U.S. Department
of Transportation

Federal Aviation
Administration

Advisory Circular

Subject: AIRPLANE SIMULATOR QUALIFICATION

Date: / /
Initiated by: AFS-205

AC No: 120-40C

1. **PURPOSE.** This advisory circular (AC) provides an acceptable means, but not the only means, of compliance with Title 14, Code of Federal Regulations (CFR) regarding the evaluation and qualification of airplane simulators used in training programs or airmen checking. Criteria specified in this AC are those used by the Federal Aviation Administration (FAA) to determine whether a simulator is qualified 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 part of the CFR. Mandatory terms used in this AC such as "shall" or "must" are used only in the sense of ensuring applicability of this particular method of compliance 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. The provisions of the regulations are controlling. This document does not interpret the regulations. Interpretations are issued only under established agency procedures. This AC applies only to the evaluation of airplane simulators. For information on airplane flight training devices, see AC 120-45, as amended.

2. **CANCELLATION.** AC 120-40B, "Airplane Simulator Qualification," dated July 29, 1991, is canceled. Operators having simulator improvement or acquisition projects in progress on the effective date of this AC have 90 days from the effective date to notify the National Simulator Program Manager (NSPM) of those projects which the operator desires to complete under the provisions of AC 120-40B.

3. **RELATED CFR PARTS AND SECTIONS.** Title 14, CFR Part 1, CFR §§ 61.57, 61.158, 61.157 and 61.158; CFR Part 61, Appendix A; CFR § 63.39; FAR Part 63, Appendix C; CFR §§ 121.407, 121.409, 121.439, and 121.441; CFR Part 121, Appendices E, F, and H; CFR §§ 125.285, 125.287, 125.291, and 125.297; CFR §§ 135.293, 135.297, 135.323, and 135.335; and CFR Part 142.

4. **RELATED READING MATERIAL.** AC 120-28C, "Criteria for Approval of Category III Landing Weather Minima"; AC 120-29, "Criteria for Approving Category I and Category II Landing Minima for CFR 121 Operators"; AC 120-35B, "Line Operational Simulations: Line-Oriented Flight Training, Special Purpose Operational Training, Line Operational Evaluation"; AC 120-41, "Criteria for Operational Approval of Airborne Wind Shear Alerting and Flight Guidance Systems"; AC 120-45A, "Airplane Flight Training Device Qualification"; AC 120-46, "Use of Advanced Training Devices (Airplane Only)"; AC 150/5300-13, "Airport Design"; AC 150/5340-1G, "Standards for Airport Markings"; AC 150/5340-4C, "Installation Details for Runway Centerline Touchdown Zone Lighting Systems"; AC 150/5340-19, "Taxiway Centerline Lighting System"; AC 150/5340-24, "Runway and Taxiway Edge Lighting System"; and AC 150/5345-28D, "Precision Approach Path Indicator (PAPI) Systems"; International Air Transport Association document, "Flight Simulator Design and Performance Data Requirements", 4th edition, 1993; AC 25-7, "Flight Test Guide for Certification of Transport Category Airplanes"; and AC 23-8A, "Flight Test Guide for Certification of Part 23 Airplanes".

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5. BACKGROUND.

a. Throughout the past decade and a half, the complexity, costs, and operating environment of modern airplanes has certainly encouraged, and perhaps mandated, an increasingly broader use of airplane simulation. Computer and simulation technology has significantly advanced over this period and, with the proper application of this technology, the FAA has permitted commensurately greater use of airplane simulators for training and checking of flight crewmembers. Using these simulators in lieu of airplanes results in safer flight training; achieves fuel conservation and reduces other costs for the operators; and at the same time, reduces adverse environmental effects. An arguably greater encouragement for the proper use of these simulators, is that they allow more indepth training than can be accomplished in airplanes themselves and permit flightcrew behavior, learned and practiced in the simulator, to be transferred directly into the airplane. Additionally, as the evolution of simulator technology has advanced and the parallel uses of simulation were increased, a similar evolution of the criteria for simulator qualification became a necessity.

b. In the late 1980's several regulatory authorities around the world, including the FAA, published new or revised documents stating the requirements for the qualification of flight simulators as applicable under their respective country's rules, regulations and policies. As a result, operators of simulators who used them to train and/or check flight crewmembers flying under more than one country's regulatory authority found themselves having to provide unique documentation for each authority. With the encouragement of persons from several wide-ranging governmental and non-governmental interests, the Flight Simulation Group of the United Kingdom's Royal Aeronautical Society (RAeS) agreed to act as the sponsor for two international seminars to focus attention on this situation. The result was the formulation of an RAeS working group consisting of recognized simulation experts and regulatory authority's representatives from around the world. Utilizing the FAA's AC 120-40B document as its foundation, this working group devoted over 10,000 man-hours into the development of a set of simulator evaluation criteria that was acceptable to all parties involved.

c. This set of evaluation criteria was presented for public comment in a conference hosted by RAeS in London on January 16 and 17, 1992. Following detailed explanation and considerable discussion, the conference delegates unanimously agreed to forward these criteria, in the form of a document entitled "International Standards for the Qualification of Airplane Flight Simulators," to the International Civil Aviation Organization (ICAO). After reviewing this document, ICAO has agreed to translate the document into the appropriate language necessary for ICAO purposes. The resulting ICAO document, "Manual of Criteria for the Qualification of Flight Simulators," First Edition, 1993, is now available through the Office of the Secretary General. The provisions of this manual have been incorporated into this AC for the evaluation and qualification of the highest two levels of airplane simulators addressed herein: Level C and Level D. Also, appropriate terms of reference have been added to the document while others have been changed to reflect correct application of terminology; e.g. "computer controlled airplanes" has been added, and "qualification test guide" has replaced "approval test guide."

d. For information purposes, the following is a chronological listing of the documents preceding this AC that addressed the qualification criteria for airplane simulator evaluation and qualification by the FAA, including the effective dates of those documents:

CFR Part 121, Appendix B	01/09/65 to 02/02/70
AC 121-14	12/19/69 to 02/09/76
AC 121-14A	02/09/76 to 10/16/78
AC 121-14B	10/16/78 to 08/29/80
CFR Part 121, Appendix H	06/30/80 to Present
AC 121-14C	08/29/80 to 01/31/83
AC 120-40	01/31/83 to 07/31/86

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AC 120-40A	07/31/86 to 07/29/91
AC 120-40B	07/29/91 to effective date of this AC

6. **DEFINITIONS.** See appendix 4 for a list of definitions and abbreviations used in this AC.

7. **DISCUSSION.**

a. The procedures and criteria for airplane simulator evaluations under the National Simulator Program (NSP) are contained in this AC. A simulator, qualified by the NSPM in accordance with the guidance and standards herein, will be recommended to the operator's principal operations inspector (POI), the training center program manager (TCPM), or the certificate holding district office (CHDO), as appropriate, for approval for use within an operator's training program. For convenience and standardization, the term "FAA local office" will be used to refer to the various options of POI, TCPM, and/or CHDO, as may be appropriate.

b. Evaluation of simulators used for training or certification of airmen under Title 14 CFR falls under the direction of the NSP. A simulator will be evaluated under the provisions of this AC if it is used in a training program approved under CFR Part 63, 121, 125, 135, or 142; or if it is used by an operator in the course of conducting the pilot-in-command (PIC) proficiency check required by CFR § 61.58 or the issuance of an airline transport pilot (ATP) certificate or type rating in accordance with the provisions of CFR § 61.157 or 61.158.

c. Under the NSP concept, a 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 a particular training program will be determined by the POI in the case of CFR Part 63, 121, 125, or 135 certificate holders or by the TCPM responsible for oversight of a training center when the training center is using the simulator to conduct checks required by CFR Part 61 or Part 142.

d. FAA evaluations of simulators located outside the United States may be performed if such simulators are being used by a U.S. operator to train or certificate U.S. airmen. Other evaluations may be conducted as deemed appropriate by the Administrator on a case-by-case basis in accordance with applicable agreements.

e. Operators may contract to use simulators already qualified and approved at a particular level for an airplane type. Such simulators are not required to undergo an additional qualification; however, they must be approved by the FAA for use in that operator's approved training program.

f. If, after reading this AC, there is any question or a need for additional clarification, the reader is encouraged to contact the NSP staff by phone, at 404-305-6100, or by mail, at P.O. Box 20636, Atlanta, GA 30320.

8. **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, that applicant 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 qualification test guide (QTG).

b. The simulator must be assessed in those areas which are essential to completing the airman training and checking process. This includes the simulator's longitudinal and lateral-directional responses; performance in takeoff, climb, cruise, descent, approach, and landing; control checks; cockpit, flight engineer, and instructor station functions checks; and certain additional requirements depending upon the complexity of

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the simulator or the qualification level sought. The motion system and visual system will 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 equally important consideration. Therefore, the simulator will be subjected to validation tests listed in appendix 2 and the functions and subjective tests from appendix 3 of this AC. These tests include a qualitative assessment of the simulator by an NSP pilot. Validation tests are used to compare objectively simulator and airplane data to ensure that they agree within specified tolerances. Functions tests provide a basis for evaluating simulator capability to perform over a typical training or testing period; determining that the simulator will satisfactorily meet each stated training objective and competently simulate each training maneuver or procedure; and verifying correct operation of the simulator controls, instruments, and systems. For initial, upgrade, or recurrent evaluations, the objective and subjective tests that are conducted must utilize the active programming on which the simulator relies to meet day-to-day training, testing, and checking requirements.

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

e. 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 tolerance, 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 is 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 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 landing test tolerances, it could be qualified at Level A.

f. Under normal circumstances, within 10 working days after determining the acceptability of a complete QTG, the NSPM will establish a date for initial or upgrade evaluations. A complete QTG will have all of the objective tests completed with not less than one-third completed on-site. Unusual circumstances may warrant establishment of an evaluation date prior to this determination being made; however, it is imperative to note that if such a schedule is agreed to, any slippage of the evaluation date at the certificate holder's request may result in a significant delay in completing the evaluation.

g. The FAA Simulator Evaluation Specialist is responsible for designating qualified pilots to assist in completing the functions and validation test during evaluations.

9. SIMULATOR DATA REQUIREMENTS.

a. The International Air Transport Association document, "Flight Simulator Design & Performance Data Requirements," 4th edition, 1993, has been recognized and accepted internationally as the most comprehensive standard available that describes the scope and content of data necessary to manufacture, purchase, or accept flight simulators.

b. The tolerances listed for parameters in appendix 2 are the maximum acceptable to the Administrator for simulator validation and must not be confused with design tolerances specified for simulator manufacture.

c. The airplane manufacturer's flight test data are the accepted standard for validating flight simulator performance and handling qualities during evaluation for initial qualification. For airplanes issued an original type certificate after June 1980 or for significant amendments to an original type certificate, or for a supplemental type certificate which would result in handling qualities or performance changes, only manufacturer's

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flight test data will be accepted for validation during initial qualification. Exceptions to this policy must be submitted to the NSPM for review and consideration. However, for airplanes which were type certificated, their flight tests completed, and data released before the issuance of this AC, the NSPM will consider the use of alternative data from the airplane manufacturer. For older airplanes, particularly those certificated before June 1980, additional flight testing may be necessary.

d. If flight test data from a source in addition to or independent of the airplane manufacturer's data are to be submitted in support of a simulator qualification, this data must be acquired in accordance with normally accepted professional flight test methods. As a minimum, proper consideration for the following areas must be an intrinsic part of any such flight test planning:

(1) Appropriate and sufficient data acquisition equipment or system.

(2) Current calibration of data acquisition equipment and airplane performance instrumentation (calibration must be traceable to a recognized standard).

(3) Flight test plan, including:

(i) Maneuvers and procedures.

(ii) Initial conditions.

(iii) Flight condition.

(iv) Aircraft configuration.

(v) Weight and center of gravity.

(vi) Atmospheric ambient and environmental conditions.

(vii) Data required.

(viii) Other appropriate factors.

(4) Appropriately qualified flight test personnel.

(5) Appropriate data reduction and analysis methods and techniques.

(6) Data accuracy. The data must be presented in a format that supports the flight simulator validation.

(7) Resolution must be sufficient to determine compliance with the tolerances of appendix 2.

(8) Presentation must be clear with necessary guidance provided.

(9) Over-plots must not obscure the reference data.

(10) The flight test plan should be reviewed with the NSP staff well in advance cofommencing the flight test. After completion of the tests, a flight test report should be submitted in support of the validation data. The report must contain sufficient data and rationale to support qualification of the simulator at the level requested.

e. For a new type or model of airplane, predicted data, validated by a limited set of initial (or preliminary) flight test data, may be used for an interim period if the prediction methodology and QTG test results have been determined to be acceptable by the NSPM. In the event that predicted data are used in programming the simulator, it must be updated as soon as practicable when actual airplane flight test data become available. Unless specific conditions warrant otherwise, simulator programming should be updated within 6 months after release of the final flight test data package by the airplane manufacturer.

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10. INITIAL OR UPGRADE EVALUATIONS.

a. An operator seeking simulator initial or upgrade evaluation must submit a request in writing to the NSPM through the FAA local office. This request must contain a Statement of Compliance (SOC) certifying that the simulator meets all of the provisions of this AC, that the cockpit configuration conforms to that of the airplane, that specific hardware and software configuration control procedures have been established, and that the pilot(s) designated by the operator and identified by name is (are) qualified in the airplane: assess(es) the simulator and find(s) that it conforms to the operator's cockpit configuration; determine(s) that the simulator systems and subsystems function equivalently to those in the airplane; and find(s) that the performance and flying qualities of the simulator are representative of the airplane. A sample letter of request is included in appendix 5.

b. The operator must 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 information:

(i) The operator's simulator identification number or code.

(ii) Airplane model and series being simulated.

(iii) Aerodynamic data revision.

(iv) Engine model and its data revision.

(v) Flight control data revision.

(vi) Flight Management System identification and revision level.

(vii) Simulator model and manufacturer.

(viii) Date of simulator manufacture.

(ix) Simulator computer identification.

(x) Visual system model and manufacturer.

(xi) 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 (including sign conventions).

(7) An SOC with certain requirements. SOC's must provide references to 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 the "Comments" column in appendix 1, "Simulator Standards," to see when SOC's are required.

(8) Recording procedures or required equipment for the validation tests.

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

(i) Name of the test.

(ii) Objective of the test.

(iii) Initial conditions.

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(iv) Manual test procedures.

(v) Automatic test procedures (if applicable).

(vi) Method for evaluating simulator validation test results.

(vii) List of all parameters driven or constrained during the automatic test and identify any constraints active during the manual test.

(viii) Tolerances for relevant parameters.

(ix) Source of Airplane Test Data (document and page number).

(x) Copy of Airplane Test Data (if located in a separate binder, state binder identification and page number for pertinent data location).

(xi) Simulator Validation Test Results as obtained by the operator. Such tests must be clearly identified as to the device being tested.

