IMPACT OF KEY FLYING QUALITIES REQUIREMENTS ON THE YC-14/C-14 DESIGN

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SUMMARY

Some of the flying qualities requirements that have a major impact on the YC-14/C-14 design are discussed. Comments are made on selected portions of the proposed revisions to MIL-F-8785B, and some suggestions for future revisions to the flying qualities specification (or standard) are presented. Particular emphasis is placed on the low speed flight regime, and on the stability and control augementation system. For instance, the definitions of stall speed and some minimum operating speeds should be modified to account for characteristics associated with a highly augmented, powered lift aircraft. The proposed revision to the definition of flying qualities levels is discussed with emphasis on the interface between flying qualities levels, atmospheric disturbances, and failure states. Also, some thoughts are presented on the application of certain requirements to an augmented aircraft.

DISCUSSION

Before discussing the individual flying qualities requirements, it would by well to first consider the general philosophy to be applied to today's more highly augmented aircraft.

A highly augmented airplane, such as the YC-14, presents a peculiar set of problems when applying the MIL-F-8785B requirements. For instance, the YC-14 flight control system provided the pilot with rate command (stick out of detent) and attitude hold (stick in detent). This is the normal "manual" mode of operation, not a pilot assist mode. The requirements in MIL-F-8785B are directed toward a rate command system. Trying to impose some of these requirements on an attitude hold system can compromise the system design and degrade its performance. An example is found in MIL-F-8785B section 3.2.2.1.1 (short period frequency and acceleration sensitivity). It is doubtful that an attitude hold type system was considered when formulating this requirement. The designer must go to MIL-F-9490D to find requirements for an attitude hold system. Use of MIL-F-9490D does not provide a complete solution since it gives system performance requirements, but does not specify flying qualities requirements per se. A similiar situation exists for a speed control system that is a part of the normal manual control mode of operation.

To alleviate problems with these various manual control modes it is recommended that: a) the applicable control mode(s) (rate command, attitude hold, etc.) should be identified for each section of MIL-F-8785B, where such identification is appropriate, and b) additional sections be incorporated into MIL-F-8785B to define those requirements not already covered adequately in MIL-F-8785B for the additional manual control modes such as attitude hold and airspeed select/hold.

The following discussion of the various flying qualities topics is organized in the same sequence as the subject headings in MIL-F-8785B; thus, the various subjects are NOT arranged by their relative order of importance.

1.5 LEVELS OF FLYING QUALITIES

Recognition of the effects of atmospheric disturbances on Flying Qualities Levels, as presented in Reference 1, is a step in the right direction. However, the particular definition of Levels proposed for revising MIL-F-8785B (Reference 1) will lead to confusion and misunderstandings, particularly during flight testing. The pilot would have to make an assessment of the atmospheric disturbance intensity before he could rate the Flying Qualities characteristics as a particular Flying Qualities Level. This would introduce significant additional variability in pilot ratings assigned by different pilots.

The atmospheric disturbance severity should not be an integral part of the definition of Flying Qualities Levels since it is more appropriately considered as part of the task or the task environment. An alternate approach to recognizing the effects of atmospheric disturbances on Flying Qualities Levels is as follows:

- o Retain the current definition of Flying Qualities Levels as given in MIL-F-8785B, Reference 2
- o Integrate the atmospheric disturbance requirements into section 3.1.10, "Applications of Levels". Suggestions for this are given below in the discussion of section 3.1.10.

This will maintain the required separation of the pilots assessment of Flying Qualities Levels and the task(s) he must perform.

A second area of concern in the definition of Flying Qualities Levels is the relationship between the definitions of Levels in MIL-F-8785B (Reference 2) and the definitions used in the Cooper-Harper pilot rating scale. Specifically, Level 3 is defined in MIL-F-8785B as:

Level 3 Flying qualities such that the airplane can be controlled safely, but pilot workload is excessive or mission effectiveness is inadequate, or both. Category A Flight Phases can be terminated safely, and Category B and C Flight Phases can be completed.

It is assumed that this definition means the Category B and C Flight Phases must be completed <u>successfully</u>. Successful completion of these Flight Phases (particularly landing) is interpreted as requiring a Cooper-Harper pilot rating better than 7, since a rating of 7 is defined as "Adequate performance not attainable with maximum tolerable pilot compensation..." (misses the runway and/or damages the airplane). Note, however, that section 1.5 of the MIL-F-8785B users guide (Reference 4) equates a Cooper-Harper pilot rating of 6.5 or better with Level 2. Thus, an airplane that is Level 3 under the MIL-F-8785B definition could be given a Cooper-Harper pilot rating of 6.5, which is equivalent to Level 2 when using the relationships given in the users guide (Reference 4). I believe that some discussion is needed to resolve this inconsistency between the two pilot rating systems.

