Federal Aviation Administration

Memorandum

Date:	November 23, 2015
To:	Manager, Boeing Aviation Safety Oversight Office, ANM-100B
From:	Manager, Transport Airplane Directorate, ANM-100
Prepared by:	Jim Voytilla, ANM-100B
Subject:	INFORMATION: Equivalent Level of Safety (ELOS) Finding for Flight Critical Thrust Reverser on the Boeing Model 787-8/-9/-10 and 747-8/-8F (Project Nos. TC6918SE-T, PS06-0496, PS06-0497, PS13-0546, PS14-1031, PS05-0211 and PS05-0212)
ELOS Memo#:	TC6918SE-T-P-2
Regulatory Ref:	§§ 25.933(a)(1)(i) and 25.933(a)(1)(ii)

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 Boeing Model 787-8 airplane.

This memo was subsequently revised to extend this ELOS to the Boeing Models 747-8, 747-8F, 787-9 and 787-10 airplanes.

Background

Title 14, Code of Federal Regulations (14 CFR) 25.933(a)(1) requires that for each turbojet reversing system - (1) Each system intended for ground operation only must be designed so that during any reversal in flight, the engine will produce no more than flight idle thrust. In addition, it must be shown by analysis or test, or both, that - (i) Each operable reverser can be restored to the forward thrust position; and (ii) The airplane is capable of continued safe flight and landing under any position of the thrust reverser.

Following an unwanted inadvertent inflight engine thrust reverser deployment on a Boeing Model 767 airplane in 1991, the Federal Aviation Administration (FAA) and Aerospace Industries Association (AIA) established a steering committee consisting of representatives from transport airplane and engine manufacturers, the FAA, the Joint Airworthiness Authorities (JAA) and Transport Canada to assess and address "Transport Turbojet Fleet Thrust Reverser System Safety." The steering committee broke this activity up into the following three tasks: 1) gather relevant in-service information, 2) provide guidelines for determining if an unsafe condition

exists on any turbojet thrust reversing system within the subsonic transport category airplane fleet, and 3) review the existing regulations and evaluate the need for amending those regulations.

The steering committee concluded that assuring adequate control margins is not practical for all transport airplane types, especially those with wing mounted high bypass ratio turbofan engines. Furthermore, the committee concluded that improved safeguards against the occurrence of unwanted inadvertent inflight deployment could provide at least an ELOS to assurances of adequate control margins following such a deployment.

Consequently, both “reliability” and “controllability” acceptance criteria were developed by the steering committee to help the FAA assess whether or not a catastrophic inflight thrust reverser deployment is anticipated to occur on a given type design.

Following completion of the first two tasks, the FAA began performing evaluations under Section 609 of the Federal Aviation Act and requiring modifications to in-service airplanes that did not meet either the “reliability” or “controllability” criteria established by the steering committee.

The committee also concluded that changes to the regulations would likely be necessary. Since the steering committee was not an approved advisory committee to the FAA, the Aviation Rulemaking Advisory Committee (ARAC) was tasked with completing the review of existing regulations and developing any needed amendments to those regulations and the associated guidance material.

In order to provide guidance using lessons learned from the 767 thrust reverser inflight deployment and from the resulting activities and investigations, the JAA developed INT/POL/25/07 (current denomination TGM/25/01) to provide policy for showing compliance to Joint Aviation Requirements (JAR) 25.933. The policy was based upon showing that an inflight thrust reverser deployment is extremely improbable as per JAR 25.1309, or in absence of such a demonstration, requiring flight tests to show full controllability across the entire flight envelope.

This policy proposes to revise JAR 25.933 "Reversing systems" of the JARs for large airplanes (JAR-25) by incorporating changes developed in cooperation with the FAA and ARAC. These proposals are intended to achieve common requirements and language between the JAR and 14 CFR requirements and also make some of the requirements more rational, while significantly improving the level of safety provided by the current requirements.

Boeing has requested to use the “Reliability Option” outlined in Acceptable Means of Compliance (AMC) 25.933(a)(1) guidance material (previously Notice of Proposed Amendment (NPA) 25E-338, “Reversing System Requirements”) in conjunction with NPA No 13/2004 to show an ELOS to § 25.933(a)(1)(i) & (ii).