(xii) A means, acceptable to the NSPM, of easily comparing the simulator test results to airplane test data.

c. The operator's simulator test results must be recorded on a multichannel recorder, line printer, or other appropriate recording media acceptable to the NSPM. Simulator results must be labeled using terminology common to airplane parameters as opposed to computer software identifications. These results must be easily compared with the supporting data by employing cross-plotting, overlays, transparencies, or other acceptable means. Airplane 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. For tests involving time histories, flight test data sheets (or transparencies thereof) and simulator test results must be clearly marked with appropriate reference points to ensure an accurate comparison between simulator and airplane with respect to time. Time histories recorded via a line printer are to be clearly identified for cross-plotting on the airplane data. Cross-plotting of the simulator data to airplane data is essential to verify simulator performance in each test. During an evaluation, the FAA will devote adequate time to detailed checking of selected tests from the QTG. The FAA evaluation serves to validate the operator's simulator test results.

d. The operator's completed QTG, the SOC, and the request for evaluation will be submitted to the FAA local office. The FAA local office 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. During the review of each QTG by representatives of the NSP, a determination will be made, on a case-by-case basis, as to the need for returning a file copy. Revisions and data updates to an original QTG should always be submitted to the NSP for review and be approved prior to incorporation into a QTG.

f. The operator may elect to accomplish the QTG validation tests while the simulator is at the manufacturer's facility. It is intended that tests at the manufacturer's facility be accomplished at the latest practical time prior to disassembly and shipment. The operator must substantiate simulator performance at the final location by repeating a representative sampling of the validation tests in the QTG and submitting those tests to the NSPM. This sample must consist of at least one-third of the QTG validation tests. The QTG must be clearly annotated to indicate when and where each test was accomplished. After review of these tests, the FAA will schedule an initial evaluation.

g. 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

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results, becomes the master QTG (MQTG). The MQTG will then remain in the custody of the operator for use in future recurrent evaluations.

h. 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) Advise the FAA local office and NSPM of the move.

(2) Prior to returning the simulator to service at the new location, the operator will 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.

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

i. When there is a change of operator, the new operator must accomplish all required administrative procedures, including the submission of the currently approved MQTG through the FAA local office to the NSPM. The MQTG must be clearly identified as property of the new operator. The FAA local office will then submit the package as described in paragraph 9.d. of this AC. The simulator may, at the discretion of the NSPM, be subject to an evaluation in accordance with the original qualification criteria.

j. 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.

11. RECURRENT EVALUATIONS.

a. For a simulator to retain its qualification, 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 Simulation Evaluation Specialist.

(1) This schedule relies on operator-conducted, quarterly checks which include approximately one-forth of the validation tests in the MQTG each quarter. These quarterly validation tests should be accomplished on an evenly distributed basis throughout the year. However, in certain circumstances, alternative arrangements may be authorized after coordination with the NSPM. The tests accomplished during the quarter in which the evaluation is to occur, and those accomplished the previous quarter, will be attested to by the operator and reviewed by the Simulation Evaluation Specialist during each scheduled recurrent evaluation. This ensures that the MQTG will be completed annually.

(2) Each scheduled recurrent evaluation, normally scheduled for 8 hours of simulator time, will consist of functions tests and a selection of 20 percent of those tests conducted by the operator since the last scheduled recurrent evaluation and a selection of 10 percent of the remaining MQTG tests.

b. Dates of recurrent evaluations will normally 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 schedule:

(1) Operators of simulators having the appropriate automatic recording and plotting capabilities may apply for evaluation under the OTP.

(2) Operators must notify the NSPM in writing of their intent to enter the OTP. If the FAA determines that the evaluation can be accommodated with 4 hours or less of simulator time, subsequent 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 viability of the OTP.

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d. If the FAA inspector plans to accomplish specific test during a normal recurrent evaluation that would require the use of special equipment or technicians, the operator will be notified as far in advance of the evaluation as practical. These tests would include latencies, through-put, control dynamics, sounds and vibrations, motion, and/or some visual system tests.

e. In instances where an operator plans to remove a simulator from active status for prolonged periods, the following procedures shall apply to requalify the simulator pursuant to this AC:

(1) The NSPM and the FAA local office shall be notified in writing with an estimate of the period that the simulator will be inactive and how it will be maintained during the inactive period.

(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 not later than the date on which the first missed 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 the entire test guide since, under the recurrent evaluation program, the MQTG is to be completed annually.

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

(5) The simulator will normally be requalified using the FAA-approved MQTG and criteria that was in effect prior to its removal from qualification; however, inactive periods exceeding 1 year will require a review of the qualification basis.

(6) If these procedures are not possible, the establishment of a new qualification basis will be necessary.

12. 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 required by the NSPM to verify its status.

b. The simulator will lose its qualification when the NSPM can no longer ascertain maintenance of the original simulator validation criteria based on a recurrent or special evaluation. Additionally, the FAA local office shall advise the operator and the NSPM if a deficiency is jeopardizing the accomplishment of training, testing, or checking requirements, and arrangements shall be made to resolve the deficiency in the most effective manner, including the withdrawal of the qualification by the NSPM or the withdrawal of approval by the POI, the TCPM, or the CHDO.

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

a. In accordance with FAR Part 121, Appendix H, operators must notify the FAA local office and NSPM at least 21 days prior to making software program or hardware changes which might impact flight or ground dynamics of a simulator. A complete list of these planned changes, including dynamics related to the motion and visual systems and any necessary updates to the MQTG, must be provided in writing. Operators should maintain a configuration control system to ensure the continued integrity of the simulator as qualified. The configuration control system may be examined by the FAA on request.

b. Modifications to or update of simulator systems (e.g., visual, motion, control loading, instructor operating station, etc.) or of simulated airplane systems (e.g., flight controls, pneumatics, electrical, hydraulic, etc.) will require an evaluation of at least that (those) system(s) modified or updated. Modifications to the host computer or significant revisions to the QTG will require re-accomplishment of those QTG tests affected by the modification or revision. Replacement of the host computer will require re-accomplishment of the

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entire QTG. In all of the above situations, a subjective evaluation may be required and the QTG tests will be conducted in accordance with the original qualification basis with the FAA reserving the right to observe the conduct of these QTG tests. Any modification or update to a simulator that would result in the simulator being upgraded to a higher level will require an initial/upgrade evaluation in accordance with paragraph 10 of this document.

14. SIMULATOR QUALIFICATION BASIS. The FAR require that simulators maintain their approved performance, functions, and other characteristics. Except as provided in paragraph 2 of this AC, all initial, upgrade, and recurrent evaluations of those simulators initially qualified according to the acceptable methods of compliance described herein will be conducted in accordance with the provisions of this AC. 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 upgrade requires an initial evaluation of that simulator in accordance with the provisions herein.

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APPENDIX 1. SIMULATOR STANDARDS

1. **DISCUSSION.** This appendix describes the minimum simulator requirements for qualifying Level A, Level B, Level C, and Level D airplane simulators. An operator desiring evaluation of an airplane simulator not equipped with a visual system (nonvisual simulator) must comply with Level A simulator requirements except those pertaining to visual systems. Appropriate regulations 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 (SOC) and, in some designated cases, an objective test. SOC's 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, requirements for SOC's 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 airplane simulated. Direction of movement of controls and switches identical to that in the airplane. 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 pilot seats are also considered part of the cockpit and must replicate the airplane.	X	X	X	X	
b. Circuit breakers that affect procedures and/or result in observable cockpit indications properly located and functionally accurate.	X	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 airplane attitude, thrust, drag, altitude, temperature, gross weight, center of gravity location, and configuration.	X	X	X	X	
d. Ground operations generically represented to the extent that allows turns within the confines of the runway and adequate control on the landing and roll-out from a crosswind approach to a landing.	X				
e. All relevant instrument indications involved in the simulation of the applicable airplane automatically responded to control movement by a crewmember or external disturbances to the simulated airplane; i.e., turbulence or windshear.	X	X	X	X	Numerical values must be presented in the appropriate units for U.S. operations; for example, fuel in pounds, speed in knots, and altitude in feet.

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SIMULATOR STANDARDS—Continued	SIMULATOR LEVEL A	B	C	D	COMMENTS
f. Communications and navigation equipment corresponding to that installed in the applicant's airplane with operation within the tolerances prescribed for the applicable airborne equipment.	X	X	X	X	See appendix 3, paragraph 1 for further information regarding long-range navigation equipment.
g. 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 pilot's panel and forward windows. Observer seats need not represent those found in the airplane but must be equipped with similar positive restraint devices.	X	X	X	X	
h. Simulator systems must simulate the applicable airplane system operation, both on the ground and in flight. Systems must be operative to the extent that normal, abnormal, and emergency operating procedures can be accomplished.	X	X	X	X	
i. Instructor controls to enable the operator to control all required system variables and insert abnormal or emergency conditions into the airplane systems.	X	X	X	X	
j. Control forces and control travel which correspond to that of the replicated airplane. Control forces should react in the same manner as in the airplane under the same flight conditions.	X	X	X	X	
k. Significant cockpit sounds which result from pilot actions corresponding to those of the airplane.	X	X	X	X	
l. Sound of precipitation, windshield wipers, and other significant airplane 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.
m. Realistic amplitude and frequency of cockpit noises and sounds, including precipitation, windshield wipers, engine, and airframe sounds. The sounds shall be coordinated with the weather representations required in FAR Part 121, Appendix H, Phase III (Level D), Visual Requirement No. 3.				X	Tests required for noises and sounds that originate from the airplane or airplane systems.
n. Ground handling and aerodynamic programming to include the following: (1) Ground effect--for example: roundout, flare, and touchdown. This requires data on lift, drag, pitching moment, trim, and power in ground effect.		X	X	X	Statement of Compliance. Tests required.

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SIMULATOR STANDARDS—Continued	SIMULATOR LEVEL A	B	C	D	COMMENTS
n. Cont'd (2) Ground reaction--reaction of the airplane upon contact with the runway during landing to include strut deflections, tire friction, side forces, and other appropriate data, such as weight and speed, necessary to identify the flight condition and configuration. (3) Ground handling characteristics--steering inputs to include crosswind, braking, thrust reversing, deceleration, and turning radius.					
o. Windshear models which provide training in the specific skills required for recognition of windshear phenomena and execution of recovery maneuvers. Such models must be representative of measured or accident derived winds, but may include simplifications which ensure repeatable encounters. For example, models may consist of independent variable winds in multiple simultaneous components. Wind models should be available for the following critical phases of flight: (1) Prior to takeoff rotation. (2) At liftoff. (3) During initial climb. (4) On final approach, nearing ground effect. The FAA Windshear Training Aid presents one acceptable means of compliance with simulator wind model requirements. The QTG should either reference the FAA Windshear Training Aid or present airplane related data on alternate methods implemented. Wind models from the Royal Aerospace Establishment (RAE), the Joint Airport Weather Studies (JAWS) Project and other recognized sources may be implemented, but must be supported or properly referenced in the QTG.			X	X	Tests required. See Appendix 6 for information applicable to all simulators, regardless of level, used to satisfy the training requirements of CFR Part 121 pertaining to a certificate holder's approved low-altitude windshear flight training program.
p. Instructor controls for wind speed and direction.	X	X	X	X	
q. Stopping time and distances for at least the following runway conditions. (1) Dry (2) Wet (3) Icy (4) Patchy Wet (5) Patchy Icy (6) Wet on Rubber Residue in Touchdown Zone			X	X	Statement of Compliance. Objective tests required for (1), (2), (3); subjective check for (4), (5), (6).

SIMULATOR STANDARDS—Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
r. Brake and tire failure dynamics (including antiskid) and decreased brake efficiency due to brake temperatures based on airplane related data.			X	X	Statement of Compliance. Tests required for decreased braking efficiency due to brake temperature.
s. 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.
t. Simulator computer capacity, accuracy, resolution, and dynamic response sufficient for the qualification level sought.	X	X	X	X	Statement of Compliance. CFR Part 121, Appendix H, specifies computer standard for Phases II & III (Level C and Level D).
u. Control feel dynamics which replicate the airplane simulated. Free response of the controls shall match that of the airplane within the tolerance given in appendix 2. Initial and upgrade evaluations will include control free response (column, wheel, and pedal) measurements recorded at the controls. The measured responses must correspond to those of the airplane in takeoff, cruise, and landing configurations. (1) For airplanes with irreversible control systems, measurements may be obtained on the ground if proper pitot static inputs are provided to represent conditions typical of those encountered in flight. Engineering validation or airplane manufacturer rationale will be submitted as justification to ground test or omit a configuration. (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.			X	X	Tests required. See appendix 2, paragraph 3.

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SIMULATOR STANDARDS—Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
v. 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 150/300 milliseconds of the time, but not before the time, when the airplane would respond under the same conditions. Visual scene changes from steady state disturbance shall occur within the system dynamic response limit of 150/300 milliseconds but not before the resultant motion onset. The test to determine compliance with these requirements should include simultaneously recording the analog output from the pilot's control column, wheel, 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 airplane response data in the takeoff, cruise, and landing configuration. The intent is to verify that the simulator system transport delays or time lags are less than 150/300 milliseconds and that the motion and visual cues relate to actual airplane responses. For airplane response, acceleration in the appropriate rotational axis is preferred.	X	X	X	X	Tests required. For Levels A and B, response must be within 300 milliseconds. For Levels C and D, response must be within 150 milliseconds.
As an alternative, a transport delay test may be used to demonstrate that the simulator system does not exceed the specified limit of 150/300 milliseconds. This test shall measure all the delays encountered by a step signal migrating from the pilot's 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. 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 hardware responses. It need only be measured once in each axis, being independent of flight conditions.					

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SIMULATOR STANDARDS—Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
w. Aerodynamic modeling which, for airplanes issued an original type certificate after June 1980, includes low-altitude level-flight ground effect, Mach effect at high altitude, effects of airframe icing, normal and reverse dynamic thrust effect on control surfaces, aeroelastic representations, and representations of nonlinearities due to sideslip based on airplane flight test data provided by the manufacturer.				X	Statement of Compliance. Tests required. See appendix 2, paragraph 4 for further information on ground effect. Mach effect, aeroelastic representations, and 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 thrust effects and a Statement of Compliance and demonstration of icing effects are required.
x. Aerodynamic and ground reaction modeling for the effects of reverse thrust on directional control.		X	X	X	Statement of Compliance. Tests required.
y. Self-testing for simulator hardware and 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 airplane standard. Automatic flagging of "out-of-tolerance" situations is encouraged.			X	X	Statement of Compliance. Tests required.
z. Timely permanent update of simulator hardware and programming subsequent to airplane modification.	X	X	X	X	
aa. A documented software and hardware control methodology which may be supported by diagnostic analysis program(s).				X	SOC required.
bb. Daily preflight documentation either in the daily log or in a location easily accessible for review. .	X	X	X	X	
3. MOTION SYSTEM.					
a. Motion (force) cues perceived by the pilot representative of the airplane motions, i.e., touchdown cues, should be a function of the simulated rate of descent (RoD).	X	X	X	X	
b. A motion system having a minimum of three degrees of freedom.	X	X			
c. A motion system which produces cues at least equivalent to those of a six-degrees-of-freedom synergistic platform motion system.			X	X	Statement of Compliance. Tests required.

