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State of ADAS, Automation, and Connectivity

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Introduction

The vehicles are currently in a new stage of development, including advanced driver assistance, connectivity and automation. The timing and path of implementation of this technology remains uncertain due to continued technology development and changing consumer preferences. Although this new technology is still evolving, understanding the current automotive landscape helps to understand what the future holds.

The Center for Automotive Research is dedicated to keeping the public informed about the current state of automotive technology. In 2017, 2019 and 2020, CAR released roadmaps outlining the current and likely future state of automotive technology. To ensure that the information contained in CAR's forecasts remains current and reflects the latest automotive technologies, trends and expectations, CAR conducts ongoing research and hosts industry roundtables. Industry roundtable experts include automakers, component vendors, technology vendors, data vendors, autonomous platform vendors and technology investors. Following the roundtable, the CAR developed an updated roadmap and white paper reflecting industry trends and expectations. This article summarizes key issues in the development and deployment of advanced driver assistance systems (ADAS), autonomous vehicles (AV), and vehicle connectivity technologies.

Advanced driver assistance systems (ADAS)

Advanced Driver Assistance Systems (ADAS) have the potential to reduce accidents and traffic inefficiencies by eliminating human error and providing real-time data on traffic conditions. Technologies included in ADAS include automatic emergency braking, adaptive cruise control, lane-keep assist, automatic parking, and various automatic emergency braking systems.

There is little debate about the potential benefits of ADAS. Eliminating human error and simplifying driving makes ADAS an attractive vision for future automotive technology. ADAS is still in the development phase, however, and a number of high-profile crashes – some fatal – have raised concerns about the safety of the technology.

There is a general lack of data and information to draw solid conclusions about the nature and causes of these crashes, but negative press has dampened enthusiasm for the technology.

Over the past two decades, ADAS technology has exploded in popularity through four distinct waves: assistance features, warning features, driver assistance features, and autonomous driving features.

1. Assistance is a technology that improves the driver's vision thanks to cameras and lights. Accessibility features became popular in the early 2000s and have since become commonplace.

2. Warning features include warning systems that use sensors and sound to warn drivers of hazards. These features are again attracting attention as they help shape driver monitoring.

3. Driver assistance features are technologies that help control the vehicle depending on the situation. These technologies have been around for decades, but advanced significantly in the late 1990s. Since then, new features have been continuously introduced to provide a high level of driving assistance. It can serve as a gateway to autonomous driving functions.

4. Autopilot function as a more advanced driver assistance function, taking responsibility and helping to drive the vehicle in specific situations.

