U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

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Subject: Aviation Databus Assurance	**Date:** XXXXXX	**AC No:** 20-Databus
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1. PURPOSE.

a. This advisory circular (AC) is for aircraft, aircraft engine, and avionics manufacturers and designers. This AC provides a means (but is not the only means) to gain Federal Aviation Administration (FAA) approval of your databus by showing the databus design performs its intended function and satisfies the applicable airworthiness requirements when installed on an aircraft or aircraft engine. This AC also offers guidance on how to get FAA approval of databus technology in an aircraft or aircraft engine.

b. Like all advisory material, this AC is not mandatory and does not constitute a regulation. Because the means of compliance in this AC are not mandatory, the term "must" applies only when you choose to follow the methods offered in their entirety.

2. MOTIVATION FOR GUIDANCE.

a. Aircraft manufacturers desire to take advantage of technology that would reduce aircraft weight and development/manufacturing time, and increase airborne system performance. This desire motivates manufacturers to consider replacing point-to-point wiring and uni-directional databuses (for example, ARINC 429 databus) with commercially available faster and lighter bi-directional databuses.

b. Aircraft and avionics manufacturers are offering several databuses for use on aircraft. The function of a databus is to transfer information between avionics modules, components, or line replaceable units (LRU) installed in an aircraft. These databuses are becoming more complex as aircraft, aircraft engine, and avionics manufacturers integrate more avionics components into the aircraft and aircraft engine data sources, requiring accommodations for larger data transfers. System design engineers have considerable flexibility when designing a databus because there are many physical and logical configurations for airborne systems architecture, data units or packets, protocols, message traffic, and so on, allowing manufacturers, vendors, and integrators more latitude when configuring databuses. This flexibility has the added burden of making it difficult to determine type design requirements, and how to maintain continued airworthiness of the databus system as required by the regulations.

c. This AC provides criteria that aircraft, aircraft engine, and avionics certification applicants must address when developing, selecting, integrating, or seeking approval of a databus technology that complies with the appropriate airworthiness requirements for an aircraft or aircraft engine. To assist you in obtaining this approval, we divided the criteria in eight categories. Each category contains criteria you as an applicant must address. However, depending on the project, you may have other project-specific criteria not specifically identified in this AC. The eight categories are:

- Safety (See paragraph 3.)
- Data integrity (See paragraph 4.)
- Databus performance (See paragraph 5.)
- Software and hardware assurance (See paragraph 6.)
- Electromagnetic compatibility (See paragraph 7.)
- Verification and validation (See paragraph 8.)
- Configuration management (See paragraph 9.)
- Security assurance (See paragraph 10.)

3. SAFETY REQUIREMENTS. As an aircraft, aircraft engine, or avionics applicant, you must determine how the databus design will affect the safe operation of the aircraft. To accomplish this task, you must follow the requirements of Title 14 of the Code of Federal Regulations (14 CFR) §§ xx.1301 and xx.1309 (where xx connotes the applicable part 23, 25, 27, 29) and the associated advisory material for the design and function of your databus. Your safety assessment of the databus design must address the following:

a. The databus architecture and implementation, using for example, the Society of Automotive Engineers' (SAE) Aerospace Recommended Practice (ARP) 4754, *Certification Considerations for Highly-Integrated or Complex Aircraft Systems* and ARP 4761, *Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment*.

b. Databus availability and reliability requirements meet the safety requirements. Your safety assessment will help determine the safety requirements.

c. Partitioning and protection of the databus' architecture and implementation requirements.

d. Failure detection, reporting, and management features such as the use of redundancy features, detecting the loss of nodes, the support of transparent shadow nodes, and the support of parallel nodes.

e. Fault containment, fault tolerance, and monitoring of the databus to protect against hardware and software faults in the host system.

f. Common cause (including common mode) and cascading failures. For each aircraft, you must perform a common cause analysis to address faults that go beyond your databus fault analysis. This common cause analysis includes a zonal safety analysis, particular risk analysis, and a common mode analysis. The location of each LRU and the routing of wiring between those components are critical in the achievement of acceptable zonal safety and determining the particular risks analyses. For critical aircraft functions supported by the databus do ***not*** route redundant channels of the databus through zones where a probable risk may cause loss of all channels. To protect databus applications, use electrical and mechanical means to isolate databus channels.

g. Methods or ways to reconfigure node(s) and the network to ensure safe operation of possible configurations and states, as appropriate.

h. Strategy for future bus expansion and how potential changes will affect system integrity and safety.

