WIND™

RICARDO

Autonomous Cars from a Unique Perspective: Reality

What Will It Take to Move the Concept from the Lab to the Production Line?

WHEN IT MATTERS, IT RUNS ON WIND RIVER

EXECUTIVE SUMMARY

There's no longer any question about it: autonomous vehicles are coming. The real question is when and how they'll move off the drawing board and test track and onto our streets and highways. Some say self-driving cars will be on the road as early as 2020, safely transporting occupants over any road, over any distance, in any weather, to virtually any destination. Others say the obstacles to autonomous cars—safety concerns, technological challenges, regulatory issues, consumer education, and cultural barriers—will take decades to overcome. But whatever the timeframe, ultimately the most pivotal issue that will drive the commercial availability of the autonomous car is production readiness.

The technological innovation propelling the autonomous car forward has been astonishing, and it continues to accelerate at a faster rate than most expected. But what's particularly new is that the innovation around autonomous vehicles is heavily software-centric. The challenge is to add value with new embedded software development tools and techniques for autonomous vehicles.

Wind River®, the leader in embedded software and a long-time partner to automotive original equipment manufacturers (OEMs), has joined forces with Ricardo, a global engineering consultancy with extensive automotive expertise, to deliver the stable and sustainable foundation the auto industry requires to support advancing the autonomous car from concept to production-ready reality. This paper examines the technical challenges facing the industry and reviews the specific capabilities Wind River and Ricardo bring to the table.

TABLE OF CONTENTS

SOFTWARE DRIVES THE VALUE OF THE AUTONOMOUS CAR

A first step on the road to production-ready autonomous cars is recognizing that software is a key piece of the vehicle value chain—as much as high-performance hardware, and low-cost systems—particularly in the autonomous car arena. Software will determine how the car plots its course, how it turns, when it changes lanes, and more. At least half of the value of the autonomous car will be derived from software.

Many automakers have therefore realized that participation in the autonomous car market requires them to be in the software business. The decision is no longer about *whether* to transform the software strategy and take ownership of the software, but *how*.

The challenges are myriad and complex. For example:

- The transfer of value changes everything, from design and development considerations to the retail model, the service and support model, the supply chain interactions, and the aftermarket. How do OEMs get a handle on the impacts that value shift will have on the economics of building an autonomous vehicle?
- Traditional software companies—such as Microsoft, Google, Apple, Samsung, and others—have increased their presence in the auto space. How can auto makers "own" the software for autonomous vehicles when much of the intellectual property is already owned by powerful software enterprises?
- Many software-related trends continue to evolve. How will automakers stay abreast of changes in software development models, safety and security requirements, open source frameworks, human–machine interface (HMI) standards, electronic control unit (ECU) integration techniques, and more?

In short, OEMs recognize the need to develop a strategy for software transformation. A solid software platform will support moving them from concept through production, to control the value stream of future vehicles.

PRODUCTION-READY SOFTWARE: CORE REQUIREMENTS

The software platform will be central to the OEM's success in the autonomous car market, but what are the critical capabilities a software platform must deliver? The key functionality must include the following:

Multi-level Integration

The software platform must have the ability to integrate the diverse software elements, sensors, and driving systems of the autonomous vehicle to deliver a cost-effective product.

To bring costs down, the autonomous vehicle must undergo an evolution that starts with the decentralized systems of today, which use multiple sensors and ECUs to deliver limited advanced driver assist system (ADAS) functions, such as rear parking cameras, adaptive cruise, blind spot detection, lane departure alert, emergency braking, and emergency assistance. Vehicle systems are evolving to partially centralized systems for safety features and functionality such as self-parking, lane-keeping, smart stop, vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication, advanced navigation, Wi-Fi hot spots, and a range of assistance with informational and monitoring applications.

The next possible phase of evolution will enable vehicles to be fully centralized systems that incorporate sensor fusion to deliver more features with fewer components. This type of technology will enable features such as valet parking, vehicle-to-pedestrian communication, augmented-reality driving assistance, smart routing with estimated time of arrival, and seamless integration with Internet devices.

