University of Denver
Autonomous Vehicle Shuttle

Automated Driving Demonstration Grants

March 21, 2019

Transportation SOLUTIONS Foundation

RTD

DENVER
THE MILE HIGH CITY

easyMile

1864 UNIVERSITY of DENVER

March 21, 2019

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

Subject: Automated Driving System Demonstration Grant

Dear Ms. Tarpgaard,

The Regional Transportation District (RTD) of Denver is excited to submit this application to the US Department of Transportation (USDOT) for the department's Automated Driving System Demonstration Grant Program. With a total project budget of $6,652,961, RTD is requesting $6,331,506 in federal funds to implement a fleet of autonomous transit vehicles at the University of Denver (DU). RTD has committed $25,000 in local match funds (cash) as well as $156,260 in staff time (in-kind) to help support this project. This amount is included in the project team's total local match of $321,455. RTD has assembled a project team with experience in the implementation of similar, smaller-scale autonomous vehicle projects. These stakeholders include the City and County of Denver, the University of Denver, EasyMile, and Transportation Solutions.

As noted, autonomous vehicles are nothing new to RTD. In January 2019, the agency, joined partners (including the City and County of Denver and EasyMile), to implement a bus route served by an autonomous transit vehicle. This service, called the 61AV, was the first autonomous shuttle on a public roadway in the state of Colorado, as well as one of the first public transportation routes operated by an autonomous vehicle in the country. RTD is constantly seeking to improve service through innovative technological advances and the University of Denver AV Shuttle project is being viewed as the next step in understanding how autonomous vehicles can be used in a transit setting.

By reducing the number of human-caused collisions, the DU AV Shuttle will have a direct impact on safety in the service area. In the proposed university environment, the project team will be able to develop a better understanding of how pedestrians, cyclists, automobiles, and autonomous vehicles interact. RTD is committed to sharing data from the demonstration project with USDOT to identify risks, opportunities, and insights relevant to USDOT safety and rulemaking priorities. We also intend to

disseminate the processes followed and provide lessons learned from the demonstration project. The information will then be sent to other transit agencies around the country with the goal of reducing barriers to the integration of autonomous vehicles into the nation's public transportation fleets.

We are excited at the prospect of working with USDOT through the Automated Driving System Demonstration Grant Program. Please contact me at bill.vanmeter@rtd-denver.com or 303-299-2448 if you have any questions or need any more information.

Sincerely,

William C. Van Meter
Assistant General Manager, Planning

Summary Table

Project Title	University of Denver Autonomous Vehicle Shuttle
Eligible Entity Applying to Receive Federal Funding	Regional Transportation District (RTD) 1660 Blake Street Denver, CO 80202
Point of Contact	Bill Van Meter, Assistant General Manager, Planning Bill.vanmeter@rtd-denver.com 303-299-2448
Proposed Location for the Demonstration	Denver, Colorado
Proposed Technologies for the Demonstration	Level 4 automated transit vehicle (according to SAE J3016) which has no steering wheel or pedals. The vehicle can carry up to 15 passengers.
Proposed Duration of the Demonstration	2 years
Federal Funding Amount Requested	$6,331,506
Non-Federal Cost Share Amount Proposed	$321,455
Total Project Cost	$6,652,961

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PART I – Project Narrative and Technical Approach

Executive Summary

The Regional Transportation District (RTD) requests an Autonomous Driving System Demonstration Grant of $6,331,506 to support the implementation of the University of Denver (DU) Autonomous Vehicle (AV) Shuttle. The total project budget is $6,652,961 and the project team has secured a total local match of $321,455. DU is a university located in south Denver which has over 12,000 students enrolled. A light rail station served by RTD's E, F, and H lines is located near the northern border of the campus and provides a critical connection to the region for students and faculty. Many studies have been conducted in the past few years by RTD, the City and County of Denver, and DU on how to improve mobility to and from the station and on campus. These studies identified the need for a circulator to provide first and last mile connections between the rail station and DU's campus as well as trips between DU's campus and the surrounding neighborhoods. DU entered into an agreement with Chariot to provide microtransit service on campus and to/from DU Station in the summer of 2018. With the recent shutdown of Chariot services nationwide, DU currently has engaged a contractor to provide shuttle service on campus on an interim basis and is interested in pursuing a longer term AV-based solution. Ridership on the service met targets for the initial stage of service implementation and merits continuation thru the AV demonstration.

Meanwhile, in January 2019, RTD launched a six-month pilot project called the 61AV. The 61AV project implemented the first fully autonomous transit vehicle on a public roadway in the state of Colorado, and one of the first in the country. The 61AV operates revenue service Monday through Friday on a fixed route that connects the 61st/Peña commuter rail station with Panasonic's Denver offices. Through an unprecedented partnership among the public and private sector, the 61AV project allows stakeholders (RTD, Denver, EasyMile, Panasonic, Fullenwider Developers LLC, Transdev) to advance an innovative, first-of-its-kind project.

With the recent departure of Chariot from DU's campus, RTD identified the DU campus area as a prime opportunity to implement the next phase of its autonomous vehicle demonstration program. The 61AV shuttle was purposefully implemented in a low-density area of Denver to help prove the technology. RTD hopes to gather operations data from this pilot to better understand the nuances of operating AVs in a transit application. Because of this ongoing pilot project, RTD is in a unique place where it can apply the data gathered and lessons learned from the 61AV to the planning of the DU AV Shuttle. RTD intends to use the same vehicle from its 61AV project for the DU AV Shuttle: EasyMile's EZ10. This vehicle is a Level 4 automated vehicle (according to SAE J3016) and has no steering wheel or pedals. Partners for the DU AV Shuttle project include RTD, DU, the City and County of Denver, EasyMile, and Transportation Solutions, the transportation management association (TMA) that covers the DU campus area. The DU AV Shuttle is proposed to run primarily on High Street and Illif Avenue and operate revenue service for 12 hours a day at 15 minute frequency. A map of the route can be seen in Figure 1 on Page 10. This service will be free and open to all, providing a significant public benefit through increased mobility in the area.

Once funding is awarded, the project team expects it to take approximately 12 months to complete all required startup tasks, which are listed in more detail in the Technical Approach. In the first year, RTD expects to complete a traffic engineering study, design and implementation of necessary infrastructure improvements (including signal retiming, bus stop installation, facility upgrades, etc), regulatory approvals, staff training, vehicle acquisition, and set-up. Following the start-up phase of the project, RTD

will begin a one (1) or two (2) year operation phase; RTD expects to begin operation of the DU AV Shuttle on July 1, 2020. This project is scalable and RTD is flexible on whether operations are funded for one (1) or two (2) years. A Gantt chart of the project schedule and all associated activities can be seen on Page 11. The project will be under continuous evaluation based on the criteria specified in this proposal and a final report will be generated summarizing the shuttle's performance. The project team also intends to create a "how to" guide for starting AV transit service that could be used by other transit agencies around the country and will include lessons learned from the DU AV Shuttle.

Goals

Safety

Through the 61AV, RTD has already implemented an AV project in an environment with some traffic, buildings, and other activity. This was intended to be a proof-of-concept, where the technology itself could be tested with little interference. RTD is now pursuing the next step and implementing the technology in a more active environment that more closely resembles situations that an AV would experience on most US roads. The project area is a university campus, and therefore has many interactions between automobiles, transit vehicles, pedestrians, and bicyclists. Implementing the AV in an environment with such varied activity poses a potential challenge, but it is one that must be solved to advance the integration of AV technology in the US. Though EasyMile completed an initial site assessment to determine the viability of the proposed route, the company will conduct a final site assessment before deployment of the AV vehicle, which is a formal risk assessment to ensure the vehicle can operate safely in the environment. Since its launch in summer 2018, DU's circulator vehicles have been involved in two separate crashes with other vehicles which were caused by human error. There have also been numerous crashes along the proposed route involving vehicles, cyclists, and pedestrians. Between 2014 and 2018, crashes occurred at the following intersections:

- Buchtel Ave & High St- 5 total crashes, 1 serious injury
- High St, north of Evans Ave- 17 total crashes, 1 pedestrian crash
- Evans Ave & High St- 26 total crashes, 1 serious injury
- High St, south of Evans Ave- 4 total crashes
- Iliff Ave, between High St to York St- 15 total crashes, 1 serious injury, 2 bike crashes, 1 pedestrian crash

The specific cause of each of these collisions varies, but human error/negligence is the most common. AV technology provides the opportunity to remove human error from the equation, and thereby improving the safety of public transportation services and other road users. DU also has completed a technical transportation analysis on the campus that measured pedestrian flows. Depending on the intersection, hundreds to thousands of pedestrians will cross paths with the DU AV Shuttle on a daily basis, providing increased safety for those pedestrians and providing policy makers with the ability to better understand how AVs and pedestrians will interact.

Data for Safety Analysis and Rulemaking

RTD understands that one of the USDOT's main goals of the ADS grant program is to provide the federal government with the data and information needed for safety and rulemaking priorities. Through its 61AV project, RTD has identified specific metrics to characterize the safety risk of ADS integration. These metrics include the number emergency stops (e-stops), the number of operator interventions (when the operator has to manually operate the AV), the reason for those interventions (weather, software errors, other external forces), and the crash rate. In addition to monitoring and reporting technical information

related to the AV technology, DU researchers will take the lead to conduct a market research study to assess the public's opinion of the AV and how its use is perceived by the public. Generally speaking, secondary research indicates that the public is currently skeptical of AVs, posing a potential barrier to the widespread adoption of the technology; improving public perception is critical to the continued implementation of AVs. The project team hopes to develop a greater understanding of what makes the public wary of AVs and how that opinion might change after interacting with the technology directly.

Collaboration

RTD has assembled an experienced team of partners to implement the DU AV Shuttle project. These partners include the City and County of Denver, the University of Denver (DU), EasyMile, and Transportation Solutions (the Transportation Management Association in the DU area). If awarded grant funding, this group of stakeholders will meet regularly to ensure the successful implementation of the shuttle. Each organization's general contribution to the project is defined below:

- RTD: project management lead; will manage the implementation and operation of the transit services and will lead the ongoing reporting efforts once the service is in operation.
- Denver: owner of the street right-of-way; will oversee the traffic engineering study and infrastructure design and installation.
- DU: will lead the research component of the project.
- Transportation Solutions: will lead the public outreach and marketing portions of the project.
- EasyMile: AV technical expert; will provide the vehicles for the project and operations technical support.

Through this group of partners, RTD is able to tap into the strengths of each organization to ensure the successful implementation of the project. In addition to these direct stakeholders, RTD will coordinate with the Denver Regional Council of Governments, Colorado Department of Transportation, Colorado State Patrol, and other agencies as needed to ensure the project is implemented safely.

Project Background

In 2006, RTD opened the Southeast Corridor light rail line, which provides rail service to the University of Denver via a station on the campus's northern edge. The light rail station provides a tremendous resource to DU for campus commuting and neighborhood connectivity. RTD, the City and County of Denver, and the University of Denver have carried out a number of studies in recent years that identified opportunities to energize the station, enhance opportunities for the institution and the neighborhood, and overcome a lack of connectivity and transportation options to the station. An *Urban Land Institute Advisory Services Panel* (2016) and the *University of Denver Campus Transportation Master Plan* (2016) both identified the need for a circulator service or shuttle system on campus to provide better car-free mobility to students and faculty wanting to get around campus and to/from the light rail station. The *University/Colorado Multi-Station Study* (2017) and *Next Steps Study* (2017) identified University Station as a potential site for the development of a "mobility hub," where seamless integration of transportation modes provides improved mobility for all. These studies also identified infrastructure projects that would promote active transportation modes and improve connections between the station and the campus, which were funded through a 2017 General Obligation Bond approved by Denver voters. Finally, in 2018, the *Denver Advantage Campus Framework Plan* was adopted by DU, calling for a blurring of boundaries between the campus and the surrounding neighborhoods and adopting the recommendations of the *University/Colorado Multi-Station Study* and the *Next Steps Study.*

Providing mobility for a demographic with low car ownership (students) is a priority for DU, RTD, and Denver and the large population of "early-adopters" makes the campus a good area to implement new technologies. DU has launched several mobility pilots in the past few years including a pilot with Lyft which provided university-subsidized trips around campus and to the light rail station, a dockless bikeshare program, and a campus shuttle service operated by Chariot. Each of these pilots had varying degrees of success, however, the demand for a campus shuttle service was clear. Once Chariot shut down operations in February 2018, DU hired another contractor to fill the void left by Chariot. Ridership on the service is growing as the population becomes more accustomed to the service provided.

Mobility on DU's campus has been studied in great detail by the projects' stakeholders. This, along with the large student population (many of whom are car-free and "early adopters" of technology) and the demonstrated demand for a campus shuttle prove that the DU campus, the surrounding neighborhoods, and the general public would benefit significantly from this project.

Project Description

The DU AV Shuttle is proposed to operate a total of 2.2 miles from the University Station, south on High Street, east on Illif Avenue, and north into the campus on an internal road where the vehicle will turn around and follow the same path back to the light rail station. EasyMile has conducted an initial site assessment for this route, however final routing will be subject to the transportation engineering study completed by Denver. A map of the proposed route can be seen in Figure 1 on Page 10. Though exact hours and schedules will be determined during the planning phase of the project, RTD anticipates operating revenue service from 7:00 AM to 7:00 PM seven days a week with 15 minute frequency. This will require a total of four (4) vehicles – 3 operating the route and one spare. RTD intends to operate the service using EasyMile's EZ10 vehicle. This is the same vehicle that RTD currently uses on its 61AV route. Further explanation on the selection of this vehicle can be found in the Technical Approach below. No fares will be collected on the vehicle and the service will be branded as another RTD bus route and open to the public.

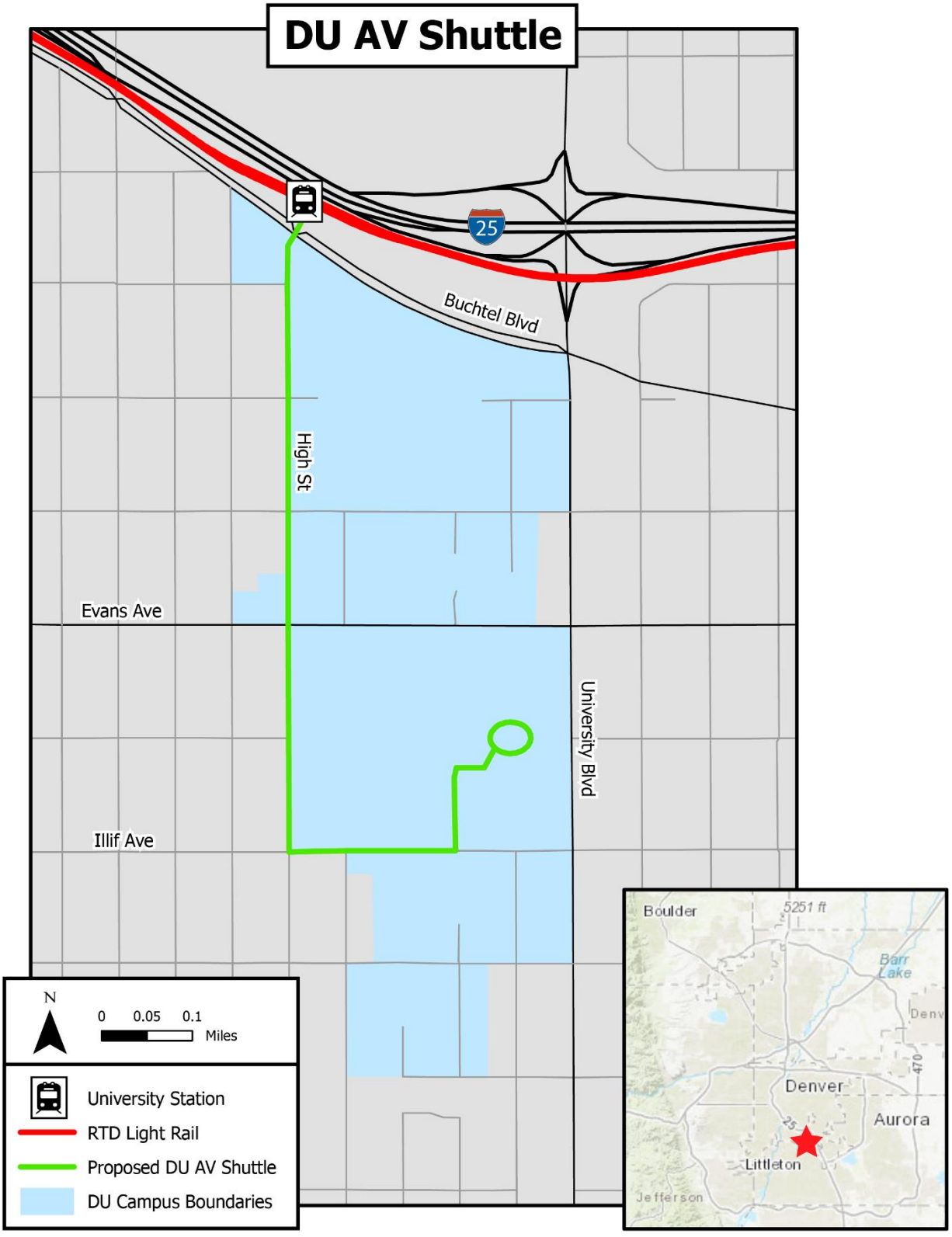
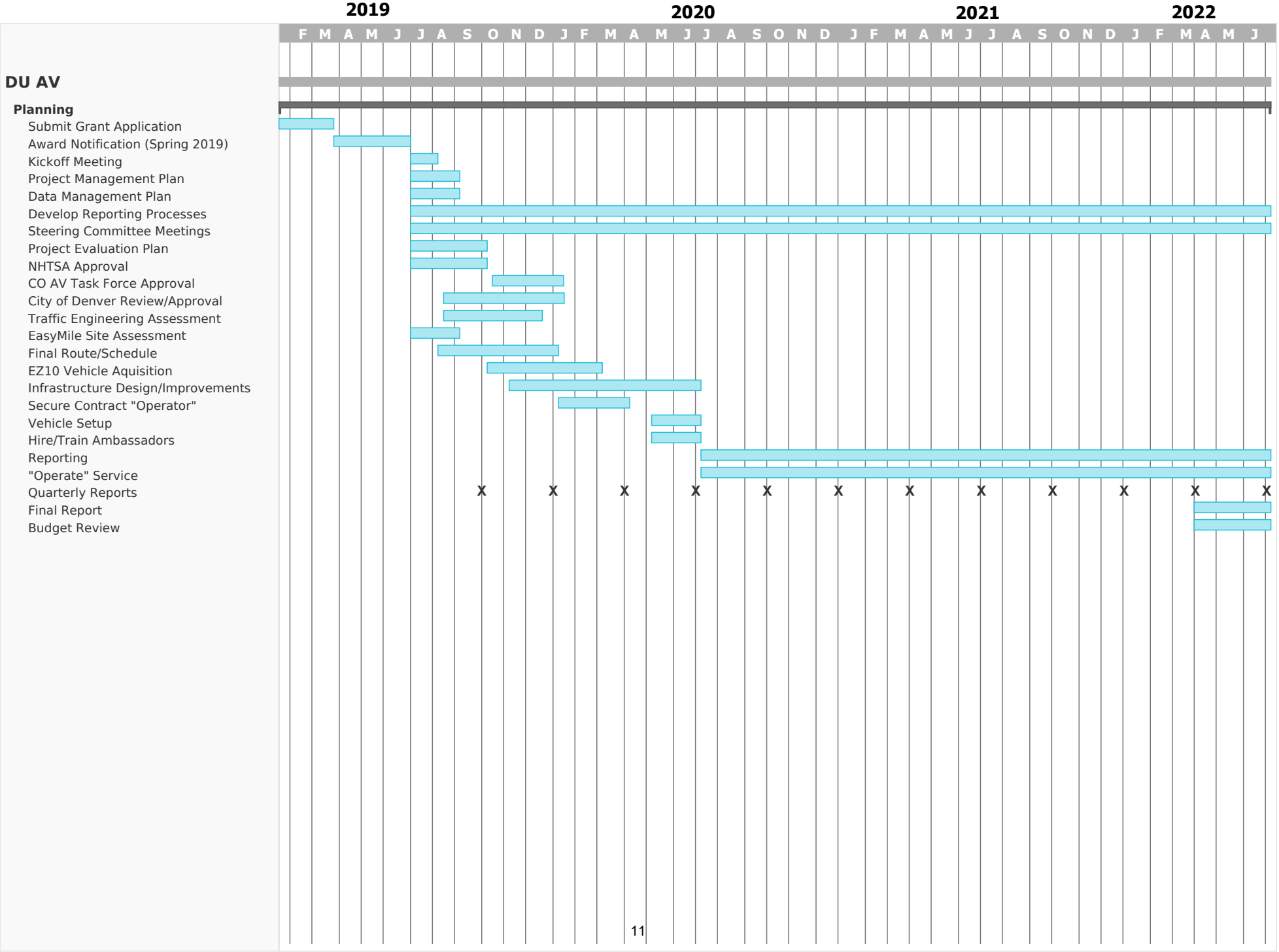


