



Federal Aviation Administration

Memorandum

Date: June 27, 2013

To: Manager, New York ACO, ANE-170

From: Manager, Transport Airplane Directorate, ANM-100

Prepared by: Kent Fredrickson, ANE-173

Subject: INFORMATION: Equivalent Level of Safety (ELOS) Finding for Digital Only Display of Turbine Engine Required Parameters on BD-500-1A10 and 1A11, FAA Project TC4948NY-T

ELOS Memo#: TC4948NY-T-P-15

Regulatory Ref: §§ 21.21(b)(1), 25.901, 25.1305, 25.1309, 25.1321, 25.1322, 25.1549 (a) to (c)

This memorandum informs the certificate management aircraft certification office of an evaluation made by the Transport Airplane Directorate (TAD) on the establishment of an equivalent level of safety (ELOS) finding for the Bombardier Model BD-500-1A10 and BD-500-1A11.

Background

Section 25.1549 requires “*For each required powerplant and auxiliary power unit instrument, as appropriate to the type of instrument--(a) Each maximum and, if applicable, minimum safe operating limit must be marked with a red radial or a red line; (b) Each normal operating range must be marked with a green arc or green line, not extending beyond the maximum and minimum safe limits; (c) Each takeoff and precautionary range must be marked with a yellow arc or a yellow line; and (d) Each engine, auxiliary power unit, or propeller speed range that is restricted because of excessive vibration stresses must be marked with red arcs or red lines.*”

The marking requirements of 14 CFR 25.1549 presume the use of analog instruments. However, the Bombardier Aerospace CSeries Model BD-5001A10 and BD-500-1A11 airplanes provide digital-only displays for the engine high-pressure turbine speed (N2), oil temperature, oil pressure and fuel flow (FF). The digital-only display of these powerplant parameters will not directly comply with the requirements of 25.1549(a) through (c). In addition, digital displays may limit the flight crew’s ability to properly monitor and operate the powerplants.

Therefore any acceptable means of demonstrating compliance with Title 14, Code of Federal Regulations (14 CFR) 25.1305 must take into account the inherent limitations of digital-only displays.

The primary engine displays on turbine engine powered transport airplanes have traditionally displayed the required engine rotor speeds, oil temperature, oil pressure and fuel flow required by 14 CFR 25.1305 in an analog-only or an analog and digital format.

Standby engine indicators (SEI), when provided, have typically displayed these parameters in either analog-only or digital only format. An increasing demand to conserve primary display space has led to digital-only primary displays for various engine parameters including those rotor speeds not normally used for power setting. This situation may result in a small, cluttered, low-resolution primary display. In addition, it is generally accepted that digital-only displays are often less effective than conventional analog displays at providing the crew with discernible indication of the parameter during a rapid transient, and quick intuitive indication of the parameters approximate level, direction and rate of change, proximity to limits, and relationship to other parameters on the same engine or the same parameter on other engines. This is why FAA Advisory Circular (AC) 20-88A, paragraph 4(c), states, "Digital indicators are most valuable when integrated with an analog display." While an analog format is not required to comply with most of the referenced rules, 14 CFR 25.1549 (a) to (c) require instrument markings that presume an analog type display format. Consequently, features of the digital format must at least provide a level of safety equivalent to that intended by compliance with 14 CFR 25.1549 (a) to (c).

The FAA have accepted a visible placard, stating the operating limits of the subject parameter, located such that it is clearly associated with that parameter; and display digits or backgrounds that change color based on the range in which the parameter is currently operating. White digits or background to indicated the normal operating range have been accepted as providing an equivalent level of safety to the green arc or line required by 25.1549(b).

