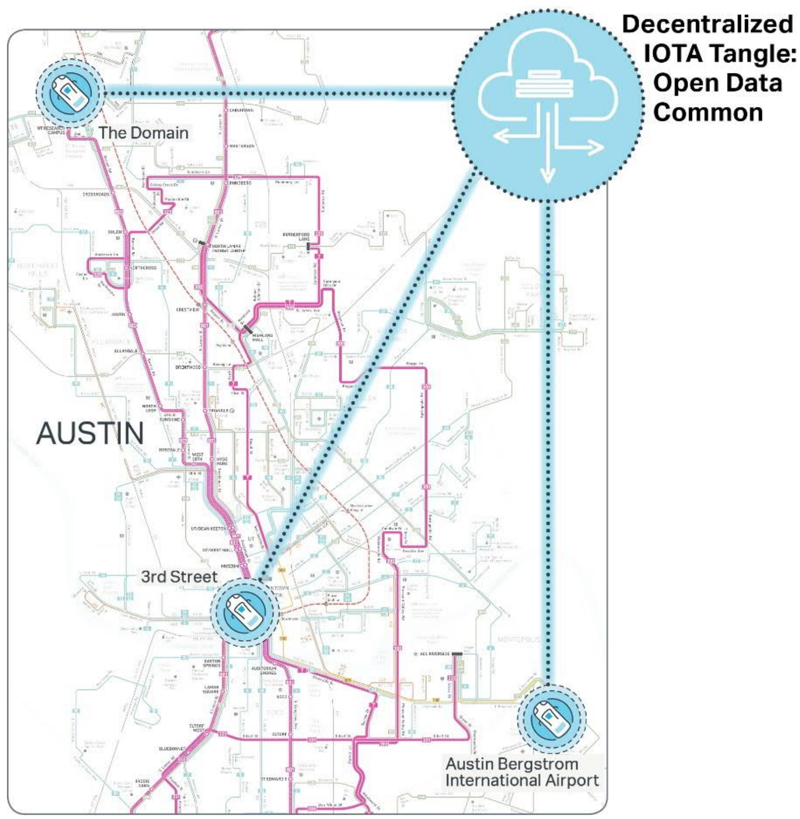
The Project will be conducted along 3rd Street in downtown Austin, between Nueces Street and Trinity Street at the location of the convention center. A return loop will run up Trinity St. to East 4th St., over to San Jacinto Blvd., and back down to 3rd St., comprising approximately 1.5 miles. The corner of Trinity St. and East 4th St. is the location of the MetroRail Downtown Station termination point, and route stops are planned at this location to tie into this commuter rail mode of transportation. Additional stops are planned along the route at each intersecting cross street, and the shuttles will be operated between the hours of 7:00a.m. to 10:00p.m. Initially, passengers will be able to board and exit the shuttles only at the specified stops along the route (fixed mode). Touch screen, intercom, and other accessible systems may also warn passengers that the vehicle will be stopping or is about to open or close the doors.

The Project will target a variety of population demographics, which vary throughout the day, and include visitors to the city, the downtown workforce, and college and high school students, among others. The location of this demonstration is also adjacent to downtown attractions like 6th Street, which in the evening offers a variety of restaurants, bars, and live music, and is adjacent to urban living centers, parks, and trails.

5f. Future Potential Use Cases in Austin

An additional use case utilizing ADS analogous to the Project would be the deployment of similar technology at ABIA. Airports have been shown to be a useful operational domain for testing automated technology as the environment provides a regular and structured route for moving people between terminal entrances and parking or rental car locations. Airports also provide a very dynamic environment of moving objects, vehicles and pedestrians, which don't precisely follow "traffic" behaviors. For instance, pedestrians at airports generally don't fit standard models of perception data because they are often pushing carts of luggage, or dragging luggage behind them, or both. The lessons learned from the Project will also be leveraged to introduce a shuttle service at ABIA, utilizing the same approaches to data management. A second use case has also been developed with ABIA, which would create an airport circulator for airport staff, which could increase the availability and amount of passenger input data into the commons.

Figure 4: Location of CASSCADDE Project and Future Use Cases in Austin



The Project will last for five years and is part of a larger program for CMTA and the CoA to safely integrate automated driving systems into the local transportation system. The Project is at the beginning of this process, and learning from this program will be used to expand this type of service, and other ADS, to other operational domains. For example, one of the largest entertainment districts in Austin, The Domain, a mixed-use entertainment area with restaurants, bars, shops, and apartments/lofts. The streets through the middle of the domain are not particularly car-friendly (as the interior of The Domain was designed with heavy pedestrian usage in mind) though an automated shuttle would fit well with these constraints. One potential planned expansion of the technology demonstrated in the Project is a use case operating within The Domain connecting to a nearby location where a major league soccer stadium, Austin FC Soccer Stadium at McKalla Place, will be built by 2021. This use case would utilize multiple shuttles to move people between the stadium and The Domain itself. The processes for data collection, transmission, and management plan developed for the Project demonstration would be refined as necessary and deployed in a similar fashion in this Domain use case.

