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Pitfalls of Designing, Developing, and Maintaining Modular Avionics Systems in the Name of Sustainability

Tammy Reeve

EMERGING ISSUES IN NEW MOBILITY
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RESEARCH REPORT

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Reeve has a Bachelor of Science in Electrical Engineering from California State University, Fullerton with an emphasis in digital hardware design and a Master of Science in Software Engineering from Seattle University. As a DER, she actively participates in and has been requested to attend FAA and European Aviation Safety Agency (EASA) working groups on various software- and hardware-related research and policy topics, including the SAE WG34 for Machine Learning and AI working group, RTCA DO-254 (Design Assurance Guidance for Airborne Electronic Hardware) FAA workshops; FAA Overarching Properties working group; RTCA DO-178C-related working groups (SC-205 DO-178C model-based subgroup, SC-190 working groups, reusable tool qualification); and development of the FAA Academy Airborne Electronic Hardware (DO-254) training course.

Reeve is a member of the RTCA Forum for Aeronautical Software and Chair for the USA DO-254 Users group. She is authorized as a Software and Airborne Electronic Hardware (PLDS, FPGAs, ASIC) DER for levels A–E, and is also authorized for EASA validation programs. She is authorized for CFR 23, 25, 27, 29, and 33 as well as working many FAA Technical Standing Orders and EASA European Technical Standard Orders.

In 2020, Reeve was awarded SAE International's J. Cordell Breed Award for Women Leaders in recognition of her work in the mobility industry.

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Pitfalls of Designing, Developing, and Maintaining Modular Avionics Systems in the Name of Sustainability

Abstract

Sustainability is both an ethical responsibility and a business concern for the aerospace industry. Military and commercial avionics developers have pushed toward a common standard for interfaces, computing platforms, and software in hopes of having "reusability" and reducing weight with backplane computing architectures, which, in theory, would support commonality across aircraft systems. The integrated modular avionics (IMA) and military Future Airborne Capability Environment (FACE) standards are two such examples. They emerged to support common computing architectures for reuse and sustainability concepts, from the beginning of aircraft development to the sundown or mortality phase. This report looks at technological, organizational, and cultural challenges making sustainability goals difficult to realize within reuse and IMA platform models. Additionally, it considers the certification aspects of reuse and examines lessons learned from a successful reusable and sustainable platform.

NOTE: SAE Edge Research Reports are intended to identify and illuminate key issues in emerging, but still unsettled, technologies of interest to the mobility industry. The goal of SAE Edge Research Reports is to stimulate discussion and work in the hope of promoting and speeding the resolution of identified issues. These reports are not intended to resolve the challenges they identify or close any topic to further scrutiny.

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Introduction: What Is Sustainability in Aviation?

When discussing the topic of sustainability, most members of the mechanical, electrical, and software engineering community think of environmental impacts related to carbon footprint and toxic materials usage; this paper explores the viability of these initiatives in the world of aviation.

Sustainability is a very overloaded term in today's cultural, political, and engineering environments. To help focus the topic of discussion in this report, the following definition of sustainability will be used:

> Sustainable engineering is the practice of designing products and processes that drive material and energy efficiencies to minimize their environmental impact while cutting costs and improving the bottom line.

This report explores the aviation industry's push toward reuse of hardware and software aspects of aviation products in the pursuit of sustainability. The primary drivers of sustainable engineering in aerospace are the improvement of the bottom line, ease of maintenance, and the opportunity to realize environmental benefits. In short, sustainable engineering approaches look to save time, improve efficiency, and reduce the use of materials and energy through the reuse of hardware platforms and software implementations (Figure 1).

What Are Reuse and Integrated Modular Avionics in Relation to Sustainability?

Over the last 20 years, aircraft development has moved away from line-replaceable units (LRUs) to an ethernet-based computing network with centralized computing racks. This move has occurred for many reasons but primarily to support reduction in aircraft weight and power

FIGURE 1. **The Lockheed Martin F-22 Raptor fifth-generation fighter aircraft is thought to be one of the first aircraft to utilize an integrated modular avionics (IMA) architecture.**

consumption. These improvements are directly related to reduced fuel consumption, which is a sustainability goal. The LRU architectures of the past relied on stand-alone boxes for functions. Each of these units required cabling and separate power, not to mention robust mechanical housing, all of which added weight to the platform. Manufacturers of traditional LRU-based avionics also tended to utilize proprietary architectures, which meant specialized maintenance for repairs and potentially specialized manufacturing [1].

