MARYLAND DEPARTMENT OF TRANSPORTATION
MARYLAND TRANSIT ADMINISTRATION

Automated Driving System Demonstration Grant Application

Maryland Department of Transportation

NOFO Number 693JJ319NF00001 | *No Two Neighborhoods Are Alike*

March 7, 2019

The Honorable Elaine L. Chao
Secretary of Transportation
United States Department of Transportation
1200 New Jersey Avenue, SE
Washington DC 20590

Dear Secretary Chao:

As Secretary of the Maryland Department of Transportation (MDOT), I am writing you to express my strong support of the MDOT Maryland Transit Administration (MDOT MTA) and its application for the *U.S. Department of Transportation Automated Driving System (ADS) Demonstration Grant*. On MDOT's behalf, I am pleased to submit the attached ADS grant application that presents an opportunity to better understand the benefits ADS technology can provide to Maryland's transit system.

I am committed to advocating for opportunities that enhance our region's transportation options to support today's needs and tomorrow's opportunities. The ADS technology presents tremendous opportunities for consumers, businesses, and Maryland's economy by providing a safer, more productive, and more efficient way to travel. Recognizing the potential implications ADSs will have on Marylanders, this grant will elevate research and next-step potentials that will provide State and federal agencies insight from the pilot and solutions to unchartered challenges.

The MDOT is a multi-modal agency with responsibility for and expertise in roadway and bridge design, tolling infrastructure, motor vehicle safety, transit, bicycle/ pedestrian issues, aviation, and ports. Since 2015, the MDOT leads a large, diverse, public-private working group as the central point of coordination of Connected and Automated Vehicle (CAV) issues in the State. The MDOT is also actively engaged in all aspects of CAV in continuing dialogue to learn from others locally and beyond our borders and integrating CAV considerations in projects, processes, and planning. The MDOT maintains that collaboration at all levels internally and externally is the key to realizing the benefits in the CAV space and to truly realize the potential to transform mobility once again.

The MDOT MTA's proposed ADS project, *No Two Neighborhoods Are Alike*, seeks to align project diversity, public benefit, economic vitality, and technology complexity by administering a series of short-term automated shuttle pilots over the course of four years in the various location types (urban, rural, industrial, and airport testing environments). This project will produce invaluable data that will illustrate the opportunities and challenges of introducing automated shuttles that link commuters with existing MDOT MTA transit modes.

I believe the ADS grant opportunity provides benefits that span all of Maryland Department of Transportation including:

- **Safety:** The National Highway Traffic Safety Administration (NHTSA) estimates ADS technology can prevent up to 94 percent of traffic deaths per year.
- **Education and awareness**: 73 percent of U.S. drivers are afraid to ride in a fully automated vehicle (AAA, May 2018).
- **Last mile solution**: The average American commuter is likely to avoid public transit if they must walk more than ¼ mile to begin or complete their trip. Automated shuttles may provide a cost-effective solution to minimize that avoidance and increase transit ridership in certain communities.

The State of Maryland is open for business and eager to support the advancement of automated driving systems to realize the potential life-saving and economic benefits, while ensuring safety for all. Maryland's Vision for CAVs is to uphold and enhance a safe, efficient, and equitable transportation future by delivering collaborative and leading-edge CAV solutions. We are embracing CAV technology and innovation through continuing collaboration with partners interested in researching, testing, and implementing CAVs in Maryland.

I support this grant application and hope that you keep my recommendation in mind when making your final funding decision. An ADS *Demonstration Grant* award will enable MDOT to produce actionable insights that will help the State of Maryland prepare for future transportation demands. If you have any questions or concerns, please contact Ms. Christine Nizer, MDOT Motor Vehicle Administration Administrator, at 410-768-7274 or cnizer@mdot.maryland.gov. Of course, you may always contact me directly.

Sincerely,

Pete K. Rahn
Secretary

cc: Ms. Christine Nizer, Administrator, MDOT MVA

Summary Table

Project Name/Title	'No Two Neighborhoods are Alike'
Eligible Entity Applying to Receive Federal Funding (Prime Applicant's Legal Name and Address)	Maryland Department of Transportation, Maryland Transit Administration The William Donald Schaefer Building 6 St. Paul St, Baltimore, MD 21202
Point of Contact (Name/Title; Email; Phone Number)	Michael Helta, Chief Innovation Officer mhelta@mdot.maryland.gov 410-767-3795
Proposed Location (State(s) and Municipalities) **for the Demonstration**	State of Maryland
Proposed Technologies for the Demonstration (briefly list)	• Integration with real-time transit applications • ADS integration with RITIS (automated data sharing, dissemination, and archiving system) • Standalone and in-vehicle communication navigation sensors
Proposed duration of the Demonstration (period of performance)	Four years
Federal Funding Amount Requested	$3.75 million
Non-Federal Cost Share Amount Proposed, if applicable	$3.75 million
Total Project Cost (Federal Share + Non-Federal Cost Share, if applicable)	$7.5 million

MARYLAND DEPARTMENT OF TRANSPORTATION
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Part 1

Project Narrative and Technical Approach

PART 1

Project Narrative and Technical Approach

1.0 EXECUTIVE SUMMARY

Low-speed automated shuttles hold tremendous potential to satisfy first-, last-, or only-mile accessibility to complement and supplement public transit systems. Realizing this potential, Maryland Department of Transportation Maryland Transit Administration (MDOT MTA) is eager to better understand how this promise can be achieved by pilot testing low-speed automated shuttles throughout Maryland's diverse landscape. MDOT MTA has six different modes of transit and is the **13th largest transit system in the US**. With a $850 million operating budget and a $3.3 billion 6-year capital budget, MDOT MTA **serves more than 100 million unlinked passenger trips per year**. The Federal Transit Administration's Strategic Transit Automation Research (STAR) Plan recognizes the potential benefits of transit bus automation but reiterates additional research, particularly physical demonstrations, is needed to fully realize the opportunities on a scalable level. Further detailed in **Figure 1.1**, MDOT MTA's *No Two Neighborhoods Are Alike* (the Project) proposes a series of diverse and scalable automated shuttle deployments to help pinpoint the opportunities and challenges of integrating ADS technology into existing transit operations.

Project Vision:

Maryland's Vision for Connected and Automated Vehicles (CAV) is to uphold and enhance a **Safe, Efficient, and Equitable** transportation future through collaborative and leading-edge CAV solutions. Maryland is open for business and eager to realize the life-saving safety and economic benefits of CAV technology.

The U.S. Department of Transportation's (USDOT) Notice of Funding Opportunity (NOFO) for Automated Driving System (ADS) Demonstration Grants (ADS NOFO) presents an opportunity to act on Maryland's CAV Vision and conduct

No Two Neighborhoods Are Alike

MDOT MTA's *No Two Neighborhoods Are Alike* project includes four phases designed to test the readiness for, and receptiveness to, the integration of low-speed automated shuttles with existing public transit infrastructure. MDOT MTA will explore varying operational environments and a diverse set of real-world use-case scenarios, building upon lessons-learned and increasing technical complexity as project phases advance. Since ***No Two Neighborhoods Are Alike,*** transit agencies need broad, scalable insights in order to realize the benefits of ADS technology.

Figure 1.1 – MDOT MTA Project Summary

Figure 1.2 – MDOT CAV Vision

	Phase 1 - Industrial	Phase 2 - Airport	Phase 3 - Rural	Phase 4 - Urban
Pilot Definition (at time of proposal)	Operational site and use-case scenarios specified, vendor partner selected, details of the pilot are defined	List of possible operational sites and use-case scenarios has been developed, but will review lessons from Ph 1 first	List of possible operational sites and use-case scenarios has been developed, but will review lessons from Ph 2 first	Concepts and requirements for future operational sites and use-case scenarios considered, but will review lessons from Ph 3 first
Pilot Emphasis	-Lessons learned -User benefits -Documentation	-Increase technical complexity -Navigating more public infrastructure	-Possible railroad crossing -Multiple use cases (parking lot & community)	-Highest level of complexity and safety -Highest level of AV operation capabilities
Key Requirements	Pilot was selected with minimal barriers in mind - demonstrate benefits and lessons quickly	Small increase in complexity from Ph 1, requiring minor needs for infrastructure and continuing to deliver benefits	Significant increase in complexity from Ph 1, may require some infrastructure enhancements, will build on lessons learned	Significant increase in complexity from Ph 1, will most likely require some infrastructure enhancements, but will still build on lessons learned

Figure 1.3 - MDOT MTA ADS Deployment Strategy

a safe, physical demonstration of ADS that will help inform State and Federal Rulemaking Transit (project lead) while encouraging strong collaboration with MDOT's private, educational, and public partners.

