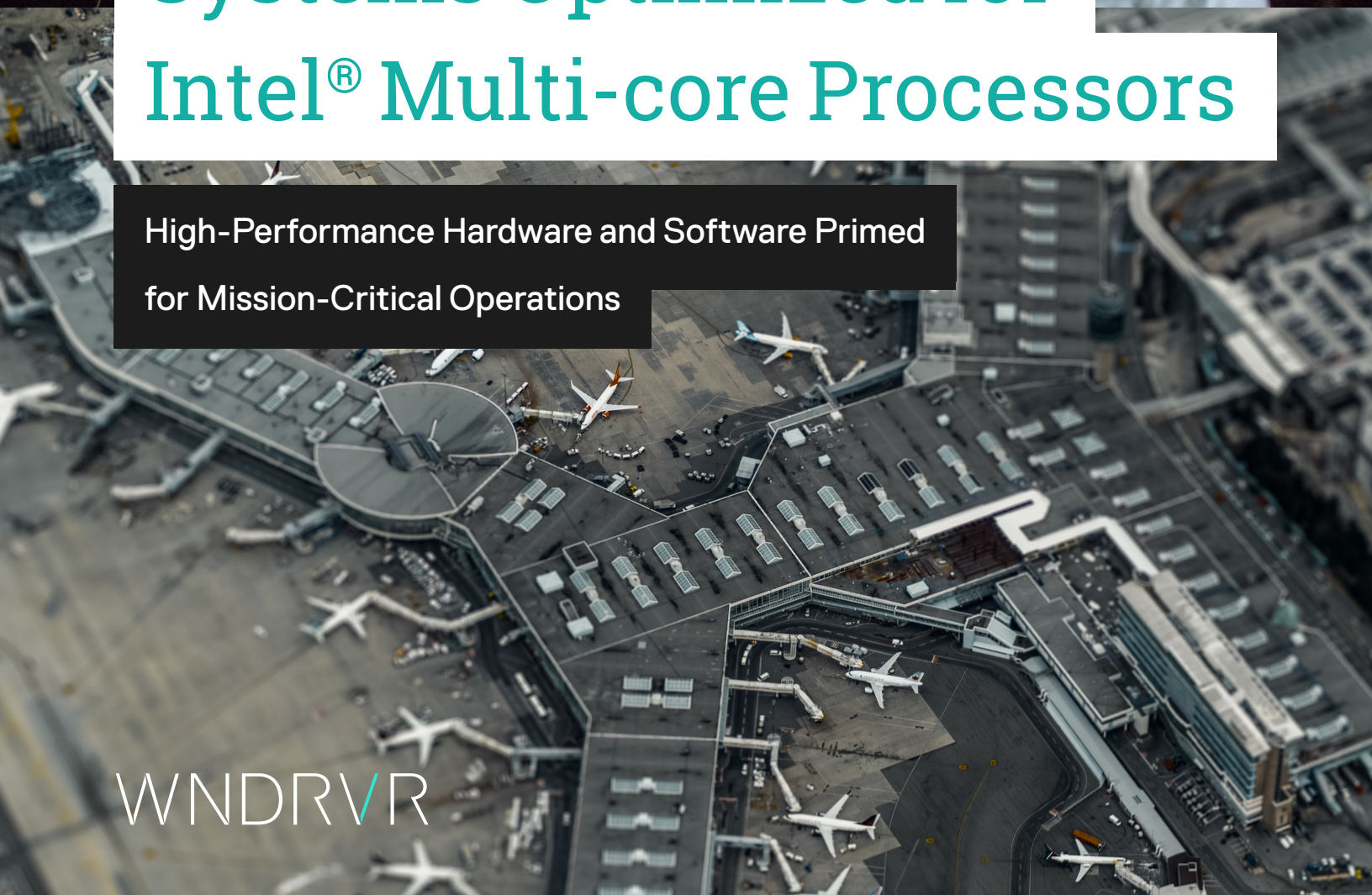
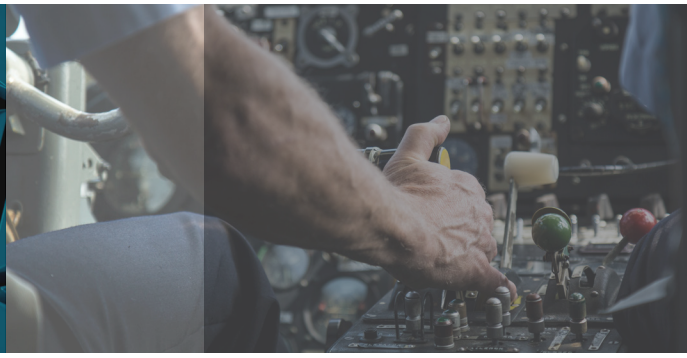
Building Real-Time Avionics Systems Optimized for Intel® Multi-core Processors