Figure 1: Map of proposed DU AV Shuttle route

Project Schedule



Technical Approach

Building on the approach taken for the successful implementation of RTD's 61AV autonomous vehicle demonstration project, RTD will convene a stakeholder steering committee to oversee and guide the implementation of the DU AV Shuttle. A full description of the members and responsibilities of the steering committee can be found in the Management Approach in Part II.

Based on RTD's experience in implementing the 61AV demonstration project to operate an autonomous vehicle on public roadways in Denver, the steps necessary to operationalize the DU AV Shuttle can be grouped into several very broad categories:

- Regulatory (Federal, State and Local)
- Contractual (external with USDOT and internal between stakeholders and with service provider)
- Operational planning (including traffic analysis and engineering design as needed, development of data capture and reporting processes and development of service delivery processes and procedures)
- Infrastructure improvements
- Operations implementation (including hiring and training of on-board "Customer Service Ambassadors" and implementation of service operations and maintenance processes)
- Marketing and communications (including public outreach and education)
- Market research (to assess consumer perspectives)

Details of the activities to be undertaken in each of these categories are as follows:

Regulatory

Federal Level

The project will be required to get a federal exemption from the National Highway Traffic Safety Administration (NHTSA) to operate an autonomous vehicle on public roads, as no autonomous shuttle complies with the current Federal Motor Vehicle Safety Standards (FMVSS). In October 2018, NHTSA updated their process for granting these approvals and EasyMile was the first to apply and be approved for projects via this new process. EasyMile worked extensively with the federal government during this change process. This is a testament to the level of experience that EasyMile has deploying the autonomous technology around the world, including the 61AV demonstration in Denver. EasyMile is recognized as being a leader in the autonomous shuttle space and they continue to work closely with NHTSA, Federal Transit Administration (FTA), Federal Highway Administration (FHWA), Volpe, and other branches of the federal government as well as with states such as California and Colorado, as driverless regulations are developed and refined.

Lauren Isaac, EasyMile's Director of Business Initiatives, and the co-chair of ITS America's Autonomous Vehicle Taskforce will lead this effort as the updated federal process requires the vehicle importer to submit vehicle and project-specific information. Once the application is submitted, the process is estimated to take 60-90 days. To date, EasyMile has successfully imported all of their vehicles (around 20 vehicles) and received approvals for all of their projects (over 30 project-specific approvals).

Though RTD is familiar with the Buy American Act, the agency is unaware of any domestic supplier of autonomous transit vehicles. It should be noted that RTD will not be purchasing the vehicles used in this demonstration, but rather be leasing them along with other accompanying services from EasyMile. RTD and EasyMile are willing to work with USDOT to address this opportunity within the constraints

identified herein. All supporting infrastructure that will be built using federal funding as part of this project will comply with the Buy American Act.

State Level

In order to provide a state regulatory framework and oversight process for autonomous vehicle demonstrations in the State of Colorado, the state created the State AV Task Force that consists of representatives of the Colorado Department of Transportation (CDOT), the Colorado Department of Revenue/Department of Motor Vehicles (CDOR/DMV) and the Colorado State Patrol (CSP). This group is responsible for reviewing and approving any autonomous vehicle pilot project on public roadways in the State of Colorado. This group will review the proposed routing and procedures associated with any such project with an eye towards all safety related aspects of the proposed project, as well as inspect all vehicles to be operated as part of any such demo project.

The RTD/EasyMile team was the first to complete Colorado's new AV regulatory process via the State AV Taskforce as part of the extensive approval process to launch RTD's 61AV demonstration project. We have every reason to believe that the Taskforce will be supportive of this project and we estimate that this approval process will take approximately 30-60 days. The exact timing of this process is dependent on the timing of the NHTSA approval process as AV Taskforce approval cannot be completed until receipt of NHTSA approval, final site analysis and traffic engineering assessments have been completed, and a final route design has been determined, as the AV Taskforce must review the final route.

Local Level

As the owner and operator of the roads over which the DU AV Shuttle will operate, Denver will also be involved in reviewing and approving final details of the proposed DU AV Shuttle project. As members of the project steering committee, Denver and DU will work with the project team to ensure the traffic engineering elements of the DU AV Shuttle project align with Denver's and the University of Denver's broader mobility goals in the project area. As evidenced by the partnership formed to submit this grant application, these parties have already reached conceptual agreement on the proposed project scope. RTD, Denver, and EasyMIle, as well as other stakeholders, all worked together to navigate the local process during the implementation of RTD's 61AV demonstration project. Denver intends to develop guidance for AV deployment in the public right-of-way, and the DU AV Shuttle will be compliant with Denver standards. The proposed project team will work together to ensure that signage, traffic signalization, and pedestrian and bike movements all work together to enhance safety and overall mobility in the project area and to secure final Denver approval of the proposed DU AV Shuttle demonstration project. It is estimated that this approval process may take approximately 90 days but the actual timeline will be affected by the findings of the detailed traffic engineering review and analysis to be discussed later.

Contractual

The contractual element of this project is essentially a series of technical business-to-business transactions to clarify roles, responsibilities, and funding flows between various participants in the DU AV Shuttle demonstration project. It is currently anticipated that contracts will need to be developed and executed to address the following:

- USDOT/RTD- the contract authorizing, defining, and funding the grant to implement the DU AV Shuttle demonstration project;

- RTD/Service provider- RTD currently has contracts in place with both Transdev LLC and First Transit Corp. to provide contracted fixed route service for RTD customers. Both of these firms have experience providing autonomous vehicle services and both of these firm's contracts with RTD provide the capacity to amend the existing contracts to include provision of additional services. It is anticipated that RTD will enter into negotiations with these firms and amend one of the contracts to include the provision of "Customer Service Ambassadors" and maintainers to provide the DU AV Shuttle service and the provision of appropriate insurance(s) for the service;
- EasyMile – it is currently anticipated that the DU AV Shuttle service will be provided utilizing an EasyMile EZ10, Gen2 driverless electric shuttle vehicle. It will be necessary to execute the appropriate lease/contract with EasyMile to provide the autonomous shuttle vehicles to be used to provide the DU AV Shuttle service. It is currently anticipated that the vehicles will be obtained through a lease to be executed between the selected service provider and EasyMile in order to facilitate a more "turn-key" approach to service delivery during the demonstration project, however the final decision may utilize a different means to obtain the vehicles; and
- If necessary, contracts or Memorandums of Understanding (MOU's) between stakeholders to clarify funding responsibilities and invoicing processes.

Operational Planning

There are a series of technical activities that must be undertaken to ensure that all necessary actions are designed and developed to provide the delivery of safe, reliable, customer focused AV shuttle service. Among these activities are:

The Selection of the AV Shuttle Vehicle

The DU AV Shuttle service will be provided using an EasyMile EZ10, Gen2 driverless electric shuttle. This vehicle will accommodate up to 15 people on board (10 seated and 5 standing), including passengers with reduced mobility (the vehicle has a passenger-activated lift that can be deployed to allow passengers with mobility devices to use the shuttle). The vehicle operates at Level 4 automation (according to SAE J3016) and has no steering wheel or pedals. The EZ10 can navigate autonomously and travel at speeds of up to 15 mph. Over 100 EZ10 autonomous vehicles have been deployed to date and have travelled over 200,000 miles in these deployments. To date, these vehicles have no accidents reported in operations, in either autonomous mode or during manual operation by a trained agent.

EasyMile made the strategic decision to work with an OEM for the design and production of their vehicles. Ligier is a French OEM and the largest European manufacturer of special lightweight vehicles. EasyMile's EZ10 is manufactured by Ligier on a dedicated assembly line in its Vichy's factory. In 2018, Ligier produced over 15,000 electric vehicles. To date, Ligier has manufactured 100 EZ10 vehicles and can assemble up to 3 per week. Ligier, a renowned automotive manufacturer and leader in specialized vehicles, complies

with all European standards and has unparallelled know-how when it comes to setting up production lines for new vehicles. Ligier established a dedicated EZ10 production line that follows automotive industry best practices. As a result, EasyMile is benefiting from Ligier's expertise in assembling vehicles and in managing the supply chain with respect to the spare and replacement parts required for maintenance and operations. EasyMile can therefore rely on economies of scale for standard parts, in addition to an excellent delivery quality.

Working in close collaboration with Bosch and Continental, two established sensor and automotive industry equipment suppliers, EasyMile is testing and integrating the latest components available on the market to stay ahead of the market and the competition. Similarly, EasyMile has established strategic partnerships with leaders in their respective fields, including, for example, Continental, Bosch, Lacroix, Nokia, Ericsson and Panasonic. These partnerships have enabled EasyMile to develop and deploy innovative solutions based on market needs.

Similar to complex transportation systems like commercial aircrafts, EasyMile has equipped the EZ10 shuttle with multiple layers of redundancy in order to maximize the safety of the passengers, other road users and the vehicle itself.

- Redundant coverage by sensors
- Independent obstacle detection function
- Fail-safe and redundant braking system
- Redundant industry-grade emergency buttons

All of these aspects have enabled EasyMile to obtain approval by authorities all around the world to drive on complex, public roads.

Braking safely is crucial. This is especially important in a campus environment such as DU. The EZ10 is equipped with several independent braking systems.

- During normal operations the autonomous system can change its speed to smoothly decelerate, using the regenerative braking system. For harder deceleration, the system, can also use the electrical calipers.
- In case of an Emergency Stops (e-stops) the autonomous system uses all the previous braking systems but also the hydraulic braking.
- In case of complete power loss, or when the vehicle is turned off, fail-safe brake is automatically activated.

This architecture mitigates the risk of failure in two braking systems and even a failure in the battery system that would lead to complete loss of electric power.

In case of an emergency situation, passengers on the EZ10 shuttle can trigger an Emergency Stop using one of the three E-Stop buttons strategically located inside the vehicle. Those buttons are continuously monitored by the PLC in such a way that if an error is detected, an E-Stop is automatically triggered by the vehicle. This monitoring can prevent a short-circuit, for instance. A Customer Service Ambassador (CSA) will also be on-board the vehicle at all times to answer customer questions and ensure the vehicle is operating safely

Since its inception, EasyMile has been working closely with the global leaders in transportation operations, receiving day-to-day feedback to improve the passenger experience. The EZ10 fully meets the quality and safety criteria for people transportation. The vehicle's subway-like sliding doors, anti-slip flooring, and hand grips are all sourced via leading suppliers within the public transportation industry.

Additionally, the vehicles are equipped with fire extinguishers, emergency hammers and can be fitted with seat belts upon request. Passengers can contact the supervision center by pressing the emergency button at any time during their journey.

EasyMile uses a variety of methods to ensure a high level accuracy for passenger counting.

- EasyMile uses passenger counters based on calibrated weights (this data is updated every half second)
- EasyMile uses the internal video cameras passenger counters
- EasyMile can also use the industry leading IRMA MATRIX, an Automatic Passenger Counting (APC) sensor with high resolution

The EZ10 is equipped with passenger rail and transit standard automatic doors, with a key locking system and an internal and external emergency unlocking system. The sensitive edges reopen the doors if an obstacle is detected to avoid any pinching. Door opening and closing is controlled via the green button inside and outside the vehicle or it can be programmed based on location or timing. This button is also touch-sensitive and incorporates braille for people with impaired vision. Accessibility for all is a priority for the acceptance of new, innovative transportation systems shared by the public. A simple touch on the blue button will automatically deploy an access ramp to help passengers entering or exiting the shuttle. Buttons are located on the inside and outside of the vehicles.

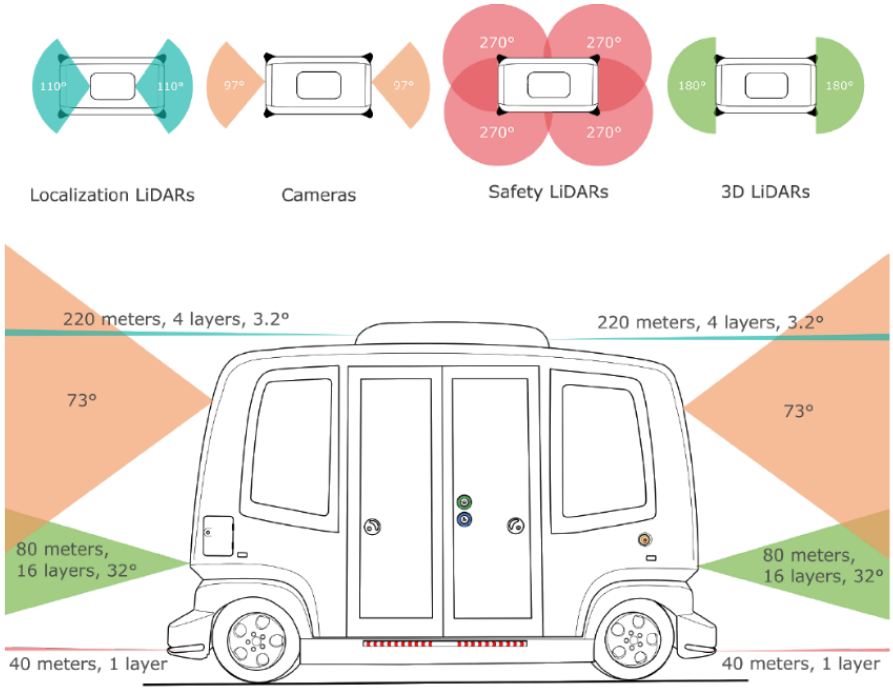
The EZ10 shuttle vehicle is equipped with both air conditioning and heating systems to offer passengers optimal comfort in all operating conditions. Air conditioning and heating may be adjusted using a touch screen inside the vehicle. The vehicle's interior has been designed by a professional team of designers from the automotive industry. The anti-slip floor, mat plastics, wooden chairs and hand grips from the transportation industry illustrate the extremely high level of quality. The EZ10 can also be equipped with wheelchair anchors points. The 6 seats and 2 stand-up seats made of wood configuration accommodates 8 seated passengers and 4 standing passengers. A 2-bench and 2 stand-up seats configuration accommodates 10 seated passengers and 5 standing passengers. The EZ10 has 8 USB chargers throughout the interior of the shuttle offering passengers the possibility to recharge their equipment.

