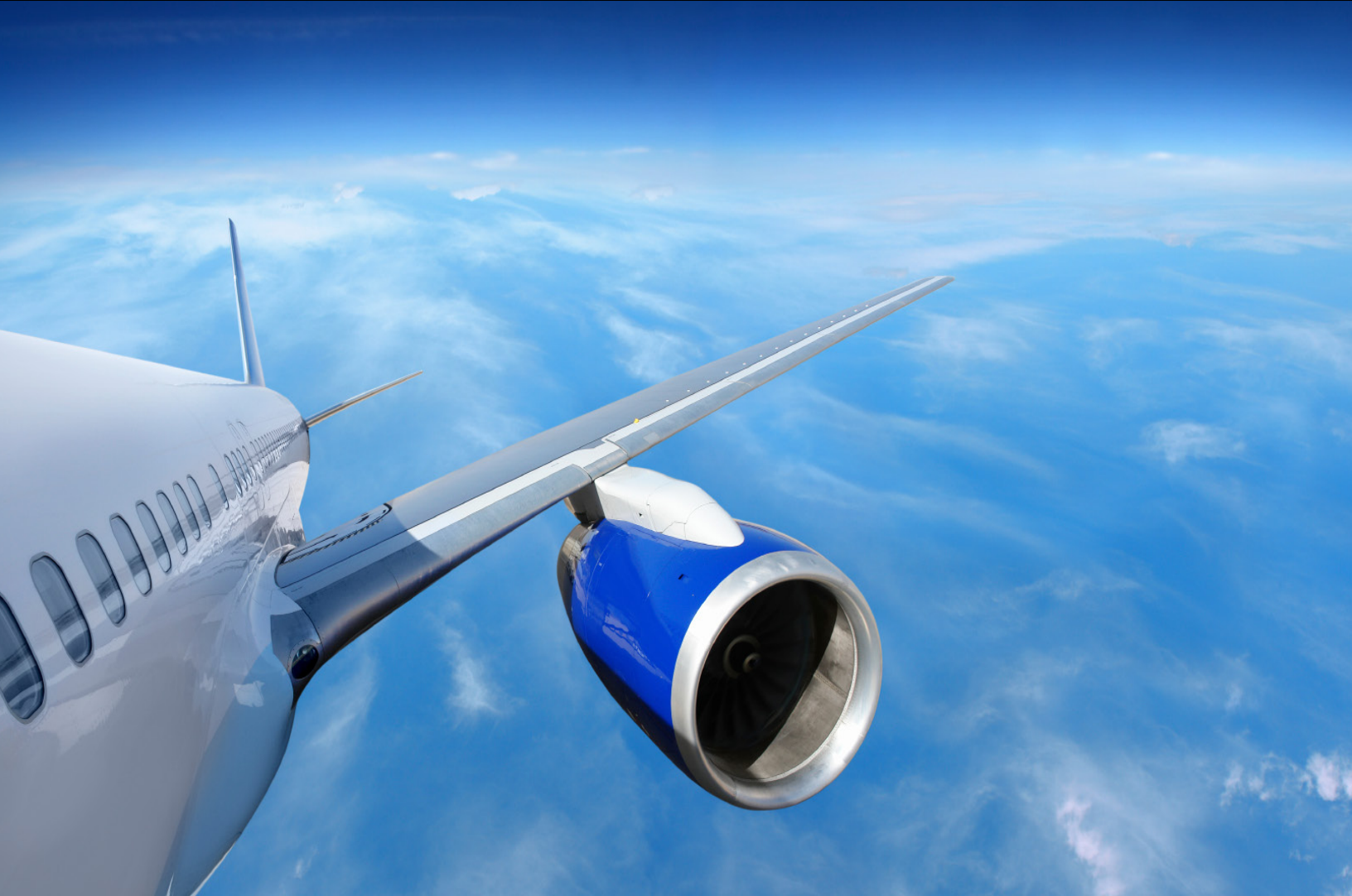




AN INTEL COMPANY

THE INTERNET OF THINGS IN COMMERCIAL AVIATION



WHEN IT MATTERS, IT RUNS ON WIND RIVER

EXECUTIVE SUMMARY

The Internet of Things (IoT) can be summed up in one word: opportunity. By connecting devices and data, IoT presents opportunities for organizations to transform themselves, gain entry into new markets, and harness data to drive more timely and powerful business decisions. At the same time, it gives consumers new opportunities to enjoy exciting new user experiences and conveniences. This paper looks at IoT opportunities in the commercial aviation industry, exploring what vendors can do to exploit the opportunities—and how Wind River® can help transform opportunity into reality.