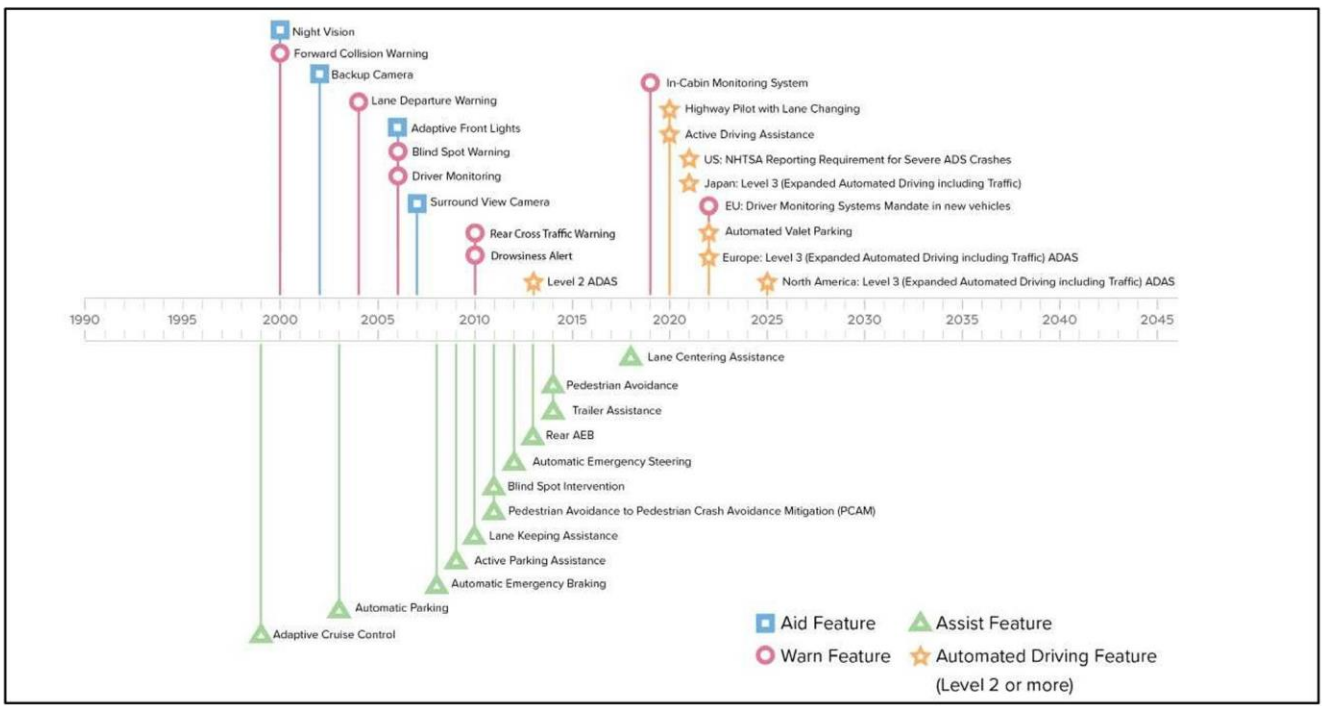

Figure 1: Driver Assist Technology Evolution

Crash Reduction and Safety

ADAS and automation technologies are touted as the solution to accidents and road safety, as their advanced technology eliminates human error. The National Highway Traffic Safety Administration (NHTSA) reports that "94% of serious crashes are caused by human error", supporting the intrinsic promise of autonomous and assisted driving (NHTSA, 2016). Statistics like these are critical to advancing the vision of fully rolling out automated and driverless vehicles.

However, the statistics provided by NHTSA that are critical to the adoption of ADAS are in some ways oversimplified (Mueller et al., 2020). Problems that can arise from ADAS include technical failures, hacking, overreliance on the technology beyond its intended use (human error), unreliable platoon technology leading to more serious accidents, failure to alert vulnerable road users of their trajectories and investments. The level drops in ADAS technology.

Despite these potential technical shortcomings, recent research predicts that ADAS technology could reduce accidents by up to 34%. Some studies suggest that this percentage could be even higher if technology can eliminate traffic violations (Mueller, 2020). Reducing accidents by just 10% could reduce the number of road deaths by the thousands.

A trend that merits further investigation is the potential for ADAS to increase travel demand even with a commensurate reduction in accident rates while increasing the total number of accidents due to increased fleet demand.

Regulation

While Congress has yet to act on automotive ADAS technology, NHTSA, whose regulatory framework focuses primarily on driver-centric safety standards, has begun revising its standards and issuing blanket orders to regulate ADAS. Their approach is to reassess the usual Federal Motor Vehicle Safety Standard (FMVSS) regulations that do not apply to ADAS technology.

As part of ADAS safety standards, NHTSA attempts to use the New Car

Assessment Program (NCAP) to assess the ADAS capabilities of a given vehicle (NHTSA, 2020). As ADAS technology is not fully compliant with the FMVSS compliance framework, they have issued a limited number of exemptions allowing each applicant company to operate up to 2,500 ADAS vehicles per year (NHTSA, 2022).

NHTSA issued a final rule in early 2022, "Driver Protections for Vehicles with Automated Driving Systems," which adjusted portions of FMVSS to account for ADAS-equipped vehicles (NHTSA, 2022).

In addition, the National Highway Traffic Safety Administration (NHTSA) has issued a general standing order requiring businesses to "at any time within 30 seconds of an accident involving vulnerable road users or until a fatality results "In cases where ADAS Level 2 technology is used, a crash is reported when the vehicle is towed, airbags are deployed, or anyone is taken to hospital for treatment" (NHTSA, 2021). Metrics and NCAP for ADAS ratings that are missing in the current FMVSS.

ADAS Naming Conventions

There are currently no federally mandated standards to ensure consistent use of terminology when referring to ADAS features such as adaptive cruise control, highway navigation, and automated parking. ADAS technology has been heavily promoted and described in different ways by companies that have developed it and integrated it into their vehicles (Williams, 2022).

