WeRide

The Voluntary Safety Self-Assessment for WeRide

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We Instill Safety into the Heart of Our Culture

WeRide was founded with the mission "To create a new mobility service that is accessible and beneficial to everyone." While our goal is to transform mobility with autonomous driving, we care deeply about the safety of our engineers, drivers as well as the entire transportation ecosystem. We instill safety into the heart of our culture.

At WeRide, safety is our top priority, with founding members of the company having set up our safety-first principle. This is a non-negotiable element of our company culture. Safety is built into the lifecycle of the product's research, development, deployment, and operation.

We have over 100 autonomous vehicles being tested on two continents on a daily basis. They all run the same software with slight configuration changes depending on local requirements. Our engineering vision is "one software, one platform, universal safety". The system must be able to accommodate different scenarios and driving policies.

In the early days of the company, we engaged with a professional services firm to conduct ISO26262, SOTIF and cyber-security training. All tech leads were required to participate in the training and acquire a certificate for the course. FMEA is widely adopted in the design document - when a new feature is introduced, engineers are required to provide a potential failure mode and effects analysis. A procedure must subsequently be put in place to minimize those risks. They are then subject to improvement and prevention during all future development.

We leverage the best elements of the high-tech and automobile industries: the fast-paced development cycle of tech industry and the rigorous design and testing process of automobile industry. This is achieved by establishing a common software protocol and a meticulously designed testing pipeline. Any new software is launched with a design document which is reviewed by a special committee. The entire pipeline includes sanity checks, unit tests, integration test, benchmark and regression test, bench test, structure test and private and public road test. Most software vulnerabilities and defects are captured by at least one of the testing components.

Engineers are encouraged to participate in road testing on a regular basis. They write trip reports and collect feedback from test passengers and drivers. Engineers gain critical insights from these testing trips, during which they fine tune the metrics which measure the safety and comfort offered by the system. Those metrics are monitored in real time on a company dashboard, and any abnormal changes will trigger an alert or even suspend the entire fleet.

GRIT Culture

Grow Together

Pursue continuous learning. Achieve fulfillment through personal development and career growth.

Results Driven

Deliver the very best in all we do. Be accountable for our results.

Innovation

Solve novel and challenging problems to revolutionize the mobility industry.

Teamwork

Leverage collective ingenuity. Be open and honest while supporting each other.

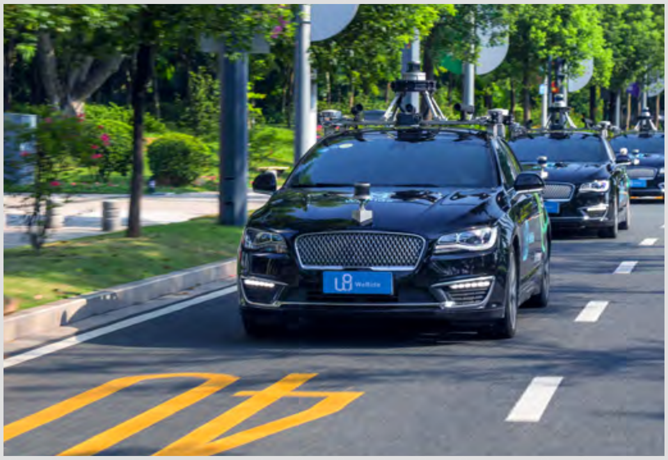
Introduction

Established in 2017, WeRide utilizes AI technology to develop safe and effective L4 autonomous driving technology. We have a highly skilled team of over 300 employees internationally, 70% of whom are Research & Development engineers. Our engineers are comprised of teams specializing in HD-Maps and Localization, Perception, Planning, Simulation, Data and Hardware. All of these components are geared towards the development of our L4 autonomous technology. With regular testing of our technology in Silicon Valley and China, we can quickly identify and resolve bugs to further progress our technology. We adhere to best practices when it comes to new software releases, and have a culture centered around safety. At WeRide, safety is our top priority.

Facility

WeRide adheres to the International Organization for Standardization ISO26262 guidelines. These guidelines are the international standard for functional safety of electronic systems in production vehicles. We use these guidelines as the foundation of our approach to safety in the development process of our self-driving platform. Regular safety seminars are conducted to ensure safety compliance within the entire facility. We highly value safety in the workplace and encourage employees to raise all safety concerns. There are also continual checks to ensure the workplace is up to Cal/OSHA standards.

