U.S. Department of Transportation

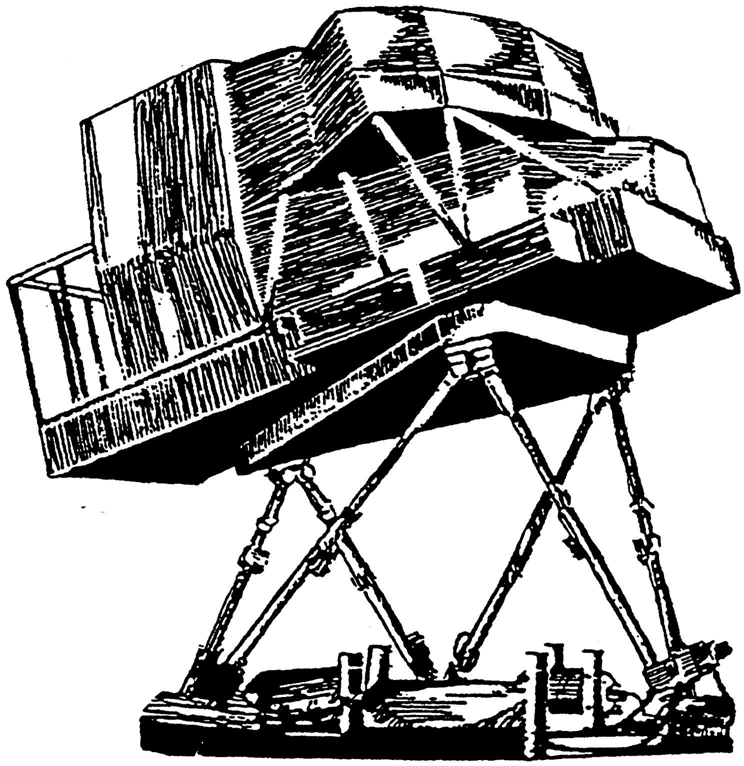
Federal Aviation Administration

Advisory Circular

AC 120-40B

Date: 7/29/91

AIRPLANE SIMULATOR QUALIFICATION



Initiated By: ASO-205

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1. PURPOSE. This advisory circular (AC) provides an acceptable means, but not the only means, of compliance with the Federal Aviation Regulations (FAR) regarding the evaluation and qualification of airplane simulators used in training programs or airmen checking under Title 14 Code of Federal Regulations (CFR). Criteria specified in this AC are those used by the Federal Aviation Administration (FAA) to determine whether a simulator is qualified and the qualification level. While these guidelines are not mandatory, they are derived from extensive FAA and industry experience in determining compliance with the pertinent FAR. Mandatory terms used in this 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 assure 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 FAR 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. See, for example, AC 120-45, Advanced Training Devices (Airplane Only) Evaluation and Qualification.

2. CANCELLATION. AC 120-40A, Airplane Simulator and Visual System Evaluation, dated July 31, 1986, is canceled. Operators having simulator improvement or acquisition projects in progress on the effective date of this advisory circular 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 120-40A.

3. RELATED FAR SECTIONS. FAR Part 1; FAR Sections 61.57, 61.58, and 61.157, FAR Part 61 Appendix A; FAR Section 63.39, FAR Part 63 Appendix C; FAR Sections 121.407, 121.409, 121.439, and 121.441; FAR Part 121 Appendices E, F, and H; FAR Sections 125.285, 125.287, 125.291, and 125.297; and FAR Sections 135.293, 135.297, 135.323, and 135.335.

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 FAR 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 120-45, Advanced Training Devices (Airplane Only) Evaluation and Qualification; AC 120-46, Use of Advanced Training Devices (Airplane Only); AC 150/5300-13, Airport Design; AC 150/5340-1F, Marking of Paved Areas on Airports; 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.