Integrated modular avionics (IMA) architectures, on the other hand, are based on a common computing platform, which is capable of hosting numerous applications utilizing a common networking protocol and underlying operating system [2]. The Boeing 777 airliner's Airplane Information Management System (AIMS) cabinet implementation was a substantial change to the traditional Boeing LRU-based architectures. As the primary supplier of this system on the 777, Honeywell used IMA architecture for the first time to provide a full cockpit integration for the primary flight-deck display systems, diagnostics, and maintenance systems (Figure 2) [3, 4].

Today's IMA platforms and hosted applications have a successful track record with regard to creating sustainable aspects in engineering. This is accomplished through reuse of hardware and basic software architecture, which then allows the specific aircraft functional applications to be hosted on an IMA platform.

How Does Civil Aviation Regulatory Considerations Intersect with Sustainability?

In addition to reuse goals, avionics developers must always consider the complexity that may be added to their compliance requirements. These requirements come from the civil aviation industry regulators: the Federal Aviation Administration (FAA) in the US and the European Aviation Safety Agency (EASA) in the European Union. The certification agencies for commercial airspace rely on regulatory law: The Code of Federal Regulations (CFR) is applied to aircraft certification in the US and Certification Specifications (CSs) in the European Union with EASA.

These regulations are applied as part of the certification basis at the time of application; however, they can shift based on changes in technology and the ongoing needs for the safety of passengers. Regulations also change with the type and size of any new aircraft. For successful sustainability of reusable hardware and software in this environment, it will always be necessary to perform a change impact assessment of the original certification basis for the initial reusable hardware or software product and then assess any changes for the new usage domain.

FIGURE 2. **Most modern cockpit systems are comprised of avionics that use IMA architectures, such as the Honeywell AIMS system.**

VladyslaV Travel photo/Shutterstock.com

In terms of the civil regulatory policy governing avionics, RTCA/DO-178C governs the development of airborne software and RTCA/DO-254 governs the development of airborne hardware. Avionics developers must comply with these standards. In the context of avionics development, there are several main situations involving reuse.

The first is the situation previously explained, the IMA. If the system being developed utilizes an IMA architecture, this means it is a complex system that will have additional regulation. A second situation is when an applicant wants to reuse a previously certified system that includes software and/or hardware. This is referred to as "previously developed software" or "previously developed hardware," and it is governed by what is included in the DO-178C and DO-254 standards. A third situation is when an applicant wants to use commercial software or hardware intellectual property in their design. This scenario has proliferated in all other segments of the electronics industry. As a result, this has forced certification authorities to address this area of concern with supplemental policy. In recent years, a number of new documents governing various aspects of this sort of reuse have been released to the industry. A fourth scenario involves the use of commercial microprocessors, which have grown incredibly complex and—with this complexity—have brought about their own regulation borne out of use and reuse concerns.

Certification of an Integrated Modular Avionics Architecture

For sustainability and reuse purposes, more and more complex avionics systems are moving to IMA architectures. These avionics systems involve hardware and software, and therefore are subject to DO-254 and DO-178C. However, the systems can be quite complex, and the complexity of things like functions of differing criticality levels sharing hardware and software resources (e.g., central processing unit and network schedules, memory, inputs, outputs) may necessitate unique design and verification assurance approaches. This means additional guidance is required.

Regulators have stepped in and delivered additional policies to address the added complexity and concerns of IMA systems. This policy provides a framework for avionics and aircraft manufacturers to certify and obtain approval of these types of systems. This was done through three levels of regulatory and industry guidance material:

1. **RTCA/DO-297 Integrated Modular Avionics (IMA) Development Guidance and Certification Considerations:** An industry-published standard for IMA systems
2. **FAA TSO C153 Integrated Modular Avionics Hardware Elements:** An FAA Technical Standing Order (TSO) that allows manufacturers to obtain stand-alone approval of printed circuit boards or modules and supporting software that come together to provide basic IMA platform resource and functions
3. **AC 20-170 Integrated Modular Avionics Development, Verification, Integration, and Approval Using RTCA/DO-297 and Technical Standard Order-C153:** An FAA aircraft-level Advisory Circular (AC) that acknowledges both preceding documents in this list and which provides clarifications for IMA application developers and aircraft integrators regarding their obligations for meeting the aircraft-level intended functions and safety and regulatory requirements when using these platforms

