Avionics in 2023

Using Modern Technology for Secure and Certified Software Development

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Executive Summary

Software development in the avionics industry is being rapidly shaped by new technologies and practices. Wind River® recently conducted a survey of technology leaders in the avionics field to better understand which technologies are impacting the industry most strongly and how businesses are leveraging modern software development to build next-generation avionics products.

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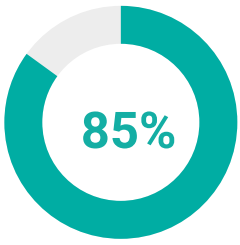
The Promise of Modern Technology in Avionics

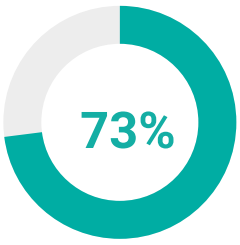
The software development tools and processes used in the avionics industry have typically trailed the IT industry by several years. High standards for safety and certification mean that the embedded system development process is document intensive and subject to strict oversight. For these reasons, software development teams in avionics tend to rely on proven development tools and workflows.

At the same time, it's evident that changing market conditions are compelling software developers in the avionics industry to evolve their practices.

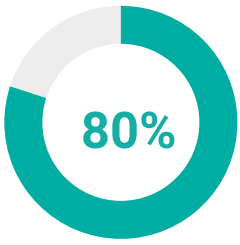
A recent Wind River survey[1] of software leaders, aimed at better understanding their priorities, uncovered the following insights:



85% see a need to increase focus on re-skilling embedded developers.

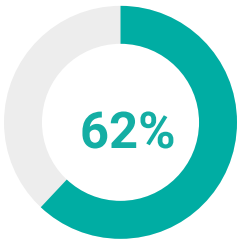


73% have increased their focus on container-based workloads for embedded systems.



80% believe there's a need to increase the focus on real-time feedback from embedded systems.

80% accelerated the focus on new business models.



62% are changing the focus on the way they work together.

NEW TECHNOLOGY IS DRIVING **MASSIVE AVIONICS INVESTMENT**

Commercial avionics systems
$54.4B by 2030[2]

Military avionics
$51B by 2023[3]

Global AI in aviation to surpass
$9.9M by 2030[4]

5G in aviation to grow to
$9.9B by 2028[5]

Beyond the general desire to modernize operations, new technologies and business priorities are helping to drive significant investment in the avionics field. Avionics investment is being propelled by new design approaches, such as microservices via containerization, as well as by autonomous controls and artificial intelligence/machine learning (AI/ML) enabled by 5G communications.

1. *Wind River, Intelligent Systems Research, 2021*
2. *Allied Market Research, Commercial Avionics Systems Market, 2022*
3. *The Brainy Insights, Military Aircraft Avionics Market, 2022*
4. *Precedence Research, Artificial Intelligence in Aviation Market Report 2022-2030*
5. *Fortune Business Insights, 5G in Aviation Market, 2022*

2023 Avionics: Current and Future Disruptors

Each of these technologies and approaches plays a specific role in embedded systems development.

Modular Containerization Keeps Everything Nimble

While containers have existed in the IT industry for decades, they're just starting to have a significant impact on the development of embedded systems. Containers can help address the many challenges of running intelligent software systems on the edge. Wrapping software and its supporting dependencies in a container allows developers to decouple applications from the underlying hardware and build modular applications that are easier to update, while also addressing some of the important challenges of managing a highly distributed software system. For example, by leveraging containerized applications, developers can push upgrades and new features as needed, allowing them to respond to zero-day cybersecurity threats far faster than they could under the current monolithic offering of software solutions. You can use the same process to release a feature and adjust a system for a given theater of operation, quickly making changes that take weeks to months under the traditional approach.

Unique challenges are posed by containerization in the embedded systems world, however. They include the tight coupling of software and hardware systems, the need for specialized development tools, and frequent low-level interactions between avionics peripherals. To meet these challenges, avionics firms may need to look beyond legacy container platforms, such as enterprise Linux, in favor of lighter-weight tools that are better suited to small-footprint embedded systems.