5. BACKGROUND.

a. The availability of advanced technology has permitted greater use of flight simulators for training and checking of flight crewmembers. The complexity, costs, and operating environment of modern aircraft also has encouraged broader use of advanced simulation. Simulators can provide more indepth training than can be accomplished in airplanes and provide a very high transfer of learning and behavior from the simulator to the airplane. The use of simulators, in lieu of airplanes, results in safer flight training and cost reductions for the operators. It also achieves fuel conservation and reduction in adverse environmental effects.

b. As technology progressed and the capabilities of flight simulation were recognized, FAR revisions were made to permit the increased use of simulators in approved training programs. Simulators have been used in training and some checking programs since the middle 1950's. Various FAR amendments gradually permitted additional simulator credits. The most significant recognition of simulator capability has occurred since the early 1970's. In December 1973, FAR Amendments 61-62 and 121-108 permitted additional use of visual simulators. Amendments to FAR Section 121.439 permitted simulators approved for "the landing maneuver" to be substituted for the airplane in a pilot recency of experience qualification. These changes to the FAR constituted a significant step toward the development of Amendments 61-69 and 121-161 issued June 24, 1980, which contained the FAA Advanced Simulation Plan. To support this plan, the National Simulator Evaluation Program was established by the FAA in October 1980. The program is administered and directed by the NSPM.

c. The need for standard criteria was necessitated by the use of simulators for training and checking. The evolution of the simulator technology and the concomitant increased permitted use has required a similar evolution of the criteria for simulator qualification. A listing of known simulator criteria should, therefore, be informative. The qualification basis for a given simulator may be any of the past criteria, depending on when the simulator was first approved or last upgraded. The following list provides the effective dates of simulator qualification criteria documents:

FAR Part 121, Appendix B	1/9/65 to 2/2/70
AC 121-14	12/19/69 to 2/9/76
AC 121-14A	2/9/76 to 10/16/78
AC 121-14B	10/16/78 to 8/29/80
FAR Part 121, Appendix H	6/30/80 to Present
AC 121-14C	8/29/80 to 1/31/83
AC 120-40	1/31/83 to 7/31/86
AC 120-40A	7/31/86

Each of these documents has addressed the greater complexity represented by succeeding generations of simulators. Complexity of the highest level is not, however, required of all simulators. In fact, simulators are divided into levels that authorize additional training and checking with increased simulator capability. Until the advent of the Advanced Simulation Plan, there were two levels of simulators--nonvisual and visual. Some visual simulators were approved for "the landing maneuver." The Advanced Simulation Plan introduced three additional levels--Phase I, Phase II, and Phase III. Those visual simulators previously approved for "the landing maneuver" were incorporated into Phase I.

The training and checking credits for nonvisual and visual simulators were delineated in FAR Part 61, Appendix A, and FAR Part 121, Appendices E and F. Credits for Phases I, II, and III were contained in the Advanced Simulation Plan. Four levels of simulators were, therefore, addressed; Basic (nonvisual and visual simulators), Phase I, Phase II, and Phase III. Each of the four levels is progressively more complex than the preceding level and each contains all the features of preceding levels plus the requirements for the designated level. As the technology has advanced, so has the qualification guidance. Efforts to keep the criteria updated are, therefore, ongoing with active participation from both industry and government resources.

d. Continuing this same process, the FAA, in coordination with industry, has reviewed a wide spectrum of devices used in training in order to provide guidance on required standards and permitted uses. While recognizing the requirement to categorize and define training devices, it became obvious that the designation of simulators was outmoded. The concept of phases was no longer applicable since it derived from an FAR provision which allowed operators to upgrade their simulator inventories in phases while enjoying certain simulator use privileges. The concept of upgrade in phases is essentially complete and the designation of "phase" for identification of simulator complexity is no longer descriptive. Operators no longer begin at a lower level of qualification and upgrade in phases. The tendency is to acquire a given level simulator that best suits their position. Therefore, simulators were redesignated. The new designations and their relationships with the simulator definitions used previously and in FAR Part 121, Appendix H, are:

Level A - Visual
Level B - Phase I
Level C - Phase II
Level D - Phase III

Nonvisual simulators are now grouped with Level 6 training devices, but must meet the requirements, except for visual, of a Level A simulator. There is no other change in their characteristics or description; just their "name." Alphabetic designations were chosen for simulators to maintain a distinction from the numerically designated training devices.

6. DEFINITIONS.

a. 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 force cueing system which provides cues at least equivalent to that of a three degrees-of-freedom motion system; and is in compliance with the minimum standards for Level A simulator.

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

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

d. Highlight Brightness is the area of maximum displayed brightness which satisfies the brightness test in appendix 1, item 4k.

e. Latency is the additional time beyond that of the basic airplane perceivable response time due to the response time of the simulator. This includes the update rate of the computer system combined with the respective time delays of the motion system, visual system or instruments.

