U.S. Department of Transportation

Federal Aviation Administration

Memorandum

Subject: **ACTION**: Request for Review and Concurrence with Equivalent Level of Safety (ELOS) for the Raytheon Model 390 Use of 1-g Stall Speed Criteria Instead of Minimum Speed in the Stall; ACE-05-04

Date: April 15, 2005

From: Manager, Wichita Aircraft Certification Office, ACE-115C

Reply to Attn. of: Lowell Foster, ACE-111

(816) 329-4125

To: Manager, Small Airplane Directorate, ACE-100

This memorandum requests your office to review and provide concurrence with the proposed finding of equivalent level of safety to the stall requirements of § 23.201 and 23.201 and various other sections of 14 CFR part 23. Raytheon has requested by their letter of December 6, 2004, reference 940-2004-12-010, to use 1-g stall speeds, rather than "traditional" $V_{S\ MIN}$ stall speeds, as the reference datum for regulatory compliance for the Model 390. The 1-g reference stall speeds will allow the scheduling of lower reference landing speeds, which will improve flight path control during landing. No improvement in the landing distances or takeoff speeds or distances will be applied for at this time.

BACKGROUND:

The Raytheon Model 390 was certified on March 23, 2001, to the requirements of part 23 as amended by Amendments 23-1 through 23-52. The use of 1-g stall criteria has, until now, only been applied to part 25 airplanes. Raytheon's request to use this stall criterion is based upon a desire to reduce the Model 390's operating speeds for the approach and landing phases. Raytheon originally proposed use of 1-g stall criteria shortly after the airplane was certified in 2001. At that time, their desire was to use this criteria to reduce operating speeds to improve takeoff field lengths. The FAA responded to that request by our letter dated November 23, 2001, which agreed to the use of 1-g stall criteria based upon additional requirements. Raytheon has addressed those additional requirements except for the following:

Raytheon will need to demonstrate that the Model 390 is still controllable within the +/- 20 degrees of roll for at least 2 kts beyond the pusher activation point. This demonstration ensures that the airplane has no hazardous rolling characteristic just beyond the pusher. Service history indicates that pilots will pull against the stick pusher in extreme situations. By demonstrating safe controllability past the pusher, Raytheon ensures additional safety margins not only for pilot reactions, but also for pusher system variance during the life of the airplane. This test will also need to be included in the production flight test procedures.

The FAA still believes that the above requirement to demonstrate that the Model 390 does not have any hazardous rolling characteristics beyond the pusher is needed to show an equivalent level of safety. The FAA no longer feels it necessary to perform this demonstration during production flight tests.

APPLICABLE REGULATIONS:

FAA POSITION:

Use of 1-g stall speeds as the performance basis requires changes to related abbreviations and symbols in 14 CFR part 1, and speeds based on multiples of stall speed presented in Subparts B, D, E, F and G of 14 CFR part 23 with Special Conditions 23-096-SC and 23-096A-SC. Speed factors in Subpart C of FAR 23 remain unchanged, since they have been applied historically to 1-g stall speeds, not V_{SMIN} stall speeds.

The following constitutes the FAA's equivalent interpretations of the referenced Federal Aviation Regulations that will provide an equivalent level of safety for the Raytheon Model 390:

CFR 14 Reference	Equivalent Interpretations for Raytheon Model 390
part 1 (Definitions and abbreviations)	
1.1	Add the following new definitions: "*Final takeoff speed* means the speed of the airplane that exists at the end of the takeoff path in the final segment climb in the en route configuration with one engine inoperative." "*Reference landing speed* means the speed of the airplane, in a specified landing configuration, at the point where it descends through the 50 foot height in the determination of the landing distance."
1.2	Add the following new abbreviations: "V_{FTO} means final takeoff speed, the speed to be flown in the final segment climb." "V_{REF} means reference landing speed." "V_{SR} means reference stall speed."

"V_{SR0} means reference stall speed in the landing configuration."

"V_{SR1} means reference stall speed in a specific configuration."