The EZ10 shuttle vehicle is equipped with a 29" internal information screen in the vehicle to provide information including audible and visual alerts to passengers about their journey, including progress, next station, arrival time, etc. The screen can also be used to broadcast media, advertisements, explanatory videos and other media as per our customer needs, synchronizing with the vehicle localization to enhance passengers' experience.

EasyMile AV Technology

The EZ 10 shuttle vehicle is equipped with the latest EasyMile autonomous technology in order to ensure safe operation of the DU AV Shuttle. The EasyMile vehicles are equipped with the technology needed for the vehicle to know where it is located, where it is going and how to get there, and what the environmental conditions are and how to adapt behavior.

The EZ10 is preprogrammed by EasyMile engineers or certified partners to run on predefined routes or network of routes, under certain circumstances. To do so, all EasyMile's vehicles, including the EZ10 are Level 4 according to the SAE definition of Driving Automation Systems for On-Road Motor Vehicles - J3016_201806. A Level 4 system is an Automated Driving System (ADS) that can itself perform all driving tasks and monitor the driving environment – essentially, do all the driving – in certain circumstances.



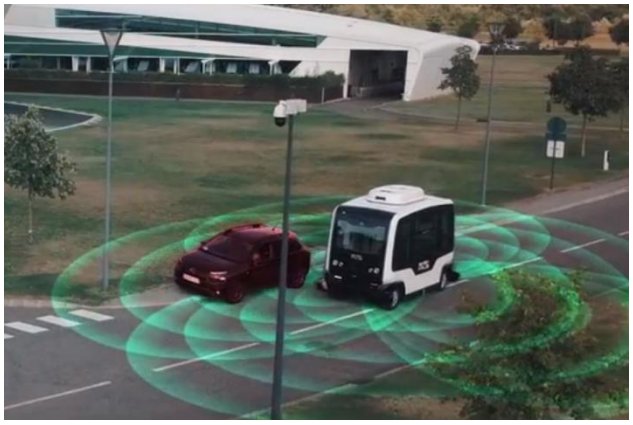
The EasyMile software has been designed to know the vehicle's exact position with centimeter-level precision, at all times. The software can obtain this level of precision through lasers scanning the environment, cameras, differential GPS, visual location, estimation using an Inertial Measurement Unit (IMU) and odometry estimation. Each of the technologies are described in more detail below.

Environmental Laser Scanning - LIDARs

The EZ10 is equipped with several different LIDARs to ensure redundancy in information collection. The first is LMS, also called Safety LIDARs. There is one at each corner of the vehicle (four total) strategically positioned 12 inches above the ground. They have a range of 130 feet and 270 degrees of horizontal scanning. They are single layer LIDAR and used for obstacle detection by high-level software and the Safety Chain as well as for navigation.

There is currently no certified LIDAR on the market, which is why EasyMile has chosen to include redundant sensor coverage sourced from different suppliers. This architecture mitigates any risk of failure of a single sensor. The four LIDARs, each scanning 270°, located at each corner of the vehicle, offer a 360° redundant perception of the environment. Any obstacle within 130 ft of the EZ10 will be detected by at least 2 to 3 LIDARs.

The next sensor type of sensor are LDRMS, also called Localization LIDARs. There are two of these sensors strategically positioned on the roof of the EZ10 to detect fixed elements in the environment (buildings, statues, tree trunks, signs, streetlights, etc.) without being disturbed by moving elements in the environment that are usually smaller and that will not be in the sensor's field of view (pedestrians, cars, bicycles, etc.). The sensor has four (4) layers, a range of 720 feet, 110 degrees of horizontal scanning, 3.2 degree vertical opening, and is used for navigation by the high-level software.



The final sensor type is VLP16, also called 3D LIDARs. There are two of these LIDARs on the EZ10 - one at the front and one at the rear of the vehicle. The LIDAR has 16 layers, a range of 260 feet, 180 degrees of horizontal scanning, 32 degree vertical opening, and is used for navigation and obstacle detection by the high-level software.

Cameras

The EZ10 is equipped with indoor and outdoor cameras. EasyMile completes the development and validation of the use of these cameras for navigation and environmental detection.

Differential GPS

The EZ10 is equipped with a global navigation satellite system (GNSS) antenna from the Canadian manufacturer Novatel. This antenna allows the EZ10 to find its way through space thanks to the constellations of GPS, Glonass and Galileo satellites. EasyMile also uses the services of a GNSS - Real Time Kinematic correction provider referred to as “SmartNet” to refine the vehicle's position, with centimeter accuracy. GNSS corrections are received via the 3/4G network, and are determined using a set of SmartNet reference bases. They do not require the installation of an additional reference base dedicated to this project, which are often problematic and vulnerable to cyber attacks.

Inertial Measurement Unit (IMU)

The EZ10 is equipped with an inertial unit capable of integrating the vehicle's movements (acceleration and angular velocity) to estimate its orientation (roll, pitch and heading angles), linear velocity and position.

Odometric Estimation

The EZ10 has sensors on the wheels to measure the vehicle's movement. Odometry is based on the measurement of wheel movements to reconstruct the overall movement of the vehicle. Starting from a known initial position and integrating the measured displacements, the current position of the vehicle can be calculated at any time.

Software Architecture

The processing power needed to run an autonomous vehicle is huge. There is no certified processing unit with enough computing power to enable obstacle detection functions. The EasyMile approach is based on adding an independent safety layer: the Safety Chain**.** This architecture mitigates the risk of

processing unit failure (due to hardware or operating system fault). By design, the EZ10 is composed of two main levels:

- An industrial-grade computer with a tailor-made version of Linux enabling better control of processing and cyber-security than commercial OS (Operating Systems). Complex filtering algorithms are embedded on this computer to monitor obstacles around the shuttle, calculate collision probabilities and adapt its behavior accordingly.
- A Safety Chain based on a certified PLC (Programmable Logic Controller) is independent from the main computer. It uses very simple algorithms and can perform emergency stops should the main computer fail to anticipate the potential collision.

The PLC used in the Safety Chain is SIL3 certified (according to IEC 61508 Functional Safety standard) and PLe certified (according to ISO 13849 “Safety of machinery - Safety-related parts of control systems” standard). The PLC performs the following tasks with a high safety level inherent to its certification:

- Continuous monitoring of critical components (such as steering and traction controllers, braking systems, LIDAR sensors, emergency buttons, main computer, etc.)
- Triggering of an emergency stop, in case of Safety Chain, emergency button activation or detected failure of monitored components. This will enable to ensure that vehicle and its passengers are safe.
- Safe Door and Automatic Ramp management (opening and closing) - one of the most critical function in transportation systems because of potential injuries, failures, and unavailability.
- The PLC outputs are always considered with the highest level of priority over the other robotics, electronic or computer systems. In case the PLC encounters a failure, its certification level ensures that it will reach its fail-safe state. In this state, our fail-safe brake will be automatically activated to enable vehicle to stop.

EasyMile has developed its own Fleet Management system called EZ Fleet which is able to handle a fleet of any type of autonomous vehicles based on real field data from the ongoing projects around the world. The EZ Fleet is the electronic brain of the whole system. It is designed to be flexible and modular, so as to enable different operating scenarios and to adapt to the various needs of our customers.

To travel autonomously, the AV shuttle vehicle runs along a pre-programmed route designed by a deployment Engineer through a known environment. Thanks to localization techniques, the vehicle knows its position on the route and moves from one station to another following its trajectory.
During deployment, the engineer makes an acquisition by driving in manual mode with the vehicle (trajectory, environment, GPS position, etc.). This acquisition is then cleaned, the trajectories reworked to be comfortable for passengers, and serves as a reference map for the vehicle during operations. This map contains the programmed speed for each road section, the activation of the indicators or bell if necessary, the presence of red lights, traffic signs (Stop, Yield, etc), stations, etc.

The high-level software collects, fuses and interprets data from the above-mentioned sensors.
In particular, a technique called S.L.A.M (Simultaneous Localization And Mapping) laser, consists in measuring the distance from surrounding objects and thus makes it possible to create a mapping of its environment. This system requires sufficient "hang points" for the laser detectors that are used to locate the vehicle in its environment. The environment around the roads planned for the EZ10 in the provision of the DU AV Shuttle service for RTD is very rich in "hang points" for LIDAR localization. The fusion of data from the various sensors ensures redundancy and robustness in the vehicle's localization, with the weak points of one system being compensated by the strong points of the others. The presence of trees

on the route, or indoor traffic are excellent examples of situations where GNSS coverage will be very low or non-existent. The system is then able to detect that the uncertainty related to GNSS information is too high (0 or very few satellites detected when the vehicles normally detect between 10 and 15) and to reject the information from this sensor. The fusion of data from the other sensors is good enough, so the vehicle will continue to run without any problems.

Several types of intersections can be programmed along the EZ10 route, where the vehicle slows down or stops depending on the situation, in order to scan the environment and decide to continue. In all circumstances, the obstacle detection functions described above remain valid. At a Stop or Yield intersection, EZ10s are able to scan the environment and take the decision to cross the intersection when the area is free. Like Yield intersections, EZ10s are to scan a pedestrian crossing and make sure there is no pedestrian crossing or about to crossing before going through. This is extremely important in environments such as the University of Denver campus with high pedestrian volumes.

Vehicle to infrastructure (V2I) communication is a key component of EasyMile's technology. The EZ10 can communicate with traffic signals via a communication network (DSRC, ITS-G5, 3G, 4G, or 5G networks) and with other infrastructure (e.g., railroad crossings), as needed. The ultimate goal is to leverage these technologies in order to introduce more complex traffic situations without human intervention. The EZ10s can read SPaT messages broadcasted by traffic light controllers to determine the Phase and Time of the light, and take the decision to cross or stop at the intersection. To do so, the EZ10 can be equipped with an OBU (On Board Unit) that can communicate using short range communication technology with traffic light controllers equipped with RSUs (RoadSide Units). EasyMile already has an extremely good relationship with V2I equipment suppliers, and can incorporate their technology.

To maximize safety, the obstacle detection features are divided into two independent subsystems: anti-collision software and a safety system. These modules are based on various sensors and LIDAR systems to detect obstacles on the road and safely control braking or stopping. The redundant layers of sensors and control units therefore guarantee maximum safety if a component fails. The braking capacity and speed of the vehicle are taken into account to evaluate whether the observed object risks causing a collision. This module uses complex filter algorithms.

This software module is based on the different LIDARs on the vehicle to slow, brake and stop the vehicle when an obstacle is perceived on the path, before calculating a circumvolution strategy. The braking capacity and speed of the EZ10 are taken into account to determine whether the perceived object is likely to cause a collision.

When an obstacle is detected in the detection area covered by the vehicle, the vehicle reacts according to the position and distance of the obstacle:

- If it is located in front of the vehicle, on its trajectory, the vehicle slows down. The distance from which the vehicle begins to slow down depends on its speed. The closer the EZ10 gets to the obstacle, the slower it slows down, until it stops completely if necessary.
- If it is located on one side of the vehicle, the EZ10 also slows down, but reaction distances are reduced.
- If it is located at the rear of the vehicle, the EZ10 does not take it into account.

The stopping time of the vehicle, following the detection of an obstacle, depends on its speed. The higher the speed, the more the vehicle anticipates its stop and begins to slow down early.

Sometimes when in operation, the predefined route (trajectory) can be blocked by a parked car, construction, fallen tree etc. Within a preprogrammed area, defined during the Setup by the deployment engineer based on the Site Assessment Report, the EZ10 is able to accurately assess this hazard, and if it is safe to do so, perform an overtake of this hazard. Following the successful overtake of the hazard, the EZ10 is able to resume normal operations.

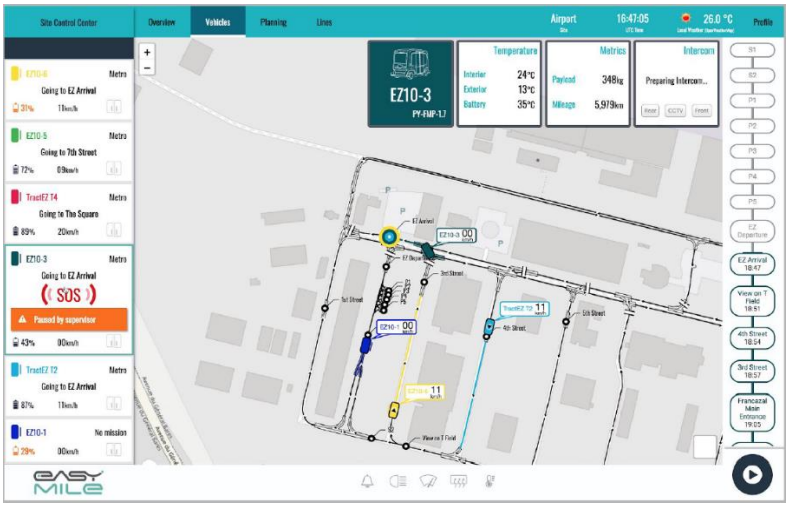
In the event that an obstacle is suddenly detected in the vehicle's safety zone in front of it or its side while running, the Safety Chain triggers an emergency stop. This happens, for example, if a pedestrian suddenly crosses in front of the vehicle or a car rapidly leaves a parking spot just in front of the EZ10. During an emergency stop, the vehicle is programmed to strongly decelerate in order to stop the vehicle quickly, but with minimal risk of the passengers falling.

EZ Fleet Modules

On the EZ Fleet interface, the supervisor will be able to see all vehicles on the sites, their position, assigned routes and destinations, as well as several vehicle parameters such as the inside temperature, the batteries state of charge, the weight etc. The EZ Fleet enable every interactions between the vehicle in operations and the Control Center.

Dynamically assign missions, adjust headway, send a vehicle to the charging point, switch between fixed route and on-demand, EZ Fleet optimize the organization of the autonomous vehicle fleet. Traffic jams on some streets, ongoing construction work blocking a road, those elements can be received and integrated into the EZ Fleet to minimize the impact on service quality.

An example of this in use would be, if an emergency stop be triggered, the supervisor can directly get in touch with the passengers accessing the CCTV camera and speakers to provide guidance. Both the front and back cameras are accessible from the interface to assess the vehicle environment. The passenger screen can also be used to push messages from the control center, for instance to provide geolocalized information, emergency procedures, next stops and ETA etc.



The EZ Fleet provides insightful and meaningful data to improve the overall operations. This module gathers information from the vehicle, site and operations and creates automatic daily, weekly or monthly operating reports. Reports can be fully customized based on customer needs. RTD and EasyMile will collaborate to gather data and develop final reports as addressed elsewhere in this proposal.

EasyMile will provide a web-based app that the Customer Service Ambassadors are required to use in order to operate and manage their vehicles. This highly-secure and flexible app provides real-time information regarding the vehicles' position, status, routing assignment, etc. and it enables the ability to

manage on-demand requests and remotely stop or re-arm the vehicle. It can also provide diagnostics in case of vehicle errors and will connect to the EasyMile HelpDesk, if needed.

EasyMile can provide operational information regarding the vehicle's status via different API options. The Position API allows third parties to access the vehicles' positions on a site at all times. This can provide valuable data location information via an organization's website, trip planning app, or other integrated information source. RTD IT staff and EasyMile staff worked together to implement this functionality in RTD's 61AV demonstration project in order to provide real time information to RTD customers through RTD's NextRide program. It is anticipated that this functionality will be incorporated into the proposed DU AV Shuttle service.

More complex than the Position API, the Monitoring API allows our partners to collect operational data to monitor operations as well as develop their knowledge about autonomous vehicle operations. The Monitoring API provides access to various data including current position, speed, battery level, external/internal temperatures, and number of passengers. It is anticipated that this functionality will be incorporated into the DU AV Shuttle service as proposed.

Cybersecurity

Because safety comes also with security, cybersecurity is a main focus throughout the entire product life. As safety aims at protecting the system from accidental failures in order to avoid hazards, cybersecurity focuses on protecting the system from intentional attacks. Safety and security share a common objective of reducing risk. A strong cybersecurity culture is one of EasyMile's fundamental management principles so each individual has the proper attitude, approach and commitment at all levels in the organization

In order to protect the safety of the passengers and of anyone around EasyMile vehicles, and to protect EasyMile and clients from financial or reputational damage, one needs not only to ensure that EasyMile's software stack is behaving correctly in normal circumstances but also that all systems are protected from malicious attacks or unauthorized access which would affect their ability to behave safely. Protecting systems means not only to ensure that vehicles and fleet management solution are generally safe from cyber attacks, but also to prevent any breach upstream by securing as much as possible access to any of the systems. That's why in order to keep EZ10 hardware and the software running on the vehicle itself, and in the Cloud during normal operations safe, a wider perimeter than just the vehicle need to be protected, which goes all the way product lifecycle.

The EasyMile Cybersecurity approach includes the vehicle itself, the vehicle's OS, vehicle-to-Cloud communications, Cloud infrastructure, information systems, employees' physical assets and security audits and penetration tests. International standards for autonomous vehicle security are not yet available, as this domain is relatively new. Therefore, EasyMile strongly inspired its best practices of Standard SAE J3061 which defines the cybersecurity for conventional vehicles. These best practices cover organizational and technical aspects of vehicle cybersecurity, including governance, risk management, security by design, threat detection and incident response and recovering. EasyMile also works with government agencies, cybersecurity experts and security research communities to maintain and advance our cybersecurity capabilities. They aim to implement the ISO 21434, Road Vehicles — Cybersecurity Engineering, which publication is scheduled for end 2019.

Site Assessment Report

Before the autonomous shuttle vehicles arrive on-site, one of EasyMile's experienced deployment engineers will identify and document all potential risks and mitigation strategies along the proposed route. Based on these findings, the EasyMile team will develop a Site Assessment Report, which summarizes EasyMile's requirements and recommendations for the site/route, and gives the scope and conditions of the AV operations on this specific site/route. A preliminary site assessment report has been conducted in order to prepare this grant application, however it is appropriate to conduct a more detailed site assessment as part of the project activities.