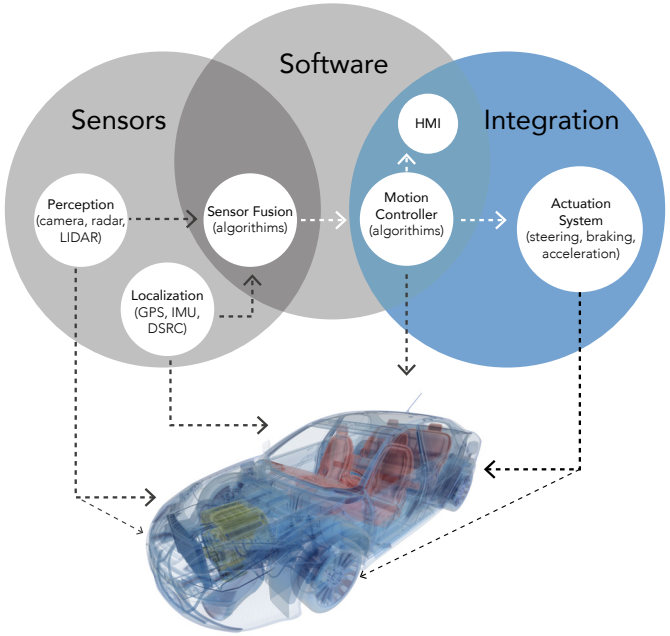

Figure 1. Integration among sensors, software, and driving systems is the first key enabler of a production-ready autonomous vehicle

Moreover, two separate networks are evolving separately, and these will need to be integrated as well: the intra-car network (also called the intra-car cloud) and the broader external network, commonly referred to as the Internet of Things (IoT). The software platform will need to accommodate the convergence of these two networks.

Integrating the intra-car network with the IoT can have real, even life-saving value, beyond syncing music devices. For example, imagine a driver who enters a vehicle wearing her Apple Watch, which is monitoring various statistics related to her health. While driving the car she becomes fatigued. Her Apple Watch detects this condition and sends a signal to an in-vehicle infotainment (IVI) unit, which relays the information to the lane-holding function in the car. This capability not only ensures that she doesn't drift into another lane, but can also provide physical feedback, for example by vibrating the steering wheel to try and wake her up. Or it could even steer her off to the side of the road in a safe fashion, so she can rest without causing harm to herself or anyone else.

Process Integration

Yet another dimension of integration is also required before production-ready autonomous cars become possible: the convergence of software processes with the automotive industry's standard development/testing/validation model—from the development of design concepts to proof-of-concepts (PoCs) to design verification and risk analysis.

In the use case of the autonomous vehicle, what becomes important for mitigating risk—both for the industry and also for its consumers—is applying the discipline, structure, and processes that have been refined and proven over many years to the complex software-driven innovations of the autonomous car, and delivering them into a production environment.

Production Verification

The final core requirement for production-ready software is the actual testing and validation, or production verification. This step will involve harnessing and integrating existing tool sets and practices, such as agent-based modeling methodologies, and leveraging them to enhance or increase the speed and effectiveness with which automakers can perform validation of these systems.

MAKING IT REAL: THE WIND RIVER/RICARDO PARTNERSHIP

To help overcome these challenges, Wind River and Ricardo have partnered to offer the synergies of their combined expertise in addition to the capabilities each partner contributes.

Wind River Helix Chassis Software Framework

As the leader in embedded software for IoT, Wind River® is uniquely capable of helping OEMs overcome the software-related obstacles of production-ready autonomous cars, and it is doing so via the Wind River Helix™ Chassis platform.

Helix Chassis brings together software, technologies, tools, and services to help automotive manufacturers unify the software systems within vehicles and manage connectivity. The Helix Chassis platform incorporates all the components needed to define and integrate systems for controlling the entertainment, navigation, drivetrain, safety, and connectivity systems throughout smart cars and other connected vehicles.

