



Federal Aviation Administration

Memorandum

Date:

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From: David W. Hempe, Manager, Aircraft Engineering Division, AIR-100

Prepared by: Brad Miller, Avionic Systems Branch, AIR-130

Subject: **Information:** Policy and Guidance for Electronic Flight Bag Class 1 & 2 System Architecture and Aircraft Connectivity

Background

The FAA has previously published AC 120-76, *Guidelines for the Certification, Airworthiness, and Operational Approval of Electronic Flight Bag Computing Devices*. This memorandum provides additional policy and guidance for Electronic Flight Bag Class 1 & 2 system architecture (e.g., portable modules, lithium batteries, charging circuitry, and rapid depressurization) and aircraft connectivity (e.g., aircraft power, data busses, mounting brackets). This memorandum is applicable to all operators conducting flight operations under Title 14 of the Code of Federal Regulations (14 CFR) part 91, 121, 125, 129, or 135, to obtain airworthiness and suitability of operations approval for the Class 1 & 2 EFB systems and aircraft connectivity.

EFB Advisory Circulars (ACs)

AC 20-159, *Obtaining Design and Production Approval of Airport Moving Map Display Applications Intended for Electronic Flight Bag Systems*, may be used to add own-ship position on an EFB Class 2 system.

AC 91-78, *Use of Class 1 or Class 2 Electronic Flight Bag (EFB)*

AC 120-76, *Guidelines for the Certification, Airworthiness, and Operational Approval of Electronic Flight Bag Computing Devices*.

1. EFB Class 1 & 2 System Architecture

1.1. EFB System Modules and Hybrid Configurations

Class 1 & 2 EFB systems may be packaged in various configurations where some of the modules are classified as portable and other modules are classified as installed. EFB system modules that

are located in the flight deck that may be removed or installed without tools are considered portable and do not require an aircraft certification design approval. An example of this architecture is an EFB class 2 system with a central processing unit (CPU) and power supply located behind the pilot's seat with a cable connected to a display unit and keyboard. If this equipment may be installed and removed in the flight deck without tools, the modules are classified as portable. There is no requirement to remove portable equipment from the flight deck after each flight and the equipment may be allowed to stay in the flight deck for indefinite periods of time.

Class 2 EFB system architecture may consist of hybrid configurations that contain both portable and installed modules. An example of this architecture is an EFB Class 2 system with a CPU and power supply located in the electrical equipment (E/E) bay with a cable connected to a display and keyboard in the flight deck. The CPU and power supply module would require an aircraft certification design approval via supplemental type certificate (STC), type certificate (TC), or amended TC and the display and keyboard would be classified as portable equipment.

An applicant may obtain an aircraft certification Technical Standard Order Authorization (TSOA) for an EFB class 2 system for functions with a failure classification no greater than "minor". Refer to AC 20-159, *Obtaining Design and Production Approval of Airport Moving Map Display Applications Intended for EFB Systems*, to add own-ship position on an EFB Class 2 system.

1.2. EFB System Lithium Battery, Charging Circuitry and Aircraft Power Connectivity

An aircraft electrical power source may provide power to Class 1 & 2 EFB systems with lithium batteries. Lithium batteries and charging circuitry may be flammable under certain conditions and could cause an unsafe condition during flight operations. In particular, lithium battery systems have the potential to pose a safety hazard when recharging. The aircraft electrical power source is not certified to mitigate unsafe conditions that could occur when connected to portable equipment (e.g., Class 1 & 2 EFB systems) which contains lithium batteries and charging circuitry.

At present, there is limited experience with the use of rechargeable lithium batteries in applications involving commercial aviation. Lithium batteries include lithium ion and lithium polymer batteries or any battery storage system with lithium based chemistry. Other users of this technology, ranging from wireless telephone manufacturers to the electric vehicle industry, have noted safety problems with lithium batteries. These problems include overcharging, over-discharging, and flammability of cell components.

Since the Class 1 & 2 EFB systems are not installed equipment and are not certified, safety requirements are needed to ensure that failure of lithium batteries or charging circuitry will not cause an unsafe condition. Class 1 & 2 EFB systems that are connected to aircraft electrical power sources must meet the requirements for the lithium battery and charging circuitry defined in this memorandum. If the EFB Class 1 & 2 system lithium batteries and charging circuitry do not meet the requirements defined in this memorandum, they are not eligible for connection to aircraft electrical power sources. For this reason, a limitation on Class 1 & 2 EFB system connectivity to the aircraft electrical power source is required to ensure compliance to §§ 25.1309 and 25.601.

The Aircraft Certification Office (ACO) is not required to participate in the evaluation of the suitability of the Class 1 & 2 EFB system for connectivity to aircraft electrical power. The Class 1 & 2 EFB system lithium battery and charging circuitry compliance to the requirements contained in this memorandum must be documented by the operator and presented to the Principal Inspector to ensure operational suitability.

