Application to Test Automated Driving Systems on Public Ways in Massachusetts

CONTACT INFORMATION:

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CERTIFICATION:

The Applicant certifies that all information contained within this application is true, accurate and complete to the best of its knowledge.

Signature of Applicant's Representative	**Abe Ghabra** *Printed Name*	**01 January 2020** *Date of Signing*

Managing Director, Las Vegas Technical Center	[redacted]	[redacted]
Position and Title	*Email address*	*Tel. No.*

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Note: Applicants should not disclose any confidential information or other material considered to be trade secrets, as the applications are considered to be public records. The Massachusetts Public Records Law applies to records created by or in the custody of a state or local agency, board or other government entity. Every record that is made or received by a government entity or employee is presumed to be a public record unless a specific statutory exemption permits or requires it to be withheld in whole or in part. The exemptions are strictly and narrowly construed. More information on the Commonwealth's Public Records Law can be found on the Secretary of the Commonwealth's website.

The Application and Detail responses should meet the Web Content Accessibility Guidelines (WCAG) 2.0 A and AA standards (see Guidelines for Accessible Electronic Document Creation).

MassDOT shall, at least every six months, review the technological advancements, federal policy progress, and developments in the automated driving systems industry and thereby adjust or modify this Application and associated requirements as appropriate.

Detail # 1: Experience with Automated Driving Systems (ADS)

Please provide information describing the Applicant's experience testing ADS-equipped vehicles within at least the preceding 12-month period.

1) A brief history of the Applicant's business as it regards ADS-equipped vehicles

Karl Iagnemma, Principal Research Scientist and Director of the Robotic Mobility Group at MIT, and Emilio Frazzoli, Professor of Aeronautics and Astronautics at MIT, have been researching autonomous vehicles ("AVs") since 2005. In August 2013, they founded nuTonomy.

Aptiv (formerly Delphi) has been at the forefront of solving mobility's toughest challenges for decades and in 2018 acquired nuTonomy to complement its existing AV technology program. Since then, the combined AV teams have rapidly expanded in Boston, MA.

Aptiv's autonomous driving engineers have been leading software development for high-performing self-driving cars since the historic 2007 DARPA Challenge. Aptiv and its affiliates have been testing AVs continuously since 2014. Aptiv's self-driving vehicles have been tested on private courses in Massachusetts, Michigan, Pennsylvania, Nevada, Singapore, and the United Kingdom; and on public roads in Massachusetts, Pennsylvania, Nevada, and Singapore. The company conducted the first coast-to-coast automated drive in the United States in 2015. In 2016, Aptiv was the first to commercially deploy autonomous vehicles globally by partnering with ride-hail company Grab in Singapore to launch the first public deployment of AVs on a ride-hail network.

Aptiv operates more than 100 autonomous vehicles on multiple continents, across a range of driving conditions and environments, including the largest commercial deployment of autonomous vehicles with a ride-hailing network deployed in Las Vegas, NV. To date, the company has provided more than 75,000 paid autonomous rides, servicing more than 3,400 destinations, while maintaining a near-perfect average passenger rating of 4.96 out of five stars.

In September 2019, Aptiv announced it was forming a new joint venture with Hyundai. Hyundai will be contributing $1.6B cash at close and $0.4B in non-cash vehicle engineering support. Aptiv will be contributing ~700 employees focused on AVs across four main technical centers (including nuTonomy) and IP for Level 4/5 AV technology. The new joint venture with Hyundai will allow us to continue working toward radically improving the safety, efficiency, and accessibility of transportation worldwide.

2) A general summary of the Applicant's experience testing on private ways (closed to the public) and public ways (while the road was open to other road users), including for example:

a) Public Private test facility name(s), location(s), and a sample of photographs, videos, roadway cross-sections, or detailed description of road types and testing activities

We utilize closed-course testing sites in every market where our AVs operate on public roads. The facilities we currently use are:

1. Boston - Suffolk Downs
2. Las Vegas - Las Vegas Motor Speedway
3. Pittsburgh - Pittsburgh International Raceway
4. Singapore - Centre of Excellence for Testing & Research of Autonomous Vehicles