High-Performance Hardware and Software Primed for Mission-Critical Operations

WNDRVR

Delivering High Performance, Safety, and Security for Avionics Use Cases

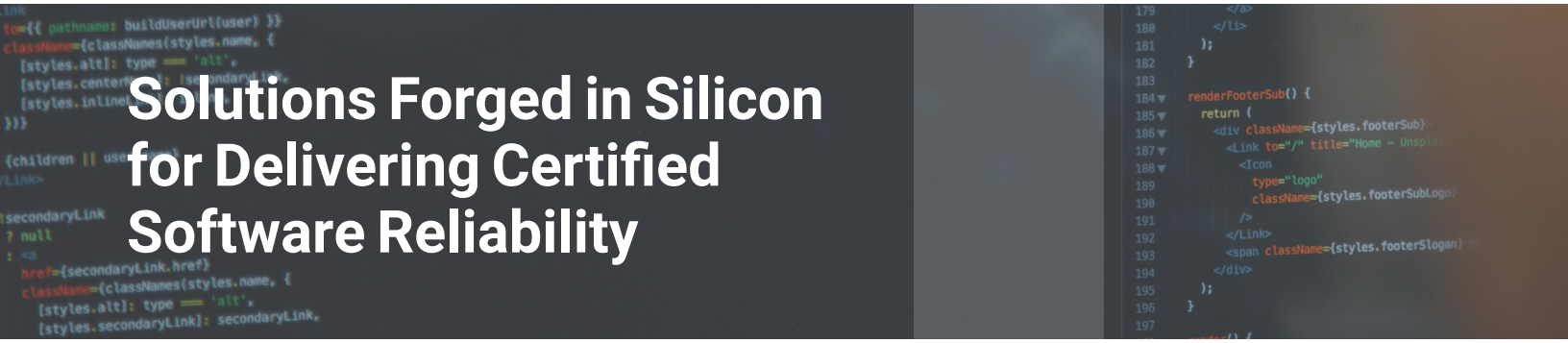


Safety is paramount in today's advanced avionics systems, leaving no room for undue latency, system failure, or security vulnerabilities. Maintaining higher levels of performance, security, and safety requires a responsive real-time operating system (RTOS) and advanced multi-core processors equipped to handle multiple concurrent operations with minimal latency and top efficiency.

VxWorks® and select embedded Intel® Xeon® D processors and embedded 11th Gen Intel® Core™ processors, ideally suited for rigorous avionics applications, are equal to this challenge.

Certified members of the embedded Intel Xeon D processor family and embedded 11th Gen Intel Core processors — combined with VxWorks real-time processing capabilities — deliver reliable, high-performing solutions for aerospace and defense applications. In a highly competitive market sector and within the exacting standards that characterize the current regulatory environment, OEMs, avionics contractors, design firms, and system architects strive to build innovative solutions that integrate interoperable, tuned components into advanced avionics systems. Intel and Wind River — with decades of co-engineering expertise and an extensive history designing optimized hardware and software innovations together — offer proven solutions to address this challenge.

> "Working with Wind River enabled us to develop Project Zero in record time with a revolutionary approach by leveraging market-leading technology."
>
> **—Dr. James Wang**
> *Vice President of Research and Technology, AgustaWestland*



Solutions Forged in Silicon for Delivering Certified Software Reliability

Building solid, reliable avionics systems requires a foundation that supports emerging hardware architectures and next-generation processor technology.

Silicon designed with latest-security advances embedded and with fail-safe component design is an important adjunct to an RTOS ready to meet the challenge of the extreme conditions, predictable behavior, and lightning-quick determinism necessary for aerospace and defense applications.