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

g. Operator, as used in this AC, identifies the person or organization requesting FAA qualification of a simulator and is responsible for continuing qualification and liaison with the FAA.

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

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

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

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

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

m. Transport Delay is the total simulator system processing time required 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.

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

o. Validation Flight Test Data, for the purpose of this AC, are performance, stability and 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. Other data, such as photographic data, may be considered acceptable flight test data after evaluation by the NSPM.

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

7. DISCUSSION.

a. The procedures and criteria for simulator evaluations under the National Simulator Evaluation Program 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) or certificate holding district office, as appropriate, for approval for use within an operator's training program.

b. Evaluation of simulators used for training or certification of airmen under Title 14 CFR fall under the direction of the National Simulator Evaluation Program. A simulator will be evaluated under the provisions of this AC if it is used in a training program approved under FAR Parts 63, 121, 125, or 135; or if it is used by an operator in the course of conducting the Pilot-in-command proficiency check required by FAR Section 61.58 or the issuance of an airline transport pilot certificate or type rating in accordance with the provisions of FAR Section 61.157.

c. Under the National Simulator Evaluation Program 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 FAR Parts 63, 121, 125, or 135 certificate holders or by the Flight Standards District Office (FSDO) responsible for oversight of a training center when the training center is using the simulator to conduct checks required by FAR Part 61.

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

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

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 desires to use another means, a proposal must be submitted to the NSPM for review and approval prior to the submittal of a detailed ATG. If an applicant chooses to utilize the approach described in this AC, the applicant must adhere to all of the methods, procedures, and standards herein.

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 or qualification level of the simulator. 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 important consideration. Therefore, the simulator will be subjected to validation tests listed in appendix 2 of this AC and the functions and subjective tests from appendix 3. These tests include a qualitative assessment of the simulator by an FAA pilot who is qualified in the respective airplane. Validation tests are used to compare objectively simulator and airplane data to assure that they agree within specified tolerances. Functions tests provide a basis for evaluating simulator capability to perform over a typical training period and to verify correct operation of the simulator controls, instruments, and systems.

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

e. A convertible simulator will be addressed as a separate simulator for each model and series to which it will be converted and 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 ATG's or a supplemented ATG, and two evaluations are required.

f. 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 flight test data will be accepted for initial qualification. Exceptions to this policy must be submitted to the NSPM for review and consideration. It is the intent of the FAA that all tests listed in this AC be applied to simulator qualification. 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. For a new type or model of airplane, predicted data validated by flight test data, which has not received final approval by the manufacturer, can be used for an interim period as determined by the FAA. In the event that predicted data are used in programming the simulator, it should 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.

g. If a problem with a validation test result is detected by the FAA Simulator Evaluation Specialist, the test may be repeated. If it still does not meet the test 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 ATG 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.

h. Evaluation dates will not be established until the ATG has been reviewed by the NSPM and determined to be acceptable. Within 10 working days of receiving an acceptable ATG, the NSPM will coordinate with the operator and

POI to set a mutually acceptable date for the evaluation. To avoid unnecessary delays, operators are encouraged to work closely with the NSPM during the ATG development process prior to making formal application.

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

9. INITIAL OR UPGRADE EVALUATIONS.

a. An operator seeking simulator initial or upgrade evaluation must submit a request in writing to the NSPM through the POI or responsible FAA FSDO. This request should contain a compliance statement 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 confirm that it is representative of the airplane in all functions test areas. A sample letter of request is included in appendix 4.

b. The operator should submit an ATG which includes:

(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:

(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.

(7) 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 appendix 1, "Simulator Standards," comments column, for SOC requirements.