Vision Systems Increase Autonomy and Precision

Based on AI/ML, evolving vision systems in avionics are driving increased autonomy. In fact, the avionics industry has embraced computer vision faster than the other technologies listed here. But, as the number of compelling use cases for computer vision in both military and civil aviation continues to expand, there remains ample room for deeper adoption.

Currently, military aircraft are employing computer vision systems to monitor pilot health and fatigue in high G-force situations, enhancing security where no copilot is present. In civilian aviation, computer vision can be used to enhance pilot awareness and allows pilots to execute complicated tasks without needing to break concentration. In both sectors, computer vision is significantly impacting maintenance processes, such as inspecting an airframe and its landing gear for damage. Vision systems can even locate patterns of wear that the human eye cannot locate on its own, pointing the way to an entirely new maintenance paradigm.

5G Enables Near Real-Time Signaling and Communication

As the idea of unmanned traffic management (UTM) becomes more mainstream, 5G can help lay the foundation for data and information sharing between drones and other forms of autonomous aircraft. Additionally, 5G technology is being used to improve supply chain efficiency, speed airplane-to-ground (ATG) communication, and facilitate communication between different components on the airframe.

Autonomous Controls Are Both Proactive and Reactive

Autonomous controls in avionics have a history dating back to the 1980s. The most visible next-generation application of autonomous systems in aviation are delivery and cargo drones, but the potential use cases go beyond low-altitude flight control. They now include systems designed to increase safety and efficiency, such as next-generation collision prevention systems that use both computer vision and artificial intelligence to help aircraft avoid obstacles in increasingly crowded airspace.

Artificial Intelligence Helps Build Faster and Smarter Systems

AI is maturing beyond a marketing buzzword into an impactful technology with numerous real-world applications in both civil and military avionics. There are already compelling AI applications in help management, flight control, and emergency systems. Broadly, these uses break down into two main categories:

Real-Time Decision Making

3-D display systems such as the synthetic vision system (SVS) provide complex renderings of the terrain below an airframe to provide greater situational awareness. Emerging uses include route planning and supersonic boom management on the next generation of hypersonic aircraft, such as the Lockheed Martin X-59.

Non–Time-Critical Decisions

Remote cloud-based analysis of sensor data collected from aircraft can be used to ensure efficient operation as part of a predictive maintenance strategy, provide conversational assistance to the flight crew, and extract knowledge from unstructured data sets such as strain sensors, vibration sensors, and piezoelectric sensors.

It is worth noting that in military avionics, sixth-generation fighters are being designed with an autonomous mode as a core feature. Machine learning and deep learning algorithms will play an integral role in the development of those systems.

> "Artificial intelligence has reached a maturity level that makes it very interesting for a wide range of applications in avionics, both commercial and military."
>
> **— Michel Chabroux,**
> Senior Director, Product Management, Wind River

Modern Software Development Is Key to New Avionics Technology

To enable these new approaches and technologies, avionics developers are increasingly turning to modern software development practices, including:

1. DevSecOps
2. Continuous integration/continuous deployment (CI/CD) and Simulation
3. Virtualization and Containers
4. Data feedback loops for AI/ML

Software development teams working in the avionics industry can use each of these practices to unlock new potential.

Understanding and Using DevSecOps in Avionics System Development

Most software developers are familiar with the DevSecOps concept and how it helps bridge the chasm between development and operations teams. Already widely adopted by enterprises, DevSecOps is starting to become a reality for embedded systems development scenarios such as avionics.

Avionics firms can expect benefits from adopting a DevSecOps software development approach:

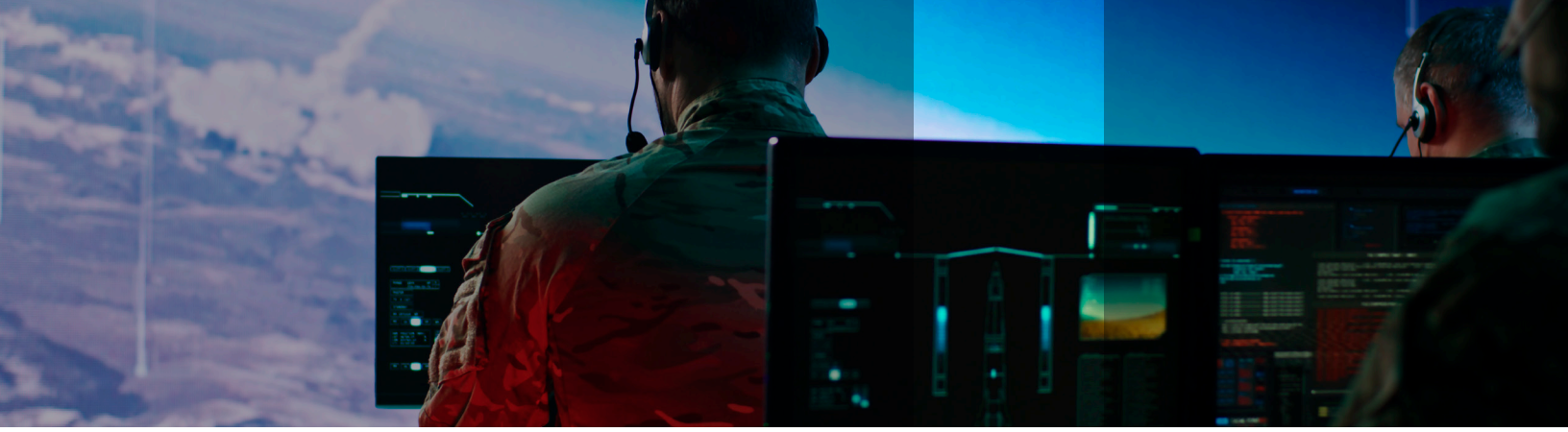
- Faster iteration on software and products
- Streamlined product development processes
- Integration of security controls deep into the development workflow
- Capture and transmission of institutional security knowledge

The biggest challenge is the need to meet strict validation and certification requirements. Typically, the approach has focused on safety, which means keeping the airplane from hurting people. Now an equal amount of attention is being paid to security, ensuring that humans cannot harm the machine.

Avionics systems that need certification by either the FAA (U.S.) or EASA (Europe) must meet strict requirements, which include:

- **DO-178C:** Governs the certification of software for airborne systems in commercial aircraft and model-based verification
- **EASA AMC 20-42:** Maps cybersecurity elements for flying machines, helping manufacturers eliminate or mitigate the impact of unauthorized electronic access
- **DO-326A/ED-202A:** The de facto industry standard for aircraft cybersecurity, released in 2018, outlining security development standards to protect engines, propellers, and other aircraft components from malicious interference
- **DO-355A/ED-204A:** Focused guidance around the operation, support, maintenance, administration, and decommissioning stages of the product lifecycle
- **DO-356A:** Compliance and airworthiness security requirements for the development process, with a focus on system manipulation and malware attack

Until recently, these standards were adopted slowly, often on a case-by-case basis. As new avionics technologies continue to move into the mainstream, however, they should be viewed as necessary standards, which means that any DevSecOps process should unfold with compliance as a prerequisite.



At the same time, high security and safety standards — as well as the long and complex development cycle — mean there's no universally applicable approach for DevSecOps in avionics. Organizations should approach their DevSecOps transformation after a deep analysis of their existing products and workflows.

Leveraging CI/CD and Simulation

Closely related to the DevSecOps model is the concept of continuous integration/continuous development (CI/CD). A CI/CD pipeline allows developers to organize the steps necessary to release a new version of their software.

Avionics firms can use CI/CD pipelines to locate and address integration, deployment, and security issues much faster than they'd be able to under a traditional development model. But, as with DevSecOps, adopting CI/CD practices in an avionics environment means addressing unique challenges that normal IT firms can't handle.

