Date: June 24, 2008

To: Manager, Small Airplane Directorate, ACE-100

From: Manger, Airplane Certification Office, ASW-150

Prepared by: Al Wilson, Flight Test Pilot, ASW-150

Subject: Equivalent Level of Safety (ELOS) for 14 Code of Federal Regulations (CFR) §§ 23.201(b)(2) and 23.203(a), Amendment (Amdt.) 23-50; Eclipse Model 500, Project TD2084AC-A, ACE-08-12

This memorandum documents concurrence for the subject finding of ELOS. We request your office to review and provide concurrence with the ELOS finding to 14 CFR part 23, §§ 23.201(b)(2) Wings Level Stall, and 23.203(a), Turning Flight and Accelerated Turning Stalls for flight into known icing (FIKI). The ELOS will allow for compliance to the regulation to be accomplished by the compensating features contained in this ELOS.

BACKGROUND:

14 CFR part 23 § 23.1419(a) states, in part, that tests of the ice protection system must demonstrate that the airplane is capable of operating safely in continuous and intermittent maximum icing conditions, as described in Appendix C of part 25. It further states that the definition of “capable of operating safely” means that the airplane performance, controllability, maneuverability, and stability must not be less than that required in part 23, subpart B. Neither the rule nor the guidance in Advisory Circular (AC) 23.1419-2C, provide any relief from the subpart B characteristics due to the capabilities of the ice protection system.

The Eclipse Model 500 incorporates an artificial stall barrier (stick pusher) to define the stall. 14 CFR part 23, § 23.201(b) requires the wings level stall characteristics must be demonstrated in flight by producing a stall as shown by a downward pitching motion of the airplane that results from the stick pusher. 14 CFR part 23, § 23.203(a) requires that turning flight and accelerated turning stalls must be demonstrated in tests by essentially the same criteria as defined in § 23.201(b).

14 CFR part 23, § 23.691 requires, in part, that if the function of an artificial stall barrier, for example, stick pusher, is used to show compliance with § 23.201(c), the system must provide a safe margin above any airspeed at which any unsatisfactory stall characteristics occur in addition to the stall criteria prescribed by §§ 23.201 and 23.203.

APPLICABLE REGULATIONS:

The applicable regulations for this ELOS are:

Section 23.201(b) Wings Level Stalls:

(a) …
(b) The wings level stall characteristics must be demonstrated in flight as follows. Starting from a speed at least 10 knots above the stall speed, the elevator control must be pulled back so that the rate of speed reduction will not exceed one knot per second until a stall is produced, as shown by either:
(1) …
(2) A downward pitching motion of the airplane that results from the activation of a stall avoidance device (for example, stick pusher); or
(3) …

Section 23.203(a), Turning Flight and Accelerated Turning Stalls:

Turning flight and accelerated turning stalls must be demonstrated in tests as follows:

(a) Establish and maintain a coordinated turn in a 30 degree bank. Reduce speed by steadily and progressively tightening the turn with the elevator until the airplane is stalled, as defined in § 23.201(b). The rate of speed reduction must be constant, and –
(1) …
(2) …

DESCRIPTION OF COMPENSATING FEATURES:

Stall Characteristics:

During stall testing for 14 CFR part 23, §§ 23.201 and 23.203 with the normal ice shapes installed, two Federal Aviation Administration (FAA) Flight Test Pilots determined that the stall characteristics were not repeatable. The lack of repeatability was primarily due to the pilot not detecting the stick pusher activation as a result of the high rearward stick forces (approximately 45 pounds) at the time of pusher activation. This was noted in the cruise configuration (gear and flaps up) at the most forward center-of-gravity (cg) location for the maximum gross weight flight condition. The high stick forces were primarily attributed to the weight/cg combination and the requirements of § 23.201(b)(2), that requires an initial trim speed of 1.5 Vs1. With the advanced stick pusher schedule for icing, this initial trim setting is above the maximum level flight speed at takeoff power, resulting in an unrealistically high trim setting.

The approach to stall was characterized by stall buffet starting approximately 10 to 15 knots above the stall warning. As airspeed slowed, the stall buffet increased and the conditions at stall were characterized by high rearward stick forces, significant stall buffet, stall warning, increased roll activity, and then pusher activation. Other than the lack of repeatability in detecting the stick pusher in accordance with § 23.201(b)(2), the wings level stall and stall warning characteristics were deemed acceptable.

