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Mission-Oriented Requirements for Updating MIL-H-8501 Volume I STI Proposed Structure

Warren F. Clement, Roger H. Hoh, Samuel W. Ferguson, III, David G .Mitchell, Irving L. Ashkenas, and Duane T. McRuer

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ABSTRACT

The structure of a new flying and ground handling qualities specification for military rotorcraft is presented in the first of two volumes. This preliminary specification structure is intended to evolve into a replacement for specification MIL-H-8501A. The new structure is designed to accommodate a variety of rotorcraft types, mission flight phases, flight envelopes, and flight environmental characteristics and to provide criteria for three levels of flying qualities, a systematic treatment of failures and reliability, both conventional and multiaxis controllers, and external vision aids which may also incorporate synthetic display content. Existing and new criteria have been incorporated into the new structure wherever they can be substantiated. A supplement to the new structure is presented in the second of the two volumes in order to explain the background and rationale for the specification structure, the proposed forms of criteria, and the status of the existing data base. Critical gaps in the data base for the new structure are defined, and recommendations are provided for the research required to address the most important of these gaps.

FOREWORD

This report comprises Volume I of a two-volume final report on Phase I of a program to develop mission-oriented flying and ground handling qualities requirements for military rotorcraft. Volume I presents a new preliminary specification structure which is intended eventually, following review and refinement, to replace the current specification MIL-H-8501A, Helicopter Flying and Ground Handling Qualities. Volume II supplements Volume I and explains some of the background and rationale for the new specification structure, the proposed forms of criteria, the status of the existing data base, and recommendations for enhancing the data base. Volume II should be read alongside Volume I. The recommendations contained herein have not been approved and should therefore be considered only tentative.

This report presents the results of work performed during the period from August 2, 1982, through May 31, 1984, under Contract NAS2-11304 from the Ames Research Center (ARC) of the National Aeronautics and Space Administration (NASA). The program of which this work is a part, however, is sponsored jointly by the U.S. Army and the U. S. Navy and is directed by the Army Aviation Research and Development Command (AVRADCOM). The technical responsibility for the program is shared between the Aeromechanics Laboratory of the U.S. Army Research and Technology Laboratories, located at Ames Research Center, Moffett Field, California, and the Directorate for Development and Qualification located at AVRADCOM, St. Louis, Missouri. Contributions to the program are also being made by representatives of NASA, the U.S. Air Force Wright Aeronautical Laboratories, and the Federal Aviation Administration through an ad hoc Technical Coordinating Committee which includes a variety of interested representatives of the U.S. Army and the U.S. Navy. The authors are particularly grateful to the co-chairmen and members of the Technical Coordinating Committee for their guidance, encouragement, and criticism throughout this effort.

Mr. David L. Key of the Aeromechanics Laboratory, a co-chairman of the Technical Coordinating Committee, served as the technical manager of this contract and was assisted initially by Mr. G. Dean Carico and subsequently by Mr. Christopher L. Blanken, also of the Aeromechanics Laboratory. The Systems Technology, Inc., (STI) technical director was Mr. Irving L. Ashkenas. Mr. Warren F. Clement served as the STI project engineer. The members of the Technical Coordinating Committee are as follows: Dr. Robert T. N. Chen, NASA ARC Flight Dynamics and Controls Branch; Messrs. Carmen Mazza and Ron Nave, Naval Air Development Center; Mr. James Hayden of the U.S. Army Aviation Engineering Flight Activity; Mr. Ralph Baker, U.S. Army Aviation Center; Mr. Robert Woodcook, AFWAL/FIGC, Wright-Patterson AFB; Mr. Jim Honaker, Federal Aviation Administration, Southwest Region; Maj. Tom Edwards, DAMA-WSA, Washington, D.C.; Dr. William White and Messrs. Gene Heacock and Robert Tomaine, U.S. Army Aviation R&D Command; Mr. Robert H. Bowes, Naval Air Test Center; Messrs. T. Lawrence

and Glenn Smith, Naval Air Systems Command; Mr. Duane Simon and Maj. William Leonard, Applied Technology Laboratory, AVRADCOM, Ft. Eustis.

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INTRODUCTION

A. BACKGROUND (From Ref. 22)

The current specification MIL-H-8501A, Helicopter Flying and Ground Handling Qualities, is a 1961 revision (Ref. 1) of a 1952 document. It gave good guidance in its early years, but by the late 1960s it had many obvious deficiencies. For example, Ref. 2 provides a detailed analytical review of these shortcomings, and empirical evidence can be seen in reports of flight-test evaluations by the Army Engineering Flight Activity (AEFA), Refs. 3 through 5. MIL-H-8501A is still used by AEFA to some extent as a yardstick for flight-test evaluation, but for procurement of the Utility Tactical Transport Aircraft System (UTTAS) and the Advanced Attack Helicopter (AAH), the Army Aviation Research and Development Command (AVRADCOM) developed a new set of handling qualities specifications and incorporated them into the Prime Item Development Specification (PIDS) (Refs. 6 and 7). The U. S. Navy used essentially the same requirements for the Light Airborne Multipurpose System (LAMPS-MARK III). For the U. S. Army Helicopter Improvement Program (AHIP), the flying and ground handling quality requirements referred to MIL-H-8501A and provided some guidance on control sensitivity and rate damping (Ref. 8).

There have been several formal attempts to revise MIL-H-8501A--a "B" version was proposed in 1968 but was never developed and adopted. The vertical/short takeoff and landing (V/STOL) specification, MIL-F-83300 (Ref. 9), was the culmination of a major effort by Cornell Aeronautical Laboratory under the sponsorship of the Air Force Flight Dynamics Laboratory. It incorporated all of the data available at the time and followed closely the structure and format of the recently revised specification for conventional aircraft, MIL-F-8785B (Ref. 10). The data and rationale for the requirements were presented in a background information and user's guide (BIUG) (Ref. 11), which was modeled after the equivalent BIUG for MIL-F-8785B (Ref. 12). MIL-F-83300 attempted to include helicopters and, in fact, it was adopted for helicopter application by the U. S. Air Force; however, the U. S. Navy and U. S. Army chose not to adopt it for their helicopter applications. Some of the reasons for this may be related to the type of criticisms provided by Ref. 13. In an attempt to overcome the perceived shortcomings of MIL-F-83300, the U. S. Army and U. S. Navy jointly sponsored Pacer Systems, Inc., to draft a revision of MIL-H-8501A. The resulting specification and an associated BIUG were drafted in March 1973. This effort included some of the concepts and structure used in MIL-F-8785B and MIL-F-83300, and many of the actual requirements were innovative, although they lacked data for substantiation. The preliminary report of this effort, however, had limited distribution and was never published in a final form.

Experience in the previous efforts to revise MIL-H-8501A showed that the primary obstacle to developing new requirements was a lack of systematic data from which new criteria could be developed and used for substantiation.

In an attempt to assess the current specifications, the latest UTTAS and AAH system specifications (Refs. 14 and 15) were compared with MIL-H-8501A and MIL-F-83300 (Ref. 16). Three other specifications have also been developed for VTOL aircraft (Refs. 17 through 19). Although these three references made notable contributions to the development of criteria, they were not included in the comparison, because they made no claims to cover helicopters and were not written as contractual documents. MIL-F-83300 shows clear advantages in its broad coverage of important handling qualities aspects and its systematic structure. Its disadvantages are that it is primarily based on V/STOL data, and explicit helicopter characteristics are only lightly covered. MIL-H-8501A and the PIDS do, of course, specifically address helicopters, and, through long familiarity, the helicopter community is comfortable with them. However, they do have rather sparse coverage of many important topics. Even where topics are addressed, many shortcomings in the MIL-H-8501A requirements have long been recognized as mentioned previously (Ref. 2). In addition, MIL-H-8501A and the PIDS lack a systematic treatment of flight envelopes and failures. In addition, all of these specifications lack mission-oriented criteria and are primarily intended for visual meteorological conditions (VMC) with only token recognition of separate requirements for instrument meterological conditions (IMC). Table 1(I) provides a comparison of these helicopter and V/STOL specifications with comments summarizing their shortcomings.

It must be recognized that the task or mission to be performed by the helicopter can have a substantial impact on the flying quality requirements. For example, in MIL-F-83300 the requirements were divided into hover and low speed (i.e., for speeds less than 35 knots) and forward flight (i.e., for speeds from 35 knots to V_{CON}). The idea was to convert to the fixed-wing requirements of MIL-F-8785B at speeds above V_{CON}, but "V-convert" became "V-consternation," especially at the idea of making helicopters comply with the rigorous requirements in MIL-F-8785B. The supporting data for the hover and low speed requirements were based largely on research investigations using a generalized hover and low speed taxi task. Few systematic investigations had been made of mission-oriented tasks, such as night nap-of-the-earth (NOE) flying, where precision of control is required in tasks, such as hover-bobup as investigated by Aiken in Ref. 20 or shipborad landings in high sea states where the ship motions and the wind and turbulence interactions result in an extremely taxing task (Ref. 21). Attention to such flight phases will necessitate significantly more stringent requirements. For speeds greater than 35 knots, the data and requirements were oriented at V/STOL approach and landing. The resulting requirements may be a good minimum for flight safety, but there is need to develop requirements to enhance performance of the operational missions that helicopters perform in this speed range.

TABLE 1(I). HELICOPTER AND V/STOL SPECIFICATIONS
(From Ref. 22)

Specification	Date	Application	Comments
MIL-H-8501	1952	Helicopters	Specifically helicopter Sparse Coverage Criteria inadequate for Army missions Lacks treatment of envelopes and failures Basically for VMC
MIL-H-8501A	1961	Minor Revision	
AGARD 408	1962	V/STOL	Not intended for helicopters Not intended for contractual purposes
MIL-F-83300	1970	V/STOL (and helicopters USAF only)	Broad coverage Systematic structure Criteria inadequate for Army missions Based on V/STOL data Basically for VMC
UTTAS PIDS	1971	UTTAS	Based on MIL-H-8501A Maneuvering criteria added
AAH PIDS	1973	AAH	
AGARD 577	1973	V/STOL	Not intended for helicopters Not intended for contractual purposes
8501B (Proposed)	1973	Helicopters	Many new unsubstantiated requirements
AHIP Spec	1981	Interim Scout	Basically MIL-H-8501A

Additional problems result from the need to perform increasingly complex missions in adverse weather and at night. The plethora of pilot aids--such as for navigation, communications, weapons, survivability, and visions aids--compete for attention and can add to the pilot's workload if not suitably integrated (Ref. 23). Definition of meaningful handling qualities criteria must therefore consider all of the pilot's tasks involved in each mission flight phase together with an integrated treatment of vehicle dynamics, flight control system characteristics, cockpit controllers, displays, and vision aids. The program of which this report is a part has attempted to initiate such a comprehensive treatment.

B. OBJECTIVES

The objectives of this program are partitioned into two phases as follows:

Phase One

1. Develop a new rotorcraft handling qualities specification structure that can accommodate the many complex interactions between mission flight phase, rotorcraft category, and the mission environment.

2. Incorporate existing criteria into the new structure to the extent that they can be substantiated.

3. Develop new criteria for guiding and circumscribing the critical design characteristics in high-priority mission flight phases. This effort is to be based on existing data and any new data generated under the auspices of this or related programs.

4. Define critical gaps in the criteria and define the research efforts required to address the most important of these gaps.

Phase Two

1. Prepare a draft specification and associated Background Information and User's Guide (BIUG) in a form that could be circulated for review and comment by appropriate government and industry authorities.

2. Perform a cycle of government and industry reviews leading to a coordinated draft specification that can be submitted for adoption as a Military Standard and its associated BIUG.

C. SCOPE OF THIS REPORT

This report fulfills only the objectives of Phase One. This effort, to develop a new general specification for flying and ground handling qualities for rotorcraft, has built upon the applicable ideas, structure, criteria, techniques, and technology developed by the fixed-wing community, the V/STOL community, and the helicopter community for flying qualities requirements. The existing but sparse data base has been used wherever possible, and recommendations are offerred for acquiring new data to support specific requirements within the recommended structure of the new specification. Specific projects for developing new data for this purpose are currently being performed and are sponsored by both the Army Aeromechanics Laboratory and the National Aeronautics and Space Administration at the Ames Research Center and by the Naval Air Development Center, Warminster, Pennsylvania.

D. ORGANIZATION OF THIS VOLUME

The balance of this volume is organized in the form of a military specification for the flying and ground handling qualities of rotorcraft. Explanations of the background and rationale for the specification structure, proposed forms of criteria, status of the existing data base, and recommendations for enhancing the data base are presented in a companion Volume II, which is intended to be read alongside this volume.

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21. Proceedings of the Navy/NASA Flying Qualities Workshop held at Naval Postgraduate School, Monterey, California, April 1977.

22. Anon., Development of Mission-Oriented Handling Qualities Requirements for Military Rotorcraft, Contract NAS2-11304, August 2, 1982.

23. Proceedings of the AIAA/NASA Ames Research Center VSTOL Conference, Palo Alto, California, June 1977.

SPECIFICATION STRUCTURE

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1. SCOPE AND DEFINITIONS

1.1 SCOPE

(This section will include definition of "rotorcraft" to include (a) all helicopters, simple, compound, and winged, (b) all autogyroes, gyrocopters, and the like, and (c) all rotor configurations.)

1.2 APPLICATION

The requirements of this specification shall be applied to assure that no limitations on flight safety or on the capability to perform intended missions will result from deficiencies in flying qualities. The flying qualities for all rotorcraft proposed or contracted for shall be in accordance with the provisions of this specification unless specific deviations are authorized by the procuring activity. Guidance on application of these requirements can be found in the Background Information and User's Guide (BIUG). Additional or alternate special requirements may be specified by the procuring activity. For example, if the form of a requirement should not fit a particular vehicle configuration or control mechanization, the procuring activity may at its discretion agree to a modified requirement that will maintain an equivalent degree of acceptability.

1.3 LEVELS OF FLYING QUALITIES

The acceptability of the handling characteristics of a rotorcraft is quantified herein in terms of "levels" that are defined for each specific mission task in Fig. 1(1.3).* Where possible, the requirements of Section 3 are stated in terms of three limiting values of one or more flying qualities parameters. Each value, or combination of values, represents a minimum condition necessary to meet one of the three "levels" of acceptability.

In some cases sufficient simulation or flight test data do not exist to allow the specification of numerical values of a flying quality parameter. In such cases it is not possible to explicitly define the lower boundary of each "level." These cases are handled by stating the required

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*The use of the standard Cooper-Harper pilot rating scale to define flying qualities levels does not imply that pilot ratings will have to be obtained in order to comply with the specification. The primary use of the scale is to correlate pilot ratings from flying qualities experiments with time history parameters used in the specification. In a few cases, quantitative time history parameters may not be available, in which case compliance will have to be accomplished via demonstration using the Fig. 1(1.3) scale.

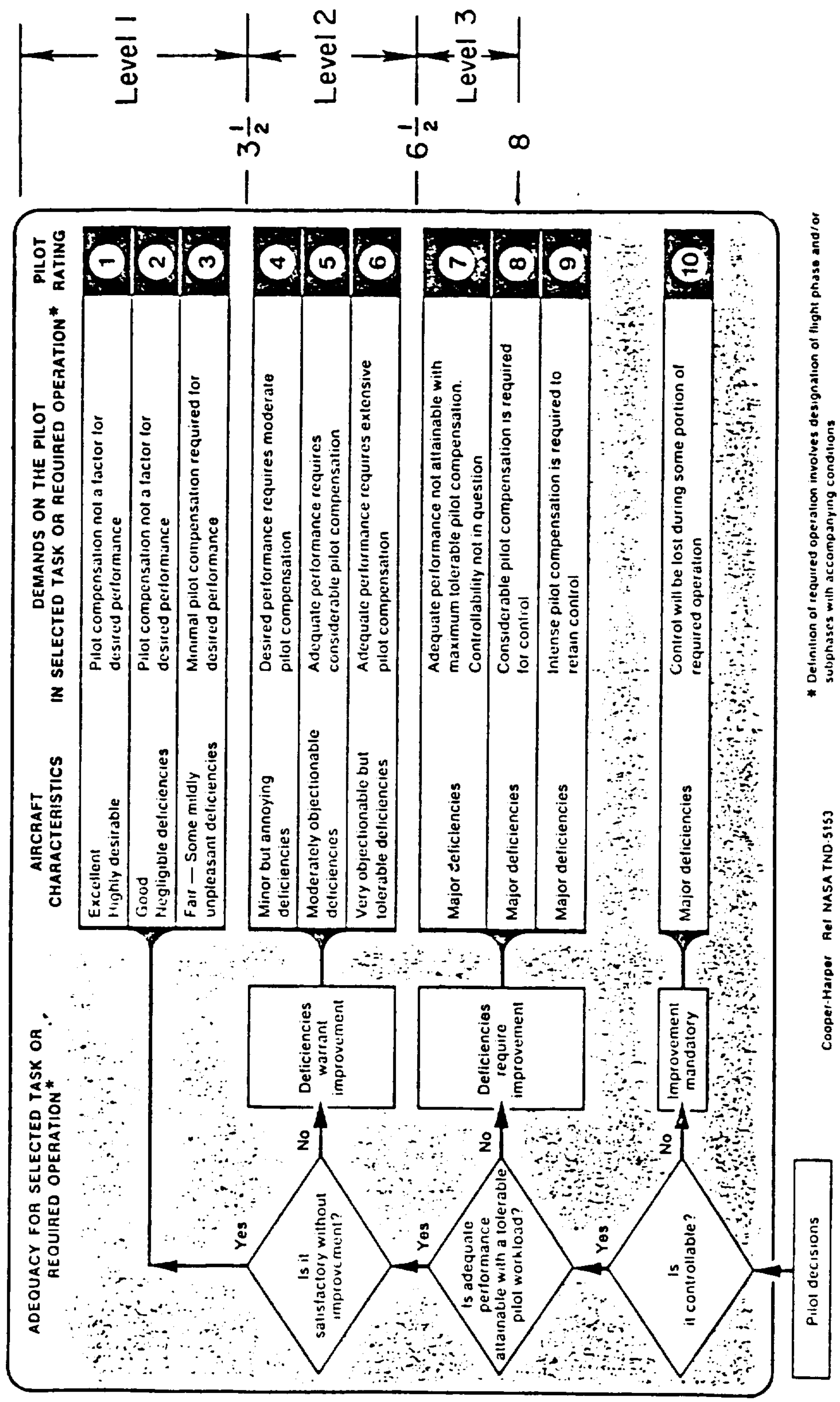

Figure 1 (1.3). Definition of Flying Quality Levels "level" of flying qualities for specified piloting tasks, which require compliance by demonstration in flight or via piloted simulation.

The requirements for rotorcraft "levels" as a function of failure states are presented in Paragragh 3.10. The effect of atmospheric disturbances on "levels" is given in Paragraph 3.17. The adjusted "level" definitions should not be construed as a recommendation to degrade flying qualities with increasing values of atmospheric disturbances.

1.4 FLIGHT ENVELOPES

1.4.1 Operational Flight Envelope. The operational flight envelope defines the boundary in which the rotorcraft is capable of operating without exceeding structural, vibration, or performance limits. As a minimum, the operational flight envelope must encompass the torque, speed, altitude, roll rate, sideslip, and load factor required to accomplish the mission task elements specified by the procuring agency from Paragraph 3.3. However, the rotorcraft shall be flight tested to vibration and performance limits, and up to predicted structural limits, with an appropriate factor of safety (usually 1.5). These limits shall constitute the operational flight envelope. All quantitative and qualitative Level 1 flying qualities requirements defined in this specification shall be satisfied throughout the operational flight envelope. Specific degradations in the presence of failures shall be allowed as specified in Paragraph 3.1.6.2

1.4.1.1 Speed Ranges Within the Operational Envelope.

1.4.1.1.1 Hover. Hovering flight is defined as all operations occurring below the ground speed at which effective translational lift occurs in a no-wind condition or 15 knots ground speed, whichever is less.

1.4.1.1.2 Low Speed. Low-speed flight is defined as all operations occurring at ground speeds between zero and 45 knots in any direction.

1.4.1.1.3 Forward Flight. Forward flight is defined as any operation with an airspeed greater than 45 knots up to the maximum speed, altitude, and load factor defined by considerations other than handling qualities.

1.4.2 Service Flight Envelopes. For each rotorcraft normal state, the contractor shall establish, subject to the approval of the procuring activity, service flight envelopes showing combinations of speed, altitude, and normal acceleration derived from rotorcraft limits as distinguished from mission requirements. The boundaries of the service flight envelopes can be coincident with or lie outside the corresponding operational boundaries.

1.4.3 Permissible Flight Envelope. The permissible flight envelopes encompass all regions in which operation of the rotorcraft is possible. These are the boundaries of flight conditions outside the operational flight envelope which the rotorcraft is capable of encountering safely. Operation in the region of retreating blade stall or in the vortex ring state might be representative of such conditions. Permissible flight envelopes define the boundaries of these areas in terms of torque, speed, altitude, roll rate, sideslip, and load factor.

1.5 DEFINITIONS OF USABLE CUE ENVIRONMENT

1.5.1 Takeoff, Landing, Nap of the Earth. The procuring activity will specify the outside visual cue (OVC) environment based on the OVC scale in Fig. 1(1.5) to be considered in designing the rotorcraft in order to meet the flying qualities requirements of this specification. All available pilot vision aids are to be considered when making a determination of the usable cue environment (UCE) for each mission task (see Section 3.3). The most adverse condition of visibility expected for each mission task shall be considered.

1.5.2 Forward Flight. For up-and-away operations, the outside visual cue environment shall be defined as either instrument or visual meteorological conditions (IMC or VMC).

1.6 DEFINITIONS OF FUNCTIONAL REQUIREMENTS*

1.6.1 Unattended Operation. Requirements characterize the stability and responses to disturbances of the augmented rotorcraft without control or intervention by the pilot--even for limited time intervals. This phase of operation can be further subdivided into "hands on" and "hands off," the latter being applicable if the role of the rotorcraft demands that the pilot be able to release the flying controls for substantial periods of time.

1.6.2 Divided Attention Operation. Requirements characterize operations among the axes of control while other axes or tasks occupy the pilot's attention for short periods of time. This phase of operation can be further subdivided into "hands on" and "hands off," the latter being applicable if the role of the rotorcraft demands that the pilot be able to release the flying controls for substantial periods of time.

1.6.3 Attended Operation. Requirements characterize any phase of flight during which the characteristics of the state of the rotorcraft necessitate continuous flying of the rotorcraft by the pilot via the flight controls.

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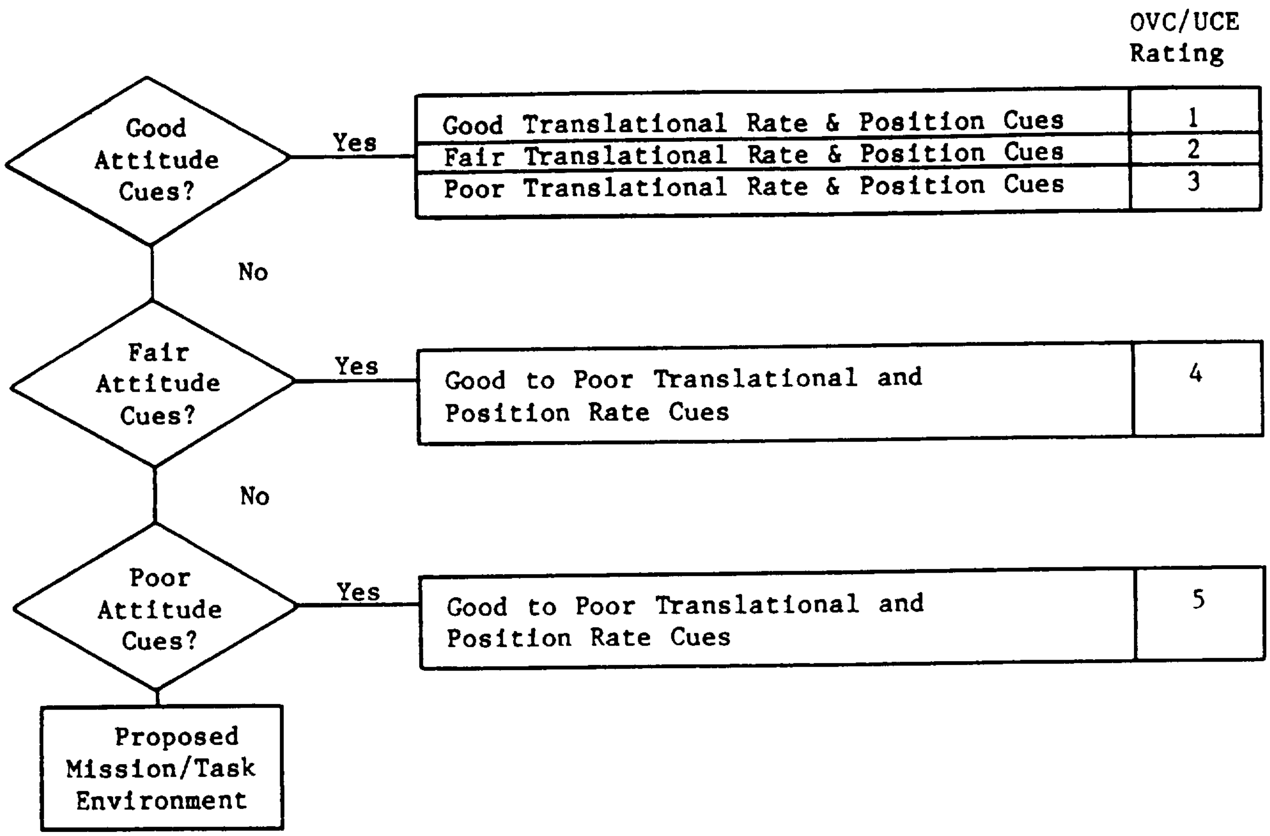
*These definitions apply to requirements in Paragraph 3.10.

Figure 1(1.5). Outside Visual Cue (OVC) and
Useable Cue Environment (UCE) Scale

The following scale shall be used to determine the outside OVC and UCE ratings in Paragraph 3.3.



Notes:

1. The scale is to be used only for operation in the vicinity of the terrain or the ship, i.e., nap-of-earth, takeoff, and landing.

2. If the scale includes all available vision aids, then it is used for determination of the UCE rating.

<u>Definitions of Cues</u>

X = Pitch or roll attitude and lateral, longitudinal, or vertical translational rate and position (x, y, and z inertial position with respect to surrounding objects)

Good X Cues: X easily and quickly perceived. Can make aggressive X corrections or changes with confidence.

Fair X Cues: Requires considerable concentration to perceive X accurately. Can make only moderate X corrections or changes with confidence.

Poor X Cues: Requires full concentration to perceive X accurately enough for aircraft control. Only small and gentle corrections in X are possible, and consistent precision X control is not attainable.

1.6.3.1 Trimmability. Requirements characterize the stability and control of the rotorcraft's steady-state operating flight conditions (and configurations) which are ordinarily equilibrium points but may include special cases of accelerated flight such as steady turning about the gravitational vertical.

1.6.3.2 Commandability. Requirements characterize the ability of the rotorcraft to perform mission-centered or emergency maneuvers, assuming that the rotorcraft response is directed by an ideal programmed controller and/or by the pilot acting in a feedback control sense.

1.6.3.3 Regulation. Requirements characterize the stability and responses to disturbances of the augmented rotorcraft with the pilot acting in a feedback control sense in order to maintain the status quo in the presence of upsets, intrusions, and environmental disturbances.