"V_{SW} means speed at which onset of natural or artificial stall warning occurs."

part 23 (Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes) with Special Conditions No. 23-096-SC

SC23.49(a)

Change to read: "The reference stall speed, V_{SR}, is a calibrated airspeed defined by the applicant. V_{SR} may not be less than a 1-g stall speed. V_{SR} is expressed as:

$$V_{SR} \geq \frac{V_{CL_{MAX}}}{\sqrt{n_{zw}}}$$

where—

$V_{C_{L_{MAX}}}$ = Calibrated airspeed obtained when the load factor-corrected lift coefficient ($\frac{n_{zw}W}{qS}$) is first a maximum during the maneuver prescribed in paragraph (c) of this section. In addition, when the maneuver is limited by a device that abruptly pushes the nose down at a selected angle of attack (e.g., a stick pusher), $V_{C_{L_{MAX}}}$ may not be less than the speed existing at the instant the device operates;

n_{ZW} = Load factor normal to the flight path at $V_{C_{L_{MAX}}}$

W = Airplane gross weight;

S = Aerodynamic reference wing area; and

q = Dynamic pressure."

NOTE: Unless AOA protection system (stall warning and stall identification) production tolerances are acceptably small, so as to produce insignificant changes in performance determinations, the flight test settings for stall warning and stall identification should be set at the low AOA tolerance limit; high AOA tolerance limits should be used for characteristics evaluations.

SC23.49(a)(1)	Remove this paragraph.
SC23.49(a)(2)	Remove this paragraph.
SC23.49(a)(3)	Remove this paragraph.
SC23.49(a)(4)	Remove this paragraph.
SC23.49(a)(5)	Remove this paragraph.
SC23.49(a)(6)	Remove this paragraph.
SC23.49(b)	Change to read: "$V_{C_{L_{MAX}}}$ is determined with:"
SC23.49(b)(1)	Insert a new paragraph that reads: "For turbine engine powered airplanes, the propulsive thrust not greater than zero at the stalling speed, or, if the resultant thrust has no appreciable effect on the stalling speed, with engine(s) idling and throttle(s) closed;"
SC23.49(b)(2)	Insert a new paragraph that reads: "The airplane in the condition existing in the test, in which V_{SR} is being used;"
SC23.49(b)(3)	Insert a new paragraph that reads: "The weight used when V_{SR} is being used as a factor to determine compliance with a required performance standard;"
SC23.49(b)(4)	Insert a new paragraph that reads: "The center of gravity in the position that results in the highest value of reference stall speed."
23.49(c)	Change to read: "V_{SR} must be determined by flight tests, using the procedure and meeting the flight characteristics specified in § 23.201 and special condition SC23.201."
23.49(d)	Change to read: "In addition to the requirements of paragraph (a) of this section, when a device that abruptly pushes the nose down at a selected angle of attack (e.g., a stick pusher) is installed, the reference stall speed, V_{SR}, may not be less than 2 knots or 2 percent, whichever is greater, above the speed at which the device operates."
SC23.51(b)(1)	Change "1.2 V_{S1}" to "1.13 V_{SR1}"

