Bi-Annual Report for MassDOT & City of Boston

1st Half 2023

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 driverless 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 operations in Las Vegas, which has safely provided more than 130,000 autonomous 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 2,000,000 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.

In September 2021, we revealed our next-gen all-electric IONIQ 5 robotaxi, developed in collaboration with Hyundai. The IONIQ 5

robotaxi is based on Hyundai's award-winning consumer IONIQ 5, and has the same passenger-centric features, 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 driverless technology package baked right into the design.

Boston has been an important part of Motional's international R&D ecosystem for over ten years. It's home to Motional's corporate headquarters, an operations hub, and state of the art closed-course testing facility. In 2021, we expanded our Boston presence with a multimillion dollar investment to grow our Seaport operations facility at Black Falcon, and increase hiring and R&D testing.

Testing activity

Our testing efforts continue to focus on the Hyundai IONIQ 5 platform, which includes more advanced hardware and technical capabilities compared to previous Motional vehicles. We are working on transitioning our testing to our IONIQ 5 test car to our IONIQ 5 prototype vehicle. The prototype vehicle incorporates passenger experience features for ride hailing. Including passenger display that shows ride information, remote control assist button to help passengers connect with a remote representative, and external displays and lights that help riders identify their vehicle.

Operational Design Domain (ODD)

Our vehicles are designed to operate in low-speed, urban environments in various conditions. We validate vehicle performance using simulation and bench tests, then in a closed-course setting before operating on public roads. To date, we have experience testing on public streets with a variety of road actors, including heavy vehicle traffic, emergency vehicles, construction, 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 traditional business hours (Monday through Friday, 9AM-5PM). This includes specialized closed-course testing at our test track in Suffolk Downs and on-road data collection and autonomous driving in the Seaport.

Takeover procedure

Motional's vehicle operators can take over and manually control the vehicle 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.

A snapshot of typical takeover examples include the following:

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

We continue to test our autonomous capabilities through closed-course track tests before transitioning to public road driving. Our IONIQ 5 vehicles are currently operating autonomously on public roads.

We are supporting internal autonomous rides around the Seaport for employees to experience the product they created and provide feedback.

We are supporting the enhancement of our sensors by collecting data while driving manually in rainy conditions. Collection of this data will help improve our autonomous performance of our cameras, radar, and lidar in rainy weather.

We are also using our IONIQ 5 robotaxis and our new simulation and virtual reality space to gather user experience feedback from the public. Motional's Product team will continue to get feedback from a diverse set of research participants regarding the capabilities they would like to see while riding in an autonomous vehicle in different scenarios.

We plan to host demonstrations for stakeholders from the city of Boston and MassDOT to learn more about our company and our technology.

Insights

In October of 2022, Motional and Uber announced a commercial agreement to launch driverless ride-hail and delivery services using Motional's IONIQ 5 robotaxis.

The 10-year, multimarket agreement creates the opportunity for effective scaling and broad adoption of AVs by pairing Motional's advanced driverless technology with Uber's

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network of millions of customers. Motional and Uber have a shared vision for AVs to offer an affordable, convenient, and safe transportation option for everyday travel. Motional's robotaxis are currently available to Uber riders in Las Vegas, and are conducting autonomous deliveries for Uber Eats customers in Los Angeles.

With this partnership, we wanted to identify some of the hurdles that must be overcome prior to launching a robotaxi service in a new market.