Vehicles



WeRide integrates autonomous technology using latest generation of Lincoln MKZs and Nissan Leafs. These vehicles meet the guidelines set by the Federal Motor Vehicle Safety Standards (FMVSS) and the National Highway Traffic Safety Administration (NHTSA).

Our engineers modify the vehicles externally with hardware sensors and internally with computer components. Our hardware team carefully establishes the optimal position for accurate placement of sensors and computing equipments, all while emphasising safety, functionality and aesthetics. Our engineers take advantage of the car's native Drive-by-Wire system in order to control acceleration, braking, steering, shifting and vehicle body functions like light and door lock/unlock functions.

The Nissan Leaf is the latest generation of cars on our self-driving vehicle platform - it is a fully electric, zero-emission passenger car. The vehicle itself is a safe and smart car that supports several L2 ADAS functions, including AEB with Pedestrian Detection, Blind Spot Warning and Lane Departure Warning. The L2 ADAS functions also serve as a stand-alone collision avoidance system. In our self-driving system, we take advantage of these L2 ADAS functions as an extra safety layer aimed at preventing any further accident our system may encounter. During the DDT (Dynamic Driving Task), the L2 ADAS system will keep sending its real-time results to the self-driving system, which in turn can take direct action when necessary to save the self-driving car from collision.

Overview of WeRide LEAF2 Retrofit Process

The Drive-by-Wire system in the Nissan Leaf serves as an interface between the self-driving system and the vehicle. It provides a wide list of vehicle information, including basic information on the cluster, all sub-system statuses and warning information. The self-driving system then takes this information into consideration when deciding if the vehicle is safe to drive before a trip. During the trip, our system checks the vehicle's status thousands of times per second to make sure the vehicle's performance and response meet our safety model's requirements.

When it comes to the redundancy capability of the Nissan Leaf platform, it supports the following sub-system redundancies such as Brake, Steering and Power Supply. The braking and steering systems benefit from the redundant power supply and can conduct a safe stop even after the main power fails. To support the DDT under our ODD, we believe these sub-system redundancies are vital parts in forming a reliable DDT fallback to achieve Minimum Risk Conditions.

The Nissan Leaf platform has the following features to support first responders: The remote operators can communicate with first responders (further details in the "Communication" Chapter) and can remotely switch the vehicle into "Full Stop" status, which disables self-driving in the AD system. In the meantime, the remote operator has the capability to remotely unlock and roll down the windows (including the driver passenger seats), which makes communication between first responders and remote operator possible.

The Nissan Leaf design does not allow self-driving under the following situations: When an airbag is deployed, any door is open, or when the parking brake is applied. The first responder can easily open any door and apply the electronic parking brake to disable the self-driving system. Furthermore, there is a high voltage switch located in the center of rear passenger seats which can disconnect the high voltage battery from the vehicle, ensuring safety of operations. We have also installed an array of equipment to allow first responders' direct and easy access to the vehicle.

Hardware

In order to achieve autonomous driving, our vehicle needs a way to see obstacles. LiDARs, Radars, and Cameras act as the “eyes” of our vehicles.

Perception

"Eyes of the Vehicle"

Outstanding recognition outperforms human drivers

The sensors installed on the vehicles cover 360 degrees, leaving no blind zones. Human drivers on the other hand may overlook changes that may happen on their left, right, and rear sides. The compute unit (the "brain") of the vehicle can process all of this information and make decisions faster than human drivers, especially when the driver is tired or distacted. The compute unit can recognize all traffic signs and signals, even those unfamiliar to many human drivers.

Multi-sensor fusion at multi-levels to improve perception quality

Our perception receives raw signals from multiple sensors, such as LiDAR, Radar, Camera, Ultrasonic, etc. Each sensor is specialized in capturing the physical world under certain conditions. Fused together, they provide a very comprehensive 3D view of the world around the vehicle in all types of conditions. The perception signals are fused at different levels. The raw signals are combined and fed to the models at pre-fusion level; the intermediate representations of objects are concatenated and fed to classifiers at middle-fusion level; and the detection results are consolidated at post-fusion to boost quality of the end result.

Multiple perception paths to achieve redundancy

Although our sensors are fused at multiple levels, they are not strictly coupled. Instead, our system consists of multiple perception paths. Each path uses one sensor as the major signal and fuses with other sensors at multiple levels. The results from each perception path are then fused at the final stage. If any of the sensors is down, only the perception path that uses this sensor as major signal goes down. The perception system can still work for enough time until the vehicle either reaches its destination or executes a safe stop.