Project Goals:

A traditional automated shuttle pilot only provides data from specific operational environments and has a limited set of use-cases. MDOT MTA is one of MDOT'S six transportation business units (TBUs) and one of only two State Department of Transportations (DOTs) in the U.S. that manage a multi-modal transit system. MDOT MTA intends to expand current industry knowledge by designing and implementing a multi-phased automated shuttle project that progressively incorporates challenging operational environments and use cases that will create actionable automated driving system (ADS) test data to MDOT, private industry ADS entrepreneurs, and USDOT. This approach is reflected in **Figure 1.3 - MDOT MTA ADS Deployment Strategy.**

MDOT MTA's objective is to test the readiness for, and receptiveness to, the integration of low-speed automated shuttles with existing multi-modal public transit infrastructure. The agency's transit services span a diverse landscape through urban, port, and rural transit

settings connecting both West Virginia and Washington, DC. MDOT MTA has designed the *No Two Neighborhoods Are Alike* project (the Project) to illustrate how real-world transit environments present varying safety and logistical challenges and inform how ADS technology may safely complement public transit modes in a scalable manner.

Project Objective:

Across four project phases, the primary objective will be to **safely and efficiently transport Maryland commuters in automated shuttles to/from high frequency MDOT MTA transit in diverse locations**. The strategy behind MDOT MTA's *No Two Neighborhoods Are Alike* project is to instill a continuous improvement methodology – incorporating lessons learned into each individual project phase; ensuring that the MDOT MTA project team builds upon the increasing knowledge and capabilities of ADS technology. Additionally, as the familiarity and understanding of ADS technology continues to grow among the Project's stakeholders, the project phases will increase in technical complexity. In doing so, the MDOT MTA project will create rich, real-time data that incorporates the latest advancements in ADS technology further benefiting the safety, rulemaking and collaboration goals of the USDOT.

The Project consists of several operational test environments for low-speed automated shuttles,

MARYLAND DEPARTMENT OF TRANSPORTATION

Maryland Department of Transportation Business Units
(Transit (project lead), Port, Motor Vehicle, Aviation, and State Highway)

UNIVERSITY OF MARYLAND — CATT LABORATORY

Public Partner
University of Maryland
Center for Advanced Transportation Technology Center for Advanced Transportation Technology (CATT Lab - Project Data Manager)

Private Partners

WSP	REMLINE	local motors by	TRADEPOINT ATLANTIC	Swiftly	moovel
Project Integrator	Stakeholder Engagement Lead	Automated Shuttle Operator	Property Manager	Real-time Manager	Fare payment app

Figure 1.4 – MDOT MTA ADS Project Partners

including industrial, airport, urban, and rural. The first demonstration will be conducted at a now thriving industrial park, Tradepoint Atlantic, due to the 'shovel-readiness' of the location and the existing high demand for additional transit solutions. The specific routes, charging station locations, staging area, and pick-up/drop-off details have been identified for Tradepoint Atlantic, however, these details for the remaining three test environments – airport, rural, and urban – remain strategically undefined based on the Project Integrator's experience with The Smart Columbus project. This reasoning is further detailed in the **Geographic Area of Demonstration** section.

Project Partners:

The interdisciplinary *No Two Neighborhoods Are Alike* team will involve Maryland's leading ADS experts including transportation partners, public institutions, and industry-leading private sector firms. Several of the project stakeholders have prior experience successfully collaborating on past and current projects which instills a level of familiarity and confidence to execute the proposed tasks. Furthermore, the automated shuttle operator, **Local Motors, is one of two Highly Automated Vehicle (HAV) vendors that has already successfully been approved as an HAV testing entity and issued permits under Maryland's HAV permit process which saves significant 'start-up' time** allowing the Project team to quickly assemble upon grant approval. A complete list project partners is in **Figure 1.4**.

Challenges, Technology, and Performance Measures

To most effectively evaluate potential operational challenges, explore use-case scenarios, and garner public acceptance feedback, the Project will advance through four phases. Each phase will take place in a different operational design domain and may or may not include different "bundles" of use-case scenarios. However, all phases will include automated shuttles connecting with existing MDOT MTA transit service. Each project phase will present specific hurdles and operational challenges for the automated shuttles moving passengers between specified locations that connect to MDOT MTA transit stops. Project phases are purposely designed to graduate in complexity to accomplish two objectives: 1) minimize project risks and; 2) build upon learned from each previous demonstration. As an industry first, MDOT MTA will use existing customer-facing technologies and integrate each application within each of the automated shuttles and record and share all related data. MDOT MTA's General Transit Feed Specification Real-time (GTFS-RT) schedule feed for trip planning, mobile ticketing, and real-time arrival displays showing all connecting transit modes will be merged with all three automated shuttles. In **Section 3.0**, the proposal provides details about planned vehicle-to-infrastructure (V2I) capabilities to ensure safe navigation of urban intersections and/or railroad crossings.

High level project **performance measures** include the following:

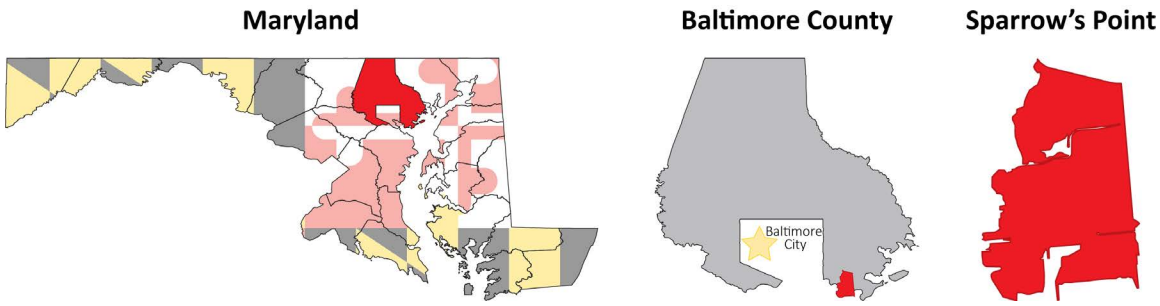

Figure 1.5 -Tradepoint Atlantic Test Site

1. Increase levels of understanding surrounding the numerous benefits and current capabilities of ADS technology among Maryland residents.
2. Document opportunities automated shuttles may offer MDOT MTA while identifying potential implementation challenges to facilitate proactive mitigation.
3. Demonstrate the value of partnerships with multiple MDOT TBUs focusing on a multi-phased, complex ADS project.
4. Receive tangible, scalable insights to inform future rulemaking on how to safely transport passengers on Maryland roads through the deployment of automated shuttles.
5. Track the operational and maintenance costs for the demonstration at each location relative to ridership to help guide future MDOT MTA transit infrastructure investments.