SC23.51(c)(2)	Change “above the takeoff surface.” to “above the takeoff surface, and”
SC23.51(c)(3)	Insert a new paragraph that reads: “A speed that provides the maneuvering capability specified in § 23.143(d).”
SC23.51(g)	Insert a new paragraph that reads: “V_{FTO}, in terms of calibrated airspeed, must be selected by the applicant to provide at least the gradient of climb required by § SC23.67(c), but may not be less than— (1) 1.18 V_{SR}; and (2) A speed that provides the maneuvering capability specified in § 23.143(d).”
SC23.57(a)	Replace “a speed is reached at which compliance with § SC23.67(c) is shown” with “V_{FTO} is reached”
SC23.67(c)	Replace “at not less than 1.25V_S” with “at V_{FTO}”
SC23.67(d)	Change to read: “In the approach configuration corresponding to the normal all-engines-operating procedure in which V_{SR} for this configuration does not exceed 110 percent of the V_{SR} for the related all-engines-operating landing configuration, the steady gradient of climb may not be less than 2.1 percent with the following:**”**
SC23.67(d)(3)	Replace “. . .but not exceeding 1.5V_S” with “. . .but not more than 1.4 V_{SR}; and”
SC23.67(d)(4)	Add new paragraph as follows: “Landing gear retracted.”
23.69(a)(4)	Replace “1.3 V_{S1}” with “1.23 V_{SR1}”
23.69(b)(5)	Replace “1.2 V_{S1}” with “1.13 V_{SR1}”
23.73(b)	Replace “23.149(c) and 1.3 V_{S0}” with “SC23.149(c) and 1.23 V_{SR0}, and a speed that provides the maneuvering capability specified in § 23.143(d).”
23.143(d)	Insert a new paragraph that reads: “The maneuvering capabilities in a constant speed coordinated turn at forward center of gravity, as specified in the following

table, must be free of stall warning or other characteristics that might interfere with normal maneuvering:

CONFIG-URATION	SPEED	MANEUVERING BANK ANGLE IN A COORDINATED TURN	THRUST/POWER SETTING
TAKEOFF	V_2	30°	ASYMMETRIC WAT-LIMITED.[1]
TAKEOFF	V_2 + XX [2]	40°	ALL-ENGINES-OPERATING CLIMB.[3]
ENROUTE	V_{FTO}	40°	ASYMMETRIC WAT-LIMITED.[1]
LANDING	V_{REF}	40°	SYMMETRIC FOR -3° FLIGHT PATH ANGLE

(1) A combination of weight, altitude and temperature (WAT) such that the thrust or power setting produces the minimum climb gradient specified in § SC23.67 for the flight condition.

(2) Airspeed approved for all-engines-operating initial climb.

(3) That thrust or power setting which, in the event of failure of the critical engine and without any crew action to adjust the thrust or power of the remaining engines, would result in the thrust or power specified for the takeoff condition at V_2, or any lesser thrust or power setting that is used for all-engines-operating initial climb procedures."

23.145(a) — Change to read: "It must be possible, at any point between the trim speed prescribed in § SC23.201(e)(3) and stall identification (as defined in § SC23.201(b)), to pitch the nose downward so that the rate of increase in airspeed allows prompt acceleration to the trim speed with –"

23.145(a)(2) — Change to read: "Power off;"

23.145(a)(3)(ii) — Change to read: "extended; and"

23.145(a)(4) — Insert new paragraph: "The airplane trimmed at the trim speed prescribed in § SC23.201(e)(3);"

23.145(b)(1)	Replace “1.4V_{S1}” with “1.3 V_{SR1}”
23.145(b)(1)	Replace “1.4 V_{S0}” with “1.3 V_{SR0}”
23.145(b)(2)	Replace “1.3 V_{S0}” with “1.23V_{SR0}”
23.145(b)(2)	Replace “1.3 V_{S1}” with “1.23V_{SR1}”
23.145(b)(3)	Replace “1.1 V_{S0}” with “V_{SW}”
23.145(b)(3)	Replace “1.1 V_{S1}” with “V_{SW}”
23.145(b)(4)	Replace “1.4 V_{S1}” with “1.3 V_{SR1}.”
23.145(b)(5)	Change to read: “With power off, landing gear and flaps extended, and the airplane as nearly as possible in trim at V_{REF}, obtain and maintain airspeeds between V_{SW} and either 1.6 V_{SR0} or V_{FE}, whichever is lower, without requiring the application of two-handed control forces exceeding those specified in § 23.143(c).”
23.147(a)	Change “1.4 V_{S1}” to “1.3 V_{SR1}.”
23.149(b)	Change “1.2 V_{S1}, where V_{S1}” to “1.13 V_{SR1}, where V_{SR1}”
23.157(b)(4)	Change “1.2 V_{S1}” to “1.13 V_{SR1}”
SC23.161(b), (c)(1), (c)(2)(i), (c)(3), & (d)	Change “1.4 V_{S1}” to “1.3 V_{SR1}.”
SC23.175(a)(2), (b)(1), (b)(2), (b)(3), & (c)(4)	Change “1.4 V_{S1}” to “1.3 V_{SR1}.”
SC23.175(b)(2)(ii)	Change “V_{MO} + 1.4 V_{S1}/2” to “(V_{MO} + 1.3 V_{SR1})/2.”
SC23.175(c)	Change “. . .at speeds between 1.1 V_{S1} and 1.8 V_{S1}” to “. . .at speeds between V_{SW} and 1.7 V_{SR1}.”
SC23.175(d)	Change “. . .at speeds between 1.1 V_{S0} and 1.3 V_{S0}” to: “. . .at speeds between V_{SW} and 1.7 V_{SR0}.”
SC23.175(d)(5)	Change “1.4 V_{S0}” to “1.3 V_{SR0}.”
SC23.177(a),(b)(1)	Change “1.2 V_{S1}” to “1.13 V_{SR1}.”

