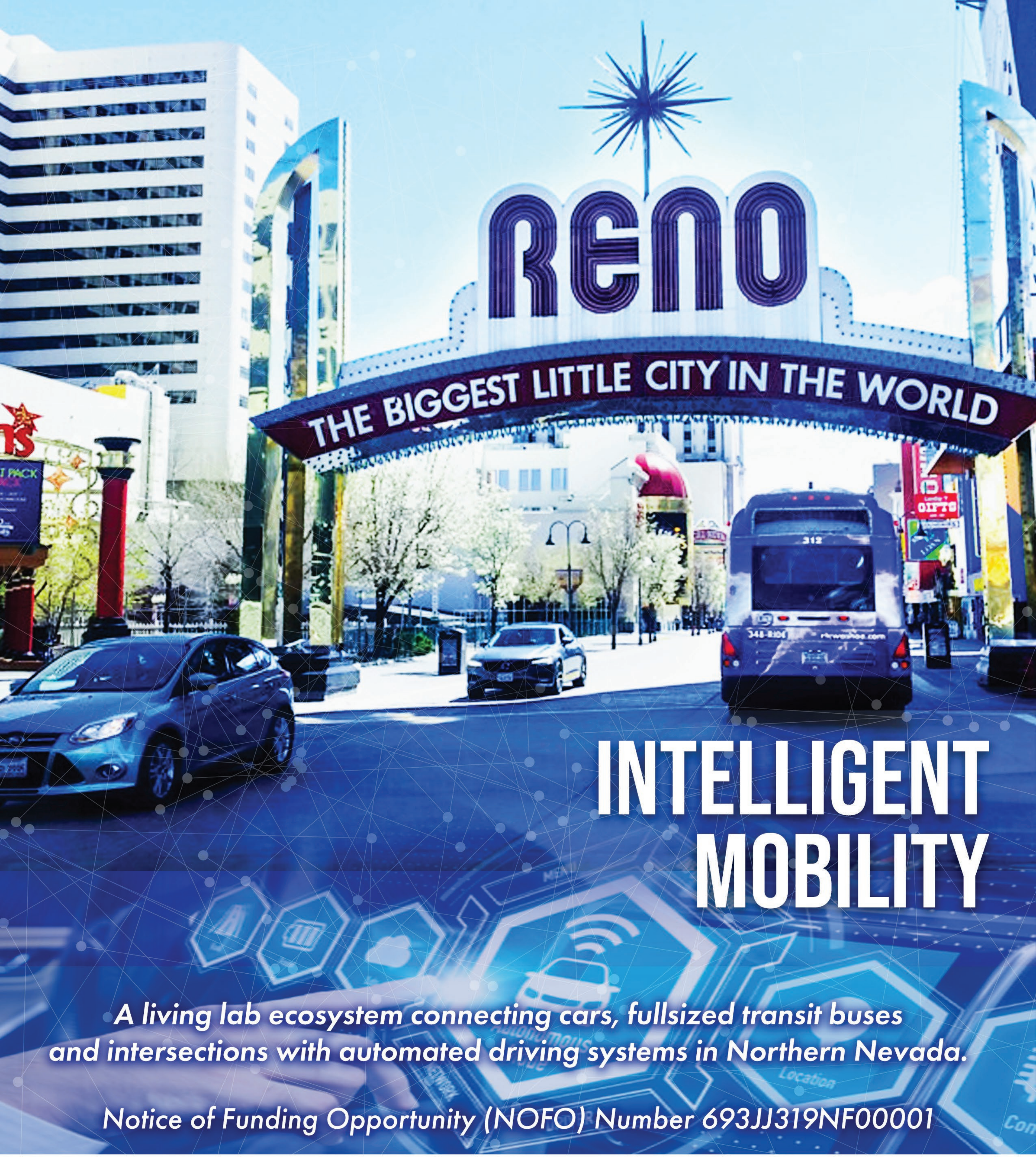

INTELLIGENT MOBILITY

A living lab ecosystem connecting cars, fullsized transit buses and intersections with automated driving systems in Northern Nevada.

Notice of Funding Opportunity (NOFO) Number 693JJ319NF00001

RTC

University of Nevada, Reno
A National Tier 1 University

EASY MILE

PROTERRA

REGIONAL TRANSPORTATION COMMISSION
Metropolitan Planning • Public Transportation & Operations • Engineering & Construction
Metropolitan Planning Organization of Washoe County, Nevada

March 20, 2019

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

RE: Automated Driving System Demonstration Grant for "A Living Lab Ecosystem: Connecting Cars, Full-sized Transit Buses and Intersections with Automated Driving Systems in Northern Nevada" UPDATE to letter dated March 18, 2019.

Dear Secretary Chao:

The Regional Transportation Commission of Washoe County (RTC), in partnership with the University of Nevada – Reno (UNR), Proterra, and EasyMile, is pleased to submit this application for the U.S. Department of Transportation's (USDOT) Fiscal Year (FY) 2018 Automated Driving System (ADS) Demonstration Grant Program.

This project, "A Living Lab Ecosystem: Connecting Cars, Full-sized Transit Buses and Intersections with Automated Driving Systems in Northern Nevada," will bring advanced connected vehicle technology and a proven ADS together in a public transit setting to advance the research and development of ADS technology. Using two 40-foot battery electric Proterra buses and a Level-3 autonomous vehicle, this project expands upon the pioneering efforts of UNR's Center for Applied Research Intelligent Mobility Initiative to test and refine systems in which vehicles sense their environment and communicate with other vehicles, infrastructure, and people.

To advance these efforts, we respectfully request $10 million to map complete traffic trajectories and explore how roadside light detection and ranging (LiDAR) data can be used in connected-traffic applications for connected and autonomous vehicles, pedestrians, and cyclists. Without this essential federal contribution, RTC and its public and private partners will be unable to fully advance its efforts to establish a test bed for autonomous and connected vehicles designed for urban traffic and intelligent traffic control.