4. DATA INTEGRITY REQUIREMENTS. Data that passes between LRUs, nodes, switches, modules, or other entities must remain accurate and meet the data integrity of the aircraft functions supported by the databus. To ensure data integrity through error detection and corrections resulting from databus architectures, evaluate databus systems for the following:

a. The maximum error rate per byte expected for data transmission.

b. A means to detect and recover from errors to meet the required safety assessment criteria. Examples are cyclic redundancy checks, built-in detection, hardware mechanisms, and architecture provisions.

c. A determination of the data load analysis to specify limitations of the databus.

d. The actual specification of the databus capacity.

e. The buffer overflow and underflow limits.

f. Issues related to the databus integrity such as nodes that transmit at random instants for an arbitrary duration (babbling idiots), nodes that send an endless stream of bits (jabbering devices), packet collisions, broadcast storms, and incomplete data packages.

g. The ability to reconfigure (if supported) the node and network (both software and hardware) in support of data integrity requirements.

h. The bi-directional error and detection implementations to address data integrity issues.

i. The switch saturation limits of the system, if applicable.

j. The allowable levels of degradation for the databus operation and performance.

k. Security issues that may affect data integrity (see Paragraph **10** of this AC).

5. DATABUS PERFORMANCE REQUIREMENTS. You must evaluate the following databus performance items:

a. The databus operating speed and scheduling of messages (timing and prioritization) that support the operational safety and integrity requirements.

b. Loss of the databus through shorting or opening of the databus connections.

c. The system interoperability to include the databus or network topology, the communication protocol between components, and any other aspects.

d. Each databus length, stub length, and each databus participant limitations.

e. Degraded databus operation and performance abilities, where applicable.

f. Retry algorithms, where applicable.

g. Bandwidth capability of the databus.

h. Data latency and efficiency.

i. Per-transmission overhead and other overhead effects.

j. The system's failure management (including failure/malfunction reporting) and the failure effects within the databus.

k. The system start-up and reintegration (when a node that has gone off line rejoins the bus) durations. You must determine and use the worst-case times for bus start-up and node reintegration for all systems using the bus.

6. SOFTWARE AND HARDWARE ASSURANCE REQUIREMENTS. The aircraft's systems, equipment, or engine must meet the software and hardware design and development assurance criteria, regardless of the bus architecture you propose (synchronous or asynchronous; uni-directional or bi-directional). The design and development assurance criteria are:

a. Each complex electronic device must meet the appropriate hardware design assurance requirements. However, some databus architecture contains complex electronic devices whose functions cannot feasibly be evaluated by test or analysis. The hardware design assurance of those devices must meet the criticality category determined by the safety assessment. To ensure the hardware design assurances are met, follow RTCA/DO-254, *Design Assurance Guidance for Airborne Electronic Hardware*, or other acceptable means of compliance.

b. To ensure the design and development of software that will function within the databus architecture, you must develop the software to the appropriate software level, per RTCA/DO-178B, *Software Considerations in Airborne Systems and Equipment Certification*, or other acceptable means of compliance.

c. When using tools to develop or verify the databus software or hardware, you may need to qualify the tools. Guidance for qualifying tools to develop software and hardware may be found in RTCA/DO-178B and RTCA/DO-254 respectively.

7. ELECTROMAGNETIC COMPATIBILITY REQUIREMENTS. To ensure proper operations of the databus, you must address the electromagnetic compatibility of the proposed databus:

a. There is a potentially large variation in electromagnetic emissions and electromagnetic susceptibility in databuses and databus components. Consider the effects of electromagnetic emissions and susceptibility when you design, select, or specify the databus you will use in the aircraft. An electromagnetically noisy databus installed throughout an aircraft is difficult to fix after installation.

b. When evaluating the databus for electromagnetic compatibility, consider the entire databus system, including the terminals, hardware, and installation. To address issues with electromagnetic emissions and susceptibility, you should not limit the RTCA/DO-160E, *Environmental Conditions and Test Procedures for Airborne Equipment*, testing requirements to only individual components because individual pieces of equipment tested in isolation may meet the RTCA/DO-160E emission requirements but create interference problems when integrated on the aircraft.

c. The electromagnetic emissions will depend on the databus design specifications for pulse rise times and settling times, databus speed, and databus topology. Databus topology may include the use of balanced differential-mode signaling and transformer-coupled connections, making the shape of the data pulse (both leading and trailing pulse edges) very important. Proposed interconnection of the databus will significantly affect the electromagnetic emissions and susceptibility. However, shielded, twisted pairs of wires with high-quality connectors for shield termination will have better electromagnetic performance than buses using unshielded wires. You should address and mitigate the effects of electromagnetic susceptibility that can cause common mode failures for redundant implementations.

d. Based on the issues presented in paragraphs **7a** through **7c** above, evaluate each databus using the following electromagnetic compatibility criteria:

(1) Databus data rate, switching speed, and pulse rise and fall times. Evaluating these criteria will help minimize spectral components interference with aircraft equipment such as sensitive aircraft radio receivers.

