Quarterly Report for MassDOT & City of Boston

1st Quarter 2021

Background

Motional is committed to designing for people: for families that need to get their children to school safely; for elderly passengers who need continued access to mobility; and for urbanites who, more than ever, have a choice in how they get around cities. We know that self-driving vehicles have the potential to bring vast benefits to humanity: increased mobility, fewer traffic-related deaths, and a greener planet. But the only way to fulfill these promises of tomorrow is to build trust in the technology today. We believe that when we demonstrate openness and collaboration, trust follows.

Our team's expertise in autonomous driving can be traced from our R&D roots at MIT and Carnegie Mellon University, where we showcased our autonomous technology in the DARPA Grand Challenge and DARPA Urban Challenge, to our present-day commercial operation in Las Vegas, which has safely provided more than 100,000 self-driving rides to members of the public. We are proud to report that our attention to safety has extended into our real-world operations. We have driven over 1,000,000 miles in complex city environments worldwide while maintaining a record of zero at-fault incidents.

Today, our global team—spanning North America and Asia—is dedicated to delivering safe and reliable production-ready SAE Level 4 robotaxis that will make roads safer and improve mobility worldwide. As we advance the technology, our people-first ethos will ensure that safety, security, and privacy are embedded in every step.

Since the formation of our autonomous driving joint venture between Hyundai Motor Group and Aptiv in March, we've made significant strides in establishing our corporate structure, building out our leadership team, and logging public road miles to advance our driverless product. After a rigorous review by a third party assessor, we began testing our Pacifica in driverless mode

on the public roads around Las Vegas in early 2021. In March 2021, we announced that we'll be migrating to an all-electric Hyundai platform, the IONIQ 5, for our AV testing.

Testing activity

Motional has started to broaden the scope of its autonomous capabilities by continuing to work on suburban elements as well as taking aim on more urban dense driving. For example, by utilizing our closed course tracks we are working on traffic light environments and ensuring consistent perception and reaction to changing traffic lights.

Our work on the Safety Steward role is continuing to grow and develop, as our Vehicle Operators are developing familiarity with the best practices. This individual will sit in the front passenger seat to oversee driverless testing. We are refining the protocols for Safety Stewards, including when and how they intervene with the emergency stop buttons. We are treating this as a skill that all of our Vehicle Operators should be able to do within their prescribed role.

Operational Design Domain (ODD)

Our vehicles are designed to operate in low-speed (<35 MPH), urban environments in various conditions. We continuously validate all vehicle performance and behavior changes to our AVs in simulation, then in a closed-course setting before operating them on public roads. To date, we have experience testing on public streets with a variety of road actors, including heavy vehicle traffic, cyclists, and pedestrians. Additionally, we have operated our AVs safely in daytime and nighttime and windy, rainy, and snowy conditions in closed-course and public road environments.

Amount of testing

Our testing occurs primarily during regular business hours (Monday through Friday, 9AM-5PM). As mentioned above, this testing includes specialized testing in closed-course and data gathering in the Seaport / South Boston area.

Takeover procedure

Safety drivers take over manual control in any situation in which they feel uncomfortable or unsafe. Planned takeovers are also done when finishing a mission or approaching situations that are not within the outlined ODD.

During the First Quarter, our safety drivers took over manual control of our AVs in the following situations:

- When emergency vehicles were in active operation (e.g., sirens and lights activated) in the roadway;
- When law enforcement officers were manually directing traffic in intersections through which our AVs were traveling;
- When construction vehicles were obstructing our lane of travel;
- When oncoming vehicles or bicycles violated lane boundaries;
- When weather conditions deteriorated rapidly; and,
- When other vehicles were exhibiting erratic behavior near our AVs.

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 cases in which the AV would have handled the situation without incident.

Description of ADS system failures

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

Goals for future testing

Continue to expand our autonomous capabilities through proven closed course track tests before transitioning to public road driving. We anticipate being on public roads in both our Pacifica and Ioniq platforms this year.

Insights

For something many of us do every day, driving is a deceptively complicated task. Safe drivers continuously update a mental model of a large number of pedestrians, cyclists, and cars, predict how those objects might move in the future, and understand which road rules apply in any given situation. This complex mental exercise grows increasingly complicated as you move from suburban to urban environments, where there are higher levels of road activity.

Yet, most drivers are able to do this instinctively and, most of the time, fairly well. However, if you'd ask a driver to explain how exactly they decided on a specific maneuver in a complicated situation, they'd be hard pressed to articulate their decision-making process, or to describe an approach that could be applied to other, similar situations. It's often an instant, instinctual decision, derived from personal experience and intrinsic knowledge.
Our vehicles are designed to be a "superhuman" driver. This means the vehicle is trained to possess the same skilled, intrinsic knowledge that human drivers have, but improved with the superior safety capabilities and reliability of an autonomous system that is never distracted, drowsy, or impaired. The result is a ride that's safe, but also smooth and comfortable, as it would be with a human driver.

While safety is always our first priority, creating a ride that's comfortable and familiar, or human-like, is paramount to growing adoption. Consumers don't want to get into a car and have the feeling that it's being driven by a robot, they want to have the feeling that it's being driven by someone that's as good of a driver as they are.

In order to make this possible, Motional has been at the forefront of research and development:

- By using vast amounts of data, our systems are able to predict the future position of other vehicles and pedestrians on the road better than existing methods. We've also conducted landmark research that proved deep-learning based object-detectors can achieve previously unseen levels of performance, while being blazingly fast. This enables the vehicle to make faster

- In addition, Motional's class researchers formalize the rules of the road and encode their hierarchy based on safe, skillful human driving. The result is an autonomous ride that's both safe and comfortable.

This approach not only benefits the passenger inside the vehicle, it ensures our vehicles' behaviors are recognizable and understandable by other drivers and road users. This is critical for large-scale deployments, and effectively integrating driverless vehicles into communities.

Feedback for municipal and state transportation engineers, planners, and policymakers

As different levels of government are considering cybersecurity and autonomous vehicles, we recommend looking to existing consensus groups, such as the UNECE WP, rather than making prescriptive requirements. These standards focus on process measures that take into account the lifecycle of usage of a platform, while allowing developers the flexibility to innovate to make their stack more robust to prevent intrusions.

A critical component of the UNECE cybersecurity standards is documentation and demonstration. It is not sufficient for security professionals to simply perform the tasks mentioned above. They must document their assumptions and claims, collect evidence to support them, and use this data to clearly and concisely present the case that their systems are trustworthy. This is analogous to the processes used to determine that vaccines are safe or to certify medical devices for use in or on humans.

While cybersecurity in the automotive industry is not as rigorously regulated as it is in the medical industry, we do have certification standards emerging. Some jurisdictions are adopting regulations to require such certifications. As with vaccines and medical devices, these standards and regulations do not ask the public to simply trust manufacturers. Manufacturers pursuing a certification must make their cases to certifying third parties. Those third parties will only attest to the accuracy of the security cases if those cases are convincing.