Our team believes we have developed a project that uniquely fits the USDOT's ADS grant request:

- This project advances the development of an automated 40-foot electric bus, which does not exist today, and will be tested and deployed on public streets;
- This project leverages the specialties of all of the project partners: Proterra's electric bus, EasyMile's proven automation technology, RTC's operational and project management excellence, and UNR's advanced technology Intelligent Mobility Living Lab;
- This project will integrate the key mobility industry trends: connected, automated, shared, and electric
- This project will advance the general public's understanding and acceptance of automated vehicles

This application proposes to advance cutting-edge vehicle technologies and traffic solutions to establish safe mobility solutions that will help build public confidence in the safety of eventual autonomous mass transit. Furthermore, the ADS Demonstration grant funding will enhance RTC's existing partnership with USDOT in helping to successfully address mobility challenges and intelligent mobility solutions in smart cities. Thank you for your consideration of this FY 2018 ADS Demonstration grant application.

Sincerely,

Lee G. Gibson, AICP
Executive Director
Regional Transportation Commission of Washoe County

SUMMARY TABLE

Project Name/Title	Intelligent Mobility: A living lab ecosystem connecting cars, full-sized buses and intersections with automated driving systems in Northern Nevada.
Eligible Entity Applying to Receive Federal Funding (Prime Applicant's Legal Name and Address)	Regional Transportation Commission of Washoe County. 1105 Terminal Way, Reno, NV 89502.
Point of Contact (Name/Title; Email; Phone Number)	David Jickling, Director of Public Transportation & Operations. djickling@rtcwashoe.com 775-335-1902
Proposed Location (State(s) and Municipalities) for the Demonstration	Nevada, Reno.
Proposed Technologies for the Demonstration (briefly list)	Proterra electric bus, 3D Lidar sensors, machine vision cameras, Lincoln MKZ with modifications to support fully automated driving, Delphi radar systems, UNR-developed automated vehicle software, EasyMile-developed automated vehicle software, switch datacenter system.
Proposed duration of the Demonstration (period of performance)	July 2019 to June 2023.
Federal Funding Amount Requested	$9,999,758
Non-Federal Cost Share Amount Proposed, if applicable	$5,993,382
Total Project Cost (Federal Share + Non-Federal Cost Share, if applicable)	$15,993,140

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PROJECT NARRITIVE AND TECHNICAL APPROACH

Executive Summary

The future of transportation is automated, connected, and electric. However, for the foreseeable future, transportation in the United States will consist of a mixture of automated, connected, and electric vehicles with traditional human-operated vehicles of all shapes and sizes. While pilot programs and demonstrations have shown that automated vehicles are capable of operating on public roads, these demonstrations have thus far been so limited in scope that it has been impossible to measure the impact and safety of automation on traffic in realistic settings. Moreover, all of the demonstrations of automated vehicles in the United States have been of personal vehicles or small shuttles. To date, there has been no development of a full-sized automated bus for public transit systems in the United States.

The Regional Transportation Commission (RTC) of Washoe County, located in Reno, Nevada, proposes to bring advanced connected vehicle technology and a proven automated driving system together in a public transit setting to advance the research and development of ADS technology. Reno is an ideal place to develop the country's first self-driving public bus, since it presents the right broad range of challenges. The buildings are taller than those in the office parks or bus yards, providing a good visual test for the complex algorithms. The weather is more taxing, arid with frequent winter snowfall. There is also lots of foot traffic associated with a vibrant downtown and major university in close proximity.

The Intelligent Mobility proposal team, led by the RTC and joined by the University of Nevada Reno (UNR), Proterra, an electric bus manufacturer whose vehicles have driven over more than 6 million miles of service in communities across North America, and EasyMile, a world-wide leader in Automated Driving Systems that has deployed AV shuttles 250 times in 23 countries, will build and demonstrate an SAE Level 4 automated full-sized electric bus in fixed-route transit operation. In addition to hardware and software for automation, the bus will feature DSRC equipment to communicate with the intersections and other street users as part of a Living Lab being developed in Reno under the technical leadership of the Nevada Center for Applied Research at UNR. The Living Lab consists of a series of intelligent intersections that use 3D laser scanners, advanced edge computers, and DSRC communication to detect and track vehicles, pedestrians, cyclists, and other road users in the Virginia Street corridor connecting downtown Reno to the University.

RTC and UNR first partnered on the Living Lab in 2017 in a project in which a driver-operated all electric Proterra buses was fully instrumented with a number of systems to sense, gather and integrate a range of data from the bus and from an environment rich in vehicle to infrastructure communications. Data collection on this bus, and on the interoperable communications, have been ongoing for two years and have provided a rich data source from which to base the proposed expansion of these technologies into a physical demonstration using a two new Proterra buses outfitted with a proven Automated Driving System.

Using the Living Lab, the proposal team will collect data to validate two claims:

1. Using an automated hardware and software system connecting vehicles and intersections will improve the overall safety of pedestrians, public transit, and all other modes of transportation operating in the corridor.
2. Automated vehicle systems can be deployed without negatively affecting traffic in the city.

The development of the automated buses and integrated on-street technology will take place from project inception through the first eleven quarters of the project. After that, demonstrations of the automated buses on public roads in the City of Reno will take place through the remainder of the project. Assuming a July 1, 2019 start date, this means that automated bus demonstrations will take place from April 1, 2022 until project completion on June 30, 2023. At the same time, UNR will continue to develop and expand the Living Lab infrastructure, and once the automated buses are ready will work with Proterra and EasyMile to conduct joint demonstrations of the buses and the automated MKZ operating concurrently in the Living Lab

Our team believes we have developed a project that uniquely fits the USDOT's ADS grant request:

- This project advances the development of an automated 40-foot electric bus, which does not exist today and will be tested and deployed on public streets;
- This project leverages the specialties of all of the project partners: Proterra's electric bus, EasyMile's proven automation technology, RTC's operational and project management excellence, and UNR's advanced technology Intelligent Mobility Living Lab;
- This project will integrate the key mobility industry trends: connected, automated, shared, and electric
- This project will advance the general publics understanding and acceptance of automated vehicles.

