Federal Aviation Administration

Memorandum

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To: Manager, Small Airplane Directorate, ACE-100

From: Manager, Special Certification Office, ASW-190

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Subject: Review and Concurrence, Equivalent Level of Safety (ELOS) for 14 CFR § 23.1311(b), Electronic Displays, Aspen Avionics, Inc, Model Electronic Flight Display 1000 System, Project SA9024SC-A

ELOS Memo#: ACE-09-15

Regulatory Ref: 14 CFR, part 23, § 23.1311(b)

This memorandum documents concurrence for the subject finding of Equivalent Level of Safety (ELOS) to 14 CFR, part 23, § 23.1311(b), Electronic Display Instrument System. The proposed ELOS will allow for the compliance to the regulation to be accomplished an Electronic Flight Display (EFD) 1000 Primary Flight Display (PFD) and Multifunction Flight Display (MFD) system architecture that attains a level of safety equivalent to the requirements of 14 CFR, part 23, § 23.1311(b). The reversionary displays on the EFD1000 MFD require a pilot action to present standby data in the event of an EFD1000 PFD (primary flight display) failure.

Although this ELOS establishes an alternate means to comply with the standby display requirements for airspeed, attitude and/or altitude under 14 CFR, part 23, § 23.1311(b), separate backup instruments may still be required to comply with the operating rules (e.g. part 91, 135, 121, etc.). Any relief from the operating rules will require specific evaluation and approval separate from any airworthiness approval issued under this project (SA9024SC-A).

BACKGROUND

EFD1000 System Overview

The Aspen Avionics EFD1000 system installation is an Electronic Flight Instrument System that provides indications of Primary Flight Information (PFI) including airspeed, altitude and attitude information. Each system is made up of several devices that together have Technical Standard Order Authorization. Aspen Avionics holds an Approved Model List (AML) STC for the

installation of the equipment in a large number of part 23 class I and II aircraft. There are two mitigating design features:

Aspen is proposing that certain dual EFD1000 configurations that make use of a PFD and MFD with manual reversion and an external backup battery. The external emergency backup battery provides greater than 30 minutes of battery operation for the EFD1000 MFD in accordance with 14 CFR, part 23, § 23.1353(h) under all foreseeable environmental conditions. The independent magnetic direction indicator required by 14 CFR, part 23, § 23.1303(c) will remain installed in the airplane.

In this instrumentation arrangement the PFD displays, primary flight information and the MFD may be configured to display flight, navigation and situational awareness information in various formats. The MFD provides two different pilot-selected methods of displaying primary flight information:

(1) As a compact attitude, airspeed and altitude indicator (hereafter the "mini PFI indicator") when so configured and selected by the pilot; and

(2) As an identical (i.e., same size, arrangement, and control in a similar location) format as the PFD when manually selected to reversionary mode through a single pilot action.

The mini PFI indicator may be configured for display in the upper left tile of the MFD thumbnail page layout via the MFD's control knobs. Other page layouts on the MFD do not support display of the mini-PFI indicator.

Full reversionary mode may be separately selected by the pilot at any time through a separate, backlit, red text "REV" button on the upper right corner of the MFD. Pilot action is required to select the reversionary display as automatic reversion is not currently implemented. When in reversion mode, the data presentation and user controls are identical to the PFD in all respects.

The ELOS is for the following configurations:

	EFD1000 Equipment				Backup Instruments			Supporting Equip	
Aircraft Configuration	EFD1000 PFD	EFD1000 MFD	EFD500 MFD	EFD1000 MFD Ext Battery	Attitude	Altitude	Airspeed	Alternate Static	IFR GPS
EFD v2.0 with Single Pitot/Static System	Req'd	Req'd	Opt	Req'd	Req'd	-	-	Req'd	Req'd
EFD v2.0 with Dual Pitot/Static System	Req'd	Req'd	Opt	Req'd	-	-	-	Req'd	Req'd

To mitigate the influence of the single pitot/static system on an otherwise redundant dual EFD1000 system installation, provisions have been incorporated in the EFD1000 software design to detect and annunciate potential degradation in the system. Furthermore, the installation manual has additional requirements, including requiring an additional independent and redundant attitude indicator in aircraft susceptible to this potential failure condition. The approach is outlined below:

- Dual EFD1000 system installations must include both an EFD1000 PFD and an EFD1000 MFD. These installations require the EFD1000 MFD to have interfaces to an instrument flight rules (IFR) certified global position system (GPS) system (level C or better). Each EFD1000 display LRU houses the main computing part of the system, a backup battery (or interface to an external backup battery) and Air Data Attitude Heading Reference System (ADAHRS). The EFD500 display can be configured only as an MFD and without ADAHRS functions.

- Each EFD1000 display (PFD and MFD) has independent interfaces to its Remote Sensor Module (RSM) for independent magnetic information.