SC23.201(d)	Add the following sentence: "These characteristics must also be demonstrated at an airspeed that is 2 knots below the stick pusher activation speed."
SC23.201(e)(1)(ii)	Change to read: "The thrust necessary to maintain level flight at 1.5 V_{SR1} (where V_{SR1} corresponds to the stalling speed with flaps in the approach position, the landing gear retracted, and maximum landing weight)."
SC23.201(e)(3)	Change "1.4 V_{S1}" to "1.3 V_{SR1}"
SC23.203(c)(1)	Change to read: "The flight idle thrust or the thrust necessary to maintain level flight at 1.5 V_{SR1} (where V_{SR1} corresponds to the stalling speed with flaps in the approach position, the landing gear retracted, and maximum landing weight)."
SC23.203(c)(3)	Change "1.4 V_{S1}" to "1.3 V_{SR1}"
23.207(b)	Add" 'If a warning device is used, it must provide a warning in each of the airplane configurations prescribed in paragraph (a) of this section at the speed prescribed in paragraphs (c) and (g) of this section."
SC23.207(c)	Change to read: "When the speed is reduced at rates not exceeding one knot per second, stall warning must begin, in each normal configuration, at a speed, V_{SW}, exceeding the speed at which the stall is identified in accordance with § 23.201(b) by not less than five knots or five percent CAS, whichever is greater. Once initiated, stall warning must continue until the angle of attack is reduced to approximately that at which stall warning began."
23.207(e)	Change to read: "The stall warning margin must be sufficient to allow the pilot to prevent stalling (as defined in § SC23.201(b)) when recovery is initiated not less than one second after the onset of stall warning in slow-down turns with at least 1.5g load factor normal to the flight path and airspeed deceleration rates of at least 2 knots per second, with the flaps and landing gear in any normal position, with the airplane trimmed for straight flight at a speed of 1.3 V_{SR}, and

	with the power or thrust necessary to maintain level flight at 1.3 V_{SR}."
23.207(g)	Insert a new paragraph that reads: "In addition to the requirement of paragraph (c) of this section, when the speed is reduced at rates not exceeding one knot per second, in straight flight with engines idling and at the center-of-gravity position specified in § SC23.49(b)(4), V_{SW}, in each normal configuration, must exceed V_{SR} by not less than three knots or three percent CAS, whichever is greater."
23.207(h)	Insert a new paragraph that reads: "Stall warning must also be provided in each abnormal configuration of the high lift devices that is likely to be used in flight following system failures (including all configurations covered by Airplane Flight Manual procedures)."
23.233(a)	Change "0.2 V_{S0}" to "0.2 V_{SR0}."

NOTE: Subpart C already uses the 1-g reference stall speed.

SUBPART D

Note: RAC uses 23.735(a)(1) a rational analysis, to comply with this requirement.

SUBPART E

NOTE: Not applicable.