(2) Databus interconnect hardware and wiring requirements for radio frequency emissions and susceptibility. An example of a hardware and wiring requirement is minimum shielding effectiveness for the databus conductors and connectors.

(3) Electromagnetic compatibility of databus components such as individual databus transceivers. Also, evaluate the overall performance of the databus as installed in the aircraft.

(4) Lightning and High-Intensity Radiated Field (HIRF) immunity commensurate with the safety classification of the functions that the databus supports. Guidance for system lightning protection is found in FAA AC 20-136, *Protection of Aircraft Electrical/Electronic Systems against the Indirect Effects of Lightning*. FAA special conditions are issued with HIRF protection requirements for individual certification projects.

8. VERIFICATION AND VALIDATION REQUIREMENTS. As an applicant, you must:

a. Validate the databus requirements for the aircraft or aircraft engine project.

b. Evaluate whether the databus meets RTCA/DO-160E environmental standards, at the levels appropriate for each of the criticality functions supported by the databus. The electromagnetic compatibility and lightning qualification is of particular concern for databus technology because verification is typically done during aircraft installation. Electromagnetic testing and validation may vary with the software used to carry out the databus architecture.

c. Perform appropriate verification of the databus in accordance with the criteria in RTCA/DO-178B and RTCA/DO-254, as discussed in paragraph **6 above**.

d. Perform a functional test of the integrated databus to ensure it meets its intended functions.

e. Verify and validate the databus operation, architecture, and performance claims. One acceptable method is to use an aircraft or databus simulator that uses the maximum throughput rate allowed for the system being tested.

f. Test the databus failure and recovery procedures by reconfiguration of nodes and networks, loss of nodes, number of recovery attempts, shorted nodes, fault coverage, etc.

g. Verify all built-in-test to ensure they function correctly.

h. Test the databus failure management features at the bench and installation levels.

i. Test the databus in a degraded mode to ensure acceptable performance.

j. When you use test benches to validate the databus, you must also perform the wiring acceptance tests by documenting the test methods or procedures used to determine the wiring harness is correct. You must use these procedures for initial installation each time you modify the harness, and whenever you perform a databus system troubleshooting exercise.

9. CONFIGURATION MANAGEMENT REQUIREMENTS. Because there are many new databus technologies, each individual aircraft's databus configuration could potentially be unique, and because of this uniqueness, changes to the databus configuration may result in an adverse effect on the databus' message traffic, data collision rates, and reliability. For databus installations, manufacturers must establish a configuration management program for the databus. This program may be stricter than programs required for past databus technologies where configurations were common and easier to manage. These installations will also require maintenance personnel and installers to use approved configuration databases and tools. They will use these databases and tools to re-establish the airworthiness of each new databus configuration. Address the following system configuration management items when developing your databus:

a. When you integrate the databus into the aircraft or aircraft engine design, consider the total system by ensuring there are mechanisms of configuration control for continued operational safety and configuration control of the modifications. The additions of nodes and applications on the databus must be assured both in certification requirements and in-service maintenance activities.

b. You must establish and maintain configuration control of the databus during certification, from design through production and maintenance by following your established standards and documented procedures. Configuration control should address the databus and the selected options for each installation, being mindful that you may need additional FAA certification for changes to previously approved configuration.

c. Document specification standards. At a minimum, you need to document physical and logical rules for the databus. Examples of physical rules are requirements for transmission media, connectors, terminations, maximum number nodes, and run lengths. Message packet definitions are an example of logical rules.

d. At a minimum, provide documentation to support development and operation of the databus such as the interface definitions document, designer's guide, and installer's guide.

e. If the databus uses multi-layered architecture, provide documentation to support and to configure layers. An example of multi-layered architecture is the Open Systems Interconnection (OSI) networking model, also known as the seven-layer model.

f. You must document databus wiring and installation requirements. These requirements should include definitions of appropriate wire and shield types, electrical bonding requirements, and any specific wire bundle routing and separation requirements.

