# Open Standards for Autonomous Cars

*An Urgent Imperative*

WHEN IT MATTERS, IT RUNS ON WIND RIVER

## EXECUTIVE SUMMARY

Every major automaker is scrambling to capitalize on the enormous potential of the autonomous car market. They are jostling for first-mover advantage, staffing up, acquiring new companies and capabilities, and innovating at an unprecedented pace. They know they cannot afford to be left behind. New competitors are emerging that are forcing accelerated change to traditional automotive business, design, and process models.

But the competitive free-for-all we are witnessing today has huge downsides: redundant and wasteful investments ending in discarded technology, fragmentation of critical safety approaches, and reactive business models that are simply unsustainable.

What is needed is a smarter approach to developing standards—particularly when it comes to the foundational software that will drive autonomous cars and ensure safety for consumers. However, automakers have vastly different perspectives on this issue. And, with no industry-wide standard to help guide car companies, some of the massive bets currently in play by automakers may not pay off in the end.

It's time for original equipment manufacturers (OEMs) and their Tier 1 suppliers to take a page from the playbook of industries such as aerospace and defense that have successfully created open standards for mission-critical software. Their model has been to cooperate on standards—and to compete on the creation and delivery of commercial products.

Leveraging decades of experience refining mission-critical and safety-critical software for embedded devices in multiple industries, including both aerospace and defense and industrial and automotive, Wind River® advocates the collaborative development of open standards for autonomous vehicle software. Wind River is ready to organize and participate in the push for open standards. This path would include the participation of all market players—including government agencies, consortia, universities, and even the collaboration of competitors within the industry—to ensure a more efficient and dynamic commercial marketplace for all.

This paper examines the possibilities of a more collaborative approach to open standards, the lessons we can learn from other industries, and next steps on the road to the standardization of software approaches and requirements for autonomous cars.

## TABLE OF CONTENTS

## CONSEQUENCES OF THE CURRENT MODEL: A CLOSER LOOK

The autonomous car is a software-defined vehicle. The functionality, the experience, and the dynamics—from dashboard instruments to the power train to safety systems to in-vehicle infotainment (IVI)—are all controlled and driven by innovative software. Simply put, autonomous car companies must consider themselves in the software business, and that means they compete on software capabilities and software cycle times. They all want to be the smartest and the fastest with each new innovation.

The problem is that many automakers are creating their own software models in isolation, and that is incredibly inefficient and wasteful. Each and every software element must be individually secured, made safe and compliant, then translated into a production-ready commercial product. When all of that happens in a one-off, bespoke fashion, every company in the value chain ends up investing more money, hiring more people, and incurring longer delays than necessary.

Those redundant investments must then be passed on to consumers, which translates to excessively high prices for autonomous cars, slower adoption rates, and higher maintenance costs, which in turn diminishes the market opportunity for OEMs, Tier 1s, and service providers.

Equally troubling, the complexity of autonomous car software makes it all the more challenging for automakers to maintain scalability as autonomous car software moves from the drawing board into production. Most automakers are relatively inexperienced in software-defined business models and will have difficulty keeping pace with the accelerating rate of change. Scaling up and into production will be a daunting challenge without standardization of core software elements.

Also, keep in mind that, with the critical safety concerns inherent in cars, government agencies are simultaneously trying to better understand and ultimately create safety, security, and operational policies around autonomous vehicles. These policies will force OEMs to adjust their technologies and development processes.

## A SMARTER APPROACH: COOPERATE ON STANDARDS, COMPETE ON DELIVERY

Clearly, a more efficient model for creating and deploying software is an imperative for the autonomous vehicle market. Defining open standards seems like the natural first step—particularly for mission-critical elements of the autonomous car's software infrastructure, such as operating systems and safety-related software.

It's important to note that open standards are not the same as open source. Open standards and open architectures are those that are publicly available and democratically created by a community. Open source is actual software code that's freely available, subject to the terms of a licensing agreement. In essence, open source software is the implementation of an open standard. Open standards will guide the software approach of a particular technology capability or requirement. In most cases, an open standard will allow the inclusion of both open and proprietary software. Open standards and open architectures accelerate the creation of a competitive and dynamic marketplace that drives efficiencies throughout the supply chain.

