# A

# Appendix

- Microtransit deployments
- Vehicle options
- Infrastructure and operational considerations
- Business models
- Technology considerations

## Microtransit Deployments

There are a number of ongoing and planned autonomous microshuttle deployments in the United States and around the world. The locations of the U.S. deployments are shown in Figure A.1 and Table A.1. The weather conditions, roadway configurations, intended ridership, and time-lines of the deployments vary greatly.

The Contra Costa Transportation Authority launched an autonomous microshuttle service to serve employees in a large office park in San Ramon, CA. The service is currently only open to select employees that have agreed to provide feedback on their experiences[1]. The Minnesota Department of Transportation is testing an autonomous shuttle on a closed course at their MnROAD testing facility in Monticello, MN. The deployment aims to analyze the operation of the vehicle in a variety of winter weather conditions[2]. Jacksonville, FL and Arlington, TX have ongoing microshuttle deployments with routes that currently operate on closed routes and are generally planned to be open to the public during events and

1 *http://www.govtech.com/fs/Driverless-Shuttle-Program-Kicks-Off-in-California-to-Tackle-First-MileLast-Mile-Mobility-Obstacle.html*

2 *http://www.dot.state.mn.us/autonomous/bus/*

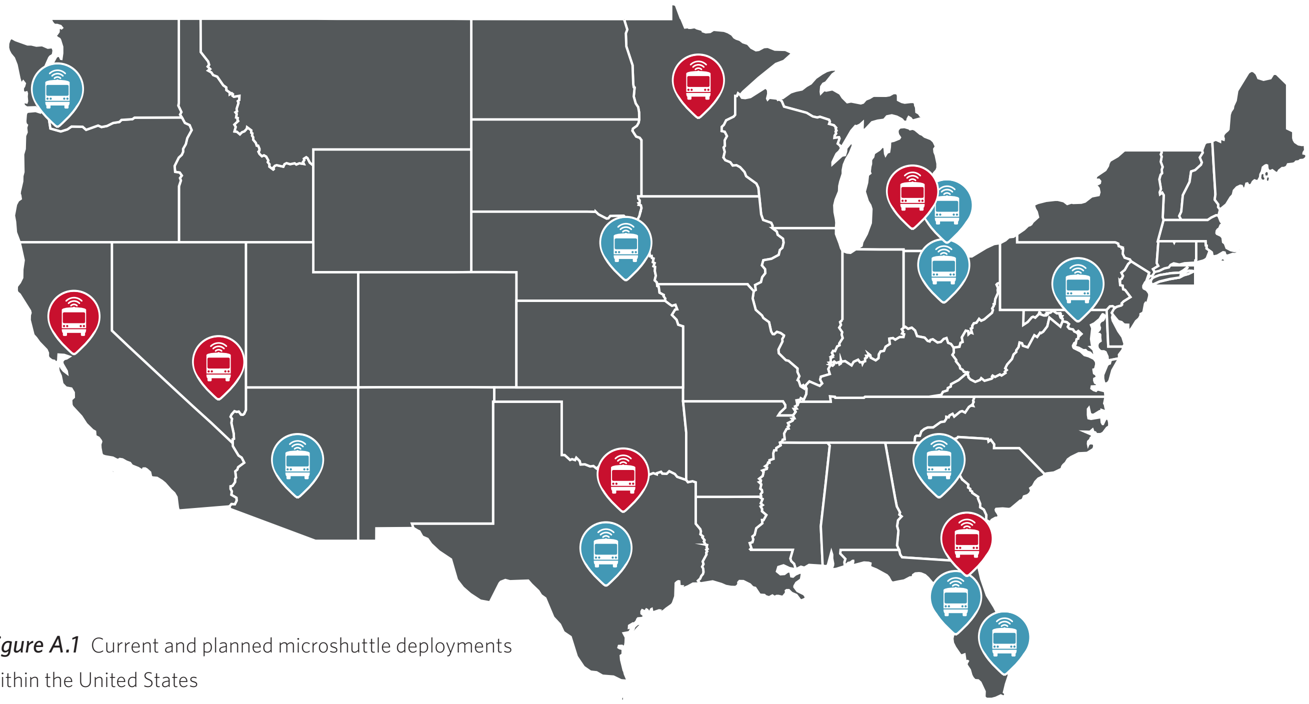

*Figure A.1* Current and planned microshuttle deployments within the United States

pre-planned functions[3][4]. A deployment in Las Vegas that was open to the public created controversy when it was involved in an incident during its inaugural day of operation. While the collision was minor and did not result in any injuries, the event was analyzed closely and it was determined that the autonomous shuttle was not at fault[5].

The ongoing microshuttle deployments are providing agencies, researchers, and other interested parties with a number of lessons learned. Public acceptance of autonomous vehicles has increased as successful testing has been completed and more communities are given a chance to experience the emerging technology first-hand. Data quantifying measures such as ridership and miles traveled is being collected throughout the projects. Once the deployments are complete, this information will be extremely valuable in shaping future autonomous shuttle operations.