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SIMULATOR STANDARDS—Continued	SIMULATOR LEVEL A	B	C	D	COMMENTS
d. A means for recording the motion response time for comparison with airplane data.	X	X	X	X	See paragraph 2.v. of this appendix.
e. Special effects programming to include the following: (1) Runway rumble, oleo deflections, effects of groundspeed and uneven runway characteristics. (2) Buffets on the ground due to spoiler/speedbrake extension and thrust reversal. (3) Bumps after lift-off of nose and main gear. (4) Buffet during extension and retraction of landing gear. (5) Buffet in the air due to flap and spoiler/speedbrake extension. (6) Stall buffet to, but not necessarily beyond, the FAA certificated stall speed, V_S. (7) Representative touchdown cues for main and nose gear. (8) Nosewheel scuffing. (9) Thrust effect with brakes set. (10) Mach buffet.		X	X	X	
f. Characteristic buffet motions that result from operation of the airplane (for example, high-speed buffet, extended landing gear, flaps, nosewheel scuffing, stall) 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 airplane data. Airplane data are also required to define flight deck motions when the airplane 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.

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SIMULATOR STANDARDS—Continued	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
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	X	
b. Continuous minimum collimated field of view of 45 degrees horizontal and 30 degrees vertical per pilot seat. Both pilot seat visual systems shall be able to be operated simultaneously.	X	X			
c. Continuous minimum collimated visual field of view of 75 degrees horizontal and 30 degrees vertical per pilot seat. Both pilot seat visual systems shall be able to be operated simultaneously.			X	X	Wide angle systems providing cross cockpit viewing must provide a minimum of 150 degrees horizontal field of view; 75 degrees per pilot seat operated simultaneously.
d. A means for recording the visual response time.	X	X	X	X	
e. Verification of visual ground segment and visual scene content at a decision height on landing approach. The QTG should contain appropriate calculations and a drawing showing the pertinent data used to establish the airplane location and visual ground segment. Such data should include, but is not limited to, the following: (1) Static airplane dimensions as follows: (i) Horizontal and vertical distance from main landing gear (MLG) to glideslope reception antenna. (ii) Horizontal and vertical distance from MLG to pilot's eyepoint. (iii) Static cockpit cutoff angle. (2) Approach data as follows: (i) Identification of runway. (ii) Horizontal distance from runway threshold to glideslope intercept with runway. (iii) Glideslope angle. (iv) Airplane pitch angle on approach. (3) Airplane data for manual testing:	X	X	X	X	

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SIMULATOR STANDARDS—Continued	SIMULATOR LEVEL A	B	C	D	COMMENTS
(i) Gross weight. (ii) Airplane configuration. (iii) Approach airspeed.					
e. Cont'd The above parameters should be presented for the airplane in landing configuration and a main wheel height of 100 feet (30 meters) above the touchdown zone. The visual ground segment and scene content should be determined for a runway visual range of 1,200 feet or 350 meters.					
f. For the NSPM to qualify precision weather minimum accuracy on simulators qualified under previous advisory circulars, operators must provide the information required in paragraph e. above.	X	X	X	X	
g. Visual cues to assess sink rate and depth perception during takeoff and landing.		X	X	X	
h. Test procedures to quickly confirm visual system color, RVR, focus, intensity, level horizon, and attitude as compared to the simulator attitude indicator.			X	X	Statement of Compliance. Tests required.
i. Night and dusk visual scene capability, free from apparent quantization.			X	X	Statement of Compliance. Tests required. Dusk scene to enable identification of a visible horizon and typical terrain characteristics such as fields, roads, and bodies of water.
j. 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.
k. Surface resolution will 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 should be confirmed by calculations in the Statement of Compliance.			X	X	Where a night/dusk system is used on a Level C simulator, this test does not apply.
l. Lightpoint size -- 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 will form a 4-degree angle or less.			X	X	This is equivalent to a lightpoint resolution of 3 arc-minutes.

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SIMULATOR STANDARDS—Continued	SIMULATOR LEVEL A	B	C	D	COMMENTS
m. Lightpoint contrast ratio -- 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.			X	X	
n. Daylight, dusk, and night visual scenes w/sufficient scene content to recognize airport, the terrain, and major landmarks around the airport and to successfully accomplish a visual 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 1,000 surfaces for daylight and 4,000 lightpoints for night and dusk scenes, 6 foot-lamberts (20 cd/m^2) of light measured at the pilot's eye position (highlight brightness) 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 "wash-out" the displayed visual scene nor fall below 5 foot-lamberts (17 cd/m^2) of light as reflected from an approach plate at knee height at the pilot's station. All brightness and resolution requirements will be reviewed at least yearly by the NSPM. The NSPM may request that objective test(s) be accomplished at any time there are indications that visual system performance is degrading. Compliance of the brightness capability may be demonstrated with a test pattern of white light using a spot photometer. **NOTE: The following tests are conducted for daylight visual scenes. When conducting these tests, cockpit ambient light levels should be maintained at Level D (Phase III) requirements.** (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 bright square for each channel using a 1 degree spot photometer. This value shall have a minimum brightness of 2 foot-lamberts (7 cd/m^2). Measure any adjacent dark squares. The contrast ratio is the bright square value divided by dark square value. Minimum test contrast ratio result is 5:1.				X	Statement of Compliance. Test required. All lighting used to meet the ambient light requirement must come on automatically when "day" is selected and any such lighting cannot be modified or overridden by pilot action or instructor selected failure modes. The use of airplane lights is discouraged.

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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 completely covering the center white square of each channel and measure the brightness using the 1 degree spot photometer. Light points or light point arrays are not acceptable. Use of calligraphic capabilities to enhance raster brightness is acceptable.					

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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 airplane 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 airplane source data.

Certain visual, sound, and motion tests in this appendix are not necessarily based upon validation data with specific tolerances. However, these tests are included here for completeness, and the required criteria must be fulfilled instead of meeting a specific tolerance.

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. Self testing of simulator hardware and programming to determine compliance with all simulator requirements is specified by FAR Part 121, Appendix H, for Phase III (Level D) simulators. It is not the intent and it is not acceptable to the FAA only to test each simulator subsystem independently. Overall integrated testing of the simulator must be accomplished to assure 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. Simulators must be compared to flight test data except as otherwise specified. For airplanes certificated prior to June 1980, 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 should represent airplane performance and handling qualities at operating weights and centers of gravity (CG) typical of normal operation. If a test is supported by airplane data at one extreme weight or CG, another test supported by airplane data at midconditions or as close as possible to the other extreme should be included. 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 augmentation devices.

For the testing of Computer Controlled Airplane (CCA), or other highly augmented airplane simulators, flight test data are required for both the Normal (N) and Non-normal (NN) control states, as indicated in the validation requirements of this appendix. Tests in the non-normal state will always include the least augmented state. Tests for other levels of control state degradation may be required as detailed by the NSPM at the time of definition of a set of specific airplane tests for simulator data. Where applicable, flight test data must record:

a. Pilot controller deflections or electronically generated inputs, including location of input;

b. Flight control surface positions unless test results are not affected by, or are independent of, surface positions.

The recording requirements of subparagraph a. and b. above apply to both normal and non-normal states. All tests in the Table of Validation Tests require test results in the Normal control state unless specifically noted otherwise in the comments sections following the Computer Controlled Airplane designation (CCA).

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Where tests in the performance section, para. 1a. through f. of this appendix, require data in the Normal control state, it indicates the preferred control state. However, if the test results are independent of control state, Non-normal control data may be substituted. Where tests in other sections of the appendix require testing in the Normal control state, then this indicates the required control state.

Where Non-normal control states are required, it indicates test data shall be provided for one or more Non-normal control states, including the least augmented state.

In the case of simulators approved under previous advisory circular, 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.

Flight 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 airplane 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. When two tolerance values are given for a parameter, the less restrictive may be used 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 Conditions Verification. When comparing the parameters listed to those of the airplane, sufficient data must also be provided to verify the correct flight condition.

For example, to show that control force is within ±5 pound (2.2 daN) in a static stability test, data to show the correct airspeed, power, thrust or torque, airplane 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 airplane, but airspeed, altitude, control input, airplane configuration, and other appropriate data must also be given. All airspeed values should be clearly annotated as to indicated, calibrated, etc., and like values used for comparison.

NOTE: The application of this appendix to simulator validation requires reference to CFR Part 121, Appendix H, to acquire full knowledge of simulator criteria for approval.

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TABLE OF VALIDATION TESTS

I = Initial Evaluation

R = Recurrent Evaluation

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
1. PERFORMANCE							
a. TAXI							
(1) Minimum Radius Turn	±3 Feet (0.9m) or 20% of Airplane Turn Radius	Ground/Takeoff		IR	IR	IR	Plot both Main and Nosegear turning radius. Data for no brakes and minimum thrust except for airplanes requiring asymmetric thrust or braking to turn.
(2) Rate of Turn vs. Nosewheel Steering Angle	±10% or ±2°/sec. Turn Rate	Ground/Takeoff		IR	IR	IR	Plot a minimum of two speeds, greater than minimum turning radius speed, with a spread of at least 5 knots.
b. TAKEOFF							
(1) Ground Acceleration Time and Distance	±5% Time and Distance or ±5% Time and ±200 Feet (61 Meters) of Distance	Ground/Takeoff	IR	IR	IR	IR	Unfactored aircraft certification data may be used. Acceleration Time and Distance should be recorded for a minimum of 80% of total Distance segment. (Brake release to V_r).

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(2) Minimum Control Speed Ground (V_{mcg}) Aerodynamic Controls Only per Applicable Airworthiness Standard or low Speed. Engine Inoperative Ground Control Characteristics	±25% of Maximum Airplane Lateral Deviation or ±5 Feet (1.5 Meters)	Ground/Takeoff	IR	IR	IR	IR	Engine failure speed must be within ±1 knot of airplane engine failure speed. Engine thrust decay must be that resulting from the mathematical model for the engine variant applicable to the simulator under test. If the modelled engine variant is not the same as the airplane manufacturers' flight test engine, then a further test may be run with the same initial conditions using the thrust from the flight test data as a driven parameter. Airplanes with reversible flight control systems must also plot Rudder Pedal Force (±10% or ±5 lbs (2.2 daN)).
(3) Minimum Unstick Speed or equivalent as provided by the airplane manufacturer.	±3 Kts Airspeed ±1.5° Pitch	Ground/Takeoff	IR	IR	IR	IR	V_{mu} is defined as that speed at which the last main landing gear leaves the ground. Main landing Gear Strut Compression or equivalent air/ground signal should be recorded. Record as a minimum from 10 Kts before start of rotation. Elevator input must precisely match airplane data.
(4) Normal Takeoff	±3 Kts Airspeed ±1.5° Pitch ±1.5° Angle of Attack ±20 Feet (6 Meters) Altitude	Ground/Takeoff and First Segment Climb	IR	IR	IR	IR	Record Takeoff profile from brake release to at least 200 ft. (61 Meters) Above Ground Level (AGL). Airplanes with reversible flight control systems must also plot Stick/Column Force (±10% or ±5 lbs (2.2 daN)).

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(5) Critical Engine Failure on Takeoff	±3 Kts Airspeed ±1.5° Pitch, ±1.5° Angle of Attack ±20 Feet (6 Meters) Altitude ±2° Bank and Sideslip Angle	Ground/Takeoff and First Segment Climb	IR	IR	IR	IR	Record Takeoff profile at near maximum take-off weight to at least 200 ft. (61 Meters) AGL. Engine failure speed must be within ±3 Kts of airplane data. Airplanes with reversible flight control systems must also plot Stick/Column Force (±10% or ±5 lbs (2.2 daN)), Wheel Force (±10% or ±3 lbs (1.3 daN)), Rudder Pedal Force (±10% or ±5 lbs (2.2 daN)). CCA: Test in Normal AND Non-normal control state.
(6) Crosswind Takeoff	±3 Kts Airspeed ±1.5° Pitch, ±1.5° Angle of Attack ±20 Feet (6 Meters) Altitude ±2° Bank and Sideslip Angle	Ground/Takeoff and First Segment Climb	IR	IR	IR	IR	Record Takeoff profile to at least 200 ft. (61 Meters) AGL. Requires test data, including wind profile, for a crosswind component of at least 20 Kts or the maximum demonstrated crosswind, if available. Airplanes with reversible flight control systems must also plot Stick/Column Force (±10% or ±5 lbs (2.2 daN)), Wheel Force (±10% or ±3 lbs (1.3 daN)), Rudder Pedal Force (±10% or ±5 lbs(2.2 daN)).
(7) Rejected Takeoff	±5% Time or ±1.5s ±7.5% Distance or ±250 ft. (±76M)	Ground/Takeoff	IR	IR	IR	IR	Record near Maximum Takeoff Weight. Autobrakes will be used where applicable. Maximum braking effort, Auto or Manual. Time and distance should be recorded from brake release to a full stop.

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(8) Dynamic Engine Failure After Takeoff	±20% Body Rates	1st Segment Climb			IR	IR	Engine failure speed must be within ±3 Kts of airplane data. Engine failure may be a snap deceleration to idle. Record Hands Off from 5 secs before to 5 secs after engine failure or 30 deg Bank, whichever occurs first, and then Hands On until wings level recovery. NOTE: For safety considerations, airplane flight test may be performed out of ground effect at a safe altitude, but with correct airplane configuration and airspeed. **CCA:** Test in Normal AND Non-normal control state.
c. CLIMB							
(1) Normal Climb All Engines Operating	±3Kts Airspeed ±5% or ±100 FPM (0.5 Meters/Sec.) Climb Rate	Climb With All Engines Operating	IR	IR	IR	IR	May be a Snapshot Test. Manufacturer's gross climb gradient may be used for flight test data. Record at nominal climb speed and mid initial climb altitude.
(2) One Engine Inoperative Second Segment Climb	±3 Kts Airspeed ±5% or ±100 FPM (0.5 Meters/Sec.) Climb Rate, but not less than the FAA-Approved Airplane Flight Manual (AFM) Rate of Climb.	Second Segment Climb With One Engine Inoperative	IR	IR	IR	IR	May be a Snapshot Test. Manufacturer's gross climb gradient may be used for flight test data. Test at weight, altitude, & temperature limited conditions.
(3) One Engine Inoperative Enroute Climb	±10% Time ±10% Distance ±10% Fuel Used	Enroute Climb			IR	IR	Approved Performance Manual data may be used. Test for at least a 5000 ft. (1550 Meters) segment.