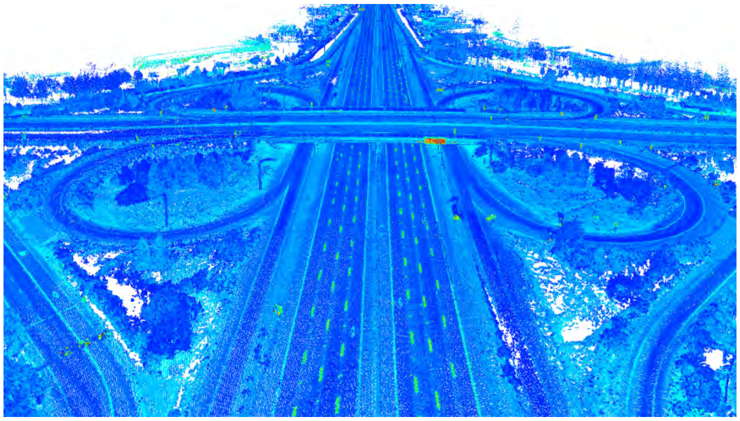
Powerful models and algorithms to recognize long tail objects

98% of driving conditions are not difficult for a perception system. The hardest part is the 2% long tail objects, e.g., potholes, small animals, water sprayed by a sprinkler truck, etc. We have developed powerful models and algorithms to accurately recognize road surface vs. regions occupied by known or unknown objects. This allows us to detect everything on the road surface, even objects we have not previously seen.

Mapping and Localization

HD-Maps comprise comprehensive information about the world that is pertinent to our autonomous vehicles. We have in-house technologies to build HD-Maps with centimeter-level precision, detailed and accurate 3D geometric structures, as well as rich semantics including lane, traffic control information, etc. We have built maps covering thousands of kilometers in our test areas.

For the safety of onboard usage of HD-Maps, we have established a complete HD-Maps production pipeline and quality assurance procedure. Our map quality assurance consists of both algorithmic assessment and human inspections to discover potential issues such as missing data, geometry inaccuracy and information discrepancy in order to ensure the completeness and precision of each map that is deployed onboard the vehicle.



We have built precise, real-time localization technologies powered by multiple sensors including LiDAR, Camera, GNSS and INS (Inertial Navigation System). These sensors complement each other and are fused together to achieve higher precision than what would have been attainable by any single module. The multi-sensor framework also creates sufficient redundancy, ensuring that the whole system is robust against the failures of each single sensor.

To ensure the accuracy and reliability of position information reported by the localization system, we have established a multi-step test procedure that includes simulation, open-loop and autonomous road tests. The tests are run before each HD-Map is released and localization software is upgraded.

Planning and Control

Planning for autonomous vehicles in urban environments enables self-driving cars to find the safest, most convenient, and most economically beneficial routes from point A to point B. As autonomous vehicles traverse the road, planning works as their "brain" by absorbing information from the sensors and digital maps, and generating a range of maneuvers and trajectory proposals.

Today, the major components of a planning system include mission, prediction, decision making and motion planning. Mission aims at providing the best route plan from origin to destination. Prediction meanwhile takes advantage of conventional and data-driven approaches to predict both short and long-term intent as well as trajectory of static and dynamic objects around autonomous vehicles.

Given routes provided by the route planner (mission), along with predictions of other obstacles, decision making is capable of deciding the best and safest high-level maneuvers for autonomous cars, e.g, making lane change at the end of merge ramp, or yielding to pedestrians before a crosswalk, without overlooking the autonomous car's intersections with the surrounding traffic environment.

By accommodating the high-level maneuver proposal given by decision making, motion planning focuses on finding the best path for the vehicle to follow while taking into account the constraints of the vehicle's motion model, waypoints that the vehicle should follow and the traffic environment, including static and dynamic obstacles.

Control then performs as the "hand and foot" of an autonomous car to control the vehicle's acceleration, braking and steering in order to follow a target trajectory as closely but also as smoothly as possible in order to avoid motion sickness or frequent braking. This is often referred to as the "comfort factor".

Software Release Evaluation

Before adding new software to the vehicle, it must be evaluated to make sure there aren't any major issues. We have deployed a Release Manager system which can help automate the release procedure and reduce manual steps. With the help of the Release Manager, we can minimize potential human errors and enforce every testing step that a release should go through.

Among the many testing methods, the critical ones include code analysis, simulation, SIL (software-in-the-loop) tests and HIL (hardware-in-the-loop) tests.

