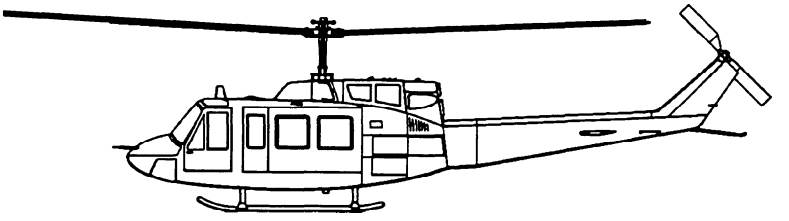
U.S Department
of Transportation

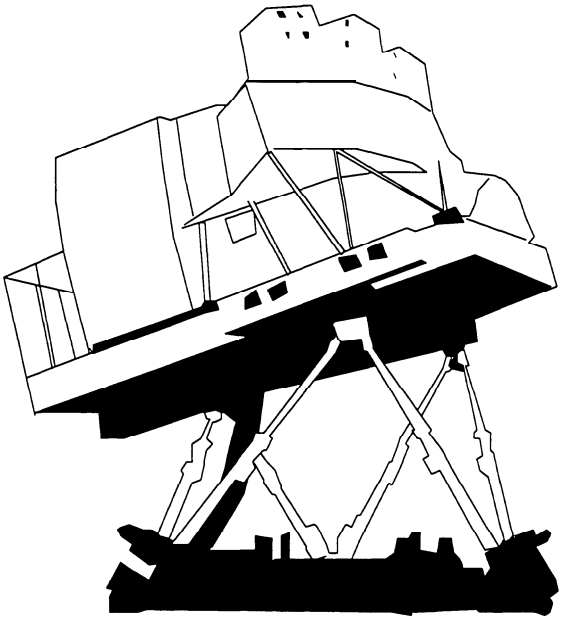
Federal Aviation
Administration

Advisory Circular

AC 120-63
Date: 10/11/94

HELICOPTER SIMULATOR QUALIFICATION





Initiated By: AFS-205

U.S. Department
of Transportation

Federal Aviation Administration

Advisory Circular

Subject: **HELICOPTER SIMULATOR QUALIFICATION**

Date: **10/11/94** AC No: **120-63**
Initiated by: **AFS-205**

1. PURPOSE. This advisory circular (AC) provides an acceptable means, but not the only means, for qualifying helicopter simulators to be used in training programs or for airman checking under various parts of the Federal Aviation Regulations (FAR). Criteria specified in this AC are those used by the Federal Aviation Administration (FAA) to determine whether a simulator is qualified for such training and checking and, if so, the qualification level. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the pertinent FAR. Mandatory terms used in this circular such as "shall" or "must" are used to ensure compliance with the criteria set forth in the advisory circular when the acceptable method of compliance described herein is used. Applicable regulations must also be referenced to ensure compliance with the provisions therein. This AC does not change regulatory requirements or create additional ones, and does not authorize changes in, or deviations from, regulatory requirements. This AC applies only to the evaluation of helicopter simulators. Criteria for the evaluation of airplane simulators are contained in AC 120-40, as revised, "Airplane Simulator Qualification."

2. RELATED FAR SECTIONS. FAR Part 1 and FAR §§ 61.51, 61.55, 61.57, 61.58, 61.63, 61.65, 61.67, 61.155, 61.157, 61.161, 61.163, 135.293, 135.297, 135.323, and 135.335.

3. RELATED READING MATERIAL. AC 150/5300-2, as revised, "Airport Design Standards - Site Requirements for Terminal Navigational Facilities"; AC 150/5340-1, as revised, "Marking of Paved Areas on Airports"; AC 150/5340-4, as revised, "Installation Details for Runway Centerline Touchdown Zone Lighting Systems"; AC 150/5340-19, "Taxiway Centerline Lighting System"; AC 150/5340-21, "Airport Miscellaneous Lighting Visual Aids"; AC 150/5340-24, "Runway and Taxiway Edge Lighting System"; AC 150/5345-28, as revised, "Precision Approach Path Indicator (PAPI) Systems"; AC 150/5390-1, as revised, "Heliport Design Guide"; and AC 120-40, as revised, "Airplane Simulator Qualification."

4. BACKGROUND.

a. The FAA has been involved in flight simulator evaluation and approval for well over three decades. As far back as 1954, air carriers were allowed to perform limited proficiency check maneuvers in AIRPLANE simulators. Credit for the use of these devices was hampered by the state of the technology available in early simulator development. More recently, however, rapid technological advances have permitted and encouraged the expanded use of flight simulators in the training and checking of flight crewmembers. In addition, the complexity, operating costs, and operating environment of modern aircraft have lead to the increasing use of advanced simulator technology. Extensive experience has proven that modern simulators can provide more in-depth training than can be accomplished in the aircraft as well as provide a very high transfer of learning and behavior from the simulator to the aircraft. Their use, in lieu of aircraft, results in safer flight training and cost reductions for the operators, while achieving fuel conservation and a significant reduction in environmental impact.

b. In recognition of expanding flight simulator capabilities, as technology has progressed, FAR revisions have been developed to permit the increased use of AIRPLANE simulators in approved training programs. To date, the FAR have not addressed the training and checking of flight crewmembers in helicopter simulators which, as a result, limited their use. Those helicopter simulators in use today have been evaluated and approved on a case-by-case basis. By exemption to the FAR, some persons have received credits for training and checking received in helicopter simulators. Provisions have been made in this document to permit the continued use of these existing simulators provided they continue to meet the criteria under which they were originally evaluated and approved.

c. The same factors that have led to the widespread use and acceptance of airplane simulators, such as technological advancements, aircraft complexity, operating cost, operating environment, enhanced training, safety, environmental impact, etc., have recently spurred a dramatic increase in interest in helicopter simulators. It is anticipated that the use of helicopter simulators will expand rapidly and that applicable regulations will be amended to extend formal credit to the use of helicopter simulators in approved training programs.

d. Evaluation and qualification of simulators and flight training devices are the responsibility of the FAA National Simulator Program Manager (NSPM). The NSPM is also responsible for the development of standards, guidance and policy concerning these devices.

5. DEFINITIONS AND APPLICATION.

a. Helicopter Simulator is a full size replica of a helicopter cockpit, representing a specific type or make, model, and series. It also includes the assemblage of equipment and computer programs necessary to represent the helicopter in ground and flight operations, a visual system providing a real time out-of-the-cockpit view, a control force system, and a motion system which provides cues that are at least equivalent to that of a three-degrees-of-freedom motion system; and is in compliance with the minimum standards for a Level B simulator. Appendix 1 describes the minimum requirements for Level B, Level C, and Level D helicopter simulators.

b. Qualification Test Guide (QTG) is a document designed to validate that the performance and handling qualities of the simulator agree within prescribed limits to those of the helicopter and that all applicable regulatory requirements have been met. The QTG includes both the helicopter and simulator data used to support the validation. The Master Qualification Test Guide (MQTG) is the FAA-approved QTG and incorporates the results of FAA witnessed tests. The MQTG serves as the reference for future evaluations.

c. Convertible Simulator is a simulator in which hardware and software can be changed so that the simulator becomes a replica of a different model, but usually of the same type, helicopter.

d. Highlight Brightness is the area of maximum displayed brightness which satisfies the brightness test in Appendix 1, Item 4.1.

e. Latency is the additional time beyond that of the basic helicopter perceivable response time due to the response time of the simulator. This includes the time delay effects of the computer system, control loading system, motion system, visual system, instruments, and all data communication and interface systems.

f. National Simulator Program Manager (NSPM) is the FAA Manager responsible for the overall administration and direction of the National Simulator Program.

g. Operator, as used in this AC, is the person or organization that requests FAA qualification of a simulator for use within the operator's FAA-approved training program and is responsible for continuing qualification and liaison with the FAA.

h. Simulation Data are the various types of data used by the simulator manufacturer and the applicant to design, manufacture, and test the flight simulator.

i. Simulator Evaluation Specialist is an FAA technical specialist trained to evaluate simulators and to provide expertise on matters concerning simulation.

j. Snapshot is a presentation of one or more variables at a given instant of time. A snapshot is appropriate for a steady state condition in which the variables are constant with time.

k. Statement of Compliance (SOC) is a certification from the operator that specific requirements have been met. The SOC incorporates references to needed sources of information for showing compliance, rationale to explain how the referenced material is used, mathematical equations and parameter values used, and conclusions reached.

l. Time History is a presentation of the change of a variable with respect to time. (It is usually in the form of a continuous data plot over the time period of interest or a printout of test parameter values recorded at multiple constant time intervals over the time period of interest.)

m. Transport Delay is the total simulator system processing time required from a pilot primary flight control input signal until a motion system, visual system, and instrument response. It is the overall time delay incurred from signal input until output response. It does not include the aircraft dynamic response of the helicopter simulated.

n. Upgrade, for the purpose of this AC, means the improvement or enhancement of a simulator for the purpose of achieving a higher level qualification.

o. Validation Flight Test Data, for the purpose of this AC, are the flight and ground handling, performance, stability and control, propulsion, and other necessary test parameters electronically recorded in a helicopter using a calibrated data acquisition system verified as accurate by the company performing the test.

p. Visual System Response Time is the interval from an abrupt control input to the completion of the visual display scan of the first video field containing the resulting different information.

6. DISCUSSION.

a. The procedures and criteria for simulator evaluation and qualification under the National Simulator Program are contained in this AC. There are currently three levels of complexity of helicopter simulators, levels B, C, and D, which are comparable in complexity and intended use to airplane simulators of the same level. Level A is reserved for potential future use. A simulator, qualified by the NSPM in accordance with the guidance and standards herein, will be recommended for approval to the operator's principal operations inspector (POI) or certificate holding district office, as applicable for use within the operator's training program.

b. Evaluation of simulators used for training or certification of airmen under Title 14 CFR fall under the direction of the National Simulator Program. A simulator will be evaluated under the provisions of this AC if it is used in a training program approved for the sponsoring operator under FAR Part 121 or 135 or if it is used as part of the FAA-approved training program by the operator in the course of conducting the Pilot-in-Command Proficiency Check required by FAR § 61.58, the issuance of an airline transport pilot (ATP) certificate or type rating in accordance with the provisions of FAR § 61.163, or the issuance of a type rating in accordance with the provisions of FAR § 61.63.

c. Under the National Simulator Program concept, the simulator is evaluated for a specific operator by an FAA Simulator Evaluation Specialist. Based on a successful evaluation, the NSPM will certify that the simulator meets the criteria of a specific level of qualification. Upon qualification by the NSPM, approval for use of the simulator in the operator's approved training program will be determined by the POI in the case of FAR Part 121, 127, 133, or 135 certificate holders or by the district office responsible for oversight of a training center when the training center is using the simulator to conduct checks required by FAR Part 61 as part of its approved training program.

d. FAA evaluation of a simulator located outside the United States will be performed if the simulator is being used by the U.S. operator to train or certificate U.S. airmen. Evaluations may be conducted otherwise as deemed appropriate by the Administrator on a case-by-case basis.

e. Operators who contract to use simulators already qualified and approved for the sponsoring operator at a particular level for a helicopter type are not subject to the qualification process. However, they are required to obtain FAA approval to use the simulator in their approved training programs.

7. EVALUATION POLICY.

a. The methods, procedures, and standards defined in this AC provide one means, acceptable to the Administrator, to evaluate and qualify a simulator. If an applicant chooses to utilize the approach described in this AC, he must adhere to all of the methods, procedures, and standards herein. However, this is not to imply that the NSPM may not apply sound engineering and/or operational judgment in the review or acceptance of data, data presentations, or other material or elements and have the application remain within the applicability of this particular method of compliance. Should an applicant desire to use another means, a proposal must be submitted to the NSPM for review and approval prior to the submittal of a detailed QTG. During the development of this AC, frequency response methods were discussed, but were not selected as the primary means of simulator validation. The FAA is, however, receptive to proposals using frequency response data as an alternative means of validation.

b. The simulator is evaluated in those areas that are essential to completing the airman training and checking process as required by regulation and by the sponsoring operator's approved training program. This may include the following: aerodynamic responses; performance in hover, takeoff, climb, cruise, descent, autorotation, approach, and landing; flight control checks; cockpit functions checks; and additional requirements depending upon the complexity or qualification level of the simulator. The motion system, instructor station functions, and visual system will also be evaluated to ensure their proper operation.

c. The intent is to evaluate the simulator as objectively as possible. Pilot acceptance, however, is also an important consideration. Therefore, the simulator will be subjected to validation tests presented in Appendix 2 of this AC, and to the functions and subjective tests presented in Appendix 3. These tests include a qualitative assessment of the simulator by an FAA pilot who is qualified in the respective helicopter. Validation tests are used to compare simulator and helicopter data objectively to ensure that they agree within specified tolerances. Functions tests are designed to provide a basis for evaluating simulator capability to perform over a typical training period and to verify correct operation of the simulator controls, instruments, and systems.

d. Tolerances, listed for parameters in Appendix 2, should not be confused with design tolerances specified for simulator manufacture. Tolerances for the parameters listed in Appendix 2 are the maximum acceptable to the Administrator for simulator validation.

e. A convertible simulator will be addressed as a separate simulator for each model and series to which it will be converted and for which FAA qualification will be sought. An FAA evaluation is required for each configuration. For example, if an operator seeks qualification for two models of a helicopter type using a convertible simulator, two QTG's or a supplemented QTG and two evaluations are required.

f. Initial qualification.