Geographic Area(s) of Demonstration

In the first phase, MDOT MTA will pilot low-speed automated shuttles in Maryland's newest economic engine – Tradepoint Atlantic - a global logistics hub located in Sparrows Point, Baltimore County Maryland. Once a large industrial park where iron and steel production were world-class, Tradepoint Atlantic is the embodiment of modern land-use transformation, bringing together rail, port, and highway access with available labor, to become a "strategically significant" **global logistics hub with innovative tenants such as Under Armour, FedEx, and Amazon**. MDOT MTA currently runs a bus route to Tradepoint Atlantic, but many of the facilities are so large that workers must traverse up to a 1/2 mile to reach their building a**s shown in Figure 5.6.**

This first pilot location will provide a first mile/last mile service connection, safely transporting commuters between local MDOT MTA bus stops and their work locations. To do so, MDOT MTA will collaborate with MDOT Maryland Port Administration (MDOT MPA) and the private developer of Tradepoint Atlantic. The Project Team strategically selected this operational environment as it features minimal traffic barriers, new pavement conditions, and a use-case scenario with clearly available benefits to Maryland transit commuters. These aspects plus the limited infrastructure adjustments that need to occur (power supply for three charging stations) make this site 'shovel-

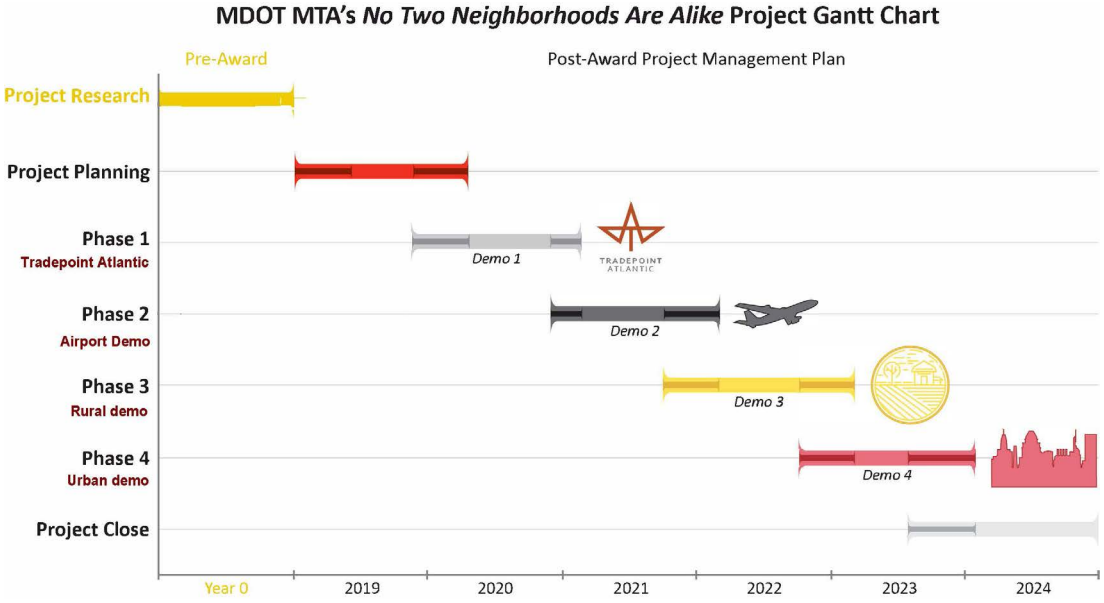

Figure 1.6 – MDOT MTA Project Gantt Chart

ready' which provides MDOT MTA an advantageously longer runway to finalize the following project phases. The Project team has strategically selected Tradepoint Atlantic as the first location for two reasons: 1) the facility is only a few years old, with new infrastructure and limited interactions with traffic on public roads and; 2) MDOT MTA's continuous improvement strategy focuses on a 'graduating' set of technical complexities which minimizes project risks and allows the Project team flexibility to incorporate the latest forms of ADS technology. Using this methodology, the Project team has selected the following demonstration categories airport, rural, and urban – that build in complexity, but omit specific route details at this stage because of **the Project Integrator's lessons-learned from managing USDOT's Smart Columbus program.** The route for the automated shuttles was predetermined too early for the Smart Columbus project and was later changed due to additional stakeholder engagement and changing project parameters. This experience provides an excellent advantage for the Project team to successfully execute the proposed objectives and offers tangible lessons-learned to support our strategic plan.

Period of Performance

The *No Two Neighborhoods Are Alike* Project schedule spans four years, as illustrated in **Figure 1.6**. Project Planning includes the intensive amount of work Project partners have already devoted to this opportunity, including in-person site visits, initial dataset exploration and analysis, travel demand pattern collection at each location, and several project inputs. Phases one through four include four proposed demonstrations. To implement the overlapping project phases, the Project Team will apply a parallel path project management strategy.

MDOT MTA's *No Two Neighborhoods Are Alike* project presents an industry-first opportunity for the USDOT to better understand ADS technology's

range of potential benefits for transit systems, and possible deployment barriers agencies must overcome. **The Project will support the development of a roadmap for how, when, and where low-speed automated shuttles can enhance and/or complement existing transit infrastructure - a goal that is important not just to MDOT, but on a national scale as well.**

2.0 GOALS

The *No Two Neighborhoods Are Alike* Project Team will deploy three low-speed automated shuttles in four terrain-varied locations over a four-year schedule. Two shuttles will be continuously ferrying passengers while one automated shuttle will be charging, ready to be swapped in. At each location, the Project Team will safely transport Maryland commuters from high frequency public transit modes (BaltimoreLink bus service, Metro SubwayLink, Light RailLink) to an optimal destination with the intent of increasing transit ridership.
To date, U.S.-based automated shuttle pilots have predominantly focused on a single fixed route within urban areas allowing for data collection under a consistent, but often singular, set of conditions. *No Two Neighborhoods Are Alike* addresses this gap by creating unique and actionable datasets benefiting both MDOT and USDOT. Our effort aligns closely with the ADS Grant's overall project goals, and more importantly supports MDOT customer needs and the following state-wide goals.

MDOT MTA ADS Safety Goals:

- Introduce Maryland employees, stakeholders, and transit riders to low-speed automated shuttles' important safety benefits in varied use-case scenarios.
- Demonstrate and document how to safely implement low-speed automated shuttle pilots in complex operational environments.

MDOT MTA ADS Data Goals for Safety Analysis & Rulemaking:

- Better understand the challenges and opportunities of introducing automated shuttles in multi-modal settings by continuously learning from real-world data.
- Receive tangible, scalable insights to inform future Maryland legislation on how to safely transport passengers on Maryland roads with low-speed automated shuttles.
- Capture the operational and maintenance implications/costs at each location relative to ridership to help guide future MDOT MTA transit investments.
- Capture qualitative and quantitative data from automated shuttle operators, operators of connecting transit modes, and passengers that utilize the automated shuttle service to develop a roadmap for how, when, and where long-term, automated shuttle operations can complement existing transit services.

MDOT MTA Collaboration Goals:

- Showcase and document how public, private, and educational entities can collectively plan, execute, and share real-time

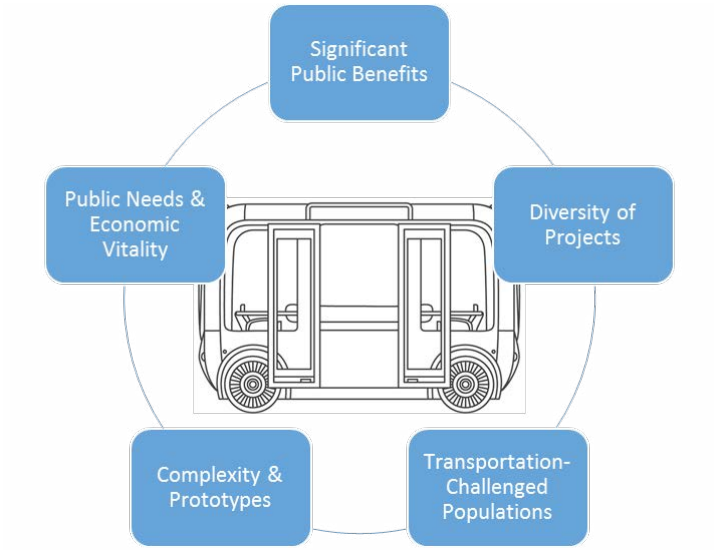

Figure 3.1 – Automated Shuttle, Goal Diagram

information related to a public-interfacing automated shuttle operations project.

- Demonstrate the value of partnerships across multiple MDOT (TBUs) and the future potential for integration with other local transit and transportation services
- Foster internal (MDOT MTA employees) and external (Commuters, community groups, and advocacy organizations) communication platforms so this pilot project can eventually lead to permanent solutions for increasing the effectiveness of Maryland public transit.

MDOT MTA Awareness & Acceptance Goals:

- Increase Maryland residents' awareness and understanding of ADS technology's numerous benefits and current capabilities.
- Provide a valuable first-, last-, or only-mile service not previously available to demonstrate the potential of low-speed automated shuttles and how this new technology can complement existing transit services.