Overcharging – In general, lithium batteries are significantly more susceptible to internal failures that can result in self-sustaining increases in temperature and pressure (i.e., thermal runaway) than their nickel-cadmium or lead-acid counterparts. This is especially true for overcharging which causes heating and destabilization of the components of the cell, leading to the formation (by plating) of highly unstable metallic lithium. The metallic lithium can ignite, resulting in a self-sustaining fire or explosion. Finally, the severity of thermal runaway due to overcharging increases with increasing battery capacity due to the higher amount of electrolyte in large batteries.

Over-discharging – Discharge of some types of lithium batteries beyond a certain voltage (typically 2.4 volts) can cause corrosion of the electrodes of the cell, resulting in loss of battery capacity that cannot be reversed by recharging. This loss of capacity may not be detected by the simple voltage measurements commonly available to flight crews as a means of checking battery status – a problem shared with nickel-cadmium batteries.

Flammability of Cell Components – Unlike nickel-cadmium and lead-acid batteries, some types of lithium batteries use liquid electrolytes that are flammable. The electrolyte can serve as a source of fuel for an external fire, if there is a breach of the battery container.

Power Connectivity

a. Use of Aircraft Electrical Power Sources. Aircraft electrical power outlets are part of the type design of the aircraft and require airworthiness certification. Additionally, electrical outlet connections should be appropriately labeled to identify the electrical characteristics (e.g., 28VDC, 115VAC, 60 or 400 Hz, etc.). An electrical load analysis should be conducted to replicate a typical EFB system to ensure that powering or charging the EFB will not adversely affect other aircraft systems and that power requirements remain within power-load budgets. A means (other than a circuit breaker) for the flight crew to de-power the EFB power source or system charger is recommended. Electrical power provisions that are certified to part 25 airworthiness requirements should follow the policy outlined in the Transport Airplane Directorate policy, “Policy Statement on Certification of Power Supply Systems for Portable Electronic Devices on Part 25 Airplanes, ANM-01-111-165”

b. Limitations to EFB Connection to Aircraft Power. The limitations on the provisions for aircraft electrical power connected to portable equipment with lithium batteries is required to ensure safe operations on the flight deck. Similar limitations for the cabin may not be applicable if a malfunction of the battery system would not produce an unsafe condition.

Aircraft Certification requires limitations to the equipment that can connect to aircraft power through a marking at the aircraft electrical power connection and in the Instructions for Continued Airworthiness (ICAW). In addition to §§ 25.863 and 25.1353 (a), (b) (1)-(4), aircraft certification requires the limitation statement for electrical

provisions to be documented on the TC, amended TC or STC. This limitation ensures that the battery system, including batteries and battery charging system, meet acceptable safety standards. The applicant must do the following:

(1) Marking. The installation of the aircraft electrical power provisions must incorporate a limitation, in the form of a marking, such as a placard. AIR approves as part of the Type Design a placard that defines what type of equipment can be connected to aircraft power. The placard provides awareness to the flight crew and maintenance personnel. The placard, must be legible, easy to see and as close as practical to the docking location(s). It must be installed as part of the STC and it indicates that equipment that is connected to these provisions must be tested in accordance with the ACO approved criteria.

Example Placard Wording:

Caution – EFB Provisions Limitation: All equipment that connects to these aircraft electrical power must be tested in accordance with the requirements of *[Company, Document, Revision, and Date]*.

Or:

Caution – EFB Provisions Limitation: No equipment containing rechargeable lithium batteries may be connected to aircraft electrical power.

(2) Limitation. AIR places in the limitation section of the approved certificate a reference to the limitation of the aircraft electrical power source. The intent of this limitation is to provide awareness to operators and to ensure there is awareness of this limitation during future certification activities.

Example wording of the limitation:

Any equipment that is attached to the provisions approved by this certificate must be tested in accordance with the requirements of *[Company, Document, Revision, and Date]*.

Or:

No equipment containing rechargeable lithium batteries may be connected to the provisions approved by this certificate.

b. Electrical Battery Power for Class 1 EFB Systems. The operator is responsible to ensure that the batteries are replaced as required, but no less often than the EFB manufacturer's recommended interval.

d. Rechargeable Battery Power for EFB Systems. To ensure an acceptable level of safety, the following criteria should be used to evaluate compliance to the certified electrical provisions.

(1) **14 CFR 25.1353.** Applicable sections to lithium batteries should be applied.

(2) **14 CFR 25.863.** The flammable fluid fire protection should be applied.

(3) **Safe Cells.** Safe cell temperatures and pressures must be maintained during any foreseeable charging or discharging condition and during any failure of the charging or battery monitoring system. The lithium battery installation must preclude explosion in the event of those failures.