### *Table A.1* Microshuttle Deployments

| | City | Shuttle | Mixed-Traffic |
|---|---|---|---|
| Current Deployments | Las Vegas, NV | Navya | Yes |
| | San Ramon, CA | EasyMile | Partial |
| | Jacksonville, FL | EasyMile | No |
| | Monticello, MN | EasyMile | No |
| | Arlington, TX | EasyMile | No |
| | Ann Arbor, MI | Navya | Yes |
| Planned Deployments | Lincoln, NE | | Yes |
| | Phoenix, AZ | | |
| | Austin, TX | | |
| | Tampa, FL | | Yes |
| | Miami, FL | | |
| | Baltimore, MD | | |
| | Columbus, OH | | Yes |
| | Detroit, MI | | |

3 *http://www.arlington-tx.gov/news/2017/11/02/schedule-free-ride-milo-arlingtons-autonomous-shuttle-month/*

4 *http://jacksonville.com/news/metro/2017-12-19/jta-opens-test-track-future-self-driving-transit-shuttles*

5 *https://www.forbes.com/sites/jimgorzelany/2017/11/08/las-vegas-lets-it-ride-with-self-driving-shuttle-service/#213a3e17748f*

# Vehicle Options

## Overview

The proposed Lincoln deployment presents a number of challenges for the current offering of autonomous vehicle platforms. The size of the deployment, the complexities of a mixed-traffic scenario, and the challenges of production have led to a narrowing of two capable platforms, each with its own strengths in relation to the Lincoln deployment. Both Navya and EasyMile have substantial experience and success in deploying vehicles, and represent the best, most cautious, and safest options that also meet the objectives of the project. A description of the advantages and disadvantages is below, followed by an overview of the critical specifications in Table A.2.



## Navya Autonom Shuttle

### Advantages

The Autonom Shuttle has a number of deployments throughout the world, several operating in mixed traffic scenarios. The vehicle is beginning production in the United States, and vehicles will be readily available for a fall 2018 deployment. This vehicle is equipped with an inductive charging system that eliminates the need for a physical detachment from charging before deployment.

### Disadvantages

The Navya vehicle is equipped with an on-board ramp that can accommodate persons with disabilities. However, this ramp must be manually deployed by an on-board "ambassador" or other traveler. Additionally, the current Navya shuttle has limitations on the length of the route with a maximum route equivalent to approximately 2.0 miles.

### Future Offerings

Navya is in the process of developing system software improvements that will allow an on-demand service within a geo-fenced area, giving the opportunity to deploy the vehicles into a larger area. The software is expected to be ready for use toward the end of 2018.

## EasyMile EZ10 Shuttle Gen2

### Advantages

The EZ10 Shuttle is a popular choice for closed-traffic systems, with many deployments throughout the United States and Europe. The shuttle offers an automatic handicapped ramp deployment, and has an API that will interface with major transit app creators. Generation 2 of the shuttle is under production, and will be available to the U.S. market by the time of Lincoln's deployment.

### Disadvantages

Produced in France, there will be a lag time for shipping, and may be an issue for the "Buy USA" requirement.
The shuttle must be recharged through the use of an external charging cable. Prior to deployment this cable must be detached manually. Additionally, the vehicle is able to operate in a narrower range of temperatures than its competitor, which may be an issue during extreme temperatures in summer and winter.

### Future Offerings

Generation 2 will offer a better array of sensors, including LiDAR. The development of Gen. 2 is specifically for commercial applications and deployment, and will include a greater range of deployment types the vehicle is capable of following.

***Table A.2*** *Vehicle Specifications*

| | | Navya Autonom Shuttle | EasyMile EZ10 Shuttle |
|---|---|---|---|
| Capacity and Dimensions | Passengers | 15 total<br>(11 seated, 4 standing) | 12 total<br>(6 seated, 6 standing) |
| | Dimensions | L 15.58′<br>W 6.92′<br>H 8.69′ | L 13.18′<br>W 6.55′<br>H 9.41′ |
| | Clearance | 7.87″ | 6.96″ running / 3.94″ in station |
| | Operating speed | 15.5 mph | 12.4 mph |
| | Empty Weight | 5291 lbs | 4079 lbs (standard);<br>Options up to 4475 lbs |
| | Gross Weight | 7606 lbs | 6680 lbs |
| | Access Ramp for Wheeled Access | Manual ramp | Automated electric access ramp |
| Power / Energy | Power | 15 nominal (25 peak) kW | 2 x 8 kW nominal |
| | Battery | Battery pack LiFePo4 | LiFePo4 |
| | Capacity | 33 kWh | 15.36 kWh (standard);<br>Options up to 30.72 kWh |
| | Average Autonomy | 9 hours | Up to 24 hours (doesn't list average) |
| | Charge duration for 90% | 8 hours (induction or plug 3.6 kW); 4 hours (plug 7.2 kW) | 8 hours (15.36 kWh battery);<br>6 hours (30.72 kWh battery) |
| | Charging Technology | Induction / Plug | Wired / on-board |
| | Charging Temperature | 32 to 104<br>degrees Fahrenheit | |
| | Operating Temperature | 14 to 104<br>degrees Fahrenheit | 23 to 95 degrees Fahrenheit |
| Localization and Obstacle Detection | LiDAR 1 | Two 360 degree multi-layers LiDARs | Hybrid localization technology combining odometry, IMU, LIDAR, GPS, and cameras. Detection LiDARs and cameras. Safety relays, emergency stop switches, audio and visual warning alarm. Permanent 3G or 4G connection to EasyMile cloud infrastructure. High speed WiFi connection. Vehicle to infrastructure communication. |
| | LiDAR 2 | Six 180 degree mono-layer LiDARs | |
| | Cameras | Front/rear cameras | |
| | Odometry | Wheel encoder +<br>Inertial unit | |
| | GNSS | RTK | |

