Motional

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Quarterly Report for MassDOT & City of Boston

3rd 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 1,500,000 miles in complex city environments worldwide while maintaining a record of zero at-fault incidents.

Today, our global team—spanning the U.S. 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 our global headquarters, Boston is a vital part of our research, development, and testing ecosystem. We're continuing to invest in our Boston operations and are currently hiring for over 100 new positions.

In early September we made an important reveal in collaboration with Hyundai, what our all electric robotaxi on the Hyundai IONIQ 5 platform will look like. The IONIQ 5 robotaxi has all the IONIQ 5's consumer-centric features that wowed the industry when unveiled this past February - such as the neo-retro design, parametric pixel lights, auto flush door handles, low-profile interior, vehicle-to-load charging system, fast-charging capabilities, and 18.8 cubic feet of storage space - plus Motional's industry-leading AV technology package baked right into the design.

A key element of Motional's partnership with Hyundai is our ability to tap into the company's long history of mass-producing vehicles. Long-term success in the emerging, crowded AV market will depend on achieving cost-effective commercialization. The IONIQ 5 was engineered from the ground up, and designed to be a technologically advanced, emissions-free crossover capable of being built at scale. This will make it easier for Motional to execute our strategy of delivering safe, cost-effective robotaxi fleets around the globe. And because Motional is the only company in its class already partnering with two major ride-hailing services - Lyft and Via - we have a clear path to market.

Testing activity

Our efforts are continuing to focus on the Hyundai Ioniq 5 platform which was announced recently. This platform comes with new hardware and better capabilities compared to previous generations

Operational Design Domain (ODD)

Our vehicles are designed to operate in low-speed, 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.

As we continue to develop and build out our Generation 2 IONIQ platform we are exploring multiple avenues for more efficient testing methods. Such methods include finding better ways to verify the basic autonomous capabilities of the vehicle before doing significant real world testing. These new practices involve multiple stakeholders within Motional to ensure that our approach is not only safe but also allowing ourselves to be more time effective.

Takeover procedure

Vehicle Operators 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. We are also refreshing our Fault Injection training with all Vehicle Operators where intentional system errors are introduced to make sure our operators takeover in the proper fashion before returning to public roads.

During the third quarter, our vehicle operators 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 vehicle operator'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 vehicle operators 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 vehicle operators 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 -
Designing the driverless ride

Although driverless commercial operations aren't a reality yet in Massachusetts, the research we are doing today is laying the groundwork for that future.

When using a ride-hail service, there is a routine and familiar series of actions. We track the car's location as it makes its way to us, and then match the license plate or car number with the information in our app. If we have luggage, we place it in the trunk and then get in, settle into the backseat, and confirm our

destination with the driver. Once our trip is underway, we may have a conversation with the driver or choose to have a silent ride. Once we arrive at our destination, we exit the vehicle, check to see if we left anything behind, and end the trip.

How can these common interactions be replicated when there's not a driver in the vehicle – and in a manner that seems intuitive and familiar for riders? An awkward and frustrating initial robotaxi experience could discourage the passenger from taking a robotaxi again. As such, Motional engineers and product teams are focused on designing our driverless experience to be as intuitive as a trip in a traditional ride-hailing vehicle – from the moment the robotaxi approaches a rider until after they exit.

Over the past couple of months, our engineers and product teams have been out in the real world in Boston testing various scenarios to ensure that we put out into the world a unique vehicle that feels familiar, safe, and comfortable.

In the Seaport, we invited the public to help us perform tests around notifications - specifically how to communicate both non-urgent and critical information to passengers. This type of testing helps our teams validate how different notification types should be classified. We also spent a day out in Jamaica Plain testing hard keys, which include the buttons that passengers can use to contact remote customer assistance or to signal the vehicle to

safely pull over. These controls allow riders to quickly access basic ride functions or speak directly to a human if needed.

Driverless vehicles have the potential to change the transportation ecosystem and enable all, including those with disabilities, to gain and maintain independent lifestyles. By testing out in the real world, we are better able to understand the needs of everyone and the insights we learn will help guide how we'll design future driverless vehicles and improve the experience for all passengers with each iteration.

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

Consistency across jurisdictions has become a common theme in our reports. For example, we discussed the value of a uniform traffic code in previous reports and how consistent reporting metrics will give policymakers comparable data from other locations. Absent movement at the federal level, coordination between state and local governments will be critical to unlocking the potential of AVs.

Motional finds several elements encouraging. First, the New England Transportation Consortium's efforts to harmonize requirements across New England make it an

easy case for AV developers to deploy across the region. A concept resembling a single regulatory market, or at least reciprocity, would significantly raise the value of smaller New England Cities for AV deployment that may not have the same market pull on their own. Without coordination, developers naturally tend towards the biggest markets in the biggest states.

Cities are home to some of the most innovative policies in consideration today. Motional is likewise encouraged to hear cities hosting AV companies coordinating policies that solve their own stakeholder needs. Although it may not create a clean bucket of single market, it does broadly make cities that collaborate more attractive to deploy in compared to cities going at it alone.

As these initiatives progress regarding AVs, Motional recommends governments focus on the elements traditionally within their authority, such as licensing or insurance requirements. Regulations around vehicle performance standards, safety, or
certifications that supplement or go beyond, overlap, or conflict with federal law, regulations, or AV guidance, may impede the development of automated vehicles. This recommendation is consistent with what NHTSA laid out for state and local policymakers in AV Policies 2.0 and 3.0. There hasn't been movement at the federal level on regulation because there is not yet consensus from experts (both within government and industry) on what that should be. It is not a trivial problem, and it has taken

NHTSA decades to develop similar standards for traditional automotive.

Motional looks forward to being an active collaborator in these initiatives and all of those to come.