Addressing Previously Developed Software and Hardware

DO-178C and DO-254 make mention of previously developed software and previously developed hardware, respectively. These mentions can be found in DO-178C Section 12.0 for previously developed software and in DO-254 Section 11.0 for previously developed hardware. In this situation, the software or hardware being reused is that which has already been developed to some level of compliance in a previous program. The applicant may use components that were previously approved, but may be required to evaluate any changes from the previous approval to the conditions of the new implementation. This is done via a change impact analysis.

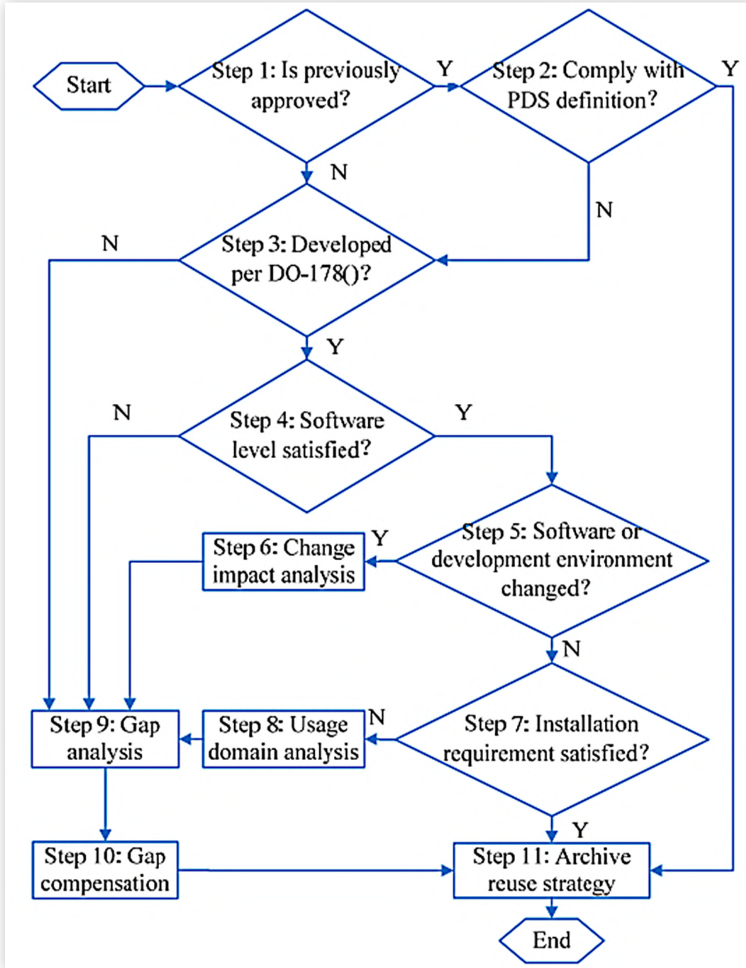
> *Components that were previously approved may be reused provided that the applicant shows that the reuse of the component is appropriate. If changes are necessary, a change impact analysis should be performed to identify the scope of the changes and the necessary activities to re-engage in to cover the changes [5].*

Each new customer that wants to reuse all or part of a previously developed and approved (i.e., compliant) avionics system must create a change impact analysis as part of the plan for reuse to understand what regulatory certification compliance credit can be taken from the initial certification effort. The impact on certification compliance is about how the hardware or software being used in the customer's aircraft will perform its function within the context of the regulations and operational requirements of the aircraft system it is now installed in. Figure 3 graphically depicts the basic flow of evaluation for using previously developed software [6].

