Aptiv's Gen 6 ADAS Platform for Software-Defined Vehicles

Advanced driver-assistance systems are not simply a line item to be added to a vehicle window sticker, a checkbox on a list of options. ADAS is a strategy, a vision. It is a path to a better future, a safer future – for everyone.

Achieving this vision requires the proper infrastructure to support it every step along the way, from the sensors and compute hardware that perceive the environment around a vehicle to the software and intelligence that make sense of the signals and decide on actions to take.

Just as importantly, an ADAS platform has to adapt as the technology evolves at both an industry and OEM level, from basic safety compliance functions to advanced levels of automation. It has to be designed today for the electrical and electronic architectures of tomorrow, such as in Aptiv's Smart Vehicle Architecture™. And it has to be flexible, truly open to innovation, recognizing that innovation can come from anyone in an ecosystem – and that some of the most useful features to come are the ones that have not yet been developed.

*Updated June 2024

A COMMON GOAL

In the automotive industry, we share a common goal: a world with zero traffic accidents and zero traffic fatalities. It is an ambitious goal, and it will take close collaboration across the entire industry to make it a reality.

According to the World Health Organization, the lives of about 1.3 million people are cut short as a result of road traffic accidents every year. More than half of those deaths involve vulnerable road users: pedestrians, cyclists and motorcyclists. Another 20 million to 50 million others suffer non-fatal but nonetheless life-changing injuries. And road traffic crashes cost most countries an estimated 3 percent of their gross domestic product.

However, the good news is that most accidents are preventable. According to NHTSA, 94 percent of accidents involve human error.

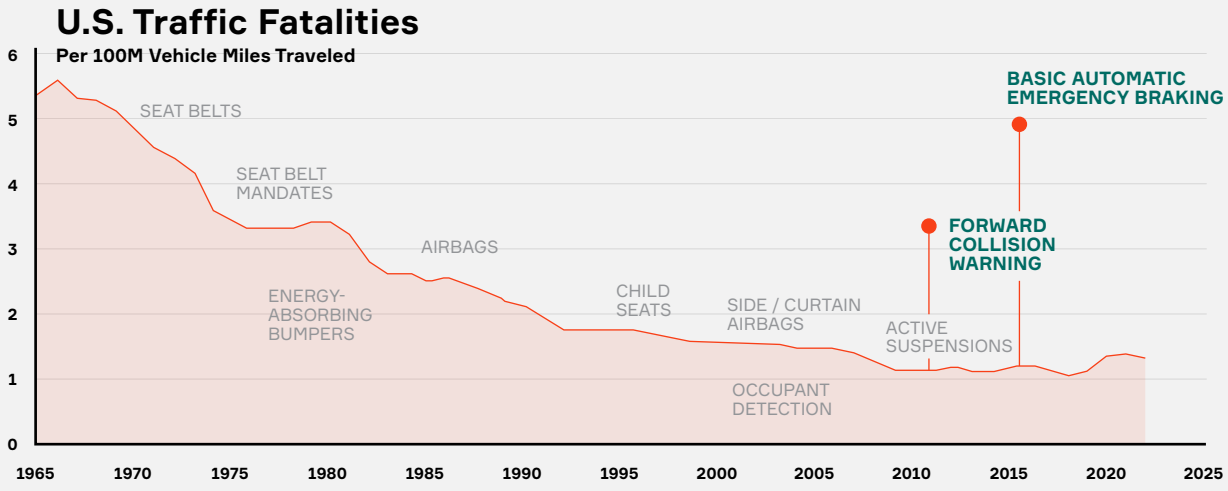
We can reduce the effects of human error through active and advanced safety.

We have already seen tremendous gains from passive safety systems such as seat belts and airbags. Largely taken for granted today, these features were instrumental in bringing the number of traffic fatalities per million miles traveled from 5.5 in the mid-1960s to a little over 1 today. But that number has plateaued, and challenges like distracted driving are adding to the headwinds.

Active safety has the potential to take the industry even closer to its goals of zero traffic accidents and fatalities. This requires embracing technologies that are flexible and scalable, that help protect vulnerable road users, and that democratize safety technology so that it can be deployed on high-volume vehicles. It means giving auto manufacturers the tools they need to collaborate so that we can more quickly reach our common goals.

PASSIVE SAFETY REACHING LIMITS

The automotive industry has reduced vehicle fatalities through passive safety advances, but active safety is critical for further progress.