(1) Only the aircraft manufacturer's flight test data will be accepted for initial simulator qualification under the following circumstances:

(a) When an original type certificate was issued after June 1980.

(b) When significant amendments are made to an original type certificate.

(c) When a supplemental type certificate would change the handling qualities or performance.

(2) Exceptions to this policy must be submitted to the NSPM for review and consideration. It is the intent of the FAA that all tests listed in this AC be applied to simulator qualification.

(3) The NSPM will consider the use of alternative data from the helicopter manufacturer for helicopters which were type certificated before the issuance of this AC. For older helicopters, additional flight testing may be necessary.

(4) For a new type or model of helicopter, predicted data validated by the manufacturer's preliminary flight test data may be used for an interim period as determined by the FAA. In the event predicted data is used in programming the simulator, it should be updated as soon as practicable when actual helicopter flight test data becomes available. Unless specific conditions warrant otherwise, this update should be accomplished within six months after release of the final flight test data package by the helicopter manufacturer.

g. If a problem with a validation test result is detected by the FAA Simulator Evaluation Specialist, the test may be repeated. If it still does not meet the test criteria, the operator may demonstrate alternative test results which relate to the test in question. In the event a validation test(s) does not meet specified criteria, but the criteria are not considered critical to the level of evaluation being conducted, the NSPM may conditionally qualify the simulator at that level. The operator will be given a specified period of time to correct the problem and submit the QTG changes to the NSPM for evaluation. Alternatively, if it is determined that the results of a validation test would have a detrimental effect on the level of qualification being sought or if the test outcome is a firm regulatory requirement, the NSPM may qualify the simulator to a lesser level or restrict maneuvers based upon the evaluation completed. For example, if a Level D evaluation is requested and the simulator fails to meet hover test criteria, it could be qualified at Level B.

h. Evaluation dates will not be established until the QTG has been reviewed by the NSPM and determined to be acceptable. Within 10 working days of receiving an acceptable QTG, the NSPM will coordinate with the operator and POI to set a mutually acceptable date for the evaluation. To avoid unnecessary delays, the operator is encouraged to work closely with the NSPM during the QTG development process prior to making formal application.

i. At the discretion of the FAA Simulator Evaluation Specialist, the operator's pilots may assist in completing the functions and validation tests during evaluations. However, only FAA personnel should manipulate the pilot controls during the functions check portion of an FAA evaluation.

8. INITIAL OR UPGRADE EVALUATION AND QUALIFICATION.

a. The operator seeking simulator initial or upgrade evaluation and qualification pursuant to this AC must submit a request in writing to the NSPM through the POI or the responsible FAA Flight Standards District Office (FSDO). This request must contain an SOC certifying that the simulator meets all of the provisions of this AC. This shall include a certification that the cockpit configuration of the simulator conforms to that of the helicopter; the specific hardware and software configuration control procedures have been established; and that the simulator is representative of the helicopter in all functional test areas, as confirmed by the operator's designated pilots. A sample letter of request is included in Appendix 4.

b. The operator shall submit a QTG which includes the following:

(1) A title page with the operator and FAA approval signature blocks.

(2) A simulator information page, for each configuration in the case of convertible simulators, providing the following:

(a) Operator's simulator identification number or code.

(b) Helicopter model and series being simulated.

(c) Aerodynamic model and data revisions (as applicable).

(d) Engine model and its data revision.

(e) Plight control model and data revisions (as applicable).

(f) Flight Management System identification and revision level.

(g) Simulator model and manufacturer.

(h) Date of simulator manufacture.

(i) Simulator computer identification.

(j) Visual system model and manufacturer.

(k) Motion system type and manufacturer.

(3) Table of contents.

(4) Log of revision and/or list of effective pages.

(5) Listing of all reference source data.

(6) Glossary of terms and symbols used.

(7) SOC's that shall provide references that include sources of information for showing compliance; rationale to explain how the referenced material is used; mathematical equations and parameter values used; and conclusions reached. Refer to Appendix 1, "Simulator Standards," comments column, for SQC requirements.

(8) Recording procedures or a list of equipment required or the validation tests.

(9) The following for each validation test designated in Appendix 2 of this AC:

(a) Name of the test.

(b) Objective of the test.

(c) Initial conditions.

(d) Manual test procedures.

(e) Automatic test procedures (if applicable).

(f) Method for evaluating simulator validation test results.

(g) Tolerances for relevant parameters.

(h) Source of Helicopter Test Data (document and page number).

(i) Copy of Helicopter Test Data.

(j) Simulator Validation Test Results, as obtained by the operator.

(k) A means, acceptable to the NSPM, of easily comparing the simulator test results to Helicopter Test Data.

c. The operator's simulator validation test results must be recorded on a multichannel recorder, line printer, or other appropriate recording media acceptable to the NSPM. Simulator results shall be labeled using terminology common to helicopter parameters instead of computer software identifications. These results shall be easily compared to the supporting data by employing cross plotting, overlays, transparencies, overplotting of manufacturer data, or other acceptable means. Helicopter data documents included in a QTG may be photographically reduced only if such reduction will not alter the graphic scaling or cause difficulties in scale interpretation or resolution. Incremental scales on graphical presentations must provide the resolution necessary for evaluation of the parameters shown in Appendix 2. The test guide will provide the documented

proof of compliance with the simulator validation tests in Appendix 2. In the case of a simulator upgrade, the operator must run all validation tests needed for the requested qualification level. Validation test results offered in a test guide for a previous initial or upgrade evaluation should not be offered to validate the simulator performance in a test guide offered for a current upgrade. For tests involving time histories, the flight test data sheets or transparencies thereof and the results of the simulator tests shall be marked clearly with the appropriate reference points to ensure an accurate comparison between simulator and helicopter data with respect to time. Operators using line printers to record time histories shall clearly mark that information taken from the line printer data output for cross-plotting on the helicopter data. The cross-plotting of the operator's simulator data to helicopter data is essential to verify simulator performance in each test. During an evaluation, the FAA will perform a detailed check of selected tests from the QTG. The FAA evaluation serves to validate the operator's simulator test results.

d. The completed QTG and the operator's compliance letter and request for the evaluation shall be submitted through the operator's POI. The PQI will then submit the total package with a letter or memorandum of endorsement to the NSPM. The QTG will be reviewed and determined to be acceptable prior to scheduling an evaluation of the simulator.

e. A copy of a QTG for each type simulator by each simulator manufacturer will be required for the NSPM's file. The NSPM may elect not to retain copies of the QTG for subsequent simulators of the same type by a particular manufacturer, but will determine the need for copies on a case-by-case basis. Data updates to an original QTG shall be provided to the NSPM in order to keep FAA file copies current.

f. The operator may elect to accomplish the QTG validation tests while the simulator is at the manufacturer's facility. Tests at the manufacturer's facility should be accomplished at the latest practical time prior to disassembly and shipment. The operator must then validate simulator performance at the final location by repeating at least 1/2 of the validation tests in the QTG and submitting those tests to the NSPM. After review of these tests, the FAA will schedule an initial evaluation. The QTG must be clearly annotated to indicate when and where each test was accomplished.

g. In the event an operator moves a simulator to a new location and its level of qualification is not changed, the following procedures shall apply:

(1) The operator should advise the POI and NSPM of the move.

(2) Before returning the simulator to service at the new location, the operator shall perform a typical recurrent validation and functions test. The results of such tests will be retained by the operator and be available for inspection by the FAA at the next evaluation or as requested.

(3) The NSPM may schedule an evaluation prior to return to service.

h. When there is a change of operator, the new operator must accomplish all required administrative procedures including the submission of the currently approved MQT Guide (MQTG) through the PQI to the NSPM. The QTG must be identified with the new operator by displaying the operator's name or logo. The PQI will then submit the package as described in paragraph 9.d. The simulator may, at the discretion of the NSPM, be subject to an evaluation in accordance with the original qualification criteria.

i. The scheduling priority for initial and upgrade evaluations will be based on the sequence in which acceptable QTG's and evaluation requests are received by the NSPM.

j. The QTG will be approved after the completion of the initial or upgrade evaluation and after all discrepancies in the QTG have been corrected. This document, after inclusion of the FAA witnessed test results, becomes the MQTG. The MQTG will then remain in the custody of the operator for use in future recurrent evaluations.

9. RECURRENT EVALUATIONS.

a. For a simulator to retain its qualification pursuant to this AC, it will be evaluated on a recurrent basis using the approved MQTG. Unless otherwise determined by the NSPM, recurring evaluations will be accomplished every 6 months by a Simulator Evaluation Specialist. Each recurrent evaluation, normally scheduled for 8 hours of simulator time, will consist of functions tests and approximately 1/2 of the validation tests in the MQTG. The entire MQTG will, therefore, be completed on an annual basis.

b. Normally, dates of recurrent evaluations will not be scheduled beyond 30 days of the date due. Exceptions to this policy will be considered by the NSPM on a case-by-case basis to address extenuating circumstances.

c. In the interest of conserving simulator time, the following Optional Test Program (OTP) is an alternative to the 8-hour recurrent evaluation procedure:

(1) The operator of a simulator having the appropriate automatic recording and plotting capabilities may apply for evaluation of that simulator under the OTP.

(2) The operator must notify the NSPM in writing of its intent to enter the OTP. If the FAA determines that the evaluation can be accommodated with 4 hours or less of simulator time, recurrent evaluations for that simulator will be planned for 4 hours. If the 4-hour period is or will be exceeded and the operator cannot extend the period, then the evaluation will be terminated and must be completed within 30 days to maintain qualification status. The FAA will then reassess the appropriateness of the OTP.

(3) Under the OTP, at least 1/2 of all the validation tests will be performed and certified by the operator between FAA recurrent evaluations. Completion of all validation tests will be required through any two consecutive recurrent evaluations. This information will be reviewed by the FAA Simulator Evaluation Specialist at the outset of each evaluation. These tests should be accomplished within the 30 days prior to the scheduled evaluation or accomplished on an evenly distributed basis during the 6-month period preceding the scheduled evaluation. Twenty percent of those tests performed by the operator for each recurrent evaluation will then be selected and repeated by the Simulator Evaluation Specialist along with 10 percent of those tests not performed by the operator.

d. Prior to arrival for an on-site evaluation, the FAA inspector will notify the operator if any tests are planned to be run that may require special equipment or technicians. These tests would include latencies, control dynamics, sounds and vibrations, or motion system tests.

e. If the operator plans to remove a simulator from active status for a prolonged period, the following procedures shall apply to requalify the simulator pursuant to this AC:

(1) The NSPM and POI shall be advised in writing. The notice shall contain an estimate of the period in which the simulator will be inactive.

(2) Recurrent evaluations will not be scheduled during the inactive period. The NSPM will remove the simulator from qualified status on a mutually established date no later than the date on which the next recurrent evaluation would have been scheduled.

(3) Before a simulator can be restored to FAA qualified status, it will require an evaluation by the NSPM. The evaluation content and time required for accomplishment will be based on the number of recurrent evaluations missed during the inactive period. For example, if the simulator were out of service for 1 year, it would be necessary to complete all tests contained in the test guide since, under the recurrent evaluation program, all validation tests in the MQTG are to be completed annually.

(4) The operator shall notify the NSPM of any changes to the originally scheduled time out of service.

(5) Normally, the simulator will be requalified using the FAA-approved MQTG and criteria that were in effect prior to its removal from qualification. Inactive periods exceeding 1 year or failure to adhere to the preceding procedures will require a review of the qualification basis.

f. In general, convertible simulators will be evaluated in alternating model configurations so that only one model configuration is evaluated during any one recurrent evaluation. This policy is dependent upon a high degree of commonality between model configurations and is subject to review by the NSPM on a case-by-case basis.