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(4) One Engine Inoperative Approach Climb for Airplanes With Icing Accountability per Approved AFM	±3 Kts Airspeed ±5% or ±100 FPM (0.5 Meters/Sec.) Climb Rate, but not less than the Approved AFM Rate of Climb	Approach Climb With One Engine Inoperative	IR	IR	IR	IR	May be a Snapshot Test. Manufacturer's gross climb gradient may be used for flight test data. Test near the FAA maximum certificated landing weight.
(5) Level Acceleration and Deceleration	±5% Time	Cruise			IR	IR	Minimum of 50 Kts speed change.
d. CRUISE (1) Cruise Performance	±.05% EPR ±5% of N_1 and N_2 ±5% of Torque ±5% of Fuel Flow	Cruise			IR	IR	May be a minimum of 2 consecutive snapshots with a spread of at least 5 minutes.
e. STOPPING (1) Deceleration Time and Distance, Wheel Brakes Using Manual Braking, Dry Runway (No Reverse Thrust)	±5% of Time. For distance up to 4000 Feet (1220 m.) ±200 Feet (61 m.) or ±10% whichever is smaller. For distance greater than 4000 Feet (1220 m.) ±5% of distance.	Landing	IR	IR	IR	IR	Time and Distance should be recorded for at least 80% of the total segment (TD to Full Stop). Data on brake system pressure must be provided. Data required for medium, light, and near maximum landing gross weights. Engineering data may be used for the medium and light gross weight conditions.
(2) Deceleration Time and Distance, Reverse Thrust, Dry Runway (No Wheel Braking)	±5% Time and the Smaller of ±10% or ±200 Feet (61 Meters) of Distance	Landing	IR	IR	IR	IR	Time and Distance should be recorded for at least 80% of the total demonstrated reverse thrust segment. Data required for medium, light, and near maximum landing gross weights. Engineering data may be used for the medium and light gross weight conditions.
(3) Stopping Distance, Wheel Brakes, Wet Runway (No Reverse Thrust)	±10% of Distance or ±200 Feet (61 Meters)	Landing			I	I	FAA-Approved AFM data is acceptable.
(4) Stopping Time and Distance, Wheel Brakes, Icy Runway (No Reverse Thrust)	±10% of Distance or ±200 Feet (61 Meters)	Landing			I	I	FAA-Approved AFM data is acceptable.

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
f. ENGINES (1) Acceleration	±10% T_i ±10% T_t	Approach or Landing	IR	IR	IR	IR	T_i = Total time from initial throttle movement until a 10% response of a critical engine parameter. T_t = Total time from T_i to 90% go-around power. Critical engine parameter should provide the best indication of power (N_1, N_2, EPR, Torque, etc.). Plot from flight idle to go-around power for a rapid (slam) throttle movement.
(2) Deceleration	±10% T_i ±10% T_t	Ground/Takeoff	IR	IR	IR	IR	Test from maximum takeoff power to 10% of maximum takeoff power (90% decay in power). Plot from maximum takeoff power to 90% decay in maximum takeoff power for a rapid (slam) throttle movement.
2. HANDLING QUALITIES a. STATIC CONTROL CHECKS** (1) Column Position vs. Force and Surface Position Calibration	±2 lbs (0.9 daN) Breakout. ±5 lbs (2.2 daN) or ±10% Force ±2° Elevator	Ground (validated with flight data)	IR	IR	IR	IR	Uninterrupted control sweep, stop to stop. Must be validated with inflight data from tests such as Longitudinal Static Stability, Stalls, etc. Static and Dynamic Flight Control tests should be accomplished at the same Feel or Impact Pressures. **CCA:** Position vs. force not applicable if airplane cockpit controller is used.

**Column, wheel, 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 is to instrument the simulator in an equivalent manner to the flight test airplane. The force and position data from this instrumentation can be directly recorded and matched to the airplane data. Such a permanent installation would eliminate the need for installation of external devices.

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(2) Wheel Position vs. Force and Surface Position Calibration	±2 lbs (0.9 daN) Breakout. ±3 lbs (1.3 daN) or ±10% Force ±1° Aileron ±3° Spoiler Angle	Ground (validated with flight data)	IR	IR	IR	IR	Uninterrupted control sweep, stop to stop. Must be validated with inflight data from tests such as Engine Out Trims, Steady State Sideslips, etc. Static and Dynamic Flight Control tests should be accomplished at the same Feel or Impact Pressures. **CCA:** Position vs. force not applicable if airplane cockpit controller is used.
(3) Rudder Pedal Position vs. Force and Surface Position Calibration	±5 lbs (2.2 daN) Breakout ±5 lbs (2.2 daN) or ±10% Force ±2° Rudder Angle	Ground (validated with flight data)	IR	IR	IR	IR	Uninterrupted control sweep, stop to stop. Must be validated with inflight data from tests such as Engine Out Trims, Steady State Sideslips, etc. Static and Dynamic Flight Control tests should be accomplished at the same Feel or Impact Pressures.
(4) Nosewheel Steering Force & Position	±2 lbs (0.9 daN) Breakout ±3 lbs (1.3 daN) or ±10% Force ±2° Nosewheel Angle	Ground	IR	IR	IR	IR	Uninterrupted control sweep, stop to stop.
(5) Rudder Pedal Steering Calibration	±2° Nosewheel Angle ±0.5° Deadband	Ground	IR	IR	IR	IR	Uninterrupted control sweep, stop to stop.
(6) Pitch Trim Calibration Indicator vs. Computed	±0.5° of Computer Trim Angle ±10% Trim Rate	Ground and Go-Around	IR	IR	IR	IR	Trim rate to be checked at pilot primary induced trim rate (ground) and autopilot or pilot primary trim rate in flight at go-around flight conditions.

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(7) Alignment of Power Lever Angle vs. Selected Engine Parameter (EPR, N^1, Torque, etc.)	±5° of Power Lever Angle	Ground	IR	IR	IR	IR	Simultaneous recording for all engines. A 5° tolerance applies against airplane data and between engines. May be Snapshot Test. NOTE: In the case of propeller powered airplanes, if an additional lever, usually referred to as the propeller lever, is present, it must also be checked. Where these levers do not have angular travel, a tolerance of ±0.8 inches (2 cm) applies.
(8) Brake Pedal Position Vs. Force and Brake System Pressure	±5 lb (2.2 daN) or 10% Force ±150 psi (1.0 MPa) or ±10% Brake System Pressure	Ground	IR	IR	IR	IR	Simulator computer output results may be used to show compliance. Relate hydraulic system pressure to pedal position in a ground static test.
b. DYNAMIC CONTROL CHECKS**							
(1) Pitch Control	±10% of time for first zero crossing, and ±10(n±1)% of period thereafter. ±10% amplitude of first overshoot. ±20% of amplitude of 2nd and subsequent overshoots greater than 5% of initial displacement (A_d). ±1 overshoot.	Takeoff, Cruise, Landing			IR	IR	Data should be normal control displacement in both directions. (Approximately 25% to 50% of full throw). Tolerances apply against the absolute values of each period (considered independently). n is the sequential period of a full cycle of oscillation. Refer to paragraph 3 this appendix. CCA: Test not applicable if airplane controller is installed in the simulator.

**Column, wheel, 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 is to instrument the simulator in an equivalent manner to the flight test airplane. The force and position data from this instrumentation can be directly recorded and matched to the airplane data. Such a permanent installation would eliminate the need for installation of external devices.

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(2) Roll Control	Same as (1) above.	Takeoff, Cruise, Landing			IR	IR	Data should be for normal control displacement (approximately 25% to 50% of full throw). CCA: Test not applicable if airplane controller is installed in the simulator.
(3) Yaw Control	Same as (1) above.	Takeoff, Cruise, Landing			IR	IR	Data should be for normal control displacement (approximately 25% to 50% of full throw). CCA: Test not applicable if airplane controller is installed in the simulator.
(4) Small Control Inputs	±20% Body Rates	Cruise and Approach			IR	IR	Small control inputs defined as 5% of total travel.
c. LONGITUDINAL							
(1) Power Change Dynamics	±3 Kts Airspeed ±100 Feet (30 Meters) Altitude ±20% or ±1.5° Pitch	Approach to Go-Around	IR	IR	IR	IR	Wing flaps should remain in the approach position. Time history of uncontrolled free response for time increment from 5 seconds before the initiation of the power change to 15 seconds after completion of the power change. CCA: Test in Normal AND Non-normal control state.
(2) Flap/Slat Change Dynamics	±3 Kts Airspeed ±100 Feet (30 Meters) Altitude ±20% or ±1.5° Pitch	Retraction, After Takeoff. Extension, Approach to Landing	IR IR	IR IR	IR IR	IR IR	Time history of uncontrolled free response for time increment from 5 seconds before the initiation of the configuration change to 15 seconds after completion of the configuration change. CCA: Test in Normal AND Non-normal control state.

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(3) Spoiler/Speedbrake Change Dynamics	±3 Kts Airspeed ±100 Feet (30 Meters) Altitude ±20% or ±1.5° Pitch	Cruise	IR	IR	IR	IR	Time history of uncontrolled free response for time increment from 5 seconds before the initiation of the configuration change to 15 seconds after the completion of the configuration change. Results required for both extension and retraction. **CCA:** Test in Normal AND Non-normal control state.
(4) Gear Change Dynamics	±3 Kts Airspeed ±100 Feet (30 Meters) Altitude ±20% or ±1.5° Pitch	Takeoff to Second Segment Climb, Approach to Landing	IR	IR	IR	IR	Time history of uncontrolled free response for a time increment of 5 seconds before the initiation of the configuration change to 15 seconds after the completion of the configuration change. **CCA:** Test in Normal AND Non-normal control state.
(5) Gear and Flap/Slat Operating Times	±1 second or ±10% of Time	Takeoff, Approach	IR	IR	IR	IR	Normal and alternate flaps, extension and retraction. Normal gear, extension and retraction. Alternate gear, extension only. All data for full range. Intermediate increment times not required. Tabular data from production airplanes are acceptable.
(6) Longitudinal Trim	±1° Pitch Control (Stab and Elev) ±1° Pitch Angle ±5% Net Thrust or Equivalent	Cruise, Approach, Landing	IR	IR	IR	IR	May be Snapshot Tests. **CCA:** Test in Normal AND Non-normal control state.

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(7) Longitudinal Maneuvering Stability (Stick Force/g)	±5 lbs (±2.2 daN) or ±10% Column Force or Equivalent Surface Position	Cruise, Approach, Landing	IR	IR	IR	IR	Test at approximately 20° and 30° of bank for approach and landing configurations. Test at approximately 20°, 30°, and 45° of bank for the cruise configuration. May be a series of snapshot test. **CCA:** Test in Normal AND Non-normal control state.
(8) Longitudinal Static Stability	±5 lbs (±2.2 daN) or ±10% Column Force or Equivalent Surface Position	Approach	IR	IR	IR	IR	Data for at least 2 speeds above and 2 speeds below trim speed. May be a series of Snapshot Tests. **CCA:** Test in Normal OR Non-normal control state.
(9) Stick Shaker, Airframe Buffet, Stall Speeds	±3 Kts Airspeed ±2° Bank for speeds higher than stick shaker or initial buffet	Second Segment Climb and Approach or Landing	IR	IR	IR	IR	Stall Warning Signal should be recorded and must occur in the proper relation to stall. Airplanes exhibiting a sudden pitch attitude change or "g break" must demonstrate this characteristic. Airplanes with reversible flight control systems must also plot Stick/Column force (±10% or ±5 lbs (2.2 daN)). **CCA:** Test in Normal AND Non-normal control state.
(10) Phugoid Dynamics	±10% of Period ±10% of Time to 1/2 or Double Amplitude or ±.02 of Damping Ratio	Cruise	IR	IR	IR	IR	Test should include 3 full cycles (6 overshoots after input completed) or that sufficient to determine time to 1/2 or double amplitude whichever is less. **CCA:** Test in Non-normal control state.
(11) Short Period Dynamics	±1.5° Pitch or ±2°/sec. Pitch Rate ±.10g Normal Acceleration	Cruise		IR	IR	IR	**CCA:** Test in Normal AND Non-normal control state.

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
d. LATERAL DIRECTIONAL (1) Minimum Control Speed, Air (V_{mca}), per Applicable Airworthiness Standard or low Speed Engine Inoperative Handling Characteristics in Air	±3 Kts Airspeed	Takeoff or Landing (Whichever is most critical in airplane)	IR	IR	IR	IR	V_{mca} may be defined by a performance or control limit which prevents demonstration of V_{mca} in the conventional manner. **CCA:** Test in Normal OR Non-normal control state.
(2) Roll Response (Rate)	±10% or ±2°/sec. Roll Rate	Cruise and Approach or Landing	IR	IR	IR	IR	Test with normal wheel deflection (about 30%). Airplanes with reversible flight control systems must also plot Wheel Force (±10% or ±3 lbs (1.3 daN)).
(3) Roll Response to Roll Controller Step Input	±10% or ±2°/sec. Roll Rate	Approach or Landing	IR	IR	IR	IR	Roll rate response. **CCA:** Test in Normal AND Non-normal control state.
(4) Spiral Stability	Correct Trend, ±2° Bank or ±10% in 20 Seconds	Cruise	IR	IR	IR	IR	Airplane data averaged from multiple tests may be used. Test for both directions. **CCA:** Test in Non-normal control state.
(5) Engine Inoperative Trim	±1° Rudder Angle or ±1° Tab Angle or Equivalent Pedal ±2° Sideslip Angle	Second Segment Climb and Approach or Landing	IR	IR	IR	IR	May be Snapshot Tests.
(6) Rudder Response	±2°/sec. or ±10% Yaw Rate	Approach or Landing	IR	IR	IR	IR	Test with stability augmentation ON and OFF. Rudder step input of approximately 25% rudder pedal throw. **CCA:** Test in Normal AND Non-normal control state.

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(7) Dutch Roll, Yaw Damper OFF	±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 and Approach or Landing		IR	IR	IR	Test for at least 6 cycles with stability augmentation OFF. CCA: Test in Non-normal control state.
(8) Steady State Sideslip	For a given rudder position ±2° Bank, ±1° Sideslip, ±10% or ±2° Aileron, ±10% or ±5° Spoiler or Equivalent Wheel Position or Force	Approach or Landing	IR	IR	IR	IR	May be a series of Snapshot Tests using at least two rudder positions (each direction for propeller driven airplanes). Airplanes with reversible flight control systems must also show Wheel Force (±10% or ±3 lbs (1.3 daN)) and Rudder Pedal Force (±10% or ±5 lbs (2.2 daN)).
e. LANDINGS							
(1) Normal Landing	±3 Kts Airspeed ±1.5° Pitch ±1.5° Angle of Attack ±10% Altitude or ±10 Feet (3 Meters)	Landing		IR	IR	IR	Test from a minimum of 200 ft. (61 Meters) AGL to Nosewheel Touchdown. Derotation may be shown as a separate segment from the time of main gear touchdown. Medium, light, and near maximum landing weights must be shown. Airplanes with reversible flight control systems must also plot Stick/Column Force (±10% or ±5 lbs (2.2 daN)). CCA: Test in Normal AND Non-normal control state.