SOURCE: NHTSA

APTIV'S GEN 6 ADAS PLATFORM

To address these needs, Aptiv has developed the sixth generation of its ADAS platform to leverage AI/ML for enhanced performance. It provides OEMs with several key elements:

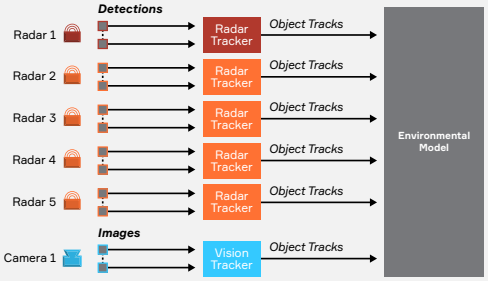
- **A sustainable platform.** Any ADAS platform built for the future has to enable the features that run on it to evolve and scale over time. OEMs want to avoid having to port features from one platform to another, which can be costly. They also want to ensure that they can enhance ADAS features throughout a vehicle's lifetime, which means taking advantage of over-the-air updates to upload software to vehicles in the field.
- **Cost effectiveness.** To bring lifesaving technologies to every part of the world, OEMs are looking to leverage their investment over the largest possible volume. For that, they need a platform that can scale from lower-cost vehicles up to premium models, one that can provide compliance with regulations at the lowest cost while still accommodating advanced differentiating features related to higher levels of automation.
- **Flexibility.** Active safety systems are complex and require high levels of integration. Some OEMs are looking for a full-system solution that provides that integration out of the box. Others want to be able to specify providers for individual features or to better integrate with a particular development environment or ecosystem, which requires an open, developer-friendly platform that encourages innovation. Aptiv's Gen 6 ADAS platform has the flexibility to support either approach, and everything in between.

APTIV'S APPROACH TO SENSOR FUSION

Aptiv's sensor fusion software centrally fuses input from radars, cameras and other sensors to intelligently deliver 360° perception.

TRADITIONAL SMART SENSOR SYSTEMS

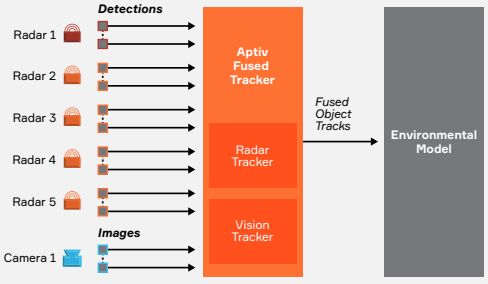
Smart sensors process environmental inputs independently, but because data is processed at each sensor, decision making is only as good as what that individual sensor can see.



example

APTIV'S APPROACH

Centralizing the intelligence means reduced latency, while combining unprocessed sensor data provides increased confidence in detections, particularly for low-level returns.



example

ELEMENTS OF THE PLATFORM

These principles inform Aptiv's approach to every aspect of our ADAS platform, starting with the software and hardware that form its fundamental building blocks:

AI/ML-ENHANCED SENSOR FUSION

The heart of the platform is in software, running either in sensors or in the domain controller. Sensor fusion software takes the inputs from multiple sensors – radars, cameras and lidars – and integrates them to better identify objects around a vehicle, distinguishing between pedestrians, cyclists, vehicles and other objects. Aptiv's approach to sensor fusion takes advantage of centralization in the domain controller to fuse the data in one step, reducing latency. Our real-time embedded neural network can classify dozens of objects within milliseconds. By fusing low-level detections centrally, the software can identify objects that would normally not be visible. This improves the reliability of detecting small, obscured or static targets. It also helps the system accurately identify and track multiple targets, such as those typically encountered in dense urban environments.

ENVIRONMENTAL MODEL

With Aptiv's approach to sensor fusion and machine learning, the platform creates a powerful, software-based environmental model. Each object is identified and tracked, and the system anticipates how those objects might behave. Machine learning allows the system to improve radar range by 50 percent, enabling the tracking of small objects that are more than 200 meters away, which is critical at high speeds. The system is better able to figure out whether an object is something that the vehicle can drive over or under. Machine learning enables the ADAS platform to account for a wide range of these kinds of corner cases (see related white paper).