(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.
(iv) Manual test procedures.
(v) Automatic test procedures (if applicable).
(vi) Method for evaluating simulator validation test results.
(vii) Tolerances for relevant parameters.
(viii) Source of Airplane Test Data (document and page number).
(ix) Copy of Airplane Test Data.
(x) Simulator Validation Test Results as obtained by the operator.
(xi) 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 should be labeled using terminology common to airplane parameters as opposed to computer software identifications. These results should be easily compared with the supporting data by employing cross-plotting, overlays, transparencies, or other acceptable means. Airplane data documents included in an ATG may be photographically reduced only if such reduction will not alter the graphic scaling or cause difficulties in scale interpretation or resolution. Incremental scales on graphical presentations must provide the resolution necessary for evaluation of the parameters shown in appendix 2. The test guide will provide the documented proof of compliance with the simulator validation tests in appendix 2. In the case of a simulator upgrade, an operator should run all validation tests for the requested qualification level. Validation test results offered in a test guide for a previous initial or upgrade evaluation should not be used to validate simulator performance in a test guide offered for a current upgrade. For tests involving time histories, flight test data sheets, or transparencies thereof, and simulator test results should be clearly marked with appropriate reference points to ensure an accurate comparison between simulator and airplane with respect to time. Operators using line printers to record time histories should clearly mark that information taken from the line printer data output for cross-plotting on the airplane data. The cross-plotting of the operator's simulator data to airplane data is essential to verify simulator performance in each test. During an evaluation, the FAA will devote its time to detailed checking of selected tests from the ATG. The FAA evaluation serves to validate the operator's simulator test results.

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

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

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

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

(1) Advise the POI and NSPM of the move.

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

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

h. When there is a change of operator, the new operator must accomplish all required administrative procedures including the submission of the currently approved Master Approval Test Guide (MATG) through the POI to the NSPM. The ATG must be identified with the new operator by displaying the operator's name or logo. The POI will then submit the package as described in paragraph 8d above. The simulator may, at the discretion of the NSPM, be subject to an evaluation in accordance with the original qualification criteria. However, a simulator having Phase I status resulting from a landing maneuver approval under AC 121-14B must meet the Phase I requirements in FAR Part 121, Appendix H, in the event of the sale or transfer of the simulator from one operator to another.

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

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

10. RECURRENT EVALUATIONS.

a. For a simulator to retain its qualification, it will be evaluated on a recurrent basis using the approved MATG. Unless otherwise determined by the NSPM, recurring evaluations will be accomplished every 4 months by a Simulator Evaluation Specialist. Each recurrent evaluation, normally scheduled for 8 hours of simulator time, will consist of functions tests and approximately one-third of the validation tests in the MATG. The MATG is to be completed annually.

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 procedure:

(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, recurrent evaluations for that simulator will be planned for 4 hours. If the 4-hour period is or will be exceeded and the operator cannot extend the period, then the evaluation will be terminated and must be completed within 30 days to maintain qualification status. The FAA will then reassess the appropriateness of the OTP.

(3) Under the OTP, at least one-third of all the validation tests will be performed and certified by operator personnel between FAA recurrent evaluations. Complete coverage will be required through any three consecutive recurrent evaluations. These tests and results will be reviewed by the FAA Simulator Evaluation Specialist at the outset of each evaluation. The one-third of validation tests executed for each recurrent evaluation should be accomplished within the 30 days prior to the scheduled evaluation or accomplished on an evenly distributed basis during the 4-month period preceding the scheduled evaluation. Twenty percent of those tests conducted by the operator for each recurrent evaluation will then be selected and repeated by the Simulator Evaluation Specialist along with 10 percent of those tests not performed by the operator.

d. With appropriate arrangement and understanding between the operator and FAA, an extended interval recurrent evaluation schedule based on semiannual FAA inspections can be arranged. The extended interval evaluation schedule relies on quarterly checks by the operator.

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

f. 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 POI shall be advised in writing. The notice shall contain an estimate of the period that the simulator will be inactive.

(2) Recurrent evaluations will not be scheduled during the inactive period. The NSPM will remove the simulator from qualified status on a mutually established date 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 MATG 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 MATG 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 and, if conditions warrant, may require the establishment of a new qualification basis.

11. <u>SPECIAL EVALUATIONS</u>.

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

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

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

a. In accordance with FAR Part 121, Appendix H, operators must notify the POI 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 MATG, 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 which impact flight or ground dynamics, systems functions, and significant ATG revisions may require an FAA evaluation of the simulator.

13. SIMULATOR QUALIFICATION BASIS. The FAR require that simulators must maintain their approved performance, functions, and other characteristics. Except as provided in paragraph 2, 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, except as noted in paragraph 9h. Any simulator upgraded to Level B, C, or D standards or any visual system or motion system upgrade requires an initial evaluation of that simulator, visual system, or motion system in accordance with the provisions herein.