# Infrastructure and Operational Considerations

There are five main components to the proposed deployment:

1. **Autonomous, Microtransit Vehicles:** There are expected to be 3 to 4 vehicles running simultaneously during the Pilot Demonstration.

2. **On-Board Equipment (OBE):** This equipment would be mounted within a vehicle and consist of the following:

    - Autonomous vehicle sensor suite
    - Communications equipment including a DSRC radio and cellular connectivity
    - Central computer that processes the inputs from the sensor suite and the vehicle vendor monitoring and operations center

3. **Roadside Equipment (RSE):** This equipment would be mounted above or adjacent to the roadside and consist of the following:

    - Traffic control devices
    - Transit vehicle monitoring
    - Communications equipment including DSRC radio and wireless access point (WAP)

4. **Microshuttle Vendor Monitoring and Operations Center:** This represents the backend monitoring capabilities that microshuttle vendors offer, including the following:

    - Vehicle video camera feed
    - Vehicle status feed
    - Vehicle override system
    - Data warehouse

5. **Lincoln Operations and Dispatch Center:** The function of this equipment is to monitor, process, store, and present information so that decisions can be made based upon the information. The following elements are included:

    - DSRC message center
    - Data warehouse

There are four primary flows of communication between these components:

- Information is exchanged between the On-Board Equipment and the Microshuttle Vendor Monitoring and Operations Center via cellular connectivity.
- Information is exchanged between the On-Board Equipment and the Roadside Equipment via DSRC connectivity.
- Information is exchanged between the Roadside Equipment and the Lincoln Operations and Dispatch Center via fiber connectivity.
- Information is transmitted between the Lincoln Operations and Dispatch Center and the Microshuttle Vendor Monitoring and Operations Center via fiber connectivity.

A conceptual system architecture is presented in Figure A.2, followed by a more detailed discussion of each element. It is assumed that the onus for decision making beyond the microshuttle's central computer will be the primary responsibility of the microshuttle vendor. The intent of this set-up is to allow the City of Lincoln to monitor vehicle status while limiting agency exposure to making safety-critical decisions.

# On-Board Equipment

The OBE consists of the autonomous sensor suite, communications equipment, and a central computer. Each of these elements is described in more detail below.

## Autonomous Vehicle Sensor Suite

The autonomous vehicle sensor suite subcomponent consists of the sensors that the vehicles rely on for object detection as typically found in autonomous vehicles as described above.

## Communications Equipment

### CELLULAR RADIO

This sub-component consists of a cellular modem for transmitting vehicle position, telematics, and the internal video camera feed back to the vendor's monitoring and operations center. The cellular radio will also be capable of receiving vehicle override commands from the vendor's monitoring and operations center.