Collaborative Partnership

Regional Transportation Commission of Washoe County

The RTC was formed in July 1979 by the Nevada Legislature. The Governor designated the RTC as the Metropolitan Planning Organization (MPO) for Washoe County. The RTC is responsible for transportation planning, the construction of streets and highways, and the operation of public transportation services. As the transit service provider, RTC operates fixed-route service (RIDE), bus rapid transit (RAPID), paratransit service (ACCESS), and commuter service between the Reno/Sparks metropolitan area and Carson City (Regional Connector). The RTC fixed-route transit network covers a 90-square mile radius and is served by 27 routes requiring 72 buses.

University of Nevada Center of Applied Research Intelligent Mobility Initiative

The UNR Intelligent Mobility Initiative brings together researchers, ideas, and resources for safe, clean and efficient transportation. UNR through its Living Lab has been pioneering effort builds on the expertise of UNR researchers in synchronized transportation, advanced autonomous systems, mass transit, cyber infrastructure, and geographical science. Since 2017, UNR and the RTC have operated a Proterra bus instrumented with a fusion of sensors and GPS-denied localization – collecting data to assess mass-transit routes. This fiber optic and microwave network links vehicles and infrastructure, and the vital information generated is processed, via secure network, through Pronghorn, the University's high performance computing system.

Proterra

Proterra is a leader in the design and manufacture of zero-emission vehicles that enable bus fleet operators to eliminate the dependency on fossil fuels and to significantly reduce operating costs while delivering clean, quiet transportation to the community. Proterra has sold more than 400 vehicles to 38 different municipal, university, and commercial transit agencies in 20 states across the USA. Proterra's configurable EV platform, battery, and charging options make its buses well suited for a wide range of transit routes. With unmatched durability and energy efficiency based on Altoona and testing, Proterra products are proudly designed, engineered and manufactured in America, with offices in Silicon Valley, South Carolina, and Los Angeles. For more information, visit: www.proterra.com

RTC Regional Connector manufactured by Proterra

No Proterra customer has experienced a failed deployment of their Proterra battery-electric buses. Proterra uses a sophisticated computer model to simulate the performance of our vehicles on a perspective customer's route(s). The simulator has been built and tested based on real-world field data and proven to provide accurate results. The Proterra route simulation tool considers all aspects of a given route, including: route distance, speed, stops, layovers, duration, grade, passenger loading, ambient temperature and associated HVAC loads required for comfortable operation, and other hotel loads required for safe and efficient operation.

Well in advance of the new Buy America requirements in the FAST Act, Proterra's buses already contain greater than 70% domestic content. And since our vehicles are proudly built in South Carolina and Los Angeles, partnering with Proterra provides transit agencies with the confidence of knowing that the FY 2020 Buy America requirements have already been demonstrated.
The 40' Proterra Catalyst completed its testing at the Pennsylvania Transportation Institute, Bus Testing and Research Center (Altoona) in April 2015. As noted in the Altoona Test Report, the

Proterra Catalyst received a best-in-class average energy efficiency of 1.70 kWh/mi which is the equivalent of 22.14 MPGe (Miles per Diesel Gallon equivalent). In addition to energy efficiency, the Proterra Catalyst broke records at Altoona for grade-ability, weight (lightest electric bus), and acceleration. The Altoona Test Report is available at: http://altoonabustest.psu.edu/buses/454.

EasyMile

Founded in 2014, EasyMile is one of the leading companies that specializes in autonomous vehicle technology and has a global reach with headquarters in Toulouse (France) and regional offices in Denver (USA), Berlin (Germany), Melbourne (Australia) and Singapore. With more than 100 highly-skilled and passionate employees with expertise in robotics, computer vision and vehicle dynamics, EasyMile supplies smart mobility solutions and autonomous technologies powering driver-less 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 is an advanced technology company which has fulfilled the vision of introducing a new mobility solution to cities around the world. We achieve 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 driver-less 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.

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 traveled with us on more than 200,000 miles. We have 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, we are proud to mention there have been no accidents involving our vehicle in operations. Our R&D, testing and deployment processes with a focus on risk assessment and management make our 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 on-board.

Project Description

The Intelligent Mobility ADS project builds on work already underway by all four partners, pulling them together under the innovative project led by the University of Nevada's (UNR) Center for Applied Research Intelligent Mobility Initiative Living Lab. The Living Lab, launched in 2017, is an ambitious effort to explore solutions for safe, clean and efficient autonomous transportation. The Lab has built on the expertise of UNR researchers in advanced autonomous systems, computer sciences, synchronized mobility, robotics and civil engineering. Advancing these technologies in public transportation is one of the primary purposes of the lab.