2. APPLICABLE DOCUMENTS

The following documents, of the issue in effect on the date of invitation for bids or request for proposal, form a part of this specification to the extent specified herein:

SPECIFICATIONS

Military

MIL-F-9490	Flight Control Systems--Design, Installation and Test of, Piloted Aircraft, General Specification for
MIL-C-18244	Control and Stabilization Systems, Automatic, Piloted Aircraft, General Specification for
MIL-F-18372	Flight Control Systems, Design, Installation and Test of, Aircraft (General Specification for)
MIL-W-25140	Weight and Balance Control Data (for Airplanes and Rotorcraft)
MIL-F-8785	Flying Qualities of Piloted Airplanes

STANDARDS

MIL-STD-756	Reliability Prediction

(Copies of documents required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. REQUIREMENTS

3.1 GENERAL REQUIREMENTS

3.1.1 Loadings. The envelope of center of gravity and weight for each flight phase shall be specified by the contractor. In addition, the contractor shall specify the maximum center of gravity excursion attainable through failure in systems or components for each flight phase.

3.1.2 Moments and Products of Inertia. The contractor shall define the moments and products of inertia of the rotorcraft associated with all loadings of Paragraph 3.1.1. The requirements of this specification shall apply for all moments and products of inertia so defined.

3.1.3 External Stores. The requirements of this specification shall apply for all combinations of external stores required by the operational missions. The effects of external stores on the weight, moments of inertia, center of gravity position, and aerodynamic characteristics of the rotorcraft shall be considered for each mission flight phase. When the stores contain expendable loads, the requirements of this specification apply throughout the range of store loadings.

3.1.4 Configurations. The requirements of this specification shall apply for all configurations required or encountered. A configuration is defined by the positions and adjustments of the various selectors and controls available to the crew except for pitch, roll, yaw, throttle, and trim controls. An example is the yaw damper ON or OFF. The selected configurations to be examined must consist of those required for performance and mission accomplishment. Additional configurations to be investigated may be defined by the procuring activity. Control positions which activate stability augmentation necessary to meet the requirements of this standard are considered to be always ON unless otherwise specified.

3.1.5 Allowable Levels for Rotorcraft Normal States.

3.1.5.1 Within Operational Flight Envelopes. The minimum required flying qualities for the rotorcraft normal mission state within the operational flight envelope will be Level 1. To account for degradation in handling qualities due to atmospheric disturbances, requirements will in some cases be adjusted as a function of disturbance magnitude.

3.1.5.2 Within Permissible Flight Envelopes. The requirements for Level 3 flying qualities must be met within the permissible flight envelope.

3.1.6 Allowable Levels for Rotorcraft Failure States.

3.1.6.1 Probability Calculation. When rotorcraft failure states exist, a degradation in flying qualities is permitted only if the probability of encountering less than Level 1 flying qualities is sufficiently small. The contractor shall determine, based on the most accurate data available, the probability of occurrence of each rotorcraft failure state per flight hour within the operational flight envelope. Each specific failure is assumed to be present at whichever point in the flight envelope being considered is most critical (in the flying qualities sense). From these failure state probabilities and effects, the contractor shall determine the overall probability, per flight hour, that one or more flying qualities are degraded to Level 2 because of one or more failures. The contractor shall also determine the probability that one or more flying qualities are degraded to Level 3. These probabilities shall be less than the values shown in Table 1(3.1)

TABLE 1(3.1). LEVELS OF ROTORCRAFT FAILURE STATES

PROBABILITY OF ENCOUNTERING	WITHIN OPERATIONAL FLIGHT ENVELOPE
Level 2 after Failure	< _____ per flight hour
Level 3 after Failure	< _____ per flight hour

3.1.6.2 Rotorcraft Failure States. The contractor shall define and tabulate all rotorcraft failure states, which consist of rotorcraft normal states modified by one or more malfunctions in rotorcraft components or systems, for example, a discrepancy between a selected configuration and an actual configuration. Those malfunctions that result in center-of-gravity positions outside the center-of-gravity envelope defined in Paragraph 3.1.1 shall be included. Each mode of failure shall be considered. Failures occurring in any flight phase shall be considered in all subsequent flight phases.

3.1.6.3 Generic Failure Modes and Effects Analysis. The requirements on the effects of specific types of failures shall be met on the basis that the specific type of failure has occurred regardless of its probability of occurrence. The allowable level of flying qualities for each specific failure shall be specified by the procuring activity.

3.1.6.4 Artificial Vision Aid Failures. The probability of failure of artificial vision aids utilized to improve the usable cue environment in Paragraph 3.3.3 shall be no greater than the values in Table 2(3.1) where the mission outside visual cues (OVC) refer to the worst case visual environment in the mission for near earth operation. The usable cue environment (UCE) refers to the above OVC as improved by the use of artificial vision aids.

TABLE 2(3.1). MAXIMUM ALLOWABLE PROBABILITY OF FAILURE FOR ARTIFICIAL VISION AIDS

Mission OVC	UCE				
	1	2	3	4	5
1	--	--	--	--	--
2	10^{-2}	--	--	--	--
3	10^{-2}	10^{-2}	--	--	--
4	10^{-4}	10^{-2}	10^{-2}	--	--
5	10^{-5}	10^{-4}	10^{-2}	10^{-2}	--

3.1.7 Dangerous Flight Conditions. Dangerous conditions may exist where the rotorcraft should not be flown. When approaching these flight conditions, it shall be possible by clearly discernible means for the pilot to recognize the impending dangers and take preventive action.

3.1.7.1 Warning and Indication. Warning and indication of approach to a dangerous condition shall be clear and unambiguous. For example, a pilot must be able to distinguish readily between retreating blade stall (which may indicate a need to decrease speed) and normal rotorcraft vibration (which indicates no need for pilot action) if, in fact, retreating blade stall results in an abrupt loss of control.

3.1.7.2 Devices for Indication, Warning, Prevention, and Recovery. It is intended that dangerous flight conditions be eliminated and the requirements of this specification be met by appropriate aerodynamic design and mass distribution rather than through incorporation of special devices for indication, warning, prevention, and recovery. If required, these devices shall at least perform their function whenever needed but shall not limit flight within the operational flight envelope. Neither normal nor inadvertent operation of such devices shall create a hazard to the rotorcraft. For Levels 1 and 2, false alarms and nuisance operation shall not be possible. Functional failure of the devices shall be indicated to the pilot.

3.1.8 Interpretation of Subjective Requirements. In several instances throughout the specification, subjective terms--such as objectionable flight characteristics, realistic time delay, normal pilot technique, and excessive loss of altitude or buildup of speed--have been employed where insufficient information exists to establish absolute quantitative criteria. Final determination of compliance with requirements so worded will be made by the procuring activity.

3.2 OPERATIONAL MISSIONS AND MISSION TASK ELEMENTS

3.2.1 Specification of Mission and Mission Task Elements. The procuring activity shall specify the operational missions to be considered by the contractor in designing the rotorcraft to meet the flying qualities requirements of this specification. These missions will include the entire spectrum of intended operational usage. The procuring activity shall specify the task elements which make up the rotorcraft mission from Tables 1(3.2) and 2(3.2). Additional task elements shall be specified as necessary based on the operational missions defined above. The selected mission task elements shall be used in identification of the required rotorcraft response type in Paragraph 3.3.

3.2.2 Mission and Mission Task Element Compliance Demonstration. The procuring activity shall specify the mission and mission task elements for which the contractor must demonstrate specification compliance. Specification compliance shall be demonstrated in accordance with the requirements of Paragraph 4. For the purposes of compliance, Appendix A provides a complete definition of each mission task element specified in Tables 1(3.2) and 2(3.2).

TABLE 1(3.2). DEFINITIONS OF MISSION TASK ELEMENTS--
NEAR EARTH MANEUVERING

Hover Flight Phase	Appendix A Maneuver
• Hover	A.1.1.1
• Precision hover in a confined area (critical azimuth, wind, etc.)	A.1.1.2
• Hover turns	A.1.1.3
• Hover rescue of personnel by external hoist	A.1.1.4
• Sonar dunking	A.1.1.5
• Shipboard stationkeeping	A.1.1.6
• Suspended loads (acquisition and deposit)	A.1.1.7
• Vertical climb	A.1.1.8
• Vertical descent	A.1.1.9
Takeoff Flight Phase	
• Takeoff to hover	A.1.2.1
• Normal takeoff	A.1.2.2
• Obstacle clearance takeoff	A.1.2.3
• Jump takeoff	A.1.2.4
• Maximum performance takeoff	A.1.2.5
• Terrain flight takeoff	A.1.2.6
• Rolling takeoff	A.1.2.7
• Slope takeoff	A.1.2.8
• Shipboard takeoff	A.1.2.9
Landing Flight Phase	
• Landing from hover	A.1.3.1
• Normal approach and landing	A.1.3.2
• Shipboard landing	A.1.3.3
• Run-on landing	A.1.3.4
• Slope landing	A.1.3.5
• Steep approach	A.1.3.6
• RAST recovery	A.1.3.7
• Water landing	A.1.3.8
Near Earth Maneuver Flight Phase	
• Bob-up/bob-down	A.1.4.1
• Sidestep unmask/remask	A.1.4.2
• Dash/quickstop	A.1.4.3
• Sideward flight	A.1.4.4
• Lateral acceleration	A.1.4.5
• Low speed control	A.1.4.6
• Rearward flight	A.1.4.7
• Lateral/vertical displacement maneuver	A.1.4.8
• Pull-up/push-over maneuver	A.1.4.9
• Mine countermeasure towing	A.1.4.10
• Sling loads	A.1.4.11
• NOE flight	A.1.4.12
• Slalom	A.1.4.13
• Weapon delivery	A.1.4.14
Autorotation Flight Phase	
• Autorotation from hover (throttle chop)	A.1.5.1
• Autorotation entry from level flight	A.1.5.2
• Autorotation landing	A.1.5.3

TABLE 2(3.2). DEFINITIONS OF MISSION TASK ELEMENTS--
UP AND AWAY FLIGHT

VMC Flight Phase	Appendix A Maneuver
• Level Flight	A.2.1.1
• Climb/descent	A.2.1.2
• Acceleration	A.2.1.3
• Deceleration	A.2.1.4
• Level turns	A.2.1.5
• Non-precision approach	A.2.1.6
• Steep approach	A.2.1.7
• Formation flight	A.2.1.8
• Stationkeeping (air-to-air refueling)	A.2.1.9
• Mid-air retrieval	A.2.1.10
• MAD/sonobouy deploy	A.2.1.11
• Instrument takeoff	A.2.1.12
IMC Flight Phase	
• Level flight	A.2.2.1
• Level turns	A.2.2.2
• Climb/descending turns	A.2.2.3
• Climbs/descents	A.2.2.4
• Acceleration/deceleration	A.2.2.5
• Precision instrument approach	A.2.2.6
Maneuvering Flight	
• Sustained G turn to limit	A.3.1.1
• Decelerating G turn	A.3.1.2
• Air-to-air maneuvers (yo-yo's, scissors, etc.)	A.3.1.3

3.3 REQUIRED ROTORCRAFT RESPONSE TYPE

3.3.1 Applicability of Requirements. The required response type resulting from Paragraph 3.3 is intended to be the minimum acceptable for the specified mission task element. A response type higher in level than that required may be provided instead. In such an event, the requirements for the higher level of response type shall apply.

3.3.2 Required Response Type for Specified Mission Task Element. The type of rotorcraft response characteristic to piloted control inputs shall have as a minimum the form specified in Table 1(3.3) for the tasks and levels of pilot control (if moderate, M, if aggressive, A) defined in Paragraph 3.2. The response characteristics defined at the top of Table 1(3.3) refer specifically to the response to controller in hover. The required responses in other flight conditions are all keyed to the specified longitudinal response as defined in Paragraph 3.3.4 [Table 3(3.3)].

TABLE 1(3.3). REQUIRED ROTORCRAFT ATTITUDE RESPONSE CHARACTERISTICS AS A FUNCTION OF TASK

Ideal outside visual cues (OVC = 1, Paragraph 1.5) and a "moderate" level of turbulence (Paragraph 3.17) are assumed

Acceleration Response Permitted	Rate Response Required	Attitude Response Required
Hover (M)	Air Refueling*	NOE (A) Low Speed/Hover
Autorotation	Air Retrieval	Weapon Delivery (A)
Formation (M)	Shipboard Recovery (M)*	Shipboard Recovery (A)
Departures	NOE (M) Fwd Speed	TBD
Approaches	TBD	
Up and Away		
Evasive Maneuvers		
Weapon Delivery (M)		
TBD		

*In addition to the basic rate response, an attitude hold or attitude retention feature is required for this task. Such attitude hold features must meet the requirements of Fig. 3(3.4).

3.3.2.1 Requirement for Acceleration Response System Type. If an acceleration (acc) response system is permitted by Table 1(3.3) the cockpit controller force and deflection inputs shall produce essentially proportional angular acceleration about the corresponding vehicle axis.

3.3.2.2 Requirement for Rate Response System Type. If a rate response system is required by Table 1(3.3), the cockpit controller force and deflection inputs shall produce essentially proportional angular velocity about the corresponding vehicle axis.

3.3.2.3 Requirement for Attitude Response System Type. If an attitude (att) response system is required by Table 1(3.3), the cockpit controller force and deflection inputs shall produce essentially proportional pitch and roll attitudes about the corresponding vehicle axis.

3.3.2.4 Requirement for Translational Rate Response [or Command (TRC)] System Type. If a translational rate response [or command (TRC)] system is required by Table 1(3.3), the cockpit controller force and deflection inputs shall produce essentially proportional translational rates along the inertial X, Y, and Z axes of motion.

3.3.3 Required Upgrading of Response Type in Conditions of Degraded Outside Visual Cues.

3.3.3.1 Single Pilot. The required response type obtained from Table 1(3.3) shall be upgraded according to Table 2(3.3) in the presence of a degraded usable cue environment (UCE) as defined in Fig. 1(1.5).

TABLE 2(3.3). REQUIRED UPGRADED RESPONSE TYPE IN THE PRESENCE OF DEGRADED UCE--SINGLE PILOT

	Upgraded Response-Type Required Due to Degraded UCE			
	UCE = 2	UCE = 3	UCE = 4	UCE = 5
When acceleration response is allowed by Table 1(3.3)	Acceleration	Rate	Attitude	TRC
When rate response is required by Table 1(3.3)	Rate	Attitude	Attitude	TRC
When attitude response is required by Table 1(3.3)	Attitude	Attitude	TRC	TRC

NOTES:

- UCE is OVC with the addition of all available artificial vision aids, see Figure 1(1.5).
- TRC is an abbreviation for translational rate command.
- Values in this table are estimates and require testing before use in a final specification.

3.3.3.2 Additional Pilot. The required response type obtained from Table 1(3.3) shall be upgraded according to Table 3(3.3) in the presence of a degraded usable cue environment (UCE) as defined in Fig. 1(1.5).

TABLE 3(3.3). REQUIRED UPGRADED RESPONSE TYPE IN THE PRESENCE OF DEGRADED UCE--ADDITIONAL PILOT

	Upgraded Response-Type Required Due to Degraded UCE			
	UCE = 2	UCE = 3	UCE = 4	UCE = 5
When acceleration response is allowed by Table 1(3.3)	Acceleration	Rate	Rate	Attitude
When rate response is required by Table 1(3.3)	Rate	Rate	Attitude	Attitude
When attitude response is required by Table 1(3.3)	Attitude	Attitude	Attitude	TRC

NOTES:

- UCE is OVC with the addition of all available artificial vision aids, see Figure 1(1.5).
- TRC is an abbreviation for translational rate command.
- Values in this table are estimates and require testing before use in a final specification.

3.3.4 Required Response Characteristics in Each Axis for Designated Rotorcraft-Control System Type. The specific response types required by this specification for each controller at all flight conditions within the operational flight envelope is given in Table 4(3.3).

TABLE 4(3.3). MINIMUM REQUIRED RESPONSE TYPE TO EACH CONTROLLER

Type of Response Required by Table 1(3.3)	Speed Regimes Para. 1.4	Type of Response to Longitudinal Controller Para. 3.4	Type of Response to Lateral Controller Para. 3.6	Type of Response to Directional Controller Para. 3.7	Type of Response to Vertical Controller Para. 3.5
Acc	Hover Low Speed Fwd Flt (VMC) Fwd Flt (IMC)	Acc Rate Rate Att	Acc Rate Rate Att	Acc Rate Att Att	Acc Acc Acc Rate
Rate	Hover Low Speed Fwd Flt (VMC) Fwd Flt (IMC)	Rate Rate Rate Att	Rate Rate Rate Att	Rate Rate Rate Att	Acc Acc Rate Rate
Att	Hover Low Speed Fwd Flt (VMC) Fwd Flt (IMC)	Att Rate Rate Att	Att Rate Rate Att	Att Rate Rate Att	Rate Rate Rate Rate
TRC	Hover Low Speed Fwd Flt (VMC) Fwd Flt (IMC)	TRC Rate Rate Att	TRC Rate Rate Att	Rate Rate Rate Att	Rate Rate Rate Rate

3.3.5 Use of the OVC/UCE Scale in Determining Required Rotorcraft Response Type. The OVC/UCE scale [Figure 1(1.5)] provides guidance for the establishment of minimum requirements for rotorcraft flight control sophistication. Figure 1(3.3) provides a flow chart outlining this process.

3.3.5.1 Procuring Agency Responsibility. The procuring agency shall be responsible for specification of the required rotorcraft mission tasks and the pilot's operational OVC environment. The procuring agency shall not specify the incorporation of specific visual, guidance, navigation, or other pilot workload reducing aids or augmentation.

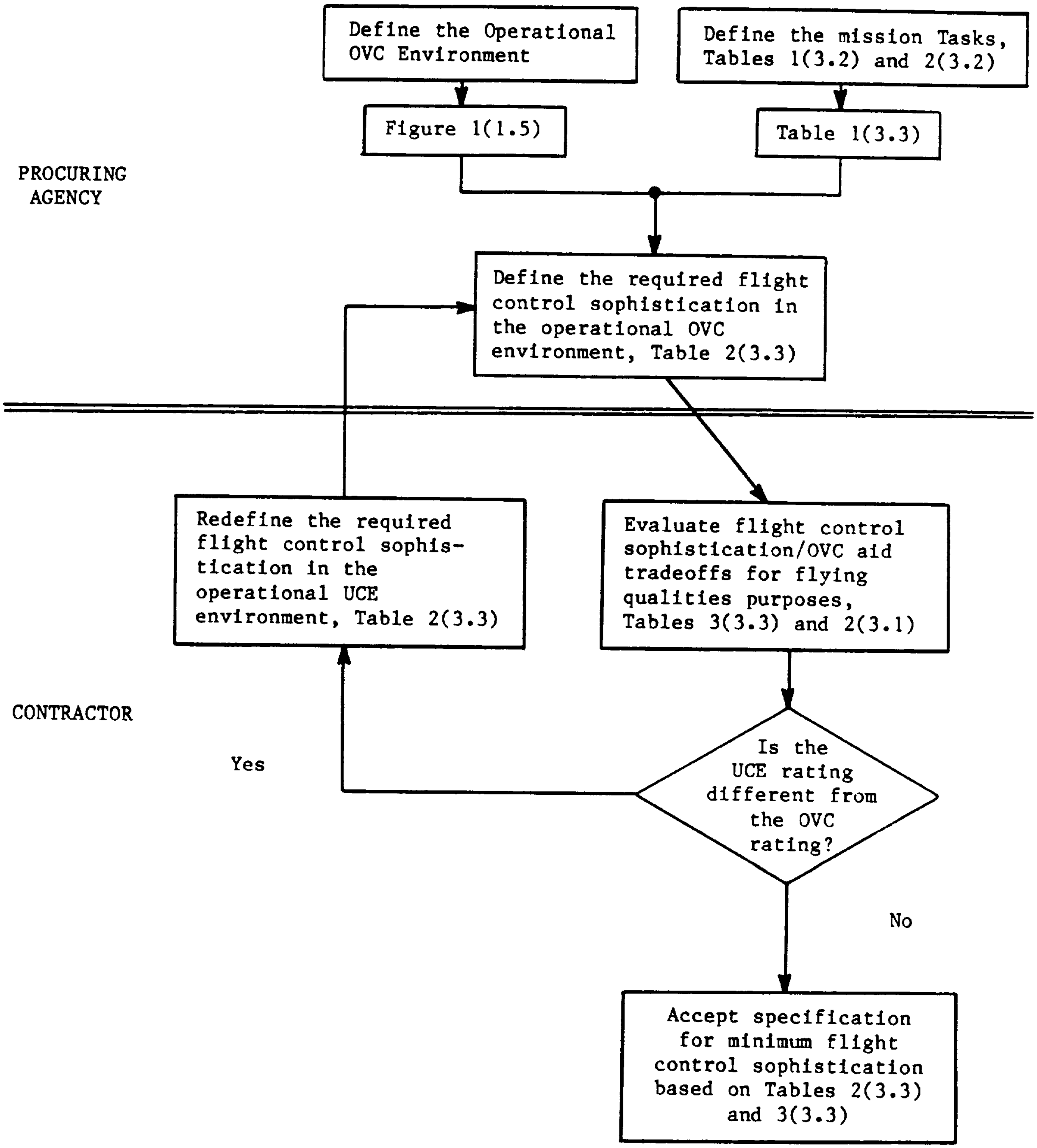


Figure 1(3.3). Methodology for Definition of the Required Rotorcraft Response Type

Mission tasks are to be chosen from Tables 1(3.2) and 2(3.2). The minimum requirements for flight control sophistication as a function of task for an OVC level of 1 are defined in Table 1(3.3). The procuring agency shall use the outputs from these tables (the required operational OVC environment rating and the OVC-1 requirement for flight control sophistication) in determining the minimum requirements for flight control sophistication in the operational (degraded) OVC environment using Tables 2(3.3), 3(3.3), and 4(3.3). This information shall be provided to the contractor as rotorcraft design requirements in the procurement specification.

3.3.5.2 Contractor Responsibility. The contractor shall evaluate the specification design requirements with respect to technology which is capable of augmenting the pilot's unaided outside visual cue (OVC) information. This technology might include night or all weather vision aids, guidance and navigation aids, as well as other pilot workload reduction devices. Tables 2(3.1) and 4(3.3) shall be used during the evaluation process. If the contractor can demonstrate to the procuring agency's satisfaction that proposed OVC aids can be substituted along with less sophisticated flight controls in replacement of the procuring agency's specification for flight control sophistication, then, with mutual agreement between the procuring agency and the contractor, the OVC scale of Fig. 1(1.5) shall be interpreted as a usable cue environment (UCE) scale, and the required response type from Table 2(3.3) shall be adjusted accordingly. Final acceptance of any such revision to the UCE rating shall be the responsibility of the procuring agency. The resulting control system sophistication required in Table 2(3.3) for the UCE (redefined OVC) rating will become the required minimum specification for control system sophistication.

3.4 RESPONSE TO THE LONGITUDINAL CONTROLLER

3.4.1 Pitch Attitude Response to the Longitudinal Controller in Low Speed and Hover. The pitch attitude response to a longitudinal controller displacement shall have the following characteristics. These requirements apply for the range of controller displacements necessary to perform the tasks specified in Paragraph 3.2.

3.4.1.1 Required Pitch Attitude Dynamics When Acceleration Response is Allowed by Paragraph 3.3.

3.4.1.1.1 Short Term Response. The time response of pitch rate to a step longitudinal controller input shall reach 86 percent of its short-term steady value within the time specified in Table 1(3.4). The short-term steady value of pitch rate is defined in Fig. 1(3.4). In the event that a short-term steady value of pitch rate cannot be defined, alternate methods of demonstrating acceptable values of λ may be applied upon agreement with the procuring activity.

TABLE 1(3.4). SHORT TERM RESPONSE REQUIREMENTS (Minimum Allowable λ)

	λ_{MIN} (1/sec)
Level 1	1.0
Level 2	0.7
Level 3	0.5

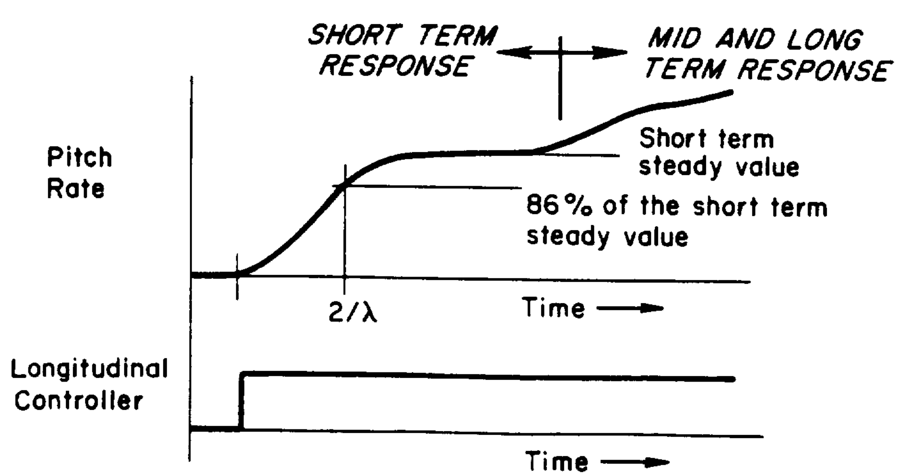


Figure 1(3.4). Definition of λ

3.4.1.1.2 Mid- and Long-Term Response. The time response of pitch attitude following a longitudinal controller pulse input shall have the characteristics specified in Table 2(3.4)

TABLE 2(3.4). MINIMUM ALLOWABLE PERIOD OF OSCILLATION FOLLOWING A LONGITUDINAL CONTROLLER PULSE INPUT

Cycles to Double (C_2) or Half ($C_{1/2}$) Amplitude (sec)	Minimum Period of Oscillation (sec)		
	Level 1	Level 2	Level 3
From $C_{1/2} > 11.5$ To $C_2 > 4.6$	12.6	7	5
$2 < C_{1/2} < 11.5$	7	1.2	1.2
$C_{1/2} < 2$	No Requirement		

3.4.1.2 Required Pitch Attitude Dynamics When Rate Response is Specified by Paragraph 3.3. The pitch rate response to a step input of the longitudinal controller shall fall within the limits specified in Table 3(3.4). The size of the input shall be varied from that required for precision tracking up to that for the most aggressive maneuvering expected for the mission. The parameters used in Table 3(3.4) are defined in Fig. 2(3.4).

3.4.1.3 Required Pitch Attitude Dynamics When Attitude Response is Specified by Paragraph 3.3. The pitch attitude response to a step input of the longitudinal controller shall fall within the limits specified in Table 4(3.4). The size of the input shall be varied from that required for precision tracking up to that for the most aggressive maneuvering expected for the mission. The parameters used in Table 4(3.4) are defined by Fig 2(3.4) with the ordinate relabeled as θ/θ_{ss}. In addition, the pitch attitude response to a pulse longitudinal controller input shall fall within the limits specified in Fig. 3(3.4) for Level 1.

TABLE 3(3.4). LIMITING VALUES FOR PITCH RATE RESPONSE-- LOW SPEED AND HOVER

Parameter			Level 1	Level 2	Level 3
T_{r_q} (sec)		Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD
τ_{d_q} (sec)		Max	TBD	TBD	TBD
X_1/X_o		Max	TBD	TBD	TBD
K_q (deg/sec/in)	Center Stick	Max	20	30	30
		Min	5	3	3
	Side Stick	Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD
K_{q_F} (lb/in)	Center Stick	Max	2	5	5
		Min	1/2	1/2	1/2
	Side Stick	Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD

where $K_q = q_{ss}/\delta_{LONG}$ $K_{q_F} = F_{LONG}/\delta_{LONG}$ - average gradient

For F_{LONG}, the gradient does not include the breakout force.

