Federal Aviation Administration

Memorandum

Date: August 24, 2015

To: Manager, International Branch, ANM-116

From: Manager, Transport Airplane Directorate, ANM-100

Prepared by: Margaret Langsted, ANM-112

Subject: INFORMATION: Equivalent Safety Finding for Digital-Only Display of Turbine Engine High Pressure Rotor Speed (N2), Oil Pressure, Oil Temperature, and Fuel Flow on the Embraer Model EMB-550 and EMB-545 airplanes, FAA Project # TC0717IB-T and AT10256IB-T

ELOS Memo #: TC0717IB-T-P-3

Regulatory Ref: §§ 21.21(b)(1), 25.901, 25.903(d)(2), 25.1305, 25.1309, 25.1321, 25.1322 and 25.1549

Revision Description: The FAA revised the memo to add the Embraer Model EMB-545.

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 Embraer Model EMB-550 and EMB-545 airplanes.

Background

Embraer has submitted a request for an ELOS finding to incorporate a digital-only presentation of engine parameters on the Model EMB-550 and EMB-545 airplanes.

The primary engine displays on turbine engine powered transport aircraft have traditionally displayed the required engine rotor speeds, oil temperature, oil pressure and fuel flow required by Title 14, Code of Federal Regulations (14 CFR) 25.1305 in an analog-only or an analog and digital format. Standby Engine Indicators (SEIs), 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[1]. This situation may result in a small cluttered, low-resolution primary display.

[1] N_1 (for EPR engines), N_2 (for N_1 engines), and N_3 (where applicable)

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 Advisory Circular (AC) 20-88A, paragraph 4(c), states that "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, § 25.1549 requires instrument markings which 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 § 25.1549.

Applicable regulation(s)

§§ 21.21(b)(1), 25.901, 25.903(d)(2), 25.1305, 25.1309, 25.1321, 25.1322 and 25.1549

Regulation(s) requiring an ELOS finding

§§ 25.1305, 25.1549(a)(b)(c)

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

The digital only indication of the High Pressure Rotor Speed, Oil Pressure, Oil Temperature and Fuel Flow still meets the intent of the requirement showing that the characteristics that would drive the need of an analog format are not required in the EMB-550 aircraft due to the following reasons:

N2 Digital Indication:

- The primary thrust setting parameter, except for idle regimes, is the low pressure rotor speed (N1), which is defined by the FADEC (Full-Authority Digital Electronic Control) according to the ambient and operating conditions.;

- The FADEC automatically calculates the minimum N2 speeds for idle settings, according to the ambient and operating conditions (ground idle, flight idle, approach idle, anti-ice bleed demand);

- The N2 is the primary means of the engine control when the engine is starting. The engine control system automatically controls the engine start sequencing (fuel flow, ignition, surge bleed valves and compressor variable geometry actuator);

- The FADEC automatically controls the fuel flow schedule, surge bleed valves and compressor variable geometry during engine transients (accels and decels);

- Both N1 and N2 are software limited to their respective maximum physical speeds, if either speeds exceeds its limit, then fuel flow is reduced to constrain the offending speed;

- An N2 overspeed protection function independent from the main software is designed to protect the engine from destructive overspeed due to control system failures that result in over fueling. This N2 overspeed protection actuates on the engine fuel shutoff valve, resulting in an engine shutdown in case of N2 overspeed detection.;

- Whenever the N2 value is exceeding its limit, the N2 indication will change the color to red (inverse video) providing a clear indication that the engine is exceeding its limit.

Oil Pressure:

- Whenever the Oil Pressure value is exceeding the limits identified in the Part 33 IM (Installation Manual), the oil pressure indication will automatically change the color to red (inverse video) providing a clear indication that the engine is exceeding its limit;

- In addition to the oil pressure digital indication, a dedicated warning CAS (Crew Alerting System) message is implemented to indicate an engine Low Oil Pressure Condition.

Oil Temperature:

- Whenever the Oil temperature value is exceeding its limit, the oil temperature indication will change the color to amber/red (inverse video) providing a clear indication that the engine is exceeding its limit;

Fuel Flow Digital Indication:

- There is no engine limit defined for fuel flow, therefore continuous monitoring is not necessary.

Explanation of how design features or alternative standards provide an ELOS to that intended by the regulation

Section 25.1549 is intended to ensure engine limits are not exceeded and to ensure that engine abnormalities that could lead to engine failure or other undesirable engine behaviors are identified by the flightcrew and addressed in a timely manner. At the time this rule was promulgated, the available technology primarily relied on flight crew awareness and direct action to respond to engine abnormalities. Analog instrumentation was required to provide appropriate crew awareness, as noted in the Background section of this Memo. Since that time, the development of FADEC systems has relieved the flight crew of much of the burden of monitoring engine indications, particularly for parameters not directly used for power setting. The compensating design features noted above, specifically the FADEC overspeed protection, N2 digital display characteristics for cautionary and warning regions, and associated engine indication and crew alerting system (EICAS) alerting, provide sufficient assurance that the intent of 25.1549 will be satisfied for the Model EMB-550 and EMB-545 airplanes.

FAA approval and documentation of the ELOS finding

The FAA has approved the aforementioned ELOS finding in project issue paper P-3. 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 finding. This ELOS memorandum number should be listed in the type certificate data sheet under the certification basis section in accordance with the statement below.

Equivalent Level of Safety Findings have been made for the following regulation(s):
§ 25.1305 Powerplant instruments, and
§ 25.1549(a), (b), and (c) Powerplant and auxiliary power unit
(documented in TAD ELOS Memo TC0717IB-T-P-3)

Original Signed by

Christopher Parker August 24, 2015

Transport Airplane Directorate, Date
Aircraft Certification Service

ELOS Originated by: Propulsion & Mechanical Systems Branch	Project Engineer: Margaret Langsted	Routing Symbol: ANM-112