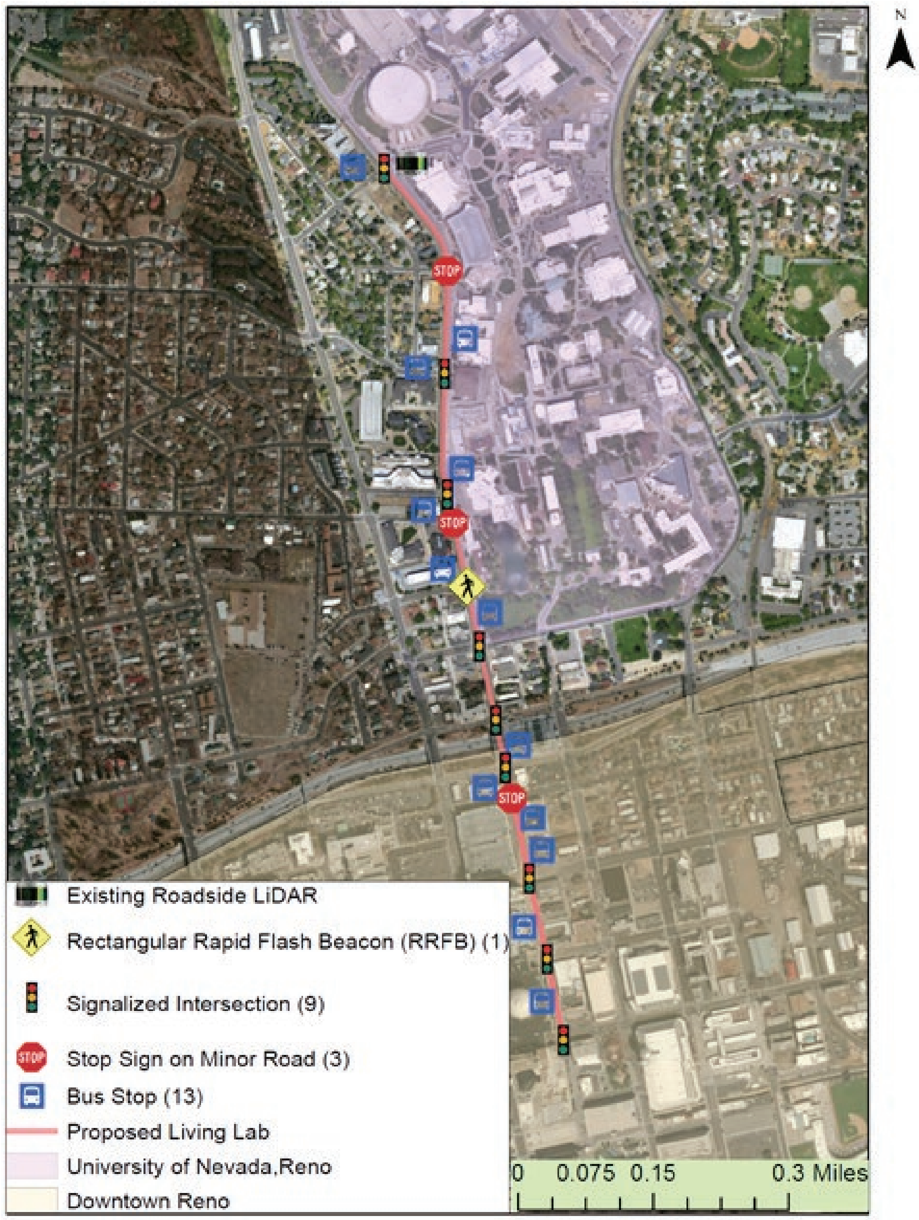


Figure 1. One-mile Living Lab arterial in Reno, Nevada.

The RTC and UNR began their collaboration in 2017 by equipping one of four Proterra BE35 electric buses operated by the RTC with AI sensors and communications equipment to begin collecting data for the Living Lab. The driver operated bus was fully instrumented with a number of systems to sense, gather and integrate a range of data.

The bus is operated on the Sierra Spirit, a downtown Reno circulator servicing the University. For nearly two years now the RTC and UNR have been quietly using Virginia Street as a living lab preparing for the next big innovation in public transit.

At the same time the bus was being equipped with sensors and operated in revenue service, UNR began integrating roadside LiDAR sensors, field data processing computers, DSRC devices, a high-speed microwave network, a high-performance computing platform, and existing traffic infrastructure such as signal controllers to provide an advanced communication system for infrastructure within the Living Lab corridor. Traffic signals and streetlights are being equipped with radios (DSRCs) that can communicate with the bus, and other connected vehicles, to inform them as to what is happening at an intersection up ahead.

Researchers have been gathering the data from the advanced communications infrastructure and AI equipped bus during all four seasons for nearly two years. The goal was to test the sensors in as many different road conditions as possible. “When you have snow on the ground, the way these vehicles and sensors are going to behave is going to be completely different to a rainy day and to extreme heat during the summer,” says Carlos Cardillo, Director of the Nevada Center for Applied Research, who leads the Living Lab program. This is not like other self-driving pilots that have sprung up elsewhere. The project is not just teaching the vehicles how to safely navigate the city, but also how to prepare a city’s infrastructure for autonomous public transportation. Researchers are actively considering and evaluating what sensors and communication tools are needed and what variables the vehicles need to be aware of in the world around them.

Project Goal

The goal of the Intelligent Mobility ADS

The future of public transportation will feature automated vehicles of many shapes and sizes. Automated buses will have to operate in environments with other automated vehicles as well as traditionally-driven vehicles. The goal of the Intelligent Mobility ADS project is to demonstrate how automated vehicles in the Living Lab corridor, both with and without connected vehicle technology, can improve overall safety of all users in the corridor. The Intelligent Mobility ADS demonstration will consist of two Automatic Driving System equipped electric Proterra Catalyst buses and an Automatic Driving System equipped passenger sedan. Having two Proterra vehicles will allow the project team to get early learnings from the first prototype which then can be incorporated into the creation of a second more robust and scalable vehicle. This second vehicle will allow the Proterra autonomous bus to advance beyond just a concept vehicle to a bus which can operate well on a physical demonstration on open roads. Both the buses and the sedan will drive on the Sierra Spirit route with the buses intending to demonstrate the technology in a typical revenue service route to provide a real life test of the system. The buses will use a sensor configuration and software system developed by the proposal team to safely navigate along the route. Simultaneously, the buses will communicate with intelligent intersections developed by the proposal team to enable the buses to safely navigate in the presence of other connected vehicles (autonomous and human-driven) and traditional unconnected, human-driven vehicles.

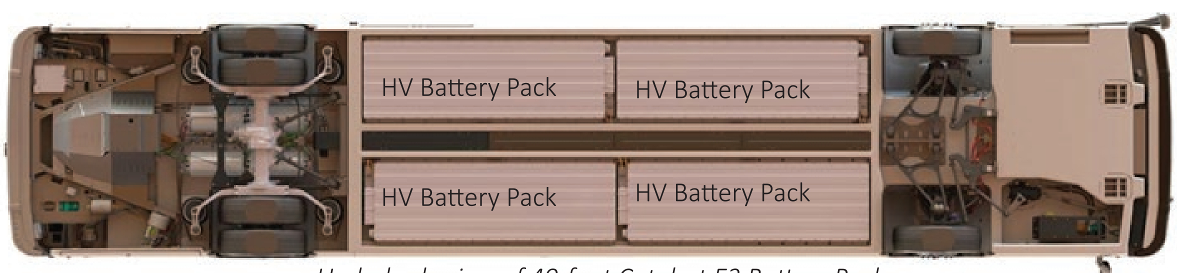
Using this existing and expanded infrastructure, the team will also propose a validation framework for ADS in real-world environments. The goal of the ADS project is to have two full-sized transit buses and the passenger car capable of L3, Conditional Automation, with L4 planned for the two buses by the end of the demonstration.