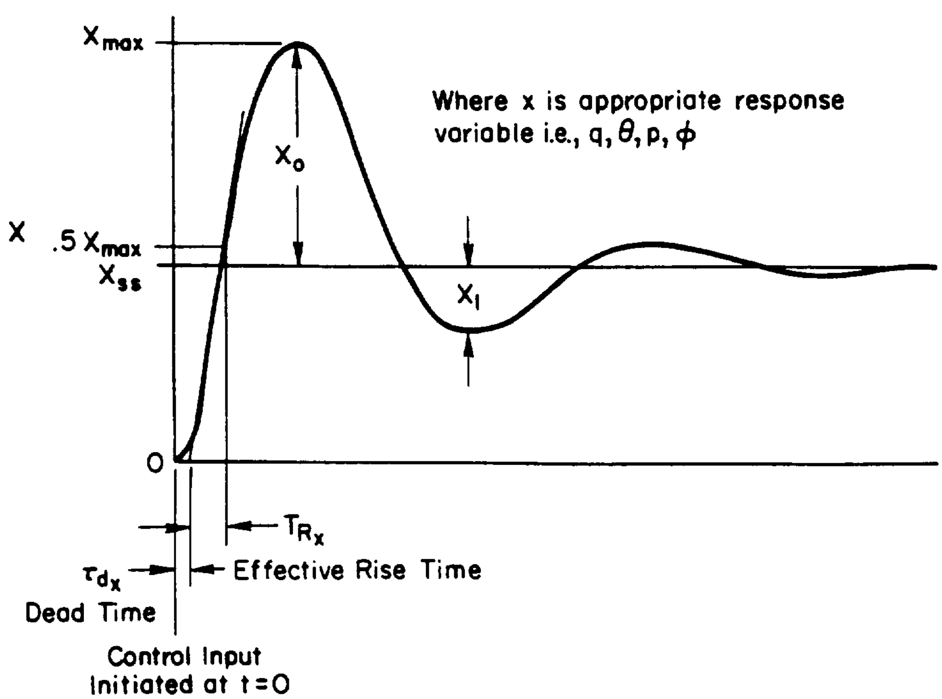


Figure 2(3.4). Definitions of Pitch Rate Response Parameters

TABLE 4(3.4). LIMITING VALUES FOR PITCH ATTITUDE RESPONSE-- LOW SPEED AND HOVER

<table>
<tr><th colspan="3">Parameter</th><th>Level 1</th><th>Level 2</th><th>Level 3</th></tr>
<tr><td colspan="2" rowspan="2">T_{r_θ} (sec)</td><td>Max</td><td>1.37</td><td>TBD</td><td>TBD</td></tr>
<tr><td>Min</td><td>TBD</td><td>TBD</td><td>TBD</td></tr>
<tr><td colspan="2">τ_{d_θ} (sec)</td><td>Max</td><td>0.45</td><td>TBD</td><td>TBD</td></tr>
<tr><td colspan="2">X_1/X_o</td><td>Max</td><td>0.35</td><td>TBD</td><td>TBD</td></tr>
<tr><td rowspan="4">K_θ (deg/in)</td><td rowspan="2">Center Stick</td><td>Max</td><td>20</td><td>28</td><td>28</td></tr>
<tr><td>Min</td><td>3</td><td>1</td><td>1</td></tr>
<tr><td rowspan="2">Side Stick</td><td>Max</td><td>TBD</td><td>TBD</td><td>TBD</td></tr>
<tr><td>Min</td><td>TBD</td><td>TBD</td><td>TBD</td></tr>
<tr><td rowspan="4">K_{θ_F} (lb/in)</td><td rowspan="2">Center Stick</td><td>Max</td><td>2</td><td>5</td><td>5</td></tr>
<tr><td>Min</td><td>1/2</td><td>1/2</td><td>1/2</td></tr>
<tr><td rowspan="2">Side Stick</td><td>Max</td><td>TBD</td><td>TBD</td><td>TBD</td></tr>
<tr><td>Min</td><td>TBD</td><td>TBD</td><td>TBD</td></tr>
</table>

where $K_\theta = \theta_{ss}/\delta_{LONG}$ $K_{\theta_F} = F_{LONG}/\delta_{LONG}$ - average gradient

where F_{LONG} does not include the breakout force

3.4.1.4 Allowable Pitch Attitude Excursions When Translational Rate Response is Required by Paragraph 3.3. The peak pitch attitude response to a step longitudinal control input shall not exceed the limits in Table 5(3.4).

3.4.2 Pitch Rate Response to Longitudinal Controller in Forward Flight.

3.4.2.1 Step Response Requirements. The pitch rate response to a step input of the longitudinal controller shall fall within the limits specified in Table 6(3.4) and defined in Fig. 2(3.4). The size of the input shall be varied from barely perceptible up to the maximum possible within safety and structural limitations. The time history of normal acceleration shall become concave downward within 2.0 seconds following the initiation of the longitudinal input and remain concave downward until the attainment of maximum normal acceleration. During the maneuver described, the time history of angular velocity shall become concave

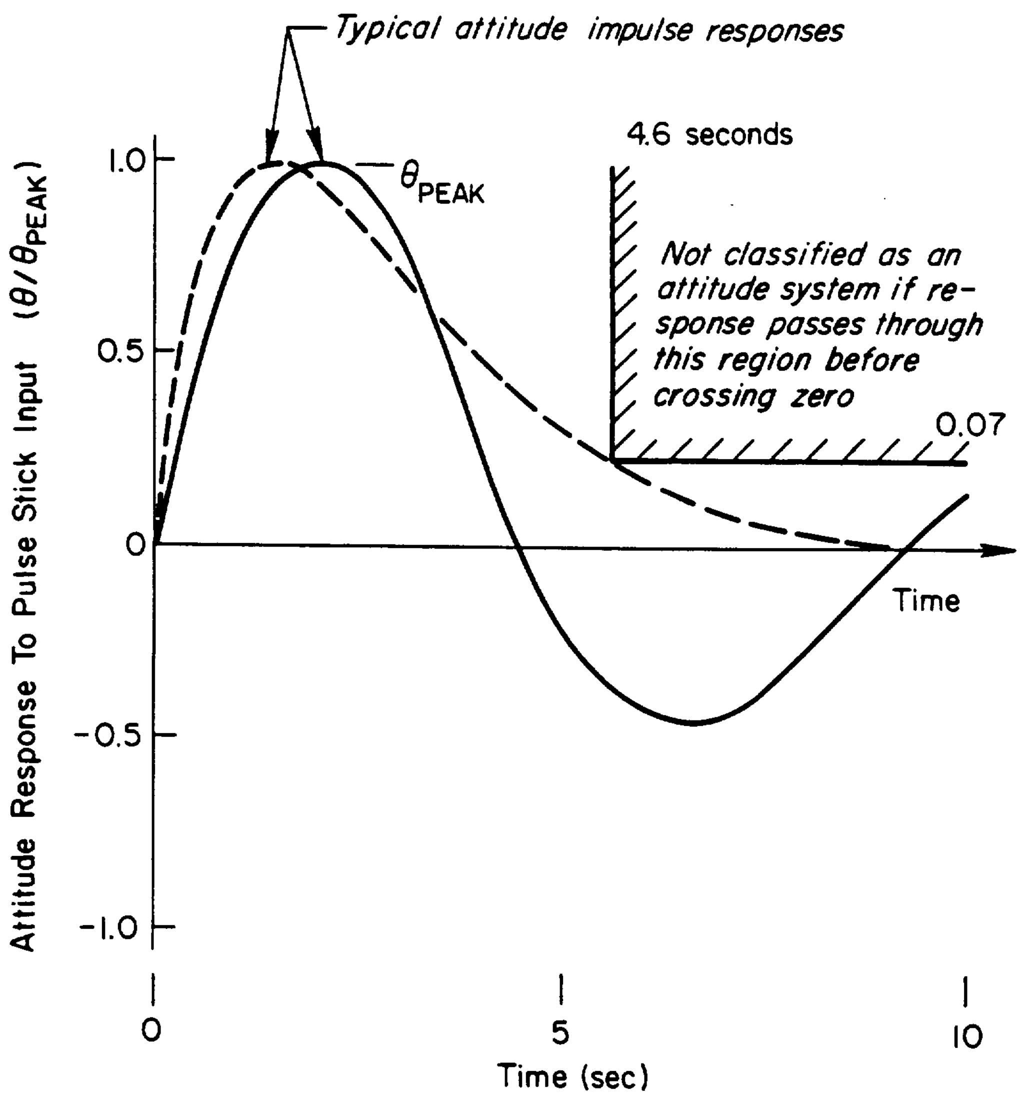


Figure 3(3.4). Definition of Attitude Response Type
(Pulse input of longitudinal controller)

TABLE 5(3.4). MAXIMUM ALLOWABLE PITCH ATTITUDE EXCURSION PER INCH OF CONTROL DEFLECTION, θ_{PEAK}/δ (deg/in)

		Level 1	Level 2	Level 3
Centerstick Controller	Max	10	20	30
	Min	TBD	TBD	TBD
Side Arm Controller	Max	30	TBD	TBD
	Min	TBD	TBD	TBD

TABLE 6(3.4). LIMITING VALUES FOR PITCH RATE RESPONSE IN FORWARD FLIGHT

Parameter			Level 1	Level 2	Level 3
T_{r_q} (sec)		Max	0.250	TBD	TBD
		Min	0.125	TBD	TBD
τ_{d_q} (sec)		Max	0.10	0.20	0.25
x_1/x_o		Max	0.306	0.444	$T_2 > 6$ sec
K_q (deg/sec/in)	Center Stick	Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD
	Side Stick	Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD
K_{q_F} (lb/in)	Center Stick	Max	2	5	5
		Min	1/2	1/2	1/2
	Side Stick	Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD

where $K_q = q_{ss}/\delta_{LONG}$ $\quad K_{q_F} = F_{LONG}/\delta_{LONG}$ - average gradient

where F_{LONG} does not include the breakout force downward within 2.0 seconds following the start of the maneuver, and remain concave downward until the attainment of maximum angular velocity; with the exception that for this purpose, a faired curve may be drawn through any oscillations in angular velocity not in themselves perceptible to the pilot.

3.4.2.2 Pulse Response Requirements. When the longitudinal control is suddenly displaced rearward from trim, the lesser distance of 1 inch or that determined by the 0.2 radian per second or 1.5 g requirement above and held for at least 0.5 second and then returned to and held at the initial trim position, the normal acceleration shall not increase by more than 0.25 g within 10 seconds from the start of the disturbance, except that 0.25 g may be exceeded during the period of control application. Further, during the subsequent nosedown motion (with the controls still fixed at trim) any normal acceleration drop below the trim value shall not exceed 0.25 g within 10 seconds after passing through the initial trim value. There shall be no objectionable flight characteristics attributable to short- or long-period damping.

3.4.3 Longitudinal Speed Response to Longitudinal Controller--Low Speed and Hover.

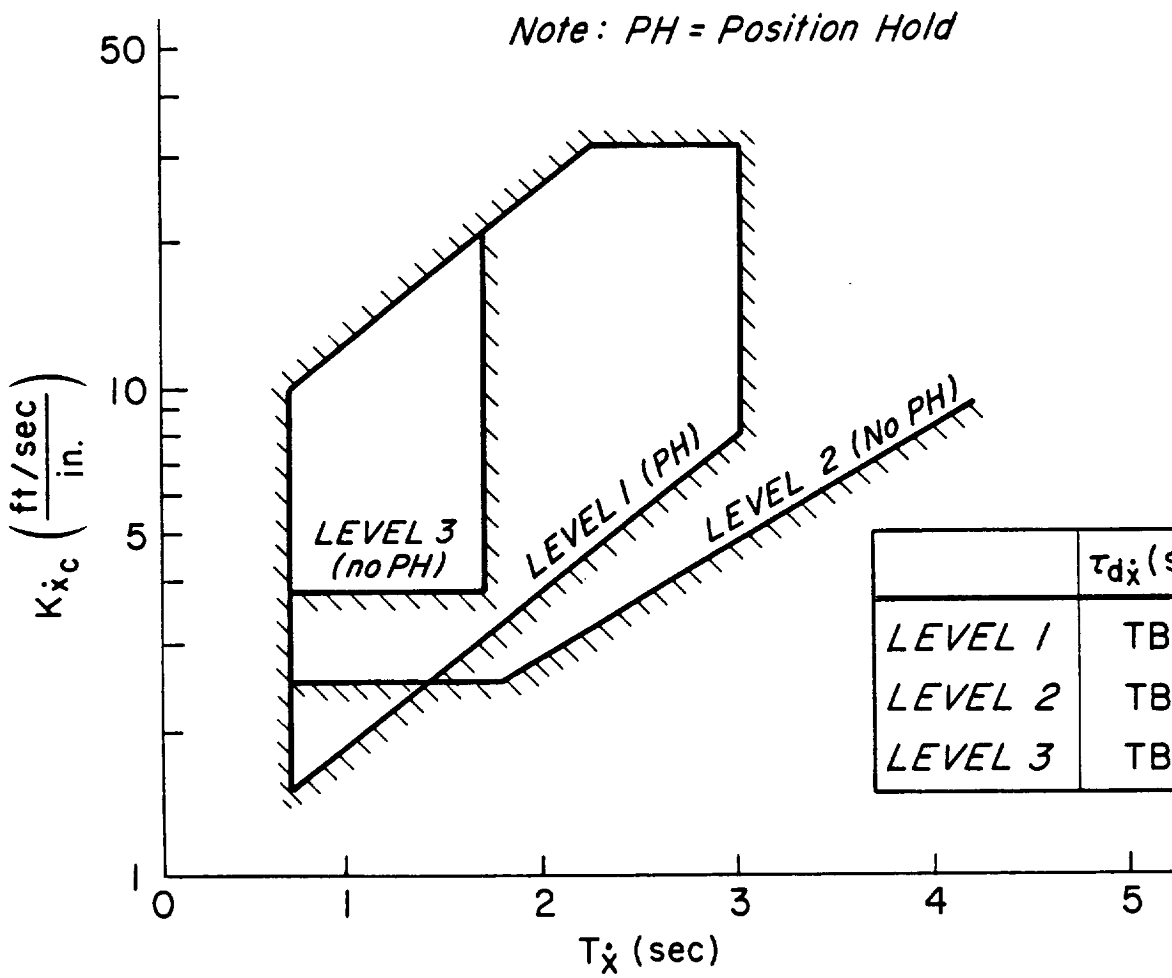
3.4.3.1 Required Speed Response When a Translational Rate Response is Specified by Paragraph 3.3. The response of longitudinal speed to a longitudinal control input shall have the characteristics defined in Fig. 4(3.4). The parameters in Fig. 4(3.4) are based on the following first-order model.

$$\frac{\dot{x}}{\delta_{LONG}} = \frac{K_{\dot{x}_c} e^{-\tau_{\dot{x}} s}}{T_{\dot{x}} s + 1}$$

Speed responses which vary significantly from this first-order form shall be deemed as unacceptable. It is intended that the criterion parameters be obtained from a time response to a step longitudinal control input as follows in Fig. 5(3.4).

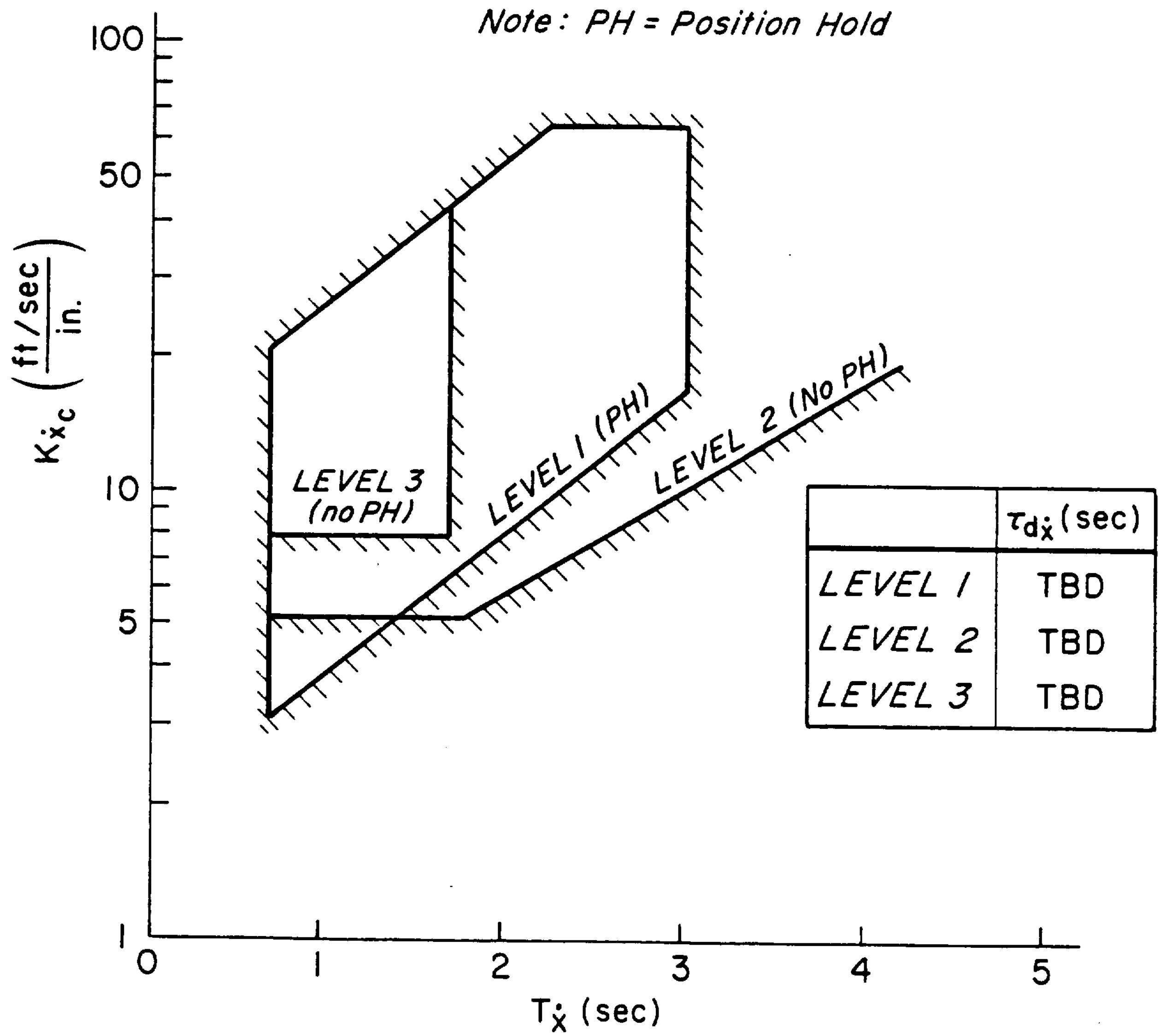
When position hold (PH) is required in Fig. 4(3.4), the translational rate, x, shall be with respect to the ground or, in the case of shipboard operations, to the ship. Zero force and/or displacement of the longitudinal controller shall result in zero steady state groundspeed or speed with respect to the ship or ground as the case may be.

3.4.4 Roll and Yaw Response to Longitudinal Controller Inputs. The maximum allowable coupling resulting from inputs to the longitudinal controller are specified in Table 7(3.4) when acceleration and rate responses are required and in Table 8(3.4) when attitude and translational rate command (TRC) responses are required. Table 7(3.4) specifies the maximum control forces and displacements required to hold the roll and yaw



	$\tau_{d\dot{x}}$ (sec)
LEVEL 1	TBD
LEVEL 2	TBD
LEVEL 3	TBD

Figure 4a(3.4). Requirements for Translational Rate Response Systems for Low Speed and Hover--Center Stick Controller



	$\tau_{d\dot{x}}$ (sec)
LEVEL 1	TBD
LEVEL 2	TBD
LEVEL 3	TBD

Figure 4b(3.4). Requirements for Translational Rate Response Systems for Low Speed and Hover--Sidestick Controller

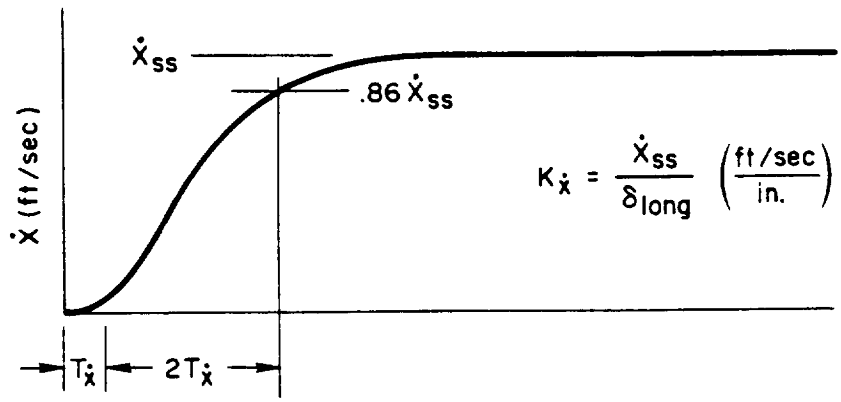


Figure 5(3.4). Response Parameters for Translational Rate Command

attitude constant in all three axes during and after longitudinal controller inputs of magnitude up to that required by the proposed operational mission. Table 8(3.4) specifies the maximum allowable excursions in rotorcraft attitude following a step longitudinal controller input with all other controls free.

TABLE 7(3.4). MAXIMUM CONTROL FORCES AND DISPLACEMENTS REQUIRED TO HOLD ATTITUDE CONSTANT DURING AND AFTER LONGITUDINAL CONTROLLER INPUT

Level	Response Required by Para. 3.3	Maximum Decoupling Force (lbs)		Maximum Decoupling Displacement (inches)	
		F_{LAT}	F_{PED}	δ_{LAT}	δ_{PED}
1	Acc	± 1.0	TBD	TBD	TBD
	Rate	TBD	TBD	TBD	TBD
2,3	Acc	TBD	TBD	TBD	TBD
	Rate	TBD	TBD	TBD	TBD

TABLE 8(3.4). PEAK YAW AND ROLL EXCURSIONS ALLOWED PER DEFLECTION OF LONGITUDINAL CONTROLLER (deg/in)

Level	Response Required by Para. 3.3	$\phi_{PEAK}/\delta_{LONG}$	$\psi_{PEAK}/\delta_{PEAK}$
1	Attitude	TBD	TBD
	TRC	TBD	TBD
2,3	Attitude	TBD	TBD
	TRC	TBD	TBD

3.4.5 Pilot-Induced Oscillations. There shall be no tendency for pilot-induced oscillations, that is, sustained or uncontrollable oscillations resulting from the efforts of the pilot to control the rotorcraft. The response dynamics of the rotorcraft plus display and control system shall not change abruptly with the response motion amplitudes unless it can be shown that this will not result in a pilot-induced oscillation.

3.4.6 Residual Oscillations. There shall be no tendency for undamped small oscillations to persist. Any sustained residual oscillations in calm air shall not interfere with the pilot's ability to perform the tasks required in service use of the rotorcraft. For Levels 1 and 2, oscillations in pitch attitude and in normal acceleration at the pilot's station greater than 0.5 degrees and 0.05 g over the frequency range TBD will be considered excessive for any flight phase. These requirements shall apply with the pitch control fixed and with it free.

3.4.7 Longitudinal Control Power--Low Speed and Hover.

3.4.7.1 When Acceleration, Rate, or Attitude Response Type is Required by Paragraph 3.3. While maintaining a spot hover as defined in Paragraph 3.2 with wind from the most critical direction relative to the rotorcraft and with the most critical distribution of loading, pitch control power remaining shall be sufficient to produce at least the following pitch attitude changes within one second of time from the initiation of the control force [Table 9(3.4)].

TABLE 9(3.4). PITCH ATTITUDE CHANGE (DEG) IN ONE SECOND

Response Required by Para. 3.3	Aggressive Maneuvering			Moderate Maneuvering		
	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
Acc and Rate	15	5	5	3	2	2
Attitude	5	2	2	3	2	2

3.4.7.2 When a TRC Response is Required by Paragraph 3.3. When a TRC response is required by Paragraph 3.3, the longitudinal velocity resulting from full longitudinal controller displacement shall be no less than

Aggressive

$$\dot{x}_{ss} \geq \begin{cases} 45\ \text{kt} & \text{Level 1} \\ \text{TBD} & \text{Level 2} \\ \text{TBD} & \text{Level 3} \end{cases}$$

Moderate

$$\dot{x}_{ss} \geq \begin{cases} 35\ \text{kt} & \text{Level 1} \\ \text{TBD} & \text{Level 2} \\ \text{TBD} & \text{Level 3} \end{cases}$$

In addition, the rotorcraft shall maintain its longitudinal position over a fixed point on the ground in a steady 35 knot (moderate) or 45 knot (aggressive) head- or tailwind with the longitudinal controller free when position hold is required.

3.4.8 Longitudinal Control Power in Forward and Sideslipping Flight.

3.4.8.1 Forward Flight. The attainment of all calibrated airspeeds throughout the specified flight envelope at all allowable loadings shall not be limited by longitudinal control power. In addition, at all trim conditions required to accomplish the mission, there shall remain a sufficient margin of control power to produce the pitch rates specified in Table 10(3.4) or the maximum load factor, whichever is least, for all allowable loadings at the specified altitudes.

TABLE 10(3.4). PITCH RATE IN 1.5 SECONDS AFTER FULL TRAVEL LONGITUDINAL CONTROLLER INPUT

Level	Aggressive Maneuvering	Moderate Maneuvering
1	15 deg/sec	TBD
2	15 deg/sec	TBD
3	TBD	TBD

3.4.8.2 Sideslipping Flight. With the rotorcraft trimmed in calm air for constant speed in steady constant-heading sideslips with full pedal deflection or maximum pedal consistent with limits set by buffet or structural considerations, a margin of at least TBD percent of the longitudinal control authority shall remain available as an allowance for the control of disturbances.

3.4.9 Longitudinal Controller Gradients and Forces.

3.4.9.1 Longitudinal Controller Gradients When Acceleration Response Type is Allowed by Paragraph 3.3. This requirement shall apply for speed perturbations of at least 30 knots in both directions (except that no airspeed limits shall be exceeded) about the trim speed. The configuration and trim may be different at each trim condition, but they must remain fixed while determining the control gradients.

Level 1: The variations of cockpit control force and control position with airspeed shall be smooth, and the local gradients shall not be negative for the longitudinal control. The gradients shall be linear within TBD percent of the average gradient about the trim speed with no objectionable changes in the slope of the force or position with speed. In the speed range between 15 and 50 KCAS forward, this same characteristic is desired, but a degree of instability is permissible. However, the magnitude of the change in the unstable direction shall not exceed 0.5 inch for longitudinal control position. The variation in longitudinal control trim position with airspeed shall be gradual.

Levels 2 and 3: The Level 1 requirements shall apply for the local control force gradients. The local pitch control position gradients may be unstable, provided the change in cockpit control position does not exceed TBD in the unstable direction over the speed range specified.

Stable pitch control gradients mean that incremental pull forces and aft displacement of the cockpit control are required to maintain slower or more rearward airspeeds and the opposite to maintain faster or more forward airspeeds.

3.4.9.2 Longitudinal Controller Force Gradient When Rate or Attitude Responses are Required by Paragraph 3.3. The average gradient of longitudinal controller force per unit of deflection shall be within the ranges specified in Tables 3(3.4), 4(3.4), and 6(3.4). In the speed range between 15 and 50 KCAS forward, the requirements of Paragraph 3.4.9.1 are acceptable. In addition the gradients must be linear within TBD percent of the average gradient at all deflections.

3.4.9.3 Longitudinal Controller Force Gradient When Translational Rate Response is Required by Paragraph 3.3. The average local gradient of longitudinal controller force per unit deflection shall be within the range specified in Table 11(3.4) for deflections less than TBD percent of full travel. Nonlinear shaping which may be required to achieve adequate control power shall be within the limits specified in Fig. 6(3.4).