3.0 FOCUS AREAS

The *No Two Neighborhoods Are Alike* Project objectives and outcomes align with the ADS Demonstration Grant Program's seven focus areas. Automated shuttles are a **complex technology**, demonstrating levels 3 or 4 of automation. However, many technical limitations still exist, so **prototyping** these vehicles in carefully selected environments for repeatable, route-based transit service mitigates risks while allowing real-time data to be collected in real-world environments to further enhance the development of ADS technology. This project supports **economic vitality** by bringing together local and regional partners to ensure local stakeholders learn through hands-on experience how they can support the development and integration of emerging technologies.

By providing first/last mile connections to fixed route transit and helping feed passengers, especially **transportation-challenged populations,** to transit in a way that without autonomy may not be cost-effective, this project helps **address market challenges and other compelling public needs.** In addition, the Project Team has carefully selected deployment categories to respond to use cases where such service would provide **significant public benefits**. Testing in one location with the same users/use

case(s) may limit a project's potential to meaningfully expand industry knowledge. However, by deploying pilots in **diverse locations**, applying lessons learned, and integrating the latest technological advancements, this Project will produce **rich**, **scalable**, **insightful data**.

Significant Public Benefits

A key objective of the *No Two Neighborhoods Are Alike* Project is to safely test the readiness, and receptiveness to, the integration of automated shuttles within existing forms of public transit in Maryland. Public transit offers an affordable solution for Maryland commuters to travel to and from work, but in many instances, a first mile/last mile connection for commuters remains as a barrier to increased transit usage. Low-speed automated shuttles may provide connectivity in terms of bridging that gap and increasing commuters overall satisfaction with public transit. By deploying shared, electric automated shuttles, MDOT MTA hopes to demonstrate benefits such as increased air quality and decreased traffic congestion due to a modal shift to a more convenient end-to-end transit option.

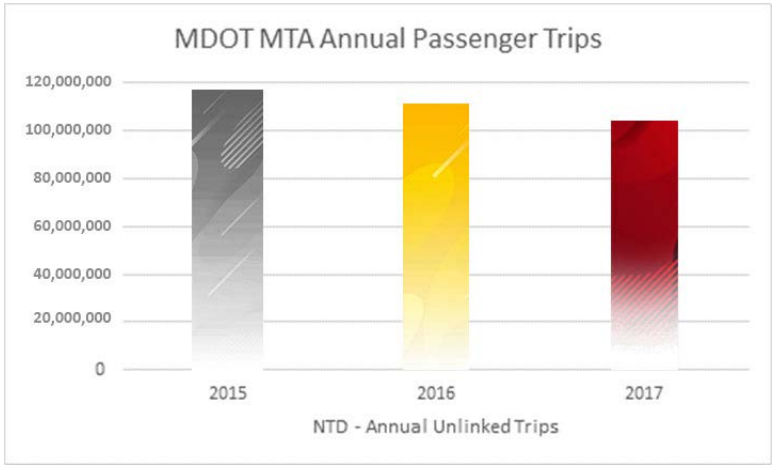

Figure 3.2 – MDOT MTA Passenger Trips

Figure 3.3 – MDOT MTA Operating Costs

A compelling case for integrating ADS technology is its potential safety benefit. Per NHTSA, the critical reason for 94 percent of 35,092 annual traffic deaths was attributed to human

error in 2016. ADS technology has a long road ahead before reaching full adoption, but the potential to remove distracted drivers from US roadways is a promising opportunity that must be pursued through projects like MDOT MTA's proposal. **Three of the four Project deployment locations will occur within or near parking lot transit stops linking to various public transit modes.** Each year in the US, there are over 50,000 crashes and over 500 deaths just in parking lots (National Safety Council). To the public benefit, MDOT MTA's project will thoroughly document all safety-related and potentially avoidable incidents to showcase the potential benefits of integrating automated shuttles within existing public transit settings.

Addressing Market Challenges and Other Compelling Public Needs

Throughout the industry, public transit agencies, including MDOT MTA, are facing increasing operational costs and decreasing ridership (**Figure 3.2** – MDOT MTA Passenger Trips). As consumer dependency on reliable transportation increases, transportation network companies (TNCs) such as Uber and Lyft, are capitalizing on innovative technologies and luring current and potential transit commuters away. Understanding the recent changes in commuter preferences, MDOT MTA is looking to embrace new technical solutions that increase reliability and decrease operational costs.

The national average paratransit trip costs $29 versus $8 for a fixed route trip. MDOT MTA's MobilityLink paratransit service averages $3.93 per passenger mile versus an overall agency average of $0.83 per mile. Low-speed automated shuttles have the potential to cost-effectively expand the reach of high frequency transit service and reduce the amount of paratransit trips. **Maryland is the fifth highest state in population density making an excellent use case for innovative solutions such as automated shuttles support existing transit services.**

Economic Vitality

Urban centers throughout the United States have grappled with the challenges associated with declining industrial and manufacturing jobs.

Then and Now – Sparrows Point, once a booming steel mill that employed over 60,000 employees collapsed beginning in the 1970s. In 2014, Tradepoint Atlantic opened its doors, bringing new promise of blue collar jobs back to the greater Baltimore region.

Figure 3.4 – Then and Now, Sparrows Point

Over the past 50 years, Baltimore City and Baltimore County have seen major job loss in industries such as steel manufacturing; Baltimore City loses approximately 12,000 part- and full-time jobs every 5 years, with a 21% decrease in permanent and part-time employers (U.S. Bureau of Economic Analysis). As in other post-industrial cities, this has resulted in higher poverty rates and a population decline in the urban core.

Simultaneously, the greater Baltimore region is the economic center for the state of Maryland, representing half of the state's GDP. A highly educated workforce coupled with a premier geographic location that provides direct access to global commerce and political centers positions the region for high-performance employment growth. Today, state and local leaders are finding ways to bridge this disconnect, ensuring that the region's success is available to all residents, regardless of their zip code.

While the region is not unique in its historical challenges, it is uniquely positioned to capitalize upon the opportunities the ADS Grant offers. To do so, MDOT MTA is partnering with Tradepoint Atlantic, who is reversing the historic job loss trend by revitalizing Sparrows Point, Maryland, with innovative companies such as Under Armour, Amazon, and FedEx. Currently, **the 3,000-acre Tradepoint Atlantic industrial area employs almost 3,000 Marylanders with a projected forecast of 20,000 employees** once the park is completed. Automated shuttles may offer a cost-effective solution to provide additional transit connections to meet the predicted rise in employees at Tradepoint Atlantic which minimizes traffic in the area and supports the growing trend of innovative solutions at this global transportation hub.

Complexity of Technology

The Project Team will collect data from a variety of sources to provide operational insight for how passengers are using (or not using) the available technology. The complex technologies involved in the Project will include GTFS-RT data for passenger trip planning, exploration of mobile ticketing to streamline vehicle boardings, and in-vehicle digital screens displaying real-time arrivals at stations and nearbytransit stops. The combination of these technologies will create the MDOT MTA ADS Customer Experience (illustrated in **Figure 3.5**) that will build a seamless transition

The MDOT MTA ADS Customer Interface Overview

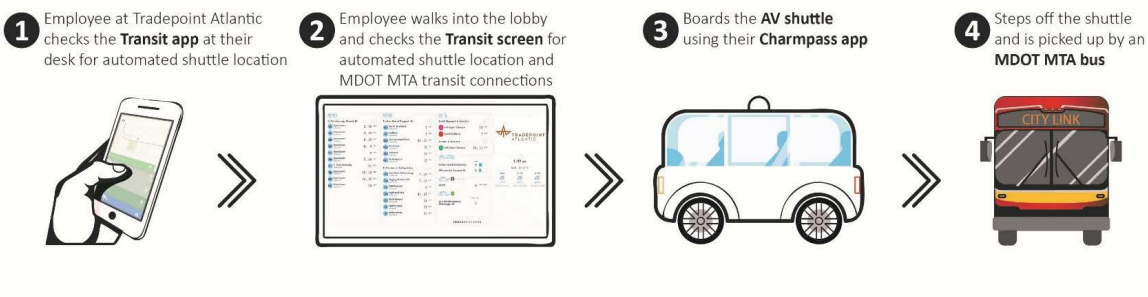

Figure 3.5 – MDOT MTA Customer Interface Diagram

between an unfamiliar form of transit, automated shuttles, and familiar forms of transit such as bus and rail.