Technical Approach

Proterra

Proterra's electric buses are unique when compared to other zero-emission battery-electric transit buses. The Proterra Catalyst family of battery-electric buses were specifically designed from the ground up to be heavy-duty electric vehicles, thus resulting in the market's best performing and most efficient buses available. Other OEMs are forced to work within the constraints of an existing metal framed body, often using high voltage battery packs that are not uniform in form factor and placed at suboptimal locations both inside and outside of the passenger cabin.

Having the foresight to design the vehicle purely as an electric vehicle, Proterra began with a lightweight, durable composite monocoque body structure manufactured from high strength fiberglass, carbon fiber, and resin with a balsa wood core. The benefits of using the composite body include: a lighter total vehicle weight (reducing the impact to local roads / infrastructure), improved vehicle efficiency / fuel economy, improved thermal and noise reducing properties, exceptional torsional stiffness (resulting in an excellent ride and handling), increased durability (LA Metro has reported that their composite bus bodies are expected to last up to 20 years), corrosion resistance, and best-in-class safety (better impact resistance). For reference, most 40' electric buses that have traditional metal framed bodies weigh an average of 5,000lbs more than Proterra's Catalyst electric buses.



Underbody view of 40-foot Catalyst E2 Battery Packs

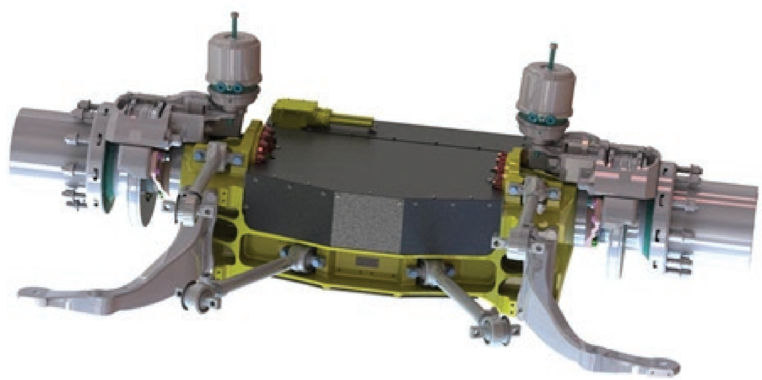
Additionally, the Catalyst battery-electric buses have a recessed cavity under the bus body, between the axles for the high-voltage battery packs. Much like purpose-built light-duty electric vehicles, placing the high voltage battery packs under the body increase vehicle safety (located outside of the passenger cabin and below the side impact zone), improve the ride and handling (centering mass between the axles and low to the ground), and optimize the use of space around the vehicle (allowing for a rear window and a clean, simple powertrain design).

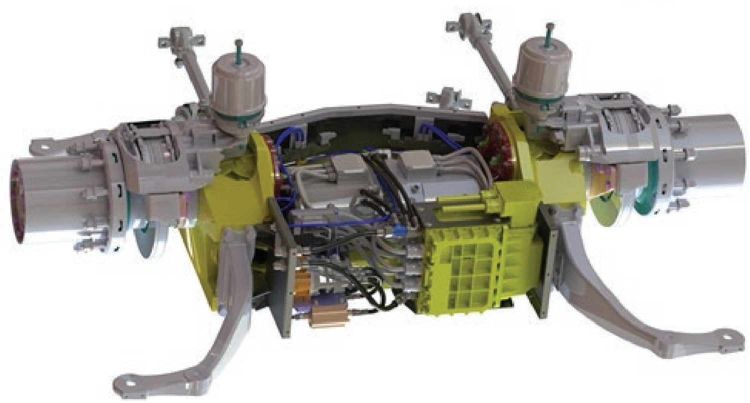
The Proterra Catalyst comes standard with all wheel air-disc brakes, a more robust ZF independent front suspension, all-electric components and accessories, a state-of-the-art vehicle multiplex system, a proven all-electric HVAC, state-of-the art high voltage battery pack components manufactured by Proterra in the United States (which meet Buy America requirements for components), and an ergonomically designed driver's station.

Proven Electric Propulsion Systems

DuoPower

To unlock even more route opportunities, Proterra has introduced the new DuoPower™ drivetrain. This new drivetrain delivers twice the horsepower and acceleration and five times the efficiency of a standard diesel engine. By combining the DuoPower drivetrain with Proterra's market-leading battery technology and lightweight composite bus body, the Catalyst vehicle provides unparalleled performance.





The DuoPower drivetrain features two electric motors that deliver an impressive 510 horsepower, accelerating a Catalyst bus from 0-20 mph in 4.5 seconds, while also achieving an industry-leading 26.1 MPGe. In addition, it can propel a bus up a 26 percent grade, which is more than twice the performance of the average 35- or 40-foot diesel bus, and 100 percent better than the average competing electric transit vehicle, making it an ideal option for transit agencies with steep hills.

The new "DuoPower" Proterra Catalyst drivetrain system employs state-of-the-art electric vehicle technology that is conveniently integrated into the rear axle of the bus. Proterra uses two190kW permanent magnet synchronous motors, each directly coupled to a multi-speed gearbox that independently drives its respective wheel. The system is capable of up to 510 peak horsepower and is controlled via an inverter which receives direct current from the high voltage battery system. The drivetrain system uses a liquid cooling circuit to reject heat through the bus heat exchanger.

The Proterra multi-speed gearbox is purpose designed and built for heavy-duty electric vehicle operation. The gear ratios were selected to maximize fuel economy for transit bus operation while ensuring best in class performance. The gearbox contains a pneumatically actuated shift mechanism to seamlessly shift between low and high gear. An external electric pump is used to circulate oil for lubrication and heat rejection. The output of the gearbox is coupled to a planetary gear reduction unit housed within the wheel hub.