10. SECURITY ASSURANCE REQUIREMENTS. Many modern databuses introduce potential security risks that are not common in traditional networked systems. Access security and data protection are two areas you should address:

a. Access Security. When airborne systems interact with the outside world through a databus or network, they become vulnerable to potential malicious attacks such as software viruses. Adopt security techniques and controls to protect access to the airborne software. Some sample techniques are:

- Encryption techniques (such as public and private key encryption, digital signatures, hash functions) to protect data transmission.
- Authentication and access control policies (such as *Discretionary Access Control* protocol and the *Mandatory Access Control* protocol).
- Intrusion detection (such as signature-based approach, anomaly-based detector, specification-based intrusion detection, bottleneck verification, host-based intrusion detection, and network-based intrusion detection).

b. Information and Data Protection. When using networks or modern databuses, you must protect critical information used and stored in airborne systems. Sample approaches are:

- Information verification methods to ensure that the data have not been corrupted during loading and storage (for example, cyclic redundancy check and checksum).
- Use of audit trails that account for data accessed (for example, keep a log of when and which critical flight data are accessed).

11. PROCEDURES FOR MEETING REQUIREMENTS. Perform the following activities to ensure you address the criteria in paragraphs **3** through **10** of this AC:

a. Develop a databus certification plan for the criteria in paragraphs **3** through **10** of this AC, and other requirements that may exist on the specific project.

b. Submit the plan to the cognizant aircraft certification office for approval.

c. After developing the databus submit a databus compliance report to show how you satisfied the criteria and regulations. If certain criteria do not apply, describe why they do not apply.

d. Address continued airworthiness requirements in the instructions for continued airworthiness section of the maintenance manual, user's guide, or other appropriate documents. At a minimum, you must address the following continued airworthiness issues:

- Performance of the databus over the life of the aircraft.
- Physical degradation of the databus components. This could include databus wire and connector corrosion, damage, and wear out.
- In-service modifications and repairs to the databus.
- Use of different configurations and functional components for obsolete databus components, due to the rapidly changing state-of-the-art databus components. Future maintenance of the databus may require the use of different configurations and functional components.
- Scheduling information for any databus components that require specific maintenance intervals.
- Information on how to remove/install databus components to support maintenance.
- Information on how to evaluate and test databus operation (system checks).

e. Perform a system-level change impact analysis to determine how modifications to the databus affect the system. The impact analysis will also determine appropriate activities needed to re-perform and re-assess the databus and affected systems. Follow your defined process when performing a change impact analysis to determine how the change may affect the continued operational safety of the aircraft on which the product is installed.

f. When using a previously approved or modified databus for a different project, use the criteria in this AC to evaluate the suitability of the databus for the new project.

12. RELATED DOCUMENTS AND HOW TO GET THEM.

a. Code of Federal Regulations. You can get copies of 14 CFR parts 21, 23, 25, 27, 29, and 33 from the FAA website at http://www.airweb.faa.gov/rgl.

b. FAA Advisory Circulars (AC) and Orders. Copies of the following ACs and orders are available from the FAA website at http://www.airweb.faa.gov/rgl.

(1) Advisory Circular 20-115, *RTCA, Inc. Document RTCA/DO-178B*;

(2) Advisory Circular 20-152, *RTCA, Inc. Document RTCA/DO-254*;

(3) Advisory Circular 21-16, *RTCA, Inc. Document RTCA/DO-160E*; and

(4) Advisory Circular 20-136, *Protection of Aircraft Electrical/Electronic Systems against the Indirect Effects of Lightning*.

c. RTCA, Inc. Documents. You can buy copies of RTCA documents from RTCA, Inc., 1828 L Street, NW, Suite 805, Washington, D.C. 20036-4008. Alternatively, you can buy copies on-line at www.rtca.org. RTCA documents referenced in this AC are:

(1) RTCA/DO-160E, *Environmental Conditions and Test Procedures for Airborne Equipment*;

(2) RTCA/DO-178B, *Software Considerations in Airborne Systems and Equipment Certification*; and

(3) RTCA/DO-254, *Design Assurance Guidance for Airborne Electronic Hardware*.

d. SAE Documents. You can buy copies of SAE documents from SAE World Headquarters, 400 Commonwealth Drive, Warrendale, PA 15096-0001. Or, you can buy copies on-line at www.sae.org. We reference the following SAE documents in this AC:

(1) Aerospace Recommended Practice (ARP) 4754, *Certification Considerations for Highly-Integrated or Complex Aircraft Systems*; and

(2) ARP4761, *Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment.*

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