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(2) Minimum/No Flap Landing	±3 Kts Airspeed ±1.5° Pitch ±1.5° Angle of Attack ±10% Altitude or ±10 Feet (3 Meters)	Minimum Certified Landing Flap Configuration			IR	IR	Test from a minimum of 200 feet (61 Meters) AGL to Nosewheel touchdown. Derotation may be shown as a separate segment from the time of MLG touchdown. Test at near Maximum Landing Weight. Airplanes with reversible flight control systems must also plot Stick/Column Force (±10% or ±5 lbs (2.2 daN)).
(3) Crosswind Landing	±3 Kts Airspeed ±1.5° Pitch ±1.5° Angle of Attack ±10% Altitude or ±10 Feet (3 Meters) ±2° Bank Angle ±2° Sideslip Angle	Landing		IR	IR	IR	Test from a minimum of 200 ft. (61 Meters) AGL to a 50% decrease in MLG touchdown speed. Requires test data, including wind profile, for a crosswind component of at least 20 Kts or the maximum demonstrated crosswind, if available. Airplanes with reversible flight control systems must also plot Wheel Force (±10% or ±3 lbs (1.3 daN)) and Rudder Pedal Force (±10% or ±5 lbs (2.2 daN)).
(4) One Engine Inoperative Landing	±3 Kts Airspeed ±1.5° Pitch ±1.5° Angle of Attack ±10% Altitude or ±10 Feet (3 Meters) ±2° Bank Angle ±2° Sideslip Angle	Landing		IR	IR	IR	Test from a minimum of 200 ft. (61 Meters) AGL to a 50% decrease in main landing gear touchdown speed.
(5) Autoland (if applicable)	±5 Feet (1.5 Meters) Flare Height ±0.5 sec T_f ±140 ft/min (.7 Meters/sec) Rate of Descent at Touchdown ±10 Feet (3 Meters) Lateral Deviation from maximum demonstrated crosswind (autoland) deviation	Landing			IR	IR	This test IS NOT a substitute for the Ground Effects test requirement. Plot Lateral Deviation and continue to Autopilot disconnect. T_f = Duration of Flare.

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(6) Go Around	±3 Kts Airspeed ±1.5° Pitch ±1.5° Angle of Attack	Go Around			IR	IR	Engine Inoperative Go Around required near Maximum Landing Weight with critical engine(s) inoperative. Normal All Engine Autopilot Go Around must be demonstrated (if applicable) at Medium Weight. **CCA:** Test in Normal AND Non-normal control state.
(7) Directional Control (Rudder Effectiveness) with symmetric reverse thrust.	±2 deg/sec yaw rate	On Ground		IR	IR	IR	Apply yaw control in both directions until reaching minimum thrust reverser operation speed. Airplane test data required. however, airplane manufacturer's engineering simulator data may be used for reference data as last resort.
(8) Directional Control (Rudder Effectiveness) with asymmetric reverse thrust.	±5 knots	On Ground		IR	IR	IR	Maintain heading with yaw control. Tolerance applies to speed at which control of yaw cannot be maintained. Airplane test data required, however, airplane manufacturer's engineering simulator data may be used for reference data as last resort.
f. GROUND EFFECT							
(1) A Test to Demonstrate Longitudinal Ground Effect	±1° Elevator or Stabilizer Angle ±5% Net Thrust or Equivalent ±1° Angle of Attack ±10% Height/Altitude or ±5 Feet (1.5 m.) ±3 Knots Airspeed ±1° Pitch Attitude	Landing		IR	IR	IR	See paragraph 4, this appendix. A rationale must be provided with justification of results.

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
g. BRAKE FADE (1) A Test to Demonstrate Decreased Braking Efficiency Due to Brake Temperature	None	Takeoff or Landing			IR	IR	Statement of Compliance required. The test must show decreased braking efficiency due to brake temperature based on airplane related data.
h. WINDSHEAR (1) A Test to Demonstrate Windshear Models	None	Takeoff and Landing			IR	IR	Windshear models are required which provide training in the specific skills required for recognition of windshear phenomena and execution of recovery maneuvers. See Appendix 6.
i. FLIGHT AND MANEUVER ENVELOPE PROTECTION FUNCTIONS (1) Overspeed	±5 Kts Airspeed	Cruise			IR	IR	The requirements of (1) through (6) are only applicable to computer controlled airplanes. Time history results are required of simulator response to control inputs during entry into protection envelope limits. Flight test data must be provided for both normal and non-normal control states.
(2) Minimum Speed	±3 Kts Airspeed	Takeoff, Cruise, and Approach or Landing			IR	IR	
(3) Load Factor	±0.1g Normal Acceleration	Takeoff, Cruise			IR	IR	
(4) Pitch Angle	±1.5° Pitch	Cruise, Go Around			IR	IR	
(5) Bank Angle	±2° or ±10% Bank	Approach			IR	IR	
(6) Angle of Attack	±1.5° AOA	Second Segment and Approach or Landing			IR	IR	
3. MOTION SYSTEM a. FREQUENCY RESPONSE	As specified by operator for simulator acceptance.		IR	IR	IR	IR	Appropriate test to demonstrate Frequency Response required.

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
b. LEG BALANCE	As specified by operator for simulator acceptance.		IR	IR	IR	IR	Appropriate test to demonstrate Leg Balance required.
c. TURN AROUND CHECK	As specified by operator for simulator acceptance.		IR	IR	IR	IR	Appropriate test to demonstrate Smooth Turn Around required.
d. CHARACTERISTIC BUFFET	See Appendix 1, para 3.f.					IR	Compliance statement required. Test required.
e. SPECIAL EFFECTS							
(1) Thrust Effects With Brakes Set	None	Takeoff			IR	IR	Qualitative assessment to determine that the effect is representative.
(2) Runway Rumble, Oleo Deflections, Effects of Ground speed and Uneven Runway Characteristics	None	Takeoff			IR	IR	Qualitative assessment to determine that the effect is representative.
(3) Bumps After Lift-Off of Nose and Main Gear	None	Takeoff			IR	IR	Qualitative assessment to determine that the effect is representative.
(4) Buffet During Retraction and Extension of Landing Gear	None	Climb			IR	IR	Qualitative assessment to determine that the effect is representative.
(5) Buffets in Air Due to Flap and Spoiler/ Speedbrake Extension and Approach-to-Stall	None	Approach			IR	IR	Qualitative assessment to determine that the effect is representative.
(6) Touchdown Cues for Main and Nose Gear	None	Landing			IR	IR	Qualitative assessment to determine that the effect is representative.
(7) Buffets On the Ground Due to Spoiler/ Speedbrake Extension and Thrust Reversal	None	Landing			IR	IR	Qualitative assessment to determine that the effect is representative.
(8) Nosewheel Scuffing	None	Ground			IR	IR	Qualitative assessment to determine that the effect is representative.
(9) Mach Buffet	None	Flight			IR	IR	Qualitative assessment to determine that the effect is representative.

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
4. VISUAL SYSTEM - (Note: Refer to Appendix 3 for additional information.)							
a. VISUAL GROUND SEGMENT (VGS)	±20% of distance. Threshold lights must be visible if they are in the calculated visual segment for the airplane. (See example in Comments.)	Landing. Static at 100 ft. (30 Meters) Wheel Height Above Touchdown Zone on Glideslope. Runway Visual Range = 1200 Ft. or 350 Meters.	IR	IR	IR	IR	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 ground segment scene content calculations. Tolerance Example: If the calculated VGS for the airplane 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. DISPLAY SYSTEMS TESTS							
(1) Visual System Color	Demonstration				I	I	
(2) Visual RVR Calibration	Demonstration				I	I	
(3) Visual Display Focus and Intensity	Demonstration				I	I	
(4) Visual Attitude vs. Simulator Attitude Indicator (Pitch and Roll of Horizon)	Demonstration				I	I	
(5) Demonstrate 10 Levels of Occulting Through Each Channel of System	Demonstration				I	I	
(6) Daylight Scene Display Brightness	≥ 6 Foot-Lamberts (20 cd/m^2) on the Display and ≥ 5 Foot-Lamberts (17 cd/m^2) at an Approach Plate Positioned at the Pilot's Knee					I	
(7) Contrast Ratio	≥ 5:1					IR	

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(8) Surface Resolution	≤ 3 arc minutes				I	I	Where a night/dusk system is used on a Level C Simulator, this test does not apply.
(9) Lightpoint Size	≤ 6 Arc Minutes				I	I	This is equivalent to a lightpoint resolution of 3 arc-minutes.
c. VISUAL FEATURE RECOGNITION							Within final picture resolution, the distances at which features are visible for tests (1) through (4) should not be less than those indicated in the specified test. Operators should indicate the light intensity level used for the test.
(1) Runway Definition, Strobe Lights, Runway Edge White Lights,	5 sm (8 km) Minimum	Approach			IR	IR	
(2) Runway Centerline Lights	3 sm (5 km) Minimum from the Runway Threshold	Approach			IR	IR	
(3) Threshold Lights and Touchdown Zone Lights	2 sm (3 km) Minimum from the Runway Threshold	Approach			IR	IR	
(4) Runway Markings	Night/Dusk Scenes Within Range of Landing Lights. Day Scene as Required by 3 Arc-Minutes Resolution.	Approach			IR	IR	
d. VISUAL SCENE CONTENT							For tests (1) through (10) specific airport models or generic airport models may be used. All models used for these tests must be available in the operator's training program. A minimum of three specific airport models is required.
(1) Airport Runways and Taxiways	(See 4.d. Comment)	Ground or Flight			IR	IR	Qualitative Assessment.

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(2) Surfaces on Runways.Taxiways and Ramps	(See 4.d. Comment)	Ground			IR	IR	Qualitative Assessment.
(3) Lighting for the Runway in Use	(See 4.d. Comment)	Ground or Flight			IR	IR	Qualitative Assessment. All lights associated with the test runway should be checked for appropriate colors (e.g.. edge lights. centerline, touchdown zone, VASI. PAPI. REIL).
(4) Ramps and Terminal Buildings	(See 4.d. Comment)	Ground			IR	IR	Qualitative Assessment.
(5) Dusk and Night Visual Scene Capability	(See 4.d. Comment)	Flight			IR	IR	Qualitative Assessment. Dusk scene environment should include visible horizon and recognition of cultural features on the ground.
(6) General Terrain Characteristics and Significant Landmarks	(See 4.d. Comment)	Flight			IR	IR	Qualitative Assessment.
(7) Capability to present Ground and Air Hazards such as another Flight airplane crossing the active runway or Converging Airborne Traffic.	(See 4.d. Comment)	Ground Flight			IR	IR	Qualitative Assessment.
(8) Operational Visual Scenes which portray representative physical relationships known to cause Landing Illusions on Short Runways. Landing Approaches Over Water. Uphill or Downhill Runways. Rising Terrain on the Approach Path and Unique Topographic Features.	(See 4.d. Comment)	Approach and landing				IR	Qualitative Assessment.
(9) Realistic Color and Directionality of Flight Airport Lighting	(See 4.d. Comment)	Ground or Flight				IR	Qualitative Assessment.
(10) Freedom From Apparent Quantization (Aliasing)	(See 4.d. Comment)				IR	IR	Qualitative Assessment.

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
e. WEATHER EFFECTS							For tests (1) through (8) specific airport models or generic airport models may be used. All models used for these tests must be available in the operator's approved training program. Weather effects described in tests (4) through (8) should be selectable via controls at the instructor station such as cloudbase, cloud effects and visibility (Kilometers/Statute Miles) and RVR (meters/feet).
(1) Special weather representations of light, medium, and heavy precipitation near a thunderstorm on takeoff, approach, and landings at and below an altitude of 2,000 ft. (610 M) above the airport surface and within a radius of 10 sm (16 km) from the airport.	(See 4.e. Comment)	Flight				IR	Qualitative Assessment.
(2) Wet and snow covered runway including runway lighting reflections for wet, partially obscured lights or snow or suitable alternative effects.	(See 4.e. Comment)	Ground				IR	Qualitative Assessment.
(3) Weather radar presentations in airplanes where radar information is presented on the pilot's navigation instruments. Radar returns should correlate to the visual scene.	(See 4.e. Comment)	Flight				IR	Qualitative Assessment.
(4) Variable cloud density.	(See 4.e. Comment)	Approach			IR	IR	Qualitative Assessment.
(5) Partial obscuration of ground scenes: the effect of a scattered to broken cloud deck.	(See 4.e. Comment)	Approach			IR	IR	Qualitative Assessment.

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(6) Gradual break out.	(See 4.e. Comment)	Approach			IR	IR	Qualitative Assessment. Visibility and cloud effects should be checked at and below an altitude of 2,000 ft (610 Meters) height above the airport and within a radius of 10 sm (16 km) from the airport.
(7) Patchy fog. Demonstration Model	(See 4.e. Comment)	Approach or Takeoff			IR	IR	Qualitative Assessment.
(8) The effect of fog on airport lighting.	(See 4.e. Comment)	Approach or Takeoff			IR	IR	Qualitative Assessment.
f. FLIGHT COMPATIBILITY							
(1) Visual system compatibility with aerodynamic programming.	Not Applicable	Ground and Flight	IR	IR	IR	IR	Qualitative tests to verify compatibility with the validity of latency, aerodynamic throughput, and visual attitude versus simulator attitude tests.
(2) Visual cues to assess sink rate and depth perception during landings.	Not Applicable	Approach and Landing		IR	IR	IR	Qualitative test to confirm that terrain features, surfaces on taxiways and ramps and other cultural features which provide cues for landing the airplane.
(3) Accurate portrayal of environment relating to simulator attitudes.	Not Applicable	Flight	IR	IR	IR	IR	
5. SOUND SYSTEM.							
a. Significant cockpit sounds which result from pilot actions corresponding to those of the airplane.	Not Applicable	Flight and Ground			IR	IR	Qualitative Assessment. Statement of Compliance or demonstration of representative sounds.

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
b. Sound of precipitation, windshield wipers, and other significant airplane noises perceptible to the flight crew during normal operations and the sound of a crash related in a logical manner to landing in an unusual attitude or in excess of the structural gear limitations of the airplane.	To Be Developed.	Flight and Ground			IR	IR	Statement of Compliance or demonstration of representative sounds. Significant airplane noises should include noises such as engine, flap, gear, and spoiler extension and retraction and thrust reversal to a comparable level as that found in the airplane.
c. Realistic amplitude and frequency of cockpit noises and sounds including engine, airframe, and precipitation sounds. The sounds shall be coordinated with weather representations which are required to be displayed in the visual scene.	To Be Developed.	Flight and Ground				IR	Test results must show a comparison of the amplitude and frequency content of the sounds.
6. SIMULATOR SYSTEMS a. VISUAL, MOTION, AND COCKPIT INSTRUMENT RESPONSE							
Visual, Motion, and Instrument Systems response to an abrupt pilot controller input,	150 milliseconds or less after airplane response.	Takeoff, Cruise Approach or Landing			IR	IR	One test is required in each axis (pitch, roll, and yaw) for each of the 3 conditions compared to airplane data
compared to airplane response for a similar input. or	300 milliseconds or less after airplane response.	Takeoff, Cruise, Approach or Landing	IR	IR			for a similar input. (Total 9 tests.) Visual change may start before motion response, but motion acceleration must occur before completion of visual scan of first video field containing different information.
Transport Delay	150 milliseconds or less after control movement.	Pitch, Roll, Yaw			IR	IR	One test is required in each axis. (Total 3 tests.)
	300 milliseconds or less after control movement.	Pitch, Roll, Yaw	IR	IR			See Appendix 1, Item 2.v.