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WHERE IS THE OPPORTUNITY WITHIN COMMERCIAL AVIATION?

Commercial aviation covers many segments, encompassing transportation, business aviation, freight, sport, and personal aviation—and in the future, autonomous unmanned aircraft. There are many factors involved in the operation and maintenance of these sectors, and as such it is a highly regulated market, with governmental control of airspace and airspace operations.

The classic IoT model (see Figure 1) shows data collected from devices and transmitted through the network to cloud services, where the real-time intelligence drives productivity gains. For commercial aviation, however, there is no single owner who controls the entire solution, or system of systems. Airlines typically own the aircraft and the associated ground maintenance facilities; communications have to go through avionics radios, the Aircraft Communications Addressing and Reporting System (ACARS) datalink, or commercial broadband services; and in flight the operations are controlled by the airspace operators, typically run by government agencies such as the FAA or EUROCONTROL.

This multi-owner, multi-tenant environment makes it particularly challenging to implement system-of-system efficiencies, and to exploit data in the emerging concepts of IoT.

Despite the conservative nature of commercial aviation, however, this is one business segment where many of today’s IoT concepts are already being applied. Two operational examples demonstrate IoT concepts very well:

- 1. Operation of the airspace as an open architecture IoT system
- 2. Use of IoT concepts in the management and operation of individual devices operating in that airspace

Operation of the Airspace As an Open Architecture IoT System

Commercial airspace operations are driving modernization efforts through programs such as NextGen (U.S.) and SESAR (Europe). These programs aim at increasing connectivity and information flow through the airspace in order to maximize efficiency and provide IoT-like value to operators and users of the airspace.

One side effect of this efficiency is a more environmentally friendly commercial aviation segment, which is beneficial for all parties; another is the creation of more efficient flight paths, reducing wait time on takeoff and landing, which leads to happier passengers who fly more often—and as a result, increased revenue.