We use these facilities to comprehensively validate software and hardware changes before we approve them for use on public roads. Our facilities are equipped with a variety of road markings, street signs, and traffic lights to replicate scenarios found on public roads in the various markets and Operating Design Domain (ODD) in which we operate. Road types at these sites include, but not limited to; bi-directional roads with two to four lanes, medians, slip lanes, roundabouts, dedicated turn lanes with two-way and four-way stop-sign-controlled intersections, and traffic light intersections with and without turn arrows. The Singapore facility, in particular, also has equipment to simulate testing in heavy rain and "urban canyons" (where there are tall buildings on either side of the roadway), both of which pose challenges to AVs.

b) Public ways testing location(s) and a sample of photographs, videos, roadway cross sections, or detailed description of road types and testing activities

We currently operate on public roads in four cities: Boston, Pittsburgh, Singapore, and Las Vegas. Road conditions in these cities include uni-directional and bi-directional travel with one to four lanes, turn lanes, medians, reversible lanes, stop sign and traffic light-controlled intersections, bike lanes and sharrows, pedestrian crossings, roadside parking, and driveway entrances.

We conduct research and development testing in Boston, Pittsburgh, Singapore, and Las Vegas. The Seaport and South Boston areas of Boston and the One North and Queenstown areas of Singapore are heavily traveled neighborhoods used for urban testing with a dense mix of pedestrians, bikes in and out of bike Lanes, vehicles of all sizes, signalized intersections, and ever-changing construction zones. The Blawnox area of Pittsburgh and certain areas of Boston's Seaport and South Boston neighborhoods are used for testing in residential and industrial environments, with a combination of wide arterial roads and narrow, residential streets.

In Las Vegas, we operate a public ride-sharing program in partnership with Lyft. We operate in the downtown area and on Las Vegas Blvd. Our testing activity in Las Vegas focuses on user experience testing as well as testing in an environment that includes heavy multi-lane vehicle traffic, signalized intersections, and dense pedestrian activity.

Currently we test in daylight, dusk, dawn, low light; light snow and rain; light to moderate wind and fog. In Las Vegas, we limit the speed of our AVs in autonomous mode to 45 mph.

c) The amount of testing conducted on public and private ways (for example in miles, hours, frequency per day, week, or month, or other metric(s))

We test our AVs daily on public and private ways up to 16 hours per day in Las Vegas and up to 40 hours per week in each of the locations in Pittsburgh, Boston, and Singapore.

d) The type(s) of vehicle(s) used for the testing

We currently operate two different vehicle platforms. We use the Chrysler Pacifica Plug-in Hybrid Electric Vehicle (PHEV) platform in Massachusetts and it is our primary R&D platform across all sites. The other, BMW 5-series, are used in our operations testing in Las Vegas on the Lyft network.

e) The SAE J3016 Level(s) of the ADS which was tested

We are currently testing Level 4 ADS.

f) The operational design domain(s)(ODD) which were tested, include geographical conditions, roadway types, speed ranges, environmental conditions, and other domain constraints

Our AVs have operated in urban driving environments, including streets in which heavy vehicle traffic, cyclists, and pedestrians are present. At our current stage of development for the Chrysler Pacificas used in Massachusetts, we limit the speed of our AVs to 35 mph. We have operated our AVs safely in daytime and nighttime and in windy, rainy, and snowy conditions both in closed-course and public road environments. We continuously validate all vehicle performance and behavior changes to our AVs in simulation then in a closed-course setting before operating them on the public roads.

g) The governmental entity that approved and/or monitored the public ways testing, if any

Our public road testing is approved and monitored by the Massachusetts Department of Transportation (MassDOT), the City of Boston, Massachusetts Port Authority (MassPort) and Economic Development Industrial Corporations (EDIC). Outside of Massachusetts, we have received Automated Vehicle Testing authorization from the Pennsylvania Department of Transportation (PennDOT) and participate in the City of Pittsburgh's voluntary AV testing program, working with their Department of Mobility and Infrastructure. In Nevada and California, we have approved permits to test autonomous vehicles on all public roads from the respective state DMV's. At the federal level, we work in close collaboration with the National Highway Traffic Safety Administration (NHTSA) and the US Department of Transportation (USDOT).

