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Quarterly Report for MassDOT & City of Boston

4th Quarter 2020

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. In November we announced our intention to begin driverless testing in the Las Vegas area, after updating our testing license with the Nevada DMV, setting up 2021 to be an exciting year for Motional and the future of mobility.

Testing activity

Our focus lately is the vehicle's performance in suburban elements. The modifications we began last quarter to our test track to support this testing is now complete, with new speed bumps, driveways elements, and more. These elements will be validated on our test track before on-road testing across all sites (Boston, Singapore, Pittsburgh, and Las Vegas).

While most of our current testing occurs with a Vehicle Operator behind the wheel, in the near future we will begin testing driverless on public roads in Nevada. Much of that preparation work occurs at our Boston testing facility. One component we are focusing on is a new role, the Safety Steward. 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.

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 Fourth 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;

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- 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

We continue to go through the design and testing process for user-friendly pick-up and drop-off. We have also conducted interviews with different accessibility groups to ensure we continue to broaden who is included in our testing. These components are crucial to making sure our platform is user friendly for a diverse and inclusive population. We plan to incorporate more learnings from this research into our testing.

As we move through the winter, we'll be increasing the amount of low-light testing, in addition to testing in adverse weather conditions, such as rain, snow, or fog. These are all tests we have undertaken

in the past; however, we plan to increase their proportion within our overall testing mix.

Looking forward to 2021, we are expecting to increase the amount of driverless testing at our closed course track as well as define key differences between operation of the AV with/without an operator behind the wheel. There will be a great deal of validation required on our closed course track before any public road driving (not planned for MA) as well as training of the Safety Steward role which is critical to the success of driverless functionality.

Insights

Transportation inequity is a profound problem which demands profound change. Motional is committed to being a part of that change. We believe driverless vehicles have the potential to provide safer, more affordable, and more accessible transportation, and we're dedicated to creating a more equitable future.

Motional is committed to building an inclusive AV design. Our engineers and roboticists are working diligently on autonomous vehicle technology while being intentional about the long-term impact of that work.

For many, mobility is a permanent and ubiquitous fixture of daily life — but this is not a universal experience. Where some have unerringly reliable access to transit, others lack it entirely. This problem is called transportation inequity. Its causes are many, including lack of services, cost of services, and expense of vehicle ownership.

We do this by ensuring an inclusive lens is applied to the ideation, creation, testing, and continuous improvement of our vehicles. We're engaging with our government partners, accessibility groups, and are expanding our research process to include a broader range of inputs from our community. Within Motional, we are committed to Diversity,

Equity and Inclusion, and are fostering educational opportunities and important conversations among employees.

There is no silver bullet or insight that will change everything. But if we all don't start asking the right questions, autonomous vehicles promises will go unfulfilled.

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

It is difficult for policymakers, AV developers, and members of the public to access reliable data on AV testing across states. Further complicating the access issue are the varying requirements and definitions for incident reporting. This means that the minimal data that is publicly available is difficult to compare, obscuring the level of safe testing that is occurring. Motional wants to be a helpful partner in the future of mobility, but unilaterally sharing information presents its own competitive complications.

Where do we go from here? City, state, and federal policymakers need to collaborate with the industry on setting a consistent standard for reporting and data-sharing. This should start with definitions and primary taxonomy before moving on to expectations around data-sharing. For example, what qualifies as a reportable incident, and what constitutes a disengagement or takeover? These need not be required or legislated; we have already seen that voluntary collaboration on best practices, like the VSSA, has been an efficient way to garner support.

US DOT has tried to address this with their AV TEST initiative. Others, like the Open Mobility Foundation, have approached it from a nuts and bolts perspective, developing an API to facilitate

such sharing. We encourage these steps and hope to see more collaboration in the future.