When reusing and planning to take compliance credit from previously approved hardware and software platforms, the change impact analysis takes into account a number of factors including the following:

1. **Change in aircraft installation:** With a new aircraft comes a potentially different certification basis or regulatory requirement. Over time, regulators have identified additional objectives and modifications to

FIGURE 3. **Flowchart for using previously developed software. Previously developed hardware follows a similar approach.**



previous requirements for how to show compliance with the regulatory law. This regulatory change means that the original product baseline certification may not be sufficient for the newer installation. Examples of changes include the following:

(a) Change in aircraft certification regulations (e.g., FAA CFRs, EASA CSs)

(b) Change in environmental conditions due to different types of aircraft or locations on aircraft where installed

(c) Change in the design assurance level assigned for the hazard category

(d) Change in interfaces to the aircraft and options related to how that system is going to be used on that aircraft

(e) Review of any previously open problem reports for impact

2. **Modifications in the new integrated system and aircraft:** This includes activated and deactivated configuration options.

3. **Modifications to the design environment or tools related to design and verification:** New tools may result in modifications to the source design or new requirements related to tool qualification.

Using Commercial Intellectual Property and the Issue of Reusable Compliance Artifacts

In most segments of the electronics industry, hardware and software component reuse, in the form of commercially available intellectual property, has been common for decades. It's as easy as selecting the component, purchasing it, and using it. It's not so easy in the aviation electronics sector to reuse commercially developed software or hardware due to certification. For hardware and software to be reused across platforms, the compliance aspects of the development need to be reused as well. Establishing agreement in terms of when, how, and by whom certification compliance artifacts could be reused was paramount to this reuse effort for avionics. Several initiatives emerged to address these challenges.

Formed by The Open Group in response to the National Technology Transfer Act and Office of Management and Budget Circular A-119, the Future Airborne Capability Environment (FACE) Consortium is a technical standard for developing portable and reusable certification artifacts [7, 8]. Its sponsor members include Boeing, Collins Aerospace, Lockheed Martin, the US Air Force Life Cycle Management Center, the US Army Program Executive Office for Aviation, and US Naval Air Systems Command.

The FAA got to work on its own guidance as well. In 2001, the FAA issued the "Commercial Off-The-Shelf (COTS) Avionics Software Study," which looked at if and how it would be feasible to implement a reuse model in a safety-critical domain such as avionics. Shortly thereafter, in 2004, it published AC 20-148 to allow software developers of reusable components to receive some "credit" for certification compliance that could be reusable. The original target for this was COTS real-time operating system vendors. Its intent was to allow these vendors to recycle and reuse the compliance artifacts and software design across systems and different aircraft applications. If successful, this would result in a reduction in schedule and cost, and ultimately, could also result in a reduction in safety risk if the reused application had a good way to manage errata and service history across platforms. This would also benefit the industry by having the COTS or reusable software developer take responsibility upfront for aspects of regulation compliance and maintenance under these standards. The alternative, which was far less desirable and would result in much wasted and redundant effort, would be having each integrator of these reusable applications revisit all the regulatory compliance and enforce these on the COTS development company for each use of a COTS product.

Similar to the FAA's AC 20-148 for reusable software, after many years of reviewing, researching, and exploring the issues, the FAA issued AC 20-152A in 2022, which addresses the topic of reusable hardware. It presents seven compliance objectives that an applicant must meet if they would like to be able to use COTS intellectual property in their airborne electronic hardware designs. These objectives were developed to address a number of pitfalls that have been encountered over the years where commercial hardware components were used in aircraft designs. For example, while it might seem like the quickest and easiest solution to use an existing part as opposed to designing it from scratch, ensuring its suitability to the intended function and ensuring it comes with proper documentation is a good requirement. Likewise, the source of the design should be trusted. Similarly, it should be designed with a level of development and verification rigor expected of the intended application. If these basic criteria cannot be met, then either the reusable component should not be used or it should be subject to a higher level of compliance scrutiny using some other methods to ensure design integrity.

Note that these documents are not the final word on this topic. The software and hardware markets are quickly evolving and the policies that govern them are not static. At the time of this writing, RTCA and EUROCAE have an active Working Group (117) developing supplemental guidance "for the use of Commercial Off-the-Shelf (COTS) software and Open Source Software (OSS) in airborne and CNS/ATM applications, as well as the use of Service History (SH) to support certification and approval compliance."