The Growing Matrix of Standards

Avionics system designers are, of necessity, becoming accustomed to the interlocking matrix of complex requirements that must be met to earn airworthiness certification. A recommended path for navigating these requirements is to use building blocks, both hardware and software, that have obtained the core certifications and simplify the process of building systems that comply with required mandates.

The following table lists the key standards and requirements that are predominant in the commercial and military avionics sectors.

Table 1. Standards and Requirements

Standard	Description
DO-178C	DO-178C, Software Consideration in Airborne Systems and Equipment Certification, spells out the safety requirements for commercial software-based systems. Certification authorities, including the FFA, EASA, and Transport Canada, use it to define approval processes.
DO-254 DAL A–E EUROCAE ED-80	Stipulates the design assurance guidelines for airborne electronic hardware. Published by the RTCA and EUROCAE, the standard has been adopted by the FAA to establish compliance requirements covering hardware components in airborne systems. Levels A through E identify the risk levels associated with requirements (A being the most serious risk).
CAST-32A (AC-20 193 and AMC-20 193)	Recommendation for safe operation of multi-core processor avionics system as created by the Certification Authorities Software Team and used by the FFA and EASA. Update in progress to new AC-20 193 and AMC-20 193 guidelines.
IEC 61508	Defines the safety requirements for electrical, electronic, and programmable systems, including design, deployment , operation, and maintenance. Recognized internationally.
ARNIC 653	Avionics Application Software Standard Interface specifies space and time partitioning for safety-critical avionics in RTOS implementations. The standard supports hosting of multiple applications on the same hardware in environments in which Integrated Modular Avionics architecture is used.
POSIX	Created and trademarked by the IEEE Computer Society, the Portable Operating System Interface helps maintain combability between operating systems and the system – and user – level programming.
FACE™	Future Airborne Capability Environment is an open standard developed by industry and government to define an open avionics environment for military airborne platforms.

The multiple levels addressed when certifying an avionics system are shown in Figure 1. By compiling airworthiness evidence packages, including the components across the full stack, suppliers, OEMs, and system architects can more readily obtain certification for a completed solution. Alex Wilson, director of the Aerospace and Defense Market Sector at Wind River, explained, "Everything flows up through the documentation for each part, so at the system level you have to create a system-wide set of safety documentation. That may break down into the different subsystems, but, at the end of day, each subsystem is tested and each integration is tested. And, depending on the level, if you're Level A [DO-254 DAL A], then it has to be independently tested and independently checked. You have to have a different group of people to the ones who wrote the software, and then you have to have another group of people that checks that everything has been done correctly."