TABLE 11(3.4). LIMITS ON LONGITUDINAL STICK FORCE GRADIENTS FOR TRC RESPONSE

Controller	Force (lb)	Level 1	Levels 2, 3
Center Stick	Min	TBD	TBD
	Max	TBD	TBD
Side Arm	Min	TBD	TBD
	Max	TBD	TBD

3.4.9.4 Longitudinal Controller Forces--Steady State Maneuvering.

3.4.9.4.1 Cockpit Longitudinal Control Feel and Stability in Maneuvering Flight at Constant Speed. In steady turning flight and in pullups at constant speed, increased pull forces and aft displacement of the cockpit pitch control shall be required to maintain increases in the magnitude of normal acceleration and nose-up pitch rate throughout the range of load factors in the flight envelope. Increases in push forces and forward displacement of the cockpit pitch control shall be required to maintain reductions in the magnitude of normal acceleration in pushovers at constant speed.

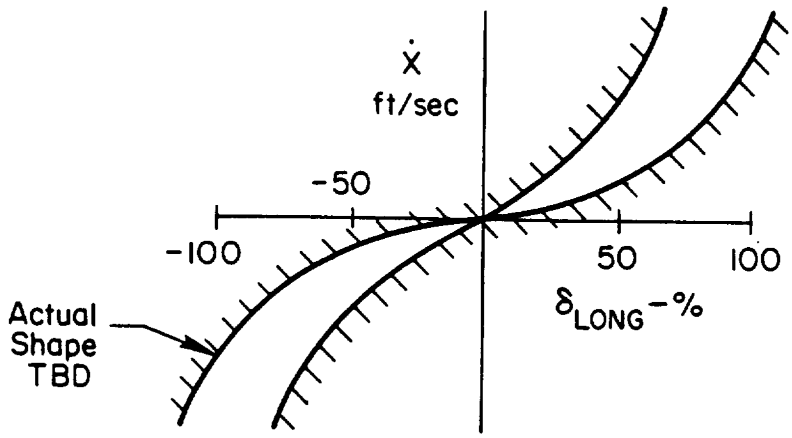


Figure 6(3.4). Limits on Longitudinal Controller Shaping for TRC Response

3.4.9.4.2 Cockpit Longitudinal Control Forces in Maneuvering Flight. At constant speed, in steady turning flight, in pullups, and in pushovers, the variation in pitch control force with the magnitude of steady-state normal acceleration shall be approximately linear within TBD percent of the average gradient. Outside this range, a departure from linearity resulting in a local gradient which differs from the average gradient for the maneuver by more than 50 percent is considered excessive, except that larger increases in force gradient are permissible at load factors greater than TBD percent of TBD limit load factor. For Levels 1 and 2, the local value of the pitch control force gradient with normal acceleration shall never be less than TBD pounds per g. There shall be no undesirable inputs to the pitch control system due to changes in linear or angular accelerations produced by gusts or thrust control inputs. The term "gradient" does not include that portion of the force versus normal acceleration curve within the pre-loaded breakout force or friction band.

3.4.9.4.3 Cockpit Longitudinal Control Forces--Transient Maneuvering Control Force per Unit "g" of Normal Acceleration. The buildup of control force during the maneuver entry must not lag the buildup of normal acceleration at the pilot's location. In addition, the frequency response of normal acceleration at the pilot station to pitch control force input shall have the following characteristics: TBD.

3.4.9.5 Additional Longitudinal Controller Force Requirements. In addition to the above, the requirements of Paragraphs 3.4.9.5.1 through 3.4.9.5.8 shall be met for all types of required responses.

3.4.9.5.1 Rate of Control Displacement. The ability of the rotorcraft to perform the required maneuvers shall not be limited by the rates of control deflection or auxiliary control operation, nor shall the rates of operation of either primary controls or auxiliary devices result in objectionable flight characteristics.

3.4.9.5.2 Transient Control Force Versus Deflection. The deflection of the pilot's control must not lead the control force throughout the frequency range of pilot control inputs. In addition, the peak pitch control forces developed during abrupt maneuvers shall not be objectionably light.

3.4.9.5.3 Longitudinal Controller Damping. All control system oscillations shall be well damped (or shall have a damping ratio greater than TBD) unless they are of such an amplitude, frequency, or phasing that they do not result in objectionable oscillations of the cockpit controls or the airframe during abrupt maneuvers, during flight in atmospheric disturbances, or following an abrupt release of the control when displaced at least one-half inch from the zero-force trim position. In no case shall control oscillation observed in flight be less stable than those observed on the ground.

3.4.9.5.4 Longitudinal Controller Free Play. The free play (and possible associated hysteresis) in the longitudinal controller shall not result in objectionable flight characteristics, especially for small amplitude inputs. For all operating conditions, free play should be within ± 1 percent of the total travel for Level 1 and ± 3 percent of the total travel for Levels 2 and 3. Freeplay is defined as controller movement without corresponding movement of the associated rotor blade, control surface, or other control device.

3.4.9.5.5 Cockpit Longitudinal Controller Centering and Breakout Forces. Cockpit longitudinal controllers should exhibit positive centering in flight at any normal trim setting. Although absolute centering is not required, the combined effects of centering, breakout force, stability, and force gradient shall not produce objectionable flight characteristics, such as poor precision-tracking ability, or permit large departures from trim conditions with controls free. Breakout forces, including friction, preload, etc., shall not be less than 1/2 pound nor more than 1 1/2 pounds for Level 1 or 4 pounds for Level 2 flying qualities.

The breakout forces shall be symmetrical for each control with a maximum tolerance of 10 percent, e.g., if the forward longitudinal control breakout force were 1.0 pound, then the allowable aft longitudinal breakout force would be in the range between 1.1 pounds and 0.9 pound. This requirement shall be met with the trim engaged and disengaged. For emergency manual operation upon single malfunction of a power-operated or power-boosted control system, the allowable breakout forces specified above shall be doubled. These values refer to the cockpit control forces required to start movement of the control surface when measured in flight. Measurement of the breakout forces made on the ground (with the rotor turning) will suffice in lieu of actual flight measurement, provided that qualitative agreement between ground measurement and flight observation is established.

3.4.9.5.6 Longitudinal Controller Force Limits--General. Unless otherwise specified in particular requirements, the maximum pitch axis control forces required without retrimming for any maneuver or task consistent with service use, shall not exceed 10 pounds for Level 1 or 20 pounds for Level 2 flying qualities (center-stick). For failures refer to Paragraph 3.10.

3.4.9.5.7 Cockpit Longitudinal Controller Force Limits--Sideslips. With the rotorcraft trimmed for straight, level flight with wings level, the pitch-control force required to maintain constant speed in steady sideslips with up to TBD pounds of pedal force in either direction, or in sideslips as specified in the TBD flight envelope, whichever is less, shall not exceed 5 pounds (AH-64 specification) in the pull direction or 2.5 pounds in the push direction. In no case, however, shall the pitch-control force in steady sideslip exceed 20 pounds [limit-failures, Table 2(3.11)]. If a variation of pitch-control force with sideslip does exist, it is preferred that increasing pull force accompany increasing sideslip, and that the magnitude and direction of the force change be similar for right and left sideslips. For Level 3 there shall be no uncontrollable pitching motions associated with the sideslips discussed above.

3.4.9.5.8 Longitudinal Controller Force Limits--Configuration or Control Mode Change. The control force changes resulting from the intentional engagement or disengagement of any portion of the primary flight control system by the pilot shall not exceed the following limits: TBD.

3.4.10 Longitudinal Controller Displacements.

3.4.10.1 Maneuvering. For all types of longitudinal controllers, the control motions in maneuvering flight shall not be so large or so small as to be objectionable. In steady turning flight and in pullups or pushovers at constant speed, the incremental control deflection required to maintain a change in normal load factor and pitch rate shall be in the same sense (aft--more positive, forward--more negative) as those required to initiate the change.

3.4.10.2 Gust Regulation. The ability of the rotorcraft to perform operational maneuvers required of it shall not be limited by control placement or rate in the presence of all relevant atmospheric disturbances specified in Paragraph 3.17. For powered or boosted controls, the effect of engine speed and the duty cycle of both primary and secondary control, together with the pilot control techniques, shall be included when establishing compliance with this requirement.

3.4.11 Longitudinal Controller Trim.

3.4.11.1 Scope and Capability. Throughout the flight envelope, it shall be possible to reduce longitudinal control forces to zero (± 0.2 pounds).

3.4.11.2 Rate of Operation of Trim--Qualitative Requirement. The trim system shall operate rapidly enough to enable the pilot to maintain low control forces under changing flight conditions normally encountered in service, yet not so rapidly as to cause oversensitivity of control or difficulties in maintaining trim precision. Uncommanded control movement shall not exceed TBD when the trim control is actuated.

3.4.11.3 Authority of Trim. The trim system shall have sufficient authority to trim the pitch response control force in the presence of the asymmetry defined in Paragraph 3.13.3.

3.4.11.4 Irreversibility of Trim. When trimmed, the pitch axis control shall maintain the "zero force" position selected by the pilot indefinitely unless changed by the pilot or by an automatic interconnecting command. If an automatic interconnecting command to the trim system operates, provision shall be made to insure that the trim system and pitch response control are restored gradually and smoothly to their original conditions on removal of the automatic interconnecting command.

3.4.11.5 Trim Failures. Following a trim failure of any type, the out-of-trim forces throughout the flight envelope shall not exceed the requirements of Paragraph 3.11.1. A trim failure shall not restrict control displacement. The failures to be considered in applying Level 2 and Level 3 requirements shall include sticking and run-away in either direction. It is permissible to meet Level 2 and Level 3 requirements by providing the pilot with alternate trim or override capabilities.

3.4.11.6 Transients and Trim Changes Among Alternate Control Modes. When engaging, switching, or disengaging control force, trim, and automatic stabilization equipment, there shall be no switching transients that require more than 0.25 inches for a center stick or TBD for a side stick controller input to maintain trim attitude. The requirements of Paragraph 3.4.9.5.2 also apply.

3.5 RESPONSE TO VERTICAL CONTROLLER

3.5.1 Pitch, Roll, and Yaw Response to Vertical Controller Inputs. The maximum allowable coupling resulting from inputs to the collective controller are specified in Table 1(3.5) when acceleration and rate responses are required and in Table 2(3.5) when attitude and translational rate command (TRC) responses are required. Table 1(3.5) specifies the maximum control forces and displacements required to hold the attitude constant in all three axes during and after collective step inputs of magnitude up to that required by the proposed operational mission. Table 2(3.5) specifies the maximum allowable excursions in rotorcraft attitude following a step collective input with all other controls free.

TABLE 1(3.5). MAXIMUM CONTROL FORCES AND DISPLACEMENTS REQUIRED TO HOLD ATTITUDE CONSTANT DURING AND AFTER COLLECTIVE INPUT

Level	Response Required by Para. 3.3	Maximum Decoupling Force (lbs)		Maximum Decoupling Displacement (inches)	
		F_{LAT}	F_{PED}	δ_{LAT}	δ_{PED}
1	Acc	± 1.0	TBD	TBD	TBD
	Rate	TBD	TBD	TBD	TBD
2,3	Acc	TBD	TBD	TBD	TBD
	Rate	TBD	TBD	TBD	TBD

3.5.2 Vertical Response to Vertical Controller Input. The height response to a collective input shall have the characteristics specified in Table 3(3.5). The criterion parameters in Table 3(3.5) are defined in Fig. 1(3.5).

3.5.3 Vertical Response Power Using Vertical Controller. Sufficient height control power shall be available to produce vertical accelerations of not less than those specified in Table 4(3.5) following an abrupt step input of the collective controller.

TABLE 2(3.5). PEAK ATTITUDE EXCURSIONS ALLOWED PER DEFLECTION OF VERTICAL CONTROLLER (deg/in)

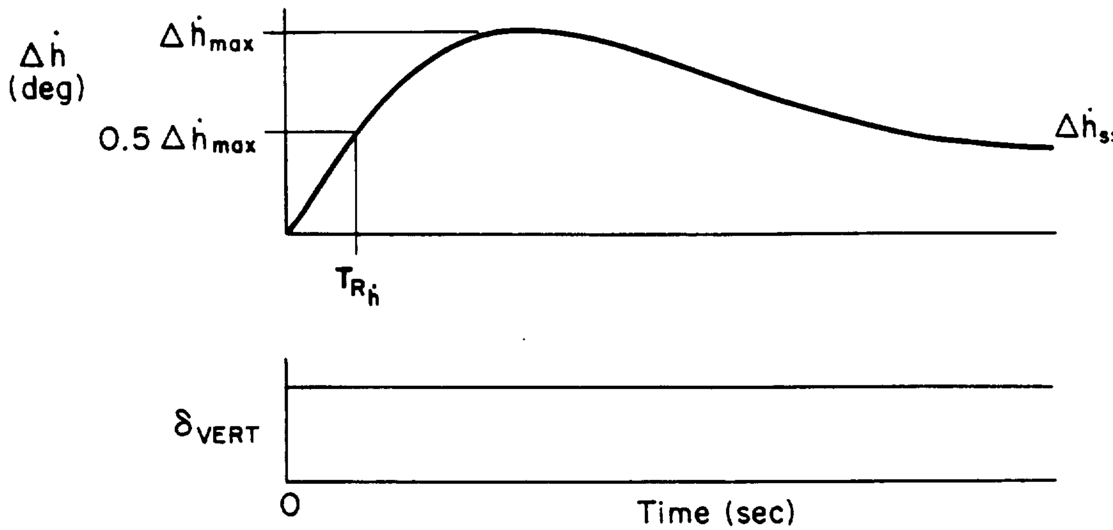
Level	Response Required by Para. 3.3	$\theta_{PEAK}/\delta_{COL}$	ϕ_{PEAK}/δ_{COL}	ψ_{PEAK}/δ_{COL}
1	Attitude	TBD	TBD	TBD
	TRC	TBD	TBD	TBD
2,3	Attitude	TBD	TBD	TBD
	TRC	TBD	TBD	TBD

TABLE 3(3.5). REQUIRED VERTICAL SPEED RESPONSE TO VERTICAL CONTROLLER

Parameter		Low Speed and Hover						Forward Flight		
		Response Required by Paragraph 3.3								
		Acceleration and Rate			Attitude and TRC			All		
		Level 1	Level 2	Level 3	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
$T_{R_{\dot{h}}}$ (sec)	Max	∞	∞	∞	3.0	7.0	∞	3.0	TBD	TBD
	Min	0.5	0.5	0.5	0.5	0.5	0.5	0.5	TBD	TBD
$\Delta\dot{h}_{MAX}/\Delta\dot{h}_{ss}$	Max	TBD	TBD	TBD	TBD	TBD	TBD	2.5	TBD	TBD
$\Delta\dot{h}_{ss}/\delta_{VERT}$ (ft/min)/in	Max	1300	TBD	TBD	1300	TBD	TBD	TBD	TBD	TBD
	Min	400	TBD	TBD	400	TBD	TBD	TBD	TBD	TBD
$K_{\dot{h}}$ (ft/sec)/in	Max	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	Min	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
K_F (lb/in)	Max	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD
	Min	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

NOTE:

1. For Levels 2 and 3 allow rate through TRC responses to degrade to response required for Level 1 acceleration systems.



Note: Pitch attitude controller is free during response

Figure 1(3.5). Definition of $\dot{h}/\delta_{COL}$ Time Response Parameters (Pitch SAS active if applicable)

TABLE 4(3.5). VERTICAL RESPONSE REQUIREMENTS

Flight Condition	Level	Incremental Vertical Acceleration (g's/in)	Minimum Flight Path Angle Change (measured from γ_{TRIM}--deg)	
			UP $\Delta\gamma$	DOWN $\Delta\gamma$
Low Speed and Hover	1 2 3	0.10 0.05 0.03		
Forward Flight	1 2 3		4 2 2	4 2 2

3.5.4 Rotor Speed Response to Collective Lift Controller or to Vertical Speed Controller. The response of TBD rotor speed measured at TBD to a collective lift control (force or displacement) input over the input range TBD to TBD shall have the following characteristics: TBD.

3.5.5 Cockpit Vertical Lift Controller and Vertical Speed Controller Characteristics.

a. When not under automatic control, the displacement shall remain fixed at all times unless the controller is moved by the pilot and shall not tend to creep, whether or not cyclic, directional, thrust, or power controls are moved. The maximum control force required for displacement shall not exceed the values specified in e (below).

b. Friction shall be adjustable from zero to 7 pounds.

c. Breakout forces shall fall within 1.0 and 3.0 pounds for Level 1 flying qualities and may not exceed 10 pounds for Level 2 flying qualities.

d. Free Play. The requirements of Paragraph 3.4.9.5.4 shall be met.

e. Unless otherwise specified in particular requirements, the maximum forces required for any maneuver or task consistent with service use shall not exceed 7 pounds for Level 1 flying qualities. For Level 2 flying qualities, the maximum force shall not exceed 15 pounds.

f. The collective control subsystem characteristics shall be such that the collective control forces required for maneuvering flight with increasing or decreasing normal accelerations (both steady state and transient) are not different from those required during unaccelerated level flight at the same airspeed.

g. The pilot-induced oscillation requirements of Paragraph 3.4.5 shall apply.

3.6 RESPONSE TO LATERAL CONTROLLER

3.6.1 Roll Response to Lateral Controller. The response of roll attitude to a lateral controller displacement shall have the characteristics defined below. These requirements apply for the range of controller displacements necessary to perform the tasks specified in Paragraph 3.2.

3.6.1.1 Hover. The requirements for the pitch response to longitudinal controller, stated in Paragraph 3.4.1, also apply to the roll response to lateral controller for hovering flight.

3.6.1.2 Low Speed and Forward Flight. The roll rate response to a step lateral control input shall have the characteristics specified in Table 1(3.6). The size of the input shall be varied from that required for precision tracking up to the most aggressive maneuvering expected for the mission. The parameters used in Table 1(3.6) are defined in Fig. 2(3.4) with the ordinate relabeled p/p_{ss}.

TABLE 1(3.6). REQUIRED ROLL RATE RESPONSE FOR LOW SPEED AND FORWARD FLIGHT

Parameter			Level 1	Level 2	Level 3
T_{r_p} (sec)		Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD
τ_{d_p} (sec)		Max	TBD	TBD	TBD
X_1/X_o		Max	TBD	TBD	TBD
K_p (deg/sec/in)	Center Stick	Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD
	Side Stick	Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD
K_{p_F} (lb/in)	Center Stick	Max	1 1/2	5	5
		Min	1/2	1/2	1/2
	Side Stick	Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD

where $K_p = p_{ss}/\delta_{LAT}$ $\quad K_{p_F} = F_{LAT}/\delta_{LAT}$

Where F_{LAT} does not include the breakout force

3.6.2 Lateral Speed Response to Lateral Controller--Low Speed and Hover. The requirements for the longitudinal speed response to longitudinal controller, stated in Paragraph 3.4.3, also apply to the lateral speed response to lateral controller in low speed and hovering flight.

3.6.3 Yaw Response to Lateral Controller.

3.6.3.1 Hover. The required pedal deflection and force to hold heading constant within ± TBD during and after abrupt lateral controller inputs shall not exceed the limits specified in Table 2(3.6). This requirement shall apply any time a constant heading mode is intended regardless of speed.

TABLE 2(3.6). LIMITS ON ROLL-TO-YAW COUPLING IN HOVER

Response Required by Para. 3.3	$\delta_{PED}/\delta_{LAT}$ (in/in)			F_{PED}/F_{LAT} (lb/lb)		
	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
Acceleration	TBD	TBD	TBD	1.0	TBD	TBD
Rate	TBD	TBD	TBD	TBD	TBD	TBD
Attitude and TRC	0.0	TBD	TBD	0.0	TBD	TBD

3.6.3.2 Low Speed and Forward Flight. The pedal deflections and forces required to achieve acceptable heading control during rolling maneuvers induced by lateral stick deflection shall not be objectionable. In the event that these characteristics are questionable, the ratio of the maximum change in sideslip angle to the initial peak magnitude in roll response, $|\Delta\beta/\varphi_{PEAK}|$ for an abrupt lateral stick pulse input shall not exceed the limit specified in Fig. 1(3.6). In addition, $|\Delta\beta/\varphi_{PEAK}| \times |\varphi/\beta|_d$ shall not exceed the limit specified in Fig. 2(3.6).

3.6.4 Pitch Response to Lateral Controller Inputs.

3.6.4.1 Pitch Response to Lateral Controller Inputs--Low Speed and Hover. The maximum allowable pitch response resulting from inputs to the lateral controller are specified in Table 3(3.6) when acceleration and rate responses are required and Table 4(3.6) when attitude and translational rate command (TRC) responses are required. Table 3(3.6) specifies the maximum pitch control forces and displacements required to hold the pitch attitude constant during and after step lateral controller inputs of

Note: $\left|\frac{\phi}{\beta}\right|_d$ *is the ratio of roll angle to sideslip angle measured at the dutch roll frequency.*

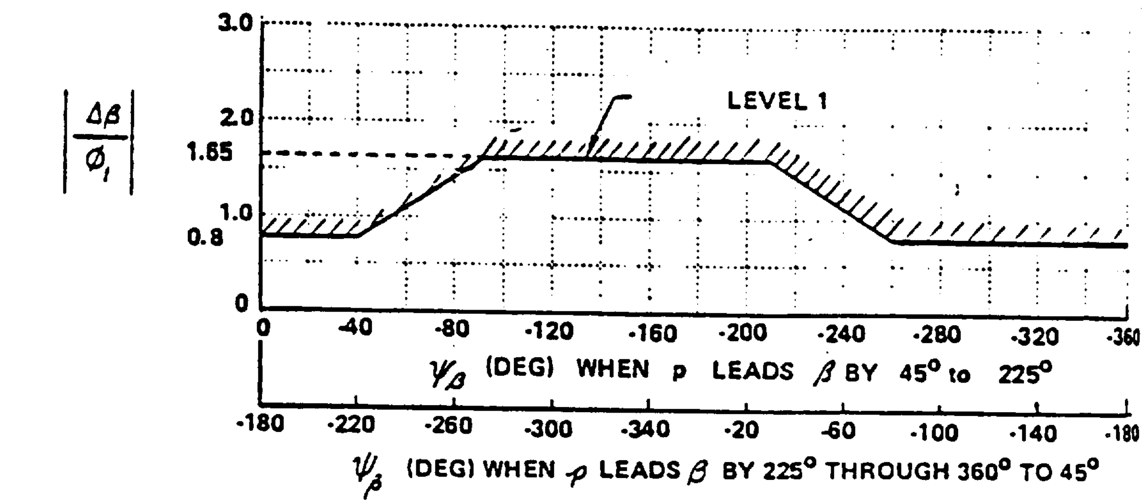


Figure 1(3.6). Sideslip Excursion Limitations (Boundary for $\left|\frac{\Delta\beta}{\phi_1}\right|$)

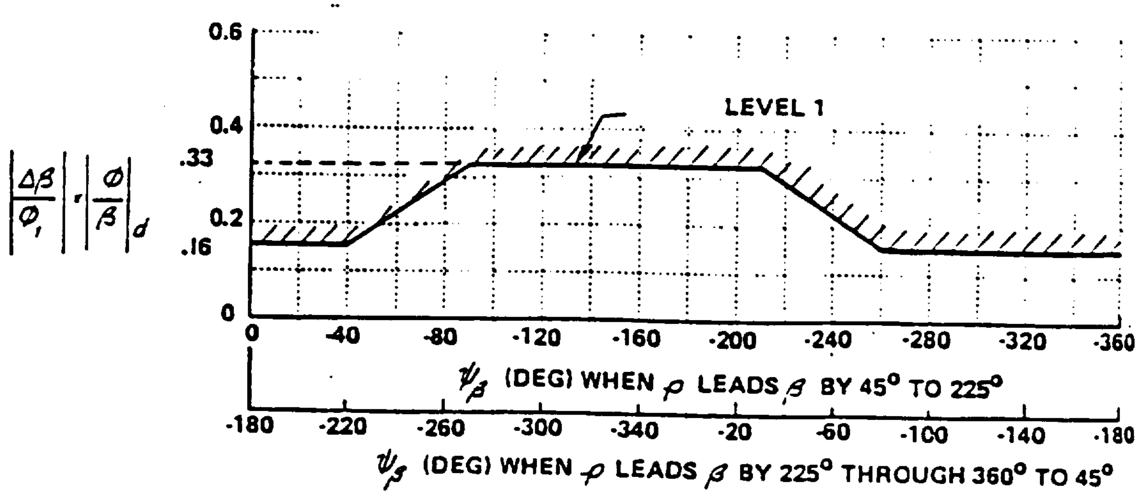


Figure 2(3.6). Sideslip Excursion Limitations (Boundary for $\left|\frac{\Delta\beta}{\phi}\right| X \left|\frac{\phi}{\beta}\right|_d$)

magnitudes up to that required by the proposed operational mission. Table 4(3.6) specifies the maximum allowable excursions in rotorcraft attitude following a step lateral controller input with all other controls free.

TABLE 3(3.6). MAXIMUM LONGITUDINAL CONTROLLER FORCE AND DISPLACEMENT REQUIRED TO HOLD PITCH ATTITUDE CONSTANT DURING LATERAL CONTROLLER INPUT IN LOW SPEED AND HOVER

Response Required by Para. 3.3	Maximum Decoupling Force (lb)			Maximum Decoupling Displacement		
	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
Acceleration	0.4 F_{LAT}	TBD	TBD	TBD	TBD	TBD
Rate	TBD	TBD	TBD	TBD	TBD	TBD

TABLE 4(3.6). PEAK PITCH ATTITUDE EXCURSIONS ALLOWED PER DEFLECTION OF LATERAL CONTROLLER

Response Required by Para. 3.3	$\theta_{PEAK}/\delta_{LAT}$ (deg/in)		
	Level 1	Level 2	Level 3
Attitude	TBD	TBD	TBD
TRC	TBD	TBD	TBD

3.6.4.2 Pitch Response to Lateral Controller Inputs--Forward Flight. The requirements of Table 5(3.6) shall be met.

3.6.5 Pilot-Induced Roll Oscillations--Qualitative Requirements. The requirements of Paragraph 3.4.5 apply.

TABLE 5(3.6). MAXIMUM LONGITUDINAL CONTROLLER FORCE AND DISPLACEMENT REQUIRED TO HOLD PITCH ATTITUDE CONSTANT DURING LATERAL CONTROLLER INPUT IN FORWARD FLIGHT

Response Required by Para. 3.3	Maximum Decoupling Force (lb)			Maximum Decoupling Displacement		
	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
Acceleration	TBD	TBD	TBD	TBD	TBD	TBD
Rate	TBD	TBD	TBD	TBD	TBD	TBD

3.6.6 Residual Oscillations. Any sustained residual oscillations in calm air shall not interfere with the pilot's ability to perform the tasks required in service use of the rotorcraft. For Levels 1 and 2, oscillations in roll attitude at the pilot's station greater than 0.5 degree will be considered excessive for any flight phase. These requirements shall apply with the lateral stick fixed and with it free.

3.6.7 Lateral Controller Power--Hover

3.6.7.1 When Acceleration, Rate, or Attitude Response Type is Required by Paragraph 3.3. While maintaining a spot hover IGE and OGE as defined in Paragraph 3.2 with wind from the most critical direction relative to the rotorcraft and with the most critical distribution of loading, roll control power remaining shall be sufficient to produce at least the roll attitude changes of Table 6(3.6) within 1 second of time from the initiation of the control force.

TABLE 6(3.6). MINIMUM ROLL ATTITUDE CHANGE (DEG) IN ONE SECOND

Response Required by Para. 3.3	Aggressive Maneuvering			Moderate Maneuvering		
	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
Acc and Rate	15	5	5	TBD	TBD	TBD
Attitude	5	2	2	TBD	TBD	TBD

3.6.7.2 When a TRC Response is Required by Paragraph 3.3. When a TRC response is required by Paragraph 3.3, the steady lateral velocity resulting from full lateral controller displacement shall be no less than

Aggressive

$$\dot{Y}_{ss} \geq \begin{cases} 45 \text{ kts} & \text{Level 1} \\ \text{TBD} & \text{Level 2} \\ \text{TBD} & \text{Level 3} \end{cases}$$

Moderate

$$\dot{Y}_{ss} \geq \begin{cases} 35 \text{ kt} & \text{Level 1} \\ \text{TBD} & \text{Level 2} \\ \text{TBD} & \text{Level 3} \end{cases}$$

In addition, the rotorcraft shall maintain its lateral position over a fixed spot on the ground in a steady 35 knot crosswind with the lateral (trimmed) controller free when position hold is required.