SENSORS

Every active safety system requires reliable, high-resolution sensors to collect data on the environment around the vehicle. Aptiv pioneered this area with the industry's first vehicle-mounted radar in 1999, and has been innovating ever since. Our next-generation forward-facing radars use imaging radar technology to detect objects 300 meters away and determine how tall those objects are. Our latest corner/side radars double the detection range from the previous generation to 200 meters, while also doubling range resolution. The vertical field of view is three times as high, and angular resolution is tripled.

Radar helps build a solid foundation in sensing, as it can reliably detect objects and their speeds in all kinds of weather and lighting conditions. And with machine learning, the platform is less dependent on other sensing modalities that cost more and require more power, such as lidar.

HIGH-PERFORMANCE COMPUTE

Signals collected by radars, cameras and lidars feed back to an active safety domain controller – or, in an SVA™ implementation, the open server platform – a centralized compute platform dedicated to interpreting those signals and executing decisions based on what the vehicle sees. Aptiv anticipated this shift to centralization more than 10 years ago and was the first in the industry to introduce a domain controller to perform those tasks.

With these elements in place, vehicle manufacturers can equip advanced features at lower cost. For example, coupling sensor fusion with the wide field of view and long range of Aptiv's corner radars allows OEMs to eliminate the need for a frontal radar in hands-free driving applications. In another example, sensor fusion can work with Aptiv's short-range high-resolution radars to cost-effectively enable automated valet parking.

ADDITIVE SCALABILITY

Aptiv's two decades of experience in active safety have given us valuable insights, not just in the requirements for advanced features, but also in the requirements for scaling safety technology across all vehicle platforms. Many of those insights came from the development of the fifth generation of our platform, called Satellite Architecture, the precursor to Aptiv's Gen 6 ADAS platform.

Satellite Architecture took the first steps toward next-generation safety by removing intelligence from the sensors and centralizing it in a domain controller. This leaves in place lighter and smaller sensors that contain only the hardware necessary to operate them. The approach reduces mass in the vehicle and simplifies packaging. As a result, it is easier and less expensive to add satellite sensors as the level of automation increases.

Satellite Architecture's centralization yields significant benefits at Level 1 and increase at Level 2 and Level 3. At Level 0, it can be more cost-effective to keep the intelligence with the small number of sensors required, depending on the desired performance.

To address these differences, Aptiv used the concept of additive scalability to specify multiple software and hardware configurations ranging from entry-level safety compliance features, to comfort and convenience features, to premium or luxury performance. With additive scalability, each configuration builds on the previous one, which has a number of benefits, including reducing design and engineering costs, simplifying the interface into the vehicle electrical architecture, and improving lifecycle management – all while increasing performance.

SATELLITE ARCHITECTURE

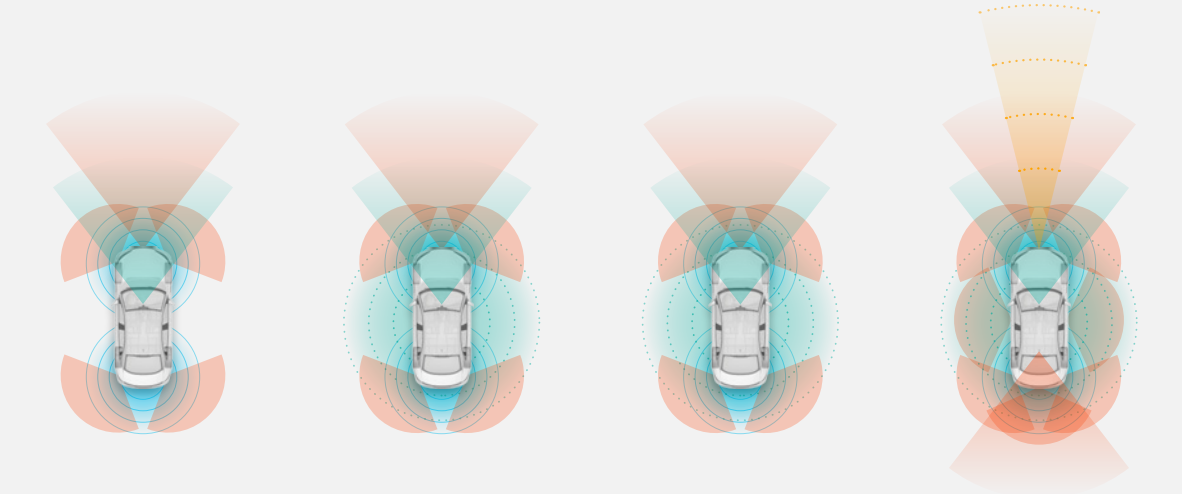
Satellite Architecture is being deployed now by multiple OEMs in every region of the world across multiple vehicle platforms, and is expected to be installed on more than 10 million vehicles over the next few years.