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TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
b. 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.					IR	IR	
(2) Self testing of simulator hardware and programming to determine compliance with Levels B, C, and D Simulator Requirements.						IR	
(3) Diagnostic analysis as prescribed in CFR Part 121, Appendix H, Phase III (Level D) Simulator Requirement No. 5.						IR	

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3. **CONTROL DYNAMICS.** The characteristics of an airplane flight control system have a major effect on the handling qualities. A significant consideration in pilot acceptability of an airplane is the "feel" provided through the cockpit controls. Considerable effort is expended on airplane feel system design in order to deliver a system with which pilots will be comfortable and consider the airplane 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 airplane. This fact is recognized in CFR Part 121, Appendix H, Phase II (Level C) Simulator Requirement 10, which states: "Aircraft control feel dynamics shall duplicate the airplane simulated. This shall be determined by comparing a recording of the control feel dynamics of the simulator to airplane measurements in the takeoff, cruise, and landing configuration."

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 airplane systems is essential. The required control feel dynamic tests dictated by CFR Part 121, Appendix H, are described in 2.b. 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 takeoff, cruise, and landing flight conditions and configurations.

For airplanes with irreversible control systems, measurements may be obtained on the ground if proper Pitot-static inputs are provided to represent airspeeds typical of those encountered in flight. Likewise, it may be shown that for some airplanes, takeoff, cruise, and landing configurations have like effects. Thus, one may suffice for another. If either or both considerations apply, engineering validation or airplane manufacturer rationale must be submitted as justification for ground tests or for eliminating a configuration. 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 alternative approach, such as computer plots which were produced concurrently and show satisfactory agreement. Repeat of the alternative method during the initial evaluation would then satisfy this test requirement.

a. Control Dynamics Evaluations. 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 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 airplane must show that the dynamic damping cycles (free response of the control) match that of the airplane within specified tolerances. The method of evaluating the response and the tolerance to be applied are described below for the underdamped and critically damped 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 airplane control system and, consequently, will enjoy the full tolerance specified for that period.

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The damping tolerance should 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 $T(A_d)$ on Figure 1 is ±5 percent of the initial displacement amplitude A_d from the steady state value of the oscillation. Oscillations within the residual band are considered insignificant. When comparing simulator data to airplane data, the process should begin by overlaying or aligning the simulator and airplane 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 airplane 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 airplane within ±10 percent. The simulator response should be critically damped also. Figure 2 illustrates the procedure.

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
$T(A_n)$	±10% of A_1, ±20% of Subsequent Peaks
$T(A_d)$	±5% of A_d = Residual Band
	Overshoots ±1

c. Alternative Method for Control Dynamics. One airplane manufacturer has proposed, and the FAA accepts, an alternative means for dealing with control dynamics. The method applies to airplanes with hydraulically powered flight controls and artificial feel systems. Instead of free response measurements, the system would be validated by measurements of control force and rate of movement.

For each axis of pitch, roll, and yaw, the control shall be forced to its maximum extreme position for the following distinct rates. These tests shall be conducted at typical taxi, takeoff, cruise, and landing conditions.

(1) Static Test - Slowly move the control such that approximately 100 seconds are required to achieve a full sweep. A full sweep is defined as movement of the controller from neutral to the stop, usually aft or right stop, then to the opposite stop, then to the neutral position.

(2) Slow Dynamic Test - Achieve a full sweep in approximately 10 seconds.

(3) Fast Dynamic Test - Achieve a full sweep in approximately 4 seconds.

NOTE: Dynamic sweeps may be limited to forces not exceeding 100 lb.

Tolerances

(1) Static Test - Items 2.a.(1)(2) and (3) of this appendix.

(2) Dynamic Test - 2 lb. or 10 percent on dynamic increment above static test.

The FAA is open to alternative means such as the one described above. Such alternatives should, however, be justified and appropriate to the application. For example, the method described here may not apply to all manufacturers' systems and certainly not to airplanes with reversible control systems. Hence, each case

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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, then more conventionally accepted methods must be used.

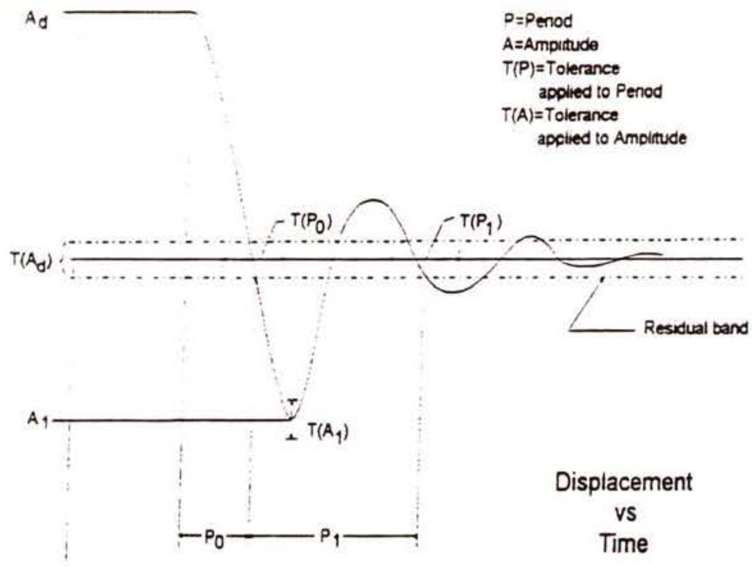

FIGURE 1. UNDER-DAMPED STEP RESPONSE

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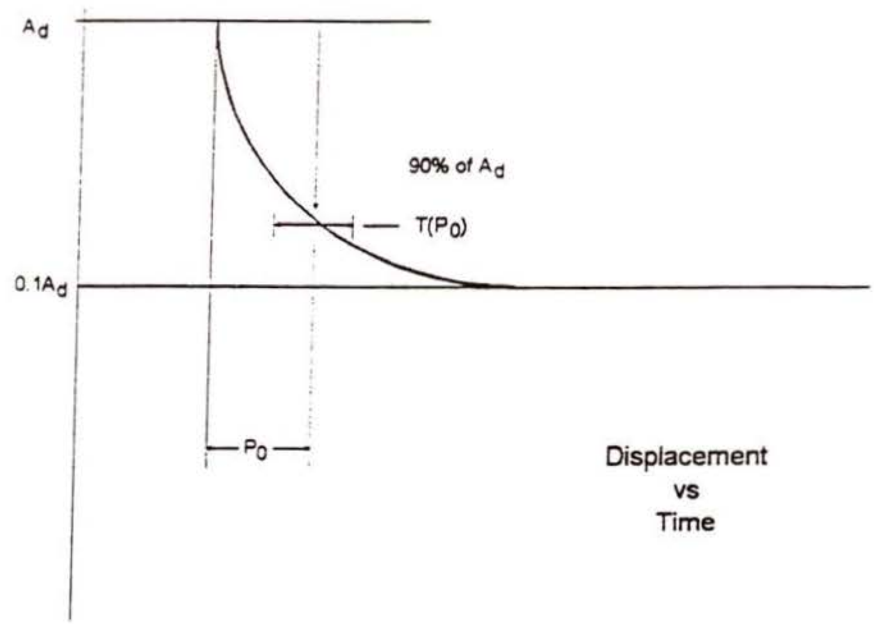

FIGURE 2. CRITICALLY-DAMPED STEP RESPONSE

4. GROUND EFFECT. During landing and takeoff, airplanes operate close to the ground for brief time intervals. The presence of the ground significantly modifies the air flow past the airplane and changes the aerodynamic characteristics. The close proximity of the ground imposes a barrier which inhibits the downward flow normally associated with the production of lift. The downwash is a function of height with the effects usually considered to be negligible above a height of approximately one wingspan. There are three main effects of the reduced downwash:

a. A reduction in downwash angle at the tail for a conventional configuration.

b. An increase in both wing and tail lift because of changes in the relationship of lift coefficient to angle of attack (increase in lift curve slope).

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c. A reduction in the induced drag.

Relative to out-of-ground effect flight (at a given angle of attack), these effects result in higher lift in ground effect and less power required for level flight. Because of the associated effects on stability, they also cause significant changes in elevator (or stabilizer) angle to trim and stick (column) forces required to maintain a given lift coefficient in level flight near the ground.

For a simulator to be used for takeoff and in particularly landing credit, it must faithfully reproduce the aerodynamic changes which occur in ground effect. The parameters chosen for simulator validation must obviously be indicative of these changes. The primary validation parameters for longitudinal characteristics in ground effect are:

a. Elevator or stabilizer angle to trim.

b. Power (thrust) required for level flight (PLF).

c. Angle of attack for a given lift coefficient.

d. Height/altitude.

e. Airspeed.

This listing of parameters assumes that ground effect data is acquired by tests during "fly-bys" at several altitudes in and out of ground effect. The test altitudes should, as a minimum, be at 10 percent, 30 percent, and 70 percent of the airplane wingspan and one altitude out of ground effect; e.g., 150 percent of wingspan. Level fly-bys are required for Level D, but not for Level C and Level B. They are, however, acceptable for all levels.

If, in lieu of the level fly-by method for Levels B and C, other methods such as shallow glidepath approaches to the ground maintaining a chosen parameter constant are proposed, then additional validation parameters are important. For example, if constant attitude shallow approaches are chosen as the test maneuver, pitch attitude, and flight path angle are additional necessary validation parameters. The selection of the test methods and procedures to validate ground effect is at the option of the organization performing the flight tests; however, rationale must be provided to conclude that the tests performed do indeed validate the ground effect model.

The allowable longitudinal parameter tolerances for validation of ground effect characteristics are:

Elevator or Stabilator Angle	±1°
Power for Level Flight (PLF)	±5%
Angle of Attack	±1°
Altitude/Height	±10% or ±5' (1.5 m.)
Airspeed	±3 Knots
Pitch Attitude	±1°

The lateral-directional characteristics are also altered by ground effect. Because of the above-mentioned changes in lift curve slope, roll damping, as an example, is affected. The change in roll damping will affect other dynamic modes usually evaluated for simulator validation. In fact, Dutch-roll dynamics, spiral stability, and roll-rate for a given lateral control input are altered by ground effect. Steady heading sideslips will also be affected. These effects must be accounted for in the simulator modeling. Several tests such as "crosswind landing," "one engine inoperative landing," and "engine failure on takeoff" serve to validate lateral-directional ground effect since portions of them are accomplished while transiting altitudes at which ground effect is an important factor.

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TABLE OF FUNCTIONS AND SUBJECTIVE TESTS-Continued	SIMULATOR LEVEL			
	A	B	C	D
e. Cont'd				
(1) Manually controlled with and without flight director to 100 ft (30 m) below CAT I minima.				
(2) With crosswind (maximum demonstrated).				
(3) With windshear.				
(D) Category II published approach.				
(1) Autocoupled, auto-throttle, autoland.				
(2) All engines operating missed approach.				
(E) Category III published approach.				
(1) With minimum/standby electrical power.				
(2) With generator/alternator failure (transient).				
(3) With 10 knot tailwind.				
(4) With 10 knot crosswind.				
(5) With rollout.				
(6) One engine inoperative.				
(iv) Missed approach.				
(A) All engines operating.				
(B) One or more engines inoperative.				
(3) Visual.	X	X	X	X
(i) Abnormal wing flaps/slats.				
(ii) Without glide slope guidance or visual vertical flightpath aid.				
f. Visual Segment and Landing.				
(1) Normal.				
(i) Crosswind (maximum demonstrated).		X	X	X
(ii) From visual traffic pattern.				
(iii) From nonprecision approach.		X	X	X

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TABLE OF FUNCTIONS AND SUBJECTIVE TESTS-Continued	SIMULATOR LEVEL			
	A	B	C	D
f. Cont'd				
(iv) From precision approach.		X	X	X
(v) From circling approach.	X	X	X	X
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.				
(2) Abnormal/emergency.	X	X	X	X
(i) Engine(s) inoperative.				
(ii) Rejected.				
(iii) With windshear.				
(iv) With standby (minimum electrical/ hydraulic) power.				
(v) With longitudinal trim malfunction.				
(vi) With lateral-directional trim malfunction.				
(vii) With loss of flight control power (manual reversion).				
(viii) With worst case failure of flight control system (most significant degradation of fly-by-wire system which is not extremely improbable).				
(ix) Other flight control system failure modes as dictated by training program.				
(x) Other.				
g. Surface Operations (Post Landing).				
(1) Landing roll and taxi.		X	X	X
(i) Spoiler operation.				
(ii) Reverse thrust operation.				
(iii) Directional control and ground handling, both with and without reverse thrust.				
(iv) Reduction of rudder effectiveness with increased reverse thrust (rear pod-mounted engines).				
(v) Brake and anti-skid operation with dry, wet, and icy conditions.				
(vi) Engine shutdown and parking.	X	X	X	X

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TABLE OF FUNCTIONS AND SUBJECTIVE TESTS-Continued	SIMULATOR LEVEL			
	A	B	C	D
c. Cont'd				
(ii) Rejected special performance.				
(iii) With failure of most critical engine at most critical point along takeoff path (continued takeoff).				
(iv) With windshear.				
(v) Flight control system failure modes.				
(vi) Other.				
d. Inflight Operation.				
(1) Climb.	X	X	X	X
(i) Normal.				
(ii) One engine inoperative.				
(iii) Other.				
(2) Cruise.	X	X	X	X
(i) Performance characteristics (speed vs. power).				
(ii) Normal turns and turns with/without spoilers (speed brake) deployed.				
(iii) High altitude handling.				
(iv) High indicated airspeed (IAS) handling.				
(v) High Mach number handling, trim, and overspeed warning.				
(vi) Normal and steep turns.				
(vii) Approach to stalls (stall warning, buffet, and g-break) cruise, takeoff, approach, and landing configuration.				
(viii) High angle-of-attack maneuvers (cruise, takeoff, approach, and landing).				
(ix) Inflight engine shutdown and restart.				
(x) Maneuvering with one or more engines inoperative.				
(xi) Specific flight characteristics, e.g., delayed clearance (DLC).				
(xii) Handling with manual flight control reversion (i.e., loss of all flight control power).				