3.1.5 CONFIGURATIONS

The current definition of configurations in Reference 2 can pose some interesting problems for the designer of an augmented aircraft. Take, for example, an aircraft on landing approach that only meets the Level 2 requirements because it operates on the back side of the power required curve. Now suppose that this aircraft uses a redundant speed hold system to provide Level 1 flying qualities for the landing approach task. A literal interpretation of the configuration definition requirements in MIL-F-8785B (Reference 2) would require that if the pilot were to be given direct control over engaging/disengaging the speed hold system, then the aircraft would have to meet the Level 1 requirements with the speed hold system disengaged as well as with the system engaged. Thus, to satisfy this requirement, it would be necessary to have the speed hold system automatically engage when landing flaps are selected. Further, no pilot override or provision to switch the redundant speed hold system off would be permitted since the aircraft would then be required to meet the Level 1 requirements with the speed hold system both engaged and disengaged. Neither of these would be a satisfactory situation since the pilot should have direct control over the time when the speed hold system is engaged/disengaged. The preceeding logic can be extended to include redundant stability and/or control augmentation systems.

It is recommended that the definition of configurations in MIL-F-8785B, Reference 2, be reworded to make provisions for redundant augmentation systems.

3.1.7 OPERATIONAL FLIGHT ENVELOPES

Two subjects will be considered in this section. The first deals with the potential benefits of augmentation systems on the Flight Phase Category C minimum operating speeds. The second subject deals with the effects of powered lift on the Flight Phase Category A minimum operating speeds.

Typical design margins for a transport aircraft call for the Flight Phase Category C minimum operating speed to be 20 percent above the "stall" speed, i.e., $V_{o_{min}} = 1.2\ V_s$. Although it was not possible to make a full evaluation during the limited YC-14 flight test program, the pilots felt that the YC-14 could be flown safely and routinely with a reduced speed margin, such as $V_{o_{min}} = 1.1\ V_s$. This confidence resulted from a variety of factors, primarily:

1) The speed hold system maintained speed accurately, thereby preventing the pilot from inadvertently slowing down.

2) The stability and control augmentation system provided rate command (controller out of detent) and attitude hold (controller in detent). The attitude hold feature reduced the pilot workload.

3) Flight control system redundancy, including the speed hold, provided fail operational capability after the first failure and fail safe operation following a second failure.

4) Engine out protection was provided through automatic sensing and subsequent reconfiguration of the flaps optimized performance and minimized the flight path perturbations following an engine failure.

5) The pilot workload was significantly reduced as a result of the flight control system features described above.

6) Rapid engine response, as a result of the reasonably high approach power settings, enabled the pilot to make rapid speed changes if the need arose.

Without the control system features incorporated in the YC-14, the pilot could encounter difficulties at lower than normal approach speeds such as 1.1 V_S; thus, system reliability requirements became a significant factor in determining the minimum normal approach speeds. These reliability requirements can be handled in an orderly manner using the approach outlined in section 3.1.10.

It is recommended that the flight control system features and capabilities be considered carefully in interpreting the current MIL-F-8785B minimum operating speed requirement which is "minimum normal approach speed" for landing approach. With proper flight control system design it would seem reasonable to reduce many of the Flight Phase Category C minimum operational speed margins below the traditional levels while maintaining adequate wind shear/gust protection and turn rate capability.

The second subject to be considered in this section deals with Flight Phase Category A minimum operating speeds. Powered lift airplanes such as the YC-14/C-14 tend to have relatively low "stall" speeds; thus, the minimum operating speeds, which are some percentage above the "stall" speeds, are also relatively low. These low minimum operating speeds can impose some stringent design requirements on the aircraft. This is particularly true for the Flight Phase Category A roll performance requirements in section 3.3.4 of MIL-F-8785B.