Applicable regulation(s)

§§ 25.933(a)(1)(i) and 25.933(a)(1)(ii)

Regulation(s) requiring an ELOS finding

§§ 25.933(a)(1)(i) and 25.933(a)(1)(ii)

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

In accordance with FAA policy, an applicant may request the use of a mature ARAC proposal, in lieu of the current requirement(s), as providing an ELOS.

The reliability option described in paragraph 8 (RELIABILITY OPTION: PROVIDE CONTINUED SAFE FLIGHT AND LANDING BY PREVENTING ANY INFLIGHT THRUST REVERSAL) of AMC 25.933(a)(1) will be the basis for the analysis to show an ELOS to § 25.933(a)(1). In meeting the intent of Paragraphs 8.b.(2) and 8.b.(3) of AMC 25.933(a)(1) Boeing may elect to follow the guidance of these paragraphs, or alternatively, perform a specific risk analysis which has been used in previous certification programs. This specific risk approach is summarized in the following section under item 3.

The ARAC, regulatory authorities and industry have recommended revisions to § 25.933(a)(1), as described above. In addition, the ARAC recommendation includes corresponding advisory material. The technical aspects of this recommendation have been agreed upon and have been accepted by the ARAC Powerplant Harmonization Working Group. The JAA developed NPA 25E-338 (ACJ 25.933(a)(1)), which is considered mature, to incorporate the ARAC recommendation under JAR-25. With the transition over to EASA, this incorporation will be made in EASA CS-25 (under NPA No 13/2004 including the Acceptable Means of Compliance (AMC) 25.933(a)(1)). The FAA has not yet adopted the ARAC recommendation into the 14 CFR.

Explanation of how design features or alternative Methods of Compliance (MoC) provide an ELOS to the level of safety intended by the regulation

In previous certification programs, the FAA has required the applicant to demonstrate an ELOS to § 25.933(a)(1) by performing, in part:

1) A rigorous qualitative safety analysis to show that no single failure or malfunction, regardless of the probability, can result in a catastrophic inflight reverser deployment. In addition to the traditional failure modes and effects analysis (FMEA), a top down analysis, at least to the assembly level, should be performed to assure that any obscure single failure modes are identified.
2) An average risk analysis in accordance with Advisory Circular (AC) 25.1309-1A which predicts that catastrophic inflight reverser deployment will not occur in the fleet life of the Boeing Model airplane under evaluation;
3) A specific risk analysis which predicts that at the beginning of each flight the aircraft will continue to meet the "no single failure" criteria of analysis number (1) above and that the risk of catastrophic inflight deployment is less than $1X10^{-6}$ / flight hour. This analysis is only required if the design can have contributory faults present for more than one flight. This

analysis must consider any aircraft configuration (including latent faults) anticipated to occur in the fleet life of the airplane type which is not proposed to be precluded from dispatch by the master minimum equipment list (MMEL). For the purpose of this analysis, a configuration whose probability of occurrence is greater than $1X10^{-8}$ must be assumed to occur unless a lower total fleet exposure time can be justified by prescribing either production or utilization limits. This analysis provides a previously unavailable tool to assist in the assessment of MMEL and maintenance review board (MRB) proposals.

4) Verification that the influences which could render these predictions invalid have been identified and acceptable means for managing these influences throughout the fleet life of the Boeing Model airplane under evaluation have been defined and implemented.

The FAA has concluded that NPA No 13/2004, in conjunction with the AMC 25.933(a)(1), effectively cover the intent of the above requirements.

Consequently, the FAA agrees that the reliability standards and the means of compliance described within these documents could be used to support a finding of an ELOS to § 25.933(a)(1) compliance.

FAA approval and documentation of the ELOS finding:

The FAA has approved the aforementioned ELOS finding in project Issue Papers P-2 or Administrative Collector Issue Paper G-6. This memorandum provides standardized documentation of the ELOS finding that is nonproprietary 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 must be listed in the type certificate data sheet under the certification basis section.

An example of an appropriate statement is provided below.

ELOS findings have been made for the following regulation(s):

> Section 25.933 paragraphs (a)(1)(i) and (a)(1)(ii), Turbojet Reversing Systems in ELOS Memo TC6918SE-T-P-2)

Transport Airplane Directorate,
Aircraft Certification Service

12/3/2015
Date

ELOS Originated by Seattle ACO	Project Engineer Sue Lucier	Routing Symbol ANM-140S