Varying use cases will include fixed route and dynamic routing to explore how best to deploy automated shuttles in certain landscapes and peak travel times. Further, MDOT MTA's digital fare payment provider will help test how incentives improve or worsen transit ridership through ADS technology. For example, if passengers receive a free single-day ticket for additional MDOT MTA modes for boarding an automated shuttle, will they be more likely to ride transit and/or try the automated shuttle? How long will the offer have to remain in place? These are the type of operational questions we hope to answer by implementing varying forms of complex technology.

In addition, and in line with USDOT's Connected Vehicle Safety for Rail initiative, a more sophisticated system may be piloted. This system could include train presence detection and/or crossing gate and flashing light technologies. Train presence detection may consist of an infrastructure-based system that detects when a train is approaching a rail crossing and alerts a vehicle system, as well as the onboard operator, if they are approaching the same crossing. **The Project team has already discussed potential areas to install standalone nodes** - made of rugged material and can process movements in year-round weather conditions - that provide persistent real-time movement of other vehicles (locomotives in this case) that communicates directions (stop, slow, safe to proceed) back to in-vehicle nodes. These separate communication nodes have pre-developed coding logic that safely guide automated shuttles through untested environments. This approach utilizes a system that is capable of providing historical site analysis, post incident discovery, and triggers to alert safety operators within each automated shuttle. All of this data will be stored and shared with necessary project stakeholders.
This system could be supplemented or substituted by enhanced crossing gate and flashing light technologies that are compatible with what a vehicle system can easily and reliably understand. Multiple solutions including those suggested may be explored, and any solution that is deployed will be redundant in nature, with the onboard operator maintaining override control at all times.

Project Diversity

Throughout the project, the Project Team will collect valuable safety insights to inform state and federal rulemaking on a scalable level for transit agencies across the US. This diverse range of demonstrations, **ranging from complex urban environments to remote rural areas, will allow both USDOT and MDOT MTA to proactively pinpoint where, when, and how low-speed automated shuttles may permanently operate and improve existing public transit services.** Specifically, the project will correlate the first/last mile automated shuttle service with rich data on operating and capital costs, changes to current ridership levels, and energy use and savings. This project data will

help ease ADS technology integration for transit agencies in a very scalable manner.

Transportation-challenged Populations

MDOT MTA's *No Two Neighborhoods Are Alike* confronts transportation-challenged areas in Maryland head-on through two major strategies:

1. Piloting ways to increase access and reliability with existing public transit infrastructure and;
2. Forging innovative partnerships and solutions that can reinvigorate the Maryland economy.

As presented in the earlier discussion on **Economic Vitality** (pg 16), the Baltimore region is actively working to reverse the historical trend of job loss and population decline. As city and state leaders identify and implement forward-thinking solutions, they must do so in a way that is sensitive to the reality that almost **30 percent of households' lack access to a private vehicle** (U.S. Census Bureau, 2013-2017). Even those with a private vehicle face expensive commutes; a recent Bloomberg study named several **Maryland counties as some of the most expensive commutes in the US** (Bloomberg). These compounding societal obstacles create an incredibly challenging transportation environment, often for those who are most vulnerable.

Low-speed automated shuttles present a new operational and financial opportunity to address reliability and accessibility issues that continue to plague the transit industry. The Project intends to capture data from automated shuttle vehicles, passengers (trip planning, ridership, and payment), sensors, and connecting transit modes to help illustrate the innovate ways in which ADS technology can benefit transit operations in a scalable manner to the benefit of the Maryland commuter. This will help tackle the first and last mile issues and allow cost-efficient solutions for Maryland commuters to travel to and from work. Additionally, many people in the United States live with conditions that can impede their ability to drive safely. These individuals could potentially rely on automated shuttles to connect them to life's opportunities. To this end, all low speed automated shuttles in the Project will be equipped with ADA accessible ramps. Information on how these ramps are used will be included in performance data sets. And finally, both the Transit app and the CharmPass app are equipped with screen-reading capabilities that increase the level of safety for sight-challenged passengers.

Prototypes

While ADS technology has improved significantly over the past decade, many limitations continue to exist. Automated shuttles provide an opportunity for transit systems to explore not just the technology readiness, but also the feasibility and implementation roadmap for new or enhanced mobility solutions that may be supported by this technology. Piloting ADS technology in a limited, controlled setting under repeatable conditions can provide real-world learnings on the actual effects of proposed operations while there is still opportunity to guide the path

ADS NOFO Demonstration Requirement	MDOT MTA Project Compliance	ADS NOFO Demonstration Requirement	MDOT MTA Project Compliance
Each demonstration must focus on the research and development of automation and ADS technology (L3 or greater).	✓	Each demonstration must include input/output user interfaces on the ADS and related applications that are accessible to users with varied abilities.	✓
Each demonstration must include a physical demonstration.	✓	Each demonstration must address how the demonstration can be scaled to be applicable across the Nation as well as include an outreach task to share demonstration status, results, and lessons learned.	✓
Each demonstration must include the gathering and sharing of data with the USDOT throughout the project, in near real time.	✓		

Figure 4.1: MDOT MTA Project Compliance with ADS NOFO Demonstration Requirements

forward. Similarly, from a technology development standpoint, there is value in exposing a technology to real world situations in a safe and controlled manner to further the development process through data collection and system validation.

This incremental project will have many constraints, including initial operations on private roadways and a human operator onboard every vehicle to ensure the safety of passengers and of the vehicle's operation. While Olli is a non-traditional vehicle that requires certain permissions to operate, Local Motors has already has already received a Maryland HAV permit to operate on roads in Maryland. This significant advantage is further detailed in the Project Readiness section within Part 2 of the Management Approach.

4.0 REQUIREMENTS

The *No Two Neighborhoods Are Alike* Project uses a phased approach for the automated shuttle demonstration that incorporates a continuous improvement methodology, which enables the Project team to incorporate lessons learned and the latest developments in ADS technology. This Project meets or exceeds the five core requirements presented in the ADS NOFO, as summarized in **Figure 4.1**.

The project pilots low-speed automated shuttle technology. Automated shuttles are physically like existing shuttle vehicles, generally with a capacity of about 10 to 20 passengers. Automated shuttles currently operate at low-speeds, on surface streets rather than freeways, and most are electric, which is efficient at these speeds - providing shared rides at SAE levels three or four automation, depending on the vendor. In most deployments to date, as well as for MDOT MTA's, a human operator

is onboard to interact with passengers, monitor the driving system, and step in when necessary.

The Project's physical demonstration involves a fleet of three automated shuttles at each deployment provided by Local Motors. During the early phases of the Project, site selection will target routes that limit exposure to more complex traffic patterns, including high-speed roads and unprotected left turns. However, as we progress into later phases of the Project, we can employ higher level vehicle capabilities and thus generate highly effective datasets with more complex use-case scenarios.

Data collection and management for this Project is supported by University of Maryland's CATT Lab, a team with extensive experience collecting, managing, and disseminating transportation system data. CATT Lab has over 10+ years' experience writing and executing Data Management Plans for public agencies including Department of Energy and Federal Highway Administration. **All data collected will be posted in real time or near real time to the existing Regional Integrated Transportation Information System (RITIS) website** that is owned and operated by the UMD CATT Lab. Protected data will secured behind a permissions login to protect Confidential Business Information and/or Personally Identifiable Information but will still be accessible to authorized analysts for the USDOT.

User interfaces for the physical demonstration are integrated with MDOT MTA's existing systems, including the CharmPass app. **These systems are provided to support a public service and have considered the needs of users with varying abilities. Similarly, the Accessible Olli has been designed by Local Motors through direct engagement with people with disabilities**. The vehicle includes a retractable ramp (**shown in Figure 5.2**), both both audible and visual information including IBM Watson-powered onboard displays that provide simplified information and reminders for people with cognitive disabilities, and software that can process sign language.
By essentially "graduating" the automated shuttles through increasingly complex environments during the four-year period, **this project will also demonstrate how scalability when using ADS technology to enhance transit can be a valuable deployment strategy for transit agencies of all types and sizes**. Just as "no two neighborhoods are alike," so it goes that "no two transit agencies are alike;" the more broadly we can pilot the automated shuttles in varying types of diverse road environments, the more valuable the research outcomes will be for a broad audience. The Project will include various forms of external communications – such as webinars, conference presentations, and white papers – to share these findings with this broader audience throughout the project period.