3.6.7.3 Unaccelerated Lateral Translating Flight. In steady rectilinear lateral translating flight, the attainment of trim calibrated airspeeds up to 45 knots for aggressive maneuvering rotorcraft and 35 knots for moderate maneuvering rotorcraft shall not be limited by lateral control power. In addition, at all trim conditions required to accomplish the specified mission task in Paragraph 3.2, there shall remain sufficient margin of control power to produce the roll rates specified in Table 7(3.6) for all allowable loadings.

TABLE 7(3.6). ROLL RATE (DEG/SEC) IN 1.5 SECONDS AFTER FULL TRAVEL LATERAL CONTROLLER INPUT

Level	Aggressive Maneuvering	Moderate Maneuvering
1	15	TBD
2	15	TBD
3	TBD	TBD

3.6.8 Lateral Controller Power--Forward Flight.

3.6.8.1 Rolling Capability. The response to full lateral controller input shall result in 30 degrees of bank angle changes within the times specified in Table 8(3.6) following an abrupt full lateral controller input.

TABLE 8(3.6). ROLL PERFORMANCE IN FORWARD FLIGHT

Required Maneuvering	Level	Minimum Time from Initiation of Control Input to 30 Deg of Bank (sec)
Aggressive	1	1.1
	2	1.5
	3	2.0
Moderate	1	1.5
	2	2.0
	3	3.0

3.6.8.2 Sideslipping Flight. For the sideslips specified in Paragraph 3.7.7.1, an increase in right bank angle shall accompany an increase in right sideslip, and an increase in left bank angle shall accompany an increase in left sideslip. For Level 1, positive effective dihedral (right roll control for right sideslip and left roll control for left sideslip) shall never be so great that more than 50 percent of the roll control power available to the pilot are required for maintaining the specified sideslip angles. The corresponding limits for Level 2 shall be 75 percent of the roll control power available to the pilot.

3.6.9 Lateral Controller Forces.

3.6.9.1 Lateral Controller Gradients.

3.6.9.1.1 In Hovering and Low Speed Flight. The gradient requirements of Table 1(3.6) shall be satisfied at sideward trim speeds both to the left and to the right up to 45 knots for aggressive maneuvering rotorcraft and 35 knots for moderate maneuvering rotorcraft. The configuration and trim may be different at each trim condition, but they must remain fixed while determining the control gradients.

3.6.9.1.2 In Forward Flight with Steady Sideslips. For the sideslips specified in Paragraph 3.7.7.1, left roll control deflection and force shall be required in left sideslips, and right roll control deflection and force shall be required in right sideslips. For Levels 1 and 2, the variation of roll control deflection and force with sideslip angle shall be linear within TBD percent of the average gradient.

3.6.9.2 Lateral Controller Force Versus Control Deflection.

3.6.9.2.1 Steady-State. The average gradient of roll-control force per unit of roll-control deflection at constant speed shall be within the ranges specified in Table 1(3.6). There shall be no objectionable nonlinearities in the variation of roll response with roll control force or deflection.

3.6.9.2.2 Transient. The deflection of the pilot's control must not lead the control force throughout the frequency range of pilot control inputs. In addition, the peak roll control forces developed during abrupt maneuvers shall not be objectionably light.

3.6.9.2.3 Damping. Damping shall meet the requirements of Paragraph 3.4.9.5.3.

3.6.9.3 Lateral Controller Centering and Breakout Forces. The lateral controller should exhibit positive centering in flight at any normal trim setting. Although absolute centering is not required, the combined effects of centering, breakout force, stability, and force gradient shall not produce objectionable flight characteristics, such as poor precision-tracking ability, or permit large departures from trim conditions with controls free. Breakout forces, including friction, preload, etc., shall not be less than 1/2 pound nor more than 1-1/2 pounds for Level 1 or 3 pounds for Level 2 flying qualities.

The breakout forces shall be symmetrical for each control with a maximum tolerance of 10 percent, e.g., if forward lateral control breakout force were 1.0 pound, then allowable aft lateral breakout force would be in the range between 1.1 pounds and 0.9 pound. This requirement shall be met with the trim engaged and disengaged. For emergency manual operation upon single malfunction of a power-operated or power-boosted control system, the allowable breakout forces specified above shall be doubled. These values refer to the cockpit control forces required to start movement of the control surface when measured in flight. Measurement of the breakout forces made on the ground (with the rotor turning) will suffice in lieu of actual flight measurement, provided that qualitative agreement between ground measurement and flight observation is established.

3.6.9.4 Lateral Controller Free Play. The free play in the lateral controller shall meet the requirements of Paragraph 3.4.9.5.4.

3.6.9.5 Lateral Controller Force Limits--General. Unless otherwise specified in particular requirements, the maximum lateral controller forces required without retrimming for any maneuver or task consistent with service use shall not exceed 6 pounds for Level 1 or 10 pounds for Level 2 flying qualities (center stick). For failures, refer to Paragraph 3.10.

3.6.9.6 Lateral Controller Force Limits--Configuration or Control Mode Change. The control force changes resulting from the intentional engagement or disengagement of any portion of the primary flight control system by the pilot shall not exceed the following limits: TBD.

3.6.10 Lateral Controller Displacements.

3.6.10.1 Maneuvering. For all types of lateral controllers, the control motions in maneuvering flight shall not be so large or so small as to be objectionable.

3.6.10.2 Gust Regulation. The requirements of Paragraph 3.4.10.2 shall be met.

3.6.11 Lateral Controller Trim.

3.6.11.1 Scope and Capability. Throughout the flight envelope, it shall be possible to reduce steady lateral controller forces to zero (± 0.2 pound).

3.6.11.2 Rate of Operation of Trim—Qualitative Requirement. The requirements of Paragraph 3.4.11.2 shall be met.

3.6.11.3 Authority of Trim. The trim system shall have sufficient authority to trim the roll control force in the presence of any asymmetry to be encountered during the mission, including failures.

3.6.11.4 Irreversibility of Trim. When trimmed, the roll axis control shall maintain the "zero force" position selected. by the pilot indefinitely unless changed by the pilot or by an automatic interconnecting command. If an automatic interconnecting command to the trim system operates, provision shall be made to insure that the trim system and roll control are restored gradually and smoothly to their original conditions on removal of the automatic interconnecting command.

3.6.11.5 Trim Failures. Following a trim failure of any type, the out-of-trim forces throughout the flight envelope shall not exceed the requirements of Paragraph 3.10. A trim failure shall not restrict control displacement. The failures to be considered in applying Level 2 and Level 3 requirements shall include sticking and run-away in either direction. It is permissible to meet Level 2 and Level 3 requirements by providing the pilot with alternate trim or override capabilities.

3.6.11.6 Transients and Trim Changes Among Alternate Control Modes. When engaging, switching, or disengaging control force, trim, and automatic stabilization equipment, there shall be no switching transients that require more than 0.25 inch for a center stick or TBD for a side-stick controller input to maintain trim attitude. The requirements of Paragraph 3.4.9.5.2 also apply.

3.7 RESPONSES TO DIRECTIONAL CONTROLLER*

3.7.1 Yaw Rate Response to Directional Controller at Hover and Low Speed. The heading response to a pedal displacement shall have the following characteristics.

3.7.1.1 When Acceleration Response is Allowed by Paragraph 3.3. The yaw rate response to an abrupt step in directional controller displacement shall have the characteristics specified in Table 1(3.7). The size of the input shall be varied from that required for precision tracking up to the most aggressive maneuvering expected for the mission. The parameters used in Table 1(3.7) are defined in Fig. 2(3.4) with the ordinate relabeled r/r_{ss}.

TABLE 1(3.7). REQUIRED YAW RATE RESPONSE TO DIRECTIONAL CONTROLLER AT HOVER AND LOW SPEED WHEN ACCELERATION RESPONSE IS ALLOWED

Parameter			Level 1	Level 2	Level 3
T_{r_r} (sec)		Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD
τ_{d_r} (sec)		Max	TBD	TBD	TBD
X_1/X_o		Max	TBD	TBD	TBD
K_r (deg/sec/in)	Center Stick	Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD
	Side Stick	Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD
K_{r_F} (lb/in)	Center Stick	Max	10	20	TBD
		Min	5	2	TBD
	Side Stick	Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD

where $K_r = r_{ss}/\delta_{DIR}$ $\qquad$ $K_{r_F} = F_{DIR}/\delta_{DIR}$

Where F_{DIR} does not include the breakout force

*Recognize that some future cockpit controls may not include pedals per se but rather three-axis or four-axis sticks.

3.7.1.2 When Rate, Attitude, or TRC Response is Specified by Paragraph 3.3. The yaw rate response to an abrupt step directional controller displacement shall have the characteristics specified in Table 2(3.7). The size of the input shall be varied from that required for precision tracking up to the most aggressive maneuvering expected for the mission. The parameters used in Table 2(3.7) are defined in Fig. 2(3.4) with the ordinate relabeled r/r_{ss}.

TABLE 2(3.7). REQUIRED YAW RATE RESPONSE TO DIRECTIONAL CONTROLLER AT HOVER AND LOW SPEED WHEN RATE, ATTITUDE, OR TRC RESPONSE IS REQUIRED

Parameter			Level 1	Level 2	Level 3
T_{r_r} (sec)		Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD
τ_{d_r} (sec)		Max	TBD	TBD	TBD
X_1/X_o		Max	TBD	TBD	TBD
K_r (deg/sec/in)	Center Stick	Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD
	Side Stick	Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD
K_{r_F} (lb/in)	Center Stick	Max	10	20	TBD
		Min	5	2	TBD
	Side Stick	Max	TBD	TBD	TBD
		Min	TBD	TBD	TBD

where $K_r = r_{ss}/\delta_{DIR}$ $\quad K_{r_F} = F_{DIR}/\delta_{DIR}$

Where F_{DIR} does not include the breakout force

3.7.2 Sideslip Response to Directional Controller in Forward Flight. The sideslip response to an abrupt pulse pedal input shall have the characteristics specified in Table 3(3.7). The size of the input shall be varied from barely perceptible to the maximum practical without exceeding structural limits. The controls should be free following the pulse input. The parameters used in Table 3(3.7) are defined in Fig. 1(3.7).

TABLE 3(3.7). REQUIRED SIDESLIP RESPONSE TO DIRECTIONAL CONTROLLER IN FORWARD FLIGHT

Parameter		Response Required by Paragraph 3.3					
		Acceleration			Rate, Attitude		
		Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
T_β (sec)	Max	12.6	12.6	12.6	6.3	12.6	12.6
$T_{1/2}$ (sec)	Max	4.6	14.0	14.0	1.7	13.9	∞
X_1/X_o	Max	0.76	0.94	1.0	0.2	0.94	1.0
X_3/X_o	Max	0.42	0.82	1.0	0.2	0.82	1.0

Note: If no more than two peaks (i.e., X_o and X_1) can be observed after the input is removed, this paragraph shall be satisfied if sideslip returns to within 5 percent of its peak value within TBD seconds for Level 1 and TBD seconds for Levels 2 and 3.

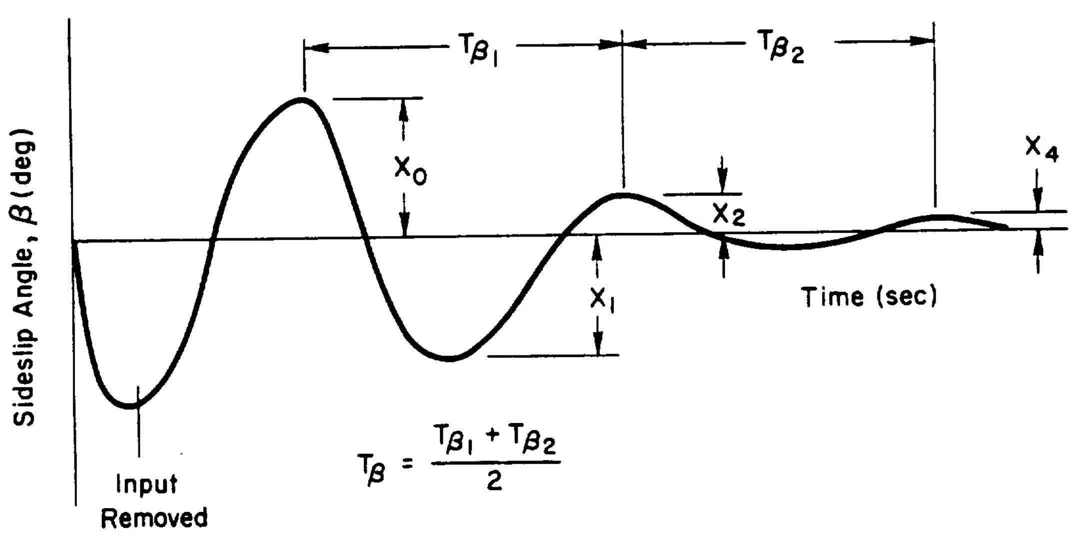


Figure 1(3.7). Definition of Yaw Response Parameters--Pulse Pedal Input

3.7.3 Pitch and Roll Coupling to Directional Controller Inputs--Low Speed and Hover. The maximum allowable coupling resulting from inputs to the pedals is specified in Table 4(3.7) when acceleration and rate responses are required and in Table 5(3.7) when attitude and TRC responses are required. Table 4(3.7) specifies the maximum control forces and displacements required to hold the pitch and roll attitude as well as altitude constant during and after step pedal inputs of magnitude up to that required by the proposed operational mission. Table 5(3.7) specifies the maximum allowable excursions in rotorcraft attitude following a step pedal input with all other controls free.

TABLE 4(3.7). MAXIMUM CONTROL FORCES AND DISPLACEMENTS REQUIRED TO HOLD PITCH AND ROLL ATTITUTDE CONSTANT DURING AND AFTER INPUT--ACCELERATION AND RATE RESPONSES

Level	Response Required by Para. 3.3	Maximum Decoupling Force			Maximum Decoupling Displacement		
		F_{LONG}	F_{LAT}	F_{COL}	δ_{LONG}	δ_{LAT}	δ_{COL}
1	Acc	±1.0	±1.0	TBD	TBD	TBD	TBD
	Rate	TBD	TBD	TBD	TBD	TBD	TBD
2,3	Acc	TBD	TBD	TBD	TBD	TBD	TBD
	Rate	TBD	TBD	TBD	TBD	TBD	TBD

3.7.4 Pilot Induced Oscillations--Qualitative Requirements. The requirements of Paragraph 3.4.5 apply.

3.7.5 Residual Oscillations. Any sustained residual oscillations in calm air shall not interfere with the pilot's ability to perform the tasks required in service use of the rotorcraft. For Levels 1 and 2, oscillations in heading and in lateral acceleration at the pilot's station greater than 0.5 degrees will be considered excessive for any flight phase. These requirements shall apply with the yaw control fixed and with it free.

TABLE 5(3.7). PEAK ATTITUDE AND VERTICAL RATE EXCURSIONS ALLOWED PER DEFLECTION OF THE DIRECTIONAL CONTROLLER--ATTITUDE AND TRC RESPONSES (deg/in)

Level	Response Required by Para. 3.3	$\theta_{PEAK}/\delta_{PED}$	ϕ_{PEAK}/δ_{PED}	$\dot{h}_{PEAK}/\delta_{PED}$
1	Attitude	TBD	TBD	TBD
	TRC	TBD	TBD	TBD
2,3	Attitude	TBD	TBD	TBD
	TRC	TBD	TBD	TBD

3.7.6 Directional Controller Power.

3.7.6.1 Hover. It shall be possible to maintain control of heading in a spot hover IGE and OGE with a TBD-knot wind from the most critical direction relative to the rotorcraft and with the most critical distribution of loading. This task shall be accomplished with not more than TBD displacement of the directional control, although the use of controls other than the directional control will be permitted. There shall be no objectionable directional oscillation(s) resulting from rotor speed governor response in performing this or any other task. In addition, while performing this task, the directional control power remaining shall be sufficient to produce at least the heading changes within 1 second of time from the initiation of the control force specified in Table 6(3.7).

3.7.6.2 Low Speed and Forward Flight. Directional stability and control characteristics shall enable the pilot to balance all yawing moments and to control yaw and sideslip. In addition, at all trim conditions required to accomplish the mission, there shall remain sufficient margin of control power to produce the yaw rates specified in Table 7(3.7) for all allowable loadings at the specified altitudes. The following specific requirements must also be met: TBD.

3.7.6.3 Asymmetric Loading. When initially trimmed directionally with each asymmetric loading specified in requirements at any speed in the operational flight envelope, yaw control power shall be sufficient to maintain a straight flight path.

TABLE 6(3.7). HEADING CHANGE (DEG) IN ONE SECOND

Response Required by Para. 3.3	Aggressive Maneuvering			Moderate Maneuvering		
	Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
Acc and Rate	TBD	TBD	TBD	6.0	3.0	2.0
Attitude and TRC	TBD	TBD	TBD	TBD	TBD	TBD

TABLE 7(3.7). YAW RATE (DEG/SEC) IN 1.5 SECONDS AFTER FULL TRAVEL DIRECTIONAL CONTROLLER INPUT

Level	Aggressive Maneuvering	Moderate Maneuvering
1	15	TBD
2	15	TBD
3	TBD	TBD

3.7.6.4 Other Conditions. Control authority shall be sufficient to assure safety throughout the combined range of all attainable speeds and sideslip. This requirement applies to the prevention of loss of control and to recovery from any situation for all maneuvering, including pertinent effects of factors such as regions of control-surface-fixed instability, gyroscope coupling, fuel slosh, the influence of symmetric and asymmetric stores, atmospheric disturbance, and rotorcraft failure states (maneuvering flight appropriate to the failure state is to be included). Consideration shall be taken of the degrees of effectiveness and certainty of operation of limiters, c.g. control malfunction or mismanagement, and transients from failures in the propulsion, flight control, and other relevent systems.

3.7.7 Directional Controller Forces.

3.7.7.1 Directional Controller Gradients in Steady Sideslips. The following requirements are expressed in terms of characteristics in directional-controller-induced steady zero-yaw-rate sideslips with the rotorcraft trimmed for zero-bank-angle straight flight in both powered and autorotative flight at all speeds above TBD knots. Sideslip angles to be demonstrated shall be the lesser of 35 degrees or $\sin^{-1}$ (35/airspeed in knots) or those prescribed by buffet or structural limitations or fuel directional control displacements. Right directional controller deflection and force shall be required to produce left sideslips, and left directional controller force and deflection shall be required to produce right sideslips.

For Levels 1 and 2, the following requirements apply. The variation of sideslip angle with pedal deflection and force shall be linear within TBD percent of the average gradient for sideslip angles between ± 25 degrees. For larger sideslip angles, an increase in directional controller deflection shall always be required for an increase in sideslip and, although a reduction of directional controller force gradient is acceptable outside this range, the following requirements shall apply:

Level 1: The gradient of sideslip angle with directional controller force shall not reverse slope.

Level 2: The gradient of sideslip angle with directional controller force is permitted to reverse slope provided the sign of the directional controller force does not reverse.

The term gradient does not include that portion of the directional controller force versus sideslip-angle curve within the preloaded breakout force or friction band.

3.7.7.2 Directional Controller Forces Versus Deflection.

3.7.7.2.1 Steady-State. The average gradient of directional controller force per unit of deflection at constant speed shall be within the limits specified in Table 1(3.7). There shall be no undesirable discontinuities in the force gradients, and the slope of the curve of force versus displacement shall be positive at all times, with the slope for the first inch of travel from trim equal to or greater than the slope for the remaining control travel. In addition, the force required by any control for a 1-inch travel from trim by the gradient chosen shall not be less than the breakout force. The directional cockpit controls may be adjustable. The directional control (pedal) characteristics shall not differ by more than 10 percent from the value at the median position when the controller is adjusted over the range available for adjustment to pilot physical dimensions.

3.7.7.2.2 Transients. The requirements of Paragraph 3.4.9.5.2 shall be met.

3.7.7.2.3 Damping. Damping shall meet the requirements of Paragraph 3.4.9.5.3.

3.7.7.3 Directional Controller Centering and Breakout Forces. The directional controller should exhibit positive centering in flight at any normal trim setting. Although absolute centering is not required, the combined effects of centering, breakout force, stability, and force gradient shall not produce objectionable flight characteristics, such as poor precision-tracking ability, or permit large departures from trim conditions with controls free. Breakout forces, including friction, preload, etc., shall not be less than 3 pounds nor more than 7 pounds for Level 1 or 15 pounds for Level 2 flying qualities. These values refer to the cockpit pedal force required to start movement of the control surface.

The breakout forces shall be symmetrical for each control with a maximum tolerance of 10 percent, e.g., if forward directional control breakout force were 1.0 pound, then allowable aft directional breakout force would be in the range between 1.1 pounds and 0.9 pound. This requirement shall be met with the trim engaged and disengaged. For emergency manual operation upon single malfunction of a power-operated or power-boosted control system, the allowable breakout forces shall be doubled. These values refer to the cockpit control force required to start movement of the control surface when measured in flight. Measurement of the breakout forces made on the ground (with the rotor turning) will suffice in lieu of actual flight measurement, provided that qualitative agreement between ground measurement and flight observation is established.

3.7.7.4 Directional Controller Free Play. The free play (and possible associated hysteresis) in the directional controller shall not result in objectionable flight characteristics, especially for small amplitude inputs. For all operating conditions, free play should be within ± 5 percent of the total travel for Level 1 and ± 10 percent of the total travel for Levels 2 and 3. Free play is defined as controller movement without corresponding movement of the associated rotor blade, control surface, or other control device.

3.7.7.5 Cockpit Yaw Response Controller Force Limits--General. Unless otherwise specified in particular requirements, the maximum yaw response control forces required without retrimming for any maneuver or task consistent with service use shall not exceed 30 pounds for Level 1 or 50 pounds for Level 2 flying qualities.

3.7.7.6 Cockpit Yaw Response Controller Force Limits--Failures. Refer to Paragraph 3.10.

3.7.8 Pedal Displacements.

3.7.8.1 Maneuvering. For all types of pedal or yaw controllers, the control motions in maneuvering flight shall not be so large or so small as to be objectionable.

3.7.8.2 Gust Regulation. The requirements of Paragraph 3.4.10.2 shall be met.

3.7.9 Directional Trim.

3.7.9.1 Scope and Capability. For all conditions and speeds specified in Paragraph 3.2, it shall be possible in steady flight to trim pedal forces to zero (± 0.2 pound). At these trim conditions, the controls shall exhibit positive self-centering characteristics. Uncommanded control movement shall not exceed TBD when trim control is actuated. All trim devices shall maintain the zero force position setting selected by the pilot.

3.7.9.2 Directional Controller with Speed Change. With the rotorcraft initially trimmed directionally with symmetric power, it shall be possible to maintain heading within TBD degrees during zero-bank-angle straight flight over a speed range of ± 30 percent of the trim speed or ± 20 knots whichever is less (except where limited by the boundaries of the flight envelope). The directional control forces shall not be greater than those in Paragraph 3.7.7.5. These requirements must be satisfied without retrimming.

3.7.9.3 Directional Controller with Asymmetric Loading. With the rotorcraft initially trimmed directionally with any asymmetric loading specified by the mission requirements at any speed in the flight envelope, it shall be possible to maintain heading within TBD degrees during straight flight throughout the flight envelope with pedal forces not exceeding TBD pounds.

3.7.9.4 Transients and Trim Changes Among Alternate Control Modes. The requirements of Paragraph 3.6.11.6 shall apply.

3.8 RESPONSE TO TRANSITION CONTROLLER

This section of the specification sets limits on the responses of variable configuration rotorcraft wherein wing tilt or pylon tilt, δ_ν, is employed. The controller utilized to vary the rotor configuration is referred to herein as the transition controller.

3.8.1 Pitch Response to Transition Controller. The peak pitch attitude response to a step change in the transition controller shall be within the limits specified in Table 1(3.8).

TABLE 1(3.8). MAXIMUM ALLOWABLE PITCH ATTITUDE RESPONSE TO TRANSITION CONTROLLER

Response Required by Para. 3.3	θ_{PEAK}/δ_ν (deg/deg)		
	Level 1	Level 2	Level 3
Acceleration	TBD	TBD	TBD
Rate, Attitude	0.15	0.5	0.5

3.8.2 Height Response to Transition Controller. The peak pitch attitude required to hold a constant vertical rate during and after a step change in the transition controller shall be within the limits specified in Table 2(3.8). These limits shall apply for transition control inputs up to and including the most aggressive expected for the mission and shall apply over all speeds within the transition envelope.

3.8.3 Transient Handling Quality Degradations in Transition.

3.8.3.1 When Acceleration Response is Allowed by Paragraph 3.3. Regions of degraded handling qualities shall be restricted to speeds above TBD knots and shall not exist for a speed range greater than 20 knots. Regions of degraded handling qualities shall not exist within TBD knots of any steady operating point required by the mission. The damping characteristics in the degraded region are specified in Table 3(3.8).

TABLE 2(3.8). MAXIMUM ALLOWABLE PITCH ATTITUDE TO CANCEL HEIGHT-TO-TRANSITION CONTROLLER COUPLING

Response Required by Para. 3.3	$\left(\frac{\Delta\theta}{\Delta\delta_{\nu}}\right)_{\dot{h}=\text{const}}$ (deg/deg)		
	Level 1	Level 2	Level 3
Acceleration	TBD	TBD	TBD
Rate, Attitude	TBD	TBD	TBD

TABLE 3(3.8). REQUIREMENTS FOR TRANSIENT DEGRADATIONS IN TRANSITION

	Level 1	Level 2	Level 3
Pitch	None	$T_2 > 4.5$ sec	$T_2 > 2.2$ sec
Roll	TBD	TBD	TBD
Yaw	TBD	TBD	TBD

3.8.3.2 When Rate or Attitude is Required by Paragraph 3.3. For Level 1 there shall be no degradation in handling qualities at any point in the transition. The Level 2 and Level 3 requirements are identical to Paragraph 3.8.3.1.

3.8.4 Response to Configuration Change (e.g., Flaps, Landing Gear, etc.). Configuration or control mode changes by automatic means shall always be called to the attention of the pilot when and after they occur. The transient motions and trim changes resulting from the automatic engagement or disengagement of any portion of the automatic flight control system(s) by automatic means shall be such that dangerous flying qualities never result. The transient motions and trim changes resulting from the intentional engagement or disengagement of any portion of the primary flight control system by the pilot shall be such that dangerous flying qualities never result. The control deflections and forces required to hold the rotorcraft attitude constant shall fall within the limits specified in Table 4(3.8).

TABLE 4(3.8). MAXIMUM ALLOWABLE CONTROL DEFLECTIONS FOR FORCES DURING CONFIGURATION CHANGE OR CONTROL SYSTEM BLENDING

Response Type at End of Configuration or Control Mode Change (Blending)	Maximum Force (lbs)			Maximum Deflection (in)		
	F_{LONG}	F_{LAT}	F_{PED}	δ_{LONG}	δ_{LAT}	δ_{PED}
Rate	TBD	TBD	TBD	TBD	TBD	TBD
Attitude	TBD	TBD	TBD	TBD	TBD	TBD
TRC	TBD	TBD	TBD	TBD	TBD	TBD

3.9 COMBINED AXES FLYING QUALITIES

3.9.1 Crosscoupling Among Axes of Manipulator(s).

a. The pitch, roll, directional, and heave axes of the manipulator(s) shall be independent of one another so that intentional inputs to one control axis will not cause inadvertent inputs to the other. This requirement is particularly relevant to the use of sidearm controllers.

b. The pitch-, roll-, directional-, and heave-control force and displacement sensitivities and breakout forces shall be compatible so that intentional inputs to one control axis will not cause inadvertent inputs to any other.