The team will review the findings with the RTD, Denver, and the steering committee, assess the feasibility of the proposed routes, and ensure that all of these observations and recommendations are appropriately addressed prior to finalizing the vehicles' route and operating profile. This site assessment will provide baseline data and will be an input into a broader traffic engineering assessment of the proposed route and operating profile to be discussed further below.

Traffic Engineering Review and Analysis

A traffic engineering consultant will be engaged to review and analyze the existing street network, existing traffic signage, traffic signalization, traffic counts and movements, pedestrian counts and movements, bicycle counts and movements, and the proposed AV shuttle route and to undertake updated data capture and analysis as may be required. The objective of this analysis is to determine what, if any, infrastructure improvements may be needed to safely and effectively implement the proposed DU AV Shuttle. Possible infrastructure improvements might include things such as AV stop improvements to ensure ADA accessibility to the DU AV Shuttle service, traffic warning signage that warns drivers of slow moving vehicles along the route, curb line adjustments, changes to traffic signalization and/or other traffic signage (stop signs, etc), and roadway striping. The study will also evaluate impacts to on-street parking, the interface between pedestrians at designated crosswalks, "social path" crossing without signal control, and opportunities for vehicle to infrastructure communications actions. This analysis, and any resultant infrastructure improvements will be an input to approval by both the State AV Taskforce and Denver as well as to RTD's safety assessment as part of RTD's SMS approach to service delivery. While a sufficient amount of work has been done prior to the submission of this proposal to ensure the viability of the route as proposed and described earlier in the document, this traffic engineering review will assess the route in greater detail to validate all aspects of the project to ensure the safe implementation of the DU AV Shuttle. The outcomes of this task will include the identification and design of all infrastructure improvements necessary to ensure the safe and effective implementation of the project. The findings of this review and assessment will provide the guidance to undertake any infrastructure improvements for this project. The time needed for this review and analysis as well as the time needed to implement any appropriate infrastructure improvements identified will have a major impact on the timeline of this project. Based on initial review, we have projected 90-120 days for the review/analysis and design of improvements, and approximately 7-8 months for implementation of infrastructure improvements (to be discussed further below). Both RTD and Denver have on-call traffic engineering consultants, and the project group would plan on engaging one of these on-call consultants to perform the engineering review.

AV Shuttle Schedule Development

Another element of the operational planning phase of the project will be the development of the final operating schedule for the DU AV Shuttle. While sufficient preplanning work has been done to

determine that the service can provide 15 minute service frequency using three (3) AV shuttle vehicles (with a fourth as a backup), it will be necessary to determine exact running times and time points at the various stops along the route to ensure that the AV shuttle service integrates appropriately with RTD's light rail service at the nearby University Light Rail Station.

AV Shuttle Vehicle Delivery

EasyMile has developed an expertise in managing the global shipping and delivery of the EZ10s and will arrange for the shipment of the vehicles from Francazal (EasyMile's test and quality assurance site) to the operating and maintenance facility for the DU AV Shuttle project. EasyMile will coordinate with RTD to be sure that appropriate personnel and equipment are available on-site to ensure that vehicles are safely and efficiently unloaded from the container(s).The EasyMile team will ensure that a staff person is on-site to unload the vehicles and validate the vehicle and all associated technology have shipped safely and is assembled appropriately. The EasyMile staff person(s) will ensure the latest software updates have been installed and confirm the vehicle is ready for operations.

Operational Policies and Procedures

Building on the work done for RTD's 61AV demonstration project, RTD and EasyMile will work with the selected "operator" to refine operating policies and procedures to guide the provision of service during the DU AV Shuttle project. Areas to be addressed include:

- Processes at the beginning and end of each service day
- Communications processes
- Emergency procedures
- Safety and security policies and procedures
- Accident and incident procedures
- General AV operating procedures
- Operating procedures for inclement weather
- Responding to AV service interruptions
- AV Maintenance procedures
- Customer service policies and procedures
- ADA policies and procedures
- AV service replacement procedures (if AV is unable to perform due to environmental/safety/ADA-related reasons)

Training Program Development

The objective of the training program for this project is to transfer the knowledge and skills needed to conduct the 'day to day' operations of the AV shuttle and the knowledge and skills needed to deploy and maintain the AV shuttle vehicle. As was done for the deployment of RTD's 61AV demonstration project, RTD and EasyMile will work with the selected service provider to ensure that all persons involved with the project develop the necessary knowledge and skill set to ensure the safe and efficient provision of the DU AV Shuttle service. A full description of RTD's training approach can be found within the Staffing Approach section in Part II.

AV Service Replacement Procedures

RTD will deploy an ADA equipped body-on-chassis vehicle to serve as a back-up vehicle should it be necessary to provide service with a non-AV vehicle for any reason. Existing procedures for the 61AV

shuttle project will be modified appropriately to ensure that all parties are familiar with the process for determining when such a replacement will take place and how to go about introducing the replacement service.

Data Capture and Reporting Processes and Procedures

Building on the work begun during the implementation of RTD's 61AV demonstration project, EasyMile and RTD will continue to develop and refine the capture and reporting of data relevant to the DU AV Shuttle project. A full description of RTD's data capture and reporting processes and procedures can be found in the Draft Data Management in Part III.

Infrastructure Improvements

The activities included in this phase of the project consist of the implementation of desired infrastructure improvements identified during the site assessment and detailed traffic engineering review and analysis mentioned above. Currently identified infrastructure improvements include AV stop improvements to meet ADA bus stop accessibility guidelines, reconfiguration of the traffic signalization at the corner of High St and Evans Ave as well as possible implementation of vehicle to infrastructure communications capability at this intersection, the potential installation of traffic warning signs to advise motorists, bicyclists, and pedestrians of slow moving vehicles in the service area, and possible adjustments to existing pedestrian crossing facilities. Additional improvements may be identified during the final AV site assessment and detailed traffic engineering review and analysis mentioned above. The timeline for this phase of the project is expected to be a minimum of 90 days and will be adjusted based on the outcome of the assessment, reviews, and analysis. The timeline for traffic engineering infrastructure improvements will impact, and essentially determine, the overall timeline for the project.

In addition to traffic engineering infrastructure improvements, it will be necessary to construct a storage facility for the AV shuttle vehicle to keep the AV vehicles in good condition and minimize curative maintenance tasks. It is planned to construct a simple facility (Tuff Shed or minimal "Butler building") that will provide overnight storage and charging of the vehicles, provide space for minimal storage of operating supplies, and an area for Customer Service Agents (CSA's) to check in and out at the beginning and end of each service day. This facility will be located either on the DU campus near the route or on RTD property near University Station. The traffic engineering assessment will analyze the impacts of these locations and make a final recommendation as to the location of the facility. Requirements for such a facility include being located within 400 feet of the route, having electricity and charging equipment, WiFi connection, a closed shed or garage, 215 square feet per vehicle for storage with a minimum height and width of 10 feet and a load capacity of 2 tons. The facility will be equipped with an

EV charging station - “Home Wallbox”, with Type 1 (SAE J1772) or Type 2 (IEC) connector. The charger will be capable of charging with at least 32A. Should the installation of a Home Wallbox not be possible, the EZ10 will be charged using a domestic plug, and a Portable EV Charger, with Type 1 (SAE J1772) or Type 2 (IEC) connectors.

Alternative EV charging products may be provided, if validated. EasyMile is currently testing a wireless charging solution. It is envisioned that wireless charging will be the first step to an automated charging solution where no human intervention will be needed to drive the vehicle to the charging station and plug it. This is designed so the vehicle can be programmed to reach the closest available charging station when reaching a certain level of battery. This will be managed directly through the Fleet Management System called EZ Fleet. This fleet system can also assign a specific charging station to a specific vehicle whenever needed.

Operations Implementation

AV Vehicle Setup and Reference Map Creation

Once the AV vehicles are on site, a trained EasyMile deployment engineer will manually drive the EZ10 on the agreed-upon routes with the purpose of “pre-learning” its possible routes and operating environment. The vehicle creates a “reference map” that represents all the routes and the site environment. Every intersection and station is defined in this map, speed limitations and the use of bell/indicators are programmed so the EZ10 knows exactly what to do and where. This process enables the AV vehicle to know its exact position by comparing its perceived environment to the “reference map.” Once the map and trajectories have been validated with one EZ10, the deployment engineer is able to transfer the information to the rest of the fleet and test with all the vehicles.

Setup Acceptance Certification

Once the vehicle and site are set up and ready for operations, EasyMile will review everything with the RTD and the rest of the project team to ensure that it is to their satisfaction. At that point, EasyMile will ask the RTD to sign a “Setup Acceptance Certificate” confirming that all aspects of the vehicles and operations are set up according to the initial EasyMile Site Assessment Report as well as the findings of the subsequent traffic engineering review and analysis.

Recruitment and Training

It is anticipated that the current service plan will require a minimum of twelve (12) Customer Service Ambassadors to operate. In order to provide flexibility of scheduling for CSA’s, it is expected that approximately 18 CSA’s would be hired and trained. Based on experience from the 61AV demonstration project, it is anticipated that the CSA’s would be recruited/selected from among the existing workforce of fixed route operators at the existing RTD contractor selected to provide the DU AV Shuttle service. Training requirements would therefore be focused on the AV technology and the particular service plan for the DU AV Shuttle, as the CSA’s would have already received training in the operation and “culture” of providing transit service to the public. Accordingly, it is expected that training would take approximately 24 hours per CSA. The timing for training activities would take place during the month leading up to service implementation.

Marketing and Communication

Automated vehicles are new concept for most Denver residents. Fears about safety and how to navigate around a driverless vehicle requires an effective public education effort that offers information for

people about the technology, how to use it, and provides guidance on how to share the road with automated vehicles. The campus setting for vehicle operations is challenging from the perspective that there is a large volume of pedestrians, especially between classes. Teaching students, faculty, staff, and nearby residents will be a project priority.

Transportation Solutions Foundation (TSF), the designated Transportation Management Association for southeast Denver will lead the public education, marketing, and community relations segment of the pilot project. TSF has been working in the area for 22 years and has strong standing relationships with employers, resident groups, and all parts of the campus community.

TSF, in coordination with the project team will develop a marketing plan for the project. The plan will include the development of a brand identity, messaging, and tactics for both informing people about the pilot and motivating people to use the service, especially when accessing RTD's light rail station. All university students, staff, and faculty are provided an RTD CollegePass which allows for unlimited usage of RTD's transit services.

The marketing plan will address:

- Digital Marketing
    - Sponsored Facebook Ads
    - Snapchat filters for:
        - SIMS to use at tabling events
        - Riders to use while using the AV shuttle
    - Email communications. TSF maintained an email list of over 6,000 residents, students, employees and others from the area.
    - Partnerships, such as Way to Go Program to share posts, etc.
    - Information on the DU, TSF and City and County of Denver websites
- Field Marketing
    - Tabling in centralized areas
    - Perimeter targeting (nearby restaurants, grocery stores, student center)
    - Grassroots
        - Door hangers at nearby multi-family and senior housing
        - Community events
        - Flyers to individuals within 0.25 miles of the service route
- Other
    - News Releases – It is important to provide news organizations with a news release or media advisory to alert them to any timely event or information relevant to the pilot.
    - Earned media:
        - Local newspapers
        - Radio
        - TV News channels
        - Blogs (i.e., StreetsBlog)
    - Mailers
- Incentives (note that federal funding will not be used for any prizes or incentives; these will be funded directly by TSF using private funds). Three types of incentives include:
    - Try incentives – to ride for the first time (i.e., merchant tie-ins)
    - Maintenance incentives – rewards, recognition, frequent users prize drawings
    - Transit passes – many people who live and work in the area have not used transit, providing passes to individuals who do not have a College Pass and challenging them to

take the AV shuttle to the RTD LRT station and go downtown or to the airport would be a good way to engage the public.

Research

The University of Denver will lead the research component of the project. The University has the capacity to develop and conduct market research to assess the perspectives and reactions of people impacted by the provision of the DU AV Shuttle service. DU intends to research four specific areas of study. This includes a market research study assessing the human impact of the DU AV Shuttle, the change in student travel patterns and behavior with the implementation of an autonomous vehicle, AV technology's role in improving safety, and the development of a prototype cyberinfrastructure to improve safety analysis of emerging technologies.

The Consumer Insights and Business Innovation Center (CiBiC) housed in the Daniels College of Business provides valuable information on technology adoption and potential for economic viability. This laboratory provides supervision to graduate-led research teams who explore questions related to human behavior and its impact on market offerings. This research group is prepared to provide longitudinal consumer and market insights into the demonstration by conducting personal interviews and online surveys, followed by focus group sessions to provide consumer and market insights. These will focus on willingness to use and attitude toward AV shuttle services, seeking to understand any barriers and challenges to use.

Additional existing research initiatives among Geography faculty focus on college student travel patterns and behavior, and how they change as a result of exposure to new modes of transportation. Dr. Andrew Goetz of the University of Denver is working with researchers at the University of Illinois at Urbana-Champaign and Macalester College in Minneapolis to investigate this topic. The researchers will collect extensive data about student travel, including mode choice, geographic patterns of travel, travel distance, trip purpose, and other factors to establish profiles of student travel behavior. These data will be augmented by intensive survey data to gain a deeper understanding of why students make their travel choices, what factors are most important to them, and how their travel experiences have changed as a result of their college environment. The introduction of the AV demonstration pilot will be an important element of this research project. Graduate students and undergraduate courses will be involved in conducting this research.

Expertise in electrical engineering and computer science coupled with geospatial studies provide a unique opportunity to contribute to technical advancements in collaboration with the AV vendor research team. This includes communication and data management for holistic traffic management to improve safety. The growing use of vehicular wireless communications, including mobile WiMAX and 5.9 GHz dedicated short range communication (DSRC), enables autonomous vehicles to communicate with other vehicles as well as with the traffic management authority in real-time. Such real-time information sharing enables increased situational awareness to act upon the dynamics of traffic condition. AVs can gain a good understanding of present traffic conditions, identify the fastest path to get to their destinations, and become aware of potential hazards. The proposed research builds upon the emerging vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication capabilities and introduces a traffic management framework through a holistic traffic signal control. In this project, we

propose a hierarchical operation framework for optimizing traffic signal settings based on a multi-agent system (MAS), which is scalable, efficient and implementable for applications in a large-scale transportation system. MAS, an integration of cognitive agents, provides a reliable solution to the real-time intelligent control of complex transportation systems. The proposed MAS operation is divided into two stages. Traffic signal setting at inter-area intersections, and AV decision making. AVs solve a local problem with moderate computational complexity for real-time application. This decentralized optimization mechanism strikes a balance between optimality and timeliness by making coordinated distributed decisions.

Finally, DU proposes the development of a prototype cyberinfrastructure (CI) to address the needs of managing, visualizing and analyzing data for community users. The CI will capture both static (e.g., roads, community boundaries) and dynamic (e.g., GPS tracking information of vehicles, weather, and traffic signals) data. Key techniques and methods to build the CI encompass cloud computing, high performance computing, Artificial intelligence (AI), Augmented Reality (AR) and data fusion. DU will perform safety analysis because safety is the highest priority to be considered for all transportation operations. The proposed CI can manage V2I data and other contextualized data in a coherent way, provide interactive visualization capabilities to enhance the interoperability among the physical transportation system for both planners and riders, and further support intelligent safety analysis using V2I data.

PART II – Management Approach, Staffing Approach, Capabilities

Management Approach

As RTD has already successfully implemented an AV shuttle in the 61AV project, the agency intends to follow a project management approach that is similar to the 61AV. Once awarded grant funding, RTD will convene a stakeholder steering committee to oversee and guide the implementation of the DU AV Shuttle. This steering committee will consist of representatives of the following organizations:

- Regional Transportation District (RTD)
- City/County of Denver
- University of Denver (DU)
- Transportation Solutions (the Transportation Management Association for the DU environment); and
- EasyMile (the supplier of the autonomous vehicle for RTD's 61AV demonstration project and the anticipated supplier of the Autonomous Vehicle for the DU AV Shuttle).

The role of the steering committee will be to finalize detailed plans for the implementation of the DU AV Shuttle and to oversee and guide the successful implementation and operation of the DU AV Shuttle. It is anticipated that Bruce Abel, RTD's Director of Special Projects, and Lauren Isaac, EasyMile's Director of Business Initiatives will co-chair this steering committee as they did with the steering committee that oversaw the successful implementation of RTD's 61AV demonstration project.

RTD has assembled an experienced team of partners to implement the DU AV Shuttle project. Each stakeholder chosen fills a specific role in the project, with a proven track record of successful project implementation in that role. RTD will be the primary project lead and will be the operator of the transit service. Denver will lead the traffic engineering study and the implementation of any infrastructure improvements. DU will lead the research component of the project while Transportation Solutions will lead the public outreach and marketing campaign. Finally, EasyMile will provide technical support for their EZ10 vehicle. A description of each stakeholder's capabilities can be found in the Capabilities section below.

Staffing Approach

RTD intends to follow a similar approach in the staffing of the DU AV Shuttle as it did for its 61AV project. EasyMile has developed and implemented a set of training modules for all aspects of the AV deployment process and has conducted these training programs for over 500 partners around the world including at RTD's 61AV demonstration project. While certain elements of the necessary training program exist from EasyMile's prior work and the implementation of RTD's 61AV demonstration project, it will be necessary to modify and expand the training program to address the specific issues surrounding the provision of the DU AV Shuttle service.