Internationally, we have received approval from Singapore's Land Transport Authority (LTA) to test autonomous vehicles. Initially, this was only for a small portion of the neighborhood of one-north. The testing area was doubled in 2016, and based on our continued success, this area has gradually expanded to encompass large swathes of the country's public roads.

h) Results of the testing

We continuously improve our software using data we gather from our testing to adapt to local driving patterns, behavior of other road users (e.g., pedestrians and cyclists), and unique situations that require a system that performs beyond the written rules of the road (e.g., navigating around double-parked cars and yielding for pedestrians crossing against the signal).

2) A description and summary of any major crashes that resulted during testing on public ways by the Applicant:

We have never had an at fault (by our technology or Vehicle Operators) incident or major crash.

a) A description of the nature of physical damage to the vehicle or vehicles and or other personal or private property
b) Whether there was a determination of fault
c) Whether any personal injuries or fatalities occurred as a result of the crash, and if so, the seriousness of any injuries
d) Whether an official report of the crash or crashes were reported to police or other governmental agencies, and if a report or reports were filed, to whom they were filed
e) Whether any of the standard safety features on the vehicle were disabled at the time of the crash

Detail # 2: Operational Design Domain

The Operational Design Domain must define the domain(s) in which the ADS is designed to properly operate, including but not limited to geographical conditions, roadway types, speed ranges, environmental conditions, and other domain constraints for testing which is anticipated to occur in Massachusetts within the approval period.

1) *Time of Day*

a. Daytime (Sunrise – Sunset)
Yes

b. Nighttime (Sunset – Sunrise)
Yes

2) Environmental Conditions

a. Clear and Fair Weather: no rain, fog or snow
Yes

b. Light Rain and Fog: less than 5 mm/hr rate of rain and fog with limited impact on visibility
Yes

c. Moderate Rain and Fog: less than 10 mm/hr rate of rain and fog with limited to moderate impact on visibility
Yes

d. Heavy Rain and Fog: less than 20 mm/hr rate of rain and fog with moderate to high impact on visibility
Yes

e. Light Snow: less than or equal to 10 mm/hr rate of unmelted snowfall, and visibility of at least 1 km
Yes

f. Moderate Snow: greater than 10 mm/hr and less than or equal to 25 mm/hr rate of unmelted snowfall, and visibility of at least ½ km
Yes

g. Heavy Snow: greater than 25 mm/hr and less than 50 mm/hr rate of unmelted snowfall, and visibility of at least ¼ km
Yes

h. Severe Weather: greater than 20 mm/hr rate of rain and fog with high impact on visibility, or greater than 50 mm/hr rate of unmelted snowfall and visibility of less than ¼ km
No

3) Road Typologies and Speeds

a. Functional Classifications (Local Roads, Collectors, Arterials, Other Road Types)
Local Roads, Collectors, and Arterials

b. Limited Access (Motor Vehicles Only) or Multi-Modal (Mixed Traffic)

Multi-Modal

c. Single or Multiple Lane

Multiple

d. Maximum Operating Speeds

35 mph

4) Situational Constraints

a. Construction and Active Work or School Zones (Including Traffic Officers)

Yes: Construction, Active Work and School Zones

No: Traffic Officers or areas with temporary signals (such as lights)

b. Signalized Intersections

Yes

c. Unprotected Left Turns

Yes

d. Unsignalized Crosswalks

Yes

e. Rotaries and Roundabouts

Yes

f. Other Situational Constraints

Detail # 3: Summary of Training and Operations Protocol

Attach a summary of the type(s) of training required of employees, contractors and/or other persons designated by the Applicant as Test Drivers, and related operational protocols for testing on public ways. Such summary should include but is not limited to:

1) A general description of the training and instruction provided on private facilities and public ways, including how a test driver is made aware of the limitations of the ADS and the safe operating parameter(s) for a given ODD

Our Vehicle Operator ("VO") training program consists of three parts:

1. Instructor-led Classroom Learning and Assessment (15+ hours)
    a. Provides candidates conceptual instruction to prepare for a role as a VO. Classroom instruction familiarizes VOs on all aspects of our fleet, including orientations to the vehicles and autonomous technology. All topics are assessed in a comprehensive exam at the end of training.