William J. White
Acting Director, Flight Standards Service

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 FAR as indicated in paragraph 3 of this AC must be consulted when considering particular simulator requirements. The validation and functions tests listed in appendices 2 and 3 must also be consulted when determining the requirements of a specific level simulator. For Levels C and D qualification, certain simulator and visual system requirements included in this appendix must be supported with a statement of compliance and, in some designated cases, an objective test. Compliance statements will describe how the requirement is met, such as gear modeling approach, coefficient of friction sources, etc. The test should show that the requirement has been attained. In the following tabular listing of simulator standards, required statements of compliance are indicated in the comment column.

2. GENERAL	SIMULATOR LEVEL A	B	C	D	COMMENTS
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	

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL A	B	C	D	COMMENTS
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 running 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, speeds in knots, altitudes in feet, etc.
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, par. 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	X	X	X	X	

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL A	B	C	D	COMMENTS
unique cockpit configurations. These seats must provide adequate vision to the pilot's panel and forward windows in visual system models. Observer seats need not represent those found in the airplane but must be equipped with similar positive restraint devices.					
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 appropriate to the simulator application 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	

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL A	B	C	D	COMMENTS
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, precipitation static, and 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: (1) Ground effect--for example: roundout, flare, and touchdown. This requires data on lift, drag, pitching moment, trim, and power in ground effect. (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.		X	X	X	Statement of Compliance. Tests required.

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL A	B	C	D	COMMENTS
(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) Short final approach. The FAA Windshear Training Aid presents one acceptable means of compliance with simulator wind model requirements. The ATG should either reference the FAA Windshear Training Aid or present ariplane related data on alternate			X	X	Tests required.

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL A	B	C	D	COMMENTS
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 ATG.					
p. Representative crosswinds and instructor controls for wind speed and direction.	X	X	X	X	
q. Representative stopping and directional control forces for at least the following runway conditions based on airplane related data. (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).
r. Representative brake and tire failure dynamics (including antiskid) and decreased brake efficient due to brake temperatures based on airplane related data.			X	X	Statement of Compliance. Tests required for decreased braking efficiency due to brake temperature.

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL A	B	C	D	COMMENTS
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 ATG.			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. FAR 121, Appendix H, specifies computer standard for Phases II & III (Levels C and 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 evaluation 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.			X	X	Tests required. See appendix 2, par. 3.

SIMULATOR STANDARDS (Cont'd)	A	B	C	D	COMMENTS
(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 ATG 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.					
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 pilots' seats, the output signal to the visual system display (including visual system	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.

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL A	B	C	D	COMMENTS
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. 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 delay encountered by a step signal migrating from the pilots' control through the control loading electronics and interfacing through all the simulation software modules in the correct order, using a handshaking protocol, finally through the normal output interfaces to the motion system, to the visual system and instrument displays. A recordable start time for the test should be provided by a pilot flight control input. The					

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL A	B	C	D	COMMENTS
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.					
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, par. 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.

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL A	B	C	D	COMMENTS
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	Statement of Compliance. Tests required.
z. Diagnostic analysis printouts of simulator malfunctions sufficient to determine compliance with the Simulator Component Inoperative Guide (SCIG). These printouts shall be retained by the operator between recurring FAA simulator evaluations as part of the daily discrepancy log required under FAR Section 121.407(a)(5).				X	Statement of Compliance.
aa. Timely permanent update of simulator hardware and programming subsequent to airplane modification.	X	X	X	X	
bb. Daily preflight documentation either in the daily log or in a location easily accessible for review.	X	X	X	X	

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL A	B	C	D	COMMENTS
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.	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.
d. A means for recording the motion response time for comparison with airplane data.	X	X	X	X	See 2.v. of this appendix.
e. Special effects programming to include:		X	X	X	
(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.					

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL A	B	C	D	COMMENTS
(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, Vs.					
(7) Representative touchdown cues for main and nose gear.					
(8) Nosewheel scuffing.					
(9) Thrust effect with brakes set.					
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				X	Statement of Compliance. Tests required.

