

# Hyundai-Aptiv AD LLC.

## Quarterly AV Testing Report

1<sup>st</sup> Quarter 2020

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## Background

We are 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 openness and collaboration are demonstrated, 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 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 around the globe 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 beginning of the year, a lot has changed, both in our office and around the world. Like everyone, we have been heavily focused on COVID-19. In early January, we banned all business travel and, weeks ahead of government orders, shut down our offices, and went entirely remote. Learning from the early cases in Singapore, we were able to adopt best practices and apply them throughout our business quickly. Since then, we have been in regular conversation with our public sector partners. When it is time to scale back up, we must ensure it is done in a way that is safe for our employees, our community, and in line with guidance from the government at all levels. Likewise, the future of transportation in cities will look different as a result of the pandemic and, we will continue to engage with our public sector colleagues on how our technology can play a role in it.

On a more positive note, in September 2019, we announced that Aptiv and Hyundai Motor Group would enter into a joint venture focused on autonomous mobility. We are happy to report that as of March 26th, 2020, the deal passed all regulatory approvals and is officially a new standalone entity. The team you are familiar with will continue tackling mobility's toughest challenges from our global headquarters in Boston, MA.

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## Testing Activity

Due to precautionary measures recommended by the city and state for COVID-19, we halted our public road autonomous testing in Massachusetts until further notice. However, earlier in the first quarter we were operating AVs in manual mode for data collection and mapping purposes throughout Seaport and South Boston.

We have continued to conduct limited, essential testing in our closed-course facility in the Boston area for testing and validating new features.

## Operational Design Domain (ODD)

Our vehicles are designed to operate in low-speed (<35 MPH), urban environments in a variety of 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 the 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 both in closed-course and public road environments.

## **Amount of Testing**

Testing is done during regular business hours (Monday through Friday, 9 AM-5 PM). As mentioned above, this testing includes both in closed-course and 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 when approaching situations that are not within the ODD.

During the First Quarter, our safety drivers took over manual control of our AV's 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 AV's were traveling;
- In certain situations in which construction vehicles were obstructing our lane of travel;
- In certain situations in which oncoming vehicles or bicycles violated lane boundaries;
- In certain situations in which weather conditions deteriorate rapidly; and,
- When other vehicles were exhibiting erratic behavior near our AV's.

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 situations in which the AV would have handled the situation without incident. We are continuously improving our AV software, and we are confident that our AVs will be able to handle each of these situations without a takeover after further development.

