



# Federal Aviation Administration

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## Memorandum

Date: JUL 18 2006

To: Manager, Small Airplane Directorate, ACE-100

From: Manager, Fort Worth Aircraft Certification Office, ASW-150

Prepared by: Lowell Foster, Aerospace Engineer, ACE-111

Subject: Review and Concurrence, Equivalent Level of Safety for 14 CFR § 23.181(b),  
Dynamic Stability, on Eclipse Model 500, Project TC3853CH-A  
(ELOS) ACE-05-34

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This memorandum documents concurrence for the subject finding of Equivalent Level of Safety (ELOS). We request your office to review and concur with the proposed ELOS finding to 14 CFR part 23, § 23.181(c), Dynamic Stability. The proposed ELOS will allow for the compliance to the regulation to be accomplished by natural stability in a reduced flight envelope and the use of a yaw damper for compliance in the entire flight envelope. Failure of the yaw damper will require the airplane to operate in the reduced operational flight envelope of natural stability.

### Background

14 CFR § 23.181(b) requires that any combined lateral-directional oscillation (Dutch Roll) occurring between the stalling speed and the maximum allowable speed appropriate to the configuration of the airplane must be damped to 1/10 amplitude in 7 cycles with the primary controls:

- (1) Free; and
- (2) In a fixed position.

14 CFR § 23.672(c) requires that, if the functioning of stability augmentation is necessary to show compliance with the flight characteristics requirements of 14 CFR part 23, such systems must comply with Section 23.671 and it must be shown that, after any single failure of the stability augmentation system:

- (1) The airplane is safely controllable when the failure or malfunction occurs at any speed or altitude within the approved operating limitations that is critical for the type of failure being considered;
- (2) The controllability and maneuverability requirements of part 23 are met within a practical operational flight envelope (for example, speed, altitude, normal acceleration, and airplane configuration) that is described in the Airplane Flight Manual (AFM); and

(3) The trim, stability, and stall characteristics are not impaired below a level needed to permit continued safe flight and landing.

Eclipse Aviation intends to comply with 14 CFR § 23.181(b):

- (1) During take-off, immediately following take-off, immediately preceding landing and during landing by natural stability of the aircraft that complies with this section; and
- (2) During all other flight phases through a stability augmentation system (yaw damper) that complies with 14 CFR § 23.672(c).

In the event of failure of the yaw damper, a reduced operating envelope in which natural stability of the aircraft complies with the requirements of 14 CFR § 23.181(b) shall be established that permits continued safe flight and landing.

### **Applicable Regulation:**

The applicable regulation is 14 CFR part 23, § 23.181(b), which states:

*Section 23.181(b) Dynamic stability.*

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*(b) Any combined lateral-directional oscillations ("Dutch roll") occurring between the stalling speed and the maximum allowable speed appropriate to the configuration of the airplane must be damped to  $\frac{1}{10}$  amplitude in 7 cycles with the primary controls--*

- (1) Free; and*
- (2) In a fixed position.*

.....

### **Compensating Features:**

During development testing of the Eclipse Model 500, it has been demonstrated that Dutch Roll characteristics do not meet the requirements of 14 CFR § 23.181(b) under certain flight conditions. In general, in the flaps up configuration, at altitudes higher than approximately 18,000 feet and at airspeeds faster than approximately 240 knots calibrated, the Dutch Roll requires more than 7 cycles to damp to 1/10 amplitude, however, it is always positively damped. In the flaps take-off and flaps landing configurations, the Dutch Roll characteristics meet the requirements at altitudes of 10,000 feet and below. It has also been demonstrated that the aircraft is safely controllable throughout the flight envelope (41,000 feet maximum altitude, 275 KEAS V<sub>mo</sub>, 0.64 M<sub>mo</sub>) regardless of the Dutch Roll damping characteristics not meeting the specified criteria.

Because of the failure to meet the Dutch Roll requirements throughout the flight envelope with natural stability, Eclipse Aviation is installing a yaw damper. The yaw damper functions through the single Autoflight System (AFS) yaw servo and is single-strand system.

In the event of failure of the yaw damper in the portion of the flight envelope where Dutch Roll characteristics do not meet the requirements of 14 CFR § 23.181(b), the aircraft shall:

- (1) Be controllable at the time of failure and during transition to a reduced operating envelope.
- (2) Meet the requirements of 14 CFR § 23.181(b) in the reduced operating envelope.

(The best statement of this guidance is provided in AC 25-7A, page 177.)

The Dutch Roll mode for small airplanes is well understood and is function of several basic design characteristics including wing sweep angle, wing dihedral angle, vertical tail size, and vertical tail moment arm. Handling qualities research and flight test shows that Dutch Roll stability characteristics has a large impact on pilot opinion of the aircraft and on pilot workload. 14 CFR § 23.181(b) requires that Dutch Roll be damped to 1/10 amplitude in 7 cycles or less. The Federal Aviation Administration (FAA) considers this requirement to be an appropriate minimum standard for part 23, single-pilot airplanes.

Typical part 23 airplanes (propeller driven, low altitude, and low speed) frequently meet the Dutch Roll requirements solely by basic design considerations. However, small turbo-jet powered airplanes that have high altitude and high speed capability frequently require yaw dampers to meet the requirement. Yaw dampers also help to reduce pilot workload and improve ride quality for passenger comfort.

Some existing aircraft meet Dutch Roll damping requirements at low altitude and low speed but not at high altitude and high speed. This is the situation with the Eclipse Model 500. In these cases, the FAA has allowed continued flight following a yaw damper failure provided the airplane is controllable and is safely transitionable to a reduced flight envelope in which Dutch Roll damping requirements are met. Therefore, the FAA position is:

- (1) Eclipse Aviation shall define a reduced operating envelope in which the Dutch Roll requirements of 14 CFR § 23.181(b) are met without yaw damper for each flap configuration.
- (2) An FAA pilot evaluation shall be made to verify that no unsafe condition exists with the yaw damper failed. This evaluation shall include controllability and transition (descent and/or deceleration) from any combination of altitude and speed critical for yaw damper failure to the reduced operating envelope, approach and landing.
- (3) A limitation shall be placed in the Airplane Flight Manual that restricts operation of the airplane to the reduced operating envelope if the yaw damper fails.
- (4) Following landing with a failed yaw damper, the airplane may be relocated if necessary to make repairs however, the relocation flight must be restricted to operations in the reduced operating envelope.

**Recommendation:** We concur that the proposed design features described as compensating features in items (1) through (4) provide an equivalent level of safety to the intent of the requirement of 14 CFR § 23.181(b).

Concurred by:

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Date

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