Introduction

This document highlights safety elements of the autonomous vehicle testing program. In addition to the required components, there are descriptions provided below courtesy of the City of Boston's autonomous vehicle testing partners. They represent a simplified version of the complex technology systems utilized and a summary of the safety driver role.

City of Boston and Commonwealth of Massachusetts Safety Requirements

Below is a summarized list of safety-related requirements for testing autonomous vehicles on Boston's roads. These requirements are specified in the current versions of the MassDOT Application & MOU and the City's Testing Plan. They are in addition to any requirements for operating a non-autonomous vehicle on those roads.

The Company

- An Applicant who desires to test AVs in Massachusetts must review and understand the policy issued September 2017 by the National Highway Traffic Safety Administration (NHTSA) entitled Automated Driving Systems: A Vision for Safety and Executive Order No. 572 issued by Governor Baker on October 20, 2016.
- A company in their application must provide:
    - a brief history of the Applicant's business as regards AVs;
    - a summary of the Applicant's experience in "off-road" testing of AV's on private facilities and the results of the testing;
    - a summary of the Applicant's experience in "on-road" testing of AV's on public ways and the results of the testing;
    - a description and summary of any crashes (regardless of the degree of seriousness) that resulted during testing of AVs by the Applicant
    - a summary of where testing is taking place and whether it has an agreement or agreements in place to test AVs in other jurisdictions at a future date.
    - a full disclosure of any testing agreements that have been terminated in any jurisdiction, regardless of the circumstances related to such termination.

The Vehicle

- A company in their application must provide:
    - a safety assessment for testing the vehicles in accordance with NHTSA's Vehicle Performance Guidance, or similar documentation
    - a "self-certification" of testing for the technology in the test vehicles under controlled conditions that simulate the real-world conditions.
    - a photocopy of the vehicle registration form for each vehicle to be used in the AV testing program

- each vehicle used for testing should follow the Performance Guidance set forth by NHTSA and meet applicable Federal Motor Vehicle Safety Standards, or provide a waiver or exemption from NHTSA, unless otherwise approved by MassDOT.

The Safety Driver

- A company in their application must provide:
  - a photocopy of the current Massachusetts driver's license of each person who has been designated to operate an AV in Massachusetts by the Applicant.
  - documentation that the Safety Drivers be at least 21 years of age, possess a valid driver's license and have driving records free of any pending cases or convictions for operation of a motor vehicle while under the influence of alcohol or drugs in any jurisdiction in which the applicant has or has had a driver's license.
  - a summary of the types of training provided to employees, contractors and/or other persons designated by the Applicant as operators of the AV test vehicles.

The Operating Conditions

- While a vehicle is operating in autonomous mode, a safety driver trained and experienced in the operation and control of AVs must be seated and secured in the driver seats of such AVs and available and able to take command of the AVs as needed.
- Operators are given specific testing plans by the City of Boston, governing the time of day, location within the city and weather conditions for which a vehicle is approved to operate in autonomous mode.

nuTonomy's Approach to Autonomous Vehicle Testing Safety

nuTonomy is developing software to enable safe, convenient autonomous mobility in urban environments. We follow a three-step process to test our autonomous vehicle software.

First, we test new versions of our software in computer simulations. These simulations recreate a wide variety of real-life traffic scenarios. The scenarios include complex traffic situations that we have encountered during our on-road testing and other traffic situations that are canonical in the industry. Our simulations are designed to ensure that our software can safely handle "edge case" scenarios that could arise in testing.

Second, if the new version of the software performs well in simulations, we proceed to testing in a private, closed course test track. We put our autonomous vehicles through a series of maneuver tests designed to stress-test the safety and performance of the software.

Third, if the closed-course testing is successful, we proceed to public road testing, within our authorized testing area. At all times during public road testing, a trained safety driver is at the wheel, ready to take over manual control.

The Role of nuTonomy's Safety Drivers and Test Engineers

Our safety drivers play a critical role in our mission to radically improve the safety, efficiency, and reliability of transportation in cities worldwide. They evaluate vehicle preparedness, conduct off-road and on-road testing, and document findings to support the research and development of our software.