Using Commercial Processors

The commercial and consumer electronics industries have come up with incredible products. Microprocessors are the intelligence behind many of these complex products. They have become so sophisticated that modern examples include systems within a single chip. They are incredibly capable; however, they pose a huge challenge to the question of safety. For applicants wanting to use these sorts of devices in their avionics products, they too face a steep learning curve in terms of compliance requirements for aircraft certification. For multi-core processors, applicants must comply with AMC 20-193/CAST-32A. Other specialty hardware such as COTS graphical processors may require other objectives and compliance requirements.

Overall, all of these reuse scenarios require a certification expert to be consulted during the planning phase of the program. Ignoring the certification aspects of reuse comes at great program peril.

Challenges to Successful Reuse of Avionics Hardware and Software

Technology

Commercial hardware platforms do not stay around for very long. The computer integrated circuit (IC) industry is constantly moving and is driven by markets that are not compatible with the very long life cycles of aviation-related products, which are meant to be certified and operated for up to 30 years. Obsolescence in hardware components often makes maintaining a common platform challenging.

Cultural

The consumer market space is continually challenging technology developers for more convenience and automation. This has influenced aircraft manufacturers and operators to offer designs for a more sophisticated passenger experience. For example, current passenger entertainment systems provide access to cellular networks and the internet, and many leverage emerging technologies, such as near-field communication, Bluetooth, and Wi-Fi. Airline operators are

FIGURE 4. **Passenger entertainment systems push the envelope of emerging technologies, with shorter development cycles and obsolescence issues that are at odds with the typically long life spans of aircraft in general.**

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competing for passengers and are offering unique, specialized environments, as well as entertainment onboard. This pushes the technology to be unique and up-to-date with the "latest and greatest" for customers. These rapidly changing technologies are not conducive to reuse and result in custom solutions across airline operators vying for the most innovative cabin experiences (Figure 4).

Another trend at odds with the avionics market is our disposable society. Culturally, electronics in the commercial space are designed to be disposable (i.e., to be thrown away with no concept of repair or maintenance). Essentially, this means that the IC market does not plan for or support long-term (i.e., 30 or more years) maintenance; instead, they are being driven by this consumer push for faster, fancier, and more features. This leaves the aviation industry with an IC market that is not aligned with the life span goals for a typical aircraft in the commercial industry.

Obsolescence becomes a real challenge for aviation developers, and this impacts the ability to reuse and standardize hardware platforms. Because avionics operate in a real-time environment, changes to hardware often result in changes to the supporting software, which may also impact the functional software applications. This makes long-term software reuse rather illusive.

Organizational

Over the years, many hardware and software programs have had the lofty goal of creating and managing reusable hardware and software platforms internally in their companies and organizations. Most of these failed after the first couple of years due to a lack of appreciation for the organizational aspects. For example, organizations failed to foresee the need to sustain these reusable products past initial development effort. Likewise, they underestimated the combined effort of deploying a common platform across multiple customers, products, and continents. Similarly, project leads are often not willing to assume the additional costs related to developing a "truly reuseable" product. There are costs associated with maintaining staff dedicated to the management across all the end customers using the common product for the life of the product in service. These personnel must manage customer-requested changes, technology obsolescence, errors that may come up during use, and quality control.

Environmental

For avionics product lines, the environmental conditions that hardware must operate in are very specific. Different zones of an aircraft have different environmental requirements. For example, something installed in a non-pressurized portion of the aircraft would require additional environmental testing versus something installed in the cabin. Anticipating all possible environmental operating conditions and developing a common platform that will work in all these conditions can be daunting and expensive.

Aviation Regulatory Considerations

Meeting regulatory compliance in the context of hardware and software reuse is another major roadblock. Complying with not only DO-178C and DO-254 but now also the myriad of additional guidance documents striving to keep up with reuse issues and processes poses even more challenges. To have a successful reuse strategy requires expertise in the area of certification compliance as well.

Lessons Learned

The aviation industry, like nearly every field that uses resources and serves the public, is looking to make operational improvements that can get behind the overall goals of sustainability. But more specifically, the field of avionics development has some truly unique aspects that make its contribution to sustainability challenging. Still, the field is ripe with opportunity, if only the industry can learn from the lessons of those leading the charge. Some of these key lessons include the following:

1. **Developing a product with a superset of features:** Full reuse potential may require a function "superset" to be developed and verified. While normal product development may gather requirements for one aircraft system or customer, for a product to be reusable, it will typically be developed with features that are a superset of functions beyond what an initial customer may want. This takes some insight and planning to ensure the product will be viable for reuse with options desirable for future customers. It is almost guaranteed that this will cost more than a basic product developed specifically for one customer.