5.0 APPROACH

To most effectively evaluate potential deployment challenges, explore use-

Project Highlight – Smart Columbus Work Experience

Staff from **MDOT MTA's Project Integrator team are supporting the Smart Columbus Connected Electric Autonomous Vehicle Project** since the initial grant proposal was prepared, and therefore the MDOT MTA project is designed to learn from lessons there. The originally proposed (and accepted) vision in Columbus was to deploy a fleet of six automated vehicles in a commercial shopping district to provide first/last mile transit service to a transit hub. However, through stakeholder outreach, additional engineering evaluation, and the benefit of time (as technology has evolved), the team determined that challenges with the deployment location as well as minimal demand for trips along the proposed route meant that any service that could be deployed would be significantly reduced from the original intention. The decision was made to change the deployment location, and once this decision was made, an automated shuttle service with a smaller fleet on and across lower speed limit roads in Downtown Columbus could be deployed much more quickly.

Figure 5.1 - Project Highlight – Smart Columbus Work Experience

case scenarios, and garner public acceptance feedback, the Project will progress through four phases. Each phase will take place in a different operational design domain and may or may not include different "bundles" of use-case scenarios. However, the common threads among all phases will be connectivity with existing transit service offerings or operations.

The phases will be separated by 'knowledge gates', each one passed only after a six-month pilot deployment followed by data analysis and strategic and operational adjustments based on lessons learned.

Another major benefit of this project's iterative approach is the ability to modify project details in response to changing conditions, as are frequently experienced in this fast-moving industry. Many – if not most – automated shuttle deployments to date have shifted course over time in response to lessons learned through initial discussions with vehicle vendors and changing perspectives on site conditions. To assume today that it is possible to accurately predict the complexity of operational domains, use-case scenarios, and technology evolution three years from now would be short-sighted. Instead, this approach leverages the fast-evolving nature of this space and allows for new lessons-learned to be incorporated at each gate.

The *No Two Neighborhoods are Alike* project has benefit from the Project Integrator's experience with the Smart Columbus project (Figure 5.1) and takes a proactive approach to meet this challenge, deploying first in an environment with fewer barriers with the intent to pivot to other environments as lessons and confidence drawn from experience allows. A preliminary list of possible operational environments and use-case scenarios has been developed and is included in this proposal. However, several of the locations require additional stakeholder outreach, additional engineering evaluation, and the benefit of technology evolution to be "deployment ready." The benefit of this approach is that location changes can be proposed, use-case scenarios can be bundled, but the underlying philosophy of learning lessons and providing benefits to MDOT MTA customers will remain front and center.

To select test locations for *No Two Neighborhoods Are Alike*, thorough site criteria was developed to identify potential locations where automated shuttles can provide a valuable transportation alternative to diverse types of users, in line with the mentioned focus areas. As a pre-requisite, at least one site will have to **fall under each of MDOT MTA's overarching categories to ensure site attribute diversity. The categories include:**

Subsequently, the ADS Project Integrators developed a set of required and ideal criteria. Required criteria were considered mandatory to be included in the Project's list of ADS deployment sites. Ideal criteria were considered complementary elements to the required criteria and played a minor role in the final site determination. Below are the required and ideal deployment site location criteria:

Required Criteria:

- Potential for automated shuttle to add sustainable long-term value
- Connection to MDOT MTA transit
- Maximum 25 miles per hour
- Electrical hookup for vehicle charging
- Paved roads
- Acceptable grades that are not too steep for automated shuttle to climb or descend
- Accommodation for overnight automated shuttle storage, such as an existing secure location or land where a storage unit may be constructed

Ideal Criteria:

- Optimal traffic lane width
- Updated traffic signal infrastructure or exclusively 4-way stop signs along the route
- City and/or state camera security systems
- Updated lane paint and signage

In addition, each site must meet minimum requirements to enable safe automated shuttle operation prior to deployment. Some of these requirements may require additional

infrastructure investment that will be staged appropriately. These minimum requirements include:

- A designated location for electrical hookup to charge the shuttles over a 24-hour period, as well as a secure space for overnight storage
- Updates to traffic signals, if applicable, such as roadside units that can provide the automated shuttles with redundant information on the signal state
- Logical, safe, and accessible signed stop locations or, if a dynamic route is pursued, locations from which the vehicle may be called
- A site assessment that includes a catalog of potential hazards and other environmental conditions, including an inventory of large vertical structures that may impact GPS satellite signals (that help orient and direct the vehicle), as well as smaller structures necessary to provide vehicle sensors with consistent objects for localization

TECHNICAL APPROACH

MDOT MTA's intent has been to secure a largely turn-key service from Local Motors, an automated shuttle vendor. Local Motors will be responsible for deploying and maintaining a fleet of three automated shuttles in various locations throughout Maryland over the four-year Project timespan through a collaborative partnership that is responsive to the needs and wants of MDOT MTA and other local stakeholders, as well as the demonstrated ability of the vehicle system Local Motors provides. The automated shuttles will initially be operating at Tradepoint Atlantic and will be shifted to the three other yet-to-be-finalized locations depending on technical capabilities and identified user needs. The system will be supported by infrastructure that includes a storage and charging facility, connected signals and other roadside equipment, and integration with existing and new trip planning and transit information platforms, including smartphone applications and physical displays.

Because this deployment is focused on access to transit, it requires a vehicle that can be safely and comfortably shared by passengers who do not know each other, including potentially higher volumes of passengers during peak periods. This led to the requirement that the automated shuttles be able to safely transport eight to fifteen passengers including the safety operator. Some passengers may be standing, so the automated shuttles must be equipped with handles for passengers to hold on to as well as seat belts for seated passengers to use. The system must also be accessible to people with varying abilities, as will be elaborated on in the following section. The Project team preferred a vehicle that is electric, to provide a platform for the charging strategy and help meet MDOT MTA's broader sustainability goals found on the following page.

Accessibility

User interfaces for the physical demonstration are integrated with MDOT MTA's existing systems, including MDOT MTA's fare payment

Figure 5.2 - Accessible Olli

app Charmpass. These systems are provided to support a public service and have considered the needs of users with varying abilities. Similarly, the Accessible Olli has been designed by Local Motors through direct engagement with people with disabilities. This vehicle includes a retractable ramp, both audible and visual information including IBM Watson-powered onboard displays that provide simplified information and reminders for people with cognitive disabilities, and software that can process sign language.

Other project elements will be designed to be usable by passengers of varying abilities, in consideration of universal design and inclusive information and communication technology (ICT) principles.

Storage and Charging

The first deployment site at Tradepoint Atlantic will involve a 'central hub' located in the center of the property (See **Figure 5.6**). This area will have a covered, secure shelter for all three automated shuttles, in addition to three separate charging stations. As the Project involves multiple phases with varied locations, the structure must be semi-permanent, so it can be easily transported in a few days' time. The ADS grant opportunity also compliments MDOT MTA's recently approved Sustainability Plan, adopted in 2018 and the first performance-driven Sustainability Program. The Project supports and complements the Sustainability Plan's goals and will identify performance measures and reporting processes to include with the Sustainability Program. Further, since each ADS pilot will only last six months, MDOT MTA plans to leave the charging stations at each location to encourage the adoption of electric vehicles (EVs).

MDOT MTA will design and implement its ADS energy strategy to help jumpstart and facilitate adoption across the state. The agency's ADS energy strategy will include:

- **Using a multi-stakeholder process to create procurement specifications and procedures to manage EV assets throughout their lifecycle.** EV assets include charging units, connectors, revenue vehicles, and maintenance equipment and will involve planning, engineering, service development, operator, maintenance, and safety expertise.
- **Expanding Maryland's EV charging network** by ensuring each pilot site can accommodate simultaneous charging of four EV vehicles. The agency will accomplish this by leveraging existing MDOT MTA EV chargers, sharing agreements with privately owned EV chargers, or acquiring and constructing new EV chargers. New EV chargers will be available for public use once the ADS pilot is complete.