SUBPART F

23.1323(b)(1) and (b)(2)	Change "1.3 V_{S1}" to "1.23 V_{SR1}."
23.1325(e)	Change ". . .in the speed range between 1.3 V_{S0} with flaps extended and 1.8 V_{S1} with flaps retracted" to ". . .in the speed range between 1.23 V_{SR0} with flaps extended and 1.7 V_{SR1} with flaps retracted."

SUBPART G

SC23.1587(b)(2)	Change "V_S" to "V_{SR}."

APPLICANT'S POSITION:

As stated in RAC's letter of December 6, 2004, reference 940-2004-12-010:

Raytheon Aircraft Company (RAC) requests an Equivalent Level of Safety (ELOS) finding to 14 CFR §§ 23.49, 23.201, 23.203 and 23.207 and associated paragraphs for the RAC Model 390 as discussed during the reference 1) meeting. The ELOS would allow use of the 1g-stall speed method instead of the minimum speed method. The 1g-stall method is based on the part 25 method described in AC27-8A, Appendix 5. The reference 2) RAC Draft 1g Issue Paper dated September 9, 2004 contains further details of this discussion.

This request is in support of a program to reduce the reference landing speeds for the Raytheon Aircraft Model 390 airplane. In addition, this action is a vital part of the program to improve the Model 390 landing characteristics and increase the landing distance margins.

Raytheon requests to use 1g stall speeds, rather than "traditional" V_S MIN stall speeds, as the reference datum for regulatory compliance for the Model 390. The 1g reference stall speeds will allow the scheduling of lower reference landing speeds, which will improve flight path control during landing. No changes in the published landing distances or takeoff speeds and distances will be applied for at this time.

APPLICABLE REGULATIONS

The affected regulations are adapted from AC 25-7A, Appendix 5. The principle regulations being addressed are 14 CFR 23.49, 23.201, 23.203 and 23.207. A listing of all the applicable regulations is found in the RAC 1g Issue Paper dated September 9, 2004 that has been transmitted to the Wichita ACO.

DESIGN FEATURES REQUIRING ELOS

The Premier 1 Model 390 airplane wing is a swept design. One of the major distinguishing features of a swept-wing design not considered in current part 23 is a characteristically flatter lift curve without a "stall" break near the maximum coefficient of lift, as in a conventional wing. The "stall" separation point may occur at a much higher angle-of-attack than the point of maximum lift and the angle-of-attack for maximum lift can only be recognized by precise test measurements or specific detection systems. This effect makes it difficult to determine the stall speed by the normal g-break or characteristics methods. Consequently the Model 390 uses the point of stick pusher application as the identification for the stall.

This recognition of the stall characteristics of swept-wing jets is one of the reasons given for imposition of the Special Conditions on the Model 390 as well as the need to establish a 1g-stall speed in lieu of a minimum operating speed.

Increasing angle-of-attack may produce very little lift yet a significant increase in drag. This requires a flying technique for the pilot different than what he may be used to with a straight wing airplane. Consequently, the Model 390 requires initial type training for all pilots.

COMPENSATING FEATURES OF PROPOSED ELOS

Use of 1-g stall speeds as the performance basis requires changes to related abbreviations and symbols in 14 CFR part 1, and speeds based on multiples of stall speed presented in Subparts B, D, E, F and G of 14 CFR part 23 with Special Conditions 23-096-SC. Speed factors in Subpart C of FAR part 23 remain unchanged, as they have been applied historically to 1-g stall speeds, not V_{SMIN} stall speeds.

With the reduced operating speed factors, airplanes equipped with stall identification devices that have a trigger point set close to or before C_{LMAX} realize lower minimum operating speeds than under the existing requirements, and hence, operate at speeds and angles-of-attack closer to the device activation point than has been experienced in operational service. To compensate for this, and hence maintain an equivalent level of safety with respect to existing 14 CFR part 23 requirements with special conditions, different requirements and test methods must be applied to the Model 390 in order to use the 1-g stall criteria.