The autonomous car market needs to adopt the approach that has been successful in other industries with mission-critical software components, such as the aerospace and defense industries. The approach these industries have taken includes two basic tenets:

- Core mission-critical elements of the software stack should be based on an open architecture model—one that is based on open standards that are accessible to all—so that innovation can focus on adding customer-visible value on top of this open foundation.
- Competitive differentiation should derive from innovation, quality, and delivery of software-defined capabilities around the open software standard.

A simple example that illustrates the advantages of the open standards model is the airbag. Airbags operate in basically the same way under the same principles. The functionality is fundamentally the same. They're essentially standardized—and the standard is designed to be rigid enough to ensure the safety of the user while allowing room for individual companies to innovate and compete on added value. As we've witnessed (for better and for worse), every airbag from every airbag supplier is not the same. Suppliers can introduce innovations that allow them to be chosen over a competitive offering, and strict adherence to safety standards helps protect consumers.

Wind River has seen how open standards drive competition, which in turn drives innovation, in multiple industries. This is why Wind River is committed to leading the discussion about open standards for the autonomous car, engaging all market players and organizing a standards body that can help determine:

- Which standards are needed
- How open standards will be defined, created, and regulated
- Which elements of intellectual property (IP) need to be standardized
- Which open standards have the highest potential for generating innovation
- Which open standards create the highest potential for risk, and how best to mitigate that risk

The next section examines how other industries have addressed these questions, providing examples and insights that will apply directly to the creation of open standards for autonomous vehicle software.

## EXAMPLES AND LESSONS LEARNED FROM OTHER INDUSTRIES

Given that the electronics systems of autonomous cars closely resemble those of commercial aircraft systems, which optimize safety, security, reliability, and availability, it is instructive to note how this industry has addressed the issue of open software standardization.

### Aerospace: Boeing and the ARINC 653 Standard

One of the earliest and best examples of how open software standards increased efficiency and created cost savings for multiple market participants was the design of the Boeing 787 Dreamliner aircraft.

Rather than create a proprietary software framework, Boeing contracted Smiths Aerospace (now GE Aviation Systems) to create the 787 Common Core System (CCS), based on the ARINC 653 specification, which enabled a diverse ecosystem of hosted function suppliers to deliver software that executed on this common core virtualization platform. The new platform in turn led to the creation of a new role-based business standard, RTCA DO-297, that defined business roles—platform suppliers, applications suppliers, and systems integrators—as well as processes and work flow for those roles. Today the Boeing 787 CCS supports more than 100 applications from over 20 suppliers on the shared CCS compute platform. This successful role-based business method has evolved into the current global standard for the development of all large commercial aircraft today.

Together, the ARINC 653 standard and the DO-297 role-based business standard delivered fundamental benefits and efficiencies for modern commercial aircraft, including the following:

- The common compute environment enables a level playing field for the entire electronic systems supply chain, and it enables a level playing field for competitors to deliver software-defined capabilities.
- The complexity, along with the size, weight, and power (SWaP), of federated compute/function boxes distributed all over the aircraft is removed. In the case of the Boeing 787, that saved more than 1,000 pounds of weight.
- ARINC 653 time and space separation architectures enable applications with different levels of safety criticality to share a common compute platform, thereby optimizing the use of computer resources and allowing the human–machine interface (HMI), flight controls, and aircraft systems to safely share the common compute resource.
- ARINC 653 was designed for safety certification, which decreased aircraft programs' certification risk. This enabled the creation of a competitive aircraft supply chain, where most new capabilities and upgrades have multiple suppliers bidding on the new opportunities, and the cost and risk of rigorous software safety is reduced.

### Defense: The FACE Initiative in Manned/Unmanned Aircraft

Several years ago the U.S. Army, U.S. Navy, and U.S. Air Force, along with nearly all U.S. defense suppliers, created a consortium to develop a new standard called the Future Airborne Capability Environment (FACE™), managed by The Open Group.

The FACE Consortium based its technology foundation on ARINC 653 and the POSIX® (UNIX®) standard so that many mission systems and non-safety-certified applications could also be included in this specification. The current FACE standard also is based on more than100 other commercial and industry standards, enabling very high levels of reuse.

The FACE standard enables any FACE component at any layer to be easily assembled with other FACE components, improving integration efficiency for all who conform to the specification. It includes a common data model that is flexible enough to include all modern military aircraft systems, and it has been adopted by the Unmanned Control Segment (UCS) standards body. To prove the applicability of this common data model across multiple platforms, it is now the Society of Automotive Engineers (SAE) standard AS6512.