The need for the relatively low minimum operational speed capability for some Category A Flight Phases should be considered further. For instance, the in-flight refuel (receiver) requirement would provide a minimum operating speed capability well below that for any available or projected tanker airplane. For example, the minimum operational speed for the YC-14 as a receiver is 150 kts (wt = 140,000 lb) while a typical minimum operating speed for refueling with the KC-135 tanker is 183 kts (wt = 170,000 lb). Typical refuel speeds for the KC-135 range from 250 to 320 kts.

As currently stated, the MIL-F-8785B rules would require the YC-14/C-14 to have significant capabilities to meet the Flight Phase Category A requirements at speeds well below those required in service. This additional capability can add significantly to the aircraft cost. It is recommended that the minimum operating speeds be specified as the higher of 1) some fraction of V_s as is now done, or 2) finite speeds which are compatible with the needs of the Flight Phase.

3.1.10 APPLICATIONS OF LEVELS

As mentioned previously in section 1.5, the effects of atmospheric disturbances should be considered in this section, along with Airplane Normal States and Failure States. Two variants to this integrated approach are shown in Figures 1 and 2, where both figures present essentially the same requirements. The first figure is based on a smooth, continuous change with failure probability while Figure 2 is based on discrete values. The data shown in these figures pertain to a Class III airplane. The values of some of the numbers would be different for other airplane classifications. The proposed approaches shown in Figures 1 and 2 have the following advantages:

1) Permits Flying Qualities Levels to be defined independent of the environment.

2) Considers that the probability of encountering both severe atmospheric disturbances and a hazardous failure simultaneously is remote. This is not to say that it is impossible, but only that it becomes sufficiently unlikely that it is not mandatory to compromise the airplane design to cover these conditions.

3) Considers the probability of the airplane being in or of entering into the more extreme Flight Envelopes (Service and Permissible).

4) The Airplane Normal State and Failure State requirements in the figures are compatible with the corresponding sections 3.1.10.1 and 3.1.10.2 of MIL-F-8785B. Figures 1 and 2 are also compatible with the turbulence and safety sections (3.1.3.7.1 and 3.1.7) of MIL-F-9490D, Reference 3.

5) Figure 2 shows a lower wind/turbulence probability of exceedence for Flight Phase Category C than for Categories A and B. The probability of exceedence was reduced for Category C since the exposure time is lower than in Categories A and B. The same type of distinction could be specified under the format used in Figure 1.

The format in Figure 1 appears more desirable since it permits the designer to more easily visualize the requirements and select the critical design points.

3.2.1.1 LONGITUDINAL STATIC STABILITY

The proposed revision to this section of MIL-F-8785B would permit a single unstable mode of motion with a time to double amplitude of no less than 6 seconds for Level 3 operation. Results from Boeing and other programs indicate that this level of instability should be acceptable. The Concord SST was certified with a 5 second time to double amplitude pitch instability for the landing approach task with the stability augmentation system inoperative. The TIFS was used to evaluate the Concord at this critical flight condition. The conclusions, given in Reference 5, state "the minimum acceptable boundary (Pilot Rating of 6.5 on the Cooper-Harper scale) determined in this investigation occurs at a T_2=2.5 seconds in light turbulence ($\sigma_{V_{g_{max}}}$ = 1.5 ft/sec) and at a T_2=4.25 seconds for moderate turbulence ($\sigma_{V_{g_{max}}} = 3.0$ ft/sec)". The SST being developed by Boeing in the late 60's and early 70's also exhibited an unstable pitch mode of motion on landing approach with augmentation system failures. Extensive piloted simulations demonstrated that a time to double amplitude of 6 seconds met Boeing requirements for Cooper-Harper pilot ratings better than 6.5. Thus, it is concluded that the proposed Level 3 limit of 6 seconds time to double amplitude is conservative, and could safely be reduced to less than 5 seconds for a single unstable mode of motion.

Another factor to consider is spiral mode stability. The current version of MIL-F-8785B permits an unstable spiral mode for all Flying Qualities Levels. The proposed revision to section 3.2.1.1 would permit only a single unstable mode of motion; thus, if there is an unstable pitch mode, the commonly accepted spiral instability would be precluded. It is recommended that the proposed revision to MIL-F-8785B be revised to allow an unstable spiral mode in combination with a single unstable longitudinal mode of motion.