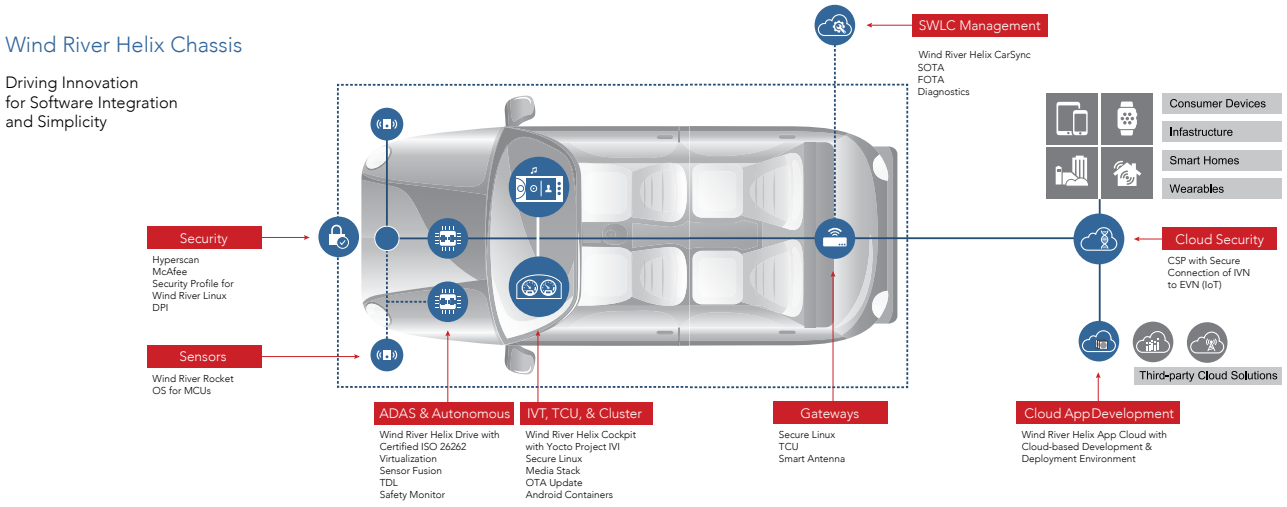

Figure 2. The elements of the Helix Chassis portfolio constitute an end-to-end, integrated solution

The Helix Chassis portfolio is designed to unite the internal network of the car with the external IoT, and ultimately, to bridge the technology siloes within a vehicle to deliver new business opportunities. Helix Chassis make it possible for data, services, and actions to flow from one environment to another, seamlessly and securely. As a result, it is possible to extract greater insights from autonomous vehicles, so that automakers can optimize the space, weight, and power of the vehicle and implement new capabilities that depend on interconnectivity among diverse software elements. Helix Chassis comprises:

Wind River Helix Drive

Wind River Helix Drive offers auto manufacturers and their Tier 1 suppliers an ISO 26262–certifiable software platform for pioneering ADAS and autonomous vehicle innovations. It enables OEMs to quickly build highly secure and reliable controls and systems for automotive safety-critical applications, and safely consolidates applications onto a single hardware platform. It also protects against malicious code through secure boot and other layered security features; and it leverages the Wind River Helix App Cloud hosted software development environment to maintain centralized control of architecture while enabling maximum flexibility in the supply chain.

Wind River Helix Cockpit

Wind River Helix Cockpit is a Linux-based, GENIVI®-aligned runtime platform specifically tuned for the IVI and digital cluster market. Based on Wind River Linux, the platform takes full advantage of the open source community and adds Wind River IP as well as third-party software components to deliver a wide infotainment feature and tool portfolio. Building IVI products using this Wind River commercial-grade platform reduces overall development costs, minimizes project risks, and shortens project timelines.

Wind River Helix CarSync

Wind River Helix CarSync is a robust over-the-air (OTA) solution for remotely managing and maintaining the integrity of embedded systems and collecting critical data across the entire lifecycle of the vehicle, both pre- and post-production.

Wind River Helix App Cloud

App Cloud is a new kind of software development platform that removes the traditional complexities of building applications for embedded devices and systems. With App Cloud, software developers can focus on writing code without worrying about setting up complex hardware environments or operating systems. And App Cloud's innovative, secure cloud-based platform makes it possible for multiple teams to collaborate across the globe. App Cloud is accessible via any modern browser, so you can use the development tools on any computer, tablet, or phone, anywhere in the world. There is no software to install.

Together, the capabilities of the Helix Chassis framework create new opportunities, value, and competitive advantages in multiple categories:

- **Increase in-car security:** Based on tested, proven, reliably secure operating systems, Helix Chassis allows automakers to build on a secure foundation and implement a more holistic security architecture.
- **Exploit the opportunities of connected infotainment:** With Cockpit, Helix Chassis provides a lower cost IVI and digital cluster platform vs. proprietary solutions, container integration, and third-party multimedia solution integrations.
- **Add value and competitive advantage via I/O HMI applications:** Helix Chassis facilitates the development and deployment of new HMI capabilities while enabling OEMs to maintain control of the software.
- **Incorporate advanced telematics features:** Helix Chassis takes full advantage of vehicle data from multiple sources, internal and external, allowing OEMs to create more robust and appealing telematics capabilities.
- **Reduce recalls through prognostics/early detection:** Helix Chassis can incorporate data and information from beyond the car's internal network, allowing for earlier detection of a wider range of potential issues.

Ricardo's Agent-Based Modeling

Ricardo offers deep expertise in one of the critical elements of creating a production-ready autonomous vehicle: virtual testing. A level-4 autonomous vehicle must be able to operate in all driving scenarios, which means extensive testing is required to develop the necessary software to ensure the vehicle responds appropriately. Specifically, Ricardo enables OEMs to leverage agent-based modeling (ABM). This simulation methodology puts agents (vehicles, people, or infrastructure) with specific behaviors (selfishness, aggression, etc.) that have connections in a defined environment (cities, test tracks, or military installations) to understand the emergent behaviors of the agent during a simulation test.