10. SPECIAL EVALUATIONS.

a. Between recurring evaluations, if deficiencies are discovered or it becomes apparent that the simulator is not being maintained to initial qualification standards, a special evaluation of the simulator may be conducted by the NSPM to verify its status.

b. The POI shall advise the operator and the NSPM if a deficiency is jeopardizing training requirements. Arrangements shall then be made to resolve the deficiency in the most effective manner, which may include the withdrawal of approval by the POI.

11. MODIFICATION OF SIMULATORS, MOTION SYSTEMS, AND VISUAL SYSTEMS.

a. The operator must notify the POI and NSPM at least 21 calendar days prior to making software program or hardware changes which might impact flight or ground dynamics of the simulator. A complete list and description of these planned changes, including dynamics related to the motion and visual systems, must be provided in writing. Any necessary updates to the MQTG shall also be identified. Operators should maintain a configuration control system to ensure the continued integrity of the simulator as qualified and to account for changes incorporated The configuration control system may be examined by the FAA cm request.

b. Modifications which impact flight or ground dynamics, systems functions, and significant QTG revisions may require an FAA evaluation of the simulator.

12. SIMULATOR QUALIFICATION BASIS. The FAR require that the simulator must maintain its approved performance, functions, and other characteristics. All initial, upgrade, and recurrent evaluations of any simulator qualified according to the acceptable methods of compliance described herein will be conducted in accordance with the provisions of this AC. Those simulators approved prior to this AC will continue to maintain their current qualification as long as they meet the standards under which they were originally approved, regardless of operator. Any simulator upgraded to Level C or Level D standards, or any visual system or motion system upgrade, requires an initial evaluation of that simulator, visual system, or motion system in accordance with the provisions herein.

13. LOSS OF QUALIFICATION/WITHDRAWAL OF APPROVAL.

a. The simulator will lose its qualification under this AC if the NSPM determines that it no longer meets the original simulator validation criteria based on a recurrent or special evaluation.

b. While not a loss of qualification, the POI may withdraw approval for the use of the simulator in the approved training program, pursuant to this AC, when a deficiency is jeopardizing training requirements. The POI will advise the NSPM that this action has been taken, and together they shall determine if further evaluation by the NSPM is required.

William J. White
Deputy Director, Flight Standards Service

APPENDIX 1. SIMULATOR STANDARDS

1. DISCUSSION. This appendix describes the minimum simulator requirements for qualifying Level B, Level C, and Level D helicopter simulators under this AC. Appropriate FAR's as indicated in paragraph 3 of this AC must be consulted when considering particular simulator requirements. The validation and functions tests listed in Appendices 2 and 3 must also be consulted when determining the requirements of a specific level simulator. For Levels C and D qualification, certain simulator and visual system requirements included in this appendix must be supported with a Statement of Compliance and, in some designated cases, an objective test. Statements of Compliance will describe how the requirement is met, such as gear modeling approach, coefficient of friction sources, etc. The test should show that the requirement has been attained. In the following tabular listing of simulator standards, required Statements of Compliance are indicated in the "Comments" column.

SIMULATOR STANDARDS	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
2. GENERAL.					
a. Cockpit, a full-scale replica of the helicopter simulated. Direction and movement of controls and switches identical to that in the helicopter. The cockpit, for simulator purposes, consists of all that space forward of a cross-section of the fuselage at the most extreme aft setting of the pilots' seats. Additional required crewmember duty stations and those required bulkheads aft of the pilots' seats are also considered part of the cockpit and must replicate the helicopter.		X	X	X	
b. Circuit breakers that affect procedures and/or result in observable cockpit indications shall be properly located and functionally accurate.		X	X	X	
c. Effect of aerodynamic changes for various combinations of drag and thrust normally encountered in flight corresponding to actual flight conditions, including the effect of change in helicopter attitude, aerodynamic and propulsive forces and moments, altitude, temperature, gross weight, center of gravity location, and configuration to include external load operations, if applicable.		X	X	X	
d. All relevant cockpit instrument indications automatically respond to control movement by a crewmember, simulated helicopter performance, or external simulated environmental effects upon the simulated helicopter, e.g., turbulence or wind shear.		X	X	X	Numerical values must be presented in the appropriate units for U.S. operations, for example, fuel in lb, speeds in kt, altitudes in ft, etc.
e. Communications and navigation equipment representing that installed in the operator's helicopter and operable within the tolerances prescribed for the applicable airborne equipment.		X	X	X	

SIMULATOR STANDARDS -Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
f. In addition to the flight crewmember stations, two suitable seats for the Instructor/Check Airman and FAA Inspector. The NSPM will consider options to this standard based on unique cockpit configurations. These seats must provide adequate vision to the instrument panel and visual system. These seats need not represent those found in the helicopter but must be equipped with positive restraint devices similar to those found in the helicopter.		X	X	X	
g. Simulator systems must simulate the applicable helicopter system operation, both on the ground and in flight. Three systems must be operative to the extent that normal, abnormal, and emergency operating procedures appropriate to the simulator application can be accomplished.		X	X	X	
h. Instructor controls to enable the instructor to control all required system variables and insert abnormal or emergency conditions into the helicopter systems.		X	X	X	
i. Static control forces and control travel which correspond to that of the replicated helicopter. Control forces should react in the same manner as in the helicopter under the same flight conditions.		X	X	X	
j. Significant cockpit sounds which result from pilot actions corresponding to those of the helicopter.		X	X	X	
k. Sound of precipitation, windshield wipers, and other significant helicopter noises perceptible to the pilot during normal operations and the sound of a crash when the simulator is landed in excess of landing gear limitations.			X	X	Statement of Compliance. For Level D, appropriate weather related sounds shall be coordinated with the weather representations specified in Appendix 3, "Functions and Subjective Tests," paragraph 2.0.
l. Realistic amplitude and frequency of cockpit noises and sounds, including engine, transmission, rotor, and airframe sounds.				X	Tests required for noises and sounds that originate from the helicopter or helicopter systems.
m. Ground handling and aerodynamic programming to include the following: **(1)** Ground effect--for example: flare, and touchdown from a running landing as well as in ground effect (IGE) hover programming.		X	X	X	Statement of Compliance. Tests required. Level B does not require hover programming.

SIMULATOR STANDARDS -Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
(2) Ground reaction--reaction of the helicopter upon contact with the landing surface during landing to include strut deflections, tire or skid friction, side forces, and other appropriate data, such as weight and speed, necessary to identify the flight condition and configuration. (3) Ground handling characteristics--control inputs to include crosswind, braking, deceleration, and turning radius.					
n. Representative crosswinds and instructor controls for wind speed and direction.		X	X	X	
o. Representative stopping and directional control forces for at least the following landing surface conditions based on helicopter related data, for a running landing. (1) Dry (2) Wet (3) Icy (4) Patchy Wet (5) Patchy Icy			X	X	Statement of Compliance. Objective tests required for (1); subjective check for (2), (3), (4), and (5).
p. Representative brake and tire failure dynamics and decreased brake efficiency due to brake temperatures based on helicopter related data.			X	X	Statement of Compliance. Tests required.
q. Simulator computer capacity, accuracy, resolution, and dynamic response sufficient for the qualification level sought.		X	X	X	Statement of Compliance.
r. Cockpit control dynamics which replicate the helicopter simulated. Free response of the controls shall match that of the helicopter within the tolerance given in Appendix 2. Initial and upgrade evaluation will include control free response (cyclic, collective, and pedal) measurements recorded at the controls. The measured responses must correspond to those of the helicopter in ground operations, hover, climb, cruise, and autorotation. (1) For helicopters with irreversible control systems, measurements may be obtained on the ground. proper pitot static inputs (if applicable) must be provided to represent conditions typical of those encountered in flight. Engineering validation or helicopter manufacturer rationale will be submitted as justification to ground test or to omit a configuration.			X	X	Tests required. See Appendix 2, paragraph 3.

SIMULATOR STANDARDS -Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
(2) For simulators requiring static and dynamic tests at the controls, special test fixtures will not be required during initial evaluations if the operator's QTG shows both test fixture results and alternate test method results, such as computer data plots, which were obtained concurrently. Repeat of the alternate method during the initial evaluation may then satisfy this test requirement.					
s. Relative responses of the motion system, visual system, and cockpit instruments shall be coupled closely to provide integrated sensory cues. These systems shall respond to abrupt pitch, roll and yaw inputs at the pilot's position within 100/150 milliseconds of the time, but not before the time, when the helicopter would respond under the same conditions.		X			Tests required. For Level B, response must be within 150 milliseconds.
Visual change may start before motion response, but motion acceleration must occur before completion of visual scan of first video field containing different information. The test to determine compliance with these requirements should include simultaneously recording the analog output from the pilot's cyclic, collective, and pedals, the output from an accelerometer attached to the motion system platform located at an acceptable location near the pilots' seats, the output signal to the visual system display (including visual system analog delays), and the output signal to the pilot's attitude indicator or an equivalent test approved by the Administrator. The test results in a comparison of a recording of the simulator's response to actual helicopter response data in hover (Levels C and D only), climb, cruise, and autorotation. For helicopter response, acceleration in the appropriate rotational axis is preferred. As an alternative, a transport delay test may be used to demonstrate that the simulator systems do not exceed the specified limit of 100/150 ms. This test shall measure all the delay encountered by a step signal migrating from the pilots' control through the control loading electronics and interfacing through all the simulation software modules in the correct order, using a handshaking protocol, finally through the normal output interfaces to the motion system, to the visual system and instrument displays. A recordable start time for the test should be provided by a pilot flight control input. The test mode shall permit normal computation time to be consumed and shall not alter the flow of information through the hardware/software system. The transport delay of the system is then the time between the control input and the individual system responses. It need only be measured once in each axis, being independent of flight conditions.			X	X	For levels C and D, response must be within 100 milliseconds.

SIMULATOR STANDARDS -Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
t. Aerodynamic modeling which, includes ground effect, effects of airframe icing (if applicable), aerodynamic interference effects between the rotor wake and fuselage, influence of the rotor on control and stabilization systems, and representations of nonlinearities due to sideslip based on helicopter flight test data provided by the manufacturer.				X	Statement of Compliance. Tests required. Nonlinearities due to sideslip are normally included in the simulator aerodynamic model, but the Statement of Compliance must address each of them. Separate tests for aerodynamic interference effects and rotor influence. A Statement of Compliance and demonstration of icing effects (if applicable) are required.
u. A means for quickly and effectively testing simulator programming and hardware. This may include an automated system which could be used for conducting at least a portion of the tests in the QTG.			X	X	Statement of Compliance.
v. Self-testing for simulator hardware programming to determine compliance with simulator performance tests as prescribed in Appendix 2. Evidence of testing must include simulator number, date, time, conditions, tolerances, and appropriate dependent variables portrayed in comparison to the helicopter standard. Automatic flagging of "out-of-tolerance" situations is encouraged.				X	Statement of Compliance. Tests required.
w. Diagnostic analysis printouts of simulator malfunctions sufficient to determine compliance with the Simulator Component Inoperative Guide (SCIG). These printouts shall be retained by the operator between recurring FAA simulator evaluations as part of the daily discrepancy log.				X	Statement of Compliance.
x. Timely permanent update of simulator hardware and programming subsequent to helicopter modification.		X	X	X	
y. Daily preflight documentation either in the daily log or in a location easily accessible for review.		X	X	X	
3. MOTION SYSTEM.					
a. Motion (acceleration) cues perceived by the pilot, representative of the helicopter motions, e.g., touchdown cues should be a function of the simulated rate of descent.		X	X	X	Motion tests to demonstrate that each axes onset cues are properly phased with pilot input and helicopter response.

SIMULATOR STANDARDS -Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
b. A motion system which produces cues in three degrees of freedom (DOF).		X			
c. A motion system which produces cues in six DOF.			X	X	Statement of Compliance. Tests required.
d. A means for recording the motion response time for comparison with helicopter data.		X	X	X	See 2.s. of this appendix.
e. Special effects programming to include the following: **(1)** Runway rumble, oleo deflections, effects of groundspeed and uneven surface characteristics. **(2)** Buffet due to transverse flow effect. **(3)** Buffet during extension and retraction of landing gear. **(4)** Buffet due to retreating blade stall. **(5)** Buffet due to settling with power. **(6)** Representative cues resulting from touchdown. **(7)** Rotor vibrations.		X	X	X	
f. Characteristic buffet motions that result from operation of the helicopter (for example, retreating blade stall, extended landing gear, settling with power) which can be sensed at the flight deck. The simulator must be programmed and instrumented in such a manner that the characteristic buffet modes can be measured and compared to helicopter data. Helicopter data are also required to define flight deck motions when the helicopter is subjected to atmospheric disturbances. General purpose disturbance models that approximate demonstrable flight test data are acceptable. Tests with recorded results which allow the comparison of relative amplitudes versus frequency are required.				X	Statement of Compliance. Tests required.
4. VISUAL SYSTEMS. **a.** Visual system capable of meeting all the standards of this appendix and Appendices 2 and 3 (Validation and Functions and Subjective Tests Appendices) as applicable to the level of qualification requested by the applicant.		X	X	X	
b. Visual system capable of providing at least a 75 degrees horizontal and 30 degrees vertical field of view simultaneously for each pilot.		X			
c. Continuous minimum collimated (or equivalent) visual field of view of 150 degrees horizontal and 40 degrees vertical available to each pilot.			X		Horizontal field of view is to be centered on the 0 degree azimuth line relative to the aircraft fuselage.