2. Hands-on, In-vehicle Training and Performance Assessment (100+ hours)
    a. VO candidates begin training by observing Safety Driver (SD) and Safety Operator (SO) roles as a back-seat passenger on public roads and our

closed course. Observation allows new VOs to learn how experienced VOs scan for hazards, communicate with each other, handle unexpected behaviors and disengage autonomous mode, as necessary. The VO's in-vehicle success is measured through four in-vehicle assessments throughout their training before they take their comprehensive VO Exam.

b. Closed Course: The first time the VO is behind the wheel is when they must complete a closed course in-vehicle assessment. After completing their first assessment, VOs must pass a manual, closed-course, in-vehicle assessment. The assessments are followed by autonomous driving training on a closed course. VOs must complete the closed course autonomous driving training before driving on a public road.

c. Public Road: Once the VO has passed all closed-course training, they begin public road training in manual mode. In this phase of public road driving, the VOs must demonstrate the ability to safely operate the AV in a dynamic environment. Subsequently, VOs begin autonomous driving on public roads in preparation for two autonomous in-vehicle assessments: one for the SD role and one for the SO role.

d. After completion of all four assessments, the candidate completes the VO Exam, which covers cumulative training to-date. Once a VO passes training, they are paired with an experienced VO for three weeks for monitoring purposes and to ensure they continue training and safety best practices.

3. Continuing Education and Recertification (20+ hours)
    a. To foster ongoing information retention, sharp skill sets and a strong safety culture, VOs participate in the Continuing Education Learning Path through our Learning Management System (LMS). In addition to rolling three-month mandatory coursework, VO recertification is required every six months. As our fleet, business and the AV environment evolve, we continually assess the need to update and add coursework.

2) Evaluation of test drivers' experience and qualifications, basic driving skills, knowledge of ADS and controls, and operational protocols

The mission of our Vehicle Operator (VO) Global Training is to consistently and comprehensively prepare every autonomous VO for their safety-critical role handling autonomous vehicles (AVs). VOs are thoroughly vetted and trained through learning experiences, opportunities to practice, individualized coaching and access to the resources required to be safe, proficient autonomous VOs.

Goals of the training are to teach VOs:

- How the AV operates, relative to both hardware and software
- Safe driving habits
- How to respond to incidents
- How to be a safety-oriented, positive and proactive member of the Operations Team

As required by state law, VOs must have a clean driving record for three years and no DUIs for ten years prior to commencement of employment. We require drug testing and background checks before hiring, as well as a third-party driving evaluation on a closed course.

Upon hiring, VOs undergo extensive vehicle-based training. Upon completing both the Safety Driver (SD) Learning Path and Safety Operator (SO) Learning Path, VOs take a comprehensive exam. Additionally, to refresh best practices and in-vehicle skills, VOs are required to re-complete the Continuing Education Learning Path, which includes mandatory coursework every three months, VO recertification every six months.

The ratio of in-class/online training time to in-car time is approximately 1:3 with 35+ hours spent learning concepts and working through the learning paths in our Learning Management System and 100+ hours spent in the AV practicing on a closed course and eventually public roads. Upon completion of all SD and SO Learning Path elements, a final VO Exam is administered to assess VO ability to safely complete required tasks. The knowledge-based exam is composed of comprehensive material covering the safety practices of the SD and SO Learning Paths.

VOs continuously improve by participating in Continuing Education for the duration of their time in the VO role. Every 6 months, the cycle repeats with re-certification required to maintain their autonomous vehicle driving and operating credentials.

3) General steps or checklist items which must be completed prior to a new test driver beginning public ways testing

Comprehensive certification exams are taken throughout the completion of the previously mentioned Safety Driver Learning Path and Safety Operator Learning Path ensure VOs have mastered the skills and concepts necessary to operate AVs on public roads.

4) The approximate number of hours or time involved in training a test driver

A minimum of 135 hours.

5) A description of the test driver's role and responsibilities when the ADS is engaged, including the extent to which the test driver may be responsible for monitoring the driving environment, vehicle performance, and/or driving automation system performance

VO roles and responsibilities vary depending on where the VO is seated. The role of the VO sitting behind the steering wheel is the Safety Driver (SD), and is responsible for vehicle safety by performing the following tasks:

- Completing the SD pre-drive safety checklist
- Understanding all test-specific behaviors
- Communicating with the SO or Test Engineer
- Scanning ahead of and around the vehicle for hazards
- Taking control of the vehicle, if necessary

6) If a safety associate will be situated in the vehicle in addition to the test driver, a description of their role and responsibilities during testing

The role of the VO in the passenger seat is the Safety Operator/Test Engineer. The SO is responsible for gathering data and monitoring the AV systems by performing the following tasks:

- Completing the SO pre-drive safety checklist
- Annotating all vehicle behavior
- Monitoring vehicle perception and behavior
- Communication with SD and a trailing vehicle (if needed)
- Logging data files to classify disengagements for review by engineering once the test is complete

7) If conducting testing without a safety associate, a description of any additional training and instruction provided to test drivers, and a summary of how the test driver, driving environment, vehicle performance, and driving automation system performance will be monitored

The two-person SD/SO team minimizes distractions; allows for peer-accountability, including identification of driver fatigue and conformance with road rules; and ensures software and surroundings are constantly monitored. Our policy mandates VOs drive no more than a maximum of four hours continuously, with a mandated break post-driving.

8) A description of the Applicant's processes, protocols, and/or physical systems for monitoring the test driver, including but not limited to:

a) Eliminating or reducing potential sources of distraction, such as the ADS human-machine interface, mobile phones or other electronic devices, and other possible sources of distraction

The mobile phone, smartwatch, and other electronic devices of the SD are kept in the glove box of the AV any time the vehicle is not in park. The ADS HMI

display faces the SO/TE at all times. It is the responsibility of the SD to ensure passengers are wearing safety belts prior to starting the AV. However, the SD does not speak with passengers while the AV is in operation; that responsibility falls to the SO or TE.

b) Proactively and reactively maintaining the test driver's awareness and active monitoring of the driving environment, vehicle performance, and/or driving automation system performance as necessary

VO's are trained to use Positive Flight Control Communication techniques. These efficient communication techniques are employed to ensure unambiguous communication at all times between the SD and the SO. The SO informs the SD when they see a potential road hazard (e.g., bicyclist, pedestrian).

Detail # 4: First Responders Interaction Plan

A First Responders Interaction Plan will be made available to the law enforcement agencies and other first responders (including fire departments and emergency medical personnel) which operate in the permitted testing areas in the Testing Locations Menu. The First Responder Interaction Plan should instruct those agencies on how to interact with the vehicle in emergency and traffic enforcement situations, including but not limited to:

1) Identifying the vehicle (make, model, color(s) and appearance, identifying decals or indicators)
2) How to:
a) Recognize whether the ADS is engaged, safely disengage the ADS, and detect and ensure that the ADS has actually been deactivated

b) Immobilize or otherwise disable the vehicle to prevent movement or subsequent ignition of the vehicle

c) Safely interact with electric, hybrid, or alternative fuel vehicles, when applicable

d) Safely remove the vehicle from the roadway

3) Any additional information as deemed necessary regarding hazardous conditions or public safety risks associated with the operation of the test vehicle
4) Applicant's primary and secondary emergency contact information (including phone numbers)

The First Responder Interaction Plan shall be reviewed on a regular basis by the Applicant and revised and resubmitted at least annually, or as changes are needed.

The First Responder Interaction Plan will be made available by MassDOT to law enforcement agencies and other first responders, including fire department and emergency medical personnel.
A copy of the First Responder Interaction Plan must be carried in the approved test vehicle(s) at all times in the glove box or another conspicuous location.

The First Responder Incident Response Plan for our Chrysler Pacifica platform is attached to the end of this application as Exhibit A.

Detail # 5: Applicant's Voluntary Safety Self-Assessment

Attach a copy of the voluntary safety self-assessment in accordance with NHTSA's Automated Driving Systems 2.0 guidance, or similar documentation which addresses the safety issues contained therein.

Note: Applicants should not disclose any confidential information or other material considered to be trade secrets, as the applications are considered to be public records. The Massachusetts Public Records Law applies to records created by or in the custody of a state or local agency, board or other government entity. Every record that is made or received by a government entity or employee is presumed to be a public record unless a specific statutory exemption permits or requires it to be withheld in whole or in part. The exemptions are strictly and narrowly construed. More information on the Commonwealth's Public Records Law can be found on the Secretary of the Commonwealth's website.

Our Safety First for Automated Driving whitepaper: https://www.aptiv.com/docs/default-source/white-papers/safety-first-for-automated-driving-aptiv-white-paper.pdf

Additional Considerations that are not addressed in the whitepaper:
1. Crashworthiness

We exclusively test using the Chrysler Pacifica PHEV ("Pacifica"). The Pacifica satisfies NHTSA's FMVSS requirements. We retain all of the active and passive crashworthiness systems of the Pacifica, including seatbelts, anti-lock braking systems, airbags, and electronic stability control. We do not modify these crashworthiness systems.