3.2.2.1.1 SHORT-PERIOD FREQUENCY AND ACCELERATION SENSITIVITY

The Level 3 frequency requirement given in this section of the basic MIL-F-8785B should be reviewed in light of the proposed revision to section 3.2.1.1. Typically, as an unaugmented airplane becomes less stable the short period roots will change from an oscillatory pair to a pair of real roots, see Figure 3. The frequency of the dominant "short period" root decreases as the stability is further reduced. Usually this dominant "short-period" root will couple with one of the "phugoid" roots, forming an oscillatory pair. This frequently occurs as the unstable real root is on the order of a time of double of 6 seconds. These characteristics, allowed under the proposed revision to section 3.2.1.1, are in conflict with the minimum Level 3 frequency requirements of 3.2.2.1.1 of MIL-F-8785B.

It is recommended that the short-period frequency requirement for Level 3 be waived when an unstable pitch axis root is permitted under section 3.2.1.1.

3.2.2.2.1 CONTROL FORCES IN MANEUVERING FLIGHT

In the proposed revision to this section, item number 2 in the "rationale for revision" states the case well for providing structural/stall protection via a nonlinear increase in stick force near n_L and/or stall. This desired type of protection could, however, be precluded by the specific wording of the proposed revision to this section. Take, for example, a Class III airplane in one of the more demanding flight phases in the Operational Flight Envelope where $n_{o_{MAX}} = n_L = 3$. The F_s/n_z must be approximately linear up to $n_z = .5\left[n_{o_{MAX}} + 1\right] = 2$. Above $n_z = 2$ an increase in F_s/n_z of "more than 50 percent is considered excessive". An increase in F_s/n_z of only 50% between $n_z = 2$ and 3 will not, in many cases, provide the necessary degree of structural/stall protection. Therefore, it is recommended that the 50% linearity requirement be modified for Class I, II and III airplanes. The 50% linearity requirement should be imposed only on reductions in the control force gradient. Restrictions should be removed, or at least opened up, on the control force linearity at load factors greater than $.5\left[n_o(+) + 1\right]$.

3.3.4.2 ROLL PERFORMANCE FOR CLASS III AIRPLANES

The proposed revision to the Class III airplane roll performance requirements correlates well with results from the YC-14 program.

3.5.5.1 FAILURE TRANSIENTS

This proposed revision to the allowable failure transient magnitudes for Level 1 and 2 operation would appear to impose unduly restrictive requirements. The vertical or lateral excursion limits of 5 feet and the ±2 degrees of bank angle limit appear tight for Flight Phase Category A tasks, and even more stringent for Category C tasks. For Category B tasks it would seem reasonable to relax the requirements significantly.

6.2.2 SPEEDS

Before getting into the detailed definition of "stall" speed, V_S, it would be well to comment on the tendency to categorize airplane operation as either STOL (short takeoff and landing) or CTOL (conventional takeoff and landing). One of the first problems in distinguishing between STOL and CTOL operations is in the definition of terms. "STOL" has vastly different meanings to different people. A survey of personnel associated with the AMST program resulted in fourteen major classifications under which they defined "STOL", and further variations of the definitions within each of these major classifications. For example, some defined "STOL" in terms of field length, somein terms of approach speed, and some in terms of the rules used to define V_S. The type of operation described by some people as "STOL" would be better classified as "assault" operation since they are considering flight conditions where a failure, such as loss of an engine, would result in loss of the airplane.

It is felt that trying to distinguish between STOL and CTOL is, in general, unwarranted for flying qualities, and it can lead to problems and confusion in the definition of minimum speeds. It is proposed that a common set of rules could be applied to both the so called STOL and CTOL operations. This proposed commonality would be particularly valid for the YC-14 since the flight control system was designed to enable the pilot to use the same piloting techniques in all flight phases from high speed down through landing on a 2000 foot field.

The definition of the "stall" speed, V_S, can have a profound influence on the design of a powered lift aircraft. This was particularly true for the YC-14 which used a speed control system to command both throttle and USB (upper surface blowing) flap position to maintain speed without disturbing the airplane's flight path. The YC-14 system mechanization was such that when the pilot dialed in a higher flight speed, the thrust would increase and the USB flap would retract enough to maintain approximately constant lift at the new speed. This movement of the USB flap redirected the engine thrust in a manner to increase the powered lift effects as the speed decreased; thus, making it possible to fly safely at speeds lower than would be possible with a fixed flap. The fail operational/fail passive and various saturation protection features built into the YC-14 speed control system helped to assure flight safety.

Several factors should be considered in the definition of V_s to take full advantage of powered lift while assuring flight safety. The important considerations are:

1) Factors such as excessive rate of sink that are not now considered in the definition of V_s.

