Federal Aviation Administration

Memorandum

Date: September 21, 2016

To: Manager, Boeing Aviation Safety Oversight Office, ANM-100B

From: Manager, Transport Airplane Directorate, ANM-100

Prepared by: Rose Len, ANM-106B

Subject: INFORMATION: Equivalent Level of Safety Finding for the Display of Powerplant Instruments Rule on Boeing Company 787-10 Model Airplanes

Memo No.: PS13-0546-P-36

Reg. Ref.: § 25.1549(b), Amendment 25-40

The purpose of this memorandum is to inform 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 Boeing 787-10 model of airplane.

Background

Title 14, Code of Federal Regulations (14 CFR) 21.21(b)(1) states that a type certificate may be issued if it is found that the applicable airworthiness regulations are met or "that any airworthiness provisions not complied with are compensated for by factors that provide an equivalent level of safety."

Section 25.1549(b) requires each powerplant and auxiliary power unit instrument, as appropriate to the type of instrument, to have the normal operating range marked with a green arc or green line, not extending beyond the maximum and minimum safe limits.

The Model 787-10 design for powerplant instruments does not have a green arc or green line marking for the normal operating range. Therefore, the Model 787-10 airplane does not directly comply with § 25.1549(b).

The range markings are intended to indicate to a flightcrew member, at a glance, that system operation is being accomplished in a safe or unsafe condition. With the advent of full authority digital engine controls (FADEC), the primary means of assuring operation within some safe engine operating limits has been taken over by automated protection features within these engine controls. Hence, such controls may be considered to provide compensating features when establishing whether or not providing a green arc or a green line, to indicate a safe condition for continuous operation, provides an ELOS. If a FADEC is designed to assure a given engine operating limit is not exceeded, then the flightcrew is no longer the primary means of preventing an exceedance of that limit. In addition, the need for flightcrew awareness of the exceedance limit, as required by the § 25.1549 markings, is greatly diminished.

The following Model 787-10 powerplant parameters do not have green arcs or green lines for the normal operating range:

- Fan rotor speed (N1),
- Thrust (via Turbofan Power Ratio) for Rolls-Royce engines only,
- Exhaust Gas Temperature (EGT),
- High pressure rotor speed (N2),
- Intermediate pressure rotor speed (N2) for Rolls-Royce engines only,
- High pressure rotor speed (N3) for Rolls-Royce engines only,
- Oil Pressure,
- Oil Temperature,
- Oil Quantity,
- Fuel Flow,
- Vibration, and
- Fuel Quantity.

Applicable regulation(s)

§ 25.1549(b) [Amendment 25-40]

Regulation(s) requiring an ELOS

§ 25.1549(b) [Amendment 25-40]

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

The Model 787-10 powerplant instrumentation is highly automated and monitors the system health and alerts the flightcrew when engine parameters fall outside their normal operating limits. Boeing flight deck engine instrumentation conspicuously displays

supplementary information to provide enhanced situational awareness, as needed. The instrument marking scheme is in accordance with the Boeing flight deck philosophy ("quiet, dark flight deck") where in the case of powerplant instruments, only non-normal conditions are indicated by instrument color change and amber or red indicator marks. The design provides indication for when the engine is operating outside of the normal operating range. Green lights, bands, or flags on the propulsion instruments are not used based on the following four factors:

(1) They are not related to propulsion operational procedures (there are no propulsion operational procedures that reference any green indications);
(2) Propulsion instrument indications are designed to turn amber or red, as applicable, when limits are exceeded. This gives the crew clear visual indications that an engine is in a non-normal operating range. In addition, a caution level alert ("ENG LIMIT EXCEED L" EICAS message or "ENG LIMIT EXCEED R" EICAS message, Master Caution Light, and Master Caution Aural tone) will annunciate to the crew if EGT, N1, N2, or N3 [Rolls-Royce engines only] exceed their respective limits while the engine is running.
(3) The Electronic Engine Control (EEC) protects against N1, N2, and N3 [Rolls-Royce engines only] exceedances.
(4) Their elimination reduces dial face clutter and simplifies instrument display. The digital-only fuel quantity indications for individual tanks and/or total fuel quantity will turn amber when a fuel quantity related crew alert is displayed, which indicates a non-normal condition associated with the highlighted tank quantity.

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

The use of display digits/background that change color based on the range in which the parameter is currently operating, in combination with flightcrew alerting features with procedures and automatic engine control features preventing exceedances provide an ELOS to the prescriptive requirement of marking parameters with green arcs or green lines for their normal operating ranges. These features reduce flightcrew workload by eliminating the need for continuously monitoring the engine and fuel system instruments.

FAA approval and documentation of the ELOS

The FAA has approved the aforementioned ELOS finding in project Issue Paper P-36, titled, Display of Powerplant Instruments. 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 Safety Findings have been made for the following regulation(s):

14 CFR 25.1549(b) (documented in TAD ELOS Memo PS13-0549-P-36).

Original Signed by

Christopher Parker September 26, 2016

Transport Airplane Directorate, Date
Aircraft Certification Service

ELOS Originated by BASOO:	Rose Len	ANM-106B