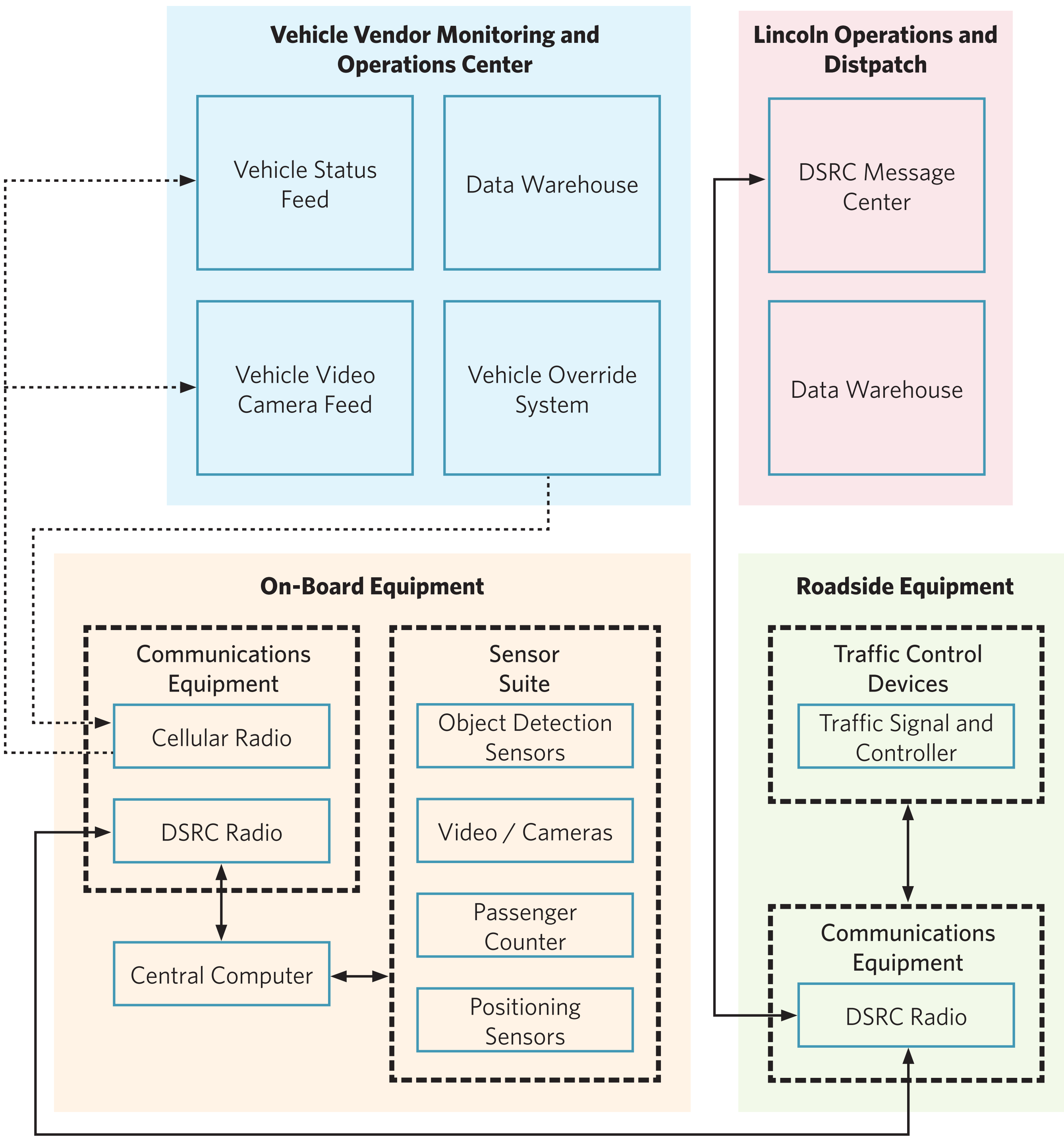


*Figure A.2 Conceptual System Architecture*

#### DSRC RADIO

This sub-component is the actual radio processor and associated firmware that is responsible for queuing, broadcasting and receiving connected vehicle messages. This radio provides communication using the SAE J2735 message set in accordance with IEEE 1609.2-2016 and IEEE 802.11p standards. In particular, this sub-system component will be responsible for broadcasting BSMs from the vehicle at a frequency of 10 Hz. This sub-system component will also be responsible for receiving V2I and V2V messages from RSEs and other OBEs, respectively. A second responsibility of this sub-system component is to ensure the authenticity of received messages and to process and provide the necessary encryption and authentication to messages received and transmitted.

#### J2735 NATIVE MESSAGE APPLICATIONS

Once messages are received by the DSRC Radio Stack, they are forwarded to the J2735 Native Message Application for decoding/parsing and processing. Collectively, these Native Message Applications must be capable of receiving and processing messages associated with:

- Basic Safety Message (Part I, Part II)
- Common Safety Request
- Map
- Signal Phase and Timing
- Traveler Information
- Roadside Alert

This sub-system component is also responsible for generating any or all J2735 messages, which are subsequently passed to the DSRC Radio Stack to be processed and transmitted. In particular, the Basic Safety Message Native Application is responsible for receiving the vehicle telematics, characteristics and positioning information and then packaging this information into a Basic Safety Message (BSM).

#### VEHICLE TELEMATICS AND POSITION

This sub-system component is responsible for obtaining the current vehicle telematics information such as speed, acceleration and other information from the vehicle and providing it to all other applications within the OBE. This sub-system component is also responsible for obtaining and providing vehicle location to other sub-system components.

#### CENTRAL COMPUTER

This sub-system component is responsible for processing inputs from the autonomous vehicle sensor suite, interpreting messages from the on-board communications equipment, and making steering, acceleration, and braking decisions for the vehicle.

## Roadside Equipment

The roadside equipment component is the point of connection between vehicles and infrastructure components. It is responsible for bridging communications among vehicles and between vehicles and the Lincoln Operations and Dispatch Center.

### Traffic Control Devices

This will consist of the traffic signal, the traffic signal controller cabinet, and the mechanism for transmitting traffic signal preemption from autonomous vehicles to the signal controller.  This could allow signal preemption if desired, and can be enabled via DSRC.

### Communications Equipment

#### DSRC RADIO STACK

This sub-system component performs virtually the same functions as the corresponding sub-system component within the OBE.

#### J2735 NATIVE MESSAGE APPLICATIONS

This sub-system component performs virtually the same functions as the corresponding sub-system component within the OBE.

