U.S. Department of Transportation
Federal Aviation Administration

Memorandum

Subject: INFORMATION:, Equivalent Level of Safety Finding (ELOS) for Bombardier Aerospace model BD-100-1A10 TC2500NY-T

Date: April 17, 2003

Reg Ref § 25.933(a)(1)(ii)

From: Manager, Transport Airplane Directorate, Propulsion/Mechanical Systems, ANM-112

Reply to Attn. of: James Delisio ANE-171

To: Manager, New York ACO

ELOS Memo # TC2500NY-T-P-1

The purpose of this memorandum is document the Equivalent Level of Safety (ELOS) Finding addressed herein in a manner that is non-proprietary and that can therefore be made available to the public. To facilitate archiving and retrieval of this ELOS finding, a unique ELOS number has been assigned. This number should be listed on the Type Certificate Data Sheet under the Certification basis ELOS section for the Bombardier Aerospace model BD-100-1A10.

Background

The Bombardier Model BD-100-1A10 Challenger 300 aircraft is powered by two Honeywell AS907 turbofan engines mounted on the rear fuselage. Bombardier has observed that the AIA document entitled "Criteria for Assessing Transport Turbojet Fleet Thrust Reverser System Safety" has concluded that the consequences of inadvertent inflight thrust reverser deployment of an engine fitted to the rear fuselage are less severe than an identical event occurring on an aircraft with wing mounted engines. There are reservations concerning the ability to retain adequate rudder and elevator control/effectiveness due to consequent airflow "plume" which affects the horizontal and vertical tail relative wind angles. It is noted that the FAA has certificated several transport aircraft without demonstrating controllability compliance by flight test with thrust reverser inadvertently deployed. These include configurations with wing mounted engines.

Based on the above considerations, and the degree of redundancy built into their thrust reverser design Bombardier has declared that their Model BD-100-1A10 aircraft will not demonstrate compliance with the subject rule. Bombardier contends that the Model BD-100-1A10 thrust reverser design protects against inflight reverser deployment to an extent, which provides a level of safety equivalent to that provided by direct compliance with the rule. Compliance with § 25.933(a)(1)(ii) is intended to completely eliminate all risk of catastrophic inflight reverser deployment from normal operation. Under § 25.933(a)(1)(ii), any residual risk of catastrophic inflight reverser deployment would be limited to scenarios involving unusual aircraft configurations, abnormal flight conditions or inappropriate flight crew actions. Therefore, any

design intended to provide an equivalent level of safety to the subject rule must limit the residual risk of catastrophic inflight reverser deployment to a similar level.

Applicable Regulations

§§ 21.21(b)(1), 25.933(a)(1)(ii), and 25.1309(b)(1), and 25.1585(a)(9)

Regulation(s) Requiring an ELOS

§ 25.933(a)(1)(ii)

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

Bombardier Aerospace (BA) intends to provide an equivalent level of safety to the requirements of FAR §§ 21.21(b)(1), 25.933(a)(1)(ii), and 25.1309(b)(1), and 25.1585(a)(9) based on substantiating by analysis, the following aspects of the design in accordance with the current proposed harmonized rulemaking from the ARAC process (Minutes of 20th Powerplant Integration Harmonization Working Group meeting, November 1998, Cannes, France - 25.933 Task Team - Thrust Reverser Harmonization, FAR/JAR 25.933 draft rule and advisory material (AC/J), Draft 10, Phase II):

- Flight deck design and procedures.
- Minimization and justification of dormant (latent) failures.
- No single failure or malfunction can result in a catastrophic in-flight reverser deployment.

- It will be demonstrated that for any combination of 2 Failures:
- neither failure will be pre-existing (dormant or undetected for more than one flight)
- occurrence of either failure will result in warning (indication) to the crew, or will be self-evident to the crew so that appropriate action can be taken.

- It will be demonstrated that for any combination of 3 or more Failures:
- all pre-existing failure scenarios will have a probability of 1 E10^{-3} or less when related to the frequency with which they are expected to occur

- Providing safe and straight forward thrust reverser lock-out procedures as part of maintainability and MMEL considerations.
- Ensure common mode failures are given appropriate consideration and referencing, separate analysis where applicable (fire hazards, rotorburst, EMC, etc.).

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

BA will demonstrate compliance in the following manner:

1) System Safety Analysis:

A quantitative system safety analysis has shown that no single failure or malfunction can result in a catastrophic in-flight reverser deployment. The analysis will also consider any combination of failures that could lead to a catastrophic in-flight deployment.
It has been demonstrated that for any combination of 2 failures neither failure will be pre-existing (dormant or undetected for more than one flight). That occurrence of either failure will result in warning (indication) to the crew, or will be self-evident to the crew so that appropriate action can be taken.

It has been demonstrated that for any combination of 3 or more failures all pre-existing failure scenarios will have a probability of 1 $E10^{-3}$ or less when related to the frequency with which they are expected to occur. The time each failure situation is expected to be present will take into account the expected delays in detection, isolation, and repair of casual failures.

2) Structural Considerations:

All structural load paths that affect thrust reversal will be shown to comply with the static strength, fatigue, damage tolerance and deformation requirements of FAR 25, thus ensuring that unwanted thrust reversal is not anticipated to occur due to failure of a structural load path, or due to loss of retention under ultimate load throughout the operational life of the airplane.

3) Uncontained Rotor Failure:

BA has produced a rotorburst analysis, which will include the effects of rotor failure on the Thrust Reverser System. Compliance will be demonstrated to the requirements of FAR/JAR 25.903(d)(1), using the harmonized advisory material of AC 20-128A, dated March 25, 1997. The analysis has addressed the effects of an uncontained rotor failure on the structural aspects of the powerplant, including the Thrust Reverser. Substantiation has been provided to demonstrate that such an event will not result in a Thrust Reverser Deployment.

4) Additional Reliability Predictions:

All assumptions made in the thrust reverser reliability and safety report has been justified through one or more of the following means:

- MIL-HDBK-217
- References to applicable analyses in failure effects determination (e.g. aerodynamic, stress, etc.)
- FAA AC 25-19 is used for determining critical maintenance requirements for dormant failures (candidate CMRs)
- Exposure time for critical dormant failures determined by fault tree analysis.

FAA approval and documentation of the ELOS

The FAA has approved the aforementioned Equivalent Level of Safety Finding addressed in issue paper P-1. This memorandum provides standardized documentation of the ELOS that is non-proprietary and can be made available to the public. The Transport Airplane Directorate has assigned a unique ELOS Memorandum number to facilitate archiving and retrieval of this ELOS. This number should be listed in the Type Certificate Data Sheet in the Certification Basis section as a statement for a TC or ATC project or on page 3 of the STC for an STC project. An example of an appropriate statement is provided below.

Equivalent Safety Findings have been made for the following regulation(s):
§ 25.933(a)(1)(ii) Reversing Systems (documented in TAD ELOS Memo TC2500NY-T-P-1)

/s/ Neil D. Schalekamp	4/17/03
Manager, Propulsion and Mechanical Systems Branch, ANM-112	Date

ELOS Originated by New York ACO:	Project Engineer: James Delisio	Routing Symbol ANE-171