Federal Aviation Administration

Memorandum

Date: February 25, 2014

To: Manager, Fort Worth Special Certification Office, ASW-190

From: Manager, Airplane and Flight Crew Interface Branch, ANM-111

Prepared by: Gregory Thiele, ASW-190

Subject: INFORMATION: Equivalent Level of Safety (ELOS) Finding for Vibration/Buffeting Compliance Criteria, Large Antenna Installed on Boeing 757-200 Aircraft, FAA Project # 10336-1

ELOS Memo#: 10336-1-F-1

Regulatory Ref: 14 CFR 25.251(b)

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 installation of a large antenna on Boeing 757-200 aircraft.

Background

The applicant proposes installation of an external antenna located on the top of and near the longitudinal midpoint of the fuselage of a Boeing 757-200 aircraft. The antenna is 34 inches long, 11.77 inches wide, 1.91 inches high, and has a frontal area of 21.92 square inches.

Compliance must be shown to Title 14, Code of Federal Regulations (14 CFR) 25.251(b), which states that each part of the airplane must be demonstrated in flight to be free from excessive vibration under any appropriate speed and power conditions up to V_{DF}/M_{DF}. The applicant requests the use of an equivalent level of safety finding to show by means other than flight testing that the installation of this upper fuselage mounted antenna would not cause excessive vibration under any appropriate speed and power conditions up to V_{DF}/M_{DF}.

The means of demonstrating compliance with § 25.251(b) is cited in the rule ("each part of the airplane must be **demonstrated in flight** to be free from excessive vibration under any appropriate speed and power conditions up to V_{DF}/M_{DF}"). Therefore, a flight demonstration out to V_{DF}/M_{DF} is required to demonstrate compliance with the rule.

When external modifications are made to an existing type design, compliance with § 25.251(b) must be addressed. The FAA has determined that if it can be shown by an acceptable method that the original compliance finding for this rule remains valid (i.e., no vibration/buffet issues exist due to the change), an equivalent level of safety has been shown. However, if the original certification for this rule does not remain valid due to potential effects of the external modification, direct compliance with the rule must be re-demonstrated.

Applicable regulation(s)

§ 25.251

Regulation(s) requiring an ELOS finding

§ 25.251(b)

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

For an external modification to an existing approved design, such as the one proposed, an evaluation must be performed to determine whether or not the modification could affect compliance with § 25.251(b). If the evaluation cannot show that compliance with § 25.251(b) would not be affected, then compliance must be re-demonstrated, and the only means for accomplishing this is by an in-flight demonstration at speeds up to V_{DF}/M_{DF}.

To evaluate whether the modification could affect the original compliance finding, the applicant may propose to use any suitable combination of the following:

1. Similarity to other approved designs. (Consider the size, shape, and location of the respective modification, the airplanes they are installed on, the respective V_{DF}/M_{DF} speeds, and the method of compliance used for the approved designs.)
2. Flowfield analysis using an acceptable computational fluid dynamics (CFD) tool. The applicant must show that the tool is valid for its intended use. For example, the tool must be capable of accurately assessing whether a shock is present, including its strength and location, and the area of separated flow. Generally, a full Navier-Stokes code with robust turbulence modeling is needed for such an analysis. Validation using flight test data is preferred, but suitable wind tunnel data may be acceptable. The applicant should also address other known limitations and characteristics of the code to be used, such as:
    a. Grid sizes and spacing.
    b. Geometric fidelity of the airplane model – the effect of simplifications of the model (e.g., ignoring flap track fairings, vortex generators, small gaps, etc., how the engines are modeled, aeroelastic effects, other differences between the actual airplane and the digital model used in the analysis).
    c. CFD modeling errors, particularly in turbulence modeling.
    d. Location of the trip point from laminar to turbulent flow.
    e. Boundary conditions (e.g., ensuring that far field conditions are applied sufficiently far away).