#### WIRELESS ACCESS POINT (WAP)

This sub-system component provides wireless coverage along the test track for the CCTV video feed transmission, if desired.  WAPs are connected to the City of Lincoln fiber optics network.

#### COMMUNICATIONS BACKHAUL CONNECTIVITY

This sub-system component provides fiber connectivity, via a network connection, to the Lincoln Operations and Dispatch Center System Component. This connectivity may be accomplished via hardwire or wireless methods.

# Vehicle Vendor Monitoring and Operations Center

The manner in which vendors monitor and vehicles and intervene in incidents varies from vendor to vendor. For the purposes of this document, it is assumed that this component will consist of the following sub-components.

### Vehicle Status Feed

This sub-component consists of the presentation of vehicle position and telematics data to the vendor monitoring and operations center.

### Vehicle Video Camera Feed

This sub-system component consists of the presentation of the internal on-board camera to the vendor monitoring and operations center.

### Vehicle Override System

This sub-system component consists of a mechanism for sending a vehicle override command to the autonomous vehicle.

### Data Warehouse

This sub-system component would serve to electronically store data from the system for additional processing and analysis.

# Lincoln Operations and Dispatch Center

The Lincoln Operations and Dispatch Center is the system component that performs management and configuration activities of the overall system, and collects and stores data and communications.

### DSRC Message Center

This sub-system component is responsible for processing all of the received DSRC messages from the RSE and configuring these messages for long-term data storage. In particular, of interest for processing would be the BSMs transmitted to the RSEs by the OBEs. This sub-system component is also responsible for processing any other alert/warning or status messages from the RSE.

### Data warehouse

This sub-system component would serve to electronically store data from the system for additional processing and analysis.

# Business Models

## Overview

There are several potential business models that could be used to fund the pilot project including:

- A fully City funded pilot,
- A pilot funded by obtaining research grant funding, or
- Funding the pilot through a public private partnership(s).

Each of potential operations could also be used in combination as well.

## City Funded

Given the relatively new nature of the technology and the objectives of the Pilot, it may be challenging for the pilot to be fully funded through fare revenue collection and/or commercialization of advertising space on the vehicles and/or stops given the short duration of the project and the unknown ridership and market penetration. One important component of the pilot will be to test how a larger deployment of shuttles could be partially supported with a reliable revenue stream. A fare-supported model would charge users of the shuttle service on either a per-month or a per-ride basis, giving passengers the flexibility adapt their payment option to their use of the shuttle. Frequent users of the service might opt for a monthly fee, while infrequent users would be better suited for a per-ride fee. The City will need to balance the fee to be low enough to attract users, but high enough to generate revenue to offset some cost of operation. A business model that partners with other organizations or businesses could offer additional ways to generate steady revenue. Heavy potential users may want a dedicated stop along the route to give better access to off-site parking, or connect to high concentrations of parking and amenities. Additionally, revenue can be generated by selling the exterior of the vehicles with “wraps”, in a similar fashion to what is typically done for buses.

- **Potential ridership revenue** – if we assume a very modest degree of ridership at 100 rides a day on average; over the course of the two year pilot, this would generate ~$73,000 in funding. As ridership increases, this funding mechanism would also increase proportionally.
- **Advertising and commercialization of the shuttle fleet.** Typical bus wrap advertising is on the ball-park of $2,000 - $8,000 for a 4 week wrap. Over two years, assuming a $5,000 price for 4 weeks, this would result in ~$130,000 in funding. Again, as ridership and utilization of the vehicles increases, this could result in increased revenue from advertising.

## Research Grants

As an alternative to the city self-funding the pilot, there are a number of research and other grant opportunities that may provide funding. Funding transit technology such as autonomous vehicles is generally an allowable component to many Federal transportation funding grants including the following:

- **Advanced Transportation Congestion Mitigation and Technology Deployment (ATCMTD) Program** ($60M each year for the next 3 years, 8-9 awardees per year)
- **Federal Transit Administration Mobility Sandbox** ($12M; ~4-5 awardees)
- **University Transportation Research Center (UTC) Grants**
- **Broad Agency Announcements** – FHWA, FTA for technology research and development (various funding amounts on differing topics) for example, in 2017 FHWA sponsored research under the Exploratory Research Grants on the Impacts of Automated Transit, Pedestrian, and Bicycling Facilities on Urban Travel Patterns.
- **FTA Grants for Enhanced Mobility of Seniors & Individuals with Disabilities - Section 5310** Formula funding to states for the purpose of assisting private nonprofit groups in meeting transportation needs of the elderly and persons with disabilities.
- **FTA Flexible Funding Programs** - **Congestion Mitigation and Air Quality Program - 23 USC 149** CMAQ provides funding to areas in nonattainment or maintenance for ozone, carbon monoxide, and/or particulate matter. States that have no nonattainment or maintenance areas still receive a minimum apportionment of CMAQ funding for either air quality

projects or other elements of flexible spending. Funds may be used for any transit capital expenditures otherwise eligible for FTA funding as long as they have an air quality benefit.