The benefits of Aptiv's Satellite Architecture are evidenced by the Gen 6 ADAS platform. They include:

- Improved sensing and perception performance
- Sensor scalability
- Flexible radar and camera packaging
- Reduced vehicle mass
- Heat dissipation
- Simplified electrical architecture
- Reduced warranty and repair cost
- Simplified lifecycle management

A RANGE OF CAPABILITIES

With Aptiv's Gen 6 ADAS platform, the configurations are grouped into four categories, though each can be modified to meet the needs of specific OEMs:



	CORE	PLUS	PRO	ULTRA
EURO NCAP	**1-4 STAR**	**4-5 STAR**	**4-5 STAR**	**5 STAR**
DRIVER ENGAGEMENT	Up to L0-L2 **(Hands-On)**	Up to L2+ **(Hands-Off)**	Up to L2++ **(Hands-Off)**	Up to L3 **(Eyes-Off)**
SOFTWARE FEATURES	**Safety and Base Convenience Features** **Containerized** **OTA Updatable**	Safety and Base Convenience Features Containerized OTA Updatable **L2+ Hands-Off Highway Policy** **Automatic Lane Change**	Safety and Base Convenience Features Containerized OTA Updatable L2+ Hands-Off All Roads Policy Automatic Lane Change **ML-Assisted Driving Policy**	Safety and Base Convenience Features Containerized OTA Updatable L2+ Hands-Off All-Roads Policy Automatic Lane Change ML-Assisted Driving Policy **L3 Eyes-Off Highway Policy**
SOFTWARE PERCEPTION	**Radar + Vision + Fusion**	Radar + Vision + Fusion **HD/ADAS Map** **Radar AI/ML**	Radar + Vision + Fusion HD/ADAS Map Radar AI/ML **Multi-Modal Localization**	Radar + Vision + Fusion HD/ADAS Map Radar AI/ML Multi-Modal Localization **+ Lidar**
ADAS HARDWARE	1x Smart Camera (Compute) 0-4x Corner Radar(s) 1x Front Radar (Optional) Surround View Camera(s) (Optional) 8-12x Ultrasonic Sensors	1x ADAS ECU (Compute) 1x Smart Camera (Compute) 4x Corner Radars 1x Front Radar 4x Surround View Cameras 8-12x Ultrasonic Sensors GNSS/IMU	1x ADAS ECU (Compute) 1x Smart Camera (Compute) 4x Corner Radars 1x Front Radar 4x Surround View Cameras 8-12x Ultrasonic Sensors GNSS/IMU	2x ADAS ECU (Compute) 1x Lidar 2x Satellite Cameras 2x Side Radars 1x Rear Radar 4x Corner Radars 1x Front Radar 4x Surround View Cameras 8-12x Ultrasonic Sensors GNSS/IMU

As OEMs enhance their ADAS offerings over time, this additive scalability approach has several attributes that facilitate those improvements:

- The features run on a common, standards-based software framework, regardless of the configuration. This allows continuity of software from one level to the next.
- Transitions from a smart-sensor architecture to a centralized domain controller architecture are seamless.
- Radars can be added easily, and the type of radar can be changed. This allows platforms to move from three-radar to five-radar configurations, for example, or incorporate imaging radars to further bolster the environmental model.
- Cameras can maintain a consistent optical path, with the same field of view and the same configuration between the lens and the imager, helping avoid revalidation costs as the equipment is upgraded.
- The configurations provide compliance functionality up to Euro NCAP 2023 five-star at a highly competitive price, while anticipating future standards. Because these compliance features are common to all configurations, Aptiv can distribute development costs over the largest possible volume on these non-differentiating features and free up OEMs to focus on differentiating features.

A KEY PART OF SVA™

The Gen 6 ADAS platform enables vehicle manufacturers to build the software- defined vehicles envisioned by Smart Vehicle Architecture™. SVA™ is Aptiv's approach to simplifying the electrical and electronic architecture in vehicles to simplify complexity, reduce costs and enable the advanced features and high degrees of automation consumers increasingly are demanding. (Learn more about the SVA™ approach in this white paper.)