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL A	B	C	D	COMMENTS
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.					
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. Optical system capable of providing at least a 45 degrees horizontal and 30 degrees vertical field of view simultaneously for each pilot.	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 for visual systems qualified under AC 121-14C and subsequent.	X	X	X	X	

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL A	B	C	D	COMMENTS
e. Verification of visual ground segment and visual scene content at a decision height on landing approach. The ATG 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: (1) Airport and runway used. (2) Glide slope transmitter location for the specified runway. (3) Position of the glide slope receiver antenna relative to the airplane main landing wheels. (4) Approach and runway light intensity setting. (5) Airplane pitch angle. 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.	X	X	X	X	
f. For the NSPM to qualify precision weather minimum accuracy on simulators qualified under previous advisory circulars, operators must provide the information required in e. above.	X	X	X	X	

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
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. Dusk scene to enable identification of a visible horizon and typical terrain characteristics such as fields, roads, bodies of water.			X	X	Statement of Compliance. Tests required.
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. 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				X	Statement of Compliance. Tests required.

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL A	B	C	D	COMMENTS
or 1,000 surfaces for daylight and 4,000 light points for night and dusk scenes, 6 foot-lamberts of light measured at the pilot's eye position (highlight brightness), 3 arc-minutes resolution for the field of view at the pilot's eye, and a display which is free of apparent quantization and other distracting visual effects while the simulator is in motion. The simulator cockpit ambient lighting shall be dynamically consistent with the visual scene displayed. For daylight scenes, such ambient lighting shall neither "washout" the displayed visual scene nor fall below 5 foot-lamberts of light as reflected from an approach plate at knee height at the pilot's station and/or 2 foot-lamberts of light as reflected from the pilot's face. All brightness and resolution requirements must be validated by an objective test and will be retested at least yearly by the NSPM. Testing may be accomplished more frequently if there are indications that the performance is degrading on an accelerated basis. Compliance of the brightness capability may be demonstrated with a test pattern of white light using a spot photometer. (1) Contrast Ratio. A raster drawn test pattern filling the entire visual scene (three or more channels) shall consist of a matrix of black and white squares no larger					

SIMULATOR STANDARDS (Cont'd)	SIMULATOR LEVEL A	B	C	D	COMMENTS
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. 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. Note: Cockpit ambient light levels should be maintained at Level D (Phase III) requirements. (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.					

SIMULATOR STANDARDS (Cont'd)	A	B	C	D	COMMENTS
(3) 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.					
(4) Light point size - not greater than 6 arc-minutes measured in a test pattern consisting of a single row of light points reduced in length until modulation is just discernible, a row of 40 lights will form a 4 degree angle or less.					
(5) Light point contrast ratio - not less than 25:1 when a square of at least 1 degree filled (i.e., light point modulation is just discernible) with light points is compared to the adjacent background.					

APPENDIX 2. SIMULATOR VALIDATION TESTS

1. DISCUSSION. Simulator performance and system operation must be objectively evaluated by comparing the results of tests conducted in the simulator to 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.

The ATG 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 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 ATG. Levels B, C, and D 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 ATG 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.

Simulators for highly augmented airplanes will be validated both in the unaugmented configuration (or failure state with the maximum permitted degradation in handling qualities) and the augmented configuration. Where various levels of handling qualities result from failure states, validation of the effect of the failure is necessary. Requirements for testing will be mutually agreed to between the operator and the NSPM on a case-by-case basis.

SIMULATOR VALIDATION TESTS (Cont'd)

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 ATG 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 (2.225 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 FAR Part 121, Appendix H, to acquire full knowledge of simulator criteria for approval.

TABLE OF VALIDATION TESTS

I = Initial Evaluation
R = Recurrent Evaluation

Test	Tolerance	Flight Condition	Qualification Requirement A	B	C	D	Comments
1. PERFORMANCE							
a. TAXI							
(1) Minimum Radius Turn	±3 Feet (0.9m) or 20% of Airplane Turn Radius	Ground/Takeoff		IR	IR	IR	
(2) Rate of Turn vs. Nosewheel Steering Angle	±10% or ±2°/sec. Turn Rate	Ground/Takeoff		IR	IR	IR	
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 segment. (Brake release to V_r).
(2) Minimum Control Speed Ground (V_{mcg}) Aerodynamic Controls Only per Applicable Airworthiness Standard or Low Speed, Engine Inoperative Ground Control Characteristics	Maximum Airplane Lateral Deviation ±25% 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.
(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.