All actuators and sensors for the gearbox are connected to the Proterra powertrain controller which is responsible shift actuation and motor torque commands. The controls have been optimized for transit bus service to balance drive feel while maximizing efficiency. The vehicle control system was designed using Proterra's state-of-the-art computer simulation model and calibrated with real-world data from customer vehicles, engineering testing utilizing proprietary drive cycles and standard FTA drive cycles (CBD, Arterial, Commuter).

The DuoPower drivetrain allows Proterra customers with more challenging routes to select a more powerful and more efficient drivetrain solution for their electric buses.

Recharging / Refueling Requirements

Plug-In / Depot Charging

All Proterra vehicles can charge the high voltage batteries using any SAE J1772 CCS Type 1 commercially available plug-in charger. The SAE J1772 CCS standard is the North American plug-in charging standard that many automotive OEMs have adopted, including GM, Ford, Chrysler, BMW, Porsche, Audi, and Volkswagen. Leveraging the automotive standard allows Proterra's customers to piggyback on the strong demand in the automotive sector for SAE J1772 CCS chargers, resulting in lower prices that are driven by open competition and market forces.

For the 2019 US DOT Program, Proterra is offering SAE J1772 CCS chargers at power levels of 60kW and 125kW. These chargers consist of a remote Power Control System (PCS) charger and a local dispenser which can be wall mounted, mounted overhead, or mounted on a small pedestal.

EasyMile

The EasyMile system that will be installed on two 40 foot Proterra buses will be adapted from the proven EasyMile Technology. The ADS demonstration will allow this technology to be developed and safely deployed.

The current EasyMile shuttles are not that different to a human being. It requires the same information to reach its destination:

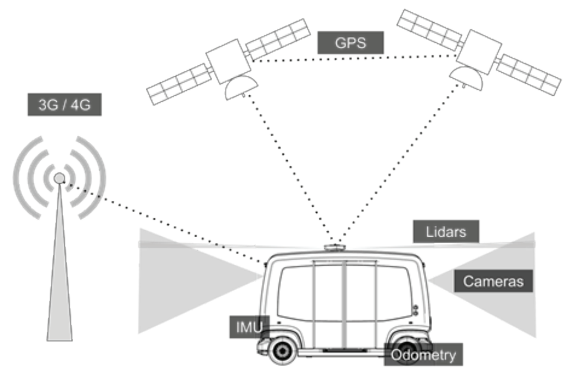
- Where is it located?
- Where is it going and how can it get there?
- What are the environmental conditions and how should it adapt its behavior?

To do so, all current 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 human need not pay attention in those circumstances.

The EZ10 is preprogrammed by EasyMile engineers or certified partners to run on predefined routes or network of routes, under certain circumstances.

Sensor Stack

The software has been designed to know the vehicle's exact position with centimeter-level precision, at all times. By merging the types of data below, the software can obtain this level of precision: Software for the ADS demonstration will be developed to the same standard as the EZ10.



- Laser scanning the environment
- Cameras
- Differential GPS
- Visual location
- Estimation using an Inertial Measurement Unit (IMU)
- Odometry estimation

Each of these safety technologies are described in more detail below.

Environmental Laser Scanning - LiDARs

The current EZ10 shuttle is equipped with several different LiDARS to ensure redundancy in information collection. The Proterra bus built for this demonstration will be built to the same standards whenever possible.

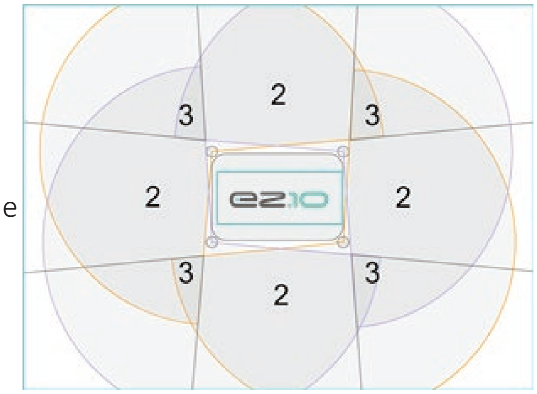
- 4 LMS, also called Safety LiDARs on the EZ10
  - One at each corner of the vehicle
  - Strategically positioned 12in above the ground
  - Single layer LiDAR
  - Range of 130 ft.
  - 270° horizontal scanning
  - Used for obstacle detection by high-level software
  - Used for obstacle detection by the Safety Chain
  - Used for navigation by the high-level software

There is currently no certified LiDARs 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.

- 2 LDRMS, also called Localization LiDARs on the EZ10

- 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.)
- 4 layers
- Range of 720ft
- 110° horizontal scanning
- 3.2° vertical opening
- Used for navigation by the high-level software



- 2 VLP16, also called 3D LiDARs on the EZ10
  - One at the front and one at the rear of the vehicle (bi-directional vehicle)
  - LiDARs 16 layers
  - Range of 260ft
  - 180° horizontal scanning
  - 32° vertical opening
  - Used for navigation by the high-level software
  - Used for obstacle detection by high-level software

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.

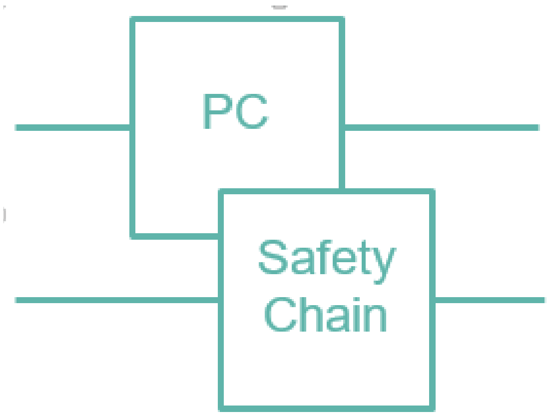
Odometric Estimation

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

Independent Obstacle detection function

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. Our 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.

Focus on the PLC

The PLC used in our 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.

Supervision - System Brain

EasyMile has developed EZ Fleet, its own Fleet Management system 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, to enable different operating scenarios and to adapt to the various needs of our customers.