- **Leveraging funding partnerships** especially through the Maryland Energy Administration's Electric Vehicle Supply (EVSE) Rebate Program. EVSE provides a 40 percent rebate, up to $4,000 per site, for electric vehicle charging infrastructure acquisition and construction. EV charger maintenance will be funded by offering EV charging as a pay-for-fee service.

- **Integrating EV content into the grant public engagement strategy** to facilitate adoption of EV and ADS systems.

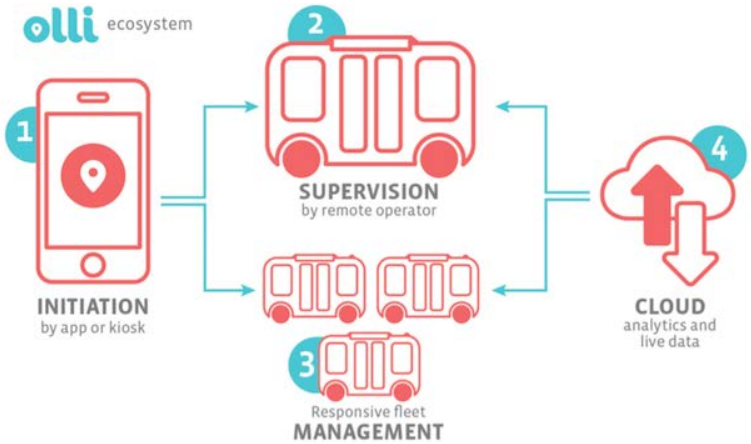

Figure 5.3 – Local Motors Olli vehicle data diagram

Connectivity

The automated shuttles will be equipped with onboard units that support dedicated short-range communications (DSRC) with other vehicles and infrastructure. There are very few other connected vehicles currently deployed on Maryland's roads, so vehicle-to-vehicle interactions over DSRC will be minimal. However, messages that are sent by the automated shuttles and any messages that are received will be logged by the system and assessed during data evaluation to determine the feasibility and evaluate the potential benefits of widespread vehicle-to-vehicle communications between connected automated shuttles and other connected vehicles going forward.

In addition to the vehicle onboard units, roadside units will be installed along routes where possible for safe, useful and efficient operations. The most significant use case for vehicle-to-infrastructure communications in the Project is the communication of Signal Phase and Timing (SPaT) data on a signalized intersection to an automated vehicle as it approaches. This will provide confirmation of the current signal phase, and whether the automated shuttle is currently permitted to cross. SPaT data will likely be the primary source of signal phase information the automated shuttle receives, and it will be supplemented by other sources, including vehicle sensors and the human operator's judgement, to determine both the signal state and whether any other hazards (such as a vehicle violating a red light) are present at the intersection. Data will also be collected on the messages sent and received by the automated shuttles during this process.

Local Motors system communicates with its fleet through a cloud-based platform to enable responsive fleet management and remote supervision, as well as to support the provision of real-time information to passengers, as shown in **Figure 5.4.**

Application Integration

Passengers of the automated shuttles will be encouraged through various means to download the CharmPass app, MDOT MTA's official mobile ticketing platform. Throughout the four-year Project period, rides on the automated shuttles will be fare-free. However, there is interest in exploring strategies for fare payment going forward, as one potential revenue source that is part of a sustainable, long-term funding solution. It should be noted that fare payments are unlikely to be enough to cover the entire costs of a service but may be used to supplement other sources.

As not all Maryland commuters own smartphones or have the ability or desire to install an application. To support this need, digital displays with be installed that will provide real-time information on connecting nearby transit modes. If a dynamic route is pursued, it will also need to be accessible to passengers who do not use smartphones. Potential strategies include a call-in option, a web-based platform, and installing physical

Figure 5.4 - MDOT MTA's Charmpass mobile fare app

kiosks at locations where people are likely to hail a ride.

Federal Requirements

Local Motors is an American motor vehicle manufacturing company, and thus the automated shuttles for this deployment comply with the Buy American Act.

Low-speed automated shuttles that are designed from the ground up, rather than automated vehicle technology that modifies existing, road-ready vehicles, generally require an exemption or waiver from the National Highway Traffic Safety Administration (NHTSA) Federal Motor Vehicle Safety Standards (FMVSS) due to their non-traditional design. Such a waiver will be pursued for the automated shuttles, and if it is delayed, the shuttles will operate on private roads until they are permitted to operate on public roads. Federal Motor Carrier Safety Regulations (FMCSR) likely do not apply to this project as the automated shuttle selected has a capacity of ten passengers, below the sixteen-passenger design threshold that triggers FMCSR compliance. As described in the previous section on accessibility, it is the intent of this Project to design and provide a service that is accessible to as many people as possible. However, while the automated shuttle will be accessible, it may not be fully ADA-compliant.

To help support these needs, as well as to maximize safety and maintain passenger comfort, a human operator will be on board every vehicle while it is in operation. In addition, the human operator will be able to assist passengers with varying needs.

Automated vehicle policy is a rapidly developing area, and legal and institutional requirements are likely to change during the planning and implementing phases of this Project. These changes and clarifications will help guide the final route selection for routes two through four.

Data

The automated shuttle vendor will have the following responsibilities regarding data sharing and management:

- Share real-time data (to be listed in Data Management Plan) with the Data Management lead
- Provide 10-15 second vehicle location ping, packaged in an Application Programable Interface (API) feed
- Track passenger boardings and alightings in real-time, including count and duration of ramp boardings and alightings
- Record of disengagements and interventions by a human operator, relative to time spent in fully automated mode
- Log of significant events, such as hard stops, evasive maneuvers, collisions, operations in inclement weather, and temporary changes in traffic patterns, that includes details on the event and the vehicle system's response
- Record of operational and safety data exchanged with other vehicles and infrastructure

As noted in **Figure 1.3 - MDOT MTA ADS Deployment Strategy,** the most challenging deployment will be the last project phase in an urban environment. Pedestrians, cyclists, vehicle traffic, infrastructure and several more obstacles will need both technical and non-technical solutions in order to ensure a safe operational environment. Knowing this, the Project Data Manager - CATT Lab - will be integrating all ADS project data into their real-time traffic platform RITIS that integrates over 400 different traffic data sources including Waze information for the last project phase. **This fusion of ADS data with RITIS, a industry leading real-time traffic platform, will offer effective means to fill the 'blind spots' of real-time traffic implications of physical ADS technology on US roadways.** Additional details and visuals are included in Part 3 - Draft Data Management Plan.

MDOT MTA reviewed the ADS NOFO amendment released on March 11th requiring all applicants that receive funds to sign a data sharing agreement. The MDOT MTA understands and accepts this requirement and is reflected in the MDOT MTA Administrator's letter of commitment and MDOT MTA's Project Data Manager (CATT Lab) letter of commitment.

Demonstration Rollout Strategy

The *No Two Neighborhoods are Alike* Project combines a continuous improvement strategy, initial route assessments, and industry experience (including the Smart Columbus Project) to develop a realistic rollout strategy. The Project Team strategically selected Tradepoint Atlantic for the first test location from a short list of possible sites (possibilities have already been

assessed in-person and are included in the proposal) for each consecutive phase. The section below details each of the phases and illustrates how the Project Team selected the overarching test categories.