TABLE OF VALIDATION TESTS (Cont'd)

I = Initial Evaluation
R = Recurrent Evaluation

Test	Tolerance	Flight Condition	Qualification Requirement A	B	C	D	Comments
1. **PERFORMANCE (TAKEOFF con't)**							
(4) Normal Takeoff	±3 Kts Airspeed ±1.5° Pitch ±1.5° Angle of Attack ±20 Feet (6 Meters) Altitude ±5.0 lb (2.224 dN) or ±10% Column Force*	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). *Applies only to reversible control systems.
(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 ±5.0 lb (2.224 dN) or ±10% Column Force* ±5.0 lb (2.224 dN) or ±10% Rudder Pedal Force* ±3.0 lb (1.334 dN) or 10% Aileron Wheel Force*	Ground/Takeoff and First Segment Climb	IR	IR	IR	IR	Record Takeoff profile at maximum takeoff weight to at least 200 ft. (61 Meters) AGL. Engine failure speed must be within ±3 Kts of airplane data. *Applies only to reversible control systems.
(6) Crosswind Takeoff	±3 Kts Airspeed ±1.5° Pitch, ±1.5° Angle of Attack ±20 Feet (6 Meters) Altitude ±2° Bank and Sideslip Angle ±5.0 lb (2.224 dN) or ±10% Column Force* ±5.0 lb (2.224 dN) or ±10% Rudder Pedal Force* ±3.0 lb (1.334 dN) or 10% Aileron Wheel Force*	Ground/Takeoff and First Segment Climb	IR	IR	IR	IR	Record Takeoff profile to at least 200 ft. (61 Meters) AGL with same relative wind profile as airplane test. *Applies only to reversible control systems.
(7) Rejected Takeoff	Overall Distance ± ? Braking Effort ± ? (To Be Determined)	Ground	IR	IR	IR	IR	Auto brakes will be used where applicable. Maximum braking effort, Auto or Manual.

TABLE OF VALIDATION TESTS (Cont'd)

I = Initial Evaluation
R = Recurrent Evaluation

Test	Tolerance	Flight Condition	Qualification Requirement A	B	C	D	Comments
1. PERFORMANCE (Con't)							
c. CLIMB							
(1) Normal Climb All Engines Operating	±3 Kts 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.
(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 Flight Manual 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 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 FAA Approved Flight Manual 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. Use near maximum landing weight.
d. 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). Brake system pressure should be available.
(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.

TABLE OF VALIDATION TESTS (Cont'd)

I = Initial Evaluation
R = Recurrent Evaluation

Test	Tolerance	Flight Condition	Qualification Requirement A	B	C	D	Comments
1. PERFORMANCE (STOPPING Con't)							
(3) Stopping Time and Distance, Wheel Brakes, Wet Runway (No Reverse Thrust)	Representative Stopping Time and Distance	Landing			I	I	FAA approved Airplane Flight Manual (AFM) data is acceptable.
(4) Stopping Time and Distance, Wheel Brakes, Icy Runway (No Reverse Thrust)	Representative Stopping Time and Distance	Landing			I	I	FAA approved AFM data is acceptable.
e. ENGINES							
(1) Acceleration	T_i ±10% T_t ±10%	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 be a measurement 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	T_i ±10% T_t ±10%	Ground/Takeoff	IR	IR	IR	IR	Test from maximum takeoff power to 10% of maximum takeoff power (90% decay in power). Time history should be provided.

TABLE OF VALIDATION TESTS (Cont'd)

I = Initial Evaluation
R = Recurrent Evaluation

Test	Tolerance	Flight Condition	Qualification Requirement A	B	C	D	Comments
2. HANDLING QUALITIES							
a. STATIC CONTROL CHECKS**							
(1) Column Position vs. Force and Surface Position Calibration	±2 lbs (0.89 daN) Breakout ±5 lbs (2.224 daN) or ±10% Force ±2° Elevator	Ground	IR	IR	IR	IR	Uninterrupted control sweep, stop to stop.
(2) Wheel Position vs. Force and Surface Position Calibration	±2 lbs (0.89 daN) Breakout ±3 lbs (1.334 daN) or ±10% Force ±1° Aileron ±3° Spoiler	Ground	IR	IR	IR	IR	Uninterrupted control sweep, stop to stop.
(3) Pedal Position vs. Force and Surface Position Calibration	±5 lbs (2.224 daN) Breakout ±5 lbs (2.224 daN) or ±10% Force ±2° Rudder	Ground	IR	IR	IR	IR	Uninterrupted control sweep, stop to stop.
(4) Nosewheel Steering Force & Position	±2 lbs (0.89 daN) Breakout ±3 lbs (1.334 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	Ground	IR	IR	IR	IR	