## **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**

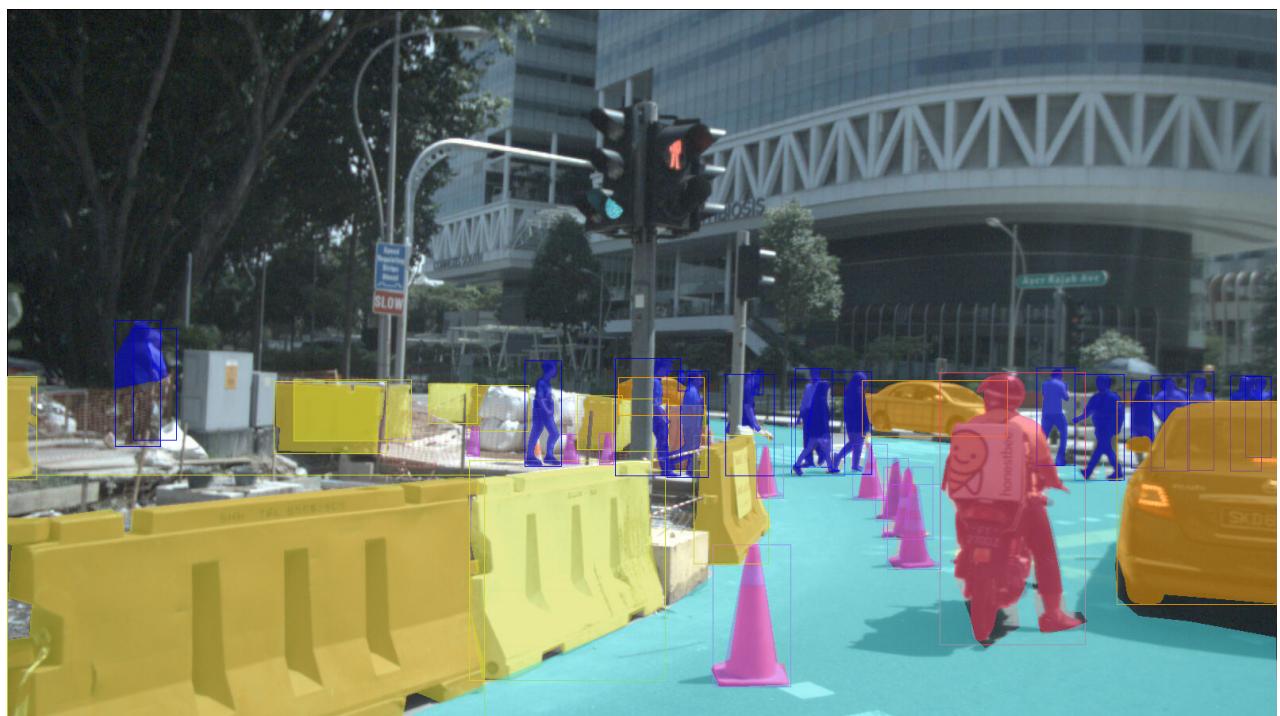
Our current development plan has us expanding the amount of higher speed testing (around 35 mph), in increasingly complex urban environments. On top of existing scenarios, we plan to layer in public testing during moderate rain, at night, or in low-light situations. These are all tests we have undertaken in the past, however, we plan to increase their proportion within our overall testing mix.

# Insights

In 2019, we released nuScenes, the industry's first large-scale open-source autonomous driving dataset, to enable the future of safe mobility through more robust industry research, data transparency, and public education of self-driving vehicles. Since it's public release, it has been cited in 152 scientific papers. During the first quarter of 2020, we announced our first significant update with nuScenes 2.0 that includes advances in lidar data and image sets.

The lidar update aims to achieve higher levels of granularity by capturing the fine shape details of articulated objects. We developed it in response to the continual advancement of self-driving technology and the need for vehicles to pick up on as much detailed information of the outside world as possible. For example, if a pedestrian or cyclist is using arm signals to communicate with other road users, our update can help inform self-driving technology of how to recognize this.

The image update was developed to serve as a sophisticated dataset that could help autonomous-driving technology successfully respond to edge cases or unfavorable driving conditions. To do this we deployed data-mining algorithms on a large volume of collected data to select interesting images containing both rare classes as well as a variety of environments including rain, snow, and nighttime. It now includes 100,000 images annotated with over 800,000 2D bounding boxes.



In light of state at home orders around the country, simulation has become increasingly important in advancing autonomous vehicle technology. Our update brings the type of data available to research and commercial developers even closer to the real-world scenarios that challenge all road users. By mastering these, the technology can deliver on its promise of increased safety for all road users.

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

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Dedicated pick-up and drop-off zones, for all ride-hailing (not specific to AVs), would make everyone's lives more accessible. It is common for drivers to improperly park in bike lanes, double park near other vehicles, or stop in the middle of the road while they wait for a rider to embark. This slows down roadway throughput, puts cyclists and pedestrians in danger, and it should go without saying, is against the law. Our vehicles are programmed to follow the law, so instead of breaking the law to follow convention, our cars would hunt for the nearest safe place to conduct a pick-up or drop-off. While this would inconvenience our riders, a better solution for everyone would be dedicated pick-up and drop-off zones. These ideally be mid-block and be repurposed from either existing street parking or shared with other temporary uses, such as commercial loading. Allocating 2-3 car lengths would allow for quick pull in or out without requiring parallel parking.