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TABLE OF FUNCTIONS AND SUBJECTIVE TESTS-Continued	SIMULATOR LEVEL			
	A	B	C	D
d. Cont'd				
(xiii) Flight control system failure modes and associated handling.				
(xiv) Other.				
(3) Descent.	X	X	X	X
(i) Normal.				
(ii) Maximum rate (clean and with speedbrake extended, etc.).				
(iii) Manual flight control reversion (i.e., loss of flight control power).				
(iv) Flight control system failure modes and associated handling.				
(v) Other.				
e. Approaches.				
(1) Nonprecision.	X	X	X	X
(i) Approach procedure(s), one or more of the following. – NDB – VOR, RNAV, TACAN/VORTAC – DME ARC – LOC/BC – LDA, LOC, SDF – GPS				
(ii) Missed approach.				
(A) All engines operating.				
(B) One or more engines inoperative.				
(2) Precision.	X	X	X	X
(i) PAR.				
(ii) DGPS.				
(iii) ILS.				
(A) Normal.				
(B) Engine(s) inoperative.				
(C) Category I published approach.				

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APPENDIX 3. FUNCTIONS AND SUBJECTIVE TESTS

1. DISCUSSION. Accurate replication of airplane systems functions will be checked at each flight crewmember position by an FAA Simulator Evaluation Specialist. This includes procedures using the operator's approved manuals and checklists. Handling qualities, performance, and simulator systems operation will be subjectively assessed by an NSP Simulator Evaluation Specialist.

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 principal navigation systems including inertial navigation systems, OMEGA, or other long-range systems, and the associated electronic display systems will be evaluated if installed. 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 required for 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 CFR Part 61 and CFR Part 121, Appendices E and F. It also contains tests to ensure compliance with CFR Part 121, Appendix H, and other regulatory provisions.

Maneuvers and procedures are included to address some features of advanced technology airplanes and innovative training programs. For example, "high angle-of-attack maneuvering" is included to provide an alternative to "approach to stalls." Such an alternative is necessary for airplanes employing flight envelope limiting technology. 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.

All 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.

TABLE OF FUNCTIONS AND SUBJECTIVE TESTS	SIMULATOR LEVEL			
	A	B	C	D
1. FUNCTIONS AND MANEUVERS				
a. Preparation for Flight.				
(1) Preflight. Accomplish a functions check of all switches, indicators, systems, and equipment at all crewmembers' and instructors' stations, and determine that the cockpit design and functions are identical to that of the airplane simulated.	X	X	X	X
b. Surface Operations (Pre-Takeoff).				
(1) Engine start.	X	X	X	X

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TABLE OF FUNCTIONS AND SUBJECTIVE TESTS-Continued	SIMULATOR LEVEL			
	A	B	C	D
b. Cont'd				
(i) Normal start.				
(ii) Alternate start procedures.				
(iii) Abnormal starts and shutdowns (hot start, hung start, etc.).				
(2) Pushback/powerback.		X	X	X
(3) Taxi.	X	X	X	X
(i) Thrust response.				
(ii) Power lever friction.				
(iii) Ground handling.				
(iv) Nosewheel scuffing.				
(v) Brake operation (normal and alternate/emergency).				
(vi) Brake fade (if applicable).				
(vii) Other.				
c. Takeoff.				
(1) Normal.	X	X	X	X
(i) Engine parameter relationships.				
(ii) Airplane acceleration characteristics.				
(iii) Nosewheel and rudder steering.				
(iv) Crosswind (maximum demonstrated).				
(v) Special performance.				
(vi) Low visibility takeoff.				
(vii) Landing gear, wing flap, leading edge device operation.				
(viii) Other.				
(2) Abnormal/Emergency.	X	X	X	X
(i) Rejected				

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APPENDIX 4. DEFINITIONS, ABBREVIATIONS, AND ACRONYMS

DEFINITIONS

Airplane Simulator - is a full size replica of a specific type or make, model and series airplane cockpit, including the assemblage of equipment and computer programs necessary to represent the airplane in ground and flight operations, a visual system providing an out-of-the-cockpit view, and a system which provides cues at least equivalent to that of a three-degree-of-freedom motion system, and is in compliance with the minimum standards for a Level A simulator as defined in this document.

Automatic Testing - is simulator testing wherein all stimuli are under computer control.

Breakout - is the force required at the pilot's primary controls to achieve initial movement of the control position.

Closed Loop Testing - is a test method for which the input stimuli are generated by controllers that drive the simulator to follow a pre-defined target response.

Computer Controlled Airplane - is an airplane where the pilot inputs to the control surfaces are transferred and augmented via computers.

Control Sweep - is movement of the appropriate pilot controller from neutral to an extreme limit in one direction (forward, aft, right, or left), a continuous movement back through neutral to the opposite extreme position, and then a return to the neutral position.

Convertible Simulator - is a simulator in which hardware and software can be changed so that the simulator becomes a replica of a different model, usually of the same type airplane. The same simulator platform, cockpit shell, motion system, visual system, computers, and necessary peripheral equipment can thus be used in more than one simulation.

Critical Engine Parameter - is the engine parameter that has the most direct relationship with and/or presents the best indication of propulsive force.

Damping - Critical Damping -- is that minimum damping of a second order system such that no overshoot occurs in reaching a steady state value after being displaced from a position of equilibrium and released. This corresponds to a relative damping ratio of 1.0.

- Overdamped -- is that damping of a second order system such that it has more damping than is required for Critical Damping, as described above. This corresponds to a relative damping ratio of more than 1.0.

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DEFINITIONS - Continued

Damping (Cont'd)	- Underdamped -- is that damping of a second order system such that a displacement from the equilibrium position and free release results in one or more overshoots or oscillations before reaching a steady state value. This corresponds to a relative damping ratio of less than 1.0.
Deadband	- is the amount of movement of the INPUT for a system for which there is no reaction in the OUTPUT or state of the system observed.
Driven	- is a test method where the input stimulus or variable is "driven" or deposited by automatic means, generally a computer input. The input stimulus or variable may not necessarily be an exact match to the flight test comparison data; it is simply driven to certain predetermined values.
Evaluation of a Simulator	- is the appraisal of a flight simulator by the FAA to ascertain whether or not the standards required for a specified qualification level are met.
Flight Test Data	- are actual airplane data obtained by the airplane manufacturer (or other approved supplier of data) during an airplane flight test program.
Free Response	- is the response of the airplane after completion of a control input or disturbance.
Frozen/Locked	- is a test condition where a variable is held constant with time.
Full Sweep	- is movement of the controller from neutral to the stop, usually aft or right stop, then to the opposite stop, then to the neutral position.
Functional Performance	- is that operation or performance that can be verified by objective data or other suitable reference material which may not necessarily be flight test data.
Functions Test	- is a quantitative assessment of the operation and performance of a flight simulator by a suitably qualified evaluator. The test can include verification of correct operation of controls, instruments, and systems of the simulated airplane under normal and non-normal conditions.
Ground Effect	- is the change in aerodynamic characteristics due to a change in the air flow past the aircraft caused by the presence of the ground.
Hands Off	- is a test maneuver conducted or completed without additional pilot control inputs after the initial inputs.
Hands On	- is a test maneuver conducted or completed with pilot control inputs as required.
Highlight Brightness	- is the area of maximum displayed brightness that satisfies the brightness test in appendix 1, paragraph 4.n.(2).

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DEFINITIONS - Continued

Icing Accountability	- is a demonstration of minimum required performance while operating in maximum and intermittent maximum icing conditions of the applicable airworthiness requirement.
Integrated Testing	- is testing of the simulator such that all airplane system models are active and contribute appropriately to the results. None of the airplane system models should be substituted with models or other algorithms intended for testing only. This may be accomplished by using controller displacements as the input. These controllers must represent the displacement of the pilot's controls, and these controls must have been calibrated.
Irreversible Control Systems	- are control systems in which movement of the control surface will not backdrive the pilot's control in the cockpit.
Latency	- is the additional time beyond that of the basic perceivable response time of the airplane due to the response of the simulator and is measured from the start of a control input to the perceivable change in motion system, visual system, or flight instrument indication.
Least Augmented State	- For those airplanes whose controllability is highly augmented via mechanical, hydraulic, or electronic means, that state of augmented controllability below which the airplane is not certificated or below which the possibility of additional deterioration is beyond mathematical probability.
Manual Testing	- is simulator testing wherein the pilot makes all normal pilot control inputs to the test without computer inputs, except for initial setup. All modules of the simulation must be active.
Master Qualification Test Guide	- See definition of Qualification Test Guide.
Non-Normal Control	- is a term used in reference to computer controlled airplanes. NON-NORMAL CONTROL is the state where one or more of the intended control, augmentation, or protection functions are not fully available. NOTE: Specific terms such as ALTERNATE, DIRECT, SECONDARY, and BACKUP may be used to define an actual level of degradation.
Normal Control	- is a term used in reference to computer controlled airplanes. NORMAL CONTROL is the state where the intended control, augmentation, and protection functions are fully available.
NSPM	- is the FAA manager responsible for the overall administration and direction of the National Simulator Program.
Objective Test	- is a quantitative assessment based on the comparison of simulator performance data to aircraft performance data.

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DEFINITIONS - Continued

Operator (or Simulator Operator)	- is a definition used in this document to indicate the person or organization holding an operating or training center certificate, requesting qualification of a simulator and is responsible for continuing qualification and liaison with the FAA.
Power Lever Angle	- is the angle of the pilot's primary engine control lever(s) in the cockpit. This may also be referred to as PLA, THROTTLE, or POWER LEVER.
Predicted Data	- are data derived from sources other than flight test.
Predicted Validation Data	- are airplane static and dynamic flight characteristics derived from sources other than flight test data.
Predicted Basic Aerodynamic Data	- are estimated basic aerodynamic coefficient data.
Protection Functions	- are systems functions designed to protect an airplane from exceeding its flight maneuver limitations.
Pulse Input	- is a step input to a control followed by an immediate return to the initial position.
Qualification Test Guide	- is the primary reference document used for evaluating an airplane simulator. It contains test results, Statements of Compliance, and other information for the evaluator to assess if the simulator meets the applicable regulatory criteria. The Master Qualification Test Guide (MQTG) is the FAA approved Test Guide and incorporates the results of the FAA witnessed tests. The MQTG serves as the reference for future evaluations.
Quantization	- is sometimes referred to as ''rastering'' or ''aliasing'' and is caused by the displayed position of a line or edge slightly changing between each frame, resulting in a wavering motion through the scene.
Reversible Control System	- is a control system in which movement of the airplane control surface will backdrive the pilot's control in the airplane cockpit.
Simulation Data	- are the various types of data used by the simulator manufacturer and the applicant to design, manufacture, and test the flight simulator.
Simulation Evaluation Specialist	- is an FAA technical specialist trained to evaluate simulators and to provide expertise on matters concerning airplane simulation.
Simulator Approval	- is the extent to which a simulator of a specified qualification level may be used by an airline or training organization as agreed by the FAA. It takes account of aircraft to simulator differences and the operating and training ability of the organization.

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ABBREVIATIONS AND ACRONYMS - Continued

NWA	- Nosewheel angle (in degrees)
P_n	- Sequential period of oscillation
P_f	- Impact or feel pressure
P_0	- Time from pilot controller release until initial X-axis crossing (X axis defined by the resting amplitude)
P_1	- First full cycle of oscillation after the initial X-axis crossing
P_2	- Second full cycle of oscillation after the initial X-axis crossing
PAPI	- Precision Approach Path Indicator
Pitch	- Pitch angle (in degrees)
PLA	- Power lever angle
PLF	- Power for level flight
psi	- pounds per square inch
RAE	- Royal Aerospace Establishment
R/C	- Rate of climb (in m/sec or ft/min)
RoD	- Rate of descent (in m/sec or ft/min)
REIL	- Runway end identifier lights
RVR	- Runway visual range (in m or ft)
sec	- second(s)
Sideslip	- Sideslip angle (in degrees)
sm	- Statute miles (1 statute mile = 5,280 ft)
SOC	- Statement of Compliance
T_f	- Total time of the flare maneuver duration
T_i	- Total time from initial throttle movement until a 10% response of a critical engine parameter
T_t	- Total time from T_i to a 90% increase or decrease in the power level specified
T(A)	- Tolerance applied to amplitude
T(P)	- Tolerance applied to period
T/O	- Takeoff
V_{mc}	- Minimum control speed
V_{mca}	- Minimum control speed, air
V_{mcg}	- Minimum control speed, ground
V_r	- Rotate speed
V_s	- Stall speed or minimum speed in the stall
VASI	- Visual Approach Slope Indicator
VGS	- Visual ground segment
WAT	- Weight, altitude, temperature
1st Segment	- That portion of the takeoff profile from liftoff to gear retraction
2nd Segment	- That portion of the takeoff profile from after gear retraction to initial flap/slat retraction
3rd Segment	- That portion of the takeoff profile after flap/slat retraction is complete

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DEFINITIONS - Continued

Simulator Qualification Level	- is the level of authorized use based on the technical capability of the simulator as set out in the technical criteria contained in this AC.
Snapshot	- is a presentation of one or more variables at a given instant of time; (however, a steady state condition must exist for approximately 5 seconds prior to, and approximately 2 seconds after, this instant of time.)
Statement of Compliance	- is a certification that specific requirements have been met and how they have been met.
Step Input	- is an abrupt input held at a constant value.
Subjective Test	- is a qualitative assessment based on established standards as interpreted by a suitably qualified person.
Time History	- is a presentation of the change of a variable with respect to time.
Transport Delay	- is the total simulator system processing time required for an input signal from a pilot primary flight control until motion system, visual system, or instrument response. It is the overall time delay incurred from signal input until output response. It does not include the characteristic delay of the airplane simulated.
Upgrade	- is for the purpose of this document the improvement or enhancement of a simulator for the purpose of achieving a higher qualification level.
Validation Data	- are airplane response data used to prove that the simulator performance corresponds to that of the airplane.
Validation Flight Test Data	- are for the purpose of this document performance, stability, control, and other necessary test parameters electrically or electronically recorded in an airplane using a calibrated data acquisition system of sufficient resolution and verified as accurate by the company performing the test to establish a reference set of relevant parameters to which like simulator parameters can be compared.
Validation Test	- is a test by which simulator parameters can be compared to the relevant validation data.
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.