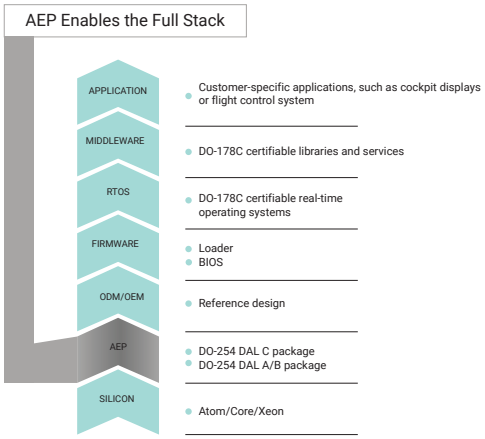


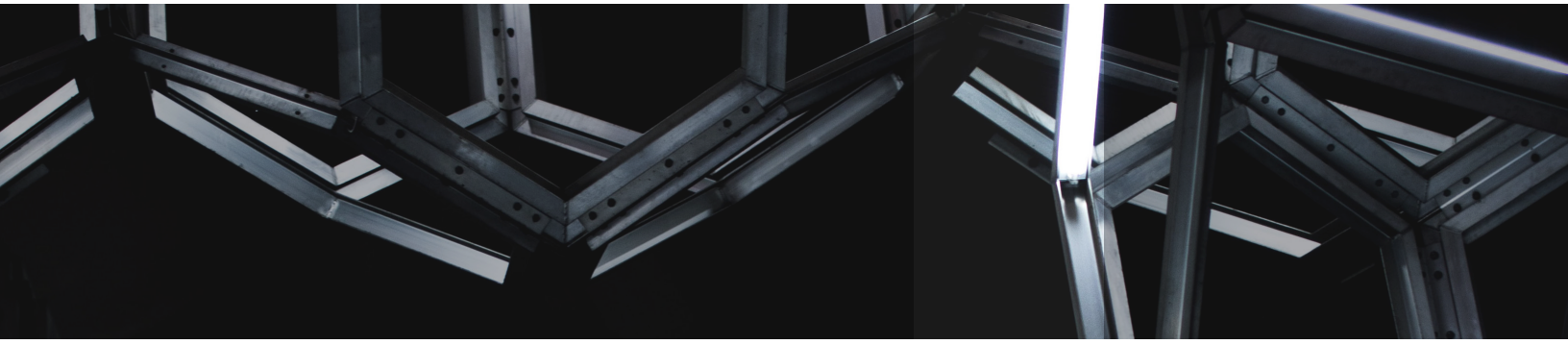
Figure 1. Certifying an avionics system requires addressing multiple levels

Intel has developed an avionics roadmap featuring processors that are tailored to certification guidelines, offering a choice of performance and size, weight, and power (SWaP) values well suited to avionics implementations. Intel has also engineered the latest multi-core processors to reduce risk and minimize complexity to adhere to CAST-32A (Soon AC-20 193 and AMC-20 193) guidelines. Intel multi-core processors deliver greater performance at lower core counts, reducing the number of inference paths to minimize complexity — an important aspect of maximizing safety in avionics system deployments.

The flight-safety evidence packages provided by Intel comprise these data assets:

- Failure modes, effects, and diagnostic analysis
- Reliability data
- Single-event effect analysis
- Shared resource management
- Production and manufacturing data

This information underlies the certification process and demonstrates the strength of flight-safety provisions integrated into a solution.



Intel Xeon D Processors for Safety-Critical Avionics Applications

Application use cases for the latest embedded Intel Xeon D-1700/2700 processors encompass numerous air-based and ground-based avionics systems, including airborne cloud-computing installations, ground stations, air traffic management, mission servers, and more. With integral hardware capabilities that enhance reliability and security, these processors deliver solid platform integrity, trusted execution processes, integrated cryptographic operations, and protected data and ID features.

This series of embedded Intel Xeon D processors provides up to 20 cores per processor, a balanced architecture with built-in acceleration and strong cybersecurity protections, and the flexibility to accommodate and adapt to real-time workloads using time-sensitive network (TSN) technology. Built-in features solve many of the performance, security, and safety challenges faced in A&D solutions, including Intel® Software Guard Extensions (Intel® SGX), Crypto Acceleration, AI acceleration, Intel® Speed Select Technology (Intel® SST), Intel® QuickAssist Technology (Intel® QAT), and more. In collaboration with Wind River, these capabilities have been made readily accessible through software optimization and tuning for seamlessly running with VxWorks.

These versatile and rugged processors are also well suited for IoT applications at the network edge, including simulation and training operations, vehicle management, sensor fusion, autonomous computer operations, and multi-use platform implementations.

Embedded 11th Gen Intel Core Processor Versatility

With a strong slate of features to support avionics system development, the embedded 11th Gen Intel Core processor family fits numerous use cases in this industry sector, including navigational aids equipment, integrated flight deck displays, visual AI flight and mission management, detect-and-avoid operations, and more. Key features include extended temperature range operation (-40 C–100 C), efficient power usage profiles, Intel® Time Coordinated Computing, Time-Sensitive Networking for precision real-time compute operations, Intel® Total Memory Encryption, Intel® Adaptive Boost Technology, Intel QuickAssist Technology, and more. With its balanced power and performance values, this processor effectively satisfies SWaP-C objectives typically used to evaluate aerospace projects.