In the absence of commonly accepted terminology, companies may advertise their ADAS features and technologies using terms that may not accurately describe the scope of their vehicle technologies and may not be understood by consumers. consumers. For example, Tesla calls its ADAS "Full Self-Driving," but it only lands on the second of SAE's five levels of automation. This lack of consensus has led to some misunderstanding and false expectations among consumers about the technology's true capabilities.

AAA is leading a working group to standardize ADAS functions and technologies to clear up confusion surrounding ADAS technologies (AAA, 2022). The working group seeks to provide an industry-wide definition of the ADAS technology suite to improve terminology understanding and portability. Although there is no consensus on the importance of adopting a standardized nomenclature, the general opinion is that standardization will be a key factor in the advancement and understanding of ADAS technology. Standardization will also be an important factor in driver training and the transferability of technical knowledge.

Business Case and Consumer Acceptance

The business case for ADAS is currently unclear due to low consumption levels. Pricing models are difficult to establish as many consumers remain sceptical and unwilling to pay for the technology (Stigler et al., 2022). A better understanding of the number of consumers who disable ADAS features in their vehicles is needed to properly model the business case for the expensive subscription model.

As the effectiveness of these technologies generally increases, adoption is expected to increase (Heineken et al., 2022). The industry believes that as these technologies gain access to more information and data, their capabilities will increase dramatically. In turn, the business case for situations such as long-distance driving and consumers seeking relief from difficult journeys will improve. However, standardization, lower prices, and technological improvements may be necessary for ADAS to overcome consumer uncertainty.

Consumer: Adoption and Risk Tolerance

Consumer scepticism of AVs is high. Industry needs to address safety issues before consumers see this as a viable solution (Stigler et al., 2022). Although the accident rate may not be higher than with conventional vehicles, it has remained high for years as publicity about accidents and misuse of technology fuels consumer distrust at towards self-driving cars. Consumers need to know and trust that AVs are safe before meaningful adoption can occur.

However, it is unrealistic to assume that AVs are 100% fool proof and safe, so ultimately consumers will have to accept some risk and understand the limitations of their vehicles (Littman, 2022). At this point, it is unclear what level of safety is required until consumers and regulators are satisfied that the risks associated with AVs are reasonable and acceptable (e.g., 10% fewer accidents? 10% fewer accidents per mile driven) 1,000 times?).

Scaling Toward Automation: Testing vs Pilots vs Launches

Progress in AV deployment typically occurs through a process of scale-down, sometimes measured against full automation (although there are business cases for lower levels of automation). Assessing progress and comparing forecasts is difficult due to the diversity of approaches and scaling goals. For example, a company may have test operations, pilot operations, and business operations, and each operation may have some degree of automation in selected SDGs, but they may be of different sizes. Pilot scale is different from Level 4 commercial availability, which is different from Level 4 market penetration. These three brands may be years apart, as they clearly represent different milestones. The

Class 4 restrictive optical drive has been tested, piloted, and released. These business models range from freight transportation to food delivery services to last mile delivery. Advancing the business case for a similar environment will yield more immediate returns than scaling to Level 5 in an unconstrained SDG that is particularly distant in time.

Other business cases have recently been piloted, including truck automation and small robotic deliveries in specific SDGs. These business cases have the potential to work in operations centres with human oversight (which can blur the lines between Layer 3 and Layer 4). However, such use cases have greater potential for immediate commercial viability than higher levels of automation with an unconstrained ODD.

Infrastructure

The potential of self-driving cars is greatest when traveling alongside other fully autonomous networked vehicles on smart highways. However, more realistic adoption models suggest that in the short term, autonomous vehicles should operate within existing infrastructure and share roads with conventional vehicles.

While intelligent infrastructure will help AVs operate more efficiently, some levels of technology do not require advanced infrastructure to operate effectively (Littman, 2022). Through short-term upgrades, the limitations of the existing infrastructure can be overcome to provide an effective AV technology platform.

Complementary sensor technologies can provide more immediate benefits than the development of new technologies based on connectivity or smart infrastructure.

While AV does not require large investments in smart infrastructure, many forms of AV technology would benefit from minor infrastructure upgrades to improve lane visibility and standardize marking and maps (Canis, 2021). For example, reducing non-standard and unclear road markings and the irregular variability of construction zones can increase the effectiveness of audio-visual technology.