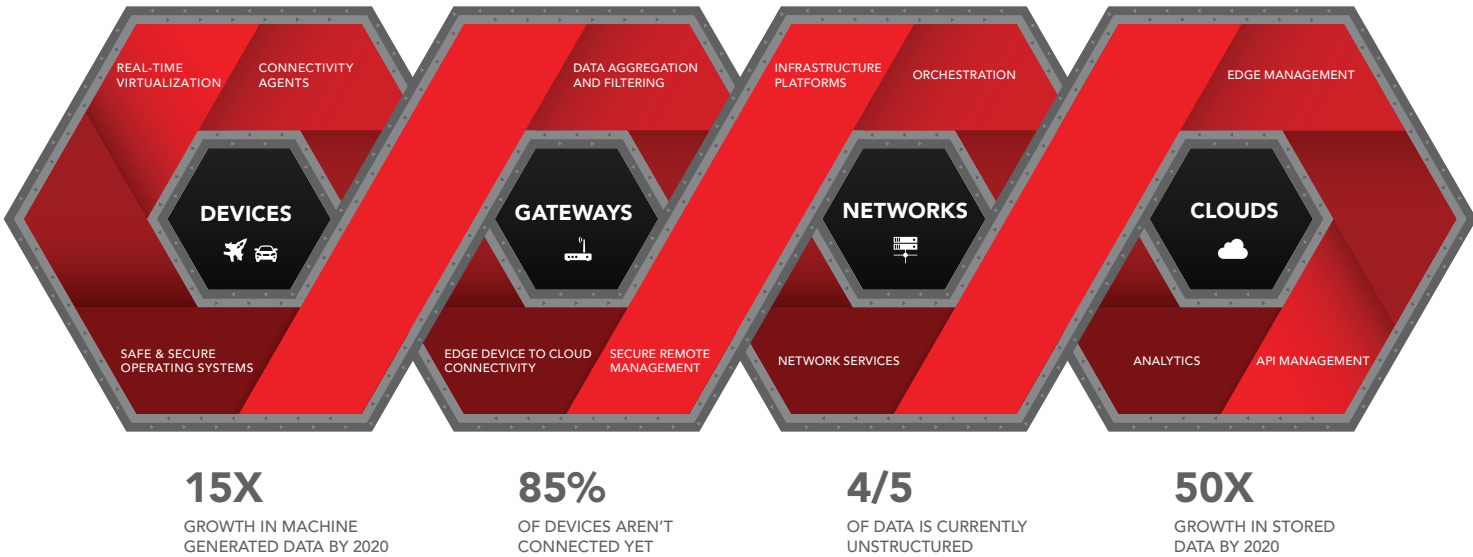


Figure 1: Wind River Internet of Things topology

The driving force behind this effort is the high value of real-time performance and navigation data in this segment, with its potential for streamlining efficiency and reducing operational expenses (OPEX). Fuel is one of the highest costs for aircraft operators; at the same time, the majority of revenue comes from passenger tickets, so having an aircraft grounded or delayed not only directly affects OPEX, but also potentially affects revenue through the impact on both passenger loyalty and brand image. As a result, the stakes are high.

In order to benefit from the opportunity offered by increased connectivity, airlines must upgrade existing systems to provide enhanced data, which must be transmitted through the aviation network (shown as the network infrastructure in Figure 1) to the air traffic control centers. Although the automation provided by these upgrades allows for the more efficient operations, it also introduces new security and safety requirements to ensure that the excellent safety record of commercial aerospace is not compromised.

One of the new services offered by these upgrades is implemented through an open, internationally agreed-upon cloud service: System Wide Information Management (SWIM) (Figure 2). SWIM aggregates data about all aspects of aircraft operations, including flight paths, coordination of takeoff and landing, weather information, and operational data about airspace and airports.

This cloud-based service provides an open architecture framework that allows system users to benefit from these new services. By combining data from various sources, additional benefits can be provided. For example, aircraft encountering turbulence can report that information through SWIM to allow other airspace users to avoid that area.

Use of IoT Concepts in the Management and Operation of Individual Devices

Device manufacturers within this segment face many challenges that can be addressed by exploiting IoT concepts. In order to operate aircraft within this space, manufacturers have to obtain an