Each vehicle used to provide the DU AV Shuttle service will have a Customer Service Ambassador (CSA) on board to ensure safety and answer questions as well as to oversee the operation of the AV vehicle used in the delivery of the service. AV related elements of the CSA training program include AV pre-trip procedures (including all safety checks), operation of AV in autonomous mode, operation of AV manual

mode, route training, identification of potential hazards in the operating environment, post-trip procedures including data collection processes and procedures, and customer service skills.

General service delivery elements of CSA training include customer service skills including knowledge of the specific operating environment, communications procedures (with RTD dispatch, etc), adverse weather/operating conditions, incidents and accidents, safety and security, ADA related procedures, adherence to time points, and general (not vehicle specific) pre and post trip procedures.

The training team makes sure that the skills of the trainees fulfill RTD's high expectations by having an exam at the end of the curriculum to have documented evidence of "fit for operation". Each successful CSA trainee receives a training certificate at the end of training and also signs off a training "lapel sheet" certifying his/her understanding of the various elements of the training program. In addition to the training outlined above for each CSA, additional training is developed and conducted as described below.

Chief Operator

The Chief Operator is an experienced CSA who participates in an additional Chief Operator training. He/she is able to manage the daily operations with the EZ10s and perform low level maintenance tasks. The Chief Operator is also EasyMile's point of contact for all questions regarding day-to-day AV performance and operations.

Training Officer

The training officer is an experienced Chief Operator who received additional Training Officer Training. He/she is able to train new CSA's.

Deployment Program Training

These trainings focus on how to set-up a new route for the EZ10 with different levels of complexity. A Setup Operator is an experienced Chief Operator who receives an additional Setup training.

Maintenance Training

This maintenance modules of AV training focus on developing the knowledge and skills needed to maintain the AV vehicle in service. During its life cycle, several preventive maintenance interventions are scheduled on the AV vehicle and corrective maintenance tasks can be necessary. These tasks fell into three main categories, according to the skill level needed to achieve the tasks:

- L0 - Tasks performed by operators:
    - Functional tests of the vehicle subsystems: infotainment, air conditioning, lights, etc.
    - Windshield wiper replacement
- L1 - Tasks performed by EasyMile or a technician trained and certified by EasyMile
    - Replacement of wearing parts: tires, brake discs, brake pads, etc. (according to manufacturer's specifications and wear and tear)
    - Draining of fluids (according to manufacturer's specifications)
- L2 - Tasks performed by EasyMile staff
    - Localization and safety pieces of equipment calibration (yearly)
    - Software updates (twice a year)

Capabilities

RTD

RTD is a regular recipient of federal transportation funding and understands the requirements and regulations that come with the award such funding. RTD has been operating transit services in the Denver region for nearly 50 years and currently provides fixed-route bus, on-demand bus, light rail, and commuter rail services. RTD's service area population is over 3 million and the agency operates over 1,000 buses and 200 rail vehicles with approximately 100 million boardings per year. RTD is constantly assessing potential new services that can be added and evaluating ways to improve existing services.

RTD has a very experienced and capable staff to manage the DU AV Shuttle project. With its 61AV pilot project, RTD has already successfully implemented an autonomous shuttle on a public roadway in the City and County of Denver. With this experience, the agency has learned of the regulatory processes and operational challenges that come with operating an autonomous vehicle. RTD intends to take the data and lessons learned from this project and apply them when planning for and operating the DU AV Shuttle.

City and County of Denver

Denver Public Works, through its employees, enhances the quality of life in Denver by efficiently delivering effective, high quality, safe, and equitable public infrastructure and services. The department delivers projects and services through the planning, design, construction, regulation and enforcement of the public right of way. This includes managing all transportation and mobility, traffic operations, and curbside management operations in addition to coordinating community outreach and design. The department also controls the operations and maintenance of the public right-of-way through wastewater, solid waste, street, fleet, and safety and industrial hygiene management. Within the project delivery administration of Public Works, the transportation teams develop, review, evaluate, implement, and support the design of transportation system improvements while collaborating with or supporting other agencies to provide and implement mobility modifications and improvements.

This administration also provides review services for private and public projects to determine conformity with transportation system standards and the Denver Comprehensive Plan, and for potential impact and mitigation measures for the community, neighborhoods, and the system as a whole. Included in this work is the management of the design and construction of projects including streets, alleys, bridges, viaducts, storm and sanitary sewers, and streetscape improvement projects. Annual programs include concrete curb and gutter, curb ramps, and various concrete street and alley projects.

The design team bids approximately 70 construction projects each year in addition to managing many other consultant agreements for professional services. This work includes the preparation of plans, specifications and cost estimates as well as the preparation and administration of contract documents for construction. The construction section provides construction administration and supervision, field engineering, and layout and inspection.

As a result, the Department of Public Works is well qualified as a partner agency to help RTD manage the traffic engineering study proposed as part of this grant proposal in order to ascertain capital improvements needed prior to the launch of an AV shuttle pilot on the DU campus as well as to help coordinate the design, review, and delivery of such improvements. In addition, our transportation operations division will be intimately involved with the deployment and ongoing operations of the

shuttle in order to ensure safety and seamless integration with the variety of other modes operating in this part of the City.

DU

The University of Denver is well positioned to contribute to an interdisciplinary research approach in support of this proposal. Several University faculty and laboratories have successful ongoing research that directly contributes to the needs of this demonstration, including longitudinal research on impacts of campus transportation options for future ridership, a strong platform for consumer insights, and the technical expertise to partner with the AV provider.

Transportation Solutions

Transportation Solutions Foundation (TSF) has operated as the Transportation Management Association for the University of Denver area since 1997. TSF has worked with most larger employers and registered neighborhood groups in the area in reducing single occupant vehicle travel, while promoting transit, biking, walking, carpooling and other sustainable forms of travel. TSF's Newsletter registrant list has approximately 6,000 people living and/or working in the area. Services of the organization are funded, in part through public grants obtained in cooperation with the Denver Regional Council of Government. Marketing and outreach services promote TSF's free services in commute program development and implementation for employers, property owners, and other entities.

Transportation Solutions has a long working relationship with a variety of stakeholders in the campus environment and engage in promotional efforts designed to create and promote more cost-effective transportation alternatives for students, faculty, staff, visitors, and nearby residents. TSF launched the first dockless bike pilot in the City of Denver at and around the DU campus. TSF studied and helped launch the microtransit service around DU Station. The organization supports annual promotional events on campus including Bike to Work Day, Earth Day, and start of year transportation challenges.

Denver Councilmember Paul Kashmann, who represents the DU area, is on the Board of Directors for TSF and provides leadership and guidance on mobility improvements in the area. He has advocated for a multi-modal transportation environment that makes it easier and safer to use transit, bike and walk in the area.

EasyMile

EasyMile is an advanced technology company which has fulfilled the vision of introducing a new mobility solution to cities around the world. EasyMile achieves this goal by transforming cities from assuming single occupancy vehicles, combustion engines, and traffic jams are the norm to increasing vehicle occupancy, electric vehicles, and improved mobility for all. This is at the heart of the company's values.

To meet this challenge EasyMile developed the EZ10, a 100% electrical shared driverless shuttle. The EZ10, developed in partnership with a leading OEM can serve many use cases, including complementing existing public transportation systems by providing people with the missing first/last mile mobility link. It can also serve campuses, airports, universities, entertainment complexes, elderly homes, and many more locations.

The EZ10 is the most deployed autonomous shuttle in the world. Since 2015, EasyMile has successfully deployed our vehicles over 250 times in over 23 countries on 4 different continents. Over 300,000

people have travelled with us on more than 200,000 miles. The company has experienced several environments (city centers, university campuses, corporate campuses, amusement parks, etc.), traffic conditions (segregated road, mixed traffic with bicycles and pedestrian, mixed traffic with low speed cars, etc.), and various weather conditions (hot countries, snow, rain, etc.). Thanks to our "Safety First" approach, EasyMile is proud to mention there have been no accidents involving our vehicle in operations. The R&D, testing, and deployment processes with a focus on risk assessment and management make EasyMile's vehicle the safest on the market. As a result of these processes, EasyMile is the first and only shuttle provider in the world to have a commercial service running fully autonomous with no operator onboard.

Resumes

The AV steering committee is a proposed committee that will oversee the implementation and operation of the DU AV Shuttle. Committee members will meet on an ongoing basis to ensure that the DU AV Shuttle is successfully implemented and operates smoothly. The following individuals will be on the AV steering committee. Their resumes are on the pages that follow.

- **Bruce Abel**- RTD, Director of Special Projects
- **Stuart Anderson**- Transportation Solutions, Executive Director
- **Lauren Isaac**- EasyMile, Director of Business Initiatives
- **Chad King**- University of Denver, Sustainability Director
- **Cindy Patton**- City and County of Denver, Strategic Advisor
- **Bill Sirois**- RTD, Senior Manager of Transit-Oriented Communities

We have also included short biographies for each of the DU faculty who will be working on the research component of the project. Their biographies begin on Page 46**.**

BRUCE A. ABEL
166 GARFIELD STREET
DENVER, COLORADO 80206
303-321-3659
Bruceabel166@comcast.net

PROFESSIONAL EXPERIENCE:

REGIONAL TRANSPORTATION DISTRICT (RTD), Denver, CO-
September 2000 to present

Director of Special Projects, (Spring 2018- current) Bruce Abel currently serves as RTD's Director of Special Projects. In this capacity Bruce is responsible for providing oversight and support for RTD's activities in new approaches to the provision of mobility for RTD customers. Bruce's most recent project was managing RTD's initial limited venture into automated vehicle technology with the implementation of RTD's 61AV autonomous shuttle demonstration project. Bruce worked as co-chair of the steering committee of a collaborative group that included RTD, the City/County of Denver, EasyMile autonomous vehicle provider, Panasonic, Fullenwider LLC (a Denver developer) and Transdev, an international transit services company, to implement this test of AV shuttle technology at the site of RTD's 61st & Pena rail station.

Assistant General Manager, Bus Operations, (July 2010- Spring 2018), Responsible for all bus service planning and bus and rail scheduling activities for regional transit agency operating over 1000 buses and 175 light rail vehicles serving a 2300+ square mile service area with a population of 2.7 million, providing over 100M passenger boardings per year. Responsible for management of an annual operating budget in excess of $270M and management and oversight of all bus services delivered by RTD including internally delivered fixed route service (600+ buses) as well as all contracted fixed route (430+ buses), ADA paratransit (320+ buses) and special services (50+buses) provided by contracted service providers on behalf of RTD.

Assistant General Manager, Customer and Contracted Services, (March 2007- June 2010), Responsible for all marketing, service planning and scheduling activities for 1000+ bus transit agency serving a 2300+ square mile service area.. Also responsible for planning, implementation and management oversight of privately contracted public transit services delivered on behalf of RTD including management oversight/quality assurance of contracted fixed-route services, ADA complementary paratransit services, special services and vanpool partnerships.

Assistant General Manager, Contracted Services, (August 2003- March 2007)**,** Responsible for planning, implementation and management oversight of privately contracted public transit services delivered on behalf of RTD including management oversight of contracted fixed-route services (5 contracts, 430+ buses), ADA complementary paratransit services (7 contracts, 320+ buses) and special services (approx. 30 buses).

Special Services Manager, (September 2000- August 2003), Responsible for planning, development and implementation of non-traditional/alternative transit services to serve specialized markets in the RTD service area. Services include general public demand response service (call-n-Ride), vanpool services, cost-sharing services to support the provision of service by other agencies, and services for special events.

SOUTHEAST TRANSPORTATION AUTHORITY (SETA), Greenwood Village, CO-
October 1998 to September 2000

Executive Director, Responsible for system planning, development, implementation and marketing of new circulator/shuttle bus service to serve the commercial areas of the City of Greenwood Village, the Denver Technological Center (DTC), and the Greenwood Plaza office park.

DAVE TRANSPORTATION /LAIDLAW TRANSIT SERVICES, INC., various locations-
September 1989- October 1998

General Manager, **Springs Transit)**, (DAVE/Laidlaw Resident Manager) Colorado Springs, CO-(November 1997- October 1998**),** Responsible for managerial, supervisory, administrative and technical activities in directing the operations of a 66 bus public transit fleet.

Manager of Management Services/Asst. Regional Manager, **(DAVE Corporate)**, Denver, CO-(October 1992- November 1997), Responsible for a broad range of managerial, technical consulting and new business development activities for a national public transportation management and consulting firm. Responsible for direct management/administration of a 43-bus public transit system with an annual operating budget of $3.6 million.

Director of Marketing/District Manager, (DAVE Corporate), Santa Ana, CA/Austin, TX-(September 1989- October 1992), Responsible for a broad range of marketing, managerial, and technical support activities for a national firm generating approximately $45 million per year in sales in public transportation operations, management, and consulting.

AMERICAN TRANSIT CORPORATION (ATC), various locations-
July 1977 to September 1989

General Manager, **Roaring Fork Transit Agency**, (ATC Resident Manager), Aspen CO-(July 1985- September 1989), Responsible for managerial, supervisory, administrative, and technical activities in directing the operations of a 47-bus public transit agency. Responsible for administering an annual operating budget of $3.3 million and supervising approximately 100 peak season employees.

Director of Marketing (ATC Corporate), St. Louis, MO-(February 1981- July 1985), Responsible for directing the marketing, planning, and new business development activities for a national firm involved in urban transportation management and consulting. Provided marketing, planning and grants management assistance to 19 ATC-managed urban transit systems throughout the U.S and project management for consulting engagements in the areas of marketing, performance auditing, and transit service development.

Director of Marketing/Planning, Winston-Salem Transit Authority, (ATC Resident Management Team), Winston- Salem, NC- (July 1977- February 1981), Responsible for directing the marketing, planning, and grants management activities of a 63-bus transit agency that carried approximately 3 million passengers annually.

CITY-COUNTY PLANNING BOARD, Winston-Salem, Forsyth County, North Carolina-
May 1975 to July 1977

EDUCATION:
University of North Carolina at Greensboro. Master of Business Administration (MBA), Concentration in Marketing;
Wake Forest University. Bachelor of Arts in Economics;
American Management Association (AMA). Management Skills Seminar;
North Carolina State Department of Transportation. Short Course Transportation Planning, Development and Re-Evaluation; and
Wake Forest University. Center for Management Development Division of Babcock Graduate School of Management: Marketing for Non-Profit Organizations

ACTIVITIES:
Past Chairman of the American Public Transit Association (APTA) Marketing Steering Committee
Past President of Colorado Association of Transportation Agencies (CASTA)
Past President, Community Health Services/VNA Board of Directors, Aspen/Pitkin County, CO

STUART M. ANDERSON

Stuart M. Anderson has 32 years of experience in developing successful urban, and transportation planning solutions. He is an internationally recognized speaker on transportation demand management and public-private partnerships for transit services. Stuart has strong expertise in regional commuter programs, having established, and supported regional programs in Houston, Toronto, Los Angeles, Austin, Denver, and other communities internationally. He is a leader in Transportation Management Associations (TMAs), and helped establish nearly 40 TMAs, and aided an additional 30 TMAs.

In Florida, he has been instrumental in: evaluating the South Florida Vanpool program, under contract to FDOT D-6; studying the formation of a South Miami Beach TMA; supporting telework material development for South Florida Commuter Services; and developed, and implemented a state-wide TDM promotional campaign for FDOT. Stuart also served as the Project Director for Telework Tampa Bay.

Stuart was previously an Associate with Steer Davies Gleave, a London-based urban planning firm, where he most recently served as a transportation advisor to the Government of São Paulo, Brazil.

He founded, and served as the President/CEO for UrbanTrans Consultants, and sold the firm on his 50th birthday in 2012.

Stuart served, under contract, as the Executive Director of the Association for Commuter Transportation, Washington, D.C. & Denver, CO. He oversaw events, and conferences, as well as professional publications. Stuart participated in, and managed a small team of lobbyists advocating for transportation investment and services. He was instrumental in the passage of the Commuter Tax Benefit Program, IRC Section 132 (f), and was also appointed as the US representative to the European Platform on Mobility Management (2000-2003).

He was a part-time Instructor for University of California, Los Angeles (UCLA TDM Certificate Program) from 1991-1993.

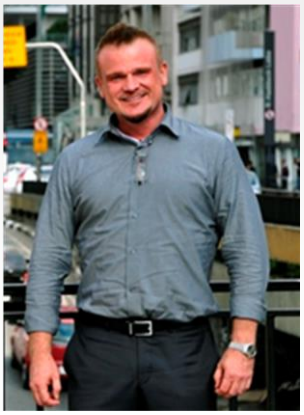
Stuart has numerous publications through the Transportation Research Board, and other professional periodicals. He co-authored USDOT's Transportation Demand Management reference guide, and USDOT's Parking Management reference guide.

EDUCATION AND EXPERIENCE

Master of Urban, and Regional Planning, **University of Southern California**, Los Angeles, CA. 1988

Graduate Fellow, **National Taichung University**, Taipei, Taiwan. 1987

Bachelor of Science, Business Management, Finance, **Brigham Young University**, Provo, UT. 1986



São Paulo, Brazil 2014

WORK EXPERIENCE

Executive Director, Transportation Solutions Foundation, Denver, CO. 2015-Present

TDM Consultant, Denver, CO
2015-Present

Associate, Steer Davies Gleave, Denver CO. 2013-2015

CEO and Founder, UrbanTrans Consultants, Denver, CO, and subsidiaries, 1996–2012:

- UrbanTrans North America, Toronto, Canada
- UrbanTrans ANZ, Melbourne, Australia
- UrbanTrans Middle East, Dubai, UAE

Administrator, Sunset Shuttle, West Hollywood Chamber of Commerce, West Hollywood, CA. 1993-1996

Vice President, Transportation Management Services, Pasadena, CA. 1991-1993

Planner, Commuter Transportation Services, Los Angeles, CA. 1986-1991

LAUREN ISAAC

Director of Business Initiatives, EasyMile

Lauren Isaac is the Director of Business Initiatives for the North American operation of EasyMile. EasyMile specializes in developing and deploying driverless technology in many vehicle applications. Most notably, EasyMile has developed electric, driverless shuttles that are designed for short distances in multi-use environments. Prior to working at EasyMile, Lauren worked at WSP where she was involved in various projects involving advanced technologies that can improve mobility in cities. Lauren wrote a guide titled "Driving Towards Driverless: A Guide for Government Agencies" regarding how local and regional governments should respond to autonomous vehicles in the short, medium, and long term. In addition, Lauren maintains the blog, "Driving Towards Driverless", and has presented on this topic at more than 100 industry conferences. She recently did a TEDx Talk, and has been published in Forbes and the Chicago Tribune among other publications.

