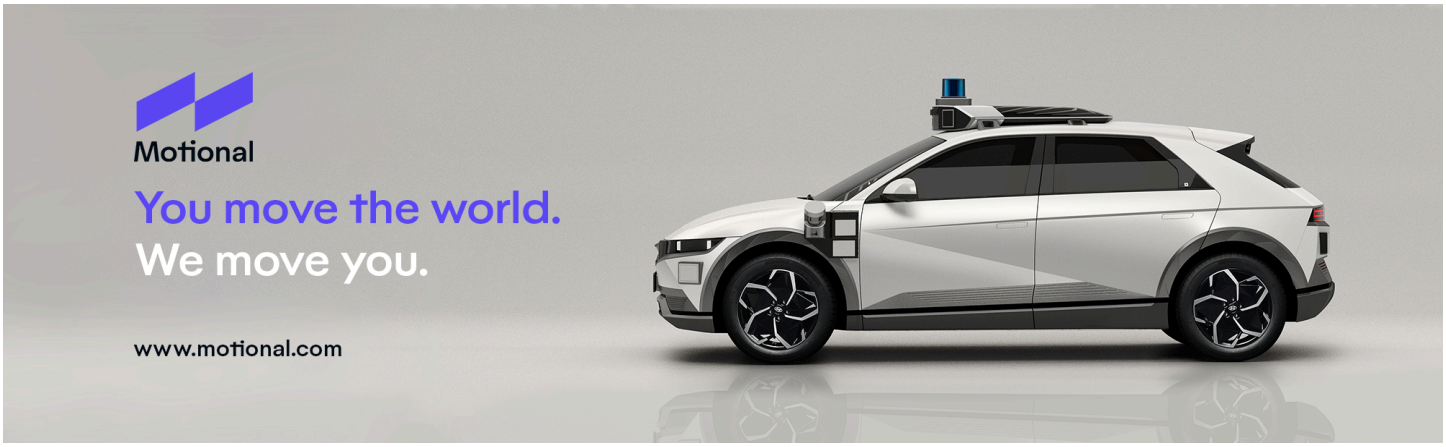

Bi-Annual Report for MassDOT & City of Boston

2nd Half 2023

Background

At Motional, we are committed to designing our technology for people: For families that need to get their children to school safely; for elderly passengers who need reliable access to transportation; 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 have 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-generation 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 our driverless technology package baked right into the design.

Boston has been an important part of our international R&D ecosystem for over ten years. In 2021, we expanded our Boston presence with a multimillion dollar investment to grow our Seaport operations facility at Black Falcon, and increased 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 our previous vehicles. This vehicle incorporates passenger experience features for ride hailing like a passenger display that shows ride information, remote control assist button to help passengers connect with a representative, and external displays and lights that help passengers identify their vehicle.

Operational Design Domain (ODD)

Our autonomous vehicles (AVs) are designed to operate in low-speed, urban environments in various conditions. We validate vehicle performance using simulation and bench tests and 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 normally occurs during traditional business hours (Monday through Friday, 9AM-5PM). This consists primarily of on-road data collection and autonomous driving in the Seaport.

Takeover procedure

Our 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 testing environment. 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 examples of typical takeovers 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 that situation 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 are supporting 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 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. Our Product team continues to receive feedback from a diverse set of research participants regarding the capabilities they would like to see while riding in an AV.

Insights

Imagine we're all part of a team driving a smart car, a car so advanced it can drive itself through the city streets without our help. This car, like a superhero, has special senses: cameras, radars, and a fancy tool called lidar, which help it see everything around the vehicle, from speeding cars to wandering pedestrians. But even superheroes have their puzzles. For instance, our AVs sometimes struggle to tell if a fast-approaching vehicle is a police car in a rush or just someone driving too fast.

This is where our team, with our clever brains and technology, steps in. We've come up with a super-smart solution called the Second-Stage Vision Network. Think of it as giving our AV a pair of glasses that help it see the world not just in shapes and sizes but with an understanding of what's happening around it. With these glasses, our AV can spot the special marks and flashing lights of a police car, and respectfully pull over.

Our AVs use various tools — cameras, different kinds of radars, and lidars — to get a clear picture of its surroundings. Each tool has its own superpower, like seeing far distances or in 3D, but they also have their weaknesses. For

example, lidar and radar don't see color, and cameras aren't great at judging distances.

As humans, we pick up on many cues when we drive, like a pedestrian's glance at a crosswalk, signaling they want to cross. Our AVs need to understand these subtle hints too, which isn't always easy with the basic tools it has. That's why our Second-Stage Vision Network is a game-changer. It adds a layer of understanding, allowing our AV to read the room (or the road, in this case) much better.

This advanced network works like magic in the background. It tracks everything around the car in real-time, spots important details, and even understands what a pedestrian planning to cross might look like. This is crucial for making our AV truly smart, helping it make better decisions, like when to stop for someone at a crosswalk or how to react to an emergency vehicle.

Training our AV to recognize these scenarios wasn't simple. We had to teach it to understand rare situations, like distinguishing between different types of emergency vehicles, which don't come around as often as regular cars or pedestrians. We improved its learning by showing it many examples, even those tricky situations that don't happen often, making our smart car even smarter and our roads safer.

So, thanks to the Second-Stage Vision Network, our team is not just making self-driving cars; we're teaching them to understand and react to the complex world around them, making sure they keep us safe and comfortable, no matter what comes their way.

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

Based on the latest findings from our fourth annual Consumer Mobility Report, which surveyed over 1,000 U.S. consumers, there is a compelling case for policymakers to enhance collaboration with AV companies like us. This collaboration is vital to address public concerns, bridge knowledge gaps, and harness AV technology's potential to meet diverse mobility needs effectively.

The report underscores the importance of demystifying AV technology for the public, highlighting a significant lack of understanding among Americans — 55% of respondents reported little to no knowledge of AVs, a figure that rises to nearly 70% among Baby Boomers. This gap in awareness and understanding presents a critical challenge, yet also an opportunity for educational initiatives and public engagement strategies to build trust and interest in AV technologies.

Safety remains the foremost concern, with 74% of respondents identifying it as a barrier to AV adoption. However, experiences with AV technology significantly mitigate these

concerns. Individuals who have used AVs express markedly less apprehension about safety, emphasizing the need for firsthand experience to foster acceptance.

Moreover, the report reveals a generational divide in attitudes toward AVs, with younger generations, particularly Gen Z and Millennials, being more open to adopting AV technology. This demographic is not only less concerned about safety but is also motivated by practical benefits such as cost savings from not having to tip ride-hail drivers. Their interest extends beyond personal transportation to autonomous delivery services, highlighting the versatile potential of AVs to transform everyday tasks.

Interestingly, despite existing deployments of AVs in several U.S. cities, a significant portion of local residents remain unaware of the availability of this technology. This disconnect points to a need for better communication and community engagement efforts to increase awareness and accessibility of AV services.

These insights underscore the importance of existing initiatives in many places, including Boston, MA:

- Implementing educational programs to increase public understanding of AV technology and its benefits.
- Supporting pilot projects and demonstrations that allow more people to experience AVs firsthand.
- Developing policies and frameworks that address safety concerns while encouraging innovation and adoption of AV technology.
- Enhancing public awareness campaigns to inform residents about the availability and advantages of AV services in their communities.

By embracing these recommendations, policymakers can play a pivotal role in accelerating the adoption of AV technology, thereby enhancing mobility, safety, and sustainability in our communities.