Truck lanes and platoons are other examples of infrastructure upgrades that yield benefits without developing smart highway technology.

In addition, the space currently used for parking can be converted into a drop-off area for autonomous carpooling vehicles.

The balance between AV development and infrastructure improvement requires planning and collaboration between government and private stakeholders.

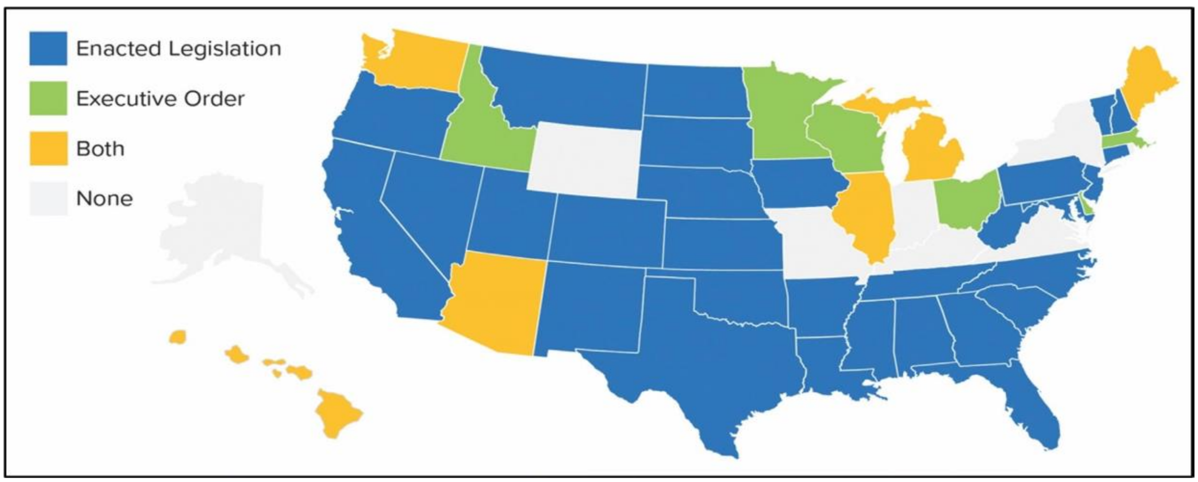

Figure 6: State AV Legislative A

Policy and Regulation

Since the federal government has delegated regulation to the states, regulation of autonomous vehicles will occur primarily at the local level (Canis, 2021). However, NHTSA has used its guidance documents to facilitate state regulation and will continue to work with states to support new regulations (NHTSA, 2020). The 4,444 self-driving cars are mostly deployed at the municipal level, requiring local coordination between businesses and local communities. It is up to local communities to decide how to fairly implement this emerging technology. There are already examples of audio-visual companies working with municipalities to enable their services to complement public transport (Cousin, 2021).

A number of regulatory initiatives will eventually lead to the implementation of AV, possibly in the form of vehicle mileage taxes, driver monitoring mandates, or collision and traffic decision-making policies.

Several organizations are helping NHTSA develop standards to support automation guidelines. For example, the NHTSA relies on the SAE Automation Levels to define the ADAS technologies used in regulatory documents and uses these levels to describe the state of the industry in its guidance documents (NHTSA, 2022). In addition, NHTSA uses the International Organization for Standardization (ISO) and Underwriters Laboratories (UL) to evaluate current industry standards as a basis for rulemaking.

Liability

Tier 4, and perhaps some Tier 3, AV technologies can shift responsibility and accountability from the owner or driver to the vehicle manufacturer. On the other hand, responsibility for ADAS technology (often limited to technology that assists the driver) may still rest with the owner or driver of the vehicle. In the UK, highly automated vehicles and their manufacturers are held accountable, creating problems for manufacturers when deploying vehicles (Ballan, 2022).

To avoid liability, companies may continue to deploy Tier 2 or Tier 2+ technology for their private vehicles. Currently, there is ambiguity in the distribution of responsibilities between consumers or providers when the technology is between Tiers 2 and 4. At this point, standards should hold consumers accountable for Tier 2 vehicles, suppliers for Tier 4 vehicles, and Tier 3 is difficult to assess.

