Federal Aviation Administration

# Memorandum

Date: August 19, 2015

To: Manager, International Branch, ANM-116

From: Manager, Transport Airplane Directorate (TAD), ANM-100

Prepared by: Todd Martin, ANM-115

Subject: INFORMATION: Equivalent Level of Safety (ELOS) Finding for Embraer's project on the Model EMB-550 and EMB-545 airplanes, FAA Project # TC0717IB-T and AT10256IB-T

ELOS Memo #: TC0717IB-T-A-11

Regulatory Ref: § 25.331(c)(2)

**Revision Description**: The FAA revised the memo to add the Embraer Model EMB-545.

This memorandum informs the certificate management aircraft certification office of an evaluation made by the TAD on the establishment of an ELOS finding for the Embraer Model EMB-550 and EMB-545 airplanes.

**Background**

Embraer requested an equivalent level of safety finding to be made with respect to Title 14, Code of Federal Regulations (14 CFR) 25.331(c)(2). Embraer proposes to show compliance to the European Aviation Safety Agency (EASA) Certification Standard (CS) 25.331(c)(2) in lieu of the FAA regulation § 25.331(c)(2).

Section 25.331(c)(2) requires, in part, that the checked maneuver be based on a rational pitching control movement. That movement is undefined, but certain minimum pitching accelerations and normal load factors are specified for the maneuver.

The EASA CS 25.331(c)(2) define minimum pitching accelerations that would result from a specific motion of the cockpit pitch control, which is applied at a frequency related to the short period rigid body mode of the airplane. The EASA CS requirement also differs

from the FAA requirement in that it specifies a negative checked maneuver where zero load factor is achieved.

**Applicable regulation(s)**

§ 25.331(c)(2), 25.337

**Regulation(s) requiring an ELOS finding**

§ 25.331(c)(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)**

The following criteria may be used in lieu of current § 25.331(c)(2) and are considered to provide an equivalent level of safety:

*"Checked maneuver between VA and VD. Nose up checked pitching maneuvers must be analyzed in which the positive limit load factor prescribed 14 CFR 25.337 is achieved. As a separate condition, nose down checked pitching maneuvers must be analyzed in which a limit load factor of 0 g is achieved. In defining the airplane loads, the cockpit pitch control motions described in sub-paragraphs (i), (ii), (iii) and (iv) of this paragraph must be used:*

*(i) The airplane is assumed to be flying in steady level flight at any speed between VA and VD and the cockpit pitch control is moved in accordance with the following formula:*

$$\delta(t) = \delta_1 \sin(\omega t) \quad \text{for} \quad 0 \leq t \leq t_{max}$$

*where* $\delta_1$ = *the maximum available displacement of the cockpit pitch control in the initial direction, as limited by the control system stops, control surface stops, or by pilot effort in accordance with RBAC/14 CFR Part 25.397(b);*

$\delta(t)$ = *the displacement of the cockpit pitch control as a function of time. In the initial direction* $\delta(t)$ *is limited to* $\delta_1$*. In the reverse direction,* $\delta(t)$ *may be truncated at the maximum available displacement of the cockpit pitch control as limited by the control system stops, control surface stops, or by pilot effort in accordance with RBAC/14 CFR Part 25.397(b);*

$$t_{max} = \frac{3\pi}{2\omega}$$

$\omega$ = *the circular frequency (radians/second) of the control deflection taken equal to the undamped natural frequency of the short period rigid mode of the airplane, with active control system effects*

