• A P T I V •

QUARTERLY AV TESTING REPORT

4th Quarter 2019

BACKGROUND

Aptiv is a global technology company that develops safer, greener and more connected solutions enabling the future of mobility. Aptiv's Autonomous Mobility team is focused on developing and commercializing autonomous vehicles and systems that enable point-to-point mobility via large fleets of autonomous vehicles (AVs) in urban driving environments. With talented teams working across the globe, from Boston to Singapore, Aptiv is the first company to deploy a commercial, autonomous ride-hailing service based in Las Vegas. Today, we have provided over 95,000 public passenger rides, with 98% of passengers rating their experience 5 out of 5 stars. At Aptiv, we believe that our mobility solutions have the power to change the world.

nuTonomy, which was acquired by Aptiv in 2017 and is now Aptiv Autonomous Mobility, began testing AVs on the public roads in Boston in January 2017 under a test plan with the City of Boston. Later in 2017, Aptiv acquired nuTonomy to complement and grow our existing AV technology program. This report covers the joint progress of Aptiv Autonomous Mobility and our nuTonomy affiliate during the Fourth Quarter of 2019.

In September 2019, Aptiv and Hyundai Motor Group announced that the two companies would enter into a joint

venture focused on autonomous mobility, reinforcing a shared vision of making mobility safer, greener, and more connected. The deal is expected to close in the second quarter of this year. The Aptiv and Hyundai Motor Group joint venture advances the development of production-ready autonomous driving systems for commercialization of Level 4 and 5 self-driving technologies. Hyundai will contribute $1.6B in cash at the close of the transaction and vehicle engineering support valued at $400M. Aptiv and Hyundai Motor Group's combined contributions total USD 4 billion, with each owning 50 percent stake in the joint venture. Aptiv will contribute intellectual property and 700 employees across five global offices in Boston, Pittsburgh, Las Vegas, Santa Monica, and Singapore.

Outside of this significant corporate milestone, our AV testing has continued on the Chrysler Pacifica PHEV platform in Boston. We continue to complete a mix of simulation, closed course, and public road tests on this vehicle as we work toward our long-term goal of deploying a high-quality autonomous transportation option for customers. In addition to this technical work, we have spent time engaging with local community members, including the First Responder community and multiple student groups, to ensure that AVs are a complementary part of Boston's mobility ecosystem. In 2020, we look forward to continued on-road testing across all of our sites as we strive to solve mobility's toughest challenges.

SUMMARY

Miles Driven

As we stated in our Report in the Fourth Quarter of 2017, Aptiv 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. Globally, Aptiv has completed over one million autonomous miles across four major markets and two countries. 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 Fourth 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.

Takeovers

Aptiv's safety drivers take over manual control in any situation in which they feel uncomfortable or unsafe. During the Fourth 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

It comes as no surprise to Massachusetts residents that driving in our state comes with a wide variety of weather conditions. Previously, we've spoken about the challenges of driving in snow. While snow still remains a challenge for AVs (and humans), in this report we wanted to address the challenges of driving in heavy fog.

In general, fog makes driving more challenging by reducing visibility. When visibility is reduced, the driver loses precious reaction time to recognize and respond to external objects. So how can

visibility be improved in heavy fog?

For human drivers, visibility is a function of eyesight, lighting, physical obstructions (e.g. cars or buildings), and environmental obstructions (e.g. fog or rain). By contrast, autonomous vehicles rely on a suite of sensors including LiDAR, Radar, and camera-based vision in lieu of human eyesight. When these sensing modalities are fused together, they achieve a similar result: the placement of objects in a 3D scene around the vehicle. Unfortunately, AV sensors still face the same lighting, physical, and environmental visibility challenges.

Aptiv AV testing in low visibility conditions on our closed course

In order to improve the ability for the AV to see through fog, we have a few different options at our disposal:

1. Rely on existing sensing modalities, like Radar, which are still capable in fog
2. Develop new sensing modalities that perform well in foggy conditions
3. Improve the algorithmic processing of sensor data to extract high quality information about objects in spite of noise created by fog

Internally, we are focused on (1) and (3). Aptiv has a deep history in developing and using Radar systems and we continue to employ these sensors in our AVs in Boston. While helpful in foggy conditions, especially with the identification of other vehicles, Radar typically does not produce a fine enough resolution of small or stationary objects. This is where our research into improved LiDAR data filtering and improved image classification of camera images is yielding significant advantages. Through this research we have been able to see deeper into foggy weather with greater certainty providing our vehicles additional time to react to external objects. While Massachusetts weather will always present challenges, we're excited about the learning opportunities it provides to make our AVs more robust and safer on the roads.

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