Insurers struggle to gather the data needed to accurately assess liability, and there is currently not enough policy guidance or legal precedent to predict likely outcomes. Some businesses choose to self-insure, making the insurance and liability path to a self-sustaining future less clear (Hall, 2022).

Technology: Hardware and Software

There is currently no consensus on the technologies needed to best support audio-visual development. AEB, LiDAR, sensors, cameras, ultrasound, mapping, positioning, computing platforms, deep learning, and IMUs are examples of technologies used in AV today.

In order to reduce costs, Tesla is already developing a road without lidar. Other companies are moving away from deep learning due to the difficulty of decompressing training data, i.e., standardizing the underlying parts and learning methods (Dickson, 2021). Additionally, if deep learning or hardware is not transparent about how it is implemented, it can be difficult to determine the root cause of failures.

NHTSA's Crash Investigation Strategy attempts to assess these technical and software crashes, but is unlikely to paint a complete picture.

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Maintenance

The maintenance cost of AV vehicles is significantly higher than that of conventional vehicles, as the hardware and associated software require additional maintenance and regular updates (Heineken et al., 2022).

AVs may have higher accident or repair costs than conventional vehicles, which may affect insurance costs. Additionally, uncertainty about the lifespan of certain technological suites in autonomous vehicles complicates long-term vehicle cost projections. For example, a sensor may have a shorter lifespan than other parts of the vehicle, but a private car owner may decide not to service the vehicle if the repair costs are too high. Fleets must also consider these additional maintenance costs over time (Littman, 2022).

Unlike passenger car owners, fleets also have to bear the cost of cleaning their vehicles. Ride-sharing services with AV fleets no longer depend on drivers to be responsible for clean, functioning vehicles, which means they have to factor in additional costs that traditional ride-sharing services like Uber and Lyft don't. into account.