   Along with defining the set of features for a reusable product, the verification of these features and configuration management usage domain needs to be set up to manage changes and variants of the product. This change management system will need to span all customers and will likely necessitate a change review board to assess changes across platforms.
2. **Commit to a well-researched set of potential customers:** Sales teams can sometimes bow to customer pressure, promising too many things to too many different clients. While a superset of functions is key to reuse, ensure this is a well-researched set and do not stray from this set. While a sale is usually good, bowing to sales pressure to non-target customers can dilute the benefits when non-target customer's specific needs are accommodated at the expense of the controlled reusable approach. The key is to anticipate the largest group of customers' features and stick to selling that, otherwise the result could be specialized part numbers and losing the benefits of reuse (i.e., larger quantity discounts in production and maintenance related to a single product). This undesirable situation could result in all kinds of variants of the original product, with each managed and sustained specifically for each customer separately.
3. **Funding the product to ensure it is sustained:** Reuseable programs will need a budget for the project to be sustained. The number one failure of reusable product lines is not understanding the full cost of managing and sustaining it but coming to terms with the fact that it's not a "one and done" situation. Reusable products have unique needs and related costs that follow them past initial development, such as the following:
   (a) **Quality assurance:** Review product development and production conformity of each new product variant.
   (b) **Development:** Update the product for obsolescence and errors found in field.
   (c) **Verification:** Update and run verification testing and analysis for changes.
   (d) **Configuration management:** Provide a problem reporting system that can support a "where used" search along with the ability to identify all affected customers.
   (e) **Project management:** Manage changes and schedules for deployment and making decisions on features to be updated or added.
4. **Use configurable parameters for variants whenever possible:** Incorporate variation in options through tailorable features using configurable parameters. For hardware and software, this can be accomplished through separately loadable data tables as configuration files. Physical jumpers to enable and disable hardware features can also be a means of incorporating features and allowing them to be disabled for customers who do not need them.
5. **Don't ignore the certification aspects of reuse:** Adopting a reuse strategy for avionics products comes with additional certification requirements. Account for this in planning and get educated as to the latest policy covering this topic. Seek advice from a certification expert if the team lacks internal expertise. Waiting until late in the program to consider the compliance facet of development can be detrimental to the program.

The common threads in all these lessons are that it takes upfront planning, a unique mindset, and dedicated staff—including certification expertise—throughout the product development process. The product development process itself is not a "one and done" situation, but rather a succession of variants, each with an extended partial development cycle to complete that variant. Only by understanding this can a team see the product through to its full reusable potential and to support it for the long haul. This is going to cost more than a typical single customer-type product and management needs to fully understand this before committing to such programs.

Summary

Realizing sustainability goals for reusable hardware and software across usage domains and supporting different customers requires commitment to sustaining the product with planning, research to determine the ideal "superset" of features that are tailorable as part of the design, and the right personnel from all organizations to continue to work on the product for as long as needed. All of this takes not only the right mindset but the right budget for success.

In avionics certification, reuse has added complexities from regulators. In recent years, they have invested in understanding and addressing the concerns of reuse and have delivered numerous new guidance documents that govern reuse in the safety-critical domain of avionics. The key is staying on top of the compliance requirements at the very earliest stages of project planning and ensuring certification expertise on the program.

By learning from all these pitfalls and approaching programs with the right budget and mindset, software and hardware reuse in avionics for sustainability is attainable.

SAE Edge Research Reports

SAE Edge Research Reports, like the present report, "Pitfalls of Designing, Developing, and Maintaining Modular Avionics Systems in the Name of Sustainability," are intended to push further out into still unsettled areas of technology of interest to the mobility industry. SAE launches these reports before attempting to form a joint working group, let alone a cooperative research program or a standards committee.