SIMULATOR STANDARDS -Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
d. Continuous minimum collimated (or equivalent) visual field of view of **180** degrees horizontal and **60** degrees vertical available to each pilot. In addition, operational chin windows representative of those found in the helicopter model simulated are required.				**X**	Horizontal field of view must be centered on the 0 degree azimuth line relative to the aircraft fuselage.
e. A means for recording the visual system response time.		**X**	**X**	X	
f. Verification of visual ground segment and visual scene content on landing approach. The **QTG** should contain appropriate calculations and a drawing showing the pertinent data used to establish the helicopter location and visual ground segment. Such data should include, but is not limited to the following: **(1)** Airport and runway used. **(2)** Glideslope transmitter location for the specified runway. **(3)** Position of the glideslope receiver antenna relative to the helicopter main landing gear. **(4)** Approach and runway light intensity setting. **(5)** Helicopter pitch angle. The above parameters should be presented for the helicopter in landing configuration and a main gear height of **100** feet **(30 m.)** above the touch-down zone. The visual ground segment and scene content should be determined for a runway visual range of **1,200** feet or **350** meters.		**X**	**X**	**X**	
g. Visual cues to assess rate of change of height, height **AGL,** translational displacements and rates, during takeoff and landing.		**X**			
h. Visual cues to assess rate of change of height, height **AGL,** translational displacements and rates, during takeoff, low altitude/low airspeed maneuvering, hover, and landing.			**X**	X	
i. Test procedures to quickly confirm visual system color, visibility, focus, intensity, level horizon, and attitude as compared to the simulator attitude indicator.			**X**	X	Statement of Compliance. Tests required.
j. Dusk scene to enable identification of a visible horizon and typical terrain characteristics such as fields, roads, and bodies of water.			**X**	**X**	Statement of Compliance. Tests required.
k. A minimum of ten levels of occulting. This capability must be demonstrated by a visual model through each channel.			**X**	X	Statement of Compliance. Tests required.

SIMULATOR STANDARDS -Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
l. Daylight, dusk, and night visual scenes with sufficient scene content to recognize heliports, airports, the terrain, and major landmarks around the landing area and to successfully accomplish low airspeed/low altitude maneuvers to include hover, translational flight, and landing. The daylight visual scene must be part of a total daylight cockpit environment which at least represents the amount of light in the cockpit on an overcast day. Daylight visual system is defined as a visual system capable of producing, as a minimum, full color presentations, scene content comparable in detail to that produced by 4,000 edges or 2,000 polygons for daylight and 4,000 light points for night and dusk scenes, 6-foot lamberts of light as measured at the pilot's eye position (highlight brightness), 3 arc-minutes resolution for the field of view at the pilot's eye, and a display which is free of apparent quantization and other distracting visual effects while the simulator is in motion. The simulator cockpit ambient lighting shall be dynamically consistent with the visual scene displayed. For daylight scenes, such ambient lighting shall neither "washout" the displayed visual scene nor fall below 5-foot lamberts of light as reflected from an approach plate at knee height at the pilot's station. All brightness and resolution requirements must be validated by an objective test and will be retested at least yearly by the NSPM. Testing may be accomplished more frequently if there are indications that the performance is degrading on an accelerated basis. **Compliance** of the brightness capability may be demonstrated with a test pattern of white light using a spot photometer. (1) Contrast Ratio. A raster drawn test pattern filling the entire visual scene (three or more channels) shall consist of a matrix of black and white squares no larger than 10 degrees and no smaller than 5 degrees per square with a white square in the center of each channel. Measurement shall be made on the center white square for each channel using a 1 degree spot photometer. This value shall have a minimum brightness of 2-foot lamberts. Measure any adjacent dark square. The contrast ratio is the bright square value divided by dark square value. Minimum test contrast ratio result is 5:1. NOTE: Cockpit ambient light levels should be maintained at Level D requirements.				X	Statement of Compliance. Tests required.

SIMULATOR STANDARDS - Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
(2) Highlight Brightness Test. Maintaining the full test pattern described above, superimpose a highlight area on the center white square of each channel and measure the brightness using the 1 degree spot photometer. Lightpoints or lightpoint arrays are not acceptable. Use of calligraphic capabilities to enhance raster brightness is acceptable. (3) Resolution shall be demonstrated by a test pattern of objects shown to occupy a visual angle of 3-arc minutes in the visual scene from the pilot's eyepoint. This shall be confirmed by calculations in the Statement of Compliance. (4) Lightpoint size shall be not greater than 6 arc-minutes measured in a test pattern consisting of a single row of lightpoints reduced in length until modulation is just discernible, a row of 40 lights shall form a 4-degree angle or less. (5) Lightpoint contrast ratio shall be not less than 25:1 when a square of at least 1 degree filled (i.e., lightpoint modulation is just discernible) with lightpoints is compared to the adjacent background.					

APPENDIX 2. SIMULATOR VALIDATION TESTS

1. DISCUSSION. Simulator performance and system operation must be objectively evaluated by comparing the results of tests conducted in the simulator to helicopter data unless specifically noted otherwise. To facilitate the validation of the simulator, a multichannel recorder, line printer, or other appropriate recording device acceptable to the NSPM should be used to record each validation test result. These recordings should then be compared to the helicopter source data.

The QTG provided by the operator must describe clearly and distinctly how the simulator will be set up and operated for each test. Use of a driver program designed to automatically accomplish the tests is encouraged for all simulators. It is not the intent of and it is not acceptable to the FAA to only test each simulator subsystem independently. Overall integrated testing of the simulator must be accomplished to ensure that the total simulator system meets the prescribed standards. A manual test procedure with explicit and detailed steps for completion of each test must also be provided.

The tests and tolerances contained in this appendix must be included in the operator's QTG. Levels B, C, and D simulators must be compared to flight test data except as otherwise specified. An operator may, after reasonable attempts have failed to obtain suitable flight test data, indicate in the QTG where flight test data are unavailable or unsuitable for a specific test. For such a test, alternative data should be submitted to the NSPM for approval. Submittals for approval of data other than flight test must include an explanation of validity with respect to available flight test information. The Table of Validation Tests of this appendix generally indicates the test results required. Unless noted otherwise, simulator tests shall represent helicopter performance and handling qualities at operating weights and centers of gravity (CG) typical of normal operation. If a test is supported by helicopter data at one extreme weight or CG, another test supported by helicopter data at midconditions or as close as possible to the other extreme should be included. Where multiple gross weights and/or CG's are specified, these data should be presented for conditions as close as possible to the operational extremes of the flight envelope. Certain tests which are relevant only at one extreme CG or weight condition need not be repeated at the other extreme. Tests of handling qualities must include validation of stability and control augmentation devices.

Simulators for augmented helicopters will be validated both in the unaugmented configuration (or failure state with the maximum permitted degradation in handling qualities) and the augmented configuration. Where various levels of handling qualities result from failure states, validation of the effect of the failure is necessary. For those performance and static handling qualities tests where the primary concern, in the unaugmented configuration, is control position, unaugmented data are not required if the design of the system precludes any affect on control position. In those instances where the unaugmented helicopter response is divergent and non-repeatable, it may not be feasible to meet the specified tolerances. Alternative requirements for testing will be mutually agreed to between the operator and the NSPM on a case-by-case basis.

In the case of helicopter simulators approved prior to the date of this advisory circular (AC), the tolerances of this appendix may be used in subsequent recurrent evaluations for any given test providing the operator has submitted a proposed QTG revision to the NSPM and has received FAA approval.

2. TEST REQUIREMENTS. The ground and flight tests required for qualification are listed in the Table of Validation Tests. Computer generated simulator test results should be provided for each test. The results should be produced on a multichannel recorder, line printer, or other appropriate recording device acceptable to the NSPM. Time histories are required unless otherwise indicated in the Table of Validation Tests.

Plight test data which exhibit rapid variations of the measured parameters may require engineering judgment when making assessments of simulator validity. Such judgment must not be limited to a single parameter. All relevant parameters related to a given maneuver or flight condition must be provided to allow overall

interpretation. When it is difficult or impossible to match simulator to helicopter data throughout a time history, differences must be justified by providing a comparison of other related variables for the condition being assessed.

a. Parameters, Tolerances, and Flight Conditions. The Table of Validation Tests of this appendix describes the parameters, tolerances, and flight conditions for simulator validation. These tolerances are intended to account for the inexactness of modeling and reference data. When two tolerance values are given for a parameter, the percentage tolerance applies to the recorded value of that parameter. The less restrictive of the two tolerance values may be used unless otherwise indicated. In those cases where a tolerance is expressed only as a percentage, the tolerance applies to the maximum value of that parameter within its normal operating range as measured from the neutral or zero position unless otherwise indicated.

If a flight condition or operating condition is shown which does not apply to the qualification level sought, it should be disregarded. Simulator results must be labeled using the tolerances and units given.

b. Flight Condition Verification. When comparing the parameters listed to those of the helicopter, sufficient data must also be provided to verify the correct flight condition. For example, to show that control force is within ±0.5 pound (0.223 decaNewton (daN)) in a static stability test, data to show the correct airspeed, power, thrust or torque, helicopter configuration, altitude, and other appropriate datum identification parameters should also be given. If comparing short period dynamics, normal acceleration may be used to establish a match to the helicopter, but airspeed, altitude, control input, helicopter configuration, and other appropriate data must also be given. All airspeed values should be clearly annotated as to indicated, calibrated, etc., and like values must be used for comparison.

c. Alternate Method for Dynamic Handling Qualities Tests. The FAA is open to alternative means for dealing with dynamic handling qualities tests. One method that has been suggested is frequency response testing. Such alternatives must be justified and appropriate to the application. Each case must be considered on its own merit on an ad hoc basis. Should the FAA find that alternative methods do not result in satisfactory simulator performance, more conventionally accepted methods must be used.

TABLE OF VALIDATION TESTS

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
L Performance							
a. Engine Assessment							
(1) start Operations							
(a) Engine Start and acceleration (transient)	Light Off Time - ● 10% or ±1 sec Torque - ±5% Rotor Speed - ● 3% Fuel Flow - ±10% Gas Generator Speed - ±5% Power Turbine speed - ±5% Turbine Gas Temp. - ±30°C	Ground Rotor Brake Used/ Not Used		X	X	X	Time histories of each engine from initiation of start sequence to steady state idle and from steady state idle to operating RPM.

TABLE OF VALIDATION TESTS—Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(b) Steady State Idle and Operating RPM Conditions	Torque - ±3% Rotor Speed - ±1.5% Fuel Flow - ±5% Gas Generator Speed - ±2% Power Turbine Speed - ±2% Turbine Gas Temp. - ±20°C	Ground		X	X	X	Present data for both steady state idle and operating RPM conditions. May be a snap shot test.
(2) Power Turbine Speed Trim	*lo% of total change of power turbine speed	Ground		X	X	X	Time history of engine response to trim system actuation (both directions).
(3) Engine and Rotor speed Governing	Torque - ±5% Rotor Speed - ±1.5%	Climb/Descent		X	X	X	Collective step inputs. Can be conducted concurrently with climb and descent performance tests.
b. Ground Operations							
(1) Minimum Radius Turn	±3 ft (0.9m) or 20% of helicopter turn Radius	Ground		X	X	X	If differential braking is used, brake force must be set at the helicopter flight test value.
(2) Rate of Turn vs. Pedal Deflection or Nosewheel Angle	±10% or ±2°/sec Turn Rate	Ground		X	X	X	
(3) Taxi	Pitch Attitude - ±1.5° Torque - ±3% Longitudinal Control Position - ±5% Lateral Control Position - ±5% Directional Control Position - ±5% Collective Control Position - ± 5%	Ground		X	X	X	Control position and pitch attitude during ground taxi for a specific ground speed, wind speed and direction, and density altitude.
(4) Brake Effectiveness	±10% of time and distance.	Ground		X	X	X	

TABLE OF VALIDATION TESTS—Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
c. Takeoff							
(1) All Engines	Airspeed - ±3 kt Altitude - ±20 ft (6.1 m) Torque - ±3% Rotor Speed - ±1.5% Vertical Velocity - ±100 fpm (0.50 m/sec) or 10% Pitch Attitude - ±1.5° Bank Attitude - ±2° Heading ±2° Longitudinal Control Position - ±10% Lateral Control Position - ±10% Directional Control Position - ±10% Collective Control Position - ±10%	Ground/Takeoff and Initial Segment of Climb		X	X	X	Time history of takeoff flightpath as appropriate to helicopter model simulated [running takeoff for Level B, takeoff from a hover far Levels C and D]. For Level B, criteria apply only to those segments at airspeeds above effective translational lift. Record data to at least 200 ft (61 meters) AGL.
(2) One Engine Inoperative	See l.c.(l) above for tolerances and flight conditions			X	X	X	Time history of takeoff flight path as appropriate to helicopter model simulated. Record data to at least 200 ft (61 meters) AGL.
d. Hover Performance	Torque - ±3% Pitch Attitude - ±1.5° Bank Attitude - ±1.5° Longitudinal Control Position - ±5% Lateral Control Position - ±5% Directional Control Position - ±5% Collective Control Position - ±5%	In Ground Effect (IGE) Out of Ground Effect (OGE)			X	X	Light/heavy gross weights. May be a snapshot test.
e. Vertical Climb Performance	Vertical Velocity - ±100 fpm (0.50 m/sec) or 10% Directional Control Position - ±5% Collective Control Position - ±5%	From OGE Hover			X	X	Light/heavy gross weights. May be a snapshot test.