Motional has a lengthy checklist to complete before picking up passengers or delivering goods. Robotaxis, after all, are part high-tech computer, part all-electric vehicle, part commercial product. They need to be trained, tested, and permitted. They need a dependable power source and a way to receive regular software upgrades. And, they need a consumer base eager to make riding in driverless vehicles part of their everyday routine. These are some of the steps Motional takes to get ready to launch a robotaxi service in a new city:

RIDER SAFETY
Nothing is more important than the safety of our passengers, as well as the safety of any drivers, pedestrians, or cyclists moving near our AVs. Before Motional launches in a new market, several tasks are conducted to ensure our AVs are safe for riders and other road users. Here are a few:

- Test drives: Motional's robotaxis undergo continuous testing to ensure the technology is ready to handle the challenges of the road. Every market is different and has its own unique features, ensuring diverse data for our vehicles to learn from. For example, in Boston the vehicles experience old, narrow, curvy streets; in Las Vegas, the vehicles experience exotic cars and pedestrians in unusual costumes.
- Mapping: Using lidar, AVs create a highly detailed 3D image of all the roadways, intersections, even buildings in a new market, so that the onboard computers know exactly where they are at all times.
- Permitting: There is currently no uniform set of federal standards that govern the operation of autonomous vehicles in the U.S. Instead, Motional works with states and municipalities to secure all needed permits.

Widespread adoption of robotaxis won't happen unless passengers trust that they are safe. Before starting passenger service in any new market, AV companies such as Motional will take multiple steps to ensure the robotaxis operate safely.

INFRASTRUCTURE
Properly supporting a fleet of robotaxis is not something that can be done on a makeshift basis, or set up overnight. The amount of charging stations, data connections, and other infrastructure needed to support the advanced technology means robotaxi companies won't operate like a traveling roadshow, capable of setting up overnight in a new town. Instead, it

will require large facilities with upgraded utility infrastructure.

Motional's robotaxis, which are built on the Hyundai IONIQ 5, an all-electric crossover, are going to be some of the most-advanced vehicles ever mass-produced. The robotaxis feature a specially designed suite of more than 30 sensors including cameras, radar, and lidar, sport a powerful onboard computer system that allows the vehicle to see, think, and drive, and a next-generation battery platform - all of that technology will require a facility substantial enough to provide the fleet with regular maintenance and servicing.

These are some of the challenges that come with launching in a new market and Motional is committed to working with business leaders and policy makers to find solutions.

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

Driverless vehicles complement existing transportation infrastructure to provide more accessible, reliable, and affordable mobility options.

Autonomous vehicles (AV's) will redefine the transportation landscape and present new opportunities for collaboration between public and private transportation providers and

networks to deliver improved mobility services for all.

Transportation Equity

Transportation is an essential part of life. For many, mobility is a permanent and ubiquitous fixture of daily life - but this is not an universal experience. While some have unerringly reliable access to transit, others lack it entirely.

At Motional, we believe driverless vehicles can help improve transportation inequities and we're committed to being part of the solution.

That's why we're building our vehicles to serve everyone everywhere. We want to reach those that are all too often left out of mobility innovations, including the elderly, the disabled, and those lacking accessible transportation options.

Robotaxis and Transit Systems

The possibilities for collaboration between AVs and public transit systems are limitless. A few of the possibilities we see are:

- **Delivering Last Mile Solutions** to get riders from their departure/destinations to transit stations. We know that a one mile walk might as well be 100 miles for the disabled, elderly, or those otherwise unable to get to and from transit stations.
- **Integrating ride-hail applications with transit systems** to offer riders real-time

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information on stations, schedules, and routes. More accessible information and easier connections could help encourage more public transit riders and limit the reliance on personal vehicles. The resulting benefits in terms of reduced traffic, sustainability, and transit ridership would be huge.

- **Providing safe and reliable options for transit gaps and peace of mind.**   For example, we see working parents as a key demographic for robotaxis. Would they rather a robotaxi safely transport their child to an after school program rather than have them walk 10 blocks alone? Or, would a young woman rather take a private robotaxi than walk between subway stations at night?

- **Connecting neighborhoods without adequate transit infrastructure to access points**. For the neighborhoods that simply don't have transit points or the schedules aren't frequent enough, robotaxis could provide reliable transportation to get a rider to the nearest access point. These neighborhoods are often low income or communities of color, and a robotaxi won't be subject to human driver bias that might inhibit those pick-ups.

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