- The installation of the dual EFD1000 displays must also be cross connected and contain version 2.0 or later software. Cross connection communicates altimeter barometric setting information between the displays. Software version 2.0 contains improved fault detection software for pitot/static system failures and also for annunciation of cross communication failures.

- Software version 2.0 provides annunciation and removal of attitude information while it determines that the aircraft is flying, but there is no indicated airspeed. The specific criteria are: Airspeed (KIAS) below 30kts while ground speed is greater than 50kts for 50ms (1 frame) and cleared if the condition clears. Airspeed is calculated by direct sensing of pitot and static pressures in the aircraft pitot-static system. Groundspeed is obtained from the connected IFR certified GPS system. The display will automatically recover once the conditions are no longer met.

If the above criteria are met, each EFD1000 display will independently sense this condition and remove its airspeed and attitude display and replace it with a red ‘X’. In addition, the pilot will be presented with an annunciation to “Check Pitot Heat” as this is the most common cause of an obstructed pitot system. Altitude information will continue to be provided on each display.

In response to this condition, the pilot will be instructed to fly by reference to an alternate attitude source, such as the mechanical standby attitude indicator or the external horizon.

The fault detection, annunciation, and accommodation approach described above account for the compelling nature of electronic displays and provide adequate mitigation for the “historically acceptable” single pitot/static system allowed by the earlier aircraft certification basis.

APPLICABLE REGULATIONS

The applicable regulation is 14 CFR, part 23, § 23.1323(b), which states:

"§ 23.1311 Electronic display instrument systems:

(b) The electronic display indicators, including their systems and installations, and considering other airplane systems, must be designed so that one display of information essential for continued safe flight and landing will remain available to the crew, without need for immediate action by any pilot for continued safe operation, after any single failure or probable combination of failures."

COMPENSATING FEATURES

Related Policy and Guidance

Advisory Circular (AC) No. 23.1311-1B, Change 1, Subject: Installation of Electronic Display in part 23 Airplanes, dated: 2/17/09, states:

"Reversionary configurations are significantly more reliable than presently certified mechanical systems, and the skills required while flying in reversionary mode are identical with those used when flying in primary mode. Traditional external standby flight instruments (either electronic or mechanical) offer potential safety problems associated with delay in pilot reaction. The pilot may delay a decision to transition to standby instruments and to transition to partial panel techniques, as opposed to the simple action the pilot would take to switch displays. A nearly identical display of all flight information in the same format as normally shown on the PFD provides a significant safety enhancement over reversion to external standby instruments. This is especially true when the size, location, arrangement, and information provided by the standby instruments is significantly different from that on the PFD."

AC 23.1311-1B, also outlines several acceptable approaches, and their respective considerations, for the approval of EFIS installations (such as the Aspen Avionics EFD1000 system) that make use of reversion methods in lieu of dedicated full time standby displays. The EFD1000 system characteristics in light of each specified consideration (as outlined in the Advisory Circular) are examined in the following sections. Where there are any differences in compliance methods or operational characteristics between the two proposed reversionary display selections, they are individually identified.

14 CFR, part 23, § 23.1311(b), describes no immediate pilot action necessary to recover from any single or probable combination of failures.

14 CFR, part 23, § 23.1311, paragraph (b) requires that "The electronic display indicators, including their systems and installations, and considering other airplane systems, must be designed so that one display of information essential for continued safe flight and landing will remain available to the crew, without need for immediate action by any pilot for continued safe operation, after any single failure or probable combination of failures."

AC 23.1311-1b, describes an acceptable ELOS method of compliance to address this specific requirement. These previously accepted methods include "Reversionary Flight Displays Instead of Standby Instruments or Dual PFDs" provided the reversionary approach meets certain criteria outlined below. Where there are differences between the Aspen Avionics approach and the Advisory Circular they are identified below:

Section 8.4.1 paragraph (c)

Consistent displays – When selected by the pilot, the reversionary mode presentation of primary flight information on the EFD1000 MFD is identical (i.e., same size, arrangement, and control in a similar location) to the EFD1000 PFD.

Independent displays – The dual EFD1000 installation provides independently powered displays (by virtue of individual dedicated batteries) with dual AHRS and dual ADC subsystems. The dedicated external battery for the EFD1000 MFD, when installed as an acceptable reversionary display, provides greater than 30 minutes of battery capacity in accordance with 14 CFR, part 23, §§ 23.1353(h) and 23.1309(b)(1).

Section 8.4.1 paragraph (d)

Single pilot action – The EFD1000 MFD reversionary display is activated through a single pilot action via a press and release of a dedicated red-text "REV" button on the upper right portion of the MFD.

Substantially the same format, size and control – When selected by the pilot, the reversionary mode presentation of primary flight information is identical in all respects to the PFD.