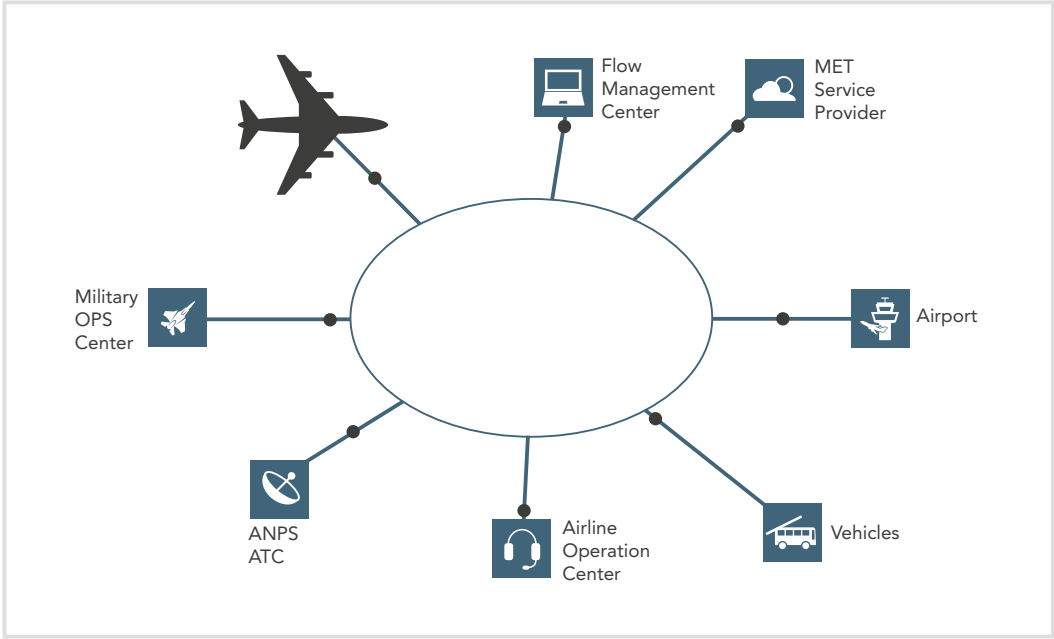


Figure 2: System Wide Information Management

aircraft type certificate, which in turn means that devices within the aircraft have to be safety-certified, typically following the RTCA DO-178 and EUROCAE ED-12 standard for software, and RTCA DO-274 and EUROCAE ED-80 for hardware. These requirements mean that development of these devices is necessarily more complex than for similar consumer devices. But they can still benefit from the opportunity and efficiencies that IoT enables.

Sensor packages that monitor an engine's usage and collect performance, vibration, and fuel consumption data have been in existence for a number of years. This data enables the engine manufacturer to advise the carrier on corrective measures, usually during scheduled maintenance phases, and has been used to predict and optimize when maintenance is required based on analyzing this data over many years of operation.

With the advent of IoT, greater connectivity to the aircraft has enabled engine manufacturers to exploit this data sooner, allowing prompter servicing as well as advising on operational changes, such as those that would result in fuel savings or other advantageous operations (for example, changing a landing sequence to put less stress on the engine).

Using IoT intelligence also drives business model changes. For example, IoT systems give engine manufacturers the ability to lease engines to carriers based on actual usage in flight, rather than selling them outright, reducing capital expenses (CAPEX) for operators. Under this business model the engine manufacturer takes responsibility for maintaining and optimizing the engine, which can be of significant value to the carrier.

In the past, carriers could mitigate the risk of equipment failure only by taking an aircraft out of service for inspection at scheduled intervals; nevertheless, in some cases equipment failure could still lead to unscheduled out-of-service aircraft, which is very expensive and disruptive for the airlines. Predictive maintenance, along with synchronized logistics—made possible by interconnected smart sensors and data analytics linked to the logistics system—reduces not only the risk of in-flight failure but also the number of aircraft sitting idle in hangars, awaiting parts and service.

With a worldwide fleet, it's essential to have the right parts and engineering resources when and where they're needed. Real-time IoT systems that can match maintenance, repair, and overhaul (MRO) requirements with parts availability can help ensure the timely delivery of parts and service engineers.

THE CHALLENGE OF DATA SECURITY

Under current regulations, security must be addressed not only as part of the aircraft type certification, following RTCA DO-326 and EUROCAE ED-202, but also as part of the ongoing airworthiness certification. Security must be addressed as part of the aircraft design, and a process must then also be put in place for ongoing security maintenance and management.

At present this is typically accomplished by making sure none of the Internet-connected devices are connected to any of the safety-critical flight systems or networks. This practice prevents malicious attacks from crossing between the Internet itself and safety-critical applications, hence maintaining the safety of the aircraft. But this solution is also very limiting, as the whole point of IoT is to free valuable device data by connecting devices to cloud-based services for exploitation; the availability of bandwidth for this data is critical for this opportunity to be realized.

Integrated Modular Avionics (IMA) already enables system design that separates applications from a safety perspective. This technology can easily be extended to provide security separation, so that data can be protected in the safety-critical flight systems but also made available for transmission to the SWIM system. However, regulations and processes need to be updated in order to mitigate the security risk and ensure that procedures are in place to prevent any compromise of safety.