We have built and deployed multiple tools to analyze the entire code base, such as unit test coverage and sanitizers (which can locate malfunctioned code). These analysis reports can help engineers reactively improve code quality. Simulation is a very critical foundation tool at WeRide, and we have invested heavily in this area. SIL/HIL tests address integration problems, latency and performance. SIL runs everything that operates onboard, even small script that clears up stale data. HIL extends SIL to the next level, integrating hardware such as sensors. Put together, SIL/HIL can intercept many potential problems before our code hits the road.

Simulation

At WeRide, we are very serious about safety and consider simulation to be a crucial system in improving safety.

We re-evaluate every human intervention during road test simulations and identify the scenarios which will result in risky situations. By leveraging this feedback loop mechanism, engineers can improve our algorithms to handle these failures in a fast, iterative manner.

Our scenario dataset increases as we collect data from road tests. Interesting data are hand-picked or automatically selected by algorithms and converted to scenarios.

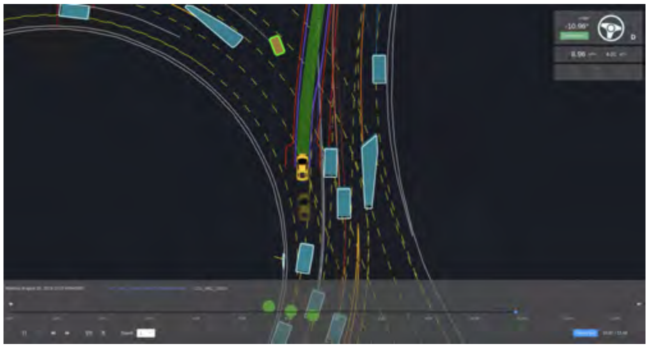
We call these scenarios base scenarios, because we will apply fuzzy algorithms to generate many more variations from them. We also rely on synthetic scenarios which are tailored to test specific tricky problems, and large-scale human driving data which can be the ground truth that our AV algorithms can learn from.

With regards to the tech stack, our simulations support a module based or full stack. A module-based simulation (e.g. simulation for planning) is relatively low cost and fast to run. A full stack simulation can involve as many onboard modules as possible.

▲ **A based scenario can be fuzzed for many more variations**

For example, we can set up a simulation to test the hand-over logic between main unit and redundant unit, which ensures the safety-critical logic works as expected.

At WeRide, we have developed a complete simulation software suite to help engineers make use of simulation easily.



First, CEP (Continuous Evaluation Platform) is a high performing distributed system that runs large scale simulation tasks. This system supports many types of workflow, like simulation, SIL tests and model benchmarking. CEP has a dedicated web UI where every engineer can easily submit a ticket to run their tests.

Second, SaaS (Simulation as a Service) is the simulation core engine which can be run on the cloud or locally in an engineer's workstation. It supports many advanced features, including determinism, perfect replay, fuzzy logic, real-time command via keyboard or joystick, batch simulation for efficiency, etc.

Third, WeRide IDE is a one-stop shop software platform which provides handy features like data visualization, issue triage UI, a simulation scenario editor and simulation control UI.

Infrastructure

The onboard monitoring system continuously oversees the health status of the entire onboard system, including the sensors, vehicle and software. When there is any type of abnormal state found onboard, the monitor will send a signal to both the remote operator (via a secured and redundant connection) and the onboard error handling logic. Onboard error handling logic will perform a safe stop when necessary. This monitoring system is redundant and each one will monitor the health status of its peers.

Our system also has remote operation capability. The vehicle's status will be reported to the operation center in real-time via a secured and redundant connection. The remote operator can also trigger remote hint, and the passenger can call for help and communicate with law enforcement via this remote operator system.