This methodology is being adopted to support advanced testing and analysis of autonomous vehicle performance. For example, Ricardo's Agent Drive leverages ABM methodologies and has been used to create real-world driving scenarios to test complex driving situations for an autonomous vehicle in a virtual environment. Additionally, Agent Drive enables the testing of random interactions, including those that could be extremely hazardous to drivers. However, because it is done in a virtual environment, it mitigates the risk of harming a vehicle occupant and reduces the cost of potential vehicle damage.

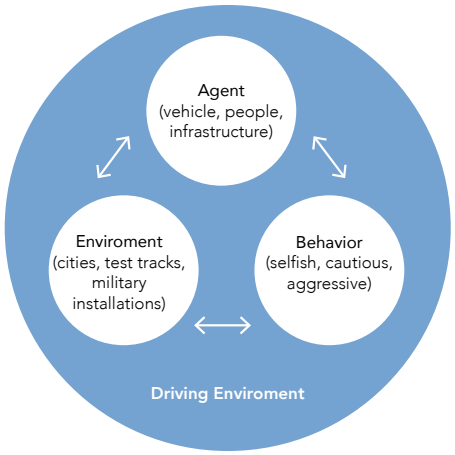

Figure 3. Ricardo's Agent Drive allows testing of driving scenarios while reducing risk and costs of on-road testing

Ricardo is working to continue development of its simulation tool by adding artificial intelligence and driver-in-the-loop (DiL) technology to its ABM capability. These technologies will help unlock the door to advancing the development of autonomous vehicles by increasing accuracy and integrating driver interaction into the testing environment.

STARTING-POINT USE CASES

The technology and system expertise to support advancing autonomous vehicles for the production line can be applied to more than traditional makes and models of automobiles. In fact, many companies outside the traditional auto industry are currently investigating these types of solutions, including the freight industry, military organizations, fleet operators, and other industries with custom vehicles. Following are two examples.

Urban Mobility

With the emergence of the Smart City and the need to transport peoples in all communities, Ricardo has worked with several non-traditional automotive organizations to design and develop urban mobility platform solutions that range from autonomous golf carts to bus platforms, and include electric vehicles with ADAS and autonomous system functionality.

Platooning

Platooning is a hot technology for the commercial truck industry today that helps reduce the carbon footprint and increase fleet management throughput. Ricardo was the project lead for the SATRE Platooning Project, implemented with several suppliers in the UK. Today Ricardo is working with Texas Transportation Institute and a handful of suppliers to implement a Class 8 Truck Platooning project that features lateral and longitudinal autonomous control.

SYNERGY: COORDINATED, TRUSTED, AND PROVEN SUPPORT

In addition to its product portfolio, Wind River offers world-class professional services and customer support. Wind River Professional Services provides automotive software integration and lifecycle management services that have helped automakers and suppliers pioneer vehicle intelligence and connectivity to boost driver safety and security while expanding the in-vehicle digital experience. A CMMI Level 3-certified organization, Professional Services has extensive expertise integrating automotive system software for all the leading manufacturers, as well as design centers around the world that offer local support and distributed development teams.

Wind River Customer Support keeps projects on schedule so customers can meet tight market windows. Its 150 engineers have an average of 10+ years of experience with device software, deep expertise with industry best practices, and an obsession with solving customer problems quickly and accurately.

Ricardo is a global consulting firm with considerable expertise in the automotive industry, and is also a specialist niche manufacturer of high-performance products. The company employs more than 2,000 professional engineers, consultants, and scientists committed to delivering outstanding projects focused on innovation in

core product areas of engine, transmission, vehicle, hybrid and electrical systems, environmental forecasting, and impact analysis.

Together, Wind River and Ricardo provide extensive and complementary IP that can be delivered to OEMs in customized service and solution offerings. Equally important, the two companies have experience working together, as well as working directly with the design, development, and testing teams of OEMs. The uniquely team-oriented, collaborative approach delivered by Wind River and Ricardo professionals helps expedite the development of production-ready systems and processes.

CONCLUSION

For OEMs who are eager to get beyond exploring the "possibilities" and "potential" of autonomous vehicles and move real vehicles onto real production lines as quickly as possible, Wind River and Ricardo offer a compelling solution. Together, the two companies can help you take the next step toward autonomous vehicle reality—in a way that maximizes innovation and minimizes cost and complexity.