Applicable regulation(s)

§§ 21.21(b)(1), 25.901, 25.1305, 25.1309, 25.1321, 25.1322, and 25.1549

Regulation(s) requiring an ELOS finding

§ 25.1549 (a) to (c)

Description of compensating design features or alternative standards which allow the granting of the ELOS (including design changes, limitations or equipment need for equivalency)

The compensating factors that provide an equivalent level of safety for the regulations not complied with are as follows:

High Pressure Rotor Speed (N2):

The C Series full-authority digital engine control (FADEC) is designed with the ability to monitor and control engine N2 rotor speed. Fuel-on selection is automatically controlled by the FADEC during engine start. Therefore, the flight crew is not required to monitor N2 rotor speed during an engine start, nor are they required to identify the fuel-on N2 rotor speed selection point. In addition, the FADEC provides overspeed protection for both the high and low pressure rotors (N2 and N1). Overspeed protection is accomplished via an independent dedicated device located within the FADEC. To ensure that there are no dormant (undetected) faults within the system that could reduce the reliability of the system and result in either a reduction in overspeed protection or an increased probability of in-flight shutdown due to incorrect operation, a number of built-in tests are conducted by the FADEC. N2 is also not used for power setting. Therefore, the flight crew is not required to monitor N2 to preclude exceeding a safe operating limit or set power.

Left and right engine N2 speed is displayed as the percent of N2 data in three digits (XX.X) when below or at 99.9, and four digits (XXX.X) when above. The digits are displayed in white, yellow, or red colors to indicate the following:

- White: Normal Operation Range,
- Red: N2 above the limit.
- Yellow dashes: Failure to receive N2 data from the FADEC

Oil Pressure and Oil Temperature:

The oil pressure and temperature parameters are processed by the FADEC and the numeric values are transmitted to the EICAS. The FADEC also transmits the color of the indications which are white unless the parameter is outside the normal operating range. These parameters are not used for controlling the engine and the rate of change or knowledge of margin to limits is not necessary for safe operation. The following are the colors of the digits used for the oil pressure and oil temperature digital displays:

Oil Pressure:

Left and right engine oil pressure data are displayed in digital notation of up to three (3) digits.

- White: Normal Operation Range
- Yellow: Oil pressure above the high pressure threshold
- Red: Oil pressure below the low pressure limit

Oil Temperature:

Left and right engine oil temperature data are displayed in digital notation of up to three (3) digits:

- White: Normal Operation Range
- Yellow: Oil temperature below takeoff precautionary threshold or above high temperature precautionary threshold
- Red: Oil temperature above high temperature limit

Fuel Flow:

Fuel flow is transmitted from the fuel flow meter processed by the FADEC and transmitted to the display and the flight management system. This parameter is not used for control, nor needs rate of change to be monitored by the crew. Left and right engine fuel flow data are displayed up to

four digits display (XXXX). There are no defined fuel flow limits but color will be used to identify normal and out of normal range:

- White - Normal Operation Range,
- Yellow –Fuel flow below low precautionary threshold or above high precautionary threshold.
- A failure to receive FF data from the FADEC, the display is three (3) yellow dashes.

Explanation of how design features or alternative standards provide an equivalent level of safety to the level of safety intended by the regulation

The compensating factor(s) raise the level of safety to that required by 14 CFR 25.1549 (a) to (c) by providing the flight crew clear indication of each engine’s N2,oil pressure and oil temperature parameters. The indications use digital display with changing colors that clearly indicate when any of these parameters has exceeded its maximum and, if applicable, minimum safe operating limit; is in the parameter’s normal operating range; or is in the parameter’s precautionary range.

FAA approval and documentation of the ELOS finding

The FAA has approved the aforementioned ELOS finding in project Issue Paper P-15. This memorandum provides standardized documentation of the ELOS finding that is non-proprietary and can be made available to the public. The TAD has assigned a unique ELOS memorandum number (see front page) to facilitate archiving and retrieval of this ELOS. This ELOS memorandum number should be listed in the type certificate data sheet under the certification basis section (TC’s & ATC’s).

Equivalent Level of Safety Findings has been made for the following regulation(s):
§ 25.1549 (a) to (c) “Power plant and auxiliary power unit instruments” (documented in TAD ELOS Memo TC4948NY-T-P-15)

Original signed by Victor Wicklund

6/27/13

Transport Airplane Directorate,
Aircraft Certification Service

Date

ELOS Originated by NYACO:	Kent Fredrickson, 516 228-7364	ANE-173
---------------------------	--------------------------------	---------

K:\Canada\BD-500 aka CSeries\CSERIES Restart\Issue Papers\Formal 1Ps\Propulsion\P-15-Digital-Engine-Param\BA ELOS Request\ P-15 TAD_ELOS_Memo_MC and KF.doc
ANE-173: KFredrickson