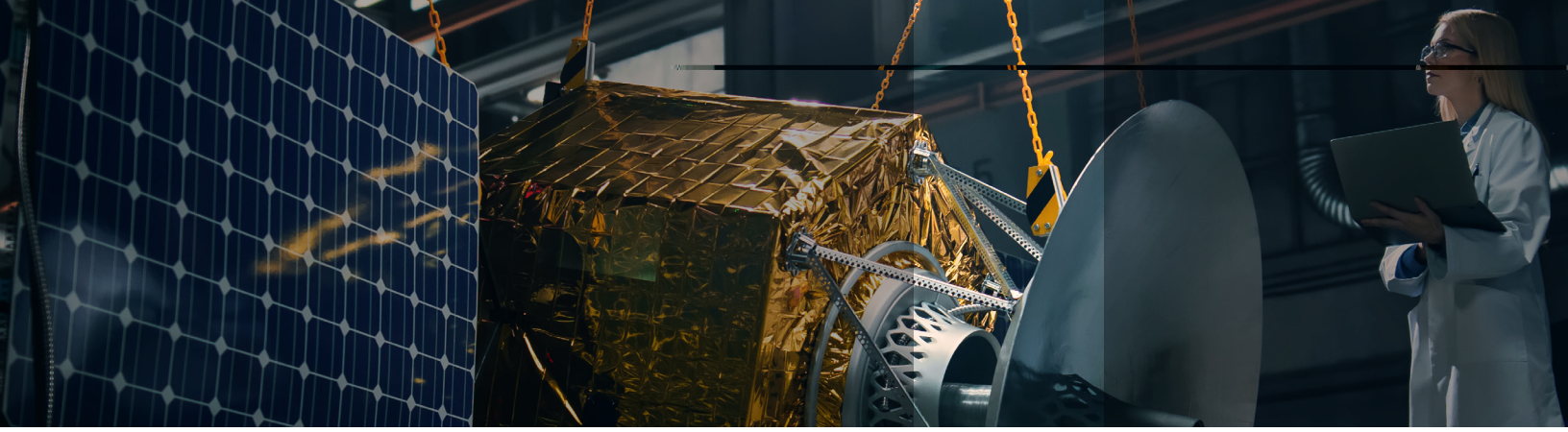
A primary challenge is that avionics hardware is extremely expensive and complex to operate. With limited access to the physical devices, software developers need to test new software in simulated environments before deployment.

In simple scenarios, Monte Carlo simulation can be sufficient to be able to judge risk for a simple or isolated system. In more complex situations, low-fidelity simulations can provide quick insights about simple software-level interactions. Popular open source tools such as QEMU are ideal for this category of mid-level machine process simulation.

At the high end, solutions such as Wind River Studio allow developers to create fully functional, large-scale simulations using a complete digital twin of their avionics environments. A high-fidelity model of a target system, including CPU behavior, interrupts, and device interactions, helps developers unearth valuable insights about an application's performance and integration issues much faster and less expensively than hardware-based testing.

What's more, Wind River and other cloud-based solutions allow development teams to run simulations from anywhere, streamlining collaboration and making testing and validation more agile.

> "The industry is aiming for CI/CD, but that doesn't mean to deploy it all the time. That means that teams are constantly ready for deployment, should that be the case."
>
> **— Michel Chabroux,**
> Senior Director, Product Management, Wind River



Virtualization and Containers Enable On-Demand Deployment

Virtualization technology has been a feature of the avionics industry for many years. Though the idea of integrated modular avionics was first formalized in 1996 in ARINC 653, the trend extends back to the late 1980s.

Today, as semiconductor vendors provide systems-on-chip (SoCs) that can make deeper consolidation and integration a reality, the idea of having multiple applications with independent levels of safety, running side by side in one device, is becoming more viable. The hardware platforms available today are powerful enough to support more and more applications, allowing a virtualization system to enable dozens of operating systems on a single platform.

There are several ways that businesses benefit from virtualization and containers to improve the development, test, deployment, and management of systems. For example, containerization allows developers to collaborate in a safety-certified simulated environment without being constrained by the amount of development hardware available.

Companies can use containers and virtualization to help create a more nimble and agile development process:

- **Linux and real-time operating systems:** Real-time operating systems provide a foundation for next-generation embedded development in avionics, reducing the time and expense of platform development and certification.
- **System upgrades:** Developers can incorporate new technologies and features on the fly, without needing to disrupt otherwise stable software or hardware systems.
- **Software-defined infrastructures:** New SoCs enable the integration of heterogeneous systems in a single, virtualized environment, reducing cost and complexity.
- **Installation of new technologies:** Containerized applications give developers the flexibility to deploy new functions into an operating environment without impacting related services.
- **Cybersecurity threat updates and patches:** Developers can quickly push security patches and upgrades to systems to respond to emerging threats, benefiting both civilian and military aviation systems.