**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.

TABLE OF VALIDATION TESTS (Cont'd)

I = Initial Evaluation
R = Recurrent Evaluation

Test	Tolerance	Flight Condition	Qualification Requirement A	B	C	D	Comments
2. HANDLING QUALITIES (STATIC CONTROL CHECKS Con't)							
(6) Pitch Trim Calibration Indicator vs. Computed	±0.5° of Computer Trim Angle ±10% Trim Rate	Ground and Go-Around	IR	IR	IR	IR	Measure trim rate for go-around. Trim rate input and surface rate time history is appropriate.
(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.
(8) Brake Pedal Position Vs. Force	±5 lb (2.224 daN) or 10% ±10% or 150 psi (1033 kPa) brake hydraulic pressure		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. ±1 overshoot.	Takeoff, Cruise, Landing			IR	IR	Data should be normal control displacement in both directions. Approximately 25% to 50% of full throw. n is the sequential period of a full cycle of oscillation. Refer to paragraph 3 this appendix.

**Column, wheel, and pedal position vs. force or time 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.

TABLE OF VALIDATION TESTS (Cont'd)

I = Initial Evaluation
R = Recurrent Evaluation

Test	Tolerance	Flight Condition	Qualification Requirement A	B	C	D	Comments
2. HANDLING QUALITIES (DYNAMIC CONTROL CHECKS** Con't)							
(2) Roll Control	Same as (1) above.	Takeoff, Cruise, Landing			IR	IR	Data should be normal control displacement. Approximately 25% to 50% of full throw.
(3) Yaw Control	Same as (1) above.	Takeoff, Cruise, Landing			IR	IR	Data should be normal control displacement. Approximately 25% to 50% of full throw.
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 configuration change to 15 seconds after completion of the configuration change.
(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.
(3) Spoiler/Speedbrake Change Dynamics	±3 Kts Airspeed ±100 Feet (30 Meters) Altitude ±20% or ±1.5° Pitch	Cruise and Approach	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.

TABLE OF VALIDATION TESTS (Cont'd)

I = Initial Evaluation
R = Recurrent Evaluation

Test	Tolerance	Flight Condition	Qualification Requirement A	B	C	D	Comments
2. HANDLING QUALITIES (LONGITUDINAL Con't)							
(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.
(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.
(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.
(7) Longitudinal Maneuvering Stability (Stick Force/g)	±5 lbs (±2.224 daN) or ±10% Column Force or Equivalent Surface	Cruise, Approach, Landing	IR	IR	IR	IR	May be series of Snapshot Tests. Force or surface deflection must be in correct direction. Approximately 20°, 30°, and 45° bank angle should be presented
(8) Longitudinal Static Stability	±5 lbs (±2.224 daN) or ±10% Column Force or Equivalent Surface	Approach					Data for at least 2 speeds above and 2 speeds below trim speed. May be a series of Snapshot Tests.

TABLE OF VALIDATION TESTS (Cont'd)

I = Initial Evaluation
R = Recurrent Evaluation

Test	Tolerance	Flight Condition	Qualification Requirement A	B	C	D	Comments
2. HANDLING QUALITIES (LONGITUDINAL Con't)							
(9) Stick Shaker, Airframe Buffet, Stall Speeds	$\pm$3 Kts Airspeed $\pm$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.
(10) Phugoid Dynamics	$\pm$10% of Period $\pm$10% of Time to 1/2 or Double Amplitude or $\pm$.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 amplitude whichever is less.
(11) Short Period Dynamics	$\pm$1.5° Pitch or $\pm$2°/sec. Pitch Rate $\pm$.10g Normal Acceleration	Cruise		IR	IR	IR	
d. LATERAL DIRECTIONAL							
(1) Minimum Control Speed, Air (V_{mca}), per Applicable Airworthiness Standard or Low Speed Engine Inoperative Handling Characteristics in Air	$\pm$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.
(2) Roll Response (Rate)	