(4) **Design.** Design of the lithium batteries must preclude the occurrence of self-sustaining, uncontrolled increases in temperature or pressure.

(5) **Gas Emission.** No explosive or toxic gases emitted by any lithium battery in normal operation, or as the result of any failure of the battery charging system, monitoring system, or EFB system which is not shown to be extremely remote, may accumulate in hazardous quantities within the airplane.

(6) **Leakage.** There must be a means to minimize the probability of leakage and possible ignition of flammable fluids or vapors that might escape. Analysis or tests should consider leakage paths and detection, flammability characteristics of system and ignition sources.

(7) **Corrosive Damage.** No corrosive fluids or gases that escape from the battery may damage surrounding structure, systems, equipment or electrical wiring.

(8) **Hazardous Effect.** Each lithium battery must have provisions to prevent any hazardous effect on structure or essential systems caused by the maximum amount of heat the battery can generate during a short circuit of the battery or of its individual cells.

(9) **Charging.** The lithium battery system must have a capability to control the charging rate of the battery automatically, so as to prevent battery overheating or overcharging, and,

(a.) A battery temperature sensing and over-temperature warning capability with a means for automatically disconnecting the battery from its charging source in the event of an over-temperature condition, or,

(b.) A battery failure sensing and warning capability with a means for automatically disconnecting the battery from its charging source in the event of battery failure.

Note: These criteria are not intended to replace 14 CFR 25.1353(b) amendment 25-123 in the certification basis of aircraft. These criteria apply only to lithium batteries and their use in portable electronic devices. The requirements of 14 CFR 25.1353(b) amendment 25-123 remain in effect for batteries and battery installations of aircraft that do not use lithium batteries.

(10) **Instructions for Airworthiness.** The Instructions for Continued Airworthiness required by 14 CFR 25.1529 (and 26.11) must contain steps to assure that the lithium battery is sufficiently charged at appropriate intervals specified by the battery manufacturer. The Instructions for Continued Airworthiness must also contain procedures to ensure the integrity of performance of the lithium batteries in spares storage to prevent the replacement of batteries

whose function is required for safe operation of the airplane with batteries that have experienced degraded charge retention ability or other damage due to prolonged storage at a low state of charge. Precautions should be included in the Instructions for Continued Airworthiness maintenance instructions to prevent mishandling of the lithium battery which could result in short-circuit or other unintentional damage that could result in personal injury or property damage.

Note 1: The term, “sufficiently charged” means the charge that is applied to rechargeable lithium batteries, which during the life of the battery, diminishes with respect to the retentive capacity of the batteries to deliver available power, where capacity is the total quantity of electricity of a cell or battery, expressed in ampere-hours. Battery life is influenced by its internal chemical reaction, and by other factors, such as temperature, shock, the number of times of recharge, etc.

Note 2: The EFB is required for safe operation of the airplane when paper products, which are required by the operating rules, are removed from the airplane and replaced by the EFB systems.

(11) Replacement Batteries. Replacement batteries must meet the requirements of items in paragraphs d.(1) through d.(10)

(12) Testing Procedure. The applicant will establish criteria in the form of testing procedures to meet items in paragraphs d.(1) through d.(9) and an ICA for item d.(10). These documents will be part of the compliance data that will be submitted to the FAA. This documentation will be referenced in the placard (see paragraph b. (1). above) and the limitation statement on the certificate (see paragraph b. (2). above).

- (a.)** The Class 2 EFB lithium battery system should be tested using RTCA/DO-311 dated March 13, 2008, as a method to show that the Class 2 EFB meets criteria (1) through (9) above. If this standard is used then all of the tests in Table 4-1 must be addressed. RTCA/DO-311 is intended to test permanently installed equipment; however, these tests are applicable and sufficient to test EFB hardware. As part of this testing:
 - (i)** The environmental conditions of the EFB should be considered and addressed by the test procedures.
 - (ii)** Results of test procedures should have a pass/fail outcome.
- (b.)** If the applicant wants to use a method other than RTCA/DO-311, the applicant may propose the alternate criteria to the local ACO for their approval. The ACO will ensure that the testing addresses items in paragraphs d.(1) through d.(9) above.
- (c.)** The testing method, such as DO-311, is part of the compliance data and must be contained in the approved data. Any change to the testing method would require an amendment to the type certificate.

(13) Test Results. The results of these tests are not part of the certification type design data of this STC and are not required to be shown to the ACO. These results are part of the data the operator would need to submit to the Principal Inspector prior to determination of suitability of operations.