Work Experience

Director of Business Initiatives, EasyMile *(April 2017 – Present)*
Lauren Isaac is the Director of Business Initiatives for the North American operation of EasyMile. Lauren leads business development, government regulations, partnerships, and marketing for EasyMile in North America.

Manager of Sustainable Transportation, WSP | Parsons Brinckerhoff *(June 2014 – April 2017)*
Lauren was involved in various projects involving advanced technologies that could improve mobility in cities. Her two key projects:

- Lauren was awarded the 2015 William Barclay Parsons fellowship, an internal research program where she developed a guide regarding how local and regional governments respond to autonomous vehicles in the short, medium, and long-term.
- Lauren was Project Manager for the Metropolitan Transportation Commission (MTC's) 511 Regional Carpool program. In this role, she managed a multi-year, multi-million dollar contract with a team that provided carpooling, vanpooling, employer services and other transportation information as part of the region's 511 Traveler Services system. Sustainable Transportation & New Mobility

Director of Business Relations, Alta Bicycle Share (now Motivate), San Francisco, CA *(June, 2013 – May 2014)*
Lauren led business development, marketing, and sponsorship activities for the company. Responsibilities included identifying and responding to international leads and requests for proposals, developing business model and strategy for pursuits, negotiating contracts, and developing and implementing the corporate marketing and sponsorship strategy. Accomplishments included:

- Leading contract negotiations with six cities anticipated to launch bike share in the following two years x Leading the development of eleven proposals and winning six
- Developing and executing a sponsorship strategy that enabled five cities to raise private funding
- Developing and executing a corporate marketing strategy that consolidated and communicated local best practices, strengthened partnerships, and engaged with future and existing clients

Manager of Transit Effectiveness and Management, Strategic Consulting Practice, Parsons Brinkerhoff, Multiple Locations *(February 2006 – May 2013)*
Served as project manager or task leader on various consulting engagements in the public transit industry in North America. Accomplishments include:

- Establishing a Transit Effectiveness and Management practice area at Parsons Brinkerhoff, including hiring new direct reports
- Providing organizational development, implementation planning, and business processes improvement services for numerous public transit clients in North America, focusing on

asset management, strategic planning, financial analysis, policy evaluation, and capital planning
- Recognition as a national leader in transit asset management, including being named a "Top 40 Under 40 in the U.S. Transit Industry" by Mass Transit Magazine and being asked to speak on a number of transit-related panels throughout the United States
- Developing and managing scopes, schedules, and budgets of projects ranging from $15,000 to $1,000,000 and leading project teams of 1 to 15 people across the company
- Leading the development of proposals and participating in proposal interviews that resulted in over $2,000,000 in new project work
- Instituting new, ongoing client relationships due to the submission of high-quality, timely deliverables and leadership in client workshops, interviews, and meetings

Analyst and Team Lead, Accenture, Reston, VA *(January 2005 – January 2006)*
Held various consulting roles in the Customer Communications (CC) Branch of the Internal Revenue Service (IRS). The Accenture project team was responsible for software development for both phone and web applications. Accomplishments include:
- Leading the Quality Assurance team of 12 analysts, including managing workloads, adhering to a multi-release schedule, managing communications, handling personnel issues, and running weekly team meetings
- Creating a training plan for IRS's CC Branch and guiding the client in maintaining SW-CMM Level 2 compliance

Chief Executive Officer, Next Insight Transportation Software, LLC, Norwalk, CT *(January 2003 – December 2004)*
Co-founded a transportation software company targeting the public sector. Responsibilities included creation of marketing/business strategy, product planning, sales, project management and implementation, contract negotiations, and customer relations. Accomplishments include:
- Acquiring multiple state and local transit agency clients and managing the installation of the software
- Conducting cold calls and follow-up sales calls to potential clients nationwide
- Creating and delivering over 35 sales presentations to transit agencies nationwide
- Leading Next Insight's technical support services and training sessions for established clients

Education
Masters of Engineering, Operations Research & Industrial Engineering, Cornell University, 2002; B.S., Operations Research & Industrial Engineering, Cornell University, 2002

Professional Affiliations
Women Transportation Seminar (WTS), Intelligent Transportation Society (ITS), American Public Transportation Association, and APTA Leadership, Class of 2010;

Chad King, PhD

1770 S Williams St, Denver, CO 80210, Phone 303-871-3345, E-mail: chad.king@du.edu

Experience

Sustainability Director, University of Denver, Center for Sustainability June 2017-Present
1 full time employee, 45 part time employees (7 FTE)

- Developed University sustainability principles, goals, and operating structures
- Served on project management teams: Multi-Station Area Study, Transportation Master Plan, Campus Master Plan
- Served as sustainability representative on three new building designs, over 280,000 GSF
- Oversee engagement and practice improvement projects in waste, energy, transportation, food, purchasing, and education with dozens of campus and community stakeholders
- Developed collaborative pilot projects on food waste, Lyft as a last mile connection, dockless bikeshare, Chariot microtransit, and 100% renewable energy
- Developed and managed professional development program for all employees through HR
- Work collaboratively with RTD, Denver City Council, City and County of Denver Public Works, Transportation Solutions, Denver Office of Economic Development Food System Manager, Denver Regional Council of Governments, Bicycle Colorado, BikeDenver, Bikes Together

Sustainability Coordinator, University of Denver, Center for Sustainability August 2012- June 2017
45 part time employees (8.5 FTE)

Founder and Co-Chair, Ohio Dominican University Sustainability Council December 2007-June 2011

Assistant Professor of Environmental Science, Ohio Dominican University August 2005-July 2012

Education

Ph.D. in Environmental Science. May 2005. University of Arizona, Tucson, AZ.
Master of Science in Environmental Science. May 2002. University of Arizona, Tucson, AZ.
Bachelor of Arts in Biology. May 1997. Eastern Mennonite University, Harrisonburg, VA.

Awards

- Commuter Hero, Denver Regional Council of Governments, 2015.
- Conley Award for Excellence in Teaching, Ohio Dominican University. 2011.

Service and Leadership

- Mayor's Sustainability Advisory Committee, 2019-present.
- Post-doctoral Advisory committee, Interdisciplinary Research Incubator for the Study of (In)Equality, University of Denver, 2014-present.
- PhD committee member, Sylvia Brady, Geography, 2017-present.
- Dining Advisory Committee, 2017-present.
- Advisor to Undergraduate Student Government Sustainability Committee, Renewable DU student organization, DU Environmental Team student organization, 2014-present.

- Judge for Metro Vision Awards, DRCOG, 2017
- Transportation Solutions Foundation, Board of Directors, 2016-present.
- Transportation Solutions Foundation, Board of Directors, Treasurer, 2018-present.
- Mayor's Bicycle Advisory Committee member, Denver, 2014-2016.
- Board Member, Friends of Alum Creek and its Tributaries (FACT), watershed advocacy, 2007-2009.
- Advisory Board, Shepherd's Corner farm/ecological education center, 2006-2008.
- McLinden Committee, Eco-justice committee of St. Mary of the Springs. 2005-2008.

Selected Reports, Publications, and Presentations

Publications
2014-2017 University of Denver Sustainability Plan
2009-2010 Ohio Dominican University Sustainability Report

Presentations
The Design Thinking Process: User-Centered Solutions to Complex and Confounding Problems. Emily Schosid and Chad King, half day workshop. Association for the Advancement of Sustainability in Higher Education, national conference. Pittsburgh, PA. Oct 2-5, 2018.

Getting to 100% Renewable Electricity. Panel Presentation, Carol Dollard, Stacey Baumbarn, Chad King, Association for the Advancement of Sustainability in Higher Education, national conference. Pittsburgh, PA. Oct 2-5, 2018.

Getting to 100% Renewable Electricity. Carol Dollard, Stacey Baumbarn, Chad King, Rocky Mountain APPA. Aurora, CO. September 25-26, 2018.

Emerging Mobility Services: Case Studies From Colorado. Panel Presentation, 15th Annual Colorado Transportation Symposium. Denver, CO. April 3, 2018.

Formalizing Sustainability Education as an Opportunity for Faculty and Staff Development. Association for the Advancement of Sustainability in Higher Education, national conference. Baltimore, MD. Oct 9-12, 2016.

Understanding why Product Lifecycles are Important in Supporting Campus Sustainability Initiatives. Panel Presentation, Association for the Advancement of Sustainability in Higher Education, national conference. Minneapolis, MN. Oct 25-28, 2015.

Building a Strong Core: Sustainability in a University Sports Complex. Association for the Advancement of Sustainability in Higher Education, national conference. Portland, OR. Oct 16-19, 2014.

Getting Rolling: Launching Comprehensive Bike Programming. Association for the Advancement of Sustainability in Higher Education, national conference. Portland, OR. Oct 16-19, 2014.

Getting Trashy: Measurable Pilot Project to Identify Best Practices. Association for the Advancement of Sustainability in Higher Education, national conference. Portland, OR. Oct 16-19, 2014.

4410 E. Vassar Ave Phone: 719-659-3012
Denver, CO 80222 E-mail: cynthiapatton@gmail.com

Cynthia L. Patton (Cindy)

Education:

University of Colorado	**Denver, Colorado**	**2007-2009**
• Master of Urban and Regional Planning, Graduation Honors		
University of Colorado	**Colorado Springs, Colorado**	**2003**
• Master of Public Administration courses, non-degree seeking		
Pepperdine University	**Malibu, California**	**2000-2002**
• B.A. History, Magna Cum Laude		
Harding University	**Searcy, Arkansas**	**1998-1999**

Experience:

City & County of Denver Department of Public Works **Sept 2018 – Present**
Strategic Advisor

As Strategic Advisor within the Office of Policy, Legislative Affairs and Special Initiatives, I work to explore and create policy supporting the initiatives and strategic framework of Denver Public Works. My work focuses on creating lasting department and/or citywide impacts often through sensitive, controversial, and/or highly visible policy issues. I advise the Executive Office on methods of approach and conduct analysis of relevant data including best practices on a variety of issues. I develop proposals, recommendations, and devise implementation strategies while assessing their respective impacts on internal and external relationships. I coordinate with the Executive Office, elected officials and the Mayor's Office on options, alternatives, and courses of action that most effectively achieve overall city goals. In addition, I work on legislative and regulatory language to support policy and special initiatives and I represent the City at various meetings with external stakeholders or partner agencies.

City & County of Denver Department of Public Works **Feb 2017 – Sept 2018**
Acting Manager – Parking and Mobility Services

As Acting Manager of Parking and Mobility Services I managed a team with 12 positions including transportation planners, administrators, and operational managers as well as a budget of nearly $3M. Under my strategic direction, the team collectively planned and operated the curb lane and off-street parking assets including thousands of on-street spaces, 3 public garages and 7 surface parking lots. My team created and administered numerous parking permit programs including those for Residential areas, valet, car share, dockless mobility, right of way parking, and bike parking. We initiated regular inventories to inform utilization and market forces and continually address community inquiries and concerns related to the programming of this space.

City & County of Denver Department of Public Works **Jan 2015 – Feb 2017**
Development and Planning Supervisor – On Street Parking Operations

As Development and Planning Supervisor for Parking Operations, I managed a team of four individuals including transportation planners focused on developing a planning, policy and operational framework for the City's on-street parking and curb lane assets in including all parking permit programs, Car Share, Valet Operations, and Bike Parking. The team was directly responsible for on-street programs including all block modifications, policy creation and revision, and strategic planning through the Area Management Plan program. These programs worked together to shift demand to multi-modal forms of transportation beyond just the single occupancy vehicle and provide better access for all modes. Under my direction, the team successfully initiated a policy and procedure documentation process which as of 2018 included more than 40 approved and recorded guidelines for consistency and transparency in decision-making.

City & County of Denver Department of Public Works **Oct 2010 – Dec 2014**
Senior City Planner – Policy Planning and Sustainability/ Parking Operations

As a Senior City Planner focused on transportation and parking management I managed and administered the planning function for Parking Operations through complex programs and projects serving to implement the vision and philosophy of the Strategic Parking Plan (SPP). My position focused on creating policy guidance and managing long and short-term transportation plans and studies specifically related to the allocation of the City's on and off-street parking resources.

City & County of Denver Department of Public Works **Dec 2008 – Oct 2010**
Associate City Planner – Policy Planning and Sustainability

As an Associate City Planner, I served the Policy, Planning, and Sustainability group to identify and programs changes to the City's multimodal transportation system and public right of way in conjunction with other City, local, regional, and state agencies. This included managing and supporting various high-profile bicycle, pedestrian and transit initiatives.

Fehr and Peers **June 2007 – Aug 2007**
Transportation Planning Intern

Transportation consultant - personal duties for project work included coordination between project managers, clients and subcontractors.

Harvestime Property Development (now Oaster Facility Solutions) **July 2004 – Feb 2007**
Program Manager, Capital Campaigns/ Office Manager

Harvestime is a property development firm that focuses on long-term planning, specialized architectural design, design-build contracts, and networking with national suppliers. I served as the the first point of contact for clients and was the liaison to subcontractors including HVAC, mechanical engineers, structural engineers, and our team of architects.

Professional Affiliations and Boards:

International Parking Institute (2013 - 2018)

Large City Working Group, International Parking Institute (2018)

Pacific Intermountain Transportation and Parking Association (PIPTA) (2015-2018)

Pacific Intermountain Transportation and Parking Association Board Member (2017-2018)

WTS (Women in Transportation Seminar) Colorado (2009-2018)

WTS Colorado Committee Chair (2012-2014)

WTS Colorado Executive Board and Board Member at Large (2014-2018)

Congress for New Urbanism (CNU) Board Member (2009-2011)

Colorado American Planning Association - Student Chapter Vice President (2008)

American Planning Association/ Colorado American Planning Association

WILLIAM A. SIROIS
5954 W Sumac Avenue
Denver, Colorado 80123
Daytime: (303) 299-2417 / Evening: (303) 738-8147

FORMAL EDUCATION

University of Iowa, Iowa City, Iowa
MA Urban and Regional Planning, May 1991

University of Northern Iowa, Cedar Falls, Iowa
BA Financial Management, May 1989

WORK EXPERIENCE

Senior Manager, Transit Oriented Communities (July 2005 till present)
Act as RTD's primary liaison with local jurisdictions, the development community and other stakeholders on land use and transit issues related to the existing and planned RTD transit system. Primary accomplishments/projects include:

- *DUS Historic Building* – Led the stakeholder working group process to develop goals, strategies and objectives for the internationally recognized redevelopment of the historic building. Led the Request for Proposals (RFP) process to select a developer for the station and assisted in the negotiation of the long term lease of the building with the selected developer.
- *TOD Pilot Program* – Developed RTD's TOD Pilot Program to test a proactive role for RTD in TOD and joint development. Successfully completed two pilots including the Alameda Denizen project which resulted in enhanced station access, a new 275 unit apartment project and served as a catalyst to a major development of the entire Broadway Marketplace. Completed the Olde Town Arvada pilot which resulted in an investment of over $25 million by the City of Arvada into a shared use parking facility as well as facilitating future private development on 8 acres of publicly owned property next to the station.
- *Rail~Volution 2017* – Chair of Local Steering Committee that lead the local conference planning for the 2017 Rail~Volution conference in Denver. Local planning responsibilities included: conducting over 20 mobile workshops, producing an opening reception at Union Station, fundraising over $180,000 to fund major elements of the conference, and organizing over 80 volunteers to help staff conference activities and tours.
- *Transit and Mobility* – Helping to lead RTD's efforts to become a "mobility integrator" in the new era of transportation and mobility. Leading RTD's efforts to develop a First and Last Mile Strategic Plan; organized RTD's Transportation Transformation (T2) Summit which brought together nearly 150 transportation and mobility practioners from around Denver to discuss how RTD can transition to be a "mobility integrator" for the region.
- *TOD Strategic Plan and other TOD Policy Efforts* – Developed RTD's first ever TOD Strategic Plan and lead additional TOD policy and procedures efforts for the agency that were adopted by the RTD Board of Directors dealing with parking and joint development.

Senior Transportation Planner, Carter & Burgess – Denver, CO (January 2002 till June 2005)
Denver office lead on transportation and land use planning issues including transit station area plans, transit-oriented development (TOD), and comprehensive transportation and land use plans. Project roles and responsibilities include:

- *I-70 East Corridor EIS, Denver, Colorado*. Task leader for transit planning and stations for high profile Downtown Denver to Denver International Airport (DIA) Corridor Environmental Impact Statement (EIS).
- *River North Plan, Denver, Colorado*. Consultant project manager which assisted the City and County of Denver staff in developing a land use and transportation small area plan for Brighton Boulevard between Downtown and I-70 and the proposed 38th and Blake station area.
- *Mason Street Transportation Corridor EA/PE, Fort Collins, Colorado*. Task leader for the station planning and design task for one of Colorado's first BRT projects.