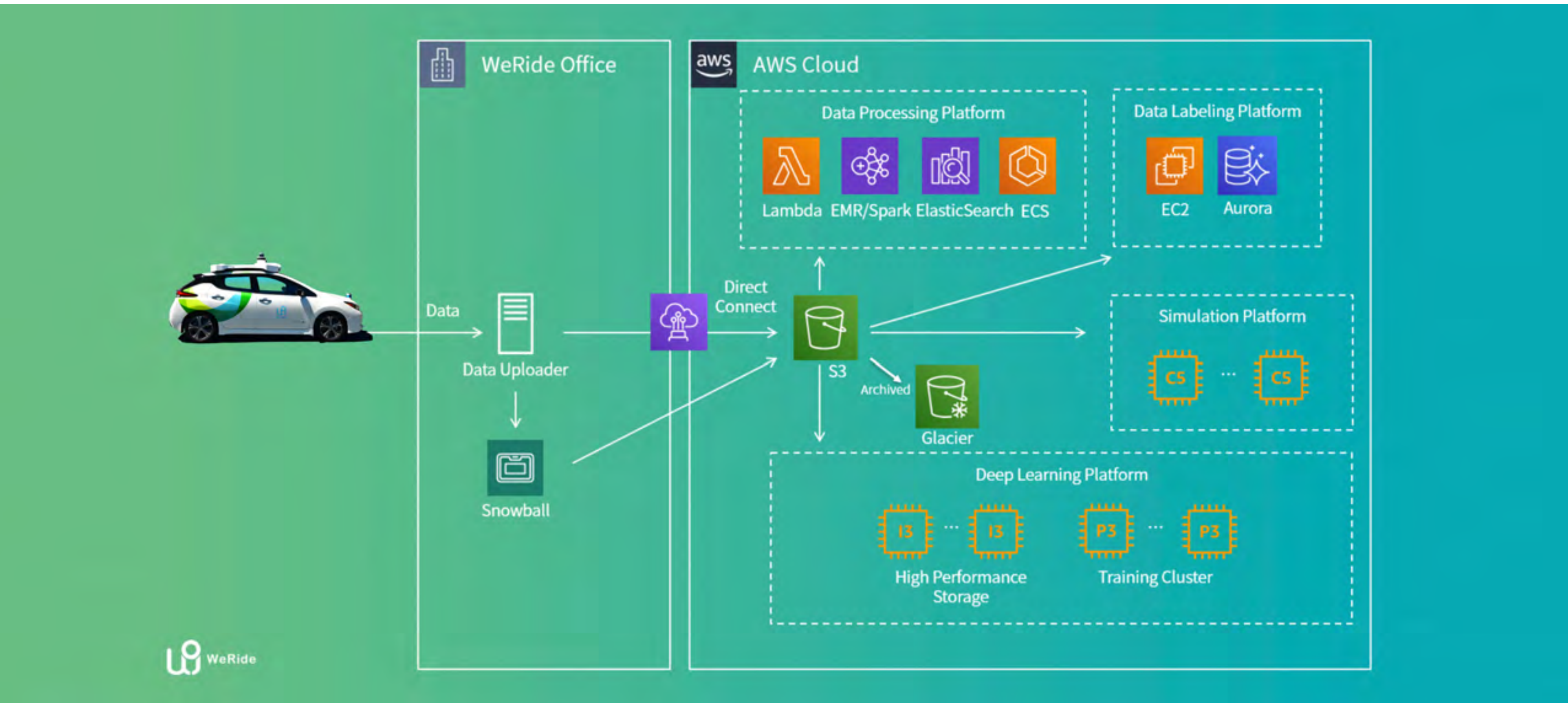
▲ **A call for help button is located at the bottom right corner of the passenger visualizer**

Data

Data is continuously collected to improve the performance of our autonomous vehicles. The data that is collected from the cars come from a variety of hardware sensors and software, and are collected whenever the car operates autonomously. Data can also be collected during manual driving as required. Our data auto-collector system is deployed on the vehicle to help with data collection. Our engineers can set what kind of data is to be collected during the test, and how long it should last. This system is integrated into our onboard computer and is optimized to improve the user experience. Once our data is collected and stored to our SSD devices, we also have an uploader system to distribute the data. This system can pre-process the data, compress and upload it to different spaces, such as our AWS cloud location or our data center which will be based on our pre-configuration. At the same time, the uploader provides a dashboard to show the progress and status of the uploading tasks.

Out of the large amount data that we collect daily, our system chooses specific data to do the labeling tasks. We have an automatic data labeling pipeline at WeRide and have built our own experienced and scalable data labeling team. Our labeling pipeline can extract the required information from the data, distribute the labeling tasks to our labelers, send back any low-quality jobs for review and finally output the labeling results. We have also developed more than ten customized labeling tools to optimize the annotation, including LiDAR obstacle labeling, image obstacle labeling, image segmentation, image curb labeling, etc. Our system can manage all the labeling tasks, like scheduling of the labelers and the entire pipeline in an optimized fashion.

At WeRide, we have built a large, scalable GPU and CPU processing platform to process the massive amounts of data we hold. This system will automatically manage computing resources and distribute tasks. Engineers who want to train models or process large amounts of data can easily begin a task using our GUI. Their tasks will then be automatically queued to run when the required resources are ready. We also have monitoring and alerting functions to keep an eye on resource usage and warn of any unexpected high-resource tasks.