HANDLING THE VOLUME OF DATA

Once the system has been secured end-to-end, the challenge of handling the vast volumes of data created by aircraft systems needs to be addressed. This means not just increasing the bandwidth of available links, but also ensuring both connectivity and quality of service, as well as the ability to adapt to situational requirements; bandwidth could be allocated to flight data rather than passengers during an emergency situation, for example.

This challenge is similar to what the commercial networking infrastructure is facing with the proliferation of smart, "video-enabled" phones and tablets. In the commercial world, bandwidth and quality-of-service challenges are being addressed with the use of high-bandwidth carrier grade network infrastructure. In addition to the high availability of these servers, they allow new approaches to the challenges of varying demand by providing a path for Network Functions Virtualization (NFV). NFV offers the

ability to dynamically configure the network infrastructure through a sophisticated management protocol that allows optimization for different situations, such as giving priority to certain data flows, or protecting parts of the network from certain attacks.

These commercial solutions can be adapted to the control and management of data as it passes through the air traffic control networks to get to the SWIM cloud. They can provide air traffic controllers the ability to quickly configure data feeds for changing operational requirements (violent storms, volcanoes, emergency situations, etc.), and manage device and data security throughout the system.

CHANGE OF SCOPE: TARGETED MARKETING

The transformation enabled by IoT extends beyond technical and business model changes to the scope of the business itself. Passenger numbers are predicted to continue growing over the next decade, creating a captive audience for product and service offerings, both for the airlines themselves and for their partners. IoT systems could target passengers with offers for future travel, car rentals, hotels, offers on excursions, and other traveler interests.

This valuable customer data needs to be identified, sorted, and published in order to enable its effective use. And, of course, the collection of this intelligence needs to be balanced with privacy and national security issues, especially when traveling to or from many diverse regions where privacy laws differ greatly.

LOOKING TO THE FUTURE: AUTONOMOUS UNMANNED AIRCRAFT

Devices have changed greatly over the last few decades, from federated devices, to connected devices, to IMA, to virtualized applications and operating systems running on open, commercial off-the-shelf architectures. The next step in this evolution will be the advent of fully autonomous devices that can make decisions independently from their human operators.

This vision is already emerging in the IoT world, with devices making decisions to shut down or change operating parameters for more efficiency based on sensor inputs and other external data sources. But this evolution will be constrained until safety and security requirements can be proven in flight operations.

There are several commercial use cases for unmanned aerial vehicles (UAVs):

- Search and rescue operations
- Remote surveillance (e.g., pipeline monitoring, electrical cable transmission monitoring)
- Farm surveillance
- Resource scanning (looking for mineral sources)
- Support during environmental or natural disasters
- Hazardous environmental assessment and control

Current regulations require UAVs to be handled manually (that is, with no autonomous operations), but as this technology advances it would be far more efficient—and even safer—to enable autonomous operations. For example, a swarm of low-cost UAVs could very quickly cover a search area looking for some particular object (e.g., a missing person, capsized yacht, or source of fire).

The operation of UAVs necessarily includes a datalink from the vehicle back to the operations center, which provides the required connectivity for an IoT system. Unmanned systems in military use are already moving toward control through a standardized cloud-based architecture, and exploitation of sensor data is where the real value of unmanned systems resides.

WIND RIVER: DRIVING SUCCESS IN THE IOT ERA

As a worldwide leader in embedded solutions, Wind River is uniquely positioned to help the commercial aviation industry take advantage of the new opportunities described in this paper. Wind River Helix™ is our portfolio of software, technologies, tools, and services for addressing the system-level challenges and opportunities created by IoT. It offers the following points of value:

- Building safe and secure systems is the hallmark of Wind River. For the past 30 years Wind River technology has been tested and proven for safety, security, and reliability, without compromising performance.
- We're now harnessing our decades of field experience to deploy advanced technologies such as software agents and microkernels to more fully integrate our ultra-reliable operating systems into IoT.