Driver-less Software Stack

Localization and Navigation Capabilities

To move autonomously, the vehicle runs along a pre-programmed route designed by a deployment engineer. 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.

Data Fusion and Interpretation

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, using laser beams (our LiDARs), the distance from surrounding objects (buildings, trees,...) 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 road planned for the EZ10 in Reno 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.

Intersection Management - Connected traffic lights

The proposed demonstration will be run on the UNR Living Lab‘s on Virginia Street in Reno. The Living Lab consists of nine signalized intersections and 13 bus stops serviced by RTC. Each of these intersections will be equipped with DSRC communications equipment, LiDAR sensors, and computer systems to enable the intersection to detect and track road vehicles, cyclists, and pedestrians and to communicate tracking information to connected vehicles (as shown in Figure 2). 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.

Intersections with Signage
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.

Pedestrian Crossing

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.

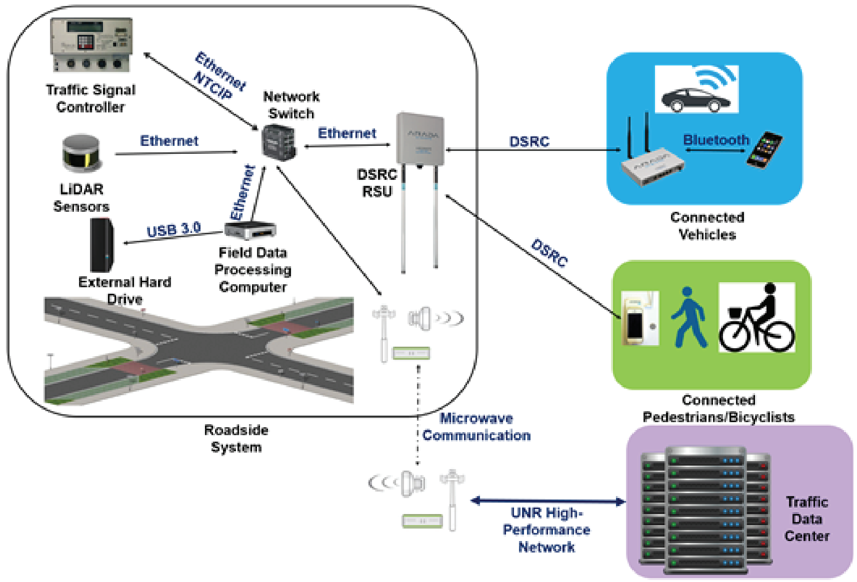
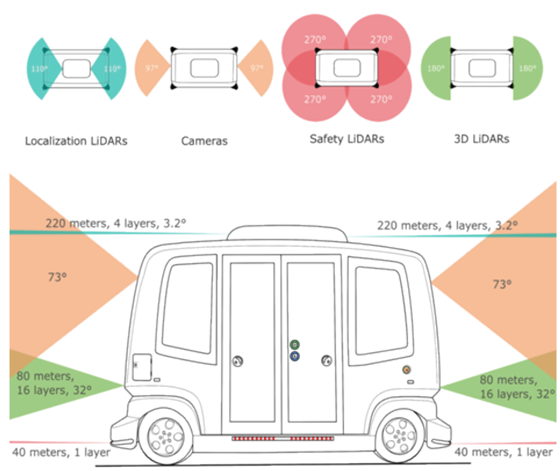


Figure 2. Diagram of Lidar-enhanced connected-traffic infrastructure at an intersection.

Intersections with Traffic Lights - DSRC
Vehicle to infrastructure (V2I) communication is a key component of EasyMile's technology. As shown in the graphic below, 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.

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 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.

University of Nevada

Through its Nevada Center for Applied Research (NCAR), the University of Nevada, Reno (UNR) has numerous resources for the development of connected and autonomous vehicle technology. Chief among these is a software-controllable 2017 hybrid Lincoln MKZ (pictured in Figure 1). This vehicle is fully instrumented to support experiments related to autonomy, and includes multiple computer systems, several cameras, multiple Velodyne LiDAR units, radar, and ultrasonic sensors. The car also contains a power distribution system that allows the UNR team to connect additional electronics for sensing, monitoring vehicle performance, and communicating with the outside world. In particular, the car is able to host "connected vehicle" technology such as onboard-dedicated short-range communications (DSRC) receivers and other network hardware. The vehicle also comes equipped with a Robot Operating System (ROS) based operating system that enables autonomous operations.

The UNR autonomous car is equipped with a number of sensors, most of which are standard for self- driving vehicles. As a research platform, the placement and arrangement of sensors is designed to adjustable to support research experiments; sensors can be added or removed easily, often within minutes. The current sensor configuration of the vehicle includes:

- GNSS. The car is equipped with a Novatel ProPak 6 GPS/IMU system. This provides vehicle position information that is typically accurate to within about one meter.
- Cameras. The car is equipped with a number of cameras to enable the car to "see" its surroundings.
- Lidar. The car is equipped with a number of LiDAR sensors to enable 3D perception.
- Radar. The car has front-facing radar for detecting vehicles in front of the car.
- Ultrasonic Sensors. Ultrasonic sensors around the car enable the detection of obstacles within one meter of the vehicle.

The coordination of sensor data is handled via a combination of open-source software and software developed in-house at the University of Nevada, Reno. This control is achieved through a collection of modules built on the Robot Operating System (ROS). The design of this collection is based on Baidu's open-source Apollo system, with substantial modifications by Nevada's team. This system provides a foundation for experimenting with novel algorithms and designs. The modules of the system perform the following functions:

- Perception. The perception system takes input from the car's cameras, lidar, radar, and