Wind River Intelligent Edge Software for Safety-Critical Avionics

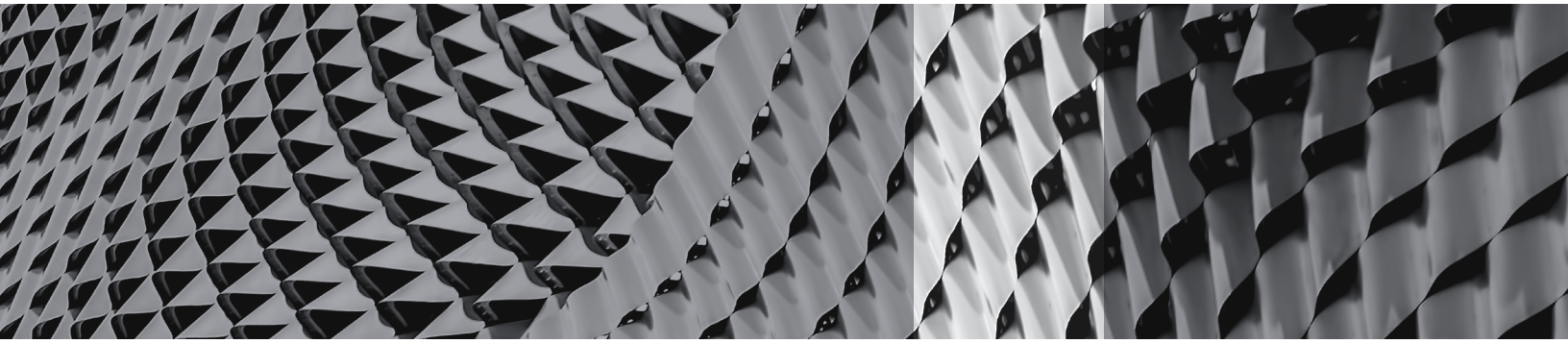
Wind River delivers top-notch software, technologies, and tools to streamline the certification process, ensure safe operation if faults occur in the avionics system. Also, Wind River provides tools to develop and test the software using advanced simulations prior to installing a solution in an aircraft, expose cybersecurity vulnerabilities, and operate safely and efficiently in a highly virtualized software-defined environment.

VxWorks, the Gold Standard RTOS for Avionics Uses

VxWorks, a part of Wind River Studio, has been deployed widely in environments where demanding conditions and real-time responsiveness are vital to the success of the mission. VxWorks meets an extensive range of safety-critical application requirements, giving technology developers a streamlined means to become certified for DO-178C, ED-12C, EN 50128, v 61508, ISO 26262, and IEC 62304. VxWorks 653 is expressly designed for avionics solutions, consolidating and orchestrating workloads upon a proven Integrated Modular Avionics (IMA) platform.

VxWorks is the only RTOS that supports both embedded 11th Gen Intel Core processors and embedded Intel Xeon D processors.

For the most demanding avionics applications, the Wind River VxWorks 653 Platform incorporates multi-level safety using a multi-core scheduler supporting hardware virtualization assist operations. On an open virtualization platform, VxWorks 653 uses robust time and space partitioning on multi-core processor platforms, including those powered by Arm®, Intel, and PowerPC processors. This technology has been widely adopted in aerospace and defense applications. More than 360 customers in over 600 safety programs have incorporated this technology, deployed and proven in more than 100 civilian and military aircraft.



Advancing Safety Provisions with Wind River Helix Virtualization Platform

Wind River Helix Virtualization Platform, a part of Wind River Studio, consolidates multiple federated systems into a single, consistent, safe, edge-compute platform for building IMA solutions. Avionics OEMs, suppliers, systems architects, and planners can rely on the features and capabilities of the real-time platform that supports x86 multi-core processors and adheres to industry certification standards, including ARINC 653; POSIX®; and FACE Technical Standard, Edition 3.0. Working fluidly with VxWorks, Helix Platform suits a broad range of safety-critical implementations in aerospace and defense where mixed-criticality applications, including legacy applications, are to be run within an RTOS environment conformant with prevailing regulatory standards.

Using Simics to Test Security, Failure-Proof Operation, and Multi-Processor Scenarios

With the sophisticated simulation software Wind River Simics®, developers and system architects can engineer robust, repeatable testing processes to thoroughly validate the operation of a complex avionics system and check for the presence of cybersecurity vulnerabilities. This simulation technology makes it possible to test effectively on virtual hardware, an important capability when exploring potential attack vectors that are difficult or impossible to check on a live system. As DevSecOps practices become more widely adopted, ensuring that security is engineered into solutions at the very earliest stages, Simics can be the tool that ensures that safety vulnerabilities are detected and eliminated before a system is released.