Program Manager/City Planner Specialist, City and County of Denver – Denver, CO (November 1995 to January 2002)
Responsible for evaluating and implementing studies, research, and policy on land use, transportation, and air quality issues. Responsibilities included:

- *Transportation Task Leader for Blueprint Denver*: *An Integrated Land Use and Transportation Plan*. Lead transportation staff person involved in the development of Blueprint Denver.
- *Program Manager for City's Light Rail Station Development Program*. Managed program that promoted the tie between transportation and land use by encouraging TOD around existing and proposed light rail stations.
- *2000 Rail~Volution Conference Organizer*. Managed local organizing committee(s) for the 2000 Rail~Volution Conference in Denver.
- *Project Manager for the Central Platte Valley (CPV) Multi-Modal Access and Air Quality Study*. Managed study of air quality and transportation issues in the CPV, a high growth activity area directly adjacent to Denver's Central Business District.

Senior Transportation Planner, Minnesota Department of Transportation (Mn/DOT), Metropolitan Division - Roseville MN (July 1992 - November 1995)
Administered and implemented short and long range planning and research activities for the Metropolitan Division. Major projects included the Metropolitan Division Transportation System Plan and the I-94 HOV Feasibility Study.

Transportation Planner, BRW, Inc. - San Diego CA (July 1991 - May 1992)
Conducted a variety of technical studies on transportation projects relating to traffic and travel demand forecasting, environmental impact analyses, corridor studies, and transportation systems planning.

PROFESSIONAL AFFILIATIONS

National Steering Committee for Rail~Volution (1998 - 2002, 2005 to present)
ULI Member (2003 – present)
TOD Best Practices Committee, ULI Colorado (2006 till present)

Research Faculty Bios

Melissa Akaka

Akaka is Associate Professor in the Marketing Department at the Daniels College of Business. She is the Elizabeth and Ali Machado Faculty Fellow and teaches topics such as marketing research, introduction to marketing, customer experience design and collaborative innovation. Her research investigates the cocreation of value in consumer cultures and consumption experiences as well as collaborative innovation and entrepreneurship in dynamic service ecosystems. Akaka's scholarly work has been published in a variety of academic journals, including Journal of Service Research, Journal of International Marketing and Industrial Marketing Management. Her work was recently recognized for being "highly cited" (in the top 1%) by Thompson and Reuters.

Ali Besharat

Dr Besharat has received numerous college-wide and university-wide fellowships, research and teaching awards. He has been featured in popular media outlets, including Yahoo!, The Week, Business Insider, WalletHub, 9NEWS, iHeartRadio, FOX 31 NEWS, Denver Post, Colorado Public Radio, Denver Business Journal, Business Observer, and CreditCards.com, among others. He has consulted with many companies, including Comcast, Danone North America, Qdoba, Expedia, Leprino, and Hyde Park Jewelers. He teaches courses in consumer behavior, marketing research, introduction to marketing, marketing management and IMC.

His areas of research interest within the domain of consumer behavior include: a) behavioral judgment and decision making and b) marketing communications and branding. His work has been published in the Journal of Consumer Psychology, International Journal of Research in Marketing, Journal of Advertising, Journal of Public Policy & Marketing, Marketing Letters, Industrial Marketing Management, Journal of Business Research, European Journal of Marketing, and Psychology & Marketing, among others. He currently serves on the Editorial Review Board of Journal of Advertising.

E. Eric Boschmann

My research focuses on the following areas of interest: job accessibility of the working poor, the mobility of older adults, urban sustainability, and the study of Denver as urban place. My primary research focus is in the area of job accessibility: understanding where people live, where they work, and the social and spatial dynamics of the intra-metropolitan journey-to-work process. I adopt a critical perspective to reveal new understandings of job accessibility through local scale analyses and mixed methods approaches. Recently I have begun a similar, but new line of research that examines the travel and mobility behaviors of older adults, particularly in the Denver metropolitan area.

Select Publications

Andrew R. Goetz and E. Eric Boschmann. 2018. *Metropolitan Denver: Growth and Change in the Mile High City*. University of Penn Press. http://www.upenn.edu/pennpress/book/15852.html

Michael A. Niedzielski, Morton O'Kelly ,and E. Eric Boschmann. 2015. Synthesizing spatial interaction data for social science research: Validation and an investigation of spatial mismatch in Wichita, Kansas. *Computers, Environment and Urban Systems* 54:204-218.

Gregory J. Kwoka, E. Eric Boschmann, and Andrew R. Goetz. 2015. The impact of transit station areas on the travel behaviors of workers in Denver, Colorado. *Transportation Research Part A: Policy and Practice* 80: 277-287

Michael A. Niedzielski and E. Eric Boschmann. 2014. Travel time and distance as relative accessibility in the journey to work. *Annals of the Association of American Geographers* 104(6):1156-1182.

E. Eric Boschmann and Sylvia A. Brady. 2013. Travel behaviors, sustainable mobility, and transit-oriented developments: A travel counts analysis of older adults in the Denver, Colorado, metropolitan area. *Journal of Transport Geography* 33:1-11.

Andrew Goetz
Research interests include transportation infrastructure and urban/economic growth, smart growth planning, rail transit systems, transit-oriented developments, intermodal transportation, air transportation and airports, globalization, and sustainability.

Research and teaching experience in transportation, urban, and economic geography; rail transit systems and transit-oriented development; smart growth and urban sustainability; economic development impacts of transportation infrastructure investment; high-speed rail; airline industry policy, structure, service, and pricing; urban, metropolitan, and statewide transportation planning and policy; intermodal transportation; airport planning and land use development; environmental impacts of transportation; transportation, land use, urban and economic growth; globalization; sustainable transportation, and other related fields.

Co-author of three books, *Metropolitan Denver: Growth and Change in the Mile-High City (Penn Press, 2018), Denver International Airport: Lessons Learned*(McGraw Hill, 1997) and *Airline Deregulation and Laissez-Faire Mythology* (Greenwood Press, 1992), and co-editor of one book, *Geographies of Air Transport* (Ashgate, 2014) as well as numerous journal articles and book chapters. Served as associate editor of the *Journal of Transport Geography* from 2004-2012, and still serves on its editorial board as well as those of *Transport Reviews* and *World Review of Intermodal Transportation Research.* Treasurer of the Commission on Transport and Geography in the International Geographical Union. Member of the Scientific Committee of Cluster Group 1 in the Network on European Communications and Transportation Activity Research (NECTAR). Held visiting fellowships at the University of Bologna (Italy) and Monash University (Australia).

Serves on the Statewide Freight Advisory Council at the Colorado Department of Transportation. Has served on the State Freight and Passenger Rail Plan Development Group for the Colorado Department of Transportation, the Denver International Airport (DIA) Community Focus Group, the Transportation Advisory Committee for the City and County of Denver's Strategic Transportation Plan, and the Transportation Advisory Committee for the Denver Regional Council of Governments [DRCOG]. Received the 2010 Edward L. Ullman Award from the American Association of Geographers for Significant Contributions to Transportation Geography.

Selected Publications
Goetz, Andrew R. Forthcoming 2019. Effects of TOD in Denver, Colorado, USA. In Knowles, R. and Ferbrache, F. (eds) *Transit Oriented Development and Sustainable Cities: Economics, Community and Methods.* Transport, Mobilities and Spatial Change Book Series. Edward Elgar.

Jonas, Andrew E.G., Andrew R. Goetz and Sylvia Brady. 2019. The global infrastructure public-private partnership and the extra-territorial politics of collective provision: The case of regional rail transit in Denver, USA. *Urban Studies.* https://doi.org/10.1177%2F0042098018811506

Goetz, Andrew R. and Anthony D. Perl. 2017. Transport policy. In Richardson, D. (ed) *The International Encyclopedia of Geography: People, the Earth, Environment, and Technology.* American Association of Geographers and Wiley/Blackwell.

Perl, Anthony D. and Andrew R. Goetz. 2017. Transport technology. In Richardson, D. (ed) *The International Encyclopedia of Geography: People, the Earth, Environment, and Technology.* American Association of Geographers and Wiley/Blackwell.

Bhattacharjee, Sutapa and Andrew R. Goetz. 2017. Response to "The impact of light rail transit on congestion in Denver: A reappraisal. *Journal of Transport Geography* 58(1): 269-271.

Bhattacharjee, S. and Goetz A.R. The rail transit system and land use change in the Denver metro region. *Journal of Transport Geography* 54: 440-450.

Kwoka, Greg, Eric Boschmann, and Andrew Goetz. 2015. The impact of transit station areas on the travel behaviors of workers in Denver, Colorado. Transportation Research Part A 80: 277-287.

Perl, A. D., & Goetz, A. R. 2014. Corridors, Hybrids and Networks: Three Global Development Strategies for High Speed Rail. Journal of Transport Geography 42: 134-144.

Jonas, A. E., Goetz, A. R., & Bhattacharjee, S. 2014. City-regionalism as a Politics of Collective Provision: Regional Transport Infrastructure in Denver, USA. Urban Studies, 51(11), 2444-2456.

Jing Li

My research interests are moderately diverse, but all fall into the general area of GIScience. They may be grouped into three more specific areas: geovisualization, spatiotemporal data modeling high performance geocomputation and web GIS. The three research areas discussed above are not mutually exclusive but complementary to each other. Natural and social phenomena are featured with high degree of spatial and temporal complexity (e.g., dust storms, wildfires, flight trajectories). To enhance our understandings of these phenomena and to support advanced scientific explorations, I have been working with my colleagues to investigate novel visualization and analytical methods, data management algorithms and state-of-the-art computing techniques. My recent work on using Graphics Processing Units (GPUs) to accelerate the visualization of dust storms can be found here.

Amin Khodaei

Joined the department of electrical and computer engineering at University of Denver in September 2013. Prior to that I was a visiting faculty at Robert W. Galvin Center for Electricity Innovation (2010-2012) and a research/instructional assistant professor at University of Houston (2012-2013). Received Ph.D. degree Illinois Institute of Technology, Chicago, IL, in 2010, the M.S. degree from Sharif University of Technology in 2007, and the B.S. degree from University of Tehran in 2005, all in Electrical Engineering. My research interests include Smart electricity grids, Microgrid design and operation, Renewable energy integration, Power system operation and planning, and Power system economics.

Selected publications:

H. K. Nguyen, A. Khodaei, and Z. Han, "Incentive Mechanism Design for Integrated Microgrids in Peak Ramp Minimization Problem," IEEE Transactions on Smart Grid, In press, 2017.

N. Nikmehr, S. Najafi-Ravadanegh, A. Khodaei, "Probabilistic Optimal Scheduling of Networked Microgrids Considering Time-Based Demand Response Programs under Uncertainty", Applied Energy, In press, 2017.

G. J. Lim, S. Kim, J. Cho, Y. Gong, and A. Khodaei, “Multi-UAV Prepositioning and Routing for Power Network Damage Assessment,” IEEE Transactions on Smart Grid, In press, 2016.

R. Eskandarpour, A. Khodaei, “Machine Learning based Power Grid Outage Prediction in Response to Extreme Events,” IEEE Power Engineering Letters, In press, 2016.

A. Kavousi-Fard, and A. Khodaei, “Efficient Integration of Plug-in Electric Vehicles via Reconfigurable Microgrids,” Energy, 2016.

Z. Li, M. Shahidehpour, S. Bahramirad, and A. Khodaei, “Optimal Settings of Traffic Signals in Smart Cities,” IEEE Transactions on Smart Grid, In press, 2015.

Cara DiEnno, PhD
In 2009, Cara completed her dissertation, "A Case Study of Social Capital and Collaboration as a Communication Process in an Urban Community-Based Ecological Restoration Project," to earn her PhD in environmental communication from the Human Dimensions of Natural Resources Department at Colorado State University. She earned her MS from CSU as well and also holds a BS in Environmental Studies and Biomedical Sciences from Western Michigan University.

Cara's work is grounded in her own commitment to social justice and engagement. In 2007, she was the recipient of a Fort Collins Community Civility Award from the mayor's office for service to the CSU campus and Fort Collins community. She has also received the Pioneer Award from the University of Denver for serving as an innovator and using her creative talents and unique perspectives to positively impact the community and the Outstanding Service Award for exemplifying the mission of the university.

Part III – Data Management Plan

Building on the work begun during the implementation of RTD's 61AV demonstration project, EasyMile and RTD will continue to develop and refine the capture and reporting of data relevant to the DU AV Shuttle project. EasyMile's EZ Fleet system compiles thousands of data points throughout the EZ10's operating day and can provide considerable information for reporting purposes. This data can provided to RTD and USDOT via EasyMile API's and combined with data gathered and reported by on-board Customer Service Ambassadors throughout the service day.

Data Description

Currently with its 61AV project, RTD/EasyMile's data reporting processes are designed to provide data/information about:

- Battery opening and closing readings to monitor and evaluate vehicle charging
- Odometer readings at opening and closing of each day to track km's/miles of AV service delivery
- Temperature readings at the opening, mid-point and close of each service day to monitor compliance with relevant NHTSA requirements
- Observations regarding precipitation types and levels
- Information regarding emergency stops (number and cause of e-stops)
- Number and cause of error readings
- Information regarding Operator/CSA interventions (cause and duration of interventions)
- Accidents and incidents
- Service availability (% of scheduled AV service that is actually delivered)
- On-time performance (currently under development)

At the moment, this data is captured real-time, reported daily, and combined into weekly reports that are analyzed and reported out. While the existing 61AV data capture processes and procedures provide a basic framework for the capture and reporting of information relevant to an AV demonstration project, it is anticipated that project team members will meet with project sponsors (USDOT) to discuss additional information that may be requested so as to further develop data capture and reporting capabilities.

Access Policies

RTD does not anticipate access restrictions on any of the above listed data.

Data Storage

Currently with the 61AV, data is captured and stored on EasyMile's EZ Fleet system. The data is then reported out to RTD where daily reports are combined with data gathered by the on-board Customer Service Ambassadors into weekly reports. RTD intends to use this same data storage structure with the DU AV Shuttle. RTD understands the need for data sharing and will work with USDOT to meet any data storage requirements requested by the department.

Part IV – Letters of Support

RTD has received letters of support from the following agencies:

- City and County of Denver
- University of Denver
- EasyMile
- Transportation Solutions
- Colorado Association of Transit Agencies
- Denver Regional Council of Governments
- AAA
- Ford Smart Mobility
- Colorado Energy Office

DENVER
THE MILE HIGH CITY

March 21, 2019

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

Subject: Autonomous Vehicle Shuttle at the University of Denver

Dear Ms. Tarpgaard,

The City and County of Denver supports the Regional Transportation District's (RTD) application to test the application of autonomous transit vehicles on the University of Denver's campus. Denver Public Works plans, designs, builds, operates and regulates the public right of way and will work closely with RTD on the implementation of this demonstration project. The City and County of Denver has committed to aggressive mobility goals including a reduced reliance on single occupancy vehicle use from 74% to 50% by 2030 and we are open to new innovations that may help us achieve that vision.

RTD recently deployed the first autonomous transit shuttle in Colorado with the AV61 pilot and Denver Public Works collaborated closely on the delivery of that project. RTD's experience in implementing transit service and innovative pilots positions them to execute this grant award. We will coordinate with RTD on the transportation/traffic and infrastructure needs prior to the initiation of the service.

Denver Public Works appreciates FHWA's consideration of RTD's request to implement an autonomous transit vehicle to improve mobility in the University of Denver area. If I can provide any additional information, please contact me at (720) 865-8712.

Sincerely,

Eulois Cleckley
Executive Director
Department of Public Works
City and County of Denver

March 21, 2019

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

Subject: Autonomous Vehicle Shuttle at the University of Denver

Dear Ms. Tarpgaard,

The University of Denver strongly supports the Regional Transportation District's (RTD) application to implement a route served by autonomous transit vehicles on the City and County of Denver's public street network and the University of Denver Campus in south Denver. This transit will provide a critical connection between the University of Denver, the surrounding neighborhoods, and the light rail station.

RTD has a proven track record for operating public transportation service in the Denver region, and recently implemented the first autonomous transit vehicle in Colorado with its AV61 pilot project. The agency's experience in implementing an autonomous vehicle makes them an ideal recipient of this grant. This project expands on years of mobility projects with the University of Denver. These began with providing annual transit passes to all employees and students. In recent years, this has expanded to include pilots testing microtransit options for connecting campus and linking to fixed transit as first and last mile solutions. These pilots seek to improve campus and community safety in a high pedestrian environment intersected with busy arterial streets. This grant will further mobility pilots in a setting full of first adopters that have a proven record of ridership with technology driven microtransit.

The University of Denver is well positioned to contribute research and technical innovation in support of this proposal. The Consumer Insights and Business Innovation Center provides valuable market research, examining information on technology adoption and potential for economic viability. This laboratory provides supervision to graduate led research teams who explore questions related to human behavior and its impact on market offerings. Research initiatives among Geography faculty focus on college student travel patterns and behavior, and how they change as a result of exposure to new modes of transportation. Expertise in electrical engineering and computer science coupled with geospatial studies provide a unique opportunity to contribute to technical advancements in collaboration with the AV vendor research team. Drawing on this innovative, interdisciplinary research team from business, geography, and engineering and computer science, the University will provide strong research support.

The University of Denver greatly appreciates FHWA's consideration of RTD's request to implement an autonomous transit vehicle to improve mobility in and near the University of Denver. For any additional information, please contact Chad King, Sustainability Director, at chad.king@du.edu

Sincerely,
Rebecca Chopp, PhD
Chancellor
University of Denver

March 21, 2019

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

Subject: Autonomous Vehicle Shuttle at the University of Denver

Dear Ms. Tarpgaard,

Easy Mile strongly supports the Regional Transportation District's (RTD) application to implement a route served by autonomous transit vehicles on the City and County of Denver's public street network and the University of Denver Campus in south Denver. This transit service would provide a critical connection between the University of Denver community, the surrounding neighborhoods, and the light rail station.