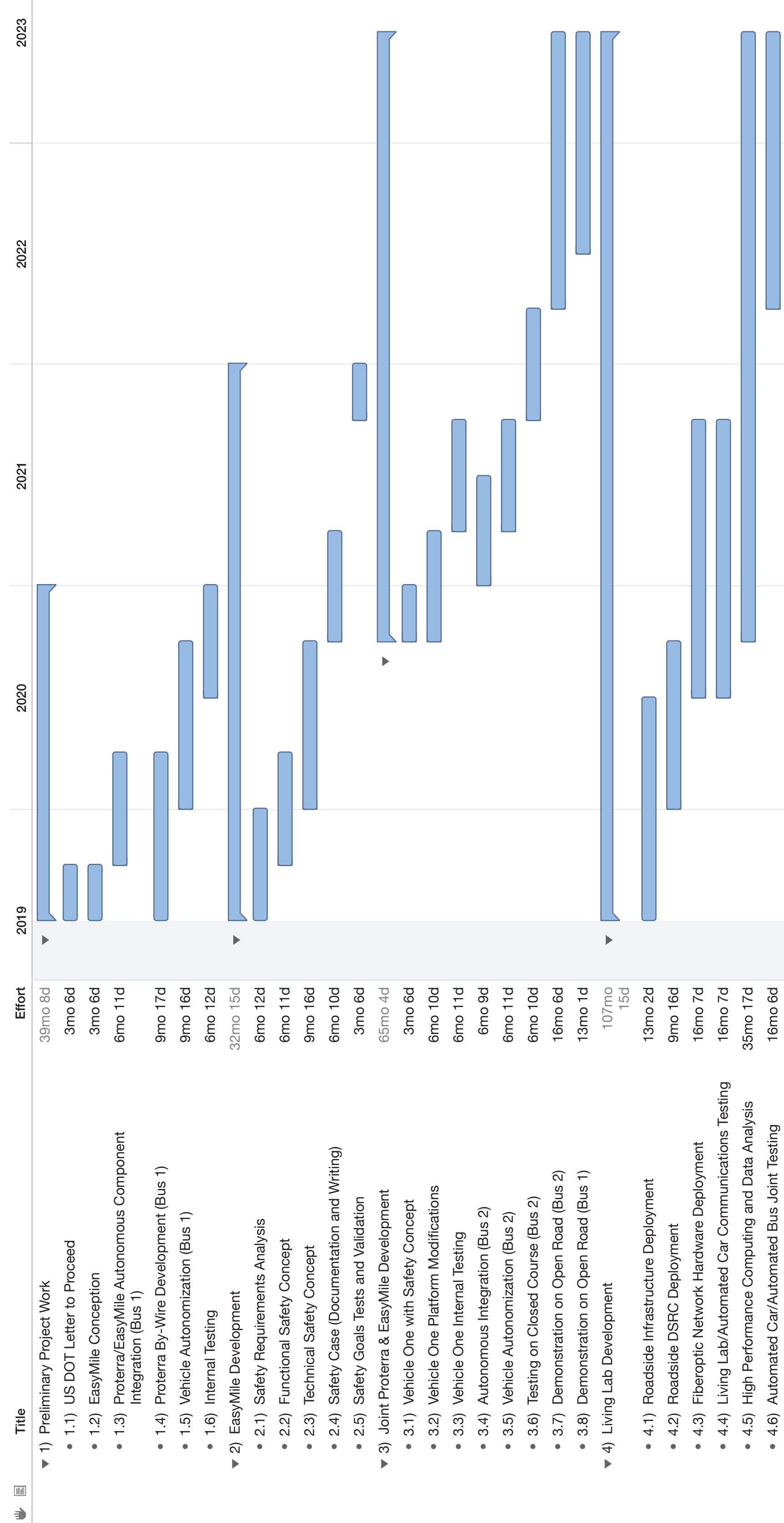
ultrasonic sensors, and uses neural networks to detect other cars, pedestrians, road signs,
- Routing. The routing system is responsible for finding a valid route from the car's current location to a user-entered destination. It does this using a high-level map of the city.
- Prediction. To safely navigate around vehicles, pedestrians, and other road users, the car is equipped with a behavior prediction module that uses deep probabilistic programming models to anticipate what agents around the car will do next.
- Localization. The localization module uses a combination of GPS location estimates and sensor readings to determine the location of the car.
- Planning. The planning module is responsible for translating the car's current route into a sequence of steering commands and desired vehicle speeds.
- Control. The control module is responsible for ensuring that the steering and speed commands generated by the planner are accurately tracked to generate a safe and comfortable experience for the car's passengers.

Autonomous Vehicle Support Equipment. In addition to the autonomous vehicle described above, the Nevada Center for Applied Research has additional support equipment that will be used to study applications of roadside sensor data to connected vehicle safety. These include storage servers for holding the large quantities of data that the project will generate, and compute servers for processing that data. In particular, NCAR hosts multiple compute servers that hold NVIDIA graphics processing units (GPUs) that accelerate the processing of geometric data such as point clouds generated by LiDAR sensors.

Project Readiness

Include description on the, current Living Lab, lessons learned and project location, much of details on the staffing should be included in the part 2

Project Schedule and Timeline



Legal and Regulatory Compliance

Federal and State Regulations
Proterra and EasyMile do not anticipate requiring any exemption from the Federal Motor Vehicle Safety Standards, Federal Motor Carrier Safety Regulations, or any other federal regulations based on their knowledge of regulations in place today.

The demonstration will take place in the City of Reno in Nevada. The State of Nevada regulates the testing and deployment of automated vehicles on public roads. Those regulations can be found in chapter 482A of the Nevada Revised Statutes, and require that any entity wishing to test or deploy automated vehicles in the state receive a certification for each such vehicle. Under Nevada's rules, entities are able to self-certify their compliance with the state's regulations. As the eventual operator of automated bus described in this proposal, the Regional Transportation Commission of Washoe County will submit the "Autonomous Vehicle Testing Registry Application" to the Nevada Department of Motor Vehicles. The University of Nevada, Reno has already applied for and received all required certifications to operate its automated sedan on public roads, and will work with the Regional Transportation Commission to apply for the testing certification for the bus.

Buy American and Domestic Vehicle Preference
The proposal team will not require exemption from either the Buy America Act or the domestic vehicle preference established in the NOFO clause at Section F, Paragraph 2.J. The proposed automated bus system will be manufactured in the United States, and the automated vehicle (a Lincoln MKZ manufactured by Ford) described in the proposal has already been purchased by the University of Nevada, Reno.