The FACE global specification is a public standard and is now supported by more than 100 government and industry member organizations and over 1,000 individuals. More than 50 U.S. government programs now have FACE as a requirement.

The FACE standardization has created a very powerful foundation for all future manned and unmanned aircraft for the U.S. military and coalition partners. By working together on similar standards, the auto industry could streamline the innovation, development, deployment, and maintenance of next-generation autonomous vehicle electronics.

**Aircraft and Automotive: OpenGL and OpenGL SC (Safety-Critical) Interfaces**

Graphics systems are increasingly complex in both aircraft and automotive vehicles today, and the standardization of graphics specifications in the aircraft industry provides a good model for the auto industry.

Today's aircraft have standardized on the Khronos Group's OpenGL and OpenGL SC specifications. This standardization has enabled the market to create both safety-critical cockpit graphics and a supply chain for OpenGL graphics drivers and tools that have full commercial off-the-shelf (COTS) RTCA DO-178C safety certification evidence for a variety of graphics devices.

Companies such as ANSYS, CoreAVI, Ensco, and Presagis have sophisticated design tools, test tools, and simulation tools that provide a clear path to DO-178C and DO-254 safety certification with their COTS product lines. Visualization of the state of a vehicle, along with its real-time Internet of Things (IoT) sensor environment, will enable the driver or the operator of a car to immediately deliver the most efficient, safe, and secure experience to future automotive users. Both aircraft and next-generation automotive dashboards are already sharing common design OpenGL tools and safety-certified platform components.

## NEXT STEPS ON THE ROAD TO OPEN STANDARDS

Wind River is deeply committed to the idea that adopting the open standards—particularly for mission-critical software—will accelerate the opportunities of the autonomous car market. Open standards will accelerate innovation, lower costs, prevent the sheer volume of software code from inflating, ensure scalability, and make production practical.

The question is where to begin and how best to move ahead. Wind River is able to lead initiatives and discussions on standardizing the operating environment and the real-time operating systems (RTOSes) of autonomous vehicles.

In addition, Wind River is leveraging its experience in other industries and other domains to facilitate the specification and incorporation of similar standards into the automotive industry.

To that end, Wind River has made VxWorks® 653, its core RTOS, openly available to every community working on autonomous cars. VxWorks is the result of decades of ongoing innovation and is the world's most widely deployed RTOS, powering billions of intelligent devices on the IoT.

VxWorks also supports industry-leading connectivity standards and networking protocols out of the box, provides safety certification and standard Java runtime support, and supports over 800 POSIX calls and many more global industry standards.

Why could VxWorks 653 work as a successful software foundation for autonomous vehicles? Because it is already proven in mission-critical, vehicle-oriented environments where failure of proper performance can result in loss of life. VxWorks powers systems that cannot fail. That cannot be said of Android in its current form, or of Linux. While those platforms offer immense compute capability, scalability, flexibility, easy integration, and broad community support, they may not be applicable to all the highly deterministic applications necessary for moving vehicles and also do not have decades of testing and proven mission-critical capabilities behind them.

VxWorks represents an intelligent starting point. It provides access to a rock-solid operating environment, which serves as a foundation from which other market players can build, integrate, and innovate to bring more contemporary capabilities. This would in turn enable scalability, speed, safety, and a community approach to further innovation.

If an automaker can leverage open standards technology that has been vetted and tested over 35 years in mission-critical applications in multiple industries, adapt that technology to automotive use cases, and collaborate across the industry to agree to safety standards, then that automaker has demonstrably taken significant steps toward de-risking that and other similar scenarios from the perspective of the consumer, the industry as a whole, and regulators. The same applies to current initiatives already underway, such as Google's testing of autonomous cars on city streets.

## CONCLUSION

By defining and adhering to open standards based on decades of experience, the auto industry can bridge the gap between the need for cost-efficient commercial differentiation and the imperative to protect consumers in an age of accelerating innovation.

The time has come for adoption of open standards for autonomous vehicles, and Wind River has the commitment, the experience, and the proven foundational technologies to build success.

To learn more about the VxWorks platform and the automotive capabilities and offerings of Wind River, visit www.windriver.com/products/vxworks/#VxWorks and www.windriver.com/products/chassis.