RTD has a proven track record for operating public transportation service in the Denver region, and recently implemented the first autonomous transit vehicle in Colorado with its AV61 pilot project. The agency's experience in implementing an autonomous vehicle makes them an ideal recipient of this grant.

Founded in 2014, EasyMile is a global industry leader in autonomous vehicle technology. EasyMile supplies smart mobility solutions and autonomous technologies powering driverless vehicles – developing software that enables automation for various transportation platforms, a powerful in-house fleet management solution for autonomous vehicles, and providing smart mobility solutions for transporting passengers or logistics on private sites, urban, suburban or rural areas in diverse environments.

EasyMile greatly appreciates FHWA's consideration of RTD's request to implement an autonomous transit vehicle to improve mobility in and near the University of Denver. If I can provide any additional information, please contact me at 206 483 6098.

Sincerely,

Sharad Agarwal

Sharad Agarwal
EasyMile
Senior Vice President

Transportation SOLUTIONS

March 10, 2019

United States Department of Transportation
1200 New Jersey Avenue, SE
Washington, DC 20590

RE: USDOT ADS DEMONSTRATION GRANT – RTD UNIVERSITY OF DENVER STATION AV SHUTTLE

To Whom it May Concern:

Transportation Solutions Foundation (TSF) is pleased to offer this letter of support for the **ADS Demonstration Grant – RTD University of Denver Station AV Shuttle.** TSF is a not-for-profit Transportation Management Association established in 1997 to create partnerships for better mobility in southeast Denver.

TSF, in cooperation with the University of Denver, Mile High Properties (senior housing) and adjacent neighborhood groups secured federal funding to conduct a Multi-Station Area Plan: Next Steps Study. The study identified station access issues and recommended consideration of an AV Shuttle to connect the rail station with the campus and the community.

The station is currently being converted into a mobility hub with a committed investment by the City and County of Denver of $8.4M for infrastructure improvements to support biking, walking and local transit access at and around the station.

University of Denver Station area has high pedestrian and bike traffic. Increasingly students are taking advantage of their RTD College pass and using rail. The southern end of campus is nearly one-mile from the station, thus requiring a shuttle. Resident groups report that the station as currently configured is not accessible for them and they desire a shuttle circulator as well.

We feel that funding an ADS Demonstration project at this location is ideal. The mixed of students, faculty, staff, senior housing and the surrounding communities make it appealing. Additionally, the University of Denver has been a national leader in innovative and sustainable transportation. TSF and the University of Denver recently tested micro-transit at this location demonstrating demand for station access.

TSF will lead the public education, marketing and community relations element of the application. **We pledge a cash match of $50,000 for the project**.

We respectfully request that you award the requested funding. It is a worthy investment in ensuring that the mobility needs of the city, and surrounding area are being served.

Sincerely,

Stuart M. Anderson, Executive Director

110 16th Street #604
Denver, CO 80202

Telephone 303 839 5197
www.coloradotransit.com

March 21, 2019

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

Subject: Autonomous Vehicle Shuttle at the University of Denver

Dear Ms. Tarpgaard,

The Colorado Association of Transit Agencies (CASTA) strongly supports the Regional Transportation District's (RTD) application to implement a route served by autonomous transit vehicles on the City and County of Denver's public street network and the University of Denver Campus in south Denver. This transit service would provide a critical connection between the University of Denver community, the surrounding neighborhoods, and the light rail station.

RTD has a proven track record for operating public transportation service in the Denver region, and recently implemented the first autonomous transit vehicle in Colorado with its AV61 pilot project. The agency's experience in implementing an autonomous vehicle makes them an ideal recipient of this grant.

In addition, RTD is a leader in transit in Colorado because they are always willing to share lessons learned as they try new things. Providing them the funding necessary to implement this new AV route will in the future help other agencies around the state assess the possibilities for this new technology in their communities.

CASTA greatly appreciates FHWA's consideration of RTD's request to implement an autonomous transit vehicle to improve mobility in and near the University of Denver. If I can provide any additional information, please contact me at 303-839-5197 or executivedirector@coloradotransit.com.

Sincerely,

Ann Rajewski
Executive Director

March 18, 2019

Finch Fulton
Deputy Assistant Secretary for Transportation Policy
Office of the Secretary of Transportation-Policy
US Department of Transportation
1200 New Jersey Avenue, SE
Washington D.C. 20590

RE: ADS Demonstration Grants AV 3.0

Dear Deputy Assistant Secretary Fulton:

The Denver Regional Council of Governments (DRCOG) is pleased to offer this letter of support for the University of Denver's application to the Automated Driving System (ADS) Demonstration Grants AV 3.0. DRCOG serves as the MPO for the greater Denver metro area which includes the University of Denver (DU) campus. The proposal to create a pilot for a driverless shuttle to serve the Regional Transportation District's light rail station at High Street and the DU campus is also actively supported by one of our Transportation Management Agencies, Transportation Solutions.

As the MPO, DRCOG funds a number of Station Area Master Plans (STAMP) throughout the region and in 2016-17, this particular transit station, and a neighboring station, were funded "...to identify a cohesive strategy and key implementable actions that will increase local connectivity, access and mobility to each station [University of Denver and Colorado Blvd.], resulting in more vibrant people-friendly stations integral to the surrounding communities." The study was led by Transportation Solutions, in partnership with the City and County of Denver and with the participation and support of the University of Denver, Regional Transportation District (RTD), Lincoln Property Company, Mile High Development, Denver City Council Members Kashmann and Black and local residents.

This application aligns closely with DRCOG's identified objectives in our long-range plan, Metro Vision 2040 and offers viable alternatives to single occupancy vehicle commutes to and from campus. It also begins to implement recommendations that evolved from the recently released Smart Mobility Blueprint which identified emerging technologies such as autonomous vehicles as an important solution to improve air quality in the Denver region as well as address growing congestion.

We are pleased to offer our support for this ADS Demonstration Grant application from the University of Denver and encourage your favorable consideration.

Sincerely,

Douglas W. Rex
Executive Director

6061 S. Willow Drive, Suite 100 Greenwood Village, Colorado 80111-5157

March 19, 2019

United States Department of Transportation
1200 New Jersey Avenue, SE
Washington, DC 20590

RE: USDOT ADS Demonstration Grant – RTD University of Denver Station AV Shuttle

To Whom it May Concern:

I am pleased to write this letter on behalf of AAA Colorado and our nearly 700,000 members in support of the **ADS Demonstration Grant – RTD University of Denver Station AV Shuttle.** While AAA Colorado is perhaps best known as Colorado's largest and most prominent motor club, our heritage is one of innovation in transportation. We were founded in 1922 to advocate for the automobile, which was then *the* cutting-edge technology in mobility. In our first major initiative, we donated more than 2,000 highway signs to the state – and numbered Colorado's highways. Since then, we have fought to strengthen Colorado's traffic safety laws, worked with automakers to optimize vehicles for Colorado's varied terrain, and even introduced Colorado's first dedicated charging truck for electric vehicles.

All told, we are uniquely positioned to recognize that the future of transportation will involve autonomous, high-occupancy vehicles. To that end, AAA launched and operated the country's first self-driving, on-road shuttle from November 2017 to October 2018 in Las Vegas. More than 32,000 people rode the shuttle during that pilot program, and, after their experience, 98 percent of riders would recommend the technology to their friends and family and more than 91 percent said that AAA made them feel safer about autonomous vehicle technology. AAA also operates the largest autonomous vehicle test site in the country, and our extensive research on autonomous and Advanced Driver Assistance Systems out of several state-of-the-art facilities is an integral part of every conversation for policymakers and car manufacturers alike.

In that spirit, AAA Colorado is proud to support this application because it uniquely will examine how autonomous technologies will fill the crucial first-mile, last-mile gap between Denver's burgeoning public transportation system and the communities it aspires to serve. Moreover, this particular community is ideal for this demonstration – as its mix of student, senior, and faculty housing and university facilities creates a core user base, while its blend of restaurants, retail, and cultural facilities will draw users from across the Denver-metro area.

It is no secret that the future of mobility looks nothing like it does today. The days of individual car ownership are numbered, to be replaced instead by a world where we rely on a variety of transportation technologies to get to where we're going – including mass transit, shuttle services, and autonomous vehicles. No project better provides an early glimpse at that very future than this proposal for the University of Denver Station.

All the very best,

J. Skyler McKinley
Director of Government Affairs
AAA Colorado

Ford Smart Mobility, LLC
One American Road
Dearborn, MI 48126

FORD SMART MOBILITY

March 15, 2019

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

Dear Members of the Selection Committee:

It is my pleasure to provide this letter of support from Ford Smart Mobility, LLC, a wholly owned subsidiary of the Ford Motor Company, to the Regional Transportation District (RTD) University of Denver Station AV Shuttle in its application for the U.S. Department of Transportation, Notice of Funding Opportunity (NOFO) Number 693JJ319NF00001 for Automated Driving System Demonstration (ADS) Grants.

At Ford Smart Mobility, we believe – as Ford always has – that freedom of movement drives human progress. Today, we're working with cities to bring that freedom to everyone, and we're collaborating with city leaders, businesses, transportation experts and commuters to create a better mobility system built on vast amounts of data tailored to the city experience.

We know RTD has been working with Transportation Solutions, University of Denver and others to move towards enhanced connectivity between the university campus and the community. RTD's application outlines key objectives which will leverage the Multi-Station Area Plan: Next Steps Study and transformation of the space into a mobility hub. The benefits of this proposed demonstration will truly help further the Grant goals of safety, informed rulemaking via data provision, and collaboration amongst a variety of partners and stakeholders.

We believe RTD has mapped out a strong project plan that will be successful in the ADS demonstration. The University of Denver station area is an ideal mix of students, faculty, staff, senior housing and residential community. With this demonstration, RTD will be able to contribute new knowledge and data towards helping to solve the challenges of safe integration of automated driving systems into the on-road transportation system.

Ford encourages the USDOT to join RTD in demonstrating how AV connectivity can enhance this high pedestrian and bike traffic area with transit. We have found that the elements of RTD's project are an important step in the continuing process to help improve safety for vehicle operators, occupants, and others sharing the road.

Please do not hesitate to contact me at jjones63@ford.com with any questions about our support of this effort.

Sincerely,

Jeff Jones

Jeffrey Jones
Vice President, N.A. City Solutions
Ford Smart Mobility, LLC

COLORADO
Energy Office

March 19, 2019

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

Subject: Autonomous Vehicle Shuttle at the University of Denver

Dear Ms. Tarpgaard,

The Colorado Energy Office strongly supports the Regional Transportation District's (RTD) application to implement a route served by electric autonomous transit vehicles on the City and County of Denver's public street network and the University of Denver Campus in south Denver. This transit service would provide a critical connection between the University of Denver community, the surrounding neighborhoods, and the light rail station.

RTD has a proven track record for operating public transportation service in the Denver region, and recently implemented the first electric autonomous transit vehicle in Colorado with its AV61 pilot project. The University of Denver project will build off lessons learned from the AV61 project and take place in a much more active area of the city, allowing the project team to better understand how autonomous vehicles interact with pedestrians, cyclists, and other vehicles. The agency's experience in implementing an autonomous vehicle makes it an ideal recipient of this grant.

The Colorado Energy Office has a strong interest in electrification of the transportation sector. Electric vehicles provide significant benefits to all Coloradans including reduced emissions and improved air quality, fuel and maintenance savings to vehicle owners, and improved grid efficiency resulting in cost savings to ratepayers. We strongly encourage you to consider this application as it helps fill a critical need while exposing thousands of Coloradans to a clean, innovative transportation technology.
.

Sincerely,

Will Toor

Will Toor
Executive Director
Colorado Energy Office

Part V – Standard Forms and Organizational Information

Standard Forms

RTD has completed the Standard Form 424 through the Grants.gov portal.

Organizational Information

a. All intellectual property and data identified in this application is “open” and available for sharing. Any intellectual property and data not identified in the application is considered proprietary.
b. DUNS#: 0697213710000
c. RTD has previously completed an A-133 Single Audit. The agency’s last A-133 Single Audit was completed on July 31, 2018.
d. RTD is not aware of any potential or organizational conflicts of interest pertaining to this grant application.
e. N/A - RTD has no terminated contracts in the past 5 years.
f. RTD is regularly receives federal funding and is aware of and understands the requirements of receiving such federal funding.
g. No violations of federal criminal law involving fraud, bribery, or gratuity have occurred in conjunction with this grant application.

Part VI – Budget Detail

Project Budget

RTD and the project team expect the total cost of this project to be $6,652,961, with a total federal share of $6,331,506. This amount includes one year of planning and setup, and two years of operations. The overall budget can be seen below in Figure 2. Note that this section (Part VI – Budget Detail) was also submitted as a separate attachment through Grants.gov as requested in the online portal.

Figure 2: Overall Project Budget

Item	Year 1 (Planning/Setup)	Year 2 (Operation)	Year 3 (Operation)	Total
Traffic Engineering Study	$297,000	$0	$0	$297,000
Infrastructure Improvements	$1,000,000	$0	$0	$1,000,000
Vehicle Storage	$150,000	$0	$0	$150,000
Vehicle Wrap	$24,000	$0	$0	$24,000
Research	$146,336	$146,336	$146,336	$439,008
Operations	$284,697	$854,100	$854,100	$1,992,897
Vehicle Lease	$271,691	$766,100	$766,100	$1,803,891
Marketing and Outreach	$93,000	$91,000	$66,000	$250,000
Escalation (Moody's CPI)	$59,950	$96,454.80	$140,896	$297,301
Contingency (4%)	$91,214	$75,306	$76,084	$242,604
Total Federal Share	**$2,377,303**	**$1,966,992**	**$1,987,211**	**$6,331,506**
RTD Local Match (cash)	$9,000	$8,000	$8,000	$25,000
Transportation Solutions Local Match (cash)	$18,000	$16,000	$16,000	$50,000
RTD In-Kind Match (staff time)	$68,120	$44,070	$44,070	$156,260
EasyMile In-Kind Match (reduced vehicle cost)	$13,585	$38,305	$38,305	$90,195
Total Non-Federal Share	**$108,705**	**$106,375**	**$106,375**	**$321,455**
Total Project Cost	**$2,486,008**	**$2,073,367**	**$2,093,586**	**$6,652,961**

Each item above is described in greater detail in the Project Narrative in Part I. Though revenue service will not be provided in Year 1, budget is still needed for the vehicle lease and operations in order to complete the AV setup process and train the Customer Service Ambassadors. Shipping, training, site assessment and setup, software licenses, maintenance, project management, insurance, monitoring API, and OBU integration are included in the vehicle lease price.

The project team has secured a total of $75,000 in direct local match (cash) and $246,455 in in-kind match, for a total local match of $321,455. The in-kind match includes estimated RTD staff time (detailed in Figure 3 below) as well as a 5% in-kind match from EasyMile, which will be realized through a discounted vehicle lease cost. A full budget breakdown of the items above can be seen in Figure 4 below.

Figure 3: RTD Staff Time (in-kind match)

RTD Staff	Cost Per Hour	Year 1 Hours	Year 2 Hours	Year 3 Hours	Total
Project Manager	$77	780	520	520	$140,140
Planner	$31	260	130	130	$16,120
Total		**$68,120**	**$44,070**	**$44,070**	**$156,260**

Figure 4: Project Budget Breakdown

Traffic Engineering	Cost Per Hour	Hours	Cost	Indirect	Total
-Project Manager	$190	200	$38,000	$3,800	$41,800
-Senior Engineer(s)	$170	600	$102,000	$10,200	$112,200
-Engineer(s)	$130	1,000	$130,000	$13,000	$143,000
-Subtotal					**$297,000**
Research	**Cost Per Hour**	**Hours**	**Cost**	**Indirect**	**Total**
-Co-Principal Investigator(s)	$150	220	$41,118	$20,847	$61,965
-Graduate Research Assistant(S)			$36,540	$18,526	$55,066
-Research Consulting Team (CiBiC)			$116,340	$58,984	$175,324
-Graduate Research assistant			$104,223	$42,430	$146,653
-Subtotal			$298,221	$140,787	**$439,008**
Marketing and Outreach	**Cost Per Hour**	**Hours**	**Cost**	**Indirect**	**Total**
-Project Manager	$150	700	$105,000	$0	$105,000
-Marketing Contractor			$100,000	$0	$100,000
-Advertising			$20,000		$20,000
-Materials			$20,000		$20,000
-Misc Social Media Fees/other			$5,000		$5,000
-Subtotal					**$250,000**
Operations	**Cost Per Hour**	**Hours**	**Cost**	**Indirect**	**Total**
-CSA's (labor)	$65	30,660	$1,992,900	$0	$1,992,897
Item					**Total**
Vehicle Lease					$1,803,891
Infrastructure Improvements					$1,000,000
Vehicle Storage Facility					$150,000
Vehicle Wrap					$24,000
Escalation					$297,301
Contingency					$242,604
RTD Staff Time (in-kind match)					$156,260
GRAND TOTAL					**$6,652,961**

Project Scalability

RTD would like to emphasize that this project is scalable, and the project team can successfully implement the project with less federal funding. The project budget could be reduced in two ways:

1. RTD could eliminate the second year of the demonstration. This would reduce the overall project cost to $4,559,375, however the DU AV Shuttle would only be in operation for one calendar year.
2. The project team would accept reduced marketing and/or research funds at USDOT discretion. The stakeholders feel that these items will bring great value to project and to USDOT, however the activities could be scaled back to reduce the overall project budget.