TABLE OF VALIDATION TESTS—Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
f. Level Flight Performance and Trimmed Flight Control Positions	Torque - ±3% Pitch Attitude - ±1.5° Sideslip Angle - ±2° Longitudinal Control Position - ±5% Lateral Control Position - ±5% Directional Control Position - ±5% Collective Control Position - ±5%	Cruise Augmentation On/Off		X	X	X	Two gross weight/CG combinations. Vary trim speeds throughout airspeed envelope. May be a snapshot test.
g. Climb Performance and Trimmed Flight Control Positions	Vertical Velocity - ±100 fpm (0.50 m/sec) or 10% Pitch Attitude - ±1.5° Sideslip Angle - ±2° Longitudinal Control Position - ±5% Lateral Control Position - ±5% Directional Control Position - ±5% Collective Control Position - ±5%	All engines operating One engine inoperative Augmentation On/Off		X	X	X	Two gross weight/CG combinations. Data presented at normal climb power conditions. May be a snapshot test.
h. Descent (1) Descent Performance and Trimmed Plight Control Positions	Torque - ±3% Pitch Attitude - ±1.5% Sideslip Angle - ±2° Longitudinal Control Position - ±5% Lateral control Position - ±5% Directional Control Position - ±5% Collective Control Position - ±5%	At or near 1,000 fpm Rate of Descent (RoD) at normal approach speed. Augmentation On/Off		X	X	X	Two gross weight/CG combinations. May be a snapshot. test.
(2) Autorotation Performance and Trimmed Plight Control Positions	Vertical Velocity - ±100 fpm (0.50 m/sec) or 10% Rotor Speed - ± 1.5% Pitch Attitude - ± 1.5° Sideslip Angle - ±2° Longitudinal Control Position ±5%	Steady descents Augmentation On/Off		X	X	X	Two gross weights. At normal operating RPM. Rotor speed tolerance only applies if collective control position is full down.

TABLE OF VALIDATION TESTS—Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
h.(2) Cont'd	Lateral Control Position ±5% Directional Control Position ±5% Collective Control Position ±5%						Speed sweep from approximately 50 kt to at least maximum glide distance airspeed. May be a snapshot test.
i. Autorotational Entry	Rotor speed ±3% Pitch Attitude ±2° Roll Attitude ±3° Yaw Attitude ±5° Airspeed - ±5 kt Vertical Velocity - ±200 fpm (1.00 m/sec) or 10%	Cruise or Climb			X	X	Time history of vehicle response to a rapid throttle reduction to idle. If cruise, data should be presented for the maximum range airspeed. If climb, data should be presented for the maximum rate of climb airspeed at or near maximum continuous power.
j. Landing							
(1) All Engines	Airspeed - ±3 kt Altitude - ±20 ft (6.1 m) Torque - ±3% Rotor Speed - ±1.5% Pitch Attitude - ±1.5° Bank Attitude - ±1.5° Heading - ± 2° Longitudinal Control Position - ±10% Lateral Control Position - ±10% Directional Control Position - ±10% Collective Control Position - ±10%	Approach/Landing		X	X	X	Time history of approach and landing profile as appropriate to helicopter model simulated (running landing for Level B, approach to a hover for Levels C and D). For Level B, criteria apply only to those segments at airspeeds above effective translational lift.
(2) One Engine Inoperative	See 1.j.(1) above for tolerances and flight conditions			X	X	X	Include data for both Category A and Category B approaches and landing as appropriate to helicopter model simulated. For Level B, criteria apply only to those segments at airspeeds above effective translational lift.
(3) Balked Landing	See 1.j.(1) above for tolerances	Approach		X	X	X	From a stabilized approach at the landing decision point (LDP).

TABLE OF VALIDATION TESTS—Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(4) Automational Landing	Torque - ±3% Rotor Speed - ±3% Vertical Velocity - ±100 fpm (0.50 m/sec) or 10 % Pitch Attitude - ±2° Bank Attitude - ±2° Heading - ±5° Longitudinal Control Position - ±10% Lateral Control Position - ± 10% Directional Control Position - ±10% Collective Control Position - ±10%	Approach/Landing			X	X	Time history of auto-rotational deceleration and landing from a stabilized autorotational descent.
2. Handling Qualities a. control system Mechanical Characteristics (1) Cyclic**	Breakout ±.25 lb (0.112 daN) or 25% Force ±0.5 lb (0.224 daN) or 10%	Ground/Static Trim On/Off Friction Off Augmentation On/Off		X	X	X	Uninterrupted control sweeps. Does not apply to aircraft hardware modular controllers.
(2) Collective/Pedals**	Breakout ±0.5 lb (0.224 daN) or 10% Force ±1.0 lb (0.448 daN) or 10%	Ground/Static Trim On/Off Friction Off Augmentation On/Off		X	X	X	Uninterrupted control sweeps.
(3) Brake Pedal Force vs. Position	±5 lb (2.224 daN) or 10%	Ground/Static		X	X	X	Simulator computer output results may be used to show compliance.
(4) Trim System Rate (all applicable axes)	Rate - ±10%	Ground/Static Trim On Friction Off		X	X	X	Tolerance applies to recoded value of trim rate.
(5) Control Dynamics (all axes)	±10% of time for first zero crossing and ±10 (N+1)% of period thereafter	Hover/Cruise Trim On Friction Off			X	X	Control dynamics for irreversible control systems may be evaluated

**Cyclic, collective, and pedal position vs. force shall be measured at the control. An alternate method acceptable to the NSPM in lieu of the test fixture at the controls would be to instrument the simulator in an equivalent manner to the flight test helicopter. The force and position data from this instrumentation can be directly recorded and matched to the helicopter data. Such a permanent installation could be used without requiring any time for installation of external devices.

TABLE OF VALIDATION TESTS-Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(5) Cont'd	±10% amplitude of first overshoot ±20% of amplitude of 2nd and subsequent overshoots greater than 5% of initial displacement ±1 overshoot	Augmentation On/Off					in a ground/static condition. Data should be for a normal control displacement in both directions in each axis (approximately 25% to 50% of full throw). N is the sequential period of a full cycle of oscillation. Refer to paragraph 3 of this appendix.
(6) Freeplay	±0.10 in	Ground/Static Friction Off		X	X	X	Applies to all controls.
b. Low Airspeed Handling Qualities							
(1) Trimmed Flight Control Positions	Torque - ● 3% Pitch Attitude - ±1.5° Bank Attitude - ±2° Longitudinal Control Position - ±5% Lateral Control Position - ±5% Directional Control Position - ±5% Collective Control Position - ±5%	Translational Flight IGE S&ward/rearward/forward Augmentation On/Off			X	X	Several airspeed increments to translational airspeed limits and 45 kt forward. May be a snapshot test.
(2) Critical Azimuth	Torque - ±3% Pitch Attitude - ±1.5° Bank Attitude - ±2° Longitudinal Control Position - ±5% Lateral Control Position - ±5% Directional Control Position - ● 5% Collective Control Position - ±5%	Stationary Hover Augmentation On/Off			X	X	May be a snapshot test. Present data for three relative wind directions (including the most critical case) in the critical quadrant.
(3) Control Response							
(a) Longitudinal	Pitch Rate - ±10% or ±2°/sec Pitch Attitude Change - ±10% or ±1.5°	Hover Augmentation On/Off			X	X	Step control input. Off axis response must show correct trend for unaugmented cases.
(b) Lateral	Roll Rate - ±10% or ±3°/sec Roll Attitude Change - ±10% or ±3°	Hover Augmentation On/Off			X	X	Step control input. Off axis response must show correct trend for unaugmented cases.

TABLE OF VALIDATION TESTS-Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(c) Directional	Yaw Rate - ±10% or ±2°/sec Heading Change - ±10% or ±2°	Hover Augmentation On/Off			X	X	Step control input. Off axis response must show correct trend for unaugmented cases.
(d) Vertical	Normal Acceleration - ±0.1g	Hover			X	X	Step control input. Off axis response must show correct trend for unaugmented cases.
c. Longitudinal Handling Qualities							Two cruise airspeeds to include minimum power required speed.
(1) Control Response	Pitch Rate - ±10% or ±2°/sec Pitch Attitude Change - ±10% or ±1.5°	Cruise Augmentation On/Off		X	X	X	Step control input. Off axis response must show correct trend for unaugmented cases.
(2) Static Stability	Longitudinal Control Position - ±10% of change from trim or ±0.25 in (6.3 mm) or Longitudinal Control Force - ±0.5 lb (0.2 23 daN) or ±10%	Cruise or Climb Autorotation Augmentation On/Off		X	X	X	Minimum of two speeds on each side of the trim speed. May be a snapshot test.
(3) Dynamic Stability (a) Long Term Response	±10% of Calculated Period ±10% of Time to 1/2 or Double Amplitude or ±.02 of Damping Ratio	Cruise Augmentation On/Off		X	X	X	Test should include three full cycles (6 overshoots after input completed) or that sufficient to determine time to 1/2 or double amplitude, whichever is less. For non-periodic response the time history should be matched.
(b) Short Term Response	±1.5° Pitch or ±2°/sec Pitch Rate ±0.1 g Normal Acceleration	Cruise or Climb Augmentation On/Off		X	X	X	Two airspeeds.
(4) Maneuvering Stability	Longitudinal Control Position - ±10% of change from trim or ±0.25 in (6.3 mm) or Longitudinal Control Force - ±0.5 lb (0.2 23 daN) or ±10%	Cruise or Climb Augmentation On/Off		X	X	X	Force may be a cross plot for irreversible systems. Two airspeeds. May be a snapshot test. Approximately 30°, and 45° bank attitude data should be presented,

TABLE OF VALIDATION TESTS-Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(5) Landing Gear Operating Time	±1 sec	Takeoff (Retraction) Approach (Extension)		X	X	X	
d. Lateral and Directional Handling Qualities							Two airspeeds to include at or near the minimum power required speed.
(1) Control Response							
(a) Lateral	Roll Rate - ±10% or ±3°/sec Roll Attitude Change - ±10% or ±3°	Cruise Augmentation On/Off		X	X	X	Step control input. Off axis response must show correct trend for unaugmented cases.
(b) Directional	Yaw Rate - ±10% or ±2°/sec Yaw Attitude Change - ±10% or ±2°	Cruise Augmentation On/Off		X	X	X	Two airspeeds to include at or near the minimum power required speed. Step control input. Off axis response must show correct trend for unaugmented cases.
(2) Directional Static Stability	Lateral Control Position - ±10% of change from trim or ±0.25 in (6.3 mm) or Lateral Control Force - ±0.5 lb (0.2223 daN) or 10% Roll Attitude - ±1.5° Directional Control Position - ±10% of change from trim or ±0.25 in (6.3 mm) or Directional Control Force - ±1 lb (0.448 daN) or 10% Longitudinal Control Position - ±10% of change from trim or ±0.25 in (6.3 mm) Vertical Velocity - ±100 fpm (0.50 m/sec) or 10%	Cruise or Climb/ Descent Augmentation On/Off		X	X	X	Steady heading sideslip. Minimum of two sideslip angles on either side of the trim point. Force may be a cross plot for irreversible control systems. May be a snapshot test.
(3) Dynamic Lateral and Directional Stability							

TABLE OF VALIDATION TESTS-Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(a) Lateral-Directional Oscillations	±0.5 sec or ±10% of Period ±10% of Time to 1/2 or Double Amplitude or ±.02 of Damping Ratio ±20% or ±1 sec of Time Difference Between Peaks of Bank and Sideslip	Cruise or Climb Augmentation On/Off		X	X	X	Two Airspeeds. Excite with cyclic or pedal doublet. Test should include six full cycles (12 overshoots after input completed) or that sufficient to determine time to 1/2 or double amplitude, whichever is less. For non-periodic response, time history should be matched.
(b) Spiral Stability	Correct Trend, ±2° Bank or ±10% in 20 sec	Cruise or Climb Augmentation On/Off		X	X	X	Time history of release from pedal only or cyclic only turns in both directions.
(c) Adverse/Proverse Yaw	Correct trend, ±2° transient sideslip angle	Cruise or Climb Augmentation On/Off		X	X	X	Time history of initial entry into cyclic only turns in both directions. Use moderate cyclic input rate.
3. Motion System**							
a Motion Envelope							
(1) Pitch		N/A					
(a) Displacement ±TBD° ±25°				X	X	X	
(b) Velocity ±TBD°/sec ±20°/sec				X	X	X	
(c) Acceleration ±TBD°/sec² • 00°/sec²				X	X	X	

**It is assumed that the three degrees of freedom (DOF) for a Level B simulator are pitch, roll, and vertical. If the installed system has more than three DOF, but less than six, or three DOF different from pitch, roll, and vertical, the motion performance will have to be established on a per case basis. A Level B simulator with a six-DOF system shall comply with Level C and Level D motion performance. If none of the descriptions apply, the applicant shall provide the NSPM with a system description and performance analysis.