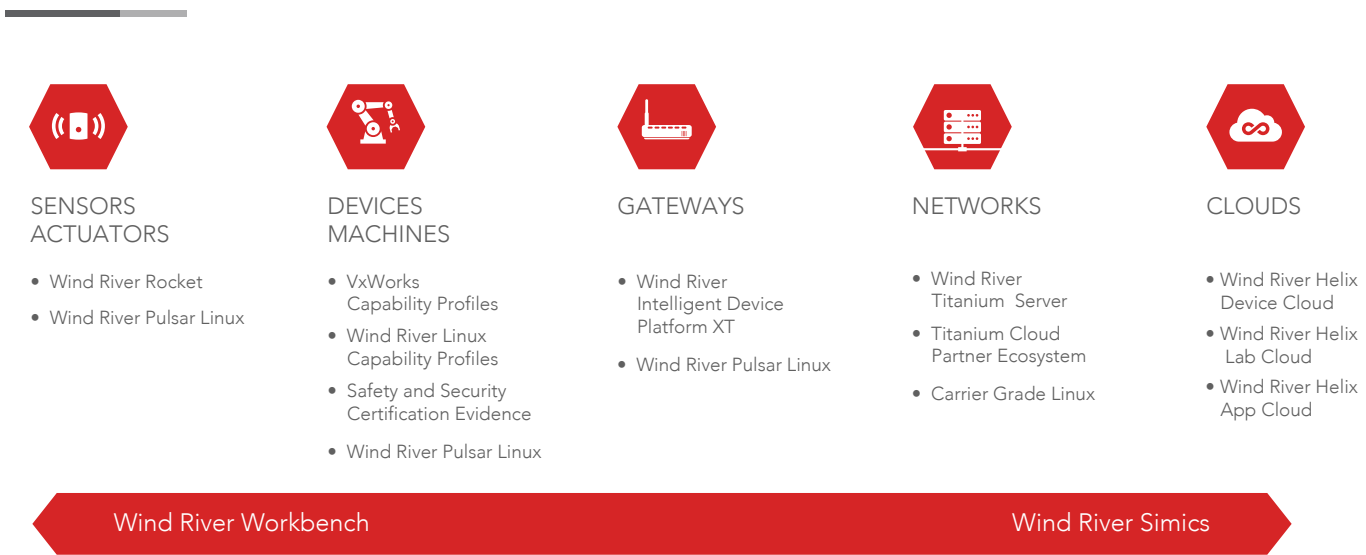


Figure 3: Wind River Helix portfolio applied to IoT topology

- Wind River Intelligent Device Platform XT offers crucial software support for the development, integration, and deployment of IoT gateways, providing secure gateways between passenger and crew networks.
- Wind River Titanium Server enables an NFV infrastructure to achieve the high reliability and high performance mandated for network-enabled systems of systems and combat clouds.
- Wind River Helix Device Cloud is a cloud-based platform that helps sensors, devices, and machines connect securely to your network infrastructure.
- Our commitment to open standards leads the industry, with a wide range of solutions using ARINC 653, Carrier Grade Linux, Eclipse, FACE™, POSIX®, and the Yocto Project.
- Wind River platform consolidation solutions enable developers to deliver powerful integrated IoT solutions quickly, while driving down size, weight, and power (SWaP) requirements and system deployment and operational costs.
- Wind River Simics® simulates systems—from the smallest to the most complex—so you can adopt new development techniques that are simply not possible with physical hardware. These new development techniques accelerate every phase of your development lifecycle, dramatically reducing the risk of shipping late, overrunning budget, and sacrificing quality.
- The global Wind River Professional Services and Wind River Education Services teams help customers gain a competitive edge by providing design support from concept through implementation.

CONCLUSION

Opportunities exist today for the deployment of IoT technologies to the commercial aviation industry. These opportunities span both operational efficiencies in commercial aircraft flight as well as opportunities to exploit real-time device data to provide integrated predictive maintenance and intelligence linked into advanced flight management and MRO systems. Future autonomous systems will also provide an excellent opportunity for new market segments as regulations are released to provide for safe operation alongside passenger-carrying aircraft.

With Wind River as a business partner, the commercial aviation industry is poised to reap the benefits of the next generation of high-value network-enabled solutions, enabling an affordable Internet of Things for commercial aviation.