Before operating a nuTonomy vehicle on public roads, our safety drivers undergo extensive screening, detailed classroom training, and behind-the-wheel practice in a closed-course environment. Additionally, we have engaged outside professional driving agencies to educate our drivers on defensive driving techniques. This process takes place over multiple months with each module requiring careful documentation and sign-off by experienced trainers and engineers. nuTonomy requires that safety drivers remain engaged in continuous training as our software evolves.

Our safety drivers are assisted by a test engineer, seated alongside the safety driver in the front passenger seat. Test engineers monitor a display that shows the objects that our autonomous vehicle software detects on the roadway and its periphery, as well as the path the vehicle plans to execute. Test engineers continuously communicate with safety drivers so that the safety drivers can anticipate how the vehicle will behave and respond accordingly. With test engineers at their side, our safety drivers can keep their eyes of the road at all times. The combination of software, safety drivers, and test engineers provides critical redundancy to ensure that our autonomous vehicles will be operated safely.

Optimus Ride's Approach to Safety Drivers and Software Operators

When testing our self-driving vehicles, Optimus Ride utilizes a minimum of two safety personnel in the vehicle at all times (one safety driver and one software operator). The safety driver sits behind the steering wheel and has the responsibility of monitoring the navigation of the vehicle, the surrounding vehicles and environment, and can take over control of the vehicle at any moment. The software operator monitors the vehicle via a computer visualization of the what the vehicle perceives around it as well as our vehicle's current state and what it will do next. The software operator communicates important information to the safety driver that ensures safe navigation – together they form a collaborative safety team.

Our recruiting of safety personnel is extensive and we evaluate each individual on three main criteria: (1) background and professional driving experience, (2) technical aptitude, and (3) professionalism. Candidates must pass a series of extensive background checks including, but not limited to, local/federal criminal records, sex offender records, and motor vehicle driving

records from all states. All safety personnel go through an evaluation period where their performance and professionalism are heavily assessed. Any individual that does not meet our high standards or background checks is immediately terminated.

All safety personnel must undergo an extensive two-week training period conducted by Optimus Ride's lead testing and validation engineers. The training program instructs safety personnel to operate the vehicle in both manual and self-driving mode. Safety personnel must show command of takeover methods and an understanding of our obstacle detection and avoidance software. Trainees gain experience by testing both indoors, outdoors, and in all weather and road conditions as permitted by our MOU.

Optimus Ride's Approach to Multi-layered Safety

Optimus Ride vehicle has multiple layers of redundancy for detecting obstacles that combine both technology and human oversight. The first layer is an array of sensors with overlapping field-of-view enabling the vehicle to detect any obstacle. The second layer of redundancy is our safety driver as they are tasked with actively monitoring the roadway and nearby sidewalks and recognize when any obstacle, including vulnerable road users, may cross in front of the vehicle's path. The third layer consists of the software operator who actively monitors our self-driving software. The software detects and tracks all obstacles on and near the road. Additionally, our software makes reasonable predictions about what obstacles are about to do. In this way, our vehicle is able to make reasonable decisions to events that are about to happen. The final layer of safety is the support from a team of safety and testing engineers from Optimus Ride. All testing is recorded to enable post-test analysis, thus enabling our engineers to continuously make improvements to our software.

Optimus Ride's Approach to Vision Zero Self-Driving Vehicles

Optimus Ride is committed to the goals of Vision Zero – to eliminate all traffic accidents in our city streets by setting safe speed regimes. Extensive studies have shown dramatic reductions in fatalities, especially at intersections, with speeds below 20 miles per hour. Optimus Ride's vehicles are programmed to adhere strictly to Vision Zero speeds. Optimus Ride is committing to developing this disruptive technology to make our streets safer. We believe self-driving vehicles have the power to change the streets of Boston and enable mobility access within our community while saving lives. We hope to engage more with the community as we develop our product in order to educate others on the benefits of the technology.