▲ **WeRide Data Architecture**

Operations

Our vehicles are regularly tested to improve performance by locating bugs in the system. Software is carefully curated to ensure safe and effective testing.

Our vehicle operators follow strict safety guidelines and are trained to be able to handle a variety of situations. Every day before testing, safety inspections are conducted to ensure the vehicles are in proper operational condition. If any issues are found, they are immediately addressed, and the vehicle cannot be tested until the issues are resolved. The operators set up the vehicle's onboard system to prepare it for autonomous driving and the car will not be able to function in an autonomous state unless all required vehicle, system, hardware, and software components are up and running.

There are at minimum of two operators in the vehicle while new software is being tested. One operator sits behind the steering wheel and is responsible for taking control from the autonomous system whenever necessary. The driver can take over by manually turning the steering wheel, pressing the brakes, or the accelerator. There is also a redundant method to take control of the vehicle by pressing the "kill" switch. This "kill" switch immediately cuts communication between the software and the Drive-by-Wire system so that the driver can have immediate control. Safety drivers are instructed to only use this method of taking over as a last resort, after the other three methods have failed to work. The other operator acts as a second pair of eyes on the road to assist the driver. They also record valuable feedback evaluating the vehicle's performance.

Data are recorded during testing and uploaded after its conclusion. Inccidents will be triaged and evaluated to find their root cause.

Communications

In order to monitor the location of an autonomous vehicle, a large screen next to the Remote Monitoring and Control Station (RMCS) displays a real-time bird's eye view of the autonomous vehicle's location superimposed on a map of the testing zone. Through this interface, the operation team can see the vehicle's current location information (e.g. street name) and metadata associated with the vehicle (e.g. speed). The engineer sitting in the back seat of the autonomous vehicle also performs monitoring duties by providing additional details regarding the vehicle itself or the surrounding environment.

Note: In this phase of testing, we will always have a safety driver inside the vehicle's backseat.

Latency: Latency is another critical value that also has to be monitored. The co-operator is also responsible for monitoring and answering calls from the communications channels (video tele-conference or phone calls with the passengers).

Data Links: Monitoring, communication, and control run over multiple 4G data links from at least two different service providers. This provides a measure of redundancy and robustness. Bandwidth-intensive services have their own dedicated 4G links in order to ensure all functions have adequate bandwidth.

One 4G data link services low bandwidth tasks, such as obtaining GPS data and transmitting the location of the vehicle, along with other textual metadata. Control commands (steering, brake, throttle, turn signals, gear shifter, rear flashing lights) are also sent over this data link because the commands are not bandwidth intensive. The cameras that stream real-time video to the RMCS each have their own 4G link. The video tele-conference with the remote operator has its own dedicated 4G data link to ensure adequate bandwidth.

Data Link Signal Latency: Since communications, monitoring, and control all rely on transmitting and receiving data in a timely fashion, data link signal latency is a key metric that directly impacts safety and testing operations.

Before deciding on the proposed zone of operation, the RMCS engineering team surveys the latency at different times during the day for different candidate zones. After analyzing the results, the engineering team chooses the zone with the best overall signal latency during business hours (the most likely time that the autonomous vehicle will be on public roads).

More importantly, while the autonomous vehicle is being operated in driverless mode, the co-operator will monitor latency at all times by visual and audible means. A real-time video latency value is displayed on the screen. Additionally, the RMCS continuously measures the latency between itself and the autonomous vehicle. When one-way latency exceeds a safe threshold, the RMCS will repeatedly emit an audible beep that reminds the remote operator to take caution when initiating vehicle control.

If the vehicle is operating under driverless mode and the video or RMCS latency remains at an elevated level that is unsafe for remote operation under busy or complex traffic conditions, the remote operator or the engineer will command the vehicle to a safe stop.

Community

We believe autonomous driving technology will dramatically transform the transportation industry into being much more safe, efficient, cost-effective and enjoyable for all. To help the public become more familiar with this advanced technology, we invited early adopters, reporters, and even skeptics to experience our self-driving vehicles firsthand. It was the first time being in an autonomous vehicle for many of them, and also gave them the opportunity to have great conversations with our team.

Ultimately, with safety principles underlying everything we do as a company, we are committed to bringing autonomous driving technology to the general population and serve our community's needs for safer and lower cost transportation.

▲ **WeRide Open Day**

▲ **WeRide US office donated masks to Valley Medical Center Foundation in San Jose to support the local community in April, 2020.**