INSIGHTS FROM AUTOMATED DRIVING

With more than a decade of automated driving experience, Aptiv knows what it takes to support affordable, fail-operational performance for power distribution, network stability and compute availability and performance. In addition to Aptiv's experience in electric vehicles and ADAS, our Smart Vehicle Architecture™ approach was born out of our experiences developing autonomous solutions, including:

- Development of self-driving technology for the DARPA challenges in 2007
- The first coast-to-coast automated drive in 2015 – when we covered nearly 3,400 miles with more than 99 percent of the drive in fully automated mode
- A first-of-its-kind partnership with Lyft, which has completed more than 100,000 automated ride-hailing experiences in Las Vegas since 2018
- The Motional joint venture with Hyundai Motor Group, which launched in 2020 to quickly become a leader in Autonomous Mobility on Demand solutions and has continued the partnership with Lyft

These experiences mean Aptiv truly understands the software architecture and system performance requirements needed to deliver ADAS systems on the path to fully autonomous driving, having already encountered and solved many challenges along the way.

Aptiv's Gen 6 ADAS platform supports several SVA™ design principles.

First, the platform abstracts hardware from software. It establishes standardized interfaces for sensors and feature functions. This gives OEMs the flexibility to specify these elements in the way that best aligns to their individual strategies and adjusts over time as their needs change.

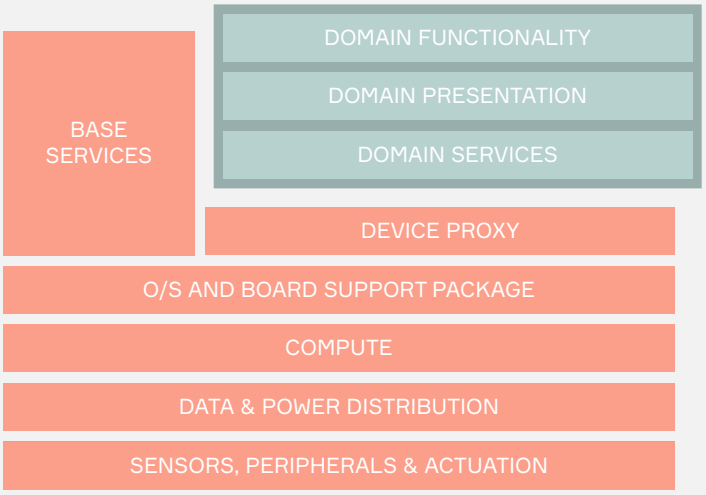
Second, the platform establishes a common software integration platform capable of supporting significant development reuse, leveraging both classic AUTOSAR and AUTOSAR Adaptive standards. By standardizing elements such as communication protocols and diagnostic services, the platform allows significant reuse of base software components, reducing development costs. And because ADAS features are pre-integrated with the architectures that support them, reuse can be as high as 90 percent for OEMs selecting from a core set of functionality.

Third, the platform is fully compatible with a zonal architecture, where I/O is separated from compute. In a zonal architecture, each sensor connects to a local zone controller, which then aggregates the data from the sensors onto a single high-speed interface that connects to the compute. That is, software in the zone controller handles the communication with the end devices, and software in the compute focuses on processing information. (Learn more about zone controllers in this white paper.)

The Gen 6 ADAS platform stretches across both the "Machine" and "Domain" aspects of the SVA™ framework. The SVA Machine provides known hardware capabilities with standardized software interfaces that are easily ported as components are added or changed. With the ADAS platform, the Machine is a dedicated ADAS domain controller, or – further in the evolution of up-integration – a serverized compute platform such as Aptiv's open server platform. Machine functionality is not directly visible to the consumer, so OEMs will want to strike the right

ADAS Integral to SVA™

TWO LAYERS: MACHINE AND DOMAIN PLATFORMS



GEN 6 ADAS PLATFORM

- Encapsulates essential capabilities in vertical stacks owned by domain specialists
- E.g., ADAS software platform, interior sensing software

SVA™ MACHINE PLATFORM

- Provides known capabilities with standardized interfaces that are easily ported to new hardware
- The machine can be a dedicated ADAS controller or a more comprehensive computer

LEGEND MACHINE DOMAIN

balance of power, performance and price. The SVA Domain encapsulates essential capabilities in vertical stacks owned by domain specialists. The consumer experiences many of these domain features every day, and therefore an open and flexible approach empowers OEMs to define that experience.