The stall characteristics appear to be compliant in all other configurations and weight/cg combinations. Qualitatively, both pilots agreed that the intensity of the pre-stall buffet, the high rearward stick forces, and the aural and visual stall warning cues provided effective low airspeed awareness cues to the pilot in preventing a stall.

Stall Margin

Stall margin is defined as the airspeed margin between stick pusher activation and an aerodynamic stall. Although an ELOS to 14 CFR part 23, § 23.691 is not specifically requested in this ELOS, the stall margin requirements are addressed to insure an adequate level of margin exists for conditions that exhibit unsafe aerodynamic stall characteristics. 14 CFR § 23.691 requires, in part, that if the function of an artificial stall barrier (stick pusher) is used part 23, to show compliance with § 23.201(c), the system must provide a safe margin above any airspeed at which any unsatisfactory stall characteristics occur. The stall margin requirements determined during original type certification and accepted for FIKI certification required a minimum of 5 knots difference for the landing (gear and flaps down) configuration and 2 knots for all other configurations. Type Inspection Authorization (TIA) testing resulted in a 3 knot margin in the landing configuration at the aft-regardless weight/cg configuration, which is less than the required 5 knot margin. The 5 knot margin is required as a result of a deep-stall tendency the model 500 has demonstrated at the aft-regardless weight/cg condition. For other gross weight/cg conditions in the landing configuration as well as the cruise and approach configurations at all gross weight/cg conditions, a minimum of 2 knots margin was required and was demonstrated during TIA testing. As stated above with regards to the wings level stall characteristics, the stall characteristics were otherwise determined compliant.

Mitigating Features

The following are compelling mitigating features in finding compliance to §§ 23.201 and 23.203:

1. This condition occurs only at forward center of gravity loadings.
2. This condition occurs only in the clean configuration.
3. This condition occurs with very conservative (larger) normal ice shapes installed as compared with ice accretion during natural icing conditions.
4. 14 CFR, part 23, § 23.201(e)(5) requires “The aircraft trimmed at a speed as near 1.5Vs1 as practical”. The installation of the ice shapes significantly increases the stall speed therefore, unrealistically increasing the trim speed. In this particular case the trim speed is approximately 178 knots equivalent airspeed (KEAS) and the stall speed 118 KEAS. This trim speed is above the maximum speed for level flight with maximum continuous power (Vh).
5. The large difference between the required trim speed and the stall speed results in an unrealistically high stick force in the range of 35 to 45 lbs.
6. The aircraft exhibits airframe buffet starting approximately 10 to 15 KEAS prior to the stall warning and increases in amplitude as the aircraft continues to decelerate to the stall.

7. The aircraft's roll activity, although controllable, increases approximately 3 to 5 KEAS prior to the stick pusher activation.
8. A very compelling "STALL STALL" voice warning is activated at stall warning.
9. A very compelling red "STALL" warning annunciation is posted on the attitude direction indicator (ADI) pitch ladder.

AIRPLANE CERTIFICATION OFFICE (ACO) RECOMMENDATION:

We agree that the mitigating features as described in items 1 through 9 above provide some level of equivalency to the prescriptive requirements of 14 CFR part 23, §§ 23.201 and 23.203. In order for the design to provide an equivalent level of safety, the design must provide the following additional features in addition to items 1 through 9 above.

Additional Stall Awareness

The design must include a visual and voice warning to enunciate to the pilot when the stick pusher is active. These additional warnings will be evaluated by FAA flight test to determine if this additional awareness will adequately mitigate (in combination with the other mitigating features) the lack of stick pusher detection due to the high stick forces.

Stall Margin

In order to accept the mitigating factors as an ELOS, Eclipse must demonstrate the following stall margins with critical ice accretions. The margins defined below in addition to the mitigating factors will insure an adequate safety margin exists for conditions that exhibit unsafe aerodynamic stall characteristics:

FLAPS	**GEAR**	**REQUIRED MARGIN**
Up	Up	2
Takeoff	Down	2
Landing	Down	5 (Note 1)

Note 1: Eclipse Aviation Corporation must determine the envelope where unsatisfactory, hazardous or unrecoverable stall characteristics occur. The 5-knot margin must exist for that envelope.

Concurred by:

Monica Merritt for 6-8-08
Manager, Airplane Certification Office, ASW-150 Date

William J. Timberlake for 6-19-08

Manager, Standards Office, ACE-110 Date

John Colomy for 6-24-08
Manager, Small Airplane Directorate, ACE-100 Date