- **FTA Formula Grants for Buses and Bus Facilities Formula Program - 5339(a)** Provides funding to states and transit agencies through a statutory formula to replace, rehabilitate and purchase buses and related equipment and to construct bus-related facilities
- **FTA Formula Grant Low and No-Emission Component Assessment Program (LoNo-CAP)** On September 29, 2016, FTA announced the opportunity for eligible institutions of higher education to apply for funding to conduct testing, evaluation, and analysis of low or no emission (LoNo) components intended for use in LoNo transit buses used to provide public transportation. The deadline for applications is November 28, 2016.
- **FTA Low or No Emission Vehicle Program - 5339(c)** Provides funding through a competitive process to states and transit agencies to purchase or lease low or no emission transit buses and related equipment, or to lease, construct, or rehabilitate facilities to support low or no emission transit buses. The program provides funding to support the wider deployment of advanced propulsion technologies within the nation's transit fleet.
- **Pilot Program for Transit-Oriented Development Planning - 5309** Provides funding to local communities to integrate land use and transportation planning with a transit capital investment that will seek funding through the Capital Investment Grant (CIG) Program.
- **Safety Research and Demonstration Program** - The Safety Research and Demonstration (SRD) Program is part of a larger safety research effort at the U.S. Department of Transportation that provides technical and financial support for transit agencies to pursue innovative approaches to eliminate or mitigate safety hazards. The SRD program focuses on demonstration of technologies and safer designs.
- **Zero Emission Research Opportunity (ZERO)** - On November 22, 2016, FTA announced the opportunity for nonprofit organizations to apply for funding to conduct research, demonstrations, testing, and evaluation of zero emission and related technology for public transportation applications.
- **NIST Smart City/NSF Smart and Connected Cities**
- **Bloomberg Smart Cities Grant Award**
- **Congestion Mitigation and Air Quality Improvement (CMAQ)** - Federal Highway Administration (this technology is an allowable activity under the CMAQ grants).

## Partnering Opportunities

Finally, there is the potential business model for the City to partner with other public/private entities to establish a microtransit autonomous vehicle proving ground in Lincoln that could attract private investment. For example, in 2017 the U.S. DOT designated 10 Autonomous Vehicle Proving Grounds across the country as locations where testing and research by both public and private entities could be performed. Several of these proving grounds have kick-started their activities through the use of a public-private partnership. For example, as part of the Texas Alliance, the City of Arlington, Texas is establishing a microtransit service within the city limits through a partnership with Chariot, a private transportation provider. The City of Lincoln could engage various industries to utilize the vehicles as a proving ground to test, in a real-world environment, emerging technologies such as those associated with electric battery utilization and charging, emergence of 5th Generation (5G) cellular technology, and new advances in pedestrian and vehicle safety systems.

# Technology Considerations

## Regulatory Environment for Autonomous Vehicles

Autonomous vehicles are being driven by private industry and are quickly moving into the market. According to the National Council on State Legislatures, "twenty-one states—Alabama, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Illinois, Louisiana, Michigan, New York, Nevada, North Carolina, North Dakota, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Virginia and Vermont—and Washington D.C. have passed legislation related to autonomous vehicles." Further, "Governors in Arizona, Delaware, Massachusetts, Washington and Wisconsin issued executive orders related to autonomous vehicles." Much of this legislation involves requirements on the performance expectations and testing needed for an autonomous vehicle manufacturer to operate vehicles on public roads in the respective state. However, some states, such as Michigan, have essentially created an "open door" policy for autonomous vehicle manufacturers.

The legislative and policy landscape for autonomous vehicles is changing and potentially changing rapidly. In September of 2017, the National Highway Traffic Safety Administration (NHTSA) issued their second version of guidelines related to highly autonomous vehicles titled "Automated Driving Systems (ADS): A Vision for Safety 2.0." This guidance document sets forth NHTSA's interpretation on roles and responsibilities between Federal and State agencies as well as defines terms and conditions associated with performance characteristics of highly-autonomous vehicles including defining the "Operational Design Domain," the "Object and Event Detection" and "Fallback position." Additionally, the guidelines set forth 12 safety priority elements and a voluntary self-assessment for manufacturers. In this guidance document, NHTSA suggests Best Practices for States Regulatory Actions as well as a division of responsibilities between the Federal and State governments (see Figure A.3).

Following the issuance of the NHTSA guidelines, the US House of Representatives passed the SELF DRIVE Act, a version of which was also subsequently passed out of the Senate Committee on Commerce, Science, and Transportation. The Senate bill has yet to undergo full vote in the Senate, but is expected to garner bi-partisian support. President Trump has further indicated his willingness to sign such a bill should it be presented following Senate vote and resolution with the House Bill. The SELF DRIVE Act would significantly change the legislative environment for States regarding highly autonomous vehicles. In particular, this act:

- **Establishes a timeline for Federal Regulatory Action:** "Not later than 24 months after the date of the enactment of this section, the Secretary of Transportation shall issue a final rule requiring the submission of safety assessment certifications regarding how safety is being addressed by each entity developing a highly automated vehicle or an automated driving system."
- **Preempts State's Regulations.** "No State or political

### Federal Responsibilities

- Setting Federal Motor Vehicle Safety Standards (FMVSSs) for new motor vehicles and motor vehicle equipment
- Enforcing compliance with FMVSSs;
- Investigating and managing the recall and remedy of noncompliance and safety-related motor vehicle defects nationwide; and,
- Communicating with and educating the public about motor vehicle safety issues.