TABLE OF VALIDATION TESTS-Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(2) Roll							
(a) Displacement ±TBD°				X			
±25°					X	X	
(b) Velocity ±TBD°/sec				X			
±20°/sec					X	X	
(c) Acceleration							
±TBD°/sec²				X			
±100°/sec²					X	X	
(3) Yaw							
(a) Displacement ±25°		N/A			X	X	
(b) Velocity ±20°/sec					X	X	
(c) Acceleration ±100°/sec²					X	X	
(4) vertical							
(a) Displacement ±TBD in				X			
±34 in					X	X	
(b) Velocity ±TBD in				X			
±24 in/sec					X	X	
(c) Acceleration ±TBD g				X			
±0.8 g					X	X	
(5) Lateral		N/A					
(a) Displacement ±45 in					X	X	
(b) Velocity ±28 in/sec					X	X	
(c) Acceleration ±0.6 g					X	X	
(6) Longitudinal							
(a) Displacement ±34 in					X	X	
(b) Velocity ±28 in/sec					X	X	
(c) Acceleration ±0.6 g					X	X	
(7) Initial Rotational Acceleration Ratio, All axes TBD°/sec²/sec				X			
300°/sec²/sec					X	X	
(8) Initial Linear Acceleration Rate							
(a) Vertical ±TBD g/sec				X			
±6 g/sec					X	X	
(b) Lateral ±3 g/sec					X	X	
(c) Longitudinal ±3 g/sec					X	X	

TABLE OF VALIDATION TESTS—Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
b. Frequency Response *Band, Hz Phase, deg* 0.1 to 0.5 –15 to –20 0.51 to 1.0 –15 to –20 1.1 to 2.0 –20 to –40 2.1 to 5.0 –40 to –100	Amplitude *Ratio, db* ±2 ±2 ±4 ±4	N/A		X	X	X	
c. Leg Balance	1.5°			X	X	X	The phase shift between a datum jack and any other jack shall be measured using a heave (vertical) signal of 0.5 Hz at ±0.25 g
d. Turn Around	0.05 g	N/A		X	X	X	The motion base shall be driven sinusoidally in heave through a displacement of 6 in (150 mm) peak to peak at a frequency of 0.5 Hz. Deviation from the desired sinusoidal acceleration shall be measured.
e. Motion Cue Repeatability				X	X	X	See paragraph 4 of this appendix.
4. Visual System (NOTE: Refer to Appendix 3 for additional visual tests.) **a. Visual Ground Segment (VGS)**	±20% of calculated VGS. Threshold lights must be visible if they are in the visual segment (see example under "Comments").	Static at 100 ft (30.5 m) wheel height above touchdown zone on glideslope		X	X	X	The QTG should indicate the source of data, i.e., ILS G/S antenna location, pilot eye reference point, cockpit cutoff angle, etc., used to make visual scene ground segment content calculations.

TABLE OF VALIDATION TESTS—Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
4.a. Cont'd		RVR = 1,200 ft or 350 meters					Tolerance example: If the calculated VGS for the helicopter is 840 ft, the 20% tolerance of 168 ft may be applied at the near or far end of the simulator VGS or may be split between both as long as the total of 168 ft is not exceeded.
b. Visual System Color	Demonstration Model				X	X	
c. Visual RVR Calibration	Demonstration Model				X	X	
d. Visual Display Focus and Intensity	Demonstration Model				X	X	
e. Visual Attitude vs. Simulator Attitude Indicator (Pitch and Roll of Horizon)	Demonstration Model				X	X	
f. Demonstrate 10 Levels of Occulting through Each Channel of System	Demonstration Model				X	X	
5. Simulator Systems							
a Visual, Motion, and Cockpit Instrument Response							
(1) Visual, Motion, Instrument System response to an abrupt pilot controller input, compared to helicopter response for a similar input	100 milliseconds or less after helicopter response	Climb, Cruise, Descent, Hover			X	X	One test is required in each axis (pitch, roll, and yaw) for each of the 4 conditions (3 conditions, Level B) compared to helicopter data for a simulator input. (Total 12 tests) (Total 9 tests, Level B)
	150 milliseconds or less after helicopter response	Takeoff, Climb, Descent		X			
or							
(2) Transport Delay	100 milliseconds or less after control movement	Pitch, Roll, Yaw			X	X	One test is required in each axis. (Total 3 tests) See appendix 1, item 2.s.
	150 milliseconds or less after control movement	Pitch, Roll, Yaw		X			

TABLE OF VALIDATION TESTS - Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
b. Sound							
(1) Realistic amplitude and frequency of cockpit noises and sounds, including transmission, rotor, and airframe sounds.						X	Test results must show a comparison of the amplitude and frequency content of the sounds that originate from the helicopter or helicopter systems. Sound data should be presented in one-third octave band or continuous frequency spectrum.
c. Diagnostic Testing							
(1) A means for quickly and effectively testing simulator programming and hardware. This could include an automated system which could be used for conducting at least a portion of the tests in the QTG.					X	X	
(2) Self testing of simulator hardware and programming.						X	
(3) Diagnostic analysis printout of simulator malfunctions sufficient to determine compliance with the SCIG.						X	

3. CONTROL DYNAMICS. The characteristics of a helicopter flight control system have a major effect on the handling qualities. A significant consideration in pilot acceptability of a helicopter is the "feel" provided through the cockpit controls. Considerable effort is expended on helicopter feel system design in order to deliver a system with which pilots will be comfortable and consider the helicopter desirable to fly. In order for a simulator to be representative, it too must present the pilot with the proper feel; that of the respective helicopter.

Recordings such as free response to an impulse or step function are classically used to estimate the dynamic properties of electromechanical systems. In any case, it is only possible to estimate the dynamic properties as a result of only being able to estimate true inputs and responses. Therefore, it is imperative that the best possible data be collected since close matching of the simulator control loading system to the helicopter systems is essential. The required control feel dynamic tests are described in **2.a.(5)** of the Table of Validation Tests of this section.

For initial and upgrade evaluations, it is required that control dynamic characteristics be measured at and recorded directly from the cockpit controls. This procedure is usually accomplished by measuring the free response of the controls using a step or pulse input to excite the system. The procedure must be accomplished in hover, climb, cruise, and autorotation.

For helicopters with irreversible control systems, measurements may be obtained on the ground. Proper pitot-static inputs (if applicable) must be provided to represent conditions typical of those encountered in flight.

Likewise, it may be shown that for some helicopters, hover, climb, cruise, and autorotation may have like effects. Thus, one may suffice for another. If either or both considerations apply, engineering validation or helicopter manufacturer rationale must be submitted as justification for ground tests or for eliminating a flight condition. For simulators requiring static and dynamic tests at the controls, special test fixtures will not be required during initial and upgrade evaluations if the operator's QTG shows both test fixture results and the results of an alternate approach, such as computer plots which were produced concurrently and show satisfactory agreement. Repeat of the alternate method during the initial evaluation would then satisfy this test requirement.

a. Control Dynamics Evaluation. The dynamic properties of control systems are often stated in terms of frequency, damping, and a number of other classical measurements which can be found in texts on control systems. In order to establish a consistent means of validating test results for simulator control loading, criteria are needed that will clearly define the interpretation of the measurements and the tolerances to be applied. Criteria are needed for both the underdamped system and the overdamped system, including the critically damped case. In the case of an underdamped system with very light damping, the system may be quantified in terms of frequency and damping. In critically damped or overdamped systems, the frequency and damping is not readily measured from a response time history. Therefore, some other measurement must be used.

b. For Levels C ***and D*** Simulators. Tests to verify that control feel dynamics represent the helicopter must show that the dynamic damping cycles (free response of the control) match that of the helicopter within specified tolerances. The method of evaluating the response and the tolerance to be applied are described below for the underdamped and critically and overdamped cases.

(1) Underdamped Response. Two measurements are required for the period, the time to first zero crossing (in case a rate limit is present) and the subsequent frequency of oscillation. It is necessary to measure cycles on an individual basis in case there are nonuniform periods in the response. Each period will be independently compared to the respective period of the helicopter control system and, consequently, will enjoy the full tolerance specified for that period.

The damping tolerance shall be applied to overshoots on an individual basis. Care should be taken when applying the tolerance to small overshoots since the significance of such overshoots becomes questionable. Only those overshoots larger than 5 percent of the total initial displacement should be considered significant. The residual band, labelled $T(A_a)$ on figure 1 is ±5 percent of the initial displacement amplitude A_a from the steady state value of the oscillation. Oscillations within the residual band are considered insignificant. When comparing simulator data to helicopter data, the process should begin by overlaying or aligning the simulator and helicopter steady state values and then comparing amplitudes of oscillation peaks, the time of the first zero crossing, and individual periods of oscillation. The simulator should show the same number of significant overshoots to within one when compared against the helicopter data. This procedure for evaluating the response is illustrated in figure 1.

(2) Critically Damped and Overdamped Response. Due to the nature of critically damped responses (no overshoots), the time to reach 90 percent of the steady state (neutral point) value should be the same as the helicopter within ±10 percent. The simulator response should be critically damped also. Figure 2 illustrates the procedure.

c. Tolerances. The following table summarizes the tolerances **(T).** See figures 1 and 2 for an illustration of the referenced measurements.

$T(P_0)$	• 10% of P_0
$T(P_1)$	±20% of P_1
$T(P_2)$	±30% of P_2
$T(P_n)$	±10(n+1)% of P_n
$T(A_d)$	±10% of A_1, ±20% of Subsequent Peaks
$T(A_0)$	• 5% of A_d = Residual Band
Overshoots	±1

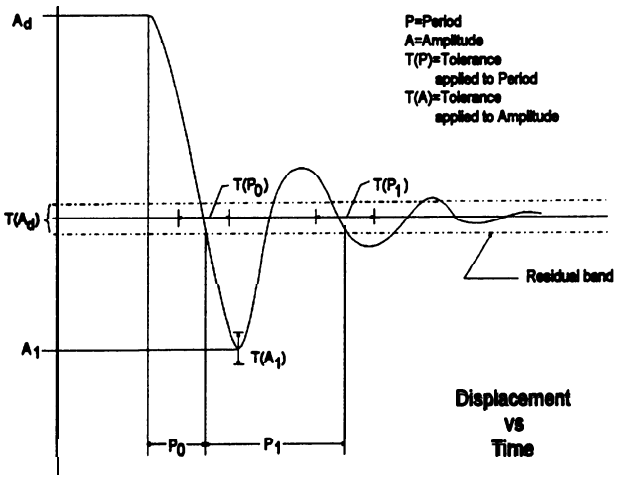


Figure 1. Underdamped Step Response

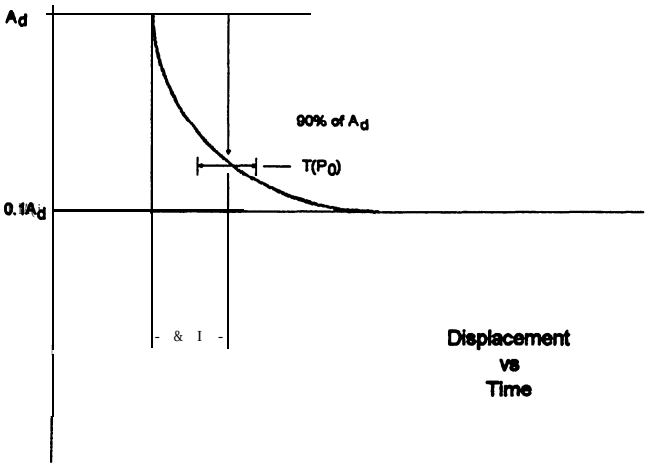


Figure 2. Critically Damped Step Response

4. MOTION TESTING.

a. Motion Cue Repeatability Testing. The motion system characteristics in the Table of Validation Tests address basic system capability, but not pilot cuing capability. Until there is an objective procedure for determination of the motion cues necessary to support pilot tasks and stimulate the pilot response which occurs in an aircraft for the same tasks, motion systems will continue to be "tuned" subjectively. Having tuned a motion system, however, it is important to involve a test to ensure that the system continues to perform as originally qualified. Any motion performance change from the initially qualified baseline can be measured objectively.