3.9.2 Control Harmony. The control forces, displacements, and sensitivities of the cockpit controls shall be compatible so that intentional inputs to one control axis will not cause inadvertent inputs to other axes. The following control force levels are considered to be limiting values compatible with the pilot's capability to apply simultaneous forces: TBD.

3.9.3 Mechanical Coupling and Mechanical Mixing. For all operating conditions, longitudinal, lateral, directional, or vertical control motions shall not produce adverse responses of the rotorcraft or trim forces due to mechanical coupling in or among the control subsystem(s). Mechanical mixing of the longitudinal, lateral, directional, or collective controls shall not result in control power limitations for any possible combination of control inputs throughout the entire range of each of the control motions.

3.9.4 Cross-Axis Coupling in Roll Maneuvers. The requirements of Paragraph 3.6 apply. In addition, in yaw-control-free, pitch-control-fixed, maximum-performance rolls through TBD degrees, entered from straight flight or from turns, pushovers, or pullups ranging from 0 g to 0.8 n_L, the resulting yaw or pitch motions and sideslip changes shall neither exceed structural limits nor cause other dangerous flight conditions involving uncontrollable motions.

3.9.5 Multiple Axis Degradation Effect. (TBA)

3.9.6 Responses to Other Inputs.

3.9.6.1 Pitch Attitude Response to a Pitch Disturbance. (TBA)

3.9.6.2 Roll Attitude Response to a Roll Disturbance. With the rotorcraft trimmed for zero bank angle in straight and level flight with the cockpit controls free, the roll attitude response to a roll disturbance shall be such that the requirements of Table 1(3.9) are met.

TABLE 1(3.9). ROLL ATTITUDE RESPONSE TO A ROLL DISTURBANCE

		Time to Halve the Bank Angle ($T_{1/2}$), sec
Acc and Rate	Low Speed and Hover	$T_{1/2} < 20$
	Forward Flight	$10 < T_{1/2} < \infty$
Attitude	Low Speed and Hover	$T_{1/2} < 2$
	Forward Flight	$T_{1/2} < 3$

3.9.6.3 Directional Response to a Yaw Disturbance. (TBA)

3.9.6.4 Heaving Response to a Vertical Disturbance. (TBA)

3.10 RESPONSE TO FAILURES

3.10.1 Failures of the Power-Operated Controls. In trimmed level flight at any speed, out-of-trim conditions resulting from an abrupt failure of a single power-operated control subsystem shall be such that:

a. With control free for at least three seconds, the resulting rate of yaw, roll, and pitch shall not exceed 10 degrees per second, and the change in normal acceleration shall not exceed ± 0.5 g.

b. There shall be no resultant restriction of control displacement.

c. The change in cockpit longitudinal control force required to maintain trim pitch attitude or zero sideslip level flight following complete or partial failure of a power-operated control subsystem or of the augmentation system shall not exceed the limits of Table 2(3.11).

d. With a single power-operated control subsystem OFF, it shall be possible to trim steady longitudinal, lateral, and directional control forces to zero under all the conditions and speed ranges.

e. With a single power-operated control subsystem OFF, the collective control shall not tend to vary from its trim position, whether or not flight, power, or thrust controls are moved.

f. With the rotorcraft trimmed in steady level flight at $V_{max\ R/C}$ or 60 KCAS, whichever is less, under single power-operated control subsystem failure conditions, it shall be possible without retrimming to make a normal approach and landing with control forces not exceeding the limits given in Paragraph 3.11.3.

g. Total engine failure, primary electrical subsystem failure, or both, shall not result in primary power-operated control subsystem failure.

h. A single power-operated control subsystem failure shall not result in degradation, failure, deactivation, or decrease of the authority of the trim subsystems.

3.10.2 Failures of the Automatic Flight Control System(s).

3.10.2.1 Maximum Allowable Rotorcraft Response. The maximum allowable rotorcraft response shall not exceed the values listed in Table 1(3.10) following any single failure in any sequence among possible sequences of failures of the automatic flight control system(s). In determining compliance with the requirements of Table 1(3.10), the controls shall be left free for 3 seconds following the automatic flight control system failure while in trimmed level flight.

TABLE 1(3.10). MAXIMUM ALLOWABLE ROTORCRAFT RESPONSE FOLLOWING ANY SINGLE FAILURE OF THE AUTOMATIC FLIGHT CONTROL SYSTEM(S)

Axis	Maximum Allowable Response with the Controls Free for 3 seconds Following any Single Failure of the Automatic Flight Control System From Trimmed Level Flight (deg, deg/sec, G's, kt, ft/sec)
Pitch	10 deg/sec
Longitudinal	TBD ft/sec or TBD g longitudinal acceleration
Vertical	0.5 g normal acceleration
Roll	10 deg/sec
Yaw	10 deg/sec except if below 40 knots; the 10 deg/sec can be increased to 20 deg/sec
Lateral	TBD ft/sec or TBD g lateral acceleration

3.10.2.2 Pilot Intervention Delay Time. In order to insure a safe recovery following any single failure, an intervention delay time between the initiation of the failure and the initiation of corrective action shall be tolerated in accordance with the requirements of Table 2(3.10) when determining compliance.

3.10.2.3 Intent of Requirement. The requirements of Paragraph 3.10.2 shall be met upon the failure of one complete subsystem or during the period of transfer from one subsystem to another, but need not be met for a simultaneous failure or both.

3.10.2.4 Landing Requirements Following a Failure.

a. Following any single failure of the automatic flight control and stability augmentation systems, the rotorcraft shall be capable of continuing flight and landing safely under instrument meteorological conditions (IMC) with a 200-foot ceiling above ground or deck level and one-half mile visibility. For this IMC, when based aboard ship, the landing platform and its environment shall be equivalent to that of an aviation facilities ship of FFG-7 class or larger, mean wind-over-deck

TABLE 2(3.10).

SUMMARY OF MINIMUM ALLOWABLE INTERVENTION TIMES FOR SYSTEM FAILURES

Phase of Flight	Rotorcraft Response $t_1 - t_0$	Pilot Response $t_2 - t_1$	Minimum Allowable Intervention Delay Time and Method of Test
Attended Operation	Time for rotorcraft to achieve change of rate about any axis of 3 deg/sec OR The time to reach a change of "G" in any axis of 0.2 OR For an attention getter to function	1/2 sec	System failures will be injected without warning to the pilot. His ability to recover as rapidly as possible without a dangerous situation developing will be used to assess system failure mode acceptability.
Divided Attention Operation Hands On	Time for rotorcraft to achieve change of rate about any axis of 3 deg/sec OR	1-1/2 sec (Decision 1 plus reaction 1/2)	The pilot will be warned of the system failure. Demonstration of compliance must show that an intervention delay time equal to 1 1/2 sec + $(t_1 - t_0)$ can be tolerated
Divided Attention Operation Hands Off	The time to reach a change of "G" in any axis of 0.2 OR For an attention getter to function	2-1/2 sec (Decision 1-1/2 plus reaction 1)	As above but intervention delay time 2 1/2 seconds + $(t_1 - t_0)$
Unattended Operation Hands On	As above but the threshold rates and "G" values are 5 deg/sec and 0.25 respectively	2-1/2 sec (Decision 2 plus reaction 1/2)	As above.
Unattended Operation Hands Off	"	4 sec (Decision 3 plus reaction 1)	As above but intervention delay time 4 sec + $(t_1 - t_0)$

TABLE 2(3.10). (Concluded)

ROTORCRAFT RESPONSE TIME INTERVAL ($t_1 - t_0$). This is the period between the failure occurring and the pilot being alerted to it by a suitable cue. The cue may take the form of an adequate tactile, audio, or visual warning. (The eye cannot be relied upon to distinguish abnormal instrument indications sufficiently early for these to be regarded as an adequate cue). In the absence of the adequate cues listed above, it can be assumed that a pilot will be alerted when the rotorcraft meets or exceeds the responses listed for unattended operation.

PILOT RESPONSE TIME INTERVAL ($t_2 - t_1$). The period commences at the time the pilot is alerted to the fact that something abnormal is happening and terminates when the controls are moved to commence the recovery maneuver. The period consists of the recognition time, decision time, and reaction time. As shown above, the recognition and decision times are assumed to increase as the pilot relaxes his level of involvement, i.e., in going from "attended operation" to "unattended operation" and also in going from "hands on" to "hands off." The reaction time is longer "hands off" than "hands on" as the pilot has to locate the controls before he can move them.

* * * * * * * * * *

conditions shall be not less than 35 knots (at 0 degrees relative to the rotorcraft), the ship's maximum absolute roll angle shall be not more than 10 degrees, and the double amplitude in heave of the ship's landing platform shall be not more than TBD feet.

b. Rotorcraft employing automatic flight control and stability augmentation systems shall possess a sufficient degree of stability and control with all of the automatic flight control and stability augmentation systems disengaged in order to allow continuation of flight and to permit a landing under conditions having OVC/UCE Rating 3 [Fig. 1(1.5)] in moderate turbulence [Table 2(3.17)]. For these conditions, when based aboard ship, the landing platform and its environment shall be as specified in Paragraph 3.10.2.4.a, mean wind-over-deck conditions shall be not less than 10 knots (at 0 degrees relative to the rotorcraft), ship's maximum absolute roll angle shall be not more than 5 degrees, and the double amplitude in heave of the ship's landing platform shall be not more than TBD feet.

3.10.2.5 Single Subsystem Requirement. In trimmed forward flight at any speed, out-of-trim conditions resulting from any failure of an automatic flight control system employing a single subsystem shall be such that the requirements of Paragraphs 3.10.1 and 3.10.2.1 are met. These requirements shall apply when a non-redundant or dependent component of the automatic flight control system is inoperative.

3.10.2.6 Loss of Engine or Electrical Power. Complete or partial loss of engine power, and/or loss of either electrical subsystem, shall not render automatic flight control equipment inoperative. Engine start during single engine or autorotational flight shall not cause the automatic flight control system to become inoperative.

3.10.3 Complete Loss of the Anti-Torque Transmission/Rotor in Forward Flight at TBD Knots or More. Following a complete loss of the anti-torque mechanism and transmission in forward flight, sufficient pitch control shall be available to allow safe flight with the weight of the anti-torque mechanism and transmission removed.

3.10.4 Loss of the Function of Anti-Torque Mechanism in Forward Flight at or Above the Speed for Minimum Power. Following loss of the function of the anti-torque mechanism in forward flight, the rotorcraft shall have sufficient directional stability to fly, at the speed for minimum power required at maximum gross weight, the steady yawed condition at a sideslip angle no greater than 20 degrees and a rate of descent no greater than TBD feet per minute. With anti-torque mechanism and transmission intact but not functioning, the rotorcraft shall be capable of a safe power-off landing at a touchdown speed no greater than 35 knots true airspeed on a level paved surface at the maximum gross weight at TBD feet and TBD degrees Centigrade without exceeding the side drift components of Paragraph 3.12.4.1.

3.10.5 Responses to Failures Not Otherwise Specified. The motions following sudden rotorcraft system or component failures shall be such that dangerous conditions can be avoided by pilot corrective action. An intervention delay time between the failure and initiation of pilot corrective action, in accordance with the requirements of Table 2(3.10), shall be incorporated when determining compliance. No single failure of any component or system shall result in Level 3 flying qualities; special failure states (Paragraph 1.6.3) are excepted. The crew member concerned shall be provided with immediate and easily interpreted indications whenever failures occur that require or limit any flight crew action or decision.

3.11 ENGINE FAILURES

3.11.1 Applicability of Criteria. The rotorcraft shall be capable of entering into power-off flight or flight with fewer than all operating engines at all power settings and any loading within the airspeed limits specified below. Further, it shall be possible to make the transition from powered flight to autorotation safely under the following conditions.

3.11.1.1 Multi-Engine Rotorcraft.

a. For the first failure under all flight conditions, the initiation of necessary manual control action shall meet the divided attention requirements of Table 2(3.10). Following subsequent failures or a simultaneous multi-engine failure, the initiation of the necessary control actions shall meet the attended operation requirements of Table 2(3.10).

b. Following a single engine power failure on a multi-engine rotorcraft, the rotorcraft shall be capable of landing aboard non-aviation type ships under 30 kt wind-over-deck (at 0 deg relative to the rotorcraft), sea level, standard day conditions at the gross weight called out for performance in the basic detail specification using the remaining engines.

3.11.1.2 Single-Engine Rotorcraft. For all flight conditions, initiation of the necessary manual control motion shall meet the divided attention operation hands-on requirements of Table 2(3.10).

3.11.1.3 Airspeed Limits. The rotorcraft shall have the following capabilities:

a. The rotorcraft shall be capable of sustaining a single engine failure at any airspeed from hover to limit airspeed as defined by the operational flight envelope at all power settings and any loading.

b. The rotorcraft shall be capable of entering into power-off autorotational flight at any airspeed from hover to 1.10 times maximum single engine level flight airspeed at all power settings and any loading.

c. The rotorcraft shall be capable of entering into power-off autorotational flight following engine failure or a simultaneous failure of two engines in a multi-engine rotorcraft in climbing flight at an airspeed for best rate of climb at all power settings and any loading.

3.11.2 Altitude Loss. At speeds between 50 KCAS and the limit airspeed as defined by the operational flight limit, the allowable altitude loss (previous to any collective control motion required for recovery) shall be no more than 50 ft from the extension of the initial flight path.

3.11.3 Control Margins and Forces. The flight control margins shall comply with the values of Table 1(3.11), and the flight control forces shall not exceed the values of Table 2(3.11) at any time during single or nonsimultaneous multi-engine failure or any partial engine failure condition and rotorcraft recovery. There shall be no tendency for automatic flight control system failure within the range of transient autorotative rotor speed values or during the engine failure.

3.11.4 Engine Power Mismatch. The capability shall exist to conduct flight with engines mismatched in power output, and the requirement of Paragraph 3.11.1.1 through 3.11.3 shall be met following failure of the engine developing the highest power.

TABLE 1(3.11). ROTORCRAFT ANGULAR RATE MARGIN

Control	Angular Rate
Longitudinal	15 degrees per second within 1.5 seconds
Lateral	15 degrees per second within 1.5 seconds
Directional	15 degrees per second within 1.5 seconds

TABLE 2(3.11). LIMIT CONTROL FORCES

Control	Control Force (pounds)
Longitudinal Cyclic	20.0
Lateral cyclic	10.0
Collective	20.0
Directional	50.0
Engine (each)	7.5*

*AAH is 5 pound limit control force.

The limit control forces for breakout including friction with adjustable friction devices set for minimum friction are as follows:

Control	Minimum-LB	Maximum-LB
Longitudinal Cyclic	0.5	2.6
Lateral Cyclic	0.5	2.2
Collective	1.0**	15.0
Directional	3.0	20.0

**May be measured with adjustable friction set.

3.12 AUTOROTATION

3.12.1 Autorotation Entry. The autorotational entry conditions shall not produce pitch, roll, or yaw attitude changes (previous to any cyclic or directional control motions required for recovery) in excess of 10 degrees except that, at speeds below that for $V_{min\ R/D}$, a 20-degree yaw will be acceptable. At no time during this maneuver shall the rotor speed fall below a safe minimum transient autorotative value (as distinct from the minimum power-off autorotative value).

3.12.2 Rotor Speed Limits. During unaccelerated autorotational flight, the pilot shall be able to maintain rotor speed between the upper and lower power-off autorotational limits. While operating within the rotorcraft altitude and loading envelopes, no rigging modifications in the collective control and main rotor blade angle relationship shall be allowed to meet this requirement.

3.12.3 Control Margins and Forces. From trimmed autorotational flight, the angular rate margin(s) specified in Table 1(3.11) shall be complied with and the flight control force(s) shall not exceed the values of Table 2(3.11) during the deceleration flare and subsequent landing.

3.12.4 Autorotational Landings

3.12.4.1 Touchdown to a Paved Surface. The rotorcraft shall be capable of making a safe touchdown from steady autorotational flight without sustaining structural failure, in any loading or external configuration (except while carrying a sling load), on a level paved surface, up to ground speeds of at least 35 knots, under calm atmospheric conditions. This shall be construed to cover landings with 0 to 3 knots wind velocity in any direction and up to a side drift of 6 knots. In autorotation, at a touchdown ground speed of 35 knots on a level paved surface, it shall be possible to bring the rotorcraft to a stop within 200 feet.

3.12.4.2 Power-Off Landings. It shall be possible, in calm air at 4000 feet, 35 degree C, at the end of stabilized autorotative descents, to make repeatedly safe, power-off autorotative landings at 15 knots in a single engine rotorcraft. A safe autorotative landing shall be possible at TBD knots in multi-engine rotorcraft. The rotor shall be able to meet this requirement at basic design weight minus jettisonable stores and less warmup fuel. Rotorcraft designed exclusively for shipboard use need only demonstrate this requirement for a sea level, standard day atmospheric condition. It is highly desirable to reduce the 15 knot landing speed to zero for single engine rotorcraft.

3.12.4.3 Power-Off Water Landings. Refer to Paragraph 3.15.

3.13 RESPONSES TO STORES RELEASE, ARMAMENT DELIVERY, AND MISSION EQUIPMENT OPERATION

3.13.1 General. The intentional release of any stores shall not result in objectionable flight characteristics for Levels 1 and 2. Positive separation of all released stores shall occur in unaccelerated flight at all airspeeds from zero up to the limit airspeed and in unaccelerated autorotational flight within the airspeed flight envelope. Released stores (including expended ordinance casings) shall not contact any portion of the rotorcraft or mission-related equipment. Following release, stores shall not come in contact with each other while in the vicinity of the rotorcraft. The requirements for emergency release of stores shall apply to any loaded state of the stores which may range from fully loaded to empty with or without aerodynamic fairings installed on the stores. The emergency release characteristics shall be adequate at all sideslip angles up to those required to perceive a 0.1 g sideforce at the pilot's station or up to the sideslip envelope limit, whichever is least. These and the following requirements shall be met for inadvertent release of stores.

3.13.2 Symmetrical Release of Stores. The rotorcraft shall be able to meet the following handling qualities requirements during and subsequent to any symmetrical release of stores.

a. No permissible flight envelope limit shall be exceeded following symmetrical release of stores. The divided attention hands-on requirement of Table 2(3.10) shall be met in determining the minimum pilot intervention delay time following the symmetrical release of stores.

b. The maximum control displacement allowed following release of stores and in order to maintain the trim condition which existed prior to release of stores shall meet the requirements of Table 1(3.13).

c. Without retrimming, the maximum control force changes required following release of stores and in order to maintain the trim condition which existed prior to release of stores shall not be more than those specified in Table 1(3.13).

d. Following symmetrical release of stores during unaccelerated level flight, there shall not be a change in normal load factor greater than 10 percent of the positive limit normal load factor while meeting the pilot intervention delay time requirements of Paragraph 3.13.2.a. This limit normal load factor shall be established in accordance with the helicopter gross weight and airspeed at the instant of stores release.

e. These requirements shall be met with automatic stabilization equipment in the most adverse condition.

3.13.3 Asymmetrical Release of Stores. The rotorcraft shall be able to meet the following requirements subsequent to any asymmetrical release of stores.

TABLE 1(3.13). CONTROL DISPLACEMENT AND CONTROL FORCE REQUIREMENTS FOR RELEASE OF STORES

Control Axis	Maximum Allowable Control Trim Displacement Change Following Stores Release	Maximum Allowable Control Force Change Following Stores Release
Longitudinal	10%	10 lb
Lateral	10%	5 lb
Directional	15%	25 lb

a. No limit of the flight envelope shall be exceeded with the flight and power controls held fixed following release of stores. The divided attention hands-on requirement of Table 2(3.10) shall be met in determining the minimum pilot intervention delay time following the asymmetrical release of stores.

b. No limit of the loading envelope shall be exceeded following normal release of stores. The emergency lateral center of gravity limits shall not be exceeded following emergency asymmetrical release of stores.

c. With the flight and power controls held constant following release of stores, sufficient control margins shall be available to return the helicopter to the trim condition that existed prior to release of stores while meeting the pilot intervention delay time requirements of Paragraph 3.13.3.a.

d. These requirements shall be met with automatic stabilization equipment in the most adverse condition.

3.13.4 Response to Mission Equipment Operation and Armament Delivery. Operation of equipment such as rotation of armament pods, refueling devices, or rescue equipment or the firing of weapons or defensive equipment such as cannon, chaff dispensors, or flares shall not cause residual oscillations, buffet, trim changes, or other characteristics which impair the tactical effectiveness of the rotorcraft under any pertinent flight condition. The delivery or pickup of cargo and towed or suspended loads shall likewise meet the same requirements. These requirements shall be met for Levels 1 and 2.

3.14 GROUND HANDLING CHARACTERISTICS

3.14.1 Rotor Start/Stop. It shall be possible while on the ground to start and stop the rotor blades in mean winds up to at least 45 knots from the most critical azimuth relative to the nose of the helicopter in the severe turbulence environment specified in Table 2(3.17). For rotorcraft based aboard ship, the mean wind requirement is increased to 60 kt in the severe turbulence environment specified in Table 2(3.17).

3.14.2 Parked Position Requirement. It shall be possible without the use of wheel chocks or skid restraints to maintain a fixed position on a level paved surface with normal rotor speed prior to lift-off throughout the gross weight, altitude, temperature, center of gravity, and wind envelope specified.

3.14.3 Wheeled Rotorcraft Taxi Requirements. The following ground handling conditions shall be met with the cyclic control in an appropriate position for maintaining the desired taxi speed condition.

a. It shall be possible, without the use of brakes, to maintain a straight path in any direction in a wind of 45 knots from any direction.

b. It shall be possible to make a complete turn in either direction by pivoting on either main landing gear in a wind of 45 knots from any direction.

c. It shall be possible to make taxi turns in either direction at yaw rates to 45 degrees per second at 20 knots ground speed (no wind) with roll angles of less than 2 degrees relative to the taxi surface. During the turns, the cyclic control stick shall be literally neutral.

d. It shall be possible to perform all required maneuvers, including taxiing and pivoting, without damage to rotor stops and without contact between the main rotor or tail rotor blades and any part of the rotorcraft structure.

3.15 WATER HANDLING CHARACTERISTICS

3.15.1 Applicability of Requirement. This requirement applies to all rotorcraft whose primary mission involves flight over water. Demonstration of compliance with this criteria will be as specified in Paragraph 4.1.

3.15.2 Water Landing Requirement. In both power-on and autorotative conditions, it shall be possible to make a landing on smooth water up to at least 20 knots surface speed with an 8 feet per second rate of descent and at least 30 knots with a 4 feet per second rate of descent.

3.15.3 Ditching Requirement. Techniques and procedures shall be established for ditching the rotorcraft on water in the event of:

a. The loss of all engine power.

b. The failure of one engine in a multi-engine rotorcraft.

The behavior of the rotorcraft should not be such as to cause immediate injury to the occupants or to make it impossible for them to escape from the exits provided.

3.15.4 Flotation and Trim Requirements. The flotation time and trim attitude of the rotorcraft shall be such as to provide the occupants with time to safely exit the rotorcraft and enter life rafts without application of the rotor brake. The flotation and trim characteristics shall be investigated throughout a range of sea states from 0 to 7 [but limited to 9.15 meters (30 feet)] of Table 1(3.15) and shall be satisfactory in waves having height/length ratios in accordance with the following:

a. 1:10 for rotorcraft with performance such that, in the event of the failure of one engine at any point en route, a landing has to be made.

b. 1:15 for rotorcraft with more than one engine, with performance such that, in the event of the failure of one engine, it is possible either to continue the flight or to land back on the takeoff area.

TABLE 1(3.15). DEFINITION OF SEA STATE

Sea State	Height of Waves	Description of Sea	Sea State	Height of Waves	Description of Sea
0	0 or less than 0.305 m (1 ft)	Glassy-calm Rippled	5	2.439 m to 3.658 m (8 to 12 ft)	Very rough
1	0.305 m to 0.610 m (1 to 2 ft)	Smooth	6	3.658 m to 6.096 m (12 to 20 ft)	High
2	0.610 m to 0.915 m (2 to 3 ft)	Slight	7	6.096 m to 12.192 m (20 to 40 ft)	Very high
3	0.915 m to 1.524 m (3 to 5 ft)	Moderate	8	12.192 m (40 ft) and over	Precipitous
4	1.524 m to 2.439 m (5 to 8 ft)	Rough	9	All Heights	Phenomenal (Confused Sea)

NOTE: The height of a wave is considered as the vertical distance between trough and crest.

3.16 VIBRATION AND RIDE QUALITY CHARACTERISTICS

3.16.1 Vibration Characteristics. The rotorcraft shall not exhibit, under any conditions of flight or ground operations, mechanical or aeroelastic instabilities (i.e., ground resonance, flutter, etc.) that degrade the flying qualities. In addition, the rotorcraft shall be free of objectionable shake, vibration, or roughness throughout the flight envelope.

3.16.2 Vibratory Control Accelerations. Vibratory accelerations at all controls in any direction shall not exceed TBD g for frequencies up to TBD cps and a double amplitude of TBD inch for frequencies above TBD cps; this requirement shall apply to all steady speeds within the rotorcraft design flight envelope and in slow and rapid transitions from one speed to another and during transitions from one steady acceleration to another.

3.16.3 Vibratory Control Forces. The magnitude of the vibratory force at the controls shall not exceed TBD pounds in any direction; preferably, any vibratory forces shall be zero pounds.

3.16.4 Ride Quality Characteristics. Noise/vibration characteristics at the pilot and crew stations at all airspeeds from 30 knots rearward to the maximum cruise airspeed shall not exceed the TBD hour contour of Figs. 1(3.16) through 3(3.16) for all missions and tasks. Noise/vibration characteristics for the TBD mission/tasks shall not exceed the TBD percentile contour of Figs. 1(3.16) through 3(3.16).