### State's Responsibilities

- Licensing human drivers and registering motor vehicles in their jurisdictions;
- Enacting and enforcing traffic laws and regulations;
- Conducting safety inspections, where States choose to do so; and,
- Regulating motor vehicle insurance and liability.

*Figure A.3 Regulatory responsibilities* subdivision of a State may maintain, enforce, prescribe, or continue in effect any law or regulation regarding the design, construction, or performance of highly automated vehicles, automated driving systems, or components of automated driving systems unless such law or regulation is identical to a standard prescribed under this chapter."

- **Provides Exemptions for Manufacturers.** "LIMITATION ON NUMBER OF VEHICLES EXEMPTED.—All exemptions granted to a manufacturer under subsections (b)(3)(B)(i) through (v) shall not exceed a total of (i) 25,000 vehicles manufactured within the first 12-month period, (ii) 50,000 vehicles manufactured within the second 12-month period, (iii) 100,000 vehicles manufactured within the third 12-month period, and, (iv) 100,000 vehicles manufactured within the fourth 12-month period."

Notwithstanding the assuming that some version of the SELF DRIVE Act will be passed by the Senate and confirmed into law in 2017/2018, there are still a number of potential legislative and regulatory actions that States such as Nebraska should consider. These areas include:

- **Providing a technology "neutral" environment.** The Nebraska legislature should consider examining the existing laws and regulations for antiquated conditions that would prohibit the adoption of highly autonomous vehicles and remove these potential barriers. For example, some states have previously had a regulation on motor vehicle operation that included a provision that the operator "must have at least one hand on the wheel at all times." Such a provision could be an impediment to adoption of highly automated vehicles.
- **Provide licensing and registration procedures for Highly Automated Vehicles.** If vehicles are becoming "drivers," there will need to be updated policy and procedures for licensing and registration of these vehicles. In particular, Nebraska and other states will have to consider the technological components, software versions, sensors, and self-driving algorithms as part of registration and licensing. For example, changing the software versions or sensor package of a vehicle could be considered to be the equivalent of changing drivers in today's environment.
- **Review traffic laws and regulations that may serve as a barrier to HAVs.** Similar to providing a technology neutral environment, there many be existing traffic laws and regulations that would serve as a barrier to adoption of HAVs. For example, a "no-texting" law that specifies that the person sitting in the driver's position in the vehicle must use a "hands-free" device might need to be modified to include situations where the vehicle is serving as the driver.
- **Notification and Permission for Testing Process.** Although the SELF DRIVE Act would prohibit Nebraska from barring adoption of highly autonomous vehicles based upon performance or to require State specific testing procedures. The Nebraska legislature may wish to consider requiring manufacturers to notify the Nebraska Department of Roads and/or the relevant local municipality when new autonomous vehicles and/or autonomous vehicle systems are being tested within the state. Additionally, requirements restricting the Operational Design Domains for testing and operation of highly autonomous vehicles could be defined by the State to exclude or promote the use of highly autonomous vehicles in certain geographic or roadway types.

Ultimately, should the SELF DRIVE Act not become law, the Nebraska legislature should consider establishing testing and performance requirements for highly autonomous vehicles in Nebraska. Even if it does become law, there are still a number of different topic areas that will need to be addressed.

## Licensing, titling, and street legality of current vehicles

### Street Legality

All passenger vehicles operating on public streets in the U.S. are subject to the Federal Motor Vehicle Safety Standards (FMVSS). The FMVSS is a mandatory set of U.S. federal regulations specifying design, construction, performance, and durability requirements for motor vehicles and regulated automobile safety-related components, systems, and design features. Transit vehicles and commercial vehicles are also subject to aspects of the FMVSS as well as other relevant policy and guidance documents.

Virtually all of the current, available, autonomous microtransit vehicles do not meet many of the FMVSS standards and are therefore not considered to be "street legal" vehicles. In some cases, manufacturers have attempted to utilize the "Low-Speed Vehicle" provision of the FMVSS for their vehicles. This statue exempts vehicles from many of the remaining safety standards provided they meet the criteria on gross-vehicle weight (< 3,000 lbs) and maximum speed less than 25 mph. With the inclusion of large batteries for propulsion, the current versions of autonomous microtransit vehicles weigh roughly twice the allowable gross-vehicle weight for a low-speed vehicle rendering them subject to the full FMVSS standards.

Recently (2017), NHTSA has began to grant exemptions from the FMVSS standards to specific manufacturers of microtransit autonomous vehicles that have demonstrated minimum safety characteristics and have agreed to other provisions such as reduced speeds. To date, both Navya and Easymile have received exemptions for their respective vehicles from NHTSA. As a result, both companies have been cleared for legal on-street operations within the parameters of their specific exemptions.