Two key concerns exist for airplanes with artificial stall identification systems:

1. Reliability, as manifested by the system functioning when required to protect the airplane from an unacceptable stall characteristic that may lead to a loss of control, and

2. Safety, as manifested by a lack of unwanted operation, which may result in a loss of control or catastrophic ground contact.

Stall identification systems are generally installed to provide protection from an unacceptable flight characteristic by preventing the airplane from reaching the angle of attack at which that characteristic will be encountered. This is particularly true of stick pushers, which provide an abrupt and authoritative nose down pitch command. Raytheon will verify that the Model 390 stall identification system performs its intended function reliably when the testing described by the equivalent regulatory requirements of referenced Issue Paper is conducted.

The safety concerns associated with most stall identification systems, particularly stick pushers, also include considering the consequences of dynamic excursions beyond the stall angle of attack, which may cause the system to apply an abrupt push force to the longitudinal control system. During takeoff and landing, where ground clearance is minimal and atmospheric disturbances are likely to be encountered, a potentially more serious situation exists than for airplanes with aerodynamic stall, which can tolerate brief excursions beyond the stall angle of attack.

Specific requirements have been incorporated in the equivalent interpretations of the current regulations to help address this situation. For the Model 390 equipped with a stall identification system that abruptly pushes the nose down at a selected angle-of-attack (e.g., a stick pusher), the reference stall speed used to determine the minimum operating speeds must not be less than the greater of 2-knots or 2 percent above the speed at which the device activates. As with natural stalling airplanes, the Model 390 equipped with a stall identification system must demonstrate certain maneuvering capability in constant speed turning maneuvers at the minimum operating speeds without encountering stall warning. Because of the requirement for a 2-knot or 2 percent margin between the reference stall speed and the device activation speed, there will be a minimum 5-knot or 5 percent margin between the stall warning speed and the device activation speed. (A 3-knot or 3 percent margin is required between the reference stall speed and the stall warning speed.)

The stall warning margin itself must be sufficient to provide more aggressive maneuvering capability (e.g., collision avoidance) without the stall identification system activating. Section § 23.207(e) of the referenced issue paper requires the stall warning margin to be capable of preventing the airplane from reaching the pusher activation angle of attack in slow-down turns at 1.5g, with entry rates greater than 2 knots per second, when pilot action to recover is not initiated until one second after the onset of stall warning.

In addressing reliability and safety concerns, Raytheon will consider the combined effects of the following variables to determine the critical fleet wide configuration for stall testing:

1. High lift device and control surface rigging - at the limits of their respective tolerance bands that is most detrimental to the production of lift;

2. Airframe build tolerances - the impact of wing angle of incidence variation relative to stall identification system vane angle;

3. Stall identification system tolerances - activation vane angles should be at the low end of the tolerance band for stall speed testing, and at the high end for stall characteristics testing; and

4. Wing leading edge condition - the effect of wing leading edge contamination (e.g., insects) on stall speeds should be determined and accounted for if significant. Raytheon should substantiate the critical height and density of the contaminant. This testing may be accomplished using an artificial contaminant.

It must be verified that threshold tolerances and system design features (e.g., filtering, phase advancing) will not result in an unsafe diminishing of the margin between stall warning and pusher activation, or pusher activation and some dangerous airplane characteristic. Investigations shall include the demonstration of maneuver margins, dynamic stall entries, the effects of atmospheric turbulence, and operation in wind shear environments where the airplane will be flown at, or very near, stall warning. These flying conditions should not result in unwanted activation of the stall identification system or aerodynamic stall prior to, or close to, activation of the stall warning system. This verification may be provided by a combination of analysis, simulation, and flight test.

[For more information related to safety and reliability concerns for stall identification systems, refer to paragraph 228 of Advisory Circular 25-7A, "Flight Test Guide for Certification of Transport Category Airplanes," dated March 31, 1998.]