OPEN DEVELOPMENT

Aptiv's Gen 6 ADAS platform provides a foundation upon which OEMs can innovate and cost-effectively deliver features that exceed consumer expectations over the lifetime of the vehicle. For many OEMs, Aptiv's ADAS platform is a proven solution that lowers total cost of ownership and reduces development risk. For OEMs with feature development capabilities, Aptiv can act as a collaboration partner, offering them the tooling and services they need in addition to the pre-integrated features provided by the platform.

The platform's development tool chain gives OEMs the flexibility to drive further innovation on top of Aptiv's proven solutions and accelerate the development of safe, green and connected features consumers want with the automotive-grade systems they can trust. OEMs can easily add features and scale them up or down for different vehicle models.

This approach facilitates up-integration as well, as features can be consolidated onto the platform. In this way, one can imagine more interior and exterior sensing functions up-integrating onto a common platform and creating a greater level of situational awareness around the vehicle.

CONSIDERING THE WHOLE VEHICLE

In developing the Gen 6 ADAS platform, Aptiv drew on our full systems insights, combined with our domain expertise in areas such as user experience and high voltage electrification. This allows us to include features designed to support the highly electrified and connected vehicles of the future while balancing performance and cost. Here are some examples:

- Driver state sensing functions, which allow OEMs to account for driver distraction and availability, can easily be up-integrated into the ADAS domain controller.
- At higher levels of automation, building trust between the vehicle and the driver is key. Through standardized application programming interfaces (APIs), Aptiv is able to provide information about how the safety system is performing to the infotainment HMI, and the HMI can in turn present the information to the driver and build confidence in the safety system.
- For electric vehicles using wireless inductive charging, getting proper alignment with the charging pad is critical. Aptiv's driver assistance features can help navigate the vehicle into perfect alignment for optimum charging.
- Our sensing and perception approach is already processing- and energy-efficient, but next-generation algorithms for features such as adaptive cruise control will help further tune them for electric vehicles to take advantage of route topology and environmental conditions.

LIFECYCLE MAINTENANCE

The key to success is to allow the platform to evolve and adapt over time – while ensuring that revalidation and deployment costs are kept to a minimum.

Aptiv's Gen 6 ADAS platform supports over-the-air updates and enhancements for the entire life of a program. OTA updates provide a scalable, low-risk and cost-effective way for OEMs to improve the user experience over time. Continuous Integration / Continuous Deployment tooling allows OEMs to quickly develop those solutions.

Managing the updates is simpler and more secure because the platform centralizes the compute power in the vehicle. Updates only have to be downloaded to that central location rather than distributed throughout the vehicle, which means that only that central component must undergo rigorous testing when new software is loaded. A simplified OTA package can also keep costs down when it comes to cloud management and airtime usage.

There are multiple ways to handle OTA updates, failures and rollbacks, and the ADAS platform can be tailored to whichever approach an OEM prefers – from limited OTA updates, to several per year achieved through Wi-Fi and cellular, to frequent updates intended to meet demanding consumer expectations and ensure the highest possible levels of safety and reliability for L3 functionality and above.

To protect these systems, Aptiv is integrating end-to-end cybersecurity protections. We are strongly aligned with industry best practices such as ISO/SAE 21434 and UNECE WP29, and our edge compute and diagnostics capabilities allow us to closely monitor vehicle performance for irregularities.

AN EYE TO THE FUTURE

Aptiv's Gen 6 ADAS platform is more than just a system or even a new generation of technology. This intelligent platform represents a fundamental shift in the way ADAS will be developed for vehicles for the foreseeable future. It is extensible, upgradeable and extremely flexible. OEMs can use the platform to grow capabilities over time in a model of continuous integration and continuous deployment, improving the consumer experience with every refresh. And every year, the platform can evolve to meet new challenges and new consumer demands.

These are the kinds of innovations that come from looking ahead to the future, as the pieces of the SVA™ vision come into focus. By standardizing where possible and providing tools to accelerate innovation, the platform not only provides the basis for this growth, it also allows the industry to advance its goal of bringing active safety to a greater number of people while simultaneously building vehicles with a differentiated user experience.

LEARN MORE AT APTIV.COM/ADASPLATFORM →