An objective assessment of motion performance change will be accomplished at least annually using the following testing procedure:

(1) The current performance of the motion system shall be assessed by comparison with the initial recorded test data.

(2) The parameters to be recorded shall be the outputs of the motion drive algorithms and the jack position transducers.

(3) The test input signals shall be inserted at an appropriate point prior to the integrations in the equations of motion (see figure **3).**

(4) The characteristics of the test signal (see figure **4)** shall be adjusted to ensure that the motion is exercised through approximately **2/3** of the maximum displacement capability in each axis. The time **T1** must be of **sufficient** duration to ensure steady initial conditions.

NOTE: If the simulator weight changes for any reason, (i.e., visual change, or structural change) then the motion system baseline performance repeatability tests must be rerun and the new results used for future comparison.

Acceleration Test Signals

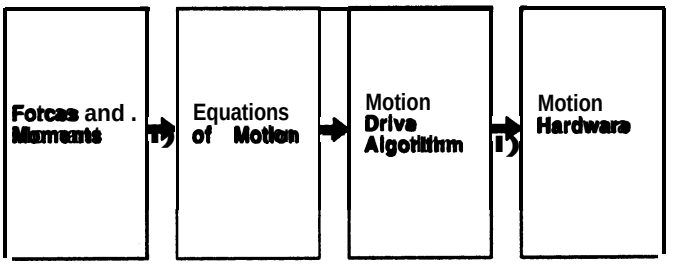


Figure 3

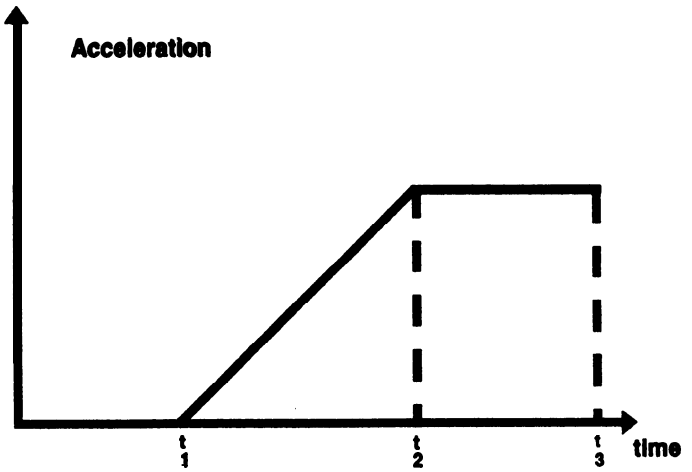


Figure 4

b. Alternative Method for Motion Systems Testing. An alternative to the procedures described and specified in Section **3.a.** and **b.** of the Table of Validation Tests and in paragraph **4.a.** of this appendix is "end to end" testing of the motion system and its associated washout, drive, and servo systems. An acceptable procedure to conduct the end to end test is, for convenience, described as **follows:**

(1) At the point at which the accelerations from the equation of motion normally excite the motion system, including the washout algorithms, a sinusoidal input would be used to excite the motion system (see figure **5).** Acceleration at the pilot station would be measured as the output. The test would be done independently in each of the six **DOF** and the response measured to determine frequency response. The resulting frequency response measured in each axis must comply with the following specification:

Gain	±2db	0.5 Hz to 5.0 Hz
Phase	0-20 deg.	1.0 Hz to 2.0 Hz

NOTE: This procedure does not account for the correctness of the algebraic sign between input and output. Consequently, care must be exercised to ensure that the signs are correct.

(2) Motion systems demonstrated by end to end testing must also comply with the displacements delineated in paragraph **3.a.**

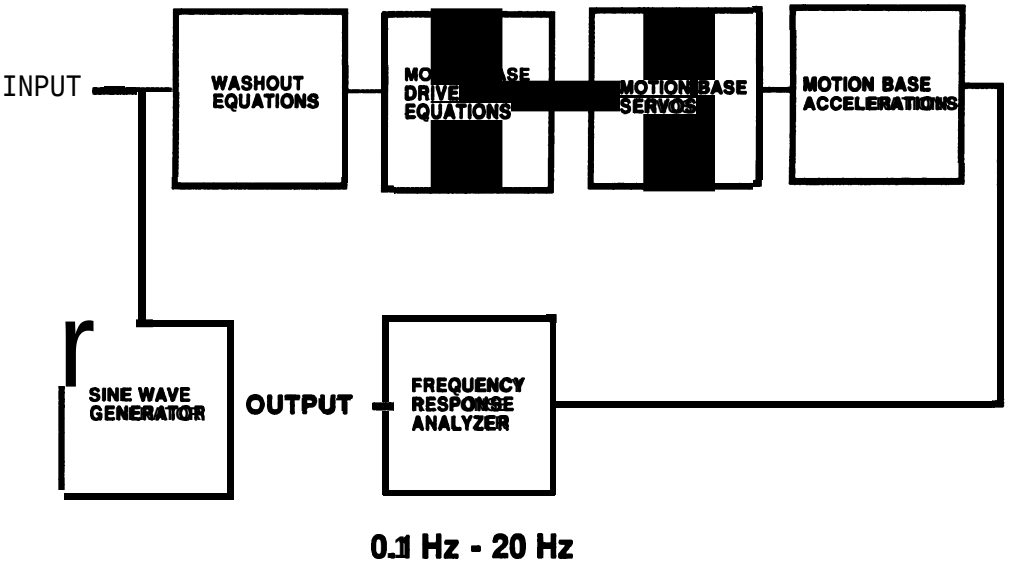


Figure 5

APPENDIX 3. FUNCTIONS AND SUBJECTIVE TESTS

1. DISCUSSION. Accurate replication of helicopter systems functions will be checked at each flight crewmember position by an FAA Simulator Evaluation Specialist. This includes procedures using the operator's approved aircraft manuals and checklists. Handling qualities, performance, and simulator systems operation will be subjectively assessed by an FAA Simulator Evaluation Specialist qualified in the respective helicopter. This assessment is subject to include operations under the full range of environmental conditions (winds, density altitudes, etc.) in which the helicopter would normally be expected to perform.

At the request of a POI, the Simulator Evaluation Specialist may assess the simulator for a special aspect of an operator's training program during the functions and subjective portion of a recurrent evaluation. Such an assessment may include a portion of a Line Oriented Flight Training (LOFT) scenario or special emphasis items in the operator's training program. Unless directly related to a requirement for the current qualification level, the results of such an evaluation would not affect the simulator's current status.

Operational systems and the associated electronic display systems will be evaluated. The Simulator Evaluation Specialist will include in his report to the POI the effect of the system operation and system limitations.

2. TEST REQUIREMENTS. The ground and flight tests and other checks used for simulator qualification are listed in the Table of Functions and Subjective Tests. The table includes maneuvers and procedures to ensure that the simulator functions and performs appropriately for use in pilot training and checking in the maneuvers and procedures delineated in FAR Part 61 and other regulatory provisions. The portion of the table addressing pilot functions and maneuvers is divided by flight phases. Visual systems tests are listed separately as are special effects.

Where a number of similar procedures are listed, such as in approaches to landing, it is not intended that the simulator have equipment installed to perform all of the listed types of approaches. However, the simulator must have equipment required by the helicopter type design and for the type of operation intended.

Systems functions will be assessed for normal and, where appropriate, alternate operations. Normal, abnormal, and emergency procedures associated with a flight phase will be assessed during the evaluation of maneuvers or events within that flight phase. Systems are listed separately under "Any Flight Phase" to ensure appropriate attention to systems checks.

SIMULATOR STANDARDS	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
1. FUNCTIONS AND MANEUVERS					
a. Preparation for Flight.		X	X	X	
(1) Preflight. Accomplish a functions check of all switches, indicators, systems, and equipment at all cockpit crewmembers' and instructors' stations and determine that the cockpit design and functions are identical to that of the helicopter simulated.					
(2) APU/Engine start and **runup.**					
(a) Normal start procedures.					

SIMULATOR STANDARDS-Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
(b) Alternate start procedures.					
(c) Abnormal starts and shutdowns (hot start, hung start, etc.)					
(d) Rotor engagement.					
(e) Systems checks.					
(f) Other.					
b. Ground Taxi.		X	X	X	
(1) Power required to taxi.					
(2) Brake effectiveness.					
(3) Ground handling.					
(4) Abnormal/emergency procedures, for example:					
(a) Brake system failure.					
(b) Ground resonance.					
(c) Other.					
c. Hover.			X	X	
(1) Takeoff to a hover.					
(2) Instrument response.					
(a) Engine instruments.					
(b) Flight instruments.					
(3) Hovering turns.					
(4) Hover power checks.					
(a) In ground effect (IGE).					
(b) Out of ground effect (OGE).					
(5) Crosswind/tailwind hover.					
(6) Abnormal/emergency procedures, for example:					
(a) Engine failure.					

SIMULATOR STANDARDS-Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
(b) Hovering autorotation.					
(c) Fuel governing system failure.					
(d) Settling with power (OGE).					
(e) Stability system failure.					
(f) Directional control malfunction.					
(g) Other.					
(7) Translating tendency.					
(8) External load operations.					
(a) Hookup.					
(b) Release.					
(9) Winch operations.					
d. Translational Flight.			X	X	
(1) Forward.					
(2) Sideward.					
(3) Rearward.					
e. Takeoff.					
(1) Normal.					
(a) From ground.			X	X	
(b) From hover.			X	X	
1. CAT A					
2. CAT B					
(c) Running.		X	X	X	
(d) Crosswind/tailwind.		X	X	X	
(e) Maximum performance.			X	X	
(f) Instrument.			X	X	
(g) Confined area.			X	X	

SIMULATOR STANDARDS—Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
(h) Pinnacle/platform.			X	X	
(i) Slope.			X	X	
(j) External load operations.			X	X	
(2) Abnormal/emergency procedures, for example.					
(a) Takeoff with engine failure before and after critical decision point (CDP).		X	X	X	
1. CAT A					
2. CAT B					
(b) Rejected takeoff.		X	X	X	
1. Land					
2. Water (if float equipped)					
(c) Other.		X	X	X	
f. Climb.					
(1) Normal.		X	X	X	
(2) Obstacle clearance.		X	X	X	
(3) Vertical.			X	X	
(4) One engine inoperative.		X	X	X	
(5) Other.		X	X	X	
g. Cruise.					
(1) Performance.		X	X	X	
(2) Flying qualities.		X	X	X	
(3) Turns.		X	X	X	
(a) Timed.					
(b) Normal.					
(c) Steep.					
(4) Accelerations and decelerations.		X	X	X	

SIMULATOR STANDARDS-Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
(5) High airspeed vibrations.		X	X	X	
(6) External load operations.			X	X	
(7) Abnormal/emergency procedures, for example:		X	X	X	
(a) Engine fire.					
(b) Engine failure.					
(c) Inflight engine shutdown and restart.					
(d) Fuel governing system failures.					
(e) Directional control malfunction.					
(f) Hydraulic failure.					
(g) Stability system failure.					
(h) Rotor vibrations.					
(i) Other.					
h. Descent.		X	X	X	
(1) Normal.					
(2) Maximum rate.					
(3) Autorotative.					
(a) Straight in.					
(b) With turn.					
(4) Other.					
i. Approach.					
(1) Non-precision.		X	X	X	
(a) All engines operating.					
(b) One or more engines inoperative.					
(c) Approach procedures, for example:					
1. NDB					
2. VOR, RNAV, TACAN					

