Federal Aviation Administration

# Memorandum

Date: 7/21/15

To: Manager, New York Aircraft Certification Office, ANE-170

From: Manager, Transport Airplane Directorate, ANM-100

Prepared by: Mike Muratore, ANE-173

Subject: INFORMATION: Equivalent Level of Safety (ELOS) Finding for Vibration/Buffeting Compliance Criteria, GoGo Ku-Band Antenna installed on Boeing 767-400ER Series Aircraft., FAA Project # ODA-2335-01

ELOS Memo#: ODA-2335-01-F-1

Regulatory Ref: § 25.251

---

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 767-400ER Series Aircraft.

In addition, the following similar projects are also covered by this same ELOS finding:

1. Vibration/Buffeting Compliance Criteria, GoGo ABS Ku-Band Antenna installed on Boeing 747-400 Series Aircraft, FAA Project # ODA-2336-01
2. Vibration/Buffeting Compliance Criteria, Ku-Band Antenna installed on Boeing 737-900ER Series Aircraft., FAA Project # ODA-2337-01
3. Vibration/Buffeting Compliance Criteria, Ku-Band Antenna installed on Boeing 757-200 Series Aircraft., FAA Project # ODA-2342-01
4. Vibration/Buffeting Compliance Criteria, Ku-Band Antenna installed on Boeing 757-300 Series Aircraft., FAA Project # ODA-2342-03
5. Vibration/Buffeting Compliance Criteria, Lynx Block 30 Antenna Radome on ATR-42-500 Series Aircraft., FAA Project # ODA-2278-03
6. Vibration/Buffeting Compliance Criteria, GoGo ABS Ku-Band Antenna installed on Boeing 737-800 Series Aircraft., FAA Project # ODA-2355-01
7. Vibration/Buffeting Compliance Criteria, Global Communications Suite Antenna installed on Boeing 767-300 Series Aircraft., FAA Project # ODA-2357-01
8. Vibration/Buffeting Compliance Criteria, Global Communications Suite Antenna installed on Boeing 767-400ER Series Aircraft., FAA Project # ODA-2357-02
9. Vibration/Buffeting Compliance Criteria, Lynx Block 30 Antenna installed on Aerospatiale ATR-142-500 Series Aircraft., FAA Project # ODA-2265-02

10. Vibration/Buffeting Compliance Criteria, GoGo ABS Ku-Band Antenna installed on Boeing 737-800 Series Aircraft., FAA Project # ODA-2363-01
11. Vibration/Buffeting Compliance Criteria, Global Communications Ku-Band Antenna installed on Boeing 777-200LR Series Aircraft., FAA Project # ODA-2278-05
12. Vibration/Buffeting Compliance Criteria, GoGo GTO Ku-Band Antenna installed on Airbus A320 Series Aircraft., FAA Project # ODA-2376-01
13. Vibration/Buffeting Compliance Criteria, GoGo ABS Ku-Band Antenna installed on Boeing 767-400ER Series Aircraft., FAA Project # ODA-2383-01
14. Vibration/Buffeting Compliance Criteria, Ku-Band Antenna installed on Boeing 737-700 Series Aircraft., FAA Project # ODA-2337-02
15. Vibration/Buffeting Compliance Criteria, Global Communications Suite Antenna installed on Boeing 737-800 Series Aircraft., FAA Project # ODA-2337-03
16. Vibration/Buffeting Compliance Criteria, Global Communications Suite Antenna installed on Airbus A321 Series Aircraft., FAA Project # ODA-2268-03
17. Vibration/Buffeting Compliance Criteria, Global Communications Suite Antenna installed on Airbus A320 Series Aircraft., FAA Project # ODA-2268-04
18. Vibration/Buffeting Compliance Criteria, Panasonic Global Communications Suite Antenna installed on Airbus A340-300 Series Aircraft., FAA Project # ODA-2315-04
19. Vibration/Buffeting Compliance Criteria, Go-go Ground to Orbit (GTO) Antenna installed on Boeing 737-500 Series Aircraft., FAA Project # ODA-2390-01
20. Vibration/Buffeting Compliance Criteria, Go-go 2KU Antenna installed on Boeing 737-800 Series Aircraft., FAA Project # ODA-2400-01
21. Vibration/Buffeting Compliance Criteria, ViaSat Antenna installed on Airbus A320 Series Aircraft., FAA Project # ODA-2405-01

## Background

The applicant proposes a modification of the noted series of aircraft that involves the installation of a Large Antenna and Radome located on the top of the fuselage of the aircraft.

Title 14, Code of Federal Regulations (14 CFR) 25.251(b) 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 this installation 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 so, then compliance must be re-demonstrated, and the only means for accomplishing this is by an in-flight demonstration at speeds up to $V_{DF}/M_{DF}$.

The FAA considers that the extent of the airplane modifications proposed by the applicant, particularly the size and location of the antenna with respect to the unmodified airplane, may cause significant changes in the aerodynamic flow field around the airplane at high speed, which may lead to excessive vibration. Potential vibration sources include unsteady flow conditions on the antenna, fuselage, tail assembly, or control surfaces arising from shocks, flow separation or other unsteadiness in the flow. Because of these potential effects, the FAA has determined that the original demonstration of compliance for § 25.251(b) may not be valid for the modified airplanes. Therefore, unless it can be shown that the modification would not affect the original § 25.251(b) compliance demonstration, compliance must be re-demonstrated by flight testing at speeds up to $V_{DF}/M_{DF}$.

Currently, there are no valid analytical methods of substantiating that there is no excessive vibration at $V_{DF}/M_{DF}$ other than flight testing to $V_{DF}/M_{DF}$. Analysis tools may be helpful, however, in determining whether a given modification may affect the original § 25.251(b) compliance finding.

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 should show that the tool is valid for its intended use. (See the section of this issue paper on Guidance for CFD Code Validation.) 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 applicant has shown that their modification does not affect the original flight test compliance demonstration by conducting analysis using a validated CFD and performing a flight test to $V_{mo}/M_{mo}$.

In order to address § 25.251 vibration and buffeting requirements, the following were completed:

1. Perform CFD analysis of the aircraft both with and without the radome, at the following speeds : $M_{mo}$, $M_{Dive}$ and 1.5G recovery at $M_{Dive}$.
2. Demonstrate analytically that the aerodynamic flow field does not change significantly between $M_{mo}$ and $M_{Dive}$.
3. Include in the flight test plan, flight to $V_{mo}$ and $M_{Mo}$ in order to demonstrate no adverse vibration and buffeting, and no adverse change to handling characteristics due to the radome installation.
4. Extrapolate that the radome installation is aerodynamically insignificant and therefore the new design compliant to § 25.251(b) and meets the level of safety intended by § 25.251.

**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 ODA-2335-01-F-1)

Original signed by Rob Duffer 7/211/5

__________________________________________ ______________________

Transport Airplane Directorate, Date
Aircraft Certification Service

| | | |
|---|---|---|
| ELOS Originated by New York ACO: | ACO Manager Gaetano Sciortino | Routing Symbol ANE-170 |