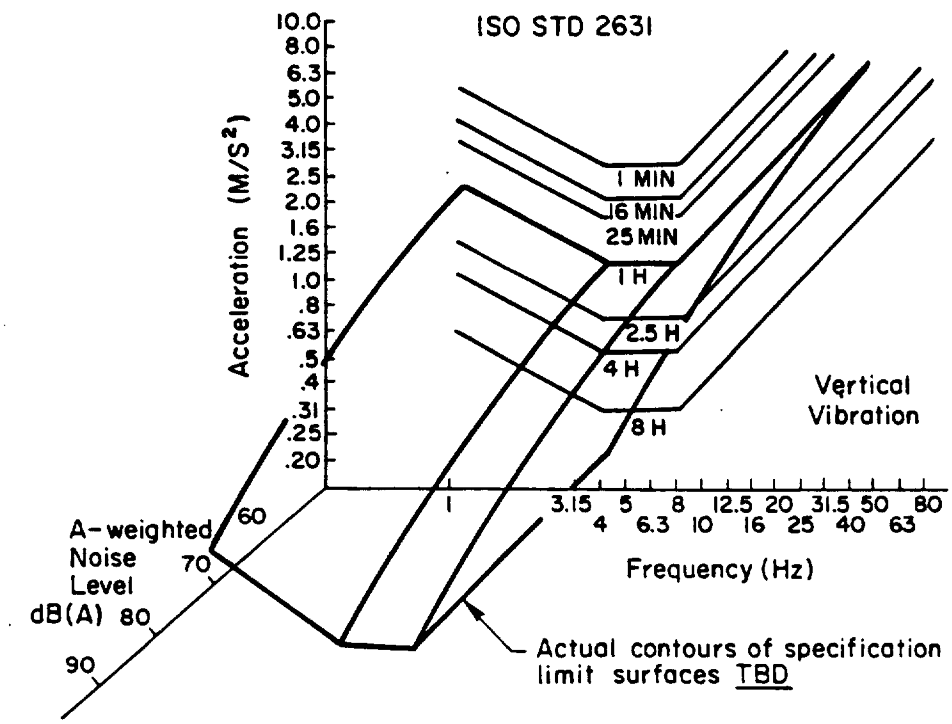


Figure 1(3.16). Noise/Vertical Acceleration Decreased Pilot Proficiency Contours

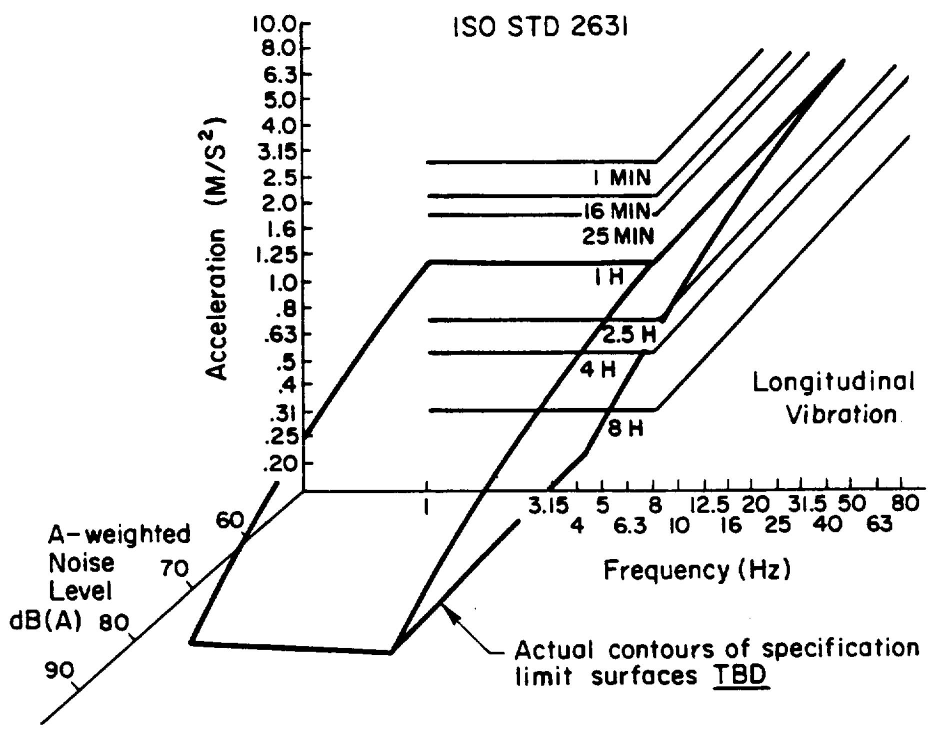


Figure 2(3.16). Noise/Longitudinal Acceleration Decreased Pilot Proficiency Contours

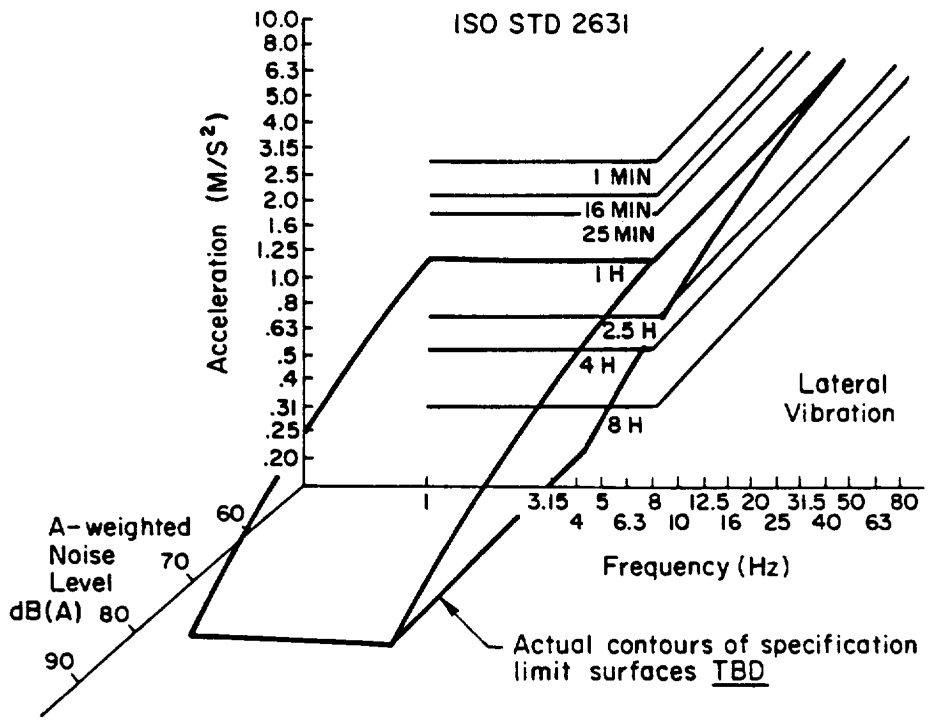


Figure 3(3.16). Noise/Lateral Acceleration Decreased Pilot Proficiency Contours

3.17 FLYING QUALITY REQUIREMENTS IN ATMOSPHERIC DISTURBANCES

3.17.1 Allowable Flying Quality Degradations in Turbulence.

3.17.1.1 When Angular Acceleration or Angular Rate Response is Required by Paragraph 3.3. The required flying quality levels are to be adjusted according to Table 1(3.17) with specific approval of the procuring agency. This requirement is intended to reflect the natural tendency of pilot workload to increase with unaugmented or lightly augmented rotorcraft in turbulence.

3.17.1.2 When Attitude or Translational Rate TRC is Required by Paragraph 3.3. No degradation in flying qualities is allowed for levels of turbulence up to and including "moderate." Otherwise the required flying quality levels are to be adjusted according to Table 1(3.17) with specific approval of the procuring agency.

3.17.2 Definition of Atmospheric Disturbances.

When demonstrating compliance via simulation, an atmospheric disturbance model consistent with the piloting task shall be included. When demonstrating compliance via flight test, representative atmospheric disturbances consistent with the piloting task shall be present wherever and whenever possible, and the term "model" herein shall be interpreted as "surrogate," if the specified disturbance is unavailable. Atmospheric disturbances--such as a mean or steady wind speed and direction, wind shear magnitude and direction, random turbulence, and discrete gusts--shall be chosen by the contractor subject to the provisions herein and the approval of the procuring activity.

3.17.2.1 Random Turbulence. Deviations in wind velocity having periods of less than 10 minutes are considered to be gusts or turbulence. For "near-earth" and "near ship" tasks defined in Paragraph 3.2 and Table 1(3.2), an anisotropic or orthotropic random turbulence model appropriate to the task shall be chosen. For selected tasks, a qualified airwake turbulence model or discrete gust model may be chosen. For up-and-away tasks defined in Paragraph 3.2 and Table 2(3.2) an isotropic random turbulence model appropriate to the task may be chosen. "Light," "moderate," and "severe" turbulence magnitudes are defined quantatively in terms of root-mean-square (rms) longitudinal gust velocity (σ_{u_g}) in Table 2(3.17). It is not necessary or even desirable to vary the rms gust velocity magnitude as a function of position or altitude when demonstrating compliance via simulation.

TABLE 1(3.17). DEFINITION OF INFERIOR BOUNDS ON LEVELS IN TERMS OF COOPER-HARPER RATINGS WHEN ACCELERATION OR RATE RESPONSE IS REQUIRED BY PARAGRAPH 3.3

Level	Atmospheric Disturbances			
	Light	Moderate	Severe	Extreme
1	3-1/2	5-1/2	7-1/2	Flying qualities such that control can be maintained long enough to fly out of the disturbance
2	6-1/2	7-1/2	Flying qualities such that control can be maintained long enough to fly out of the disturbance	Flying qualities such that pilot can regain control after being upset
3	8	Flying qualities such that control can be maintained long enough to fly out of the disturbance	Flying qualities such that pilot can regain control after being upset	No requirement

TABLE 2(3.17). ATMOSPHERIC DISTURBANCE DEFINITIONS FOR SIMULATION AND FLIGHT TEST

Magnitude	σ_{u_g} (ft/sec)
Light	0-3
Moderate	4-5
Severe	6-10
Extreme	11-24

3.17.2.2 Windshear. Windshears, defined as an integral part of "moderate" turbulence, are given as follows:

Decreasing Headwind:	Not to exceed 3.4 ft/sec^2
Decreasing Tailwind:	Not to exceed 1.7 ft/sec^2
Vector Shear:	9 deg/sec; mean wind speed $V_w = 20$ kt
Duration of All Shears:	At least 10 sec

Wind shears shall be accompanied by one-half the root-mean-squared level of "moderate" turbulence in Table 2(3.17).

3.17.2.3 Steady Crosswind. The following steady crosswind components corresponding to "light," "moderate," and "severe" disturbances are recommended:

Qualitative Atmospheric Disturbance Level	Steady Crosswind (kt)
Light	0-10
Moderate	11-30
Severe	31-45

These crosswinds should exist at touchdown. When complying via piloted simulation, the wind values may be invariant with time, position, or altitude. In flight test it is only necessary that the crosswind component specified exist at altitudes high enough to require the pilot to establish a definite crosswind correction in a steady hover and in low speed flight in ground effect.

3.17.2.4 Application of Disturbance Models in Simulation. The gust and turbulence velocities shall be applied to the rotorcraft equations of motion through the aerodynamic terms only, and the direct effect on the aerodynamic sensors shall be included when such sensors are part of the rotorcraft augmentation system. Application of the disturbance model depends on the range of frequencies of concern in the analyses of the rotorcraft. When rotor and structural modes are significant, the exact distribution of turbulence velocities should be considered. For this purpose, it is acceptable to consider u_g and v_g as being one-dimensional functions only of x, but w_g shall be considered two dimensional, a function of both x and y, for the evaluation of aerodynamic forces and moments.

When rotor and structural modes are not significant, rotorcraft rigid-body responses may be evaluated by considering uniform gust or turbulence immersion along with linear gradients of the disturbance velocities. The uniform immersion is accounted for by u_g, v_g, and w_g defined at the rotorcraft center of gravity. The angular velocities due to turbulence are equivalent in effect to rotorcraft angular velocities. Approximations for these angular velocities are defined (precise only at very low frequencies) as follows:

$$q_g = -\frac{\partial w_g}{\partial x} \quad , \quad p_g = \frac{\partial w_g}{\partial y} \quad , \quad r_g = \frac{\partial v_g}{\partial x}$$

The turbulence components u_g, v_g, w_g, and p_g shall be considered mutually independent in a statistical sense. However, q_g is correlated with w_g, and r_g is correlated with v_g

3.17.3 Atmospheric Disturbances When Demonstrating Compliance via Flight Test or Piloted Simulation. If specification compliance is to be demonstrated by flight test or piloted simulation using the mission tasks defined in Appendix A, such demonstrations should be conducted in magnitudes of turbulence up to and including "moderate" as defined in Paragraph 3.17.2.

3.17.4 Atmospheric Disturbances for New Specification Data. Any data generated in support of criteria to be used in the flying quality specification shall include piloted evaluations in atmospheric disturbances defined as "moderate" in Paragraph 3.7.2.

3.17.5 Sensitivity of Trim Attitude to Steady Winds. The local slope of the equilibrium attitude-speed relationship shall not exceed 0.6 degrees per knot for speed perturbations of at least 10 knots in either direction about the trim speed. Thirty-five knots or the limits of the flight envelope, ± 10 degrees roll attitude, or an attitude change of ± 10 degrees in pitch need not be exceeded. The configuration and trim may be different at each trim condition, but they must remain fixed while determining the attitude-speed variations about the trim condition. The fuselage reference bank attitudes must not exceed ± 10 degrees at any trim speed. These requirements shall be satisfied at all forward trim speeds, backward trim speeds, and sideward trim speeds both to the left and to the right, up to the limits of the operational flight envelope or 35 knots, whichever is less in magnitude.

3.17.6 Sensitivity of Equilibrium Control Power to Steady Winds. The local slope of the equilibrium control power-speed relationships shall not exceed the values in Table 3(3.17) for the specified axes of velocity in either direction. The configuration must remain fixed while determining the equilibrium control power-speed relationships. The requirements involving purely horizontal speeds shall be satisfied at all forward trim speeds, backward trim speeds, and sideward trim speeds both to the left and to the right, up to the limits of the operational flight envelope or 60 knots, whichever is less in magnitude. The requirements involving purely vertical trim speeds shall be satisfied in both up and down directions to the limits of the operational flight envelope or 1200 feet per minute, whichever is less in magnitude.

TABLE 3(3.17). MAXIMUM SENSITIVITY OF EQUILIBRIUM CONTROL POWER TO TRIMMED VELOCITIES

Axis of Velocity	Control Power	Maximum Sensitivity
Longitudinal	Longitudinal	TBD $(\frac{rad}{sec^2\text{-}kt})$
	Vertical	TBD $(\frac{g}{kt})$
Lateral	Lateral	TBD $(\frac{rad}{sec^2\text{-}kt})$
	Directional	TBD $(\frac{rad}{sec^2\text{-}kt})$
Vertical	Vertical	TBD $(\frac{g}{ft/min})$

3.17.7 Pitch Attitude Response to Longitudinal Gust Velocity. The maximum allowable pitch attitude response shall not exceed the limits in Table 4(3.17) in the presence of a decreasing headwind velocity step function representative of "moderate" turbulence with manual or automatic closed-loop regulation of longitudinal position while stationkeeping in hover or low speed.

3.17.8 Longitudinal Position Response to Longitudinal Gust Velocity. The maximum allowable longitudinal position response shall not exceed the limits in Table 5(3.17) in the presence of a decreasing headwind velocity step function representative of "moderate" turbulence with manual or automatic closed-loop regulation of longitudinal position while stationkeeping in hover or low speed.

3.17.9 Roll Attitude Response to Lateral Gust Velocity. The maximum allowable roll attitude response shall not exceed the limits in Table 6(3.17) in the presence of a decreasing crosswind velocity step function representative of "moderate" turbulence with manual or automatic closed-loop regulation of lateral position while stationkeeping at hover or low speed.

TABLE 4(3.17). PITCH ATTITUDE RESPONSE TO A DECREASING HEADWIND VELOCITY STEP FUNCTION WITH MANUAL OR AUTOMATIC CLOSED-LOOP REGULATION OF LONGITUDINAL POSITION WHILE STATIONKEEPING AT HOVER OR LOW SPEED

Type of Closed Loop Regulation of Longitudinal Position	Type of Response Required by Table 1(3.3)	Response Parameter [Fig. 1(3.17)]	Flying Qualities		
			Level 1	Level 2	Level 3
Manual	Rate	$\frac{\Delta\theta_{max}}{\Delta\theta_{ss}}$	TBD	TBD	TBD
		max $\Delta\tau^{\theta}_{u_g}$ (sec)	TBD	TBD	TBD
Manual	Rate with Attitude Hold	$\frac{\Delta\theta_{max}}{\Delta\theta_{ss}}$	TBD	TBD	TBD
		max $\Delta\tau^{\theta}_{u_g}$ (sec)	TBD	TBD	TBD
Manual	Attitude	$\frac{\Delta\theta_{max}}{\Delta\theta_{ss}}$	TBD	TBD	TBD
		max $\Delta\tau^{\theta}_{u_g}$ (sec)	TBD	TBD	TBD
Manual	TRC	$\frac{\Delta\theta_{max}}{\Delta\theta_{ss}}$	TBD	TBD	TBD
		max $\Delta\tau^{\theta}_{u_g}$ (sec)	TBD	TBD	TBD
Automatic	TRC with Position Hold	$\frac{\Delta\theta_{max}}{\Delta\theta_{ss}}$	TBD	TBD	TBD
		max $\Delta\tau^{\theta}_{u_g}$ (sec)	TBD	TBD	TBD

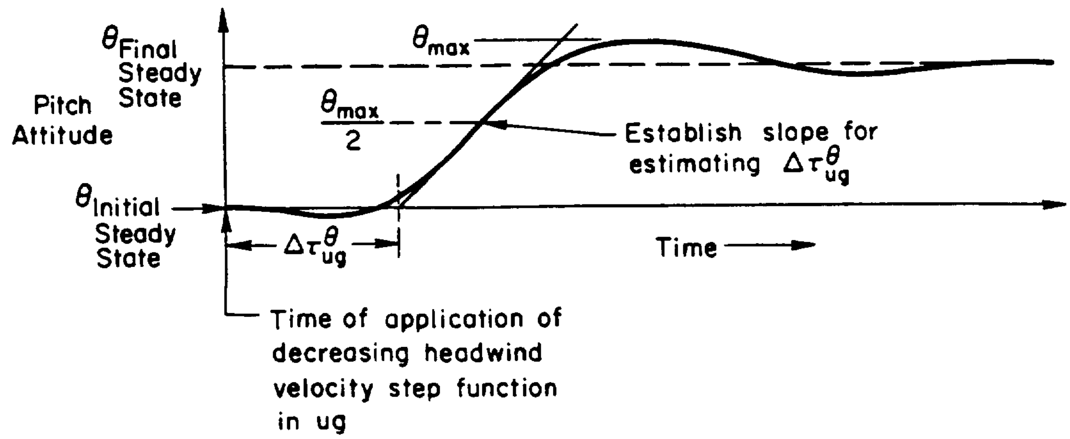


Figure 1(3.17). Definitions of Pitch Attitude Response Parameters in Table 4(3.17)

$$\frac{\Delta\theta_{max}}{\Delta\theta_{ss}} = \frac{[\theta_{max} - \theta_{initial}]_{steady\ state}}{[\theta_{final} - \theta_{initial}]_{steady\ state}}$$

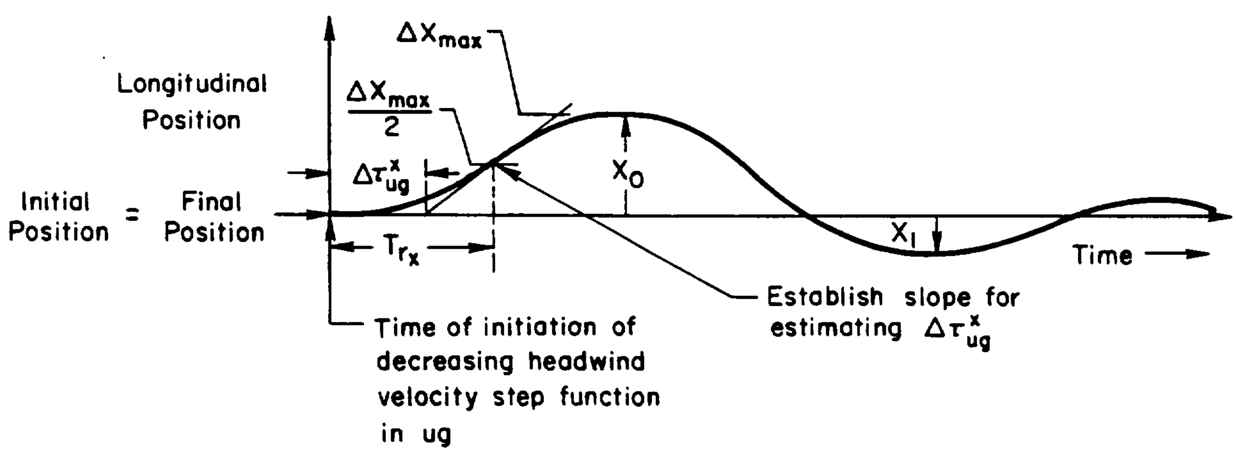


Figure 2(3.17). Definitions of Longitudinal Position Response Parameters in Table 5(3.17)

TABLE 5(3.17). LONGITUDINAL POSITION RESPONSE TO A DECREASING HEADWIND VELOCITY STEP FUNCTION WITH MANUAL OR AUTOMATIC CLOSED-LOOP REGULATION OF LONGITUDINAL POSITION WHILE STATIONKEEPING AT HOVER OR LOW SPEED

Type of Closed Loop Regulation of Longitudinal Position	Type of Response Required by Table 1(3.3)	Response Parameter [Fig. 2(3.17)]		Flying Qualities		
				Level 1	Level 2	Level 3
Manual	Rate	T_{r_x} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^{x}_{u_g}$	Max	TBD	TBD	TBD
		X_1/X_o	Max	TBD	TBD	TBD
Manual	Rate with Attitude Hold	T_{r_x} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^{x}_{u_g}$	Max	TBD	TBD	TBD
		X_1/X_o	Max	TBD	TBD	TBD
Manual	Attitude	T_{r_x} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^{x}_{u_g}$	Max	TBD	TBD	TBD
		X_1/X_o	Max	TBD	TBD	TBD
Manual	TRC	T_{r_x} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^{x}_{u_g}$	Max	TBD	TBD	TBD
		X_1/X_o	Max	TBD	TBD	TBD
Automatic	TRC with Position Hold	T_{r_x} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^{x}_{u_g}$	Max	TBD	TBD	TBD
		X_1/Xo	Max	TBD	TBD	TBD

TABLE 6(3.17). ROLL ATTITUDE RESPONSE TO A DECREASING CROSSWIND VELOCITY STEP FUNCTION WITH MANUAL OR AUTOMATIC CLOSED-LOOP REGULATION OF LATERAL POSITION WHILE STATIONKEEPING AT HOVER OR LOW SPEED

Type of Closed Loop Regulation of Lateral Position	Type of Response Required by Table 1(3.3)	Response Parameter [Fig. 1(3.17)]*	Flying Qualities		
			Level 1	Level 2	Level 3
Manual	Rate	$\frac{\Delta\phi_{max}}{\Delta\phi_{ss}}$	TBD	TBD	TBD
		max $\Delta\tau^{\phi}_{v_g}$ (sec)	TBD	TBD	TBD
Manual	Rate with Attitude Hold	$\frac{\Delta\phi_{max}}{\Delta\phi_{ss}}$	TBD	TBD	TBD
		max $\Delta\tau^{\phi}_{v_g}$ (sec)	TBD	TBD	TBD
Manual	Attitude	$\frac{\Delta\phi_{max}}{\Delta\phi_{ss}}$	TBD	TBD	TBD
		max $\Delta\tau^{\phi}_{v_g}$ (sec)	TBD	TBD	TBD
Manual	TRC	$\frac{\Delta\phi_{max}}{\Delta\phi_{ss}}$	TBD	TBD	TBD
		max $\Delta\tau^{\phi}_{v_g}$ (sec)	TBD	TBD	TBD
Automatic	TRC with Position Hold	$\frac{\Delta\phi_{max}}{\Delta\phi_{ss}}$	TBD	TBD	TBD
		max $\Delta\tau^{\phi}_{v_g}$ (sec)	TBD	TBD	TBD

*Use Fig. 1(3.17) with $\theta = \phi$, $u_g = v_g$, "pitch" = "roll," and "Headwind" = Crosswind"

3.17.10 Lateral Position Response to Lateral Gust Velocity. The maximum allowable lateral position response shall not exceed the limits in Table 7(3.17) in the presence of a decreasing crosswind velocity step function representative of "moderate" turbulence with manual or automatic closed-loop regulation of lateral position while stationkeeping at hover or low speed.

3.17.11 Directional Response to Sidestep or Lateral Gust Velocity. The maximum allowable heading response shall not exceed the limits in Table 8(3.17) in the presence of a sidestep or a decreasing crosswind velocity step function representative of "moderate" turbulence with manual or automatic closed-loop regulation of heading while stationkeeping at hover or low speed.

3.17.12 Vertical Position Response to Vertical Gust Velocity. The maximum allowable vertical position response shall not exceed the limits in Table 9(3.17) in the presence of a decreasing up-draft velocity step function representative of "moderate" turbulence with manual or automatic closed-loop regulation of vertical position while stationkeeping at hover or low speed.

3.17.13 Requirements for Rotorcraft Failure States in Atmospheric Disturbances. Failure states shall be evaluated in moderate levels of atmospheric disturbance.

a. A Level 2 rotorcraft shall not degrade below Level 3 in the presence of failures and moderate atmospheric disturbances.

b. A Level 3 rotorcraft shall have flying qualities in the presence of failures and moderate atmospheric disturbances such that control can be maintained long enough to fly out of the disturbance.

TABLE 7(3.17). LATERAL POSITION RESPONSE TO A DECREASING CROSSWIND VELOCITY STEP FUNCTION WITH MANUAL OR AUTOMATIC CLOSED-LOOP REGULATION OF LATERAL POSITION WHILE STATIONKEEPING AT HOVER OR LOW SPEED

Type of Closed Loop Regulation of Lateral Position	Type of Response Required by Table 1(3.3)	Response Parameter [Fig. 2(3.17)]*		Flying Qualities		
				Level 1	Level 2	Level 3
Manual	Rate	T_{r_y} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^y_{v_g}$	Max	TBD	TBD	TBD
		Y_1/Y_o	Max	TBD	TBD	TBD
Manual	Rate with Attitude Hold	T_{r_y} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^y_{v_g}$	Max	TBD	TBD	TBD
		Y_1/Y_o	Max	TBD	TBD	TBD
Manual	Attitude	T_{r_y} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^y_{v_g}$	Max	TBD	TBD	TBD
		Y_1/Y_o	Max	TBD	TBD	TBD
Manual	TRC	T_{r_y} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^y_{v_g}$	Max	TBD	TBD	TBD
		Y_1/Y_o	Max	TBD	TBD	TBD
Automatic	TRC with Position Hold	T_{r_y} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^y_{v_g}$	Max	TBD	TBD	TBD
		Y_1/Y_o	Max	TBD	TBD	TBD

*Use Fig. 2(3.17) with $x = y$, $u_g = v_g$, "Longitudinal" = "Lateral," and "Headwind" = "Crosswind."

TABLE 8(3.17). HEADING RESPONSE TO A SIDESTEP OR DECREASING CROSSWIND VELOCITY STEP FUNCTION WITH MANUAL OR AUTOMATIC CLOSED-LOOP REGULATION OF HEADING WHILE STATIONKEEPING AT HOVER OR LOW SPEED

Type of Closed Loop Regulation of Heading	Type of Response Required by Table 1(3.3)	Response Parameter [Fig. 2(3.17)]		Flying Qualities		
				Level 1	Level 2	Level 3
Manual	Rate	T_{r_ψ} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^{\psi}_{v_g}$	Max	TBD	TBD	TBD
		ψ_1/ψ_o	Max	TBD	TBD	TBD
Automatic	Rate with Attitude Hold	T_{r_ψ} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^{\psi}_{v_g}$	Max	TBD	TBD	TBD
		ψ_1/ψ_o	Max	TBD	TBD	TBD
Automatic	Attitude, TRC, or TRC with Position Hold	T_{r_ψ} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^{\psi}_{v_g}$	Max	TBD	TBD	TBD
		ψ_1/ψ_o	Max	TBD	TBD	TBD

*Use Fig. 2(3.17) with $x = \psi$, $u_g = v_g$, "Longitudinal Position" = "Heading," and "Headwind" = "Crosswind."

TABLE 9(3.17). VERTICAL POSITION RESPONSE TO A DECREASING UP-DRAFT STEP FUNCTION WITH MANUAL OR AUTOMATIC CLOSED-LOOP REGULATION OF VERTICAL POSITION WHILE STATIONKEEPING AT HOVER OR LOW SPEED

Type of Closed Loop Regulation of Directional Position	Type of Response Required by Table 1(3.3)	Response Parameter [Fig. 2(3.17)]*		Flying Qualities		
				Level 1	Level 2	Level 3
Manual	Rate	T_{r_z} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^z_{w_g}$	Max	TBD	TBD	TBD
		Z_1/Z_o	Max	TBD	TBD	TBD
Manual	Rate with Attitude Hold	T_{r_z} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^z_{w_g}$	Max	TBD	TBD	TBD
		Z_1/Z_o	Max	TBD	TBD	TBD
Manual	Attitude	T_{r_z} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^z_{w_g}$	Max	TBD	TBD	TBD
		Z_1/Z_o	Max	TBD	TBD	TBD
Manual	TRC	T_{r_z} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^z_{w_g}$	Max	TBD	TBD	TBD
		Z_1/Z_o	Max	TBD	TBD	TBD
Automatic	TRC with Position Hold	T_{r_z} (sec)	Max	TBD	TBD	TBD
			Min	TBD	TBD	TBD
		$\Delta\tau^z_{w_g}$	Max	TBD	TBD	TBD
		Z_1/Z_o	Max	TBD	TBD	TBD

*Use Fig. 2(3.17) with $x = z$, $u_g = w_g$, "Longitudinal" = "Vertical," and "Headwind" = "Up-draft."