Studio leverages the container specification promoted by the Open Container Initiative of the Cloud Native Computing Foundation. Standardized image specification, runtime specification, and distribution specification help maximize the interoperability and portability of applications while also helping to reduce friction in the containerized software development process.

The Value of AI and Data Infusion in Secure and Certified Avionics

Both artificial intelligence (AI) and machine learning (ML) have matured at a rapid pace. Today, numerous impactful applications of both technologies are improving the safety and reliability of avionics systems while also providing businesses entirely new models to generate value and profit. Opportunities include:

- **Improved situational awareness:** Computer vision systems are being designed to give pilots a better understanding of the air traffic, weather, and terrain around them, reducing their mental load and helping them focus.
- **Increased safety and security:** Processing and presenting complex air traffic data via AI/ML gives pilots an intuitive way to contend with the growing number of commercial aircraft, while helping military pilots better understand targets and threats.

• **Predictive maintenance and supply chain management:** Analyzing data collected by sensors throughout the airframe can help aerospace companies proactively identify maintenance issues and ensure the availability of replacement components.
• **Streamlined flight systems and operations:** Flight path programming, such as that deployed by Alaska Airlines during the COVID-19 pandemic, can reduce fuel consumption and shorten flight times.

Data Feedback Loops Improve AI and ML Outcomes

How can avionics companies use data to improve quality, security, and operational outcomes? The data landscape has created enormous opportunities. There are four primary sources of data that businesses can leverage to feed data-hungry AI models:

- Platform and application data
- System/device data
- Operations/infrastructure data
- Customer/user data

Businesses can leverage data feedback loops to refine their AI models, creating a virtuous cycle of AI-powered decision-making that optimizes the health, performance, and maintenance of operational technology systems. Examples include:
• **Customer experience:** Customer data can play an important role in civilian aviation customer experience, helping planes be more responsive to passengers' unique needs and helping promote loyalty.
• **Real-life modeling:** Engineers can leverage AI to refine models created in MATLAB and other modeling software to help minimize deviations and increase efficiency.
• **Predictive maintenance:** Sensor data from around the airframe can help maintenance engineers anticipate, prioritize, and address issues that would be difficult to detect otherwise. According to the Advisory Council for Aviation Research and Innovation in Europe (ACARE), predictive maintenance could save up to €700 million ($744M USD) per year in Europe alone.
• **New AI-driven business models:** The avionics industry felt the COVID-19 pandemic. Massive cuts in air travel and aviation equipment forced business leaders to look beyond new features as the primary source of revenue and reevaluate their businesses from the ground up.

Following the lead of companies in adjacent industries such as automotive, avionics companies are now starting to explore how to leverage AI and ML to open new sources of profit. Like BMW's recently released heated-seat-as-a-service option, on-demand services, video streams, and other subscription-based services have the potential to continue unlocking entirely new streams of value for forward-thinking companies.

Modern Technologies Will Help Avionics Systems Developers Meet Future Demand

Businesses in the avionics field that take the time to ensure that data infusion is taking place at every stage of the development process — development, deployment, operation, and service — will enjoy the prospect of almost limitless opportunity as AI, computer vision, autonomation, and other new technologies continue to improve and find new and impactful applications in avionics.

As always, the primary focus must remain functional safety. That means mitigating worker error and hardware failure in the dynamic avionics operating environment while maintaining strict adherence to the industry's safety regulations.

WIND RIVER SOFTWARE IS USED ACROSS 740+ PROJECTS BY 320+ CUSTOMERS IN 120+ AIRCRAFTS.

Wind River Studio: A Cloud-Native Platform for Mission-Critical Intelligent Edge Systems

Studio helps avionics firms leverage modern software development processes and tools with minimal stress.

A completely cloud-native environment with full CI/CD pipeline infrastructure, automated processes for testing with simulation, data ingestion and collection, and more, Studio provides a complete toolset for developing, deploying, and operating mission-critical intelligent systems across the edge.

To learn more, visit windriver.com/studio.