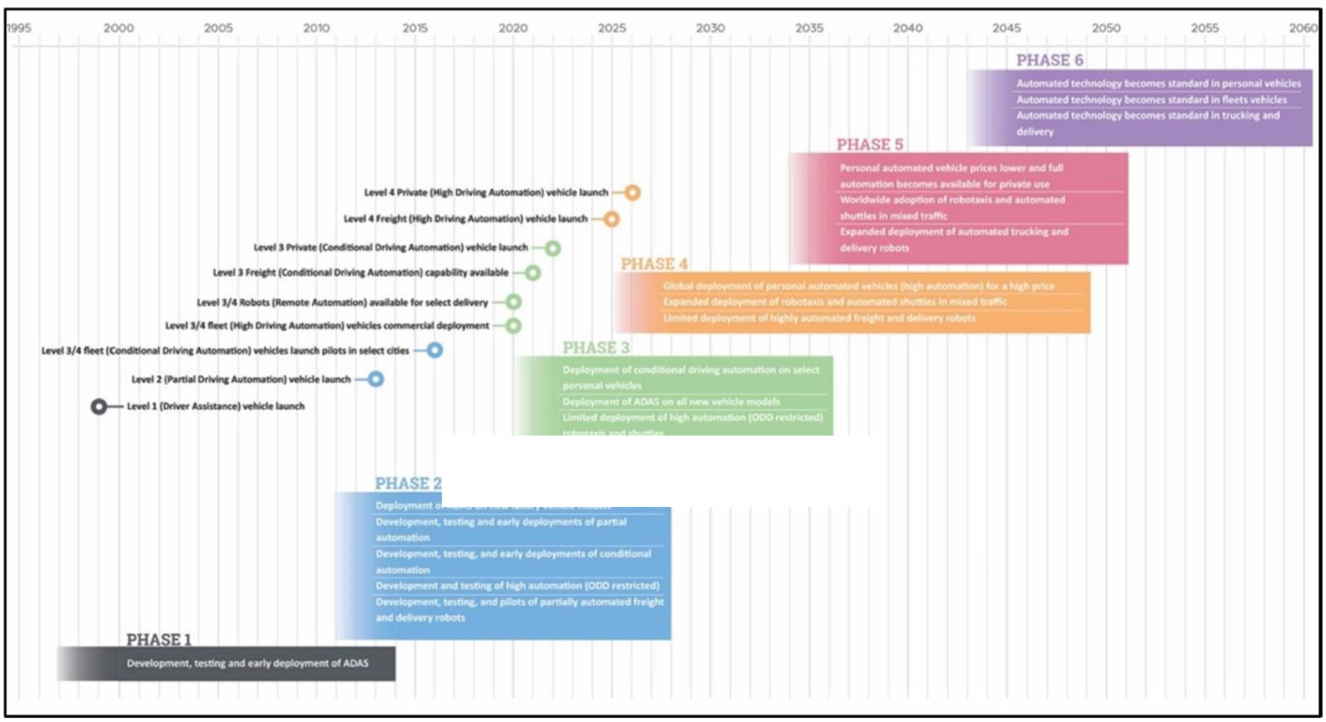

Figure 7: Approximate Deployment Projections

Business Case for Connectivity and the Cost Elements from OEMs

Initially, the value proposition of connected vehicles and V2X was security and subsequent optimization of connected fleets. Since then, the value proposition has shifted from safety – the effort to rely on connectivity for all safety decisions – to manufacturers recognizing the value of vehicle data (Hall, 2022).

While safety is not the only business case, OEMs have realized the value of data and the need to collect it to effectively assess vehicle functionality through cloud computing. Even without C-V2X and DSRC, data on driving habits can still be collected using cloud-based connected vehicle technology. Cloud-based technologies may present lower cost barriers and regulatory uncertainty than C-V2X and DSRC, but manufacturers still need to manage multiple cost elements to ensure adequate network speeds across all sites.

Manufacturers must also determine the cost elements of distributing their technology. In those cases, automakers could opt to run their own 5G networks, which could be the least expensive solution, industry experts told the roundtable.

Business Case for Connectivity in Automation

Connectivity can enhance autonomous vehicles in specific applications, such as platoon and fleet operations (Brown et al., 2021). These applications can provide increased security in some cases, even if the connection is deployed independently of automation and vice versa. Specific ecosystems, such as fleets, can make an important contribution to improving security through connected applications and deployment experiences. As the market evolves, some ecosystems will be more beneficial than others, and adoption will be driven by the best business cases.

Currently, cloud-based connectivity is the basis for AV data evaluation. Data could be a significant cost barrier due to the insurance implications that currently prevent AV companies from allowing vehicle-to-vehicle communications. Data breaches would also increase AV vehicle insurance costs, prompting 4,444 companies to limit connections to inner loops and limit performance reviews to the current case (Dyson & Ross, 2022).

As federal standards and communications technologies evolve, the business case for vehicle communications will become more cost effective. The communications business case will enable bunching, fleet operations, accident reduction and congestion relief, but cloud-based connectivity will be the currently dominant vehicle communications platform.

Conclusion

The landscape for this vehicle technology has changed in recent years as ADAS, automation and connectivity mature. Barriers to widespread adoption of ADAS include lack of standardization, high prices, and consumer uncertainty. Overcoming these barriers to ADAS adoption will likely be achieved by educating consumers on how to use the technology, with prices becoming more accessible and the benefits of the technology becoming apparent. AVs face challenges in achieving broad market penetration, but as the past few years have progressed, the obstacles are easier to identify. VA implementation is currently incremental and targeted at specific SDGs, making their short-term effects more predictable. If Fleet AVs are successful in their limited SDG, deployments could expand to new areas. However, as development stalls, regulators and investors have tempered expectations that high levels of automation are imminent, allowing industry progress ahead of further changes in policy strategy or investment in AVs. Vehicle connectivity is also facing changes due to regulatory and technological uncertainty. Adoption of advanced V2X technologies such as C-V2X and DSRC is limited due to data issues, lack of infrastructure, and regulatory irregularities. Despite the stagnation of this advanced V2X technology, the automotive industry has quickly adapted to regulatory uncertainty and the short-term business case to deliver connectivity through applications such as cloud-based connectivity. The reason for persisting in finding ways to implement connected car technologies lies in their benefits, such as vehicle performance evaluation, security, and data monetization. Over time, advanced V2X technologies may replace cloud-based technologies, but cloud-based technologies provide a modern business case. While the development of ADAS, automation and connectivity is much more complex than expected many years ago, today's use cases apply to everyone, although some are limited. Developments leading to the widespread use of ADAS, high-performance Level 4 AV fleets, and the adoption of C-V2X remain uncertain, but the obstacles to achieving these goals are now clear.

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