Federal Aviation Administration

Memorandum

Date: 3/20/2015

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

From: Manager, Transport Airplane Directorate, ANM-100

Prepared by: Ram Rambrich, ANE-172

Subject: INFORMATION: Equivalent Level of Safety (ELOS) Finding for Vertical Acceleration Sensor for Flight Data Recorder installed on a BD-700-2A12 & BD-700-2A13 airplane, FAA Project # AT7180NY-T & AT7285NY-T

ELOS Memo #: AT7180NY-T-GA-SA-04

Regulatory Ref: §§ 25.1459 (a) (2)

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 Model BD-700-2A12 & BD-700-2A13 airplane.

Background

The Bombardier Global 7000 and 8000 will utilize a methodology for acquiring accelerometer data similar to other recently certified transport category aircraft, that differs from the configuration specified by the applicable regulation.

The FDR does not employ an accelerometer installed as required per FAR 25.1459(a)(2), but uses instead a vertical acceleration measurement from the Inertial Reference Unit (IRU).

Applicable regulation(s)

§§ 25.1459 (a) (2)

Regulation(s) requiring an ELOS finding

§§ 25.1459 (a) (2)

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

Three IRUs will be located in the center fuselage under-floor rack in a rigid portion of the structure, free from any low frequency structural bending. An on-board software correction will be performed by the Primary Flight Control Computer to adjust acceleration to the aircraft center of gravity. The algorithm for this calculation is the same used to adjust measurements to the center of rotation for the flight controls.

Each PFCC receives vertical acceleration data from IRU #2 and sends the adjusted acceleration data to the DMC. DMC channel lA sends vertical acceleration to the FDR via ARINC 717 from the PFCC in control.

The IRS vertical acceleration used in the calculation complies with the accelerometer range, sample rate, minimum resolution and accuracy specified by the regulation.

Explanation of how design features or alternative standards provide an ELOS to that intended by the regulation.

The validation of the Flight Data Recorder acceleration data will be accomplished by means of flight test. A vertical accelerometer will be mounted with the CG limits in accordance with A WM 525.1459(a)(2). The data will be recorded and a comparison analysis will be performed between the accelerometer and the IRU accelerometer data to verify compliance with AWM 525.1459(a)(2).

Bombardier will also address the following criteria/characteristics of the IRU accelerometer to show they are equivalent to the vertical accelerometer literally referred to in A WM 525.1459(a)(2).

1. Changes in the operating mode of the electronic flight control system (e.g. normal, PFCC direct, Remote Electronics Unit-direct and Alternate Flight Control Unit), should not affect vertical acceleration recording.

IRU acceleration is transmitted directly to each of the three PFCCs which calculate vertical acceleration at the MAC and then transmit it to the DMC via a high speed ARINC 429 for output to the FDR. This acceleration measurement is executed independently from the FBW function and will only be affected if all three PFCCs fail. The probability of this event shall be demonstrated to be less than lE-09 failures per flight hour, i.e. commensurate with a catastrophic failure.

2. The IRU output of vertical acceleration should function properly under the maximum dynamic conditions (rates of change of attitude and acceleration) attainable by the aeroplane.

IRU vertical acceleration will comply with the range and accuracy identified in Appendix M to 14 CFR Part 121, Appendix E to 14 CFR Part 91 and Appendix F to 14 CFR Part 135, namely -3g to +6g (dynamic conditions). The IRU parameter used for this function has a range of ±8g (unbiased), far exceeding the limit load (+4g, -2g) and ultimate load (+6g, -3g) for the fuselage.

The IRU vertical acceleration output would only "limit" if the combination of acceleration and pitch rate exceeds 8g. Non-compliance to the requirement to provide a measurement of up to 6g at MAC will only occur if the relative acceleration of the center fuselage under-floor avionics rack (IRU location), due to acceleration in the pitch axis plus acceleration at the MAC, exceeds the +8g unbiased capability of the IRU. For this to occur the center fuselage under-floor avionics rack structure would be subjected to a biased acceleration of + 7 g, which is beyond ultimate load and would probably result in structural failure.

