QUARTERLY AV TESTING REPORT

2nd QUARTER 2019

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BACKGROUND

nuTonomy is an autonomous vehicle (AV) company. We are a part of Aptiv, a global mobility technology company. Our mission is to radically improve the safety, efficiency, and accessibility of transportation in cities worldwide. Since January 2017, we have been testing our AV's on the public roads in Boston. nuTonomy and the City of Boston have agreed to a Test Plan, which asks nuTonomy to report on our AV testing quarterly. This Report covers our progress during the Second Quarter of 2019.

In the Second Quarter of 2019, nuTonomy decommissioned the familiar Renault Zoe vehicle platform. The Zoe vehicle platform, with significant customizations, has performed all of our autonomous testing in Boston to date. However, as our engineering and design teams evaluated the technology requirements and customer needs in a fully autonomous vehicle, it became clear that the Zoe could not meet all of the criteria. Eventually, we selected the Chrysler Pacifica PHEV as a new base vehicle platform. The Pacifica vehicle provides a number of advantages over the Zoe: additional passenger space, domestic availability in the US, and improved mounting locations for sensors and computers. We believe this new vehicle platform will enable our team to operate AV's more safely, more efficiently, and more comfortably.

Aptiv, the parent company of nuTonomy, recently released a new whitepaper on the safe development of AVs titled: "Safety First for Automated Driving". This paper was co-developed by members of our team and key safety representatives from ten partner automotive companies around the world. These partners, Audi, Baidu, BMW, Continental, Daimler, FCA, Here, Infineon, Intel, and Volkswagen, also have a strong interest in AV safety. The paper lays out 12 guiding principles for designing — and later testing and validating — safe automated vehicles. These 12 guiding principles include: safe operation; operational design domain; vehicle operator-initiated handover; security; user responsibility; vehicle-initiated handover; interdependency between the vehicle operator and the automated system; safety assessment; data recording; passive safety; behavior in traffic; and a safety layer. We intend for this work to contribute to existing activities within the industry to create a safe standard for automated driving that can grow and adapt as the technology advances.

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SUMMARY

Miles Driven

As we stated in our Report in the Third Quarter of 2017, nuTonomy has exceeded the 600 autonomous miles required for Phases B1, B2, C1, and C2 of the Test Plan. As always, it is important to note that our autonomous driving in Boston represents a small fraction of accumulated autonomous mileage. While our footprint in Boston is small, our autonomous driving in Boston is high leverage: the complexity of road conditions and the density of vehicles, pedestrians, cyclists, and other road users accelerates our research.

Locations Driven

During the Second Quarter, we operated our AV's in autonomous mode on streets in the Seaport and in the periphery of South Boston. Specific roadways include: A Street, Black Falcon Avenue, B Street, Bond Drive, Boston Wharf Road, Congress Street, Courthouse Way, Cypher Street, D Street, Dorchester Avenue, Drydock Avenue, E Street, Fan Pier Boulevard, Fargo Street, Harbor Shore Drive, Northern Avenue, Pier Four Boulevard, Richards Street, Seaport Boulevard, Sleeper Street, Summer Street, Tide Street, West 1st Street, West 2nd Street, and various small connector streets. Additionally, we operated our AVs in manual mode for data collection and mapping purposes throughout the remainder of the Seaport and South Boston neighborhoods. We also conducted testing in our closed-course facility in the Boston area.

Crash Reports

We have not produced any crash reports, because our AV's have not been involved in any collisions during our testing in Boston.

Failures with Autonomous Mode

We did not experience any unanticipated failures or disruptions while driving in autonomous mode. As we explain below in greater detail, in certain traffic scenarios our safety drivers take over manual control because of known limitations of the current state of AV software.

SUMMARY

Takeovers

nuTonomy's safety drivers take over manual control in any situation in which they feel uncomfortable or unsafe. During the Second Quarter, our safety drivers took over manual control of our AV's in the following situations:

1. when emergency vehicles were in active operation (e.g., sirens and lights activated) in the roadway;
2. when law enforcement officers were manually directing traffic in intersections through which our AV's were traveling;
3. in certain situations in which construction vehicles were obstructing our lane of travel;
4. in certain situations in which oncoming vehicles or bicycles violated lane boundaries;
5. in certain situations in which weather conditions deteriorate rapidly; and,
6. when other vehicles were exhibiting erratic behavior near our AV's.

A safety driver's decision to take over manual control in a given situation does not necessarily indicate that continued autonomous operation in those situations would be unsafe. Because we instruct our safety drivers to err on the side of caution, we expect that takeovers will occur in many situations in which the AV would have handled the situation without incident. We are continuously improving our AV software, and we are confident that our AVs will be able to handle each of these situations without a takeover after further development.

LEARNING

What We Have Learned

A large part of designing the right product is first understanding the needs, behaviors, and workflows of all types of users. For autonomous vehicles, many of the user experiences are new and unfamiliar to our passengers. Over the past few years, our product team has been hard at work researching and testing concepts to understand what makes a smooth passenger experience in our AVs. We have engaged thousands of first-time and repeat passengers in our Las Vegas pilot and have also engaged smaller, focused user groups to study passenger needs in detail. Specifically, we have been studying the passenger experience while in transit and the concept of perceived safety.

While our technology team is focused on delivering a safe ride, our product team must consider how to make our passengers feel safe. In pursuit of this goal, we've developed a display screen for passengers that shows a simple and intuitive visualization of the vehicle's route and surroundings. We showcase relevant information, like other road users and objects in the road, with greater emphasis placed on the most relevant and vulnerable. This display also serves as the primary interaction channel between the passenger and the vehicle, highlighting important safety instructions, route information, and location-based information.

As a result of our user testing, we've been able to refine this display to show passengers more relevant and understandable visualizations. Specifically, we've learned the importance of building trust with the passenger through accuracy and consistency. By accurately representing other road users on the screen, passengers felt comfortable that the vehicle would react safely to them. Vehicle intent is another concept we try to convey through this display. We've experimented with thought bubbles and vehicle path markings to explain to passengers what the vehicle is thinking. It is important that these visualizations are consistent with actual vehicle behavior, otherwise trust is quickly broken. When we can display all of these items accurately and consistently, we find users rapidly become comfortable and stop paying close attention to the display, indicating a sense of safety. If we are going to bridge the trust gap with the general public they will need to feel as safe as they actually are. Our research over the last year has helped us do just that.

As always, we thank Governor Baker, Mayor Walsh, Secretary Pollack, and their teams for their continued support of our AV testing in Boston.

IMAGES

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