These reports are intended to be concise overviews of major unsettled areas where vital new technologies are emerging. An unsettled area is characterized more by confusion and controversy than established order. Early practitioners must confront an absence of agreement; their challenge is often not to seize the high ground but to find common ground. These scouting reports from the frontiers of investigation are intended merely to begin the process of sorting through critical issues, contributing to a better understanding of key problems, and providing helpful suggestions about possible next steps and avenues of investigation.

SAE Edge Research Reports, therefore, are fundamentally distinct from the more formal working groups approach and far removed from the more mature research program and standards development process.

Next Steps for Modular Avionics Systems

This publication should be considered only as a first step toward clarifying the issues around modular avionics and sustainability. The intention behind this and other SAE Edge Research Reports is to start a dialogue among interested parties on important industry-wide topics that require further attention. The expectation is that these explorations of unsettled areas of technology will lead to the formation of working groups and, ultimately, committees that can address and resolve the issues they raise. In turn, this will help produce a framework for developing a common vocabulary of definitions, best practices, protocols, and standards needed to support continued progress toward safer and more innovative products.

Recommendations

The overall recommendations of this report can be summarized as follows:

1. When planning to reuse hardware or software in avionics systems that require certification, be sure to utilize one of the recognized standards and work with regulator guidance to support successful reuse of the data.
2. Plan for a long-term sustaining budget and staff to maintain the reusable platforms across customers.
3. Management and leadership should commit to a set of features in advance that will support the maximum number of customers and avoid the temptation to change for every requested customization.

Definitions

AC - Advisory Circular

AIMS - Airplane Information Management System

CFR - Code of Federal Regulations

COTS - Commercial Off-the-Shelf

CS - Certification Specifications

DER - Designated Engineering Representative

EASA - European Aviation Safety Agency

ETSO - European Technical Standard Order

FAA - Federal Aviation Administration

FACE - Future Airborne Capability Environment

IC - Integrated Circuit

IMA - Integrated Modular Avionics

LRU - Line-Replaceable Unit

PLD - Programmable Logic Device

TSO - Technical Standing Order

US - United States [of America]

Term	Meaning
Aircraft function	The capability of the aircraft is provided by the hardware and software of the systems on the aircraft. [ED-124]
Application	Software and/or application-specific hardware with a defined set of interfaces that, when integrated with a platform(s), performs a function. [ED-124]
Backplane	The hardware circuit board, mechanical components, and connectors that implement a physical connection between the different circuit board assemblies and data networks and power buses.
Cabinet	Result of the integration of hardware modules mounted within one rack. [ETSO-2C153]
Compliance credit	Evidence that a set of objectives related to certification requirements has been reached for a component or a set of components. Credit can be full or partial, meaning that, in case of partial credit, some objectives allocated to the component were not yet satisfied and should be completed at another stage.
Component	A self-contained hardware part, software part, database, or combination of them that is configuration-controlled. A component does not provide an aircraft function by itself. [ED-124 Chapter 2.1.1]
Federated system	Aircraft equipment architecture consists of primarily line-replaceable units that perform a specific function, connected by dedicated interfaces or aircraft system data buses. [ED-124]
IMA system	Consists of an IMA platform(s) and a defined set of hosted applications. [ETSO-2C153]
Incremental certification	The incremental certification process is the process by which EASA agrees to grant compliance credit to IMA modules/platforms or hosted applications considered independently, based on activities performed at intermediate steps.
Module	A component or collection of components that may be accepted by themselves or in the context of an IMA system. A module may also comprise other modules. A module may be software, hardware, or a combination of hardware and software, which provides resources to the IMA system-hosted applications. [ED-124]
Module/platform configuration	The action of setting some adjustable characteristics of the module/platform in order to adapt it to the user context. By extension, the result of this action. NOTE: A configuration table is one way but not the only way to configure a module/platform.
Usage domain	The usage domain of an IMA module is defined as an exhaustive list of conditions (such as configuration settings, usage rules, etc.) to be respected by the user(s) to ensure that the IMA module continues to meet its characteristics. Compliance with the usage domain ensures that: • The module is compliant with its functional, performance, safety, and environmental requirements specified for all implemented intended functions; • The module characteristics documented in the user guide/manual remain at the levels guaranteed by the manufacturer; • The module remains compliant with the applicable airworthiness requirements (including continuing airworthiness aspects). [Adapted from ETSO-2C153, without reference to the ETSO Minimum Performance Standard.]

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