5g. Regulatory Environment

5g(1). Legal & Regulatory Obstacles

The regulatory environment in the COA is very permissive regarding automated vehicles and ADS. In 2017, the Texas legislature passed Senate Bill 2205 which set state authority regulations for the operation of automated motor vehicles or automated driving systems. Texas is also one of the few states which allows AVs to operate whether or not a human operator is physically present in the vehicle. AVs are expected to follow traffic and motor vehicle laws and have a title, registration, and insurance in accordance with Texas law. Automated vehicles must also be equipped with an automated driving system as well as a recording device that complies with federal law and federal motor vehicle safety standards (FMVSS).

Additional legislation was introduced in the Texas Legislature in 2019 to cover identification, software, and liability. House Bill 113 requires that when registering automated vehicles, applicants must identify that the vehicle is automated. Vehicles must also have a failure alert system and the most recent software updates released by the manufacturer of the automated driving system. House Bill 119 defines who is liable for damage from an accident involving an automated vehicle.

5g(2). Environmental Regulations and Permitting

The City of Austin Project will occur on an existing roadway and will not disturb the surrounding environment. Therefore, the Project will not trigger the need for a federal or municipal environmental review. COA will comply with all city regulations and permitting requirements necessary to implement the Project, including requirements outlined in the Land Use Development and Environmental Code.

5g(3). Federal Motor Vehicle Safety Standards (FMVSS) & Federal Motor Carrier Safety Regulations (FMCSR)

Demonstration partner CMTA has been notified by their vehicle supplier that an FMVSS exemption to operate a downtown shuttle in Austin for each manufacturer has been granted.

COA will not be seeking FMCSR exemptions for this ADS demonstration project.

5g(4). Buy American

COA anticipates being fully compliant with the Buy American Act. The City will not be seeking an exemption.

5h. Other obstacles

5h(1). OEM Collaboration and Data Sharing

Private industry is very protective of anything that is viewed as a competitive advantage, and with advanced technologies such as automated shuttles, this protection extends to the diversity of data streams produced by the vehicle. These data streams are tightly coupled to the internal decision-making algorithms that uniquely represent the capabilities of the technology, and therefore can reveal characteristics in the design or execution of the system where a competitor may capitalize. For this reason, OEMs are often reluctant to share any data; if they do share data, it is highly aggregated or even redacted, such that its use in data analytics is significantly curtailed. Data-sharing models have begun to emerge in which private OEM technology suppliers and public agencies can mutually benefit from sharing certain types of data which are produced by the vehicle or are due to activity of the vehicle. These arrangements protect the intellectual property data integrity for the OEM while providing useful data to public agencies to help evaluate the feasibility of the technology for more extensive use-cases.

The project team and supporting partners have established a working relationship which will be leveraged during the initial phase of the proposed Project to establish an agreement for data sharing, which will include the following:

- The type of data that can be generated and shared between the OEM and the public agency. This will include descriptions of data completeness;
- The source of each data type and the extraction method;
- The frequency of data generation by type;
- The frequency of data transmission by type; and
- The size of data by type.

This will provide the framework for a mutually-beneficial data exchange plan, as well as help to determine the data storage needs and transmission bandwidth expected.

5h(2). Liability and Post-Crash Investigation

The project team recognizes the risk associated with operating these AVs in a live environment with vehicles, cyclists, scooters, and pedestrians, and the possibility exists that a crash will occur during the execution of the demonstration. ATD and APD share the same vision and goals of USDOT related to the safe operation of ADS on Austin’s on-road transportation system. As part of the Project, APD will help train ATD project staff on performing crash analysis and investigations. In addition, APD can help connect ATD with individuals and/or businesses who have this skill to ATD's project team for further collaboration and training. As part of this partnership, and as an in-kind contribution to the project, APD will also provide access to crash investigation photogrammetry and other crash analysis solutions currently being used by APD to the project team for education and training purposes. Once a crash with an ADS enabled vehicle takes place, ATD will be responsible for crash investigation scene analysis, data gathering, and reporting.