2. Federal, State, and Local Laws

We operate with the approval of state and local officials and comply with local, state and federal laws. Our AVs are programmed to follow the traffic laws, and our SDs and SO/TEs take manual control of the AV if necessary, to avoid a violation of the traffic

laws. In the event that complying with the traffic laws would result in a risk to human life or health, our AVs are programmed to violate the traffic laws as minimally as possible to avoid the safety risk.

Detail # 6: Motor Vehicles in Testing Program

Attach a photocopy of the vehicle registration form for each Test Vehicle. If the Title number for the motor vehicle is not displayed on the registration itself, provide a photocopy of the Title or Certificate of Origin. Please note any exemptions by USDOT, EPA, or any other such exemptions for each vehicle, and provide a copy of such exemption, if available.
Additional vehicles may be added at any time after initial approval by sending the necessary information to: AVs@dot.state.ma.us.
Titles and Registrations for vehicles in our MA testing program are attached to the end of this document as Exhibit B.

Detail # 7: Drivers in Testing Program

Attach a photocopy of the current driver's license of each human operator who will be designated as a Test Driver to operate a test vehicle in Massachusetts by the Applicant. If the Applicant uses a driver who has been licensed in another state within the past year, it shall provide a copy of the license and a certified copy of the driving record (no more than 30 days old) of the driver.
Personal information will be protected from disclosure in accordance with the Driver's Privacy Protection Act and 18 U.S.C. § 2725.
Additional Test Drivers may be added at any time after initial approval by sending the necessary information to: AVs@dot.state.ma.us.

A list of our drivers in our testing program and their drivers' licenses are attached to the end of this document as Exhibit C.

Detail # 8: Insurance Requirements

Provide any insurance certificates and statements evidencing all insurance requirements listed in the Memorandum of Agreement.
All of our affiliates and subsidiaries are covered by a blanket insurance policy. We are transitioning the way we evidence our insurance coverage for contractual arrangements through a website hosted by our broker, Marsh. The Memorandum of Insurance ("MOI") is a paperless and environmentally friendly way of evidencing insurance coverages and

limits. The rights of the counterparty are precisely the same as a paper certificate and the website is updated on a real-time basis.
In addition, there is also a blanket endorsement to our general and auto liability policies, which states that any counterparty is automatically named as an additional insured as a result of a contractual agreement or contract. If there is an agreement in place with this language in it, the endorsement is automatically triggered.
The link to this website is provided here:
https://online.marsh.com/marshconnectpublic/marsh2/public/moi?client=530269898

Detail # 9: Additional Questions

Please provide answers to the following questions where possible. Responses will assist in the development of local and State policies pertaining to ADS. Please do not disclose any confidential business information or other sensitive proprietary content.

1) Please explain why the organization is applying to test in Massachusetts.

We are proud to be testing our AVs in Massachusetts. Our mission is to make mobility safer, greener, and more connected. In pursuit of this mission, we are building software and hardware to power AVs. Developing AV technology requires testing in diverse real-world conditions. Massachusetts mixed weather, road surfaces, and traffic patterns provide technical challenges that make it an attractive area for testing AVs.

The Boston core engineering team started working together at MIT in 2005 as part of the DARPA Grand Challenge. This team went on to form nuTonomy in 2013. In 2017, Aptiv (another company based in Boston) acquired nuTonomy. Since then, we have been expanding our Boston office, attracting engineers from around the globe. Furthermore, the world-leading educational institutions and workforce in Boston make it an attractive location to recruit talent. The future JV will also be headquartered in Boston in large part because of the advantages of such an educated workforce.

2) Will the organizations' efforts create temporary or permanent employment in the Commonwealth?

The Boston office is one of our primary autonomous mobility R&D centers, with over 100 engineers and growing. This office is focused on software development of all AV functionality, product analysis, and user experience testing. Solving these challenges requires a stable and growing engineering workforce of the highest caliber. In addition to engineering, when the joint venture with Hyundai becomes active, Boston will be the global headquarters for this venture.