2) Thrust management and the use of a speed hold system that may include flap configuration management. The manner in which such a system is used in determining V_s can become significant, as can the failure modes and redundancy level.

3) The flight safety implications of an engine failure, both in terms of controllability and go-around climb performance capability.

V_s as defined in the AMST proposal instruction package included the factors discussed above. This definition is shown in Figure 4. It appears that this definition of V_s is equally applicable to other airplane types, thus it is recommended for adoption in MIL-F-8785B.

REFERENCES

1. "Proposals for Revising MIL-F-8785B 'Flying Qualities of Piloted Aircraft'", AFFDL-FGC-Working Paper, August 1977, corrected February 1978.

2. "Military Specification Flying Qualities of Piloted Airplanes", MIL-F-8785B, 7 August 1969.

3. "Military Specification Flight Control Systems - Design, Installation and Test of Piloted Aircraft, General Specification for", MIL-F-9490D (USAF), 6 June 1975.

4. "Background Information and User Guide for MIL-F-8785B (ASG), 'Military Specification - Flying Qualities of Piloted Airplanes'", AFFDL-TR-69-72, C. R. Chalk, et al, August 1969.

5. "In-Flight Simulation of Minimum Longitudinal Stability for Large Delta-Wing Transports in Landing Approach Touchdown", AFFDL-TR-72-143, R. Wasserman and J. F. Mitchell, February 1973.