*included where appropriate, but not less than*

$$\omega = \frac{\pi V}{2V_A} \text{ radians per second, where:}$$

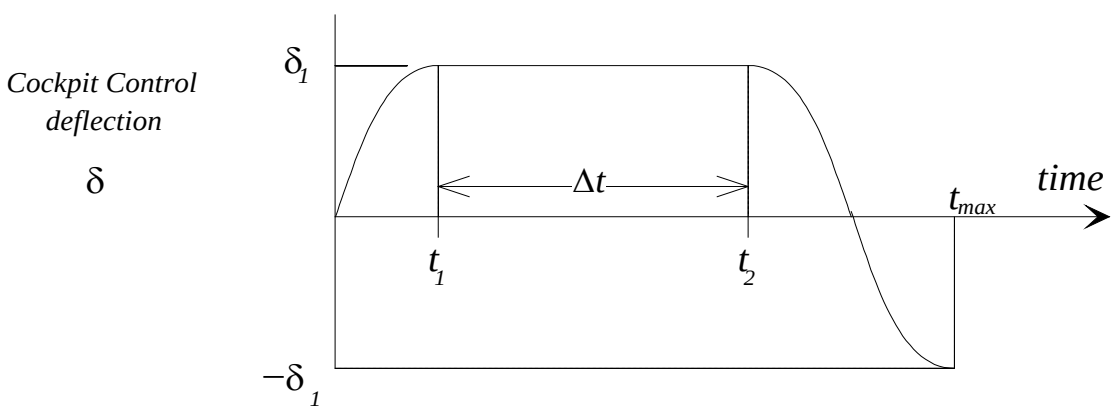
$V$ = *the speed of the airplane at entry to the maneuver;*
$V_A$ = *the design maneuvering speed prescribed in RBAC/FAR 25.335(c).*

*(ii) For nose-up pitching maneuvers, the complete cockpit pitch control displacement history may be scaled down in amplitude to the extent just necessary to ensure that the positive limit load factor prescribed in RBAC/14 CFR Part 25.337 is not exceeded. For nose-down pitching maneuvers, the complete cockpit control displacement history may be scaled down in amplitude to the extent just necessary to ensure that the normal acceleration at the c.g. does not go below 0 g.*

*(iii) In addition, for cases where the airplane response to the specified cockpit pitch control motion does not achieve the prescribed limit load factors, then the following cockpit pitch control motion must be used:*

$$\delta(t) = \delta_1 \sin(\omega t) \quad \text{for} \quad 0 \le t \le t_1$$
$$\delta(t) = \delta_1 \quad \text{for} \quad t_1 \le t \le t_2$$
$$\delta(t) = \delta_1 \sin(\omega[t + t_1 - t_2]) \quad \text{for} \quad t_2 \le t \le t_{max}$$

*where:* $t_1 = \pi/2\omega$
$t_2 = t_1 + \Delta t$
$t_{max} = t_2 + \pi/\omega;$
$\Delta t$ = *the minimum period of time necessary to allow the prescribed limit load factor to be achieved in the initial direction, but it need not exceed five seconds (see figure below).*




*(iv) In cases where the cockpit pitch control motion may be affected by inputs from systems (for example, by a stick pusher that can operate at high load factor as well as at 1 g), then the effects of those systems shall be taken into account.*

*(v) Airplane loads that occur beyond the following times need not be considered:*

*(1) For the nose-up pitching maneuver, the time at which the normal acceleration at the c.g. goes below 0 g;*
*(2) For the nose-down pitching maneuver, the time at which the normal acceleration at the c.g. goes above the positive limit load factor prescribed in RBAC/14 CFR Part 25.337; and*
(3) $t_{max}$."

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

The standard provided above defines minimum pitching accelerations that would result from a specific motion of the cockpit pitch control, which applied at a frequency related to the short period rigid body mode of the airplane. The EASA CS requirement also specifies a negative checked maneuver where zero load factor is achieved.

**FAA approval and documentation of the ELOS finding**

The FAA has approved the aforementioned ELOS finding in project issue paper A-11. 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(s):
§ 25.331(c)(2) Checked Maneuver Loads (documented in TAD ELOS Memo TC0717IB-T-A-11)

***Original Signed by***

*Suzanne Masterson* August 19, 2015

Transport Airplane Directorate, Date
Aircraft Certification Service

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| ELOS Originated by: Airframe & Cabin Safety Branch | Project Engineer: Todd Martin | Routing Symbol: ANM-115 |