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ABBREVIATIONS AND ACRONYMS

A_d	- Total initial displacement of pilot controller (initial displacement to final resting amplitude)
A_n	- Sequential amplitude of overshoot after initial X-axis crossing; e.g., A_1 = 1st overshoot
AC	- Advisory circular
AFM	- FAA-approved Airplane Flight Manual
AGL	- Above ground level (in meters (m) or feet (ft))
Airspeed	- Calibrated airspeed unless otherwise specified (in knots (kt))
Altitude	- Pressure altitude (in m or ft) unless specified otherwise
AOA	- Angle of attack (in degrees)
Bank	- Bank/roll angle (in degrees)
CCA	- Computer controlled airplane
cd/m²	- candela/meter² (3.4263 candela/meter² = 1 ft-Lambert)
cm	- centimeter(s)
daN	- decaNewton(s)
deg	- degree(s)
EPR	- Engine pressure ratio
FAA	- Federal Aviation Administration (U.S.)
ft	- foot or feet (1 ft = 0.304801 m)
ft-Lambert	- foot-Lambert (1 ft-Lambert = 3.4263 candela/meter²)
fuel used	- Mass of fuel used (in kilos or pounds)
g	- Acceleration due to gravity (in m or ft/sec²) (1 g = 9.81 m/sec² or 32.2 feet/sec²)
G/S	- Glideslope
Height	- Height above ground = AGL (in m or ft)
IATA	- International Airline Transport Association
ICAO	- International Civil Aviation Organization
ILS	- Instrument landing system
IQTG	- International Qualification Test Guide
km	- kilometer(s) (1 km = 0.62137 statute miles)
kPa	- kiloPascal (kiloNewton/meters²) (1 psi = 6.89476 kPa)
kt	- knots calibrated airspeed unless otherwise specified (1 kt = 0.5148 m/sec or 1.689 ft/sec)
lb	- pound(s)
m	- meter(s) (1 m = 3.28083 ft)
Medium	- Normal operational weight for flight segment
min	- minute(s)
MLG	- Main landing gear
MPa	- MegaPascals (1 psi = 6.89476 X 10^{-3} MegaPascals)
ms	- millisecond(s)
n	- Sequential period of a full cycle of oscillation
N	- NORMAL CONTROL used in reference to computer controlled airplanes
nm	- Nautical mile (1 nm = 6,080 ft)
NN	- NON-NORMAL CONTROL used in reference to computer controlled airplanes
Nominal	- Normal operational weight, configuration, speed, etc., for the flight segment specified
N_1	- Low pressure rotor revolutions per minute
N_2	- High pressure rotor revolutions per minute

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TABLE OF FUNCTIONS AND SUBJECTIVE TESTS-Continued	SIMULATOR LEVEL			
	A	B	C	D
3. SPECIAL EFFECTS				
a. Runway rumble, oleo deflections, effects of groundspeed and uneven runway characteristics.		X	X	X
b. Buffets on the ground due to spoiler/speedbrake extension and thrust reversal.		X	X	X
c. Bumps after lift-off of nose and main gear.		X	X	X
d. Buffet during extension and retraction of landing gear.		X	X	X
e. Buffet in the air due to flap and spoiler/speedbrake extension and approach-to-stall buffet.		X	X	X
f. Touchdown cues for main and nose gears.		X	X	X
g. Nosewheel scuffing.		X	X	X
h. Thrust effect with brakes set.		X	X	X
i. Brake and tire failure dynamics (including antiskid) and decreased brake efficiency due to high brake temperatures based on airplane related data. These representations should 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 airplane.			X	X
j. Sound of precipitation and significant airplane 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 airplane noises should include noises such as engine, flap, gear, and spoiler extension and retraction and thrust reversal to a comparable level as that found in the airplane. 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 airplane.			X	X
k. Effects of airframe icing.			X	X

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TABLE OF FUNCTIONS AND SUBJECTIVE TESTS-Continued	SIMULATOR LEVEL			
	A	B	C	D
b. Cont'd (4) Runway markings within range of landing lights for night scenes; as required by 3 arc-minute resolution on day scenes.				
c. Airport scene content including the following: (1) Airport runways and taxiways. (2) Runway definition. (i) Runway surface and markings. (ii) Lighting for the runway in use, including runway edge and centerline lighting, touchdown zone, VASI, and approach lighting of appropriate colors. (iii) Taxiway lights.	X	X	X	X
d. Operational landing lights.	X	X	X	X
e. Instructor controls of the following: (1) Cloudbase. (2) Visibility in statute miles (km) and runway visual range (RVR) in ft (m). (3) Airport selection. (4) Airport lighting.	X	X	X	X
f. Visual system compatibility with aerodynamic programming.	X	X	X	X
g. Visual cues to assess sink rates and depth perception during landings. (1) Surface on taxiways and ramps. (2) Terrain features.		X	X	X
h. Dusk and night visual scene capability.			X	X
i. Minimum of three specific airport scenes. (1) Surfaces on runways, taxiways, and ramps.			X	X

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TABLE OF FUNCTIONS AND SUBJECTIVE TESTS-Continued	SIMULATOR LEVEL			
	A	B	C	D
(2) Lighting of appropriate color for all runways, including runway edge, centerline, VASI, and approach lighting for the runway in use. (3) Airport taxiway lighting. (4) Ramps and terminal buildings that correspond to an operator's LOFT and Line Oriented Simulator scenarios.				
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 and within a radius of 10 miles (16 km) from the airport, 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 lighting.			X	X
l. A capability to present ground and air hazards such as another airplane crossing the active runway or converging airborne traffic.			X	X
m. Operational visual scenes which portray physical relationships known to cause landing illusions such as short runways, landing approaches over water, uphill or downhill runways, rising terrain on the approach path, and unique topographic features.				X
n. Special weather representations of light, medium, and heavy precipitation near a thunderstorm on takeoff, approach, and landings at and below an altitude of 2,000 ft (610 m) above the airport surface and within a radius of 10 miles (16 km) from the airport.				X
o. Wet and snow-covered runways, including runway lighting reflections for wet, partially obscured lights for snow, or suitable alternative effects.				X
p. Realistic color and directionality of airport lighting.				X
q. Weather radar presentations in airplanes where radar information is presented on the pilot's navigation instruments. Radar returns should correlate to the visual scene.				X
r. Freedom from apparent quantization (aliasing).			X	X

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TABLE OF FUNCTIONS AND SUBJECTIVE TESTS-Continued	SIMULATOR LEVEL			
	A	B	C	D
g. Cont'd				
(A) Engine and systems operation.				
(B) Parking brake operation.				
(vii) Other.				
h. Any Flight Phase.				
(1) Airplane and powerplant systems operation.	X	X	X	X
(i) Air conditioning and pressurization.				
(ii) Anti-icing/deicing.				
(iii) Auxiliary powerplant.				
(iv) Communications.				
(v) Electrical.				
(vi) Fire detection and suppression.				
(vii) Flaps/leading edge devices/speed brakes				
(viii) Flight controls.				
(ix) Fuel, oil.				
(x) Hydraulic.				
(xi) Landing gear.				
(xii) Oxygen.				
(xiii) Pneumatic.				
(xiv) Powerplant.				
(xv) Pressurization.				
(2) Flight management and guidance systems.	X	X	X	X
(i) Airborne radar.				
(ii) Automatic landing aids.				
(iii) Autopilot.				

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TABLE OF FUNCTIONS AND SUBJECTIVE TESTS-Continued	SIMULATOR LEVEL			
	A	B	C	D
h. Cont'd				
(iv) Collision avoidance system.				
(v) Flight control computers.				
(vi) Flight data displays.				
(vii) Flight management computers.				
(viii) Head-up displays.				
(ix) Navigation systems.				
(x) Stall warning/avoidance.				
(xi) Stability and control augmentation.				
(xii) Windshear avoidance equipment.				
(3) Airborne procedures.	X	X	X	X
(i) Holding.				
(ii) Air hazard avoidance.			X	X
(iii) Windshear.				
(4) Other.				
2. VISUAL SYSTEM				
a. Accurate portrayal of environment relating to simulator attitudes.	X	X	X	X
b. The distances at which runway features are visible should not be less than those listed below. Distances are measured from runway threshold to an airplane aligned with the runway on an extended 3-degree glide slope.	X	X	X	X
(1) Runway definition, strobe lights, approach lights, runway edge white lights and Visual Approach Slope Indicator (VASI) system lights from 5 statute miles (8 kilometers (km)) of the runway threshold.				
(2) Runway centerline lights and taxiway definition from 3 statute miles (4.8 km).				
(3) Threshold lights and touchdown zone lights from 2 statute miles (3.2 km).				

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FIGURE 1. SAMPLE LETTER OF REQUEST

Name, POI, ____________________________ (Operator)

FAA FSDO ____________________________

Address

City, State, Zip

Dear Mr. ________________________ :

(Operator/sponsor name) ____________________ requests evaluation of our (type) __________________ airplane 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 CFR Section 121.407 (or CFR Section 135.335 or 125.297), CFR Part 121, Appendix H, and the guidance of AC 120-40C. Appropriate hardware and software configuration control procedures have been established. Our pilot(s), (name) ________________ [and (name) ________________], who are qualified on (type) ____________ airplane, have assessed the simulator and found that it conforms to the (operator/sponsor name) ______________________ (type) __________________ airplane cockpit configuration and that the simulated systems and subsystems function equivalently to those in the airplane. The above named pilot(s) have also assessed the performance and flying qualities of the simulator and find that it represents the respective airplane.

(Added comments as desired.)

Sincerely,

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FIGURE 2. SAMPLE SIMULATOR INFORMATION PAGE

OPERATOR

OPERATOR SIMULATOR CODE:	BA707#1
AIRPLANE MODEL:	Stratos BA707-320
AERODYNAMIC DATA REVISION:	BA707-320 CPX-8D July 1988
ENGINE MODEL AND REVISION:	CPX-8D-RPT-1 June 1988
FLIGHT CONTROLS DATA REVISION:	BA707-320 May 1988
FLIGHT MANAGEMENT SYSTEM:	Berry XP
SIMULATOR MODEL AND MANUFACTURER:	MTD-707 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

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FIGURE 3. SAMPLE QTG COVER PAGE

OPERATOR NAME

OPERATOR ADDRESS

FAA QUALIFICATION TEST GUIDE

(AIRPLANE MODEL)

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

(Simulator Location)

FAA Initial Evaluation
Date: __________

__________________________ Date: ________
(Operator Approval)

__________________________ Date: ________
Manager, National
Simulator Program, FAA

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APPENDIX 6. WINDSHEAR QUALIFICATION

1. APPLICABILITY. This appendix applies to all simulators used to satisfy the training requirements of CFR Part 121 pertaining to the certificate holder's approved low-altitude windshear flight training program.

2. STATEMENT OF COMPLIANCE. A statement of compliance (SOC) is required to include the following:

a. Verifies that the aerodynamic model is based on airplane data supplied by the airplane manufacturer, or other named source, and that any change to environmental wind parameters, including variances in those parameters for windshear conditions, once inserted for computation, should result in the correct simulated performance.

b. Examples where environmental wind parameters are currently evaluated in the simulator (such as crosswind takeoffs, crosswind approaches, and crosswind landings).

3. QUALIFICATION BASIS. The addition of windshear programming to a simulator in order to comply with the qualification for required windshear training does not change the original qualification basis of the simulator.

4. MODELS. The windshear models installed in the simulator software that will be used for qualification evaluation must do the following:

a. Provide cues necessary for recognition of the onset of a windshear phenomena and potential performance degradation that would require a pilot to initiate recovery procedures. The cues must include one or more of the following, as may be appropriate:

(1) Rapid airspeed change of at least ±15 knots (kt).

(2) Stagnation of airspeed during the takeoff roll.

(3) Rapid vertical speed change of at least ±500 feet per minute (fpm).

(4) Rapid pitch change of at least ±5°.

b. Be adjustable in intensity (or other parameter to achieve the desired effect) so that after encountering and recognizing the windshear, and with the application of recommended procedures for escape from such a windshear, the following results may be achieved:

(1) The performance capability of the simulated airplane permits the pilot to maintain a satisfactory flightpath.

(2) The performance capability of the simulated airplane does not permit the pilot to maintain a satisfactory flightpath (crash).

c. Be available for use in the approved windshear flight training program. The means used to accomplish the "nonsurvivable" scenario of paragraph 4b(2), which involves operational elements of the simulated airplane, must reflect parameters which fall within the dispatch limitations of the airplane.

5. TESTS.

a. The operator should identify two of the required training windshear models (one takeoff and one approach) to be demonstrated for Qualification Test Guide (QTG) purposes and should define the wind components of these two models for the survivable scenario. This definition should be presented in graphical

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format so that all components of the windshear are shown, including initiation point, variance in magnitude, and either time or distance correlation as may be appropriate. The simulator must be operated at the same gross weight, airplane configuration, and initial airspeed in both of the following situations for the two models selected (total of four tests):

(1) Through calm air.

(2) Through the selected survivable windshear.

b. In each of these four situations, at an "initiation point" (that point being where the onset of windshear conditions is, or would have been recognized, depending on the test being run), the recommended procedures for windshear recovery shall be applied, and the results shall be recorded, as specified in paragraph 6. These recordings shall be made without the presence of programmed random turbulence and, for the purposes of this testing, it is recommended, although not required, that the simulator be flown by means of the simulator's autodrive function (for those simulators that have autodrive capability) during the tests. Turbulence which results from the windshear model is to be expected, and no attempt may be made to neutralize turbulence from this source.

6. RECORDING PARAMETERS.

a. In each of the four QTG cases, an electronic recording (time history) must be made of the following parameters:

(1) Indicated or calibrated airspeed.

(2) Indicated vertical speed.

(3) Pitch attitude.

(4) Indicated or radio altitude.

(5) Angle of attack.

(6) Elevator position.

(7) Engine data (thrust, N_1, or throttle position).

(8) Wind magnitudes.

b. These recordings shall be initiated at least 10 seconds prior to the initiation point and continued until recovery is complete or ground contact is made. For those simulators not capable of electronic recording of the above parameters, video recordings which have been cross-plotted into a time history format will be considered an acceptable means of data presentation. If data of sufficient resolution for elevator position is not obtainable using this method of video cross-plotting, then stick position may be used. Special, temporary instrumentation readout installations may be required to record these parameters on video tape.

7. EQUIPMENT INSTALLATION. For those simulators where windshear warning, caution, or guidance hardware is not provided as original equipment with the airplane and, therefore, is added to the airplane and simulator, an SOC is required stating that the simulation of the added simulator hardware and/or software, including associated cockpit displays and annunciations, functions the same or equivalent to the system(s) installed in the airplane. This statement shall be supported by a block diagram that describes the input and output signal flow and compares it to the airplane configuration.

8. QUALIFICATION TEST GUIDE.

a. All QTG material (performance determinations recordings, etc.) should be forwarded to the National Simulator Program Manager (NSPM) at the following address:

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Federal Aviation Administration (FAA)
Flight Standards National Simulator Program Office (AFS-205)
Attn: NSPM
1701 Columbia Ave.
College Park, Georgia 30337

b. The simulator will be scheduled for an evaluation in accordance with normal procedures. Use of recurrent evaluation schedules will be used to the maximum extent possible.

c. During the on-site evaluation, the evaluator should ask the operator to run the performance tests and record the results. The results of these on-site tests will be compared to those results previously approved and placed in the QTG.

d. QTG's for new or upgraded simulators shall contain or reference the information described in paragraphs 2, 4, 5, 6, and 7 of this appendix, as may be appropriate for the simulator.

9. FUNCTIONAL EVALUATION. A simulator evaluation specialist must fly the simulator in at least two of the available windshear scenarios to evaluate subjectively the performance of the simulator as it encounters the programmed windshear conditions according to the following:

a. One scenario will include parameters that enable the pilot to maintain a satisfactory flightpath.

b. One scenario will include parameters that will not enable the pilot to maintain a satisfactory flightpath (crash).

c. Other scenarios may be examined at the discretion of the simulator evaluation specialist.

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