As Wilson noted, "Simics can take you a long way through the certification steps. You can make sure all your test cases and your test harnesses are all working correctly on Simics, and that all the tests pass. And the final tests you do on the hardware are all-around performance and real issues. You can actually test more on Simics than you can on real hardware. Simics allows you to do things like fault injection. For instance, you can say, 'I'm running on this piece of hardware, but what happens if this particular piece fails?' You can see how the software behaves given that hardware failure. It is very hard to do that on real hardware."

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—**Alex Wilson,**
Director, Aerospace and Defense Market Sector, Wind River

Standardization Drives Design Interoperability

Across both the commercial and military avionics sectors, the need for establishing standards for systems and aligning the ecosystem around agreed-upon guidelines reduces uncertainties in solution reliability, safety, and agility.

Military Embedded Systems Editorial Director John McHale explained the benefits in this way: "CAAS [Common Avionics Architecture Systems] uses common hardware components to lower lifecycle costs and enable more effective upgrades. FACE™ (Future Airborne Capability Environment) does this through software. Both initiatives are effective because what they do — enabling commonality and reuse across multiple platforms through standard interfaces — makes economic sense."[1] Rather than being built on an entirely new standards platform, FACE amplifies and extends POSIX and ARINC 653 standards.

For FACE, a certificate of conformance is achieved by testing solutions against the standardized API sets. VxWorks 653 Safety Base Profile has earned FACE 2.1 conformance and was the first product to attain FACE certification. Wind River Helix™ Virtualization Platform has gained FACE 3.0 conformance. Wind River Linux conforms with the FACE 3.0 General Purpose Profile and is the only version of Linux to be certified for the FACE standard.[2]

1 *militaryembedded.com/avionics/computers/avionics-and-standards*
2 *blogs.windriver.com/wind_river_blog/2020/06/how-the-operating-system-segment-fits-into-the-face-architecture*

Evolving Functional Safety Awareness

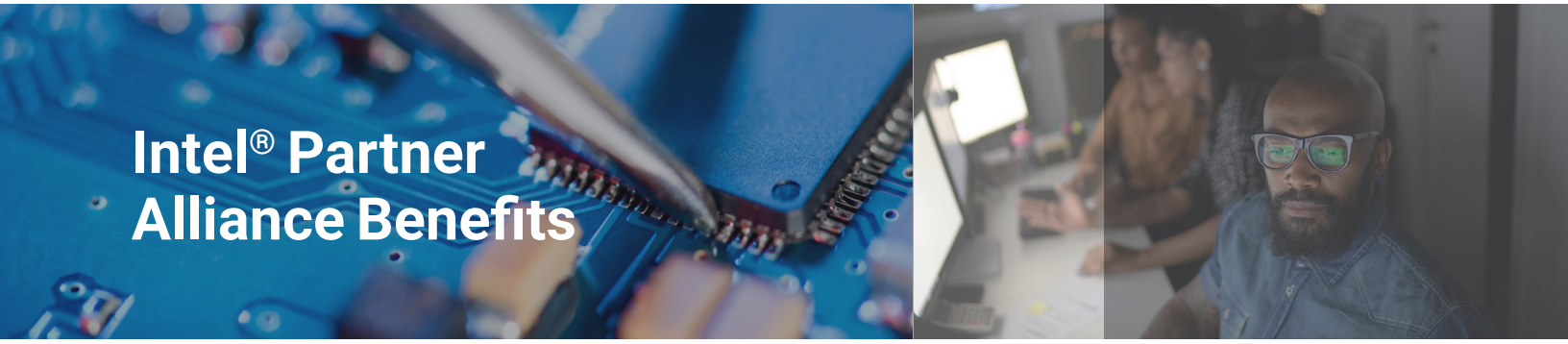
The sophisticated nature of the latest avionics systems has spurred greater awareness of the need for vital functional safety issues, favoring solutions that are integral to the hardware and software rather than bolt-on solutions added after products are released.

Both Intel and Wind River have substantial expertise with the escalating requirements that must be met to conform to more stringent certification standards and ensure that functional safety remains a foremost design priority throughout prolonged development cycles — from the earliest planning and design stages to simulations, development, and deployment. DevSecOps development processes can enhance these goals.