3. A vibration analysis, usually based on the results of the flowfield analysis addressed in (2).
4. Flight testing to a speed from which the analyses described in this paragraph can be used to extrapolate the findings to V_{DF}/M_{DF}. As a minimum, flight testing must be conducted to at least V_{MO}/M_{MO}.

<u>CFD Code Validation</u>

To use a CFD tool in showing that the modification does not affect compliance with § 25.251(b), the tool, the applicant should show that the tool is valid for its intended use. The CFD tool needs to be capable of accurately assessing whether a shock is present, including its strength and location, and the area of separated flow. Generally, a full Navier-Stokes code with robust turbulence modeling is needed for such an analysis. Validation using flight test data is preferred, but suitable wind tunnel data may be acceptable.

Code validation includes:

- Showing that the code accurately models flow phenomena of interest (e.g. transonic shocks, shock induced flow separation, shock-boundary layer interaction and separated flows) that may result from the modification.
- Showing that the person/organization performing the analysis is experienced and qualified to properly run the code and interpret the results.

The accuracy of the modeling of the flow field phenomena of interest should be demonstrated by comparing flow field characteristics (e.g., pressure distributions, shock strength/location, etc.) predicted by the model to flight test or wind tunnel data for a configuration (including shape, location, and airframe) similar to the modification being evaluated at airspeeds up to V_{DF}/M_{DF}. In addition, if there are no significant flow field phenomena of interest (e.g. transonic shocks, shock induced flow separation, shock-boundary layer interaction and separated flows) shown with the configuration being evaluated, a comparison should be made to another configuration that does exhibit such phenomena. (Validation depends on the flow phenomena of interest being present to show that the code will accurately model such flow phenomena.) Known limitations and characteristics of the model should be addressed, such as grid sizes and spacing, geometric fidelity of the airplane model, turbulence modeling fidelity, boundary conditions, and strength and location of shocks/ recovery.

The test cases used to validate the code should be agreed be agreed to in advance by the FAA.

<u>Aerodynamic Analysis</u>

An aerodynamic analysis using the validated code may be used to show that compliance with § 25.251(b) will not be affected by the modification provided the code validation has been accepted by the FAA.

The aerodynamic analysis need not cover all flight conditions. The critical flight conditions should be identified and those that need to be analyzed in detail selected. The applicant should document how these critical flight conditions have been identified.

The applicant should analyze the effects of all simplifications or assumptions applied to the aerodynamic model (i.e., the analytical representation of the modified and unmodified airplanes) and show that these simplifications would not lead to an inappropriate conclusion.

After FAA acceptance of both the code validation and the results of the aerodynamic analysis, it is not required to perform a flight test to V_{DF}/M_{DF} to show that the modification did not affect compliance with § 25.251(b). However, a flight test to V_{MO}/M_{MO} should be performed with a qualitative assessment that no buffeting condition exists up to that speed to show compliance with § 25.251(d).

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

The alternative standards provide an equivalent level of safety to that intended by the regulation by using an acceptable means to show that the original flight test compliance demonstration of the unmodified airplane remains applicable to the modified airplane.

In this case, the applicant has accepted the alternative standards described above and will show compliance to § 25.251(b) by conducting a flowfield analysis using a validated Navier/Stokes computational fluid dynamics tool and flight testing to V_{MO}/M_{MO}.

FAA approval and documentation of the ELOS finding

The FAA has approved the aforementioned ELOS finding in project Issue Paper F-1. 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 limitations and conditions section of the supplemental type certificate (STC). An example of an appropriate statement is provided below.

Equivalent Level of Safety Findings have been made for the following regulation(s):
§ 25.251 Vibration and buffeting (documented in TAD ELOS Memo 10336-1-F-1)

Rob Duffer — 2/25/2014

Transport Airplane Directorate,
Aircraft Certification Service — Date

ELOS Originated by: Fort Worth Special Certification Office	Project Engineer: Gregory Thiele	Routing Symbol: ASW-190