5h(3). Cybersecurity Threats and Mitigation

The IOTA Foundation has integrated development security operations (DevSecOps) processes into the nature of its developer culture, meaning that the leading strategies behind the Secure Software Development Life Cycle has been followed by integrating security auditing and assessment processes into the development methodology for the data management plan. The project team has used industry leading tools and techniques to assist with automating the process during development and performing fast and scalable review procedures for all software developed. The project team will work with some of the industry's leading security professional from across the globe as advisers for the development and architecture teams. The project team will ensure all applications that are produced are extensively audited by leading international third-party cyber security companies at various stages throughout the development processes. The final portion of the design and development phase will include a security analysis and audit, a security review by advisors and specialists, culminating in a security outline detailing the results.

5i. Risk

COA and its project partners will conduct quality control measures in compliance with a defined quality program. A quality control and risk management plan will be developed and used as part of the active management of the Project. As part of the risk management plan, a risk register has been developed that clearly outlines the identified risks, severity of risk impact, mitigation and action owner. The risk register will be used on an active basis during the management of the Project to continually monitor and control risk. Table 2 is an example of an existing preliminary risk assessment matrix the City has developed for the Project. This matrix identifies potential risks, assesses a likelihood of occurrence, and then proposes a mitigation strategy to address the potential risk.

Table 2: Risk Identification and Mitigation Register: CASSCADDE Project

Risk Identification and Mitigation Register: CASSCADDE Project		
Risk Description	Level of Risk	Mitigation Strategy
Operability of Technology Does Not Meet Performance Expectations	1 – Very Low 2 - Low 3 - Medium 4 – Very High 5 - Very High	The project team and supporting partners will closely monitor the performance of all technologies used in the proposed demonstration, and those not meeting performance expectations will be subject to replacement at the supplier's expense.
Privacy and Proprietary Information from the Demonstration is Not Protected	1 – Very Low 2 - Low 3 - Medium 4 – Very High 5 - Very High	All data collected during the operation of this demonstration will be encrypted and compartmentalized very close to the source of collection, prior to being transmitted and stored within the distributed data management platform.
Environmental Regulatory Approvals, Permitting, and Clearances are Not Approved	1 – Very Low 2 - Low 3 - Medium 4 – Very High 5 - Very High	COA anticipates no permitting. If needed, the Project will obtain a categorical exclusion, given there is right of way acquisition and no ground disturbance associated with the Project.
Demonstration Schedule Slips	1 – Very Low 2 - Low 3 - Medium 4 – Very High 5 - Very High	The physical demonstration along the 3rd Street route is scheduled to run for approximately three years. Should this prove to be too short of a time to capture sufficient data, or conversely, too costly an exercise to run for its full duration, the demonstration can be scaled accordingly.
Cost of the Demonstration Project Exceeds Estimate	1 – Very Low 2 - Low 3 - Medium 4 – Very High 5 - Very High	The project team will closely track costs as part of the overall project management plan and will work to prevent scope creep during the course of the project.

5j. Cost Share

The COA is seeking an ADS Demonstration grant award of $6,916,371.00. The COA and CMTA will contribute a $6,368,929.73 local match comprising vehicles, equipment, and labor.

Table 3: Cost Share Summary: CASSCADDE Project

GENERAL BUDGET ALLOCATION	YEAR 1	YEAR 2	YEAR 3	YEAR 4	TOTAL
FEDERAL FUNDING AMOUNT					
LABOR	$ 1,278,460	$ 1,372,813	$ 1,541,097	$ 2,017,217	$ 6,209,587
OTHER DIRECT COSTS	$ 416,696	$ 96,696	$ 96,696	$ 96,696	$ 706,784
SUBTOTAL FEDERAL SHARE	$ 1,695,156	$ 1,469,509	$ 1,637,793	$ 2,113,913	$ 6,916,371
NON-FEDERAL AMOUNT					
CITY OF AUSTIN COST SHARE - LABOR	$ 1,656,268	$ 1,218,106	$ 1,464,209	$ 1,736,547	$ 6,075,130
CITY OF AUSTIN COST SHARE - OTHER DIRECT COSTS	$ 270,231	$ 7,856	$ 7,856	$ 7,856	$ 293,800
SUBTOTAL NON-FEDERAL SHARE*	$ 1,926,499	$ 1,225,963	$ 1,472,065	$ 1,744,403	$ 6,368,930
TOTAL	$ 3,621,655	$ 2,695,472	$ 3,109,858	$ 3,858,316	$ 13,285,301
*All Non-Federal Cost Share Provided by City of Austin					

A detailed summary of the COA and its project partner's cost share can be found in Part 6: Budget Detail of the larger application package.