1.3 Rapid Decompression Considerations

Based on the intended function and proposed operating environment of the Class 1 & 2 EFB system, environmental testing for rapid depressurization may need to be performed. However, since many Class 1 & 2 EFBs were originally COTS electronic systems adopted for aviation use, testing done on a specific EFB base model configuration may be applied to other aircraft installations and these generic environmental tests need not be duplicated. It is the responsibility of the operator to provide documentation that these tests have been accomplished. EFB Class 1 & 2 systems are required to meet rapid depressurization test criteria if the EFB systems by themselves replace paper products required by the operating rules. If EFB systems do not replace paper products required by the operating rules or other mitigations are available then the EFB system are not required to meet rapid depressurization test criteria.

1.4 EFB Mounting Devices on Aircraft

An unsafe condition must not be created when attaching any EFB to the control yoke attachment/mechanism or mounting device. For example, the weight of the EFB and mounting bracket combination may affect flight control system dynamics; even though the mount alone may be light enough to be insignificant. The equipment when mounted and/or installed should not present a safety-related risk or associated hazard to any flight crewmember. A means to store or secure the device when not in use should be provided. Additionally, the unit (or its mounting structure) should not present a physical hazard in the event of a hard landing, crash landing, or water ditching. EFB systems and their power cords should not impede emergency egress.

1.5 Stowage Area for EFB Systems

A stowage area with a securing mechanism for EFB systems is recommended for storage of portable units when they are not in use. EFB systems that are not secured in a mounting device during use should be designed and used in a manner that prevents the device from jamming flight controls, damaging flight deck equipment, or injuring flight crewmembers should the device move about as a result of turbulence, maneuvering, or other action.

2. EFB Class 1 & 2 Aircraft Connectivity

2.1 Aircraft Electrical Power

The aircraft electrical power source may provide power to EFB systems with lithium batteries. Lithium batteries and charging circuitry may be flammable under certain conditions and could cause an unsafe condition during flight operations. In particular, lithium battery systems have the potential to pose a safety hazard when recharging.

The aircraft electrical power source is not certified to mitigate unsafe conditions that could occur when connected to portable equipment (e.g. Class 1 & 2 EFB systems) which contains lithium batteries and charging circuitry. The aircraft electrical power source must have a limitation on portable equipment connectivity with lithium batteries to ensure compliance with Title 14 Code of Federal Regulations section 25.1309 and 25.601.

2.2. Aircraft Data Bus Connectivity

AC 120-76 policy allows both Class 1 and 2 EFB systems to have read-only data connectivity to other aircraft systems. It also allows both Class 1 and 2 EFB systems to transmit data using Aircraft Administrative Communications (AAC) only. Data connectivity may be wired or wireless, but must only be accomplished using a certification approval (TC, STC, or amended TC). Data connectivity to other systems is not authorized except if connected to a system completely isolated from other aircraft avionics and systems (e.g., hardware firewall). Any connection to a certified aircraft data port (e.g., ARINC 429 Data bus) must be evaluated using a certification approval (TC, STC, or amended TC).

The EFB system may be connected to an avionics data bus, file server, or wireless network. When connected to other aircraft data buses and/or communication systems, EFB failures should not adversely affect other installed aircraft systems.

(1) Class 2 EFB systems may be connected to non-essential data buses, essential data busses, file servers, printers, routers, etc. If the EFB is connected to a certified data link (either wired or wireless) where the data link, through the certification process, has an approved firewall protection to aircraft systems, then there is no further evaluation required prior to connecting the EFB to the data link port.

(2) EFB connections to an ARINC-429 port require that the protection mechanisms (ARINC-429 interface circuitry) for non-interference be demonstrated as part of the TC, amended TC or STC approval. No credit for ARINC-429 non-interference is granted for the EFB Class 1 & 2 internal interface.

2.3 Environmental Hazards Identification and Qualification Testing

Class 1 and 2 EFB system radio frequency (RF) emissions data need to be evaluated in accordance with AC 91.21-1, current version. Class 1 and Class 2 EFB systems should demonstrate that they meet appropriate industry-adopted environmental qualification standards for radiated emissions for equipment operating in an airborne environment. In general, Class 1 and Class 2 EFB systems should be evaluated using RTCA/DO-233, *Portable Electronic Devices Carried on Board Aircraft* (current version), but if the device is wireless-enabled (i.e., Bluetooth, Wi-Fi, etc.), then DO-294, *Guidance on Allowing Transmitting Portable Electronic Devices (T-PEDs) on Aircraft* (current version), should be used. An appropriate alternative would be to test the device in accordance with section 21, Category M, of RTCA/DO-160, *Environmental Conditions and Test Procedures for Airborne Equipment*, current edition.

Any Class 1 or Class 2 EFB used in aircraft flight operations should be demonstrated to have no adverse impact on other aircraft systems (non-interference). The manufacturer, installer, or operator may accomplish the testing and validation to ensure proper operation and non-interference with other installed systems. Possible interference when portable EFB systems are moved about in the cockpit should be addressed.

Please contact Brad Miller, (202) 385-4628, for any additional information on this subject.

David W. Hempe
Manager, Aircraft Engineering Division

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