Avionics solutions span multiple use cases encompassing 5G networked communications in ground stations, embedded satellite deployments, aircraft navigation and air defense systems, air traffic control, and more. Technologies that are becoming indispensible in this industry sector include real-time determinism, Time-Sensitive Networking, virtualization, and container technology — co-enabled in hardware and software solutions developed by Intel and Wind River.

Components that have been proven to work together effectively elevate functional safety to requisite levels and include design elements to meet certification standards. AI, IoT, and virtualized components are often integrated into solutions. As cloud computing and the intelligent edge evolve further, enabling highly manageable software-defined environments, intelligence and real-time decision-making have become more essential in avionics systems. Harnessing these advantages requires specialized design and development expertise, experienced engineering, and fully tested interoperable components.

> "When I think about intelligent systems and new capabilities in aerospace and defense, it's not the individual assets, but how they get integrated to deliver a specific outcome. The 'glue' that holds these different assets together creates a much more effective and efficient way to achieve your objectives, whether it's a business outcome on Wall Street or a military outcome on the battlefield."
>
> **—Roberto Valla,**
> *Field Digital Transformation Officer for A&D, Wind River*



Intel® Partner Alliance Benefits

As a long-standing member of the Intel® Partner Alliance, Wind River collaboratively builds solutions for Internet of Things (IoT) implementations. Membership in the IoT Solutions Community brings together like-minded organizations to unlock opportunities across a global marketplace. Benefits include advanced training, access to a wide range of development resources, and many promotional benefits.

intel partner Gold

Avionics Safety with Intel and Wind River

The time-consuming, technically complex tasks involved in meeting airworthiness criteria can be simplified by means of processor-specific Flight Safety Evidence Packages (FSEPs) available from Intel. Embedded Intel Xeon D processors and embedded 11th Gen Intel Core processors include airworthiness evidence packages for DO-254 DAL C and DO-254 DAL A, as well as confirmed support for the leading DO-178C certifiable real-time operating system, VxWorks.

Use of select Intel processors also provides a clear pathway for meeting CAST-32A (AC-20 193 and AMC-20 193) objectives for demonstrating effective, safety-aligned multi-core processor usage. All of these combined factors help minimize efforts when certifying solutions for airworthiness standards and avionics deployments, enabling system integrators to independently achieve DO-254 certification up to DAL A.

VxWorks CERT Edition has also gained an outstanding reputation in the avionics sector and achieved certifications and evidence packages supporting DO-178C, IEC 61508, IEC 62304, and ISO 26262 safety standards.

In the future, Intel, Wind River, and other ecosystem partners will be delivering flight safety evidence and full avionics solution stacks for a variety of Intel processors and Wind River software components.

Additional Resources

To explore the ways in which VxWorks provides RTOS capabilities for embedded systems, read VxWorks: Redefining the Role of the RTOS.

Learn the ways in which Wind River Simics can expose cybersecurity threats and test complex system scenarios before installing an avionics solution in an aircraft.

For more information on cybersecurity threats, read this white paper: Cybersecurity Trends in Aerospace and Defense Applications.

For more information on airworthiness and multi-core processors, read this solution brief: Airworthiness Enablement of Systems Using Intel Multi-Core Processors.

To learn more about how Intel enables airworthiness certification, contact your Intel account executives.

To learn more about certification of safety-critical applications, visit VxWorks Safety Platforms.

About Wind River

Wind River is a global leader in delivering software for mission-critical intelligent systems. For 40 years, the company has been an innovator and pioneer, powering billions of devices and systems that require the highest levels of security, safety, and reliability. Wind River software and expertise are accelerating digital transformation across industries, including automotive, aerospace, defense, industrial, medical, and telecommunications. The company offers a comprehensive portfolio supported by world-class professional services and support and a broad partner ecosystem. To learn more, visit Wind River at www.windriver.com.

Wind River is a global leader of software for the intelligent edge. Its technology has been powering the safest, most secure devices since 1981 and is in billions of products. Wind River is accelerating the intelligent transformation of mission-critical edge systems that demand the highest levels of security, safety, and reliability.