The IRU, DMC, PFCC and FDR have been qualified to D0-160 Section 7, Category B.

3. The IRU, PFCC, Digital Flight Data Recorder (DFDR), and data bosses should function normally during power interruptions of less than 200 milliseconds.

The equipment necessary to achieve the "Vertical Acceleration" sensing and recording function in the Global 7000/8000 are the PFCCs, IRU #2, DMC IA and the FDR. These LRUs are all DC powered.

Bus power interruptions typically originate from 115 VAC power sources switching.

Under normal operation, a power interruption on the AC Buses will not generate an interruption on the DC Buses due to DC cross-tie during such predicted events.

Under abnormal conditions, power interruptions up to 200ms may occur on AC buses and also DC bus 1, DC Bus 2 and DC ESS Bus 2. DC ESS Bus 1 is not affected by power interruptions since the batteries are float charging and always connected to DC ESS Bus 1.

The PFCCs will not be subjected to power interruptions due to additional power provided by engine-driven PMGs for PFCCs 1 and 2, and due to PFCC3 being connected to DC ESS Bus 1.

DMC channel lA provides the ARINC 717 data to the FDR and will continue operate during power interruptions due to being connected to DC ESS Bus 1.

The FDR and IRU #2 are connected to DC ESS Bus 2 and are qualified per D0-160 to continue operating during power interruptions of 1 sec.

Evidence will be provided in the DMC, PFCC, IRU and FDR qualification test procedure and test results.

4. The IRU, PFCC, DFDR, and data busses should resume recording vertical acceleration within 500 milliseconds of power being restored following a power interruption of less than 2 seconds.

Bombardier will demonstrate the impact on vertical acceleration recording function for adverse effects observed during electrical power input qualification of the IRU, PFCC, DMC and FDR. If the function is interrupted, it should be restored within 30 seconds of the D0-160 normal minimum voltage being applied at the equipment terminals.

5. Accuracy of the recorded vertical acceleration data should be shown using flight test data collected for both Global 7000/8000 models, for the full loading envelope (with consideration of future expansion), and by using combinations of fuel, cargo and passengers, including minimum fuel and

max cargo. Accuracy under dynamic conditions should be demonstrated between -3g and +6g at the maximum attainable rate of change of acceleration for a wide range of loads, including heavy and zero-flare landings, and upset recovery. The reference accelerometer measurements should be corrected for datum to determine the true vertical acceleration.

The accuracy of the recorded vertical acceleration will be demonstrated at the maximum values achieved during flight testing for all flight phases and ground operations. Typically these are between -1.0g and +2.5g. Correlation between IRU derived data and acceleration at the MAC will use a reference accelerometer mounted within 25% of MAC and corrected for datum. Any values exceeding these will l)e verified by reference to IRU supplier specifications and test results. The acceleration correction algorithm performed in the PFCC will be verified by testing on a system rig and/or software high level testing. Aircraft level testing will be performed on both the Global 7000 and Global 8000 aircraft types to ensure that the vertical acceleration is acceptable for the different physical configurations.

6. Latency should not exceed 0.25 seconds and delay jitter should not exceed 0.1 second, including changes in data routing due to faults and failures.

The system design complies with these requirements. The transition delay between the IRU measurements and the FDR system is 230ms maximum. All three PFCCs continuously calculate the FDR vertical acceleration. In the event of a PFCC failure the DMC will immediately revert to another PFCC source.

FAA approval and documentation of the ELOS finding

The FAA has approved the aforementioned ELOS finding in project Issue Paper GA-SA-04 titled Vertical Acceleration Sensor in Flight Data Recorder FAR 25.1459 (a) (2). 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 finding. This ELOS memorandum number should be listed in the type certificate data sheet under the Certification Basis section in accordance with the statement below:

Equivalent Level of Safety Findings have been made for the following regulation:

§ 25.1459 (a) (2) Vertical Accelerometer Sensor in Flight Data Recorder (documented in TAD ELOS Memorandum AT7180NY-T-GA-SA-04)]

Original signed by Robert Duffer — 3/20/15

Transport Airplane Directorate, Aircraft Certification Service — Date