SIMULATOR STANDARDS-Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
3. ASR					
4. Circling (if requested by operator)					
NOTE: Simulators with visual systems which permit completing a circling approach without violating FAR § 91.175(e) may be approved for that particular circling approach procedure.					
5. Helicopter only					
6. Other					
(d) Missed approach.					
1. All engines operating					
2. One or more engines inoperative					
(2) Precision.		X	X	X	
(a) All engines operating.					
(b) One or more engines inoperative.					
(c) Approach procedures, for example:					
1. PAR					
2. MLS					
3. ILS					
-- Manual (raw data)					
-- Flight director only					
-- Auto pilot coupled					
-- CAT I					
-- CAT II					
4. Other					
(d) Missed approach.					
1. All engines operating					
2. One or more engines inoperative					

SIMULATOR STANDARDS (Continued)	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
(3) Visual.					
(a) Normal.		X	X	X	
(b) Steep.		X	X	X	
(c) Shallow.		X	X	X	
(d) CAT A profile.		X	X	X	
(e) CAT B profile.		X	X	X	
(f) External load.			X	X	
(g) Visual segment from precision approach.		X	X	X	
(h) Visual segment from circling approach.		X	X	X	
(i) Abnormal/emergency procedures, for example:		X	X	X	
1. Directional control failure					
2. Hydraulics failure					
3. Fuel governing failure					
4. Autorotation					
5. Stability system failure					
6. Other					
j. Landing.					
(1) Normal.					
(a) From a hover.			X	X	
(b) Running.		X	X	X	
(c) Pinnacle/platform.			X	X	
(d) Confined area.			X	X	
(e) Slope.			X	X	
(f) Crosswind/tailwind.		X	X	X	
(2) Abnormal/emergency procedures, for example:					

SIMULATOR STANDARDS-Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
(a) From autorotation.			X	X	
(b) One engine inoperative.		X	X	X	
(c) Directional control failure.			X	X	
(d) Hydraulics failure.		X	X	X	
(e) Stability system failure.		X	X	X	
(f) Other.		X	X	X	
k. Any Flight Phase.					
(1) Helicopter and powerplant systems operation.		X	X	X	
(a) Air conditioning.					
(b) Anti-icing/deicing.					
(c) Auxiliary power-plant.					
(d) Communications.					
(e) Electrical.					
(f) Fire detection and suppression.					
(g) Stabilizer.					
(h) Flight controls.					
(i) Fuel and oil.					
(j) Hydraulic.					
(k) Landing gear.					
(l) Oxygen.					
(m) Pneumatic.					
(n) Powerplant.					
(o) Flight control computers.					
(p) Stability and control augmentation.					
(q) Other.					

SIMULATOR STANDARDS—Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
(2) Flight management and guidance system.		X	X	X	
(a) Airborne radar.					
(b) Automatic landing aids.					
(c) Autopilot.					
(d) Collision avoidance system.					
(e) Flight data displays.					
(f) Flight management computers.					
(g) Head-up displays.					
(h) Navigation systems.					
(i) Other.					
(3) Airborne procedures.		X	X	X	
(a) Holding.					
(b) Air hazard avoidance.					
(c) Retreating blade stall recovery.					
(d) Mast bumping.					
(e) Other.					
l. Engine Shutdown and Parking.		X	X	X	
(1) Engine and systems operation.					
(2) Parking brake operation.					
(3) Rotor brake operation.					
(4) Abnormal/emergency procedures.					
2. VISUAL SYSTEM					
a. Accurate portrayal of environment relating to simulator attitudes and position.		X	X	X	
b. The distances at which airport/heliport features are visible should not be less than those listed below. Distances are measured from runway threshold to a helicopter aligned with the runway on an extended 3-degree glideslope.		X	X	X	

SIMULATOR STANDARDS—Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
(1) Runway definition, strobe lights, approach lights, runway edge white lights and VASI/PAPI lights from 5 statute miles (8 kilometers) of the runway threshold. (2) Runway centerline lights, helipad perimeter lights, and taxiway definition from 3 statute miles (4.8 kilometers). (3) Threshold lights and touchdown zone lights from 2 statute miles (3.2 kilometers). (4) Runway and helipad markings within range of landing lights for night scenes; as required by 3 arc-minute resolution on day scenes.					
c. Representative airport/heliport scene content including the following: (1) Airport runways, helipads, and taxiways. (2) Runway/helipad definition. (a) Runway/helipad surface. (b) Lighting for the runway in use, including runway edge and centerline lighting, touchdown zone, VASI, and approach lighting of appropriate colors. (c) Helipad perimeter and taxiway lights.		X	X	X	
d. Operational landing lights.		X	X	X	
e. Instructor controls of the following: (1) Cloud base-cloud tops. (2) Visibility in statute miles (km) and RVR in feet (meters). (3) Airport/heliport selection. (4) Airport/heliport lighting.		X	X	X	
f. Visual system compatibility with vehicle mathematical model.		X	X	X	
g. Visual cues to assess sink rate, translational rates, and height AGL during landings.		X	X	X	
h. Dusk and night visual scene capability. (1) Surface on runways/helipads, taxiways, and ramps.			X	X	

SIMULATOR STANDARDS-Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
(2) Terrain features.					
i. Minimum of three specific airport/heliport scenes. (1) Surfaces and markings on runways, helipads, taxiways, and ramps. (2) Lighting of appropriate color for all landing areas including runway edge, centerline, VASI/PAPI, and approach lighting for the runway in use. (3) Helipad perimeter and taxiway lighting. (4) Ramps and terminal buildings and vertical objects which correspond to an operator's LOFT and Line Oriented Simulator scenarios (LOS).			X	X	
j. General terrain characteristics and significant landmarks.			X	X	
k. At and below an altitude of 2,000 ft. (610 m) height above the airport/heliport and within a radius of 10 miles (16.1 kilometers) from the airport/heliport, weather representations, including the following: (1) Variable cloud density. (2) Partial obscuration of ground scenes; the effect of a scattered to broken cloud deck. (3) Gradual break out. (4) Patchy fog. (5) The effect of fog on airport/heliport lighting.			X	X	
l. A capability to present ground and air hazards such as another aircraft crossing the active runway and converging airborne traffic.			X	X	
m. Operational visual scenes which provide a cue rich environment sufficient for precise low airspeed/low altitude maneuvering and landing.			X	X	
n. Operational visual scenes which portray representative physical relationships known to cause landing illusions such as short runways, landing approaches over water, uphill or downhill landing areas, rising terrain on the approach path, and unique topographic features.				X	

SIMULATOR STANDARDS-Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
o. Special weather representations of light, medium, and heavy precipitation near a thunderstorm on takeoff, approach, and landing at and below an altitude of 2,000 feet (610 m) above the airport/heliport surface and within a radius of 10 miles (16.1 kilometers) from the airport/heliport.				X	
p. Wet and snow-covered landing areas including runway/helipad lighting reflections for wet, partially obscured lights for snow, or suitable alternative effects.				X	
q. Realistic color and directionality of airport/heliport lighting.				X	
r. Weather radar presentations in helicopters where radar information is presented on the pilot's navigation instruments. Radar returns should correlate to the visual scene.				X	
s. Dynamic visual representation of rotor disk tip path plane.				X	
t. Freedom from apparent quantization (aliasing).				X	
3. SPECIAL EFFECTS.					
a. Buffet rumble, oleo deflections, effects of groundspeed and uneven surface characteristics.		X	X	X	
b. Buffet due to transverse flow effect.		X	X	X	
c. Buffet during extension and retraction of landing gear.		X	X	X	
d. Buffet due to retreating blade stall.		X	X	X	
e. Buffet due to settling with power.		X	X	X	
f. Representative touchdown cues for landing gear.		X	X	X	
g. Rotor vibrations.		X	X	X	
h. Representative brake and tire failure dynamics and decreased brake efficiency due to high brake temperatures based on helicopter related data. These representations must be realistic enough to cause pilot identification of the problem and implementation of appropriate procedures. Simulator pitch, side loading, and directional control characteristics should be representative of the helicopter.			X	X	

SIMULATOR STANDARDS-Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
i. Sound of precipitation and significant helicopter noises perceptible to the pilot during normal operations and the sound of a crash when the simulator is landed in excess of landing gear limitations. Significant helicopter noises should include engine, rotor, transmission, landing gear, and other airframe sounds to a comparable level as that found in a helicopter. The sound of a crash should be related in some logical manner to landing in an unusual attitude or in excess of the structural gear limitations of the helicopter.			X	X	
j. Effects of airframe icing (if applicable).			X	X	

FIGURE 1. SAMPLE LETTER OF REQUEST

Name, POI, _____ (Operator)

FAA FSDO _____

Address

City, State, Zip

Dear Mr. _____ :

(Name) _____ requests evaluation of our (type) _____ helicopter simulator for Level _____ qualification. The (name) _____ simulator with (name) _____ visual system is fully defined on page _____ of the accompanying qualification test guide (QTG). We have completed tests of the simulator and certify that it meets all applicable requirements of Advisory Circular (AC) 120-XX. Appropriate hardware and software configuration control procedures have been established. Our pilots, (name) _____ have assessed the simulator and found that it conforms to the (type) _____ helicopter cockpit configuration and that the simulated systems and subsystems function equivalently to those in the helicopter. Our pilots have also assessed the performance and handling qualities of the simulator and find that it represents the respective helicopter.

(Added comments, as desired)

Sincerely,

FIGURE 2. SAMPLE SIMULATOR INFORMATION PAGE

OPERATOR

OPERATOR SIMULATOR CODE:	H-62 #1
HELICOPTER MODEL:	Whirly H-62
AERODYNAMIC DATA REVISION:	H-62 CPX-8D July 1988
ENGINE MODEL AND REVISION:	CPX-8D-RPT-1 June 1988
FLIGHT CONTROLS DATA REVISION:	H-62 May 1988
FLIGHT MANAGEMENT SYSTEM:	Berry XP
SIMULATOR MODEL AND MANUFACTURER:	MTD-62 Tinker
DATE OF SIMULATOR MANUFACTURE:	1988
SIMULATOR COMPUTER:	CIA
VISUAL SYSTEM MODEL AND MANUFACTURER:	ClearView P-T 5 Channel
VISUAL SYSTEM COMPUTER:	LMB-6
MOTION SYSTEM:	Tinker 6 DOF

FIGURE 3. SAMPLE QTG COVER PAGE

OPERATOR NAME

OPERATOR ADDRESS

FAA QUALIFICATION TEST GUIDE

(HELICOPTER MODEL)

(Type of Simulator)
(Simulator Identification Including Manufacturer,
Serial Number, Visual System Used)

(Simulator Location)

FAA Initial Evaluation
Date: _____

_____ Date: _____
(Operator Approval)

_____ Date: _____
FAA Manager, National
Simulator Program

APPENDIX 5. ABBREVIATIONS AND ACRONYMS

A - Amplitude

AC - Advisory Circular

AGL - Above Ground Level

APU - Auxiliary Power Unit

ASR - Airport Surveillance Radar

C - Centigrade

CAT I - Category I Approach

CAT II - Category II Approach

CAT A - Category A Takeoff or Landing

CAT B - Category B Takeoff or Landing

CDP - Critical Decision Point

CFR - Code of Federal Regulations

CG - Center of Gravity

daN - decaNewtons

DOF - Degrees of Freedom

FAA - Federal Aviation Administration

FAR - Federal Aviation Regulations

fpm - Feet Per Minute

FSDO - Flight Standards District Office

ft - Foot or Feet

g - Gravity

G/S - Glideslope

IGE - In Ground Effect

ILS - Instrument Landing System

in - Inches

k - Kilometers

kt - Knot(s)

lb - Pound(s)

LDP - Landing Decision Point

LOFT - Line Oriented Flight Training

LOS - Line Oriented Simulator Scenarios

ABBREVIATIONS AND ACRONYMS - Continued

m - Meter(s)

MLS - Microwave Landing System

mm - Millimeter(s)

MQTG - Master Qualification Test Guide

m/sec - Meter(s) Per Second

NDB - Nondirectional Beacon

NSPM - National Simulator Program Manager

OGE - Out of Ground Effect

OTP - Optional Test Program

P - Period

PAPI - Precision Approach Path Indicator

PAR - Precision Approach Radar

POI - Principal Operations Inspector

QTG - Qualification Test Guide

ROD - Rate of Descent

RNAV - Area Navigation

RPM - Revolutions Per Minute

RVR - Runway Visual Range

SCIG - Simulator Component Inoperative Guide

sec - Second(s)

SOC - Statement of Compliance

TACAN - Tactical Air Navigation

T(A) - Tolerance Applied to Amplitude

T(P) - Tolerance Applied to Period

TBD - To Be Decided

U.S. - United States

VASI - Visual Approach Slope Indicator

VGS - Visual Ground Segment

VOR - Very High Frequency Omnidirectional Range

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