Beyond the functions within Aptiv and nuTonomy, the AV technology we are developing is the catalyst for an entirely new industry ecosystem. As AV fleet sizes grow, so will the needs of other industry partners. It will require highly trained technicians to service vehicles, calibrate sensors, and more. Our perspective is that these functions may be done within our organization in the short term but will eventually be done by fleet servicing partners or owner-operators who will upskill staff or develop entirely new training programs. To assist in this, we have already begun engaging with local vocational schools and look forward to deepening our engagement as the unique ecosystems start to take shape here in Massachusetts.

3) Does the organization have a long-term vision of automated mobility? If so, what does that look like?

Today, we develop autonomous systems for ride-hailing providers and robotaxis. The most immediate opportunity for autonomous mobility is enabling safer, greener, and more connected mobility in urban cities.

We believe that ride-hailing networks will be the first to operate robotaxis because initially, driverless cars will only be able to operate in specifically mapped areas.

We will provide the technology that enables automated driving through traditional OE vehicles retrofitted with our integrated L4 system and expect to have a validated driverless system available for robotaxi deployment in geo-fenced locations starting in 2022.

We expect to begin to offer self-driving technology for personal ownership in 2030.

4) Please explain how your organization attempts to address the priorities identified in the Regional Memorandum of Agreement for AV testing[1], with particular attention to the societal benefits enumerated.

One of the central priorities in the Regional Memorandum of Agreement for AV testing is safety. AVs have an unprecedented opportunity to reduce accidents of all kinds on the roads. To us, safety is not a competition, and we have contributed to several efforts to uplift safety across the industry. We committed substantial company brainpower to help develop Singapore's Technical Reference 68, including expertise on functional safety, cybersecurity, and AV decision-making architecture. We also released a white paper titled "Safety First for Automated Driving," in which we collaborated with a consortium of leading automotive companies. It lays out the best practices for building safe AVs and validating their safety. Safety is the central pillar of our culture, and it shows. In over one million miles driven on public roads around the world since 2017, we have not had any

[1] https://www.mass.gov/how-to/how-to-test-autonomous-vehicles-in-massachusetts

AV-at-fault accidents - all while being the only company in the world to have AVs deployed on both left-hand drive (LHD) and right-hand drive (RHD) roads.

As stated earlier, the business model we are striving towards is one of robotaxis, owned and operated in fleets. When it comes to lowering congestion, emissions, and total vehicle miles traveled, shared vehicles, rather than individually owned, will be crucial. An AV with a high quality of service that provides first- and last-mile connectivity to other transport modes can help entice people away from private vehicles and reduce congestion. Our current vehicle platform is a plug-in hybrid electric vehicle (PHEV), another critical factor in reducing emissions. Early research by one of nuTonomy's founders, Emilio Frazzoli, laid the groundwork for how all these components come together to benefit the transport system. In "Toward a Systematic Approach to the Design and Evaluation of Automated Mobility-on-Demand Systems: A Case Study in Singapore," Prof. Frazzoli simulates an AV system in Singapore that could serve the entire country's demand with 1/3rd of the vehicles at present. We are striving towards a future where robotaxis work in conjunction with public transportation and micro-mobility — fewer cars, with lower emissions traveling for shorter distances with the help of public transportation.

Developing this technology with deep roots in Boston will have downstream impacts across the local economy. First, there will be spillover to local research institutions. Though ultimately unsuccessful in its bid, our USDOT grant application in collaboration with MIT, the City of Boston, MassDOT, and others is an excellent example of the potential. Secondly, Boston remains one of our world-class technical centers and will be the home of our future AV joint-venture with Hyundai Motor Group. Solving the biggest challenges in mobility requires a workforce at the cutting edge - meaning great jobs within Massachusetts. Lastly, the development of AVs here seeds the beginning of an entirely new industry ecosystem to support it. We have already begun outreach to local technical schools to ensure the talent pipeline fills up early.

Ensuring that AVs deliver on their promise for roads that are safer and greener than today is not occurring in a vacuum. We applaud the government's part of the regional MOA for their leadership and look forward to collaborating further on the future of transportation in Massachusetts.

Exhibit D: Testing Plan

Aptiv Services US LLC and it's affiliate nuTonomy, Inc request unbounded permission to test our Autonomous Vehicles in the City of Boston. We currently have no requests to conduct pilots at this time. If we wish to expand our testing area or conduct pilots, we will request the appropriate permissions from MassDOT and update this document accordingly.