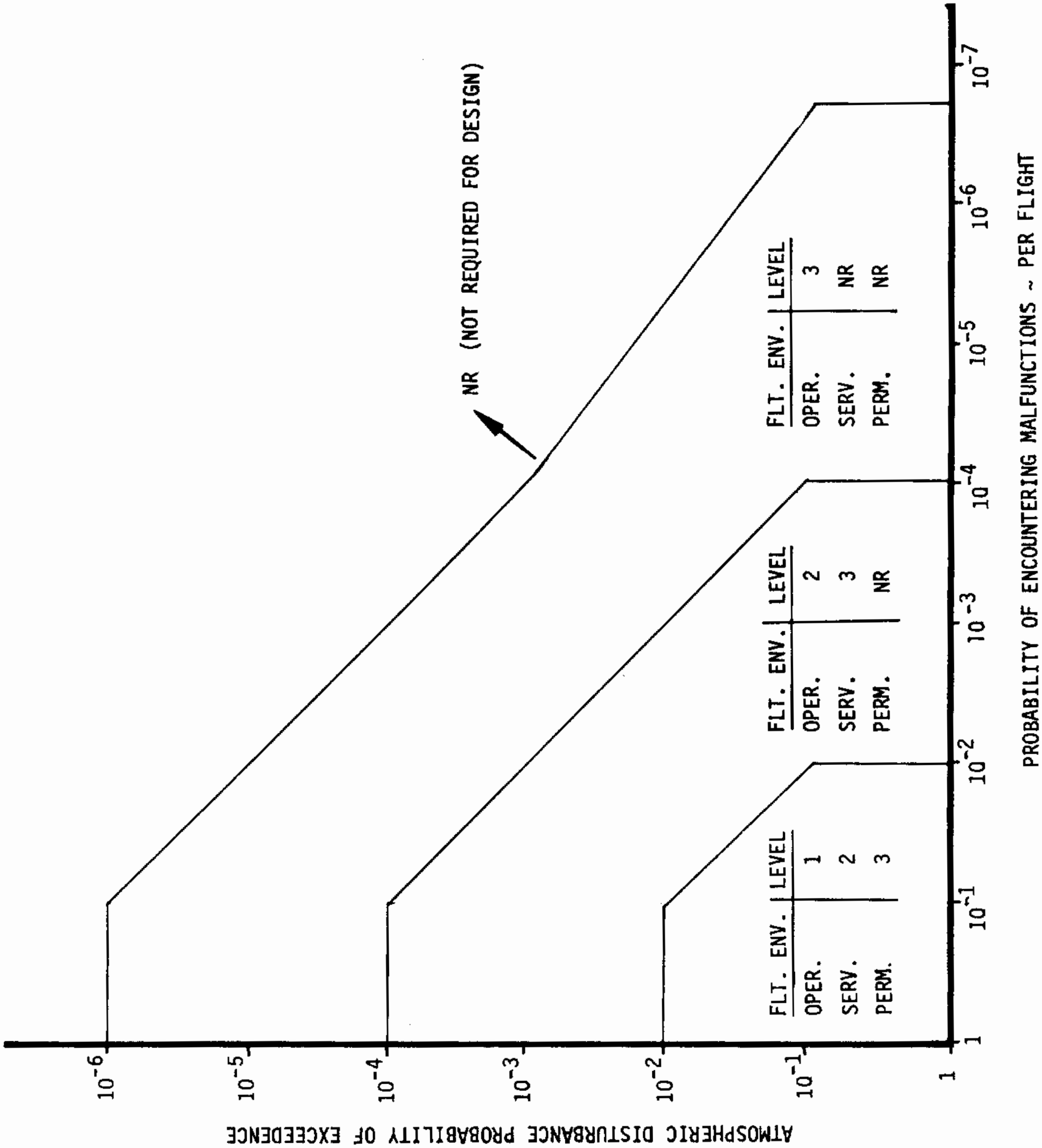

FIGURE 1 APPLICATION OF LEVELS

FIGURE 2b

FLYING QUALITIES REQUIREMENTS - GENERAL FAILURE STATES - PEACETIME CONDITIONS

- "FLIGHT CRITICAL SYSTEMS" FAILURES
- "NORMAL" OPERATING MODE
- FLYING QUALITIES MAY EXCEED MINIMUM LEVELS SHOWN

PROBABILITY OF ENCOUNTERING MALFUNCTION(S) ~ PER FLIGHT	MINIMUM FLYING QUALITIES LEVEL AFTER MALFUNCTION		
	OPERATIONAL	SERVICE	PERMISSIBLE
Greater Than 10^{-2}	Level 1	Level 2	Level 3
Less Than 10^{-2}	Level 2	Level 3	NR [1]
Less Than 10^{-4}	Level 3	NR	NR
Less Than $5x10^{-7}$	NR [1]	NR	NR

The above flying qualities levels must be maintained up to wind/turbulence severity associated with the following probability of exceedence

PROBABILITY OF ENCOUNTERING MALFUNCTION(S) ~ PER FLIGHT	WIND/TURBULENCE PROBABILITY OF EXCEEDENCE					
	OPERATIONAL		SERVICE		PERMISSIBLE	
	CATEGORIES A & B	CATEGORY C	CATEGORIES A & B	CATEGORY C	CATEGORIES A & B	CATEGORY C
Greater Than 10^{-2}	10^{-2}	10^{-1} [2]	10^{-2}	10^{-1} [2]	10^{-2}	10^{-1} [2]
Less Than 10^{-2}	10^{-2}	10^{-1}	10^{-1}	$10^{-0.5}$	NR [1]	NR
Less Than 10^{-4}	10^{-1}	$10^{-0.5}$	NR	NR	NR	NR
Less Than $5x10^{-7}$	NR	NR	NR	NR	NR	NR

In addition, for Category C in the Operational Flight Envelope, the flying qualities shall meet or exceed:

PROBABILITY OF ENCOUNTERING MALFUNCTION(S) ~ PER FLIGHT	WIND/TURBULENCE LEVEL PROBABILITY OF EXCEEDENCE [3]		
	10^{-1}	10^{-3}	10^{-5}
Greater Than 10^{-2}	Level 1	Level 2	Level 3
Less Than 10^{-2}	Level 2	Level 3	NR
Less Than 10^{-4}	Level 3	NR [1]	NR
Less Than $5x10^{-7}$	NR	NR	NR

[1] "NR" means Not Required for design - aircraft may be lost due to malfunction(s).

[2] Category C crosswind/tailwind component limits at 13 KTS/ 6 KTS (measured at 50 ft.) for malfunctions occurring no more than once in 100 flights, and 8 KTS/4 KTS for malfunctions occurring no more than once in 10,000 flights.

[3] The crosswind/tailwind limits from Fig 2a shall apply.

FIGURE 2a

MINIMUM REQUIRED FLYING QUALITIES FOR

- AIRCRAFT NORMAL STATES
- "NORMAL" OPERATING MODE
- VARYING WIND/TURBULENCE SEVERITY

HANDLING QUALITIES REQUIRED	WIND/TURBULENCE PROBABILITY OF EXCEEDENCE [1]					
	OPERATIONAL FLT ENVELOPE		SERVICE FLT ENVELOPE		PERMISSIBLE FLT ENVELOPE	
	CAT A & B	CAT C	CAT A & B	CAT C	CAT A & B	CAT C
Level 1	10^{-2}	10^{-1}	NR	NR [2]	NR	NR
Level 2	10^{-4}	10^{-3}	10^{-2}	10^{-1}	NR	NR
Level 3	10^{-6}	[3] 10^{-5}	10^{-4}	10^{-3}	10^{-2}	10^{-1}

[1] Flying qualities level must be maintained up to wind and turbulence severity associated with specified probability of exceedence

[2] "NR" means Not Required for design.