Phase 1 – Industrial (Tradepoint Atlantic)

- Initial test routes are all located on private property
- Road infrastructure is brand new
- Slow speeds throughout property
- Booming transit ridership
- Deemed most 'shovel-ready' site to begin ADS Project

Phase 2 – Airport

- Example routes have connecting high frequency MDOT MTA transit modes
- The potentials areas for testing are somewhat confined, not exposed to high traffic speeds
- Recently updated road infrastructure
- MDOT MAA is currently testing HAVs in the area, employees are accustomed to ADS technology

Phase 3 - Rural

- Potential routes have an increased level of complexity
- Each route has a railroad crossing that will need to integrate OBUs and RSUs to ensure the highest level of safety is included
- GPS signal strength is lower than urban areas, so the route will need undergo a LiDAR scan
- Road infrastructure quality is not as good as some of the sites the ADS team surveyed

Phase 4 – Urban

- The highest level of complexity due to pedestrian and vehicle interactions
- Potential routes have been identified, but the initial focus is on ADS education and awareness
- This last phase will incorporate lessons learned from all 3 previous phases and will ensure the latest form of ADS technology available is incorporated into MDOT MTA's procurement strategy to 1) ensure the highest

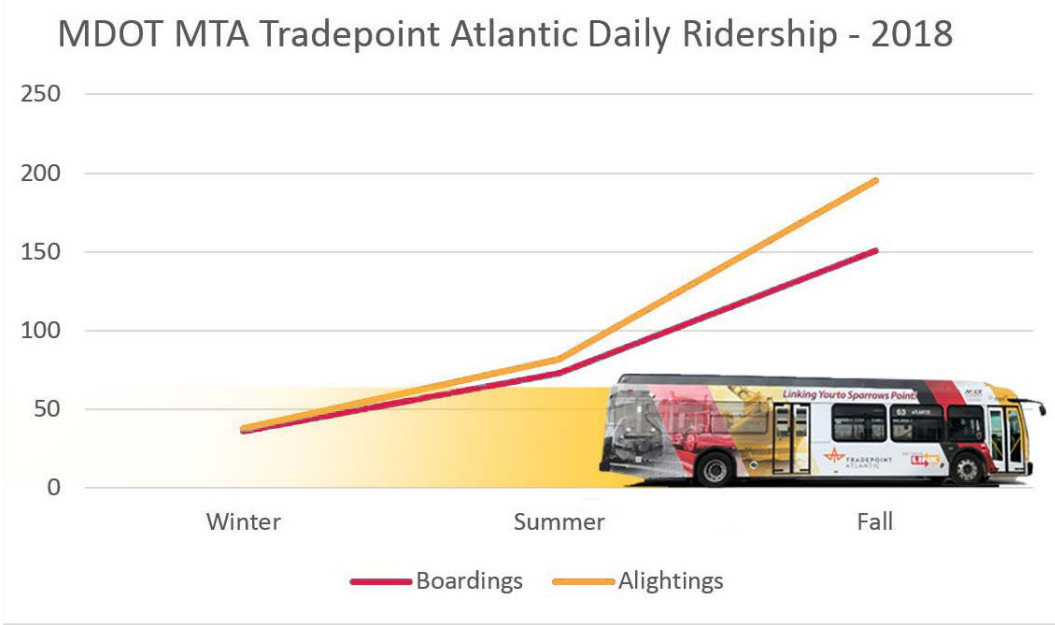

Figure 5.5 – MDOT MTA ridership increase at Tradepoint Atlantic

level of safety and 2) produce rich test data that will inform federal and state rulemaking

Tradepoint Atlantic Demonstration

MDOT MTA has chosen the newly-created and thriving Tradepoint Atlantic site for the first of four demonstrations for several reasons. Of the 10 routes the ADS team assessed over the course of 6 weeks, the the 3 proposed routes at Tradepoint Atlantic are the most 'shovel-ready' for the following reasons:

- Pavement is in excellent condition
- Multiple locations to store and charge automated shuttles
- High demand for additional transit modes throughout the area based on site visits, ADS project supporters, and MDOT MTA Automatic Passenger Count (APC) data from bus route 63

Objective(s):

1. Transport workers from FedEx, Amazon, and potentially Under Armor to the local MDOT MTA bus stops throughout the day
2. Increase current transit ridership through the deployment of automated shuttles and connected passenger experience (combination of fare payment app, GTFS-RT, and transit displays)
3. Increase downloads of Transit App (a mobile trip planner) and CharmPass (fare payment app)

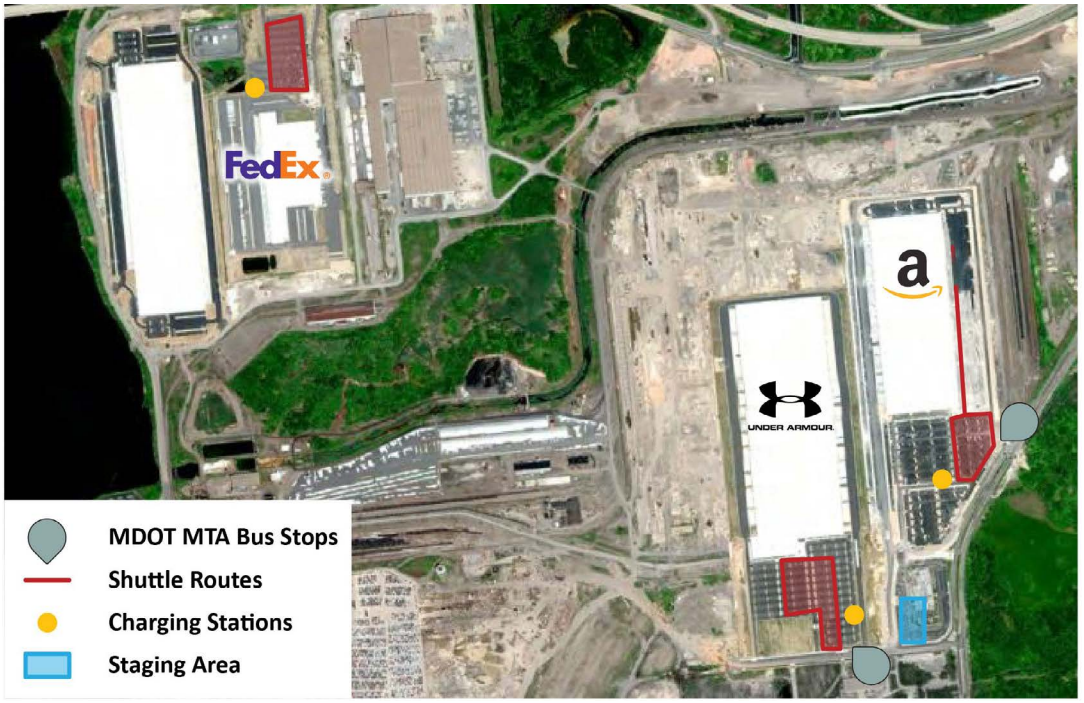

Figure 5.6 – Tradepoint Atlantic route map

Use Case(s):

- Pilot on-demand routing with automated shuttles at one location (2 shuttles staged at both end/starting points)
- Pilot frequency-based routing with automated shuttles at multiple locations (Two vehicles operating continuously at two different sites within the Tradepoint Atlantic region, a third vehicle charging as back-up)

While the vehicles are in operation at Tradepoint Atlantic, planning for future stages will continue. The

following proposed service areas and routes are preliminary and subject to change. However, it is helpful to introduce project ideas early to begin engaging potential project partners and stakeholders, while also providing a baseline for performance measurement of operations at the Tradepoint Atlantic site, helping define what success leading into subsequent phases may look like and how future operating parameters may be determined.

The following diagram includes a high-level overview illustrating the amount of research, site analysis, and data collection the Project team has collected to identify potential testing for Phases 2 through 4. Additional materials include routes summaries, images from site visits, and MDOT MTA transit data can be found in the Appendix section.

Increasing in Complexity

Airport - Phase 2

- Use cases involve MDOT MTA Light Rail and/or bus
- Tech complexities include RFID gate signals, heavy traffic, and pedestrians
- Leverage existing partnership with Baltimore/Washington International Thurgood Marshall Airport (BWI Airport)

Rural - Phase 3

- Use cases include one of two potential MARC Commuter Rail stations in Western Maryland linking to nearby communities.
- Tech companies include Dedicated Short-Range Communications (DSRC), railroad crossings, and low signage
- Leverage existing partnership community centers, CSX, and MARC commuters

Urban - Phase 4

- Use cases include MDOT MTA Light Rail and/or bus and/or bus in two potential urban locations in Baltimore, Maryland.
- Tech complexities include multiple roadside unit signaling, dynamic routing, and Light Rail real-time ‘feeder system’
- Leverage existing partnership with schools, community centers, Baltimore Department of Transportation

Figure 5.7 – Phase 2 through 4 demonstration summaries

**Pins represent potential pilot locations*