Federal Aviation Administration

Memorandum

Date: February 13, 2015

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

From: Manager, Transport Airplane Directorate, ANM-100

Prepared by: Bruce Valentine, ANE-173

Subject: INFORMATION: Equivalent Level of Safety (ELOS) Finding for Vibration/Buffeting Compliance Criteria, Large Antenna and Radome Installed on Airbus A340-200 Aircraft, FAA Project SA07745NY-T.

ELOS Memo#: SA07745NY-T-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 Airbus A340-200 Series Aircraft.

Background

As part of the JRG SA07745NY-T project, the applicant proposes installation of an external radome located on the upper fuselage of an Airbus A340-200 as part of an STC project. The dimensions of the radome are 64 inches long, 35 inches wide and 10.5 inches high. The radome is mounted between airframe stations C53.4 and C53.7.

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.

Aerodynamic Analysis

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

J.R.G. Design, Inc. intends to demonstrate "no effect of FAR 25.251(b)" with this antenna/ radome installation on the A340-200 aircraft by analysis. Installation location is shown in Applicants Appendix 1. The A340-200 installation is similar to the installations that were accomplished on prior A340-200 STC's and completed by Airbus.

Analysis and Flight Test for A340-200

Aeromechanical Solutions and Rose Engineering will compile an analysis using a validated program code to show that the air flow path and reattachment of the airflow is well prior to having any effect on the horizontal or vertical tail sections of the aircraft. Using reasoning and logic through extensive experience, critical flight conditions have been identified and have been analyzed in detail. In addition, the accuracy of the modeling of the flow field phenomena of interest will 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 up to VDF / MDF airspeeds. The validation comparisons produced or reproduced are demonstrated by using known limitations and characteristics and are 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 analysis will show that the effects of all simplifications for the aerodynamic model have been analyzed and that these simplifications do not affect the results of the analysis.

J.R.G. Design, Inc. with Aeromechanical Solutions and Rose Engineering will use the results of the aerodynamic analysis to substantiate that no buffeting condition exists up to VMO/MMO to comply with §25.251(b). In addition, we will conduct a flight test to Vmo/Mmo to show compliance with 25.251 (d).

Code Validation

The program code used by Aeromechanical Solutions and Rose Engineering assures that :

- It has been designed for investigations which are necessary for the modification (e.g. aerodynamic analysis)
- The limits (e.g. speed limits) the code have been designed for are applicable for the investigation of this installation
- Is able to accurately model flow phenomena (e.g. transonic shocks, shock induced flow separation, shock-boundary layer interaction and separated flows) which are relevant for this special modification

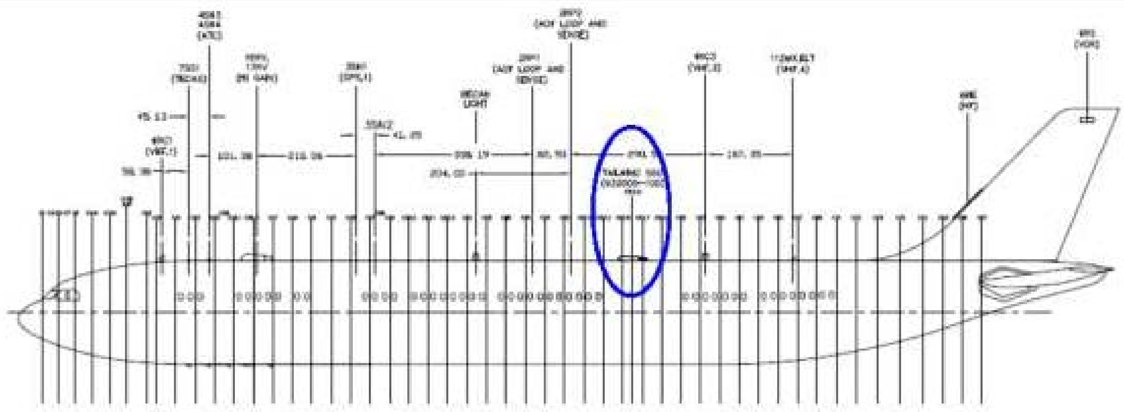
Aeromechanical Solutions and Rose Engineering will utilize an known and similar case of a KC 135 that had an installation of a similar belly mounted radome. The KC135 installation used a combination of wind tunnel and flight test to VDF/MDF to compile data to support the conclusions for the installation on the KC135. Rose Engineering will take the KC135 data and use the program code to demonstrate that it can accurately duplicate the flow characteristics derived from flight test/wind tunnel data. In support of this project, Rose Engineering will submit a report to of this comparison as credit for code validation.

APPLICANT CONCLUSIONS

A numerical investigation has been carried out to determine the limit airloads on the TW550 radome installed on the A340-200 airplane. The radome was installed on the upper fuselage just aft of the wings at FS 53.4+8”. Numerical flow solutions were obtained for various aircraft operating conditions at the limits of the flight envelope for the aircraft to define the conservative forces acting on the radome. Details of the pressure distributions and resulting forces on the outside of the radome and surrounding fuselage were presented for cases having higher loads. Data from these numerical solutions can be used to design the radome shell and its attachments and to evaluate the additional forces on the aircraft resulting from the radome installation. Changes in the forces due to the installation of the TW550 radome were presented and found to be insignificant on both the horizontal and vertical tails. Fuselage loading was examined and the differences in loading due to the presence of the TW550 radome are insignificant when compared to the total aerodynamic plus inertial loading used in the original design. The fuselage pressures, in conjunction with the reaction loads transmitted from the radome and its attachment, are available from the present aerodynamic analyses upon request.

With the completion of the analysis and the Aircraft Flight Test monitoring the stability of the mounted radome demonstrates the installation of the radome on the A340-200 at frame station C53.4 and C53.7 will not affect 25.251(b) or (d) and is applicable to the A340-200.

Appendix 1



a) Radome Installation Location

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 SA07745NY-T-F-1).

Original signed by Rob Duffer — 2/13/15

Transport Airplane Directorate,
Aircraft Certification Service

Date

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