[3] Category C CROSSWIND/TAILWIND COMPONENT LIMITS:

FLYING QUALITIES (OPERATIONAL ENVELOPE)	90° CROSSWIND AT 50 FT.	180° TAILWIND AT 50 FT.
Level 1	13 KTS	6 KTS
Level 2	30 KTS	10 KTS
Level 3	30 KTS	15 KTS

- Landing flying qualities may be satisfied by increasing indicated airspeed beyond V_{TH} by an amount equal to one-half the mean wind plus the "peak" gusts, not to exceed an increase of 20 knots.
- For Category C turbulence roughness length of Z = .15 ft. shall be used for design

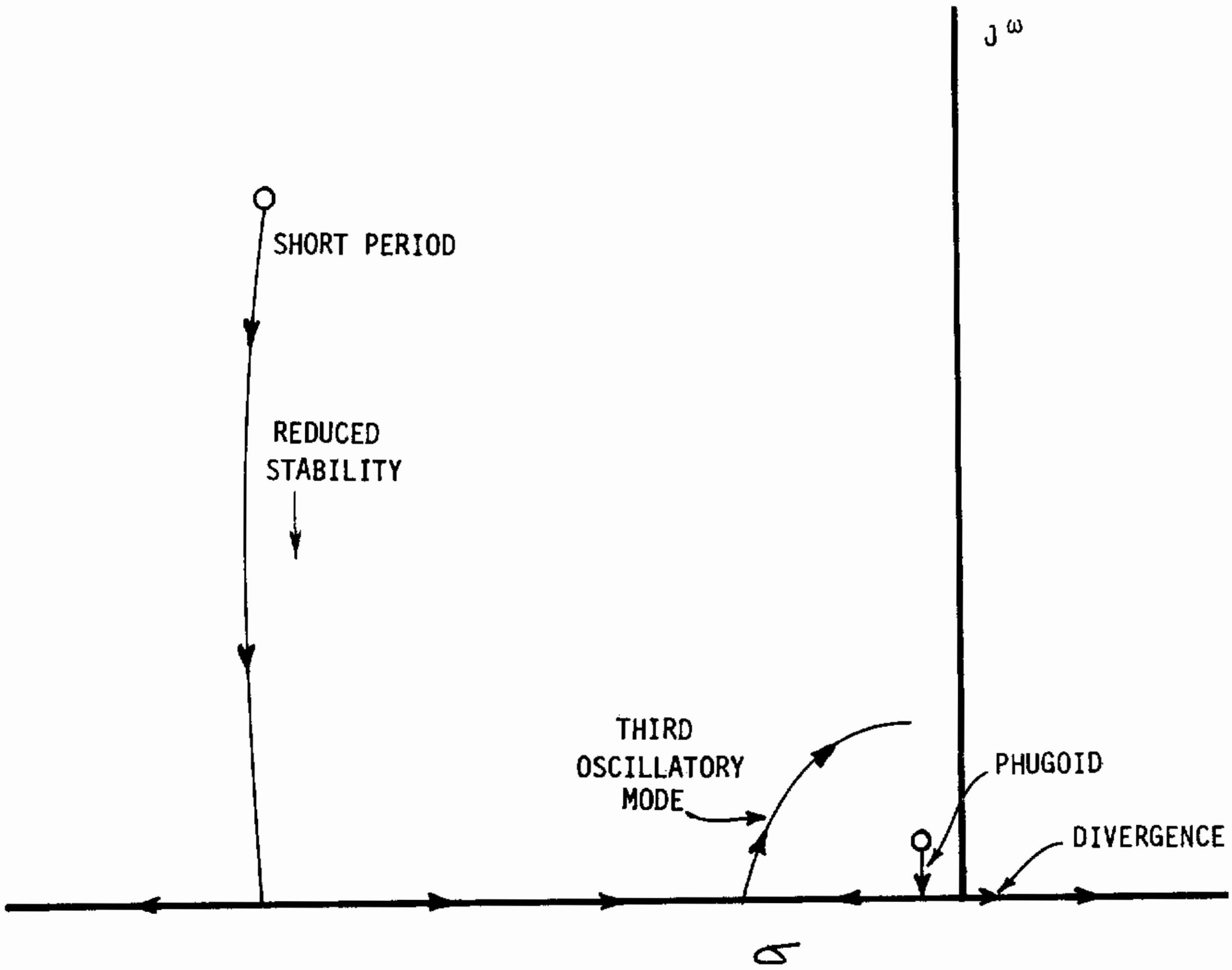

FIGURE 3 LOCUS OF PITCH AXES ROOTS AS CENTER OF GRAVITY MOVES AFT

3.1.9.2 Minimum Permissible Speed (V_s). The minimum permissible speed for a specified configuration shall be the highest of:

a. Speed, with constant heading angle, for flight at $C_{L_{max}}$ (the first local maximum of the lift coefficient vs angle of attack which occurs as C_L is increased from zero).

b. Speed at which uncontrollable pitching, rolling or yawing occurs; i.e., loss of control about a single axis.

c. Minimum demonstrated speed-due to intolerable buffet, structural vibration, angle of attack effects, or an excessive rate of sink.

The minimum permissible speed shall be determined for:

a. 1g normal to the flight path.

b. Approach to stall at ½ knot to 1 knot per second.

c. Most unfavorable center of gravity.

d. Out of ground effect.

e. The following condition that results in the highest minimum permissible speed for each flight phase. Assault takeoff and assault landing are excluded from this consideration.

Flight Phase	Thrust Control Setting	All Engines Operating (AEO)/ Critical Engine Inoperative (CEI)
Takeoff	Takeoff	AEO and CEI
Approach/Landing	Takeoff	CEI
Approach/Landing	Approach	AEO
Go-Around	Go-Around	AEO and CEI
Descent/ Deceleration	Minimum Allowable*	AEO and CEI
All Other	TLF at 1.2 V_s	AEO and CEI

*Minimum allowable includes reverse thrust.

FIGURE 4 "Stall" speed definition from the AMST proposal instruction package.

Jerry Lockenour, Northrop: Were simulations conducted by Boeing in setting (or verifying) the 6 sec. T_2 on SST, etc.? Did these simulations include a good simulation of flare and touchdown?
Answer: Yes, simulations were conducted. Yes, the touchdown simulation included the best simulation possible for flare and touchdown.