Single action which is recognizable and accessible – The EFD1000 MFD reversionary display is activated through use of a separate button on the upper right portion of the MFD. The response time is less than one second. The reversionary display with a separate, back lit red text "REV" button is typically installed immediately beside the PFD, but may also be installed at a location in the pilot's primary maximum field of view as described in AC 23.1311-1B, Section 15.3.

Section 8.4.2 paragraph (b)

Data/modes transferred to promote seamless reversion display – The cross communication path between the displays is provided to pass updated barometric setting information between displays. Information that is not related to Primary Flight Information (e.g., navigation configuration data such as navigation source, selected course, selected heading, altitude bug, minimums bug, airspeed bug) is not passed between the displays, and, therefore, must be configured or verified by the pilot, as necessary, prior to entering critical phases of flight. These procedures are provided via the EFD1000 Airplane Flight Manual System (AFMS). The pilot is also instructed to verify the reversionary display configuration is correct after manual reversion selection (i.e., following an actual PFD failure).

In addition to the above requirements, Section 8.4.2, paragraph (c) describes that manual activation is acceptable when selected "before entering critical phases of flight." The intent of this section is understood not to require reduction of capability by dictating full reversion, but rather to ensure that primary flight information remains available to ensure "continued safe operation, after any single failure or probable combination of failures" and that useable critical flight information remains available throughout these critical flight phases. Accordingly, Aspen is proposing that the additional mitigation is afforded by a mechanical standby attitude indicator enabling full use of the MFD during critical phases of flight (specifically, takeoff, landing, final and missed approach). For these critical phases of flight, the standby mechanical attitude indicator provides the necessary flight information to ensure "continued safe operation" without the need for "immediate pilot action", as described by AC 23.1311, Section 8.2.1, and the MFD reversion mode provides the "information essential for continued safe flight and landing" and is available via a single pilot action.

In this manner, should the PFD fail, the pilot can continue to safely operate the aircraft by reference to the independent mechanical attitude indicator. Thereafter, the pilot would select full reversion on the MFD (single pilot action via the separate, backlit, red text "REV" button on the MFD) and continue the flight to a safe landing. This combined approach of a traditional dedicated standby attitude instrument and reversion displays that are identical in size, presentation, arrangement, and function to the primary flight display provides the necessary information to ensure immediate "continued safe operation" followed by full information for "continued safe flight and landing." This approach provides the added safety benefit of enabling continued use of the non-required but safety-enhancing information available via the MFD throughout all phases of flight.

Alternate Configurations

Aircraft with redundant (i.e., dual) pitot/static systems – For those aircraft with dual pitot-static systems, each EFD1000 display would be connected to an independent pitot/static system and would be able to provide fully independent and redundant primary flight information. These independent installations of the EFD1000 system would not need to rely on a combination of redundant electronic displays and a mechanical attitude indicator. The reversionary display (EFD1000 MFD) would provide all primary flight information in the event of a primary flight display (EFD1000 PFD) failure, and an independent mechanical attitude indicator would not be required. Since a separate mechanical attitude indicator would not be available for "continued safe operation," the pilot will be required to configure the reversionary display and select the primary flight information (mini-PFI indicator or full reversion mode) on the MFD for display prior to entering critical phases of flight; this requirement will be contained in the flight manual supplement normal procedures. This variant of the installation directly adheres to the guidance provided in Section 8.4.2, paragraph (c), of AC 23.1311-1b, where that manual activation is acceptable when selected "before entering critical phases of flight."

SUMMARY

In summary:

- Aspen seeks an ELOS finding to 14 CFR, part 23, § 23.1311(b) by combining a dedicated mechanical attitude indicator in the pilot's primary field of view with manual PFD reversion on the MFD.

- Upon PFD failure, the information needed for continued safe operation (e.g., mechanical attitude in the case of a single pitot/static equipped aircraft) is available without need for immediate action.

- Thereafter, one display of information essential for continued safe flight and landing is available to the crew with one button press.

- AFMS instructions will require the pilot to configure the reversionary display as needed prior to entering critical phases of flight. The pilot can then return to normal MFD function.

- If those configurations where a dedicated mechanical attitude indicator is not installed, the pilot will be required to configure the reversionary display to show primary flight information prior to entering and during all critical phases of flight.

CONCLUSION

In summary, the dual EFD1000 system installations configuration proposed herein are consistent with the accepted methods and operational principles identified in AC 23.1311-1B for reversionary displays in response to a single failure or probable combination of failures. The proposed dual EFD1000 display installation configurations feature improved safety, improved reliability, improved situational awareness, improved pilot reaction and transition, and provide an equivalent level of safety to 14 CFR part 23, § 23.1311(b).

RECOMMENDATION: The FAA concurs that the proposed design features described as compensating features in items as supplemented by the information from the background provides an equivalent level of safety to the requirement of 14 CFR, part 23, § 23.1311(b).

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Date

ELOS Originated by Fort Worth ACO:	Rick Ritz Manager, Special Certification Office	Routing Symbol ASW-190