## Licensing and Titling

Licensing and titling very much remain a State function and States where autonomous vehicles have begun to operate on public roads have licensed and titled these vehicles, exempting them from the relevant requirements that require a driver (if any).

## Insurance and Liability

Insurance is a key consideration for the adoption of autonomous vehicles as they represent a potential shift in liability from the human driver to the autonomous operator. Various states have addressed this issue differently. For example, in Michigan, Senate Bill No. 996[1] requires:

> "When engaged, an automated driving system or any remote or expert-controlled assist activity shall be considered the driver or operator of the vehicle for purposes of determining conformance to any applicable traffic or motor vehicle laws and shall be deemed to satisfy electronically all physical acts required by a driver or operator of the vehicle. A motor vehicle manufacturer shall insure each vehicle in a participating fleet as required under this act and chapter 31 of the insurance code of 1956, 1956 PA 218, MCL 500.3101 to 500.3179. For each SAVE project in which it participates, during the time that an automated driving system is in control of a vehicle in the participating fleet, a motor vehicle manufacturer shall assume liability for each incident in which the automated driving system is at fault, subject to chapter 31 of the insurance code of 1956, 1956 PA 218, MCL 500.3101 to 500.3179."

Other States have required a human operator to be on-board and have set minimum insurance requirements. For example, SB 260 in Connecticut requires "...testing, including having an operator seated in the driver's seat and providing proof of insurance of at least $5 million."

Generally, insurance for autonomous microtransit operations will reside with the vehicle manufacturers and the operators of the vehicles. The extent of liability between these two groups will depend upon the nature of the incident/accident as well as other factors such as maintenance and the testing and provisioning of routine system updates and software patches. For the purposes of this pilot, the City is expecting to contract both the system operation as well as the leasing of vehicles, which should limit insurance liability of the City.

## Operations and maintenance

Autonomous microtransit vehicles such as those that are being considered for this pilot typically include electric propulsion systems that require very little maintenance beyond a regular recharge cycle and a climate controlled environment for storage to preserve the integrity of the batteries. However, like all vehicles, routine maintenance for replacement of worn tires and some of the other mechanical systems such as the wheelchair ramp and door actuators will need to be performed. Additionally, the vehicles will need to be cleaned regularly.

The City intends to contract these services under an operations and maintenance service contract.

1 http://www.legislature.mi.gov/documents/2015-2016/publicact/htm/2016-PA-0333.htm

## Meeting "Buy USA" requirements

In 2014, the Nebraska Department of Roads in collaboration with the Federal Highway Administration established guidelines for the implementation of and conformance to the "Buy America" (BA) provisions introduced in the "The Moving Ahead for Progress in the 21st Century Act" (MAP-21). These guidelines were intended for all projects that include Federal funds. Provisions for BA remain active and are still requirements for many federally funded projects. For example, as indicated in the Nebraska Department of Roads Division of Safety Grant Contract Proposal Guide [2], "The National Highway Traffic Safety Administration (NHTSA) indicated any product (equipment or materials) purchased using NHTSA federal highway safety grant funds must be made or assembled in America (documentation is also required). NHTSA may waive Buy America requirement if: (1) the application would be inconsistent with the public interest; (2) such materials and products are not produced in the US in sufficient and reasonably available quantities and of a satisfactory quality; or (3) the inclusion of domestic material will increase the cost of the overall product by more than 25 percent."

These grant requirements would become relevant to the City if Federal funds are employed as part of this pilot project. However, in the case of autonomous microtransit vehicles, the City should expect to receive an exemption as there are very limited numbers of manufacturers that can provide vehicles capable of operating in mixed-traffic, on-road capacity. To date, only three manufactures have vehicles that would meet the expected performance requirements (Easymile, Navya, and Local Motors). Of these, the Local Motors vehicle is produced in the U.S., Navya is expecting to launch U.S. production in the first quarter of 2018, and EasyMile has established a U.S. office in Denver, but production is still being performed in France.

## Personal security of riders

The personal security of riders is always a key consideration for any transit agency. In this pilot, the City will include an on-board ride facilitator who will be there to assist riders and to ensure that the vehicle and its occupants are safe and secure. Additionally, each vehicle will be remotely monitored and will have the ability to remotely access in-vehicle video to monitor on-board conditions for the safety of the traveling public.

## Cyber-security and the vehicles

The autonomous microtransit vehicles will be remotely monitored in real-time with information being transmitted to a centralized monitoring center every 15 milliseconds. All vehicle communications and access to electronic communications are only available through proprietary software systems that include the manufacturer's cyber security protocols. Data collection by the system will not be available to the City or to the general public. However, summary records such as the number of travelers from a given origin to a given destination can be obtained. Video records are subject to subpoena and other legal initiated access, but will not otherwise be made available to the City or the traveling public. These records are considered to be proprietary information needed by the manufacturers to monitor performance.

Electrical components within the vehicle are secured behind locked access panels and require password protection and other security credentials to access.

2 http://dot.nebraska.gov/media/6207/policies17.pdf

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