EXPLANATION FOR PROVIDING AN ELOS

The use of the 1-g methods for stall speed identification has been accepted for part 25 airplanes. The reasoning showing why this method is equivalent to the V_{Smin} method is described in AC 25-7A, Appendix 5. The use of the 1-g methods on the part 23 RAC Model 390 is based on the special conditions imposed from the part 25 regulations and the initial type rating training required by the flight crews.

The 1-g stall requirements were derived to provide a more realistic and consistent basis for the definition of stall speed as the minimum speed at which wing lift alone can support the weight of the airplane in level flight. The 1g-stall method applies reduced operating speed factors for determining the minimum operating speeds in order to compensate for the 1g stall speeds being higher than $V_{S\ MIN}$ speeds. The net result is little or no change in operating speeds for airplanes with aerodynamic stall, thus leading to a finding of equivalent safety. For the Model 390, the only reduction in operating speeds being currently sought is the landing approach reference speed in which a reduction of 3 to 4 knots will be applied.

Because the airplane will be operating closer to the aerodynamic stall of the airplane, additional testing has been imposed requiring part 25.203(b) stall characteristics to be demonstrated 2 knots below the stick pusher activation. This testing will determine that no hazardous condition exists in relation to stall characteristics, which a pilot might accidentally encounter. Additional testing demonstrating an acceptable maneuver margin above stall warning will also be required as described in the draft Issue Paper referenced above.

To meet these characteristically flatter lift curve conditions, the Model 390 design incorporates an angle-of-attack driven stick shaker and stick pusher system. The stick pusher is only intended to provide stall identification during intentional stalls. Operational pilots, per type training, will recover at shaker activation and will never experience the pusher. Thus, stall warning is the primary means to prevent an inadvertent stall.

The current certification basis for stall warning is SC23.207(c), which reads

"During the stall tests required by §23.201(b) and §23.203(a)(1), the stall warning must begin at a speed exceeding the stalling speed by seven percent or any lesser margin if the stall warning has enough clarity, duration, distinctiveness or similar properties."

The FAA presented a NPRM, "l-g Stall Speed as the Basis for Compliance with Part 25 of the Federal Aviation Regulations (Docket No. 28404, Notice No. 95-17)." In this NPRM, FAA discusses the rationale for 1-g stall speeds, attendant changes in the multiplying factors to determine the minimum operating speeds and the relationship of various airplane design configurations, including devices that abruptly push the nose down (e.g., stick pushers).

The applicant agrees with the FAA position presented in the NPRM for 1-g stall speeds which is stated below:

"However, the reduced factors would allow lower minimum operating speeds to be established for those airplanes that have a minimum speed in the stalling maneuver approximately equal to the 1-g stall speed. One particular class of airplanes for which this applies is airplanes equipped with devices that abruptly push the nose down (e.g., stick pushers) near the angle-of-attack for maximum lift. These devices are typically installed on airplanes with unacceptable natural stalling characteristics. The abrupt nose down push provides an artificial stall indication and acceptable stall characteristics and prevents the airplane from reaching a potentially hazardous natural aerodynamic stall. The minimum speed obtained in this maneuver is approximately equal to the 1-g stall speed."

The key point is the consideration of the 1-g stall speed being approximately the same as the minimum speed realized with the stick pusher.

In addition, the 1-g stall speed criteria would provide for a more precise definition of stall warning. SC23.207(c) states stall warning should be "seven (7) or any lesser margin" above the stall identification speed. The 1-g stall speed criteria provides a reference speed at least 2 knots or 2% above the stall identification and requires stall warning to be at least 3 knots or 3% above that reference speed. The total stall warning margin of 5 knots or 5% above stall identification is consistent with the part 23 stall warning margin requirement of "not less than 5 knots" per 23.207(c).

This is the same requirement discussed in the NPRM for 1-g stall:

"The FAA proposes to require a larger stall warning margin for airplanes equipped with devices that abruptly push the nose down at a selected angle-of-attach (e.g., stick pushers). Inadvertent operation of such a device, especially close to the ground, can have more serious consequences than a comparable situation in which the pilot of an airplane without the device inadvertently slows to V_{SR}. Therefore, the FAA proposes adding 25.207(d) to require the stall warning, for airplanes equipped with one of these devices, to occur at least at 5 knots or 5%, whichever is greater, above the speed at which the device activates. This proposal is intended to retain the existing level of safety for airplanes equipped with such devices."

While the use of the 1-g stall speed criteria for the Model 390 would result in lower reference speeds due to reduced multiplying factors, this has been accounted for in the criteria itself. Specifically, the NPRM for 1-g stall speed states:

"Traditionally, the existing multiplying factors have applied to these airplanes. The proposal to define the reference stall speed as the 1-g stall speed would not affect these airplanes, but reducing the multiplying factors would allow lower minimum operating speeds to be established. Therefore, this proposal would allow those airplanes to be operated at speeds and angles-of-attack closer to the pusher activation point than has been experienced in operational service."

In order to take advantage of these lower operating speeds and still show a safe stall margin, the 1-g stall speed criteria places three additional requirements on stall warning. First, maneuver margin would have to be demonstrated with the airplane free of stall warning in various defined maneuvers. Second, accelerated stall warning margin would have to be demonstrated with the warning margin sufficient to allow the pilot to prevent stalling. And finally stall warning would have to be provided for abnormal configuration of high lift devices. These requirements ensure adequate operational stall warning. The NPRM for 1-g stall states:

"These proposed maneuver margin requirements are intended to ensure that the level of safety in maneuvering flight is not reduced by the proposed change to the reference stall speed and the reduction in the multiplying factors used to determine the minimum operating speeds."

The Model 390 can be shown to have an equivalent level of safety to the stall reference speed, stall warning margins and multiplying factors used for establishment of the reference landing approach speed.

While maintaining an equivalent level of safety for the noted speeds and warning margins, an opportunity to improve safety is provided by the reduced energy of the airplane at reduced speeds during field operations.

CONCLUSION:

The FAA supports Raytheon's efforts to reduce the approach reference speed. We also agree that this should be the only application for the 1-G stall speed without further FAA involvement. Jets historically have a higher occurrence of runway overruns on landing when compared to the whole GA fleet. While these accidents seldom result in injury, the opportunity for injury is always there. Reducing the approach reference speed should increase the safety margins for landing runway-overrun accidents.

The FAA agrees with the applicant’s position and the use of the part 25 1-G stall criteria as equivalent to part 23 requirements and the accompanying special conditions for the Raytheon Model 390 series with the addition of the following:

Stall warning and identification (stick shaker and pusher) device will meet the current part 25 standards for reliability, operation, and maintenance; however, a higher probability of stalling must be used to reflect the part 23, single pilot environment. This guidance is available in AC-25-7, Chapter 8, section (e), “System Reliability and Safety.” Paragraph (e)(1)(ii) assigns a value of 10^{-5} per flight hour as the probability of entering a stall. Part 23/part 91 operations would expect at least an order of magnitude higher probability of entering a stall when compared to part 25/part 135&121 operations.

The reason for this additional requirement is the part 23 accident history, which includes several part 23 jets. Stall accidents are in the top 5 fatal accident causes for all part 23 classes including part 23 jets. Furthermore, the applicant states that pilots require a Type Rating, which includes training to push out of a high angle-of-attack situation at the onset of stick shaker instead of proceeding to the full stall. We believe that pilots are trained to maintain pitch attitude and power out of the slow speed condition. With the exception of the private pilot rating, pilots do not receive any stall training, or slow speed training that includes pushing the nose down because of the FAA’s concern about losing altitude.

Concurred by:

Margaret Kline *3/8/05*

Manager, Chicago Aircraft Certification Office, ACE-115C Date

Patrick R. Mullen *4/14/05*

for Acting Manager, Standards Office, ACE-110 Date

Nancy C. Lane *4/15/05*

for Acting Manager, Small Airplane Directorate,
Aircraft Certification Service, ACE-100 Date