Bill Rickard, DAC: T_2=6 sec. is unconservative for moderate to heavy turbulence, or for long term tasks. DAC opposes this revision.
Answer: The revision to the spec does not even call for Level 3 type failure probabilities (equated with encountering "Level 3") in moderate to heavy turbulence. Thus, the question has no bearing on the discussion. I agree that the T_2= 6 sec. is only acceptable over short time periods such as the 5 min. allowed in the AMST spec.

Chick Chalk, Calspan: Slow divergence is not a factor in closed loop operation.
Answer: I agree.

Bob Woodcock, AFFDL/FGC: I'm confused about what leads you to think that we want to require the same flying qualities, augmentation on and off?
Answer: No, I think I have interpreted this section of the spec correctly. The YC-14 speed command/hold system could be switched on or off at will by the pilot. Thus, it could be considered "normal operation" in either case. The problem comes in landing where the speed command/hold system is required to achieve Level 1. It becomes immediately apparent to the pilot at speeds used for landings on a 2000 ft field. Thus, it should not be required to meet the requirements in succeeding sections required under the current sording in section 3.1.5.

Similar problems could occur with a stability augmentation system where a normal operation could consist of switching the augmentation system off for training. Since this then becomes "normal operation" it could be construed to require Level 1 with the system off. These topics are explained in greater detail in my paper.

Tim Sweeney, ASD: I still believe that you have misinterpreted that paragraph of the specification. It does not say that Level 1 requirements have to be met with selectable configurations engaged and disengaged. It specifically states that all configurations REQUIRED or ENCOUNTERED in the flight phase are covered. This wording catches situations such as are encountered on aircraft with a single-channel SAS if the pilot is instructed to turn it off when in close proximity to the ground as in landing or to another aircraft as in aerial refueling. For such flight phases, the Level 1 requirement would have to be met with the SAS off. The statement in that spec paragraph which deals with "yaw damper ON or OFF" is merely an example of a selected configuration.