3.18 CONTROL MODE BLENDING

This section will be written during Phase II and will include requirements on blending time and method of actuation, i.e., pilot or automatic. The effect of this type of trim (series or parallel) will also be included.

4. QUALITY ASSURANCE PROVISIONS

4.1 PROCEDURES FOR DEMONSTRATING COMPLIANCE

Compliance with the quantitative requirements of Section 3 shall be demonstrated through analysis. In addition, compliance with many of the requirements will be demonstrated by simulation, model test, flight test, or a combination of the three. The methods for demonstrating compliance shall be established by agreement between the procuring activity and the contractor. Representative flight conditions, configurations, external store complements, loadings, etc., shall be determined for detailed investigations in order to restrict the number of design and test conditions. The selected design points must be sufficient to allow accurate extrapolation to the other conditions at which the requirements apply.

4.1.1 Analysis. The analytical methods, procedures, assumptions, etc., applied shall be made available to the procuring activity. In some instances (e.g., control power) compliance may be demonstrated partially or wholly by analysis when the analytical model is validated with flight test data and approved by the procuring activity. In other instances (e.g., control in turbulence) analysis will provide information on specific test conditions requiring simulation, flight test, or both.

4.1.2 Simulation. The danger, extent, or difficulty of flight testing may dictate simulation rather than flight test to evaluate some conditions and events, such as the influence of severe disturbances, hazardous events close to the ground, combined failure states and disturbances, etc. In addition, by agreement with the procuring activity, piloted simulation shall be performed before the first flight of a new rotorcraft design in order to demonstrate the suitability of the flying and handling qualities and also to demonstrate compliance with qualitative requirements in atmospheric disturbances. Where simulation is the ultimate method of demonstrating compliance for a requirement, the simulation model shall be validated fully with flight test data.

4.1.3 Model Test. Model testing may be the only practical way for demonstrating compliance with some of the requirements in this specification, e.g., the ditching and flotation requirements of Paragraph 3.15 can be demonstrated by model test much more safely and practically than by full scale test or flight test.

4.1.4 Flight Test. The required flight tests will be defined by operational, technical, and safety considerations as decided jointly by the procuring activity, the test agency, the contractor, and other involved agencies using results from Paragraphs 4.1.2 and 4.1.3. It is expected that flight test demonstration of the requirements in calm air and selected requirements in at least moderate turbulence will be accomplished.

4.2 DESIGN AND TEST CONDITIONS

4.2.1 Test Conditions. Table 1(4.2) specifies general guidelines, but the peculiarities of the specific rotorcraft design may require additional or alternate test conditions. [Table 1(4.2) includes columns for the requirement number in Section 3, title of the requirement, critical distribution(s) of loading, normal load factor(s), altitude(s), speeds, flight phase(s), tasks, and both deterministic and stochastic components of flight environments.]

4.2.2 Mission Task Compliance Demonstration. Each mission task element specified by the procuring agency from Tables 1(3.2) and 2(3.2) shall be flight tested according to the quantitative requirements of Appendix A.

4.3 DOCUMENTATION

Each requirement for which compliance is demonstrated shall be documented in a report. Demonstration of compliance through flight test shall be documented both for the requirements of Section 3 and of Appendix A in a final report. Cooper-Harper ratings taken in the process of demonstrating compliance should be included whenever appropriate for the purpose of expanding the flying qualities data base.

5. PREPARATION FOR DELIVERY

Section 5 is not applicable to this specification.

6. NOTES

6.1 INTENDED USE

6.2 DEFINITIONS

6.2.1 General.

6.2.2 Speeds.

6.2.3 Thrust and Power.

6.2.4 Control Parameters.

6.2.5 Longitudinal Parameters.

6.2.6 Lateral-Directional Parameters.

6.2.7 Flight Envelopes.

6.3 GAIN SCHEDULING

6.4 EFFECTS OF AEROELASTICITY, CONTROL EQUIPMENT, AND STRUCTURAL DYNAMICS

6.5 APPLICATIONS OF LEVELS

6.6 SUPERSEDING DATA

6.7 RELATED DOCUMENTS AND CROSS REFERENCE INDEX

APPENDIX A

DEFINITION OF FLYING QUALITY TASKS FOR DIRECT PERFORMANCE ASSESSMENT

NOTE: Successful demonstration of these task requirements will satisfy the compliance requirements of this specification for the purposes of demonstrating mission suitability.

A.1 DEFINITIONS OF MISSION TASK ELEMENTS--NEAR EARTH MANEUVERING

A.1.1 Hover Flight Phase.

A.1.1.1 Hover.

a. Spot Hover (IGE). In _____-knot winds from _____ degrees relative bearing, with gusts up to ____ knots, UCE* Level ____, maintain (for at least ___ minutes) the rotorcraft's c.g. within a ___ foot-radius circle. Altitude ± _____ feet, zero ground speed ± _____ knots, heading and attitude ± ___ degrees.

b. Spot Hover (OGE). In _____-knot winds from _____ degrees relative bearing, in gusts up to ___ knots, UCE Level ___, maintain (for at least ___ minutes) altitude ___ feet, ± ___ feet, c.g. within a _____-foot radius circle. Zero ground speed ± ____ knots, heading and attitude ± ___ degrees.

c. Example from AAH Spec.

10.3.3.1.1 It shall be possible to hover in calm air (winds up to 5 knots at any azimuth) over a given spot on the ground for all terrain clearances up to the disappearance of ground effect, with less than ± 0.25 inch of cyclic and ± 1.0 inch directional control movement (for collective requirement, see 10.3.7.1).

10.3.7.1 It shall be possible to maintain positive control of altitude within ± 0.5 foot by use of the collective control while hovering at constant rotor speed throughout the rotorcraft loading and hovering envelopes under the conditions of 10.3.3.1.1. This shall be accomplished with a minimum amount of collective control motion required, and in any case it shall be possible to accomplish this with less than ± 0.5 inch movement of the collective control. There shall be no objectionable vertical oscillation tendencies resulting from engine governor response.

10.3.7.2 The collective control shall not tend to vary from its trim position whether or not flight, thrust, or power controls are moved.

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*Usable Cue Environment (UCE).

A.1.1.2 Precision Hover in a Confined Area (Critical Azimuth, Wind, etc.). (See above requirements.)

A.1.1.3 Hover Turns.

a. (TBD) Deg Hovering Turns (IGE, OGE). Same as spot hover but start and stop within ± ___ degrees of prescribed heading.

A.1.1.4 Hover Rescue of Personnel by External Hoist.

A.1.1.5 Sonar Dunking.

a. Establish Spot Hover and Dunk. In ___-knot winds from ____ degrees relative bearing, with gusts up to ____ knots, UCE Level ____, maintain (for at least ____ min) the rotorcraft's c.g. within a ___ foot-radius circle. Altitude ± ____ feet, zero ground speed ± ____ knots, heading and attitude ± ____ degrees. Dunk up to ____ pounds load having dimensions less than ___ feet long by ___ feet wide by ___ feet high and described as ____________________.

A.1.1.6 Shipboard Stationkeeping.

a. Vertrep Stationkeeping. Engage automatic hover position control system with altitude and heading hold functions. Maintain (for at least ____ minutes) prescribed position within a ____ foot-radius circle, altitude ± ____ feet, zero ground speed ± ___ knots, heading and attitude ± ___ degrees.

A.1.1.7 Suspended Loads (Acquisition and Deposit).

a. Acquisition. In ____-knot winds from ____ degrees relative bearing, with gusts up to ____ knots, UCE Level ____, maintain (for at least _____ minutes) the rotorcraft's c.g. within a _____ foot-radius circle. Altitude ± ___ feet, zero ground speed ± ___ knots, heading and attitude ± ____ degrees. Acquire up to ____ pounds load having dimensions less than ____ feet long by ____ feet wide by ___ feet high and described as ______________________________.

A.1.1.8 Vertical Climb. Same as spot hover except for ____ feet change in altitude. Climb at ___ feet per minute to prescribed altitude, ± ___ feet.

A.1.1.9 Vertical Descent. Same as spot hover except for ___ feet change in altitude. Descend from prescribed altitude at _____ feet per minute, ± ___ feet per minute, to IGE hover.

A.1.2 Takeoff Flight Phase.

A.1.2.1 Takeoff to Hover. It shall be possible to make satisfactory, safe vertical takeoffs in 45-knot winds (with ± 15 percent gust velocities) with wind azimuths ± 45 degrees from the nose of the rotorcraft or 35-knot winds (with ± 15 percent gust velocities) from any azimuth.

A.1.2.2 Normal Takeoff.

A.1.2.3 Obstacle Clearance Takeoff.

A.1.2.4 Jump Takeoff.

A.1.2.5 Maximum Performance Takeoff.

A.1.2.6 Terrain Flight Takeoff.

A.1.2.7 Rolling Takeoff. From a level paved surface, it shall be possible to make satisfactory, safe rolling takeoffs with wheel type gear up to ground speeds of 35 KTAS.

A.1.2.8 Slope Takeoff.

A.1.2.9 Shipboard Takeoff.

A.1.3 Landing Flight Phase.

A.1.3.1 Landing From Hover. It shall be possible to make satisfactory, safe vertical landings in 45-knot winds (with ± 15 percent gust velocities) with wind azimuths ± 45 degrees from the nose of the rotorcraft or 35-knot winds (with ± 15 percent gust velocities) from any azimuth.

A.1.3.2 Normal Approach and Landing.

a. Under UCE Level ____, with ____-knot winds from ____ degrees relative bearing in gusts up to ___ knots, at approach speed, ± ___ knots, maintain ____ degrees descent, ± ___ degrees, attitude and heading ± ___ degrees.

b. Final Approach; UCE Level ____, proceeding from descent at 100-foot height, touch down within _______ feet of desired spot at less than _____ feet per second sink rate and 0 to _____ knots ground speed. Maintain heading ± ___ degrees, roll attitude ± ___ degrees.

c. Assault Landings, UCE Level _____, with ______-knot winds from ____ degrees relative bearing in gusts up to ____ knots, from a speed of _____ knots at ____-feet altitude, come to landing within ____ feet of desired spot at less than ___-feet per second sink rate and 0 to ___ knots ground speed in no more than _______ seconds, maintaining heading ± ___ degrees

d. Low-Speed Assault Landing. From a speed of 60 knots at _____-foot altitude, establish maximum rate of turn and execute landing on point of maneuver initiation in no more than ___ seconds.

d. Example from AAH Spec.

10.3.7.3 During approaches to a landing or to a hover from forward flight, it shall be possible to control vertical speed to within ± 1.0 foot per second with less than ± 0.5 inch movement of the collective control in calm wind conditions (winds less than 5 knots).

A.1.3.3 Shipboard Landing. With Wind over deck at _____ knots from _____ degrees, Sea State _____, approach bearing _____ degrees, UCE Level _____, maintain lineup ± _____ degrees, closure rate _____ knots ± _____ knots. Maintain altitude _____ feet ± _____ feet until acquiring ____ degrees ± ____ degrees glide slope. Reduce closure rate to ___ knots ± ____ knots on glide slope until range to go becomes less than ___ feet. Arrest closure rate and descent rate over designated stationkeeping position at height over deck ___ feet ± ___ feet. (If vertrep, maintain stationkeeping position for ____ minutes to place and release load). If recovery is by RAST, maintain stationkeeping position until a messenger cable is lowered, connected to a recovery-assist cable from the shipboard unit, and raised until the shipboard cable automatically connects to a probe in the rotorcraft. Call for _____ pounds ± _____ pounds cable tension. Maintain stationkeeping position until anticipated lull in deck motion will be acceptable for touchdown within ______ feet of desired spot at less than ____ feet per second sink rate and zero ± ____ knots closure rate while maintaining heading ____ degrees ± ____ degrees and attitude ± ___ degrees.

a. Example from LAMPS MK. III Specification.

10.3.2.7.3 The rotorcraft employing automatic stabilization and stability augmentation equipment shall possess a sufficient degree of stability and control with all the equipment disengaged to allow continuation of flight and the maneuvering necessary to permit a landing under instrument flight rules (IFR); 200 foot ceiling above deck, 1/2 mile visibility. For this situation, the landing platform is construed to be an aviation facilities ship deck of the FFG-7 class size or larger. Landing conditions shall not be less than 25 knots wind over the deck, 10 degrees ship roll in Sea State 5. The recovery assist and securing system shall be utilized as required.

A.1.3.4 Run-On Landing. For both power-on and autorotative conditions, it shall be possible to make satisfactory, safe run-on landings on a level paved surface, with wheel and skid gear, up to ground speeds of 35 knots. This shall include landings with 3 knots ground speed in any direction and up to a side drift of at least 6 knots when landing with a ground speed of 35 knots.

A.1.3.5 Slope Landing. The rotorcraft shall be capable of making satisfactory takeoffs from and landings onto sloped terrain in calm winds (winds less than 5 knots from any azimuth relative to the nose of the helicopter). Takeoffs from and landings onto a slope as defined in Table A.1.3.5 will be possible with any rotorcraft orientation relative to

TABLE A.1.3.5. DEFINITION OF LANDING ON A SLOPE

Type of Mission Task	Slope Landing Requirements for All Azimuths, (deg)	Slope Landing Requirements With The Longitudinal Axis Oriented 90 deg, (deg)
All mission tasks except the following	8 deg	8 deg
Scout and attack	10 deg	10 deg
Shipboard landing* and medium transport	12 deg	12 deg
Tactical and assault transport	12 deg	15 deg
Heavy lift transport	15 deg	15 deg

the slope. Additionally, for normal loadings, landing onto a slope as defined in Table 1(3.14) shall be possible with the helicopter longitudinal axis oriented 90 degrees (sideways) to the slope (full control displacement may be used).

A.1.3.6 <u>Steep Approach</u>.

A.1.3.7 <u>RAST Recovery</u>.

A.1.3.8 <u>Water Landing</u>.

A.1.4 <u>Near Earth Maneuver Flight Phase</u>.

A.1.4.1 <u>Bob-Up/Bob-Down</u>.

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*Sikorsky document SER 520189 states that 12 degrees is okay for the SH-60B.

a. Unmask Bob-Up (IGE, OGE). Same as spot hover except for ____ feet vertical displacement from behind mask (upwind or downwind) up to prescribed altitude ± ______ feet in ______ seconds, and maintain position for ___ seconds.

b. Remask Bob-Down (OGE, IGE). Same as spot hover except for ____ feet vertical displacement down to prescribed height, ± ___ feet behind mask in ___ seconds, and maintain position for ___ seconds.

A.1.4.2 Sidestep Unmask/Remask.

a. Unmask (L,R) Sidestep (OGE, IGE). Same as spot hover except for ____ ft lateral displacement from behind mask (upwind or downwind) to prescribed position within a ____ foot-radius circle in ____ seconds, and maintain position for ___ seconds.

b. Remask (R,L) Sidestep. Same as spot hover except for ____ feet lateral displacement to prescribed position within a ____ foot-radius circle behind mask in ______ seconds, and maintain position for ___ seconds.

A.1.4.3 Dash/Quickstop. In _____-knot winds from _____ degrees relative bearing, with gusts up to ____ knots, UCE Level ____, from spot hover dash forward ___ feet on a straight course toward a mask as fast as possible and terminate in a quickstop behind mask within a ___ foot-radius circle while maintaining prescribed altitude IGE ± _____ feet, heading ± ___ degrees, and roll attitude ± ___ degrees.

Example from AAH Spec.

10.3.3.1.3 With the rotorcraft trimmed in stabilized level flight in ground effect (IGE) at maximum forward speed, it shall be possible to safely accomplish a "quick stop" decelerating maneuver to IGE hover. It shall be possible to accelerate, using maximum continuous power, from a trimmed IGE hover condition to maximum forward speed. The variation in lateral cyclic and directional control shall be minimal during these maneuvers. Collective, power, and thrust control manipulation shall not result in an objectionable pilot workload.

A.1.4.4 Sideward Flight. (L,R) Sideward flight at ___ knots CAS. With ______-knot winds from ______ degrees relative bearing in gusts up to _____ knots, UCE Level _____, maintain prescribed altitude ± _____ feet, airspeed ± ___ knots, heading and attitude ± ___ degrees.

A.1.4.5 Lateral Acceleration.

A.1.4.6 Low Speed Control.

a. Example from AHIP Specification. This requirement applies for all gross weight and altitudes at which it is possible to hover IGE under zero wind conditions. It shall be possible to obtain and maintain heading for any steady level flight velocities up to 35 knots with gust spreads up to 20 knots (i.e., winds varying from 15 to 35 knots) with minimum pilot workload and without requiring unusual control manipulation. For steady translational flight or hover in steady winds, the objective is that the heading and directional control deviations should be such that the root mean squared (RMS) deviations from trim not exceed 2.0 degrees and 0.22 inches, respectively. If automatic stabilization and control or stability augmentation equipment, or both, are utilized to meet this requirement, a failure or disengagement shall not result in RMS deviations more than double those specified above.

A.1.4.7 Rearward Flight. Rearward flight at ______ knots CAS. With _____ knots winds from _____ degrees relative bearing in gusts up to _____ knots, UCE Level _____, maintain prescribed altitude ± _____ feet, airspeed ± ___ knots, heading and attitude ± ___ degrees.

A.1.4.8 Lateral/Vertical Displacement Maneuver.

a. Example from UTTAS Specification.

10.3.3.3.2 The rotorcraft shall be capable of independent lateral and vertical displacements of 200 feet within 1100 to 1300 feet of longitudinal displacement (measured from the point of the pilot's initial control inputs) at 150 KTAS with zero wind.

A.1.4.9 Pull-Up/Push-Over Maneuver.

a. Example from UTTAS Specification.

10.3.3.3.3 From a level unaccelerated flight condition at 150 KTAS, it shall be possible to attain, within 1.0 second from the initial control input, a sustained load factor of 1.75 g's in a symmetrical pull-up. Following this load factor build-up, it shall be possible to maintain a minimum load factor of 1.75 g's for 3.0 seconds after the initial attainment of 1.75 g's. Airspeed at the end of the 1.75 g, 3.0 second duration segment of the maneuver shall not be less than 120 KTAS. Also, from a level unaccelerated flight condition at 150 KTAS, it shall be possible to attain, within 1.0 second from the initial control input, a sustained load factor of 0.25 g's (0.0 g's desired) in a push-over. Following the attainment of this load factor, it shall be possible to maintain a load factor of 0.25 g's (0.0 g's desired) for 2.0 seconds. At no time during this maneuver shall it be necessary to manipulate the collective pitch purely to maintain the rotorcraft structural integrity; however, collective movement is otherwise authorized. At no time during either the pull-up or push-over maneuvers described above shall angular deviations in roll and yaw greater than ± 10 degrees from the initial unaccelerated level flight conditions be permitted.

A.1.4.10 Mine Countermeasure Towing.

a. Straight and Level Flight at ____ knots CAS. With ____-knot winds from ____ degrees relative bearing in gusts up to ____ knots, UCE Level ____, maintain prescribed altitude ± ____ feet, airspeed ± ____ knots, heading and attitude ± ____ degrees. Maintain ____ pounds ± ____ pounds cable tension.

b. Level Turns. ____-degrees per second turn from straight and level flight. Same as straight and level flight except, instead of heading, maintain prescribed yaw rate ± ____ degrees per second. Maintain cable skew angle ____ degrees ± ____ degrees with ____ pounds ± ____ pounds cable tension.

A.1.4.11 Sling Loads.

a. Climb From Hover. Initial climb, UCE Level ____, accelerate at least ____ knots per second to prescribed climb airspeed ± ____ knots. Maintain heading and roll attitude ± _____ degrees, rate of climb at least ___ feet per minute, ± ___ feet per minute.

b. Straight and Level Flight at ______ knots CAS. With ____-knot winds from ____ degrees relative bearing in gusts up to ____ knots, UCE Level ____, maintain prescribed altitude ± ____ feet, airspeed ± ___ knots, heading and attitude ± ___ degrees.

c. Turns.

d. Contour Flight. UCE Level ____, with winds from any direction up to ______ knots, in gusts up to ______ knots, vertical gusts up to ____ feet per second; follow moderate terrain features (average ridge-to-valley distance ______ feet, average slope _____ degrees) within ______ to ______ feet at ______ knots airspeed, ± ______ knots maintaining heading ± ___ degrees.

e. NOE Flight. UCE Level ___, with winds from any direction up to ____ knots, in gusts up to ___ knots; at ___ knots ± ___ knots ground speed, follow local terrain features with serpentine maneuvers while controlling altitude within ______ to ______ feet and heading within ± ___ degrees of prescribed course.

A.1.4.12 NOE Flight.

a. Terrain Following. UCE Level _____, with winds from any direction up to ______ knots, in gusts up to ______ knots, vertical gusts up to ____ feet per second, follow moderate terrain features (average ridge-to-valley distance 2400 feet, average slope 7.5 degrees) within to ______ feet at ______ knots airspeed, ± ______ knots maintaining heading ± ___ degrees.

b. Nap-of-the Earth Flight. UCE Level ____, with winds from any direction up to ____ knots, in gusts up to ____ knots; at ____ knots ± ____ knots ground speed, follow local terrain features with serpentine maneuvers while controlling altitude within _______ to _______ feet and heading within ± ___ degrees of prescribed course.

A.1.4.13 Slalom. In ____-knot winds from ____ degrees relative bearing, with gusts up to ___ knots, UCE Level ___, negotiate quasi-random serpentine course among ___ obstacles (average obstacle spacing ___ feet, standard deviation in spacing _____ feet) as fast as possible while maintaining prescribed altitude ± ___ feet.

A.1.4.14 Weapon Delivery.

a. Target Tracking. UCE Level _____ (gusts up to _____ knots with _____-knot winds from any direction), maintain pitch attitude and heading ± ______ degrees, roll attitude ± ______ degrees, rate of descent ± ___ feet per minute at rates of descent up to ___ feet per minute.

b. Target Acquisition. UCE Level ____ (gusts up to ____ knots with _____-knot winds from any direction), stabilize change in heading of _____ degrees in no more than _____ seconds to allowances in target tracking.

c. Gunnery Run. In gusts up to ____ knots, UCE Level _____, with ________-knot winds from any direction and rates of descent up to _____ feet per minute at any prescribed airspeed above 60 knots CAS, maintain pitch attitude and heading ± ______ degrees, roll attitude ± ___ degrees, rate of descent ± ___ feet per minute.

d. Tear Drop Maneuver. From a speed of 60 to 100 knots, establish maximum rate of turn, maintaining airspeed ± ____ knots, and execute gunnery run on point of maneuver initiation in no more than ___ seconds.

e. Break Off Maneuver. Change from _____-feet per minite rate of descent, ± ___ feet per minute, to _____ feet per minute rate of climb, ± ____ feet per minute; and change heading 180 degrees, ± ___ degrees, at any prescribed airspeed above 60 knots in no more than ___ seconds.

f. Example: AHIP Maneuvers for Tarket Acquisition and Tracking. (See A.1.4.6)

A.1.5 Autorotation Flight Phase.

A.1.5.1 Autorotation From Hover (Throttle Chop).

A.1.5.2 Autorotation Entry From Level Flight. UCE Level ___. At any airspeed up to V_{max}, establish engine-out rate of descent of _____ feet per minute, ± ____ feet per minute. Maintain pitch and roll attitude ± ___ degrees, heading, ± ___ degrees.

A.1.5.3 Autorotational Landing. UCE Level ____. Starting from prescribed airspeed between 3 and 100 knots, altitude above 300 feet, touch down within 50 feet of desired spot, maintaining heading ± 15 degrees, roll attitude ± 5 degrees, touch down at less than 10-feet per second sink rate, and zero ground speed ± 10 knots.

A.2 DEFINITION OF MISSION TASK ELEMENTS--UP AND AWAY FLIGHT

A.2.1 VMC Flight Phase.

A.2.1.1 Level Flight. Straight and Level Flight at ____ knots CAS. With ____ knots winds from ___ degrees relative bearing in gusts up to ____ knots, UCE Level ____, maintain prescribed altitude ± ____ feet, at ___ knots airspeed ± ___ knots, heading and attitude ± ___ degrees.

A2.1.2 Climb/Descent.

a. ____-feet per minute climb from straight and level flight. Maintain prescribed climb airspeed with tolerances same as straight and level flight except, instead of altitude, maintain prescribed rate of climb ± ___ feet per minute.

b. From straight and level flight at ___ feet ± ___ knots CAS and ______ feet ± ______ feet altitude, establish a rate of descent of ____ feet per minute, ± ____ feet per minute, attitude ± ____ degrees, airspeed ± ___ knots, heading ± ___ degrees in ___ seconds.

A.2.1.3 Acceleration. At least ____________ feet per second, to ________ knots CAS ± ___ knots, while maintaining prescribed altitude, ± ___ feet, roll attitude and heading ± ___ degrees.

A.2.1.4 Deceleration. At least ____________ knots per second, to _______ knots CAS ± ____ knots, while maintaining prescribed altitude, ± ___ feet. roll attitude and heading ± ___ degrees.

A.2.1.5 Level Turns. 3-degrees per second turn from straight and level flight. Same as straight and level flight except, instead of heading, maintain prescribed yaw rate ± ___ degrees per second.

A.2.1.6 Non-Precision Approach.

A.2.1.7 Steep Approach.

A.2.1.8 Formation Flight.

A.2.1.9 Stationkeeping (Air-to-Air Refueling). In ___-knot winds from ____ degrees relative bearing, with gusts up to ____ knots, UCE Level ___, maneuver to acquire prescribed station in turbulence generated by formation. Maintain prescribed separation ± ______ feet, altitude ± ______ feet, airspeed ± ______ knots, heading ± ______ degrees, attitude ± ___ degrees.

A.2.1.10 Mid-Air Retrieval.

A.2.1.11 MAD/Sonobouy Deploy.

A.2.1.12 Instrument Takeoff.

A.2.2 IMC Flight Phase.

A.2.2.1 Level Flight.

A.2.2.2 Level Turns.

A.2.2.3 Climb/Descending Turns.

A.2.2.4 Climbs/Descents. Climb IFR from straight and level flight. Maintain prescribed climb airspeed ± ______ knots, heading ± ____ degrees, attitude ± ____ degrees, rate of climb ____ feet per minute, ± ____ feet per minute.

A.2.2.5 Accelerations/Decelerations.

A.2.2.6 Precision Instrument Approach.

A.2.3 Maneuvering Flight.

A.2.3.1 Sustained G Turn to Limit.

A.2.3.2 Decelerating G Turn.

A.2.3.3 Air-to-Air Maneuvers (Yo-Yo's, Scissors, etc.).

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16. Abstract

The structure of a new flying and ground handling qualities specification for military rotorcraft is presented in the first of two volumes. This preliminary specification structure is intended to evolve into a replacement for specification MIL-H-8501A. The new structure is designed to accommodate a variety of rotorcraft types, mission flight phases, flight envelopes, and flight environmental characteristics and to provide criteria for three levels of flying qualities, a systematic treatment of failures and reliability, both conventional and multiaxis controllers, and external vision aids which may also incorporate synthetic display content. Existing and new criteria have been incorporated into the new structure wherever they can be substantiated. A supplement to the new structure is presented in the second of the two volumes in order to explain the background and rationale for the specification structure, the proposed forms of criteria, and the status of the existing data base. Critical gaps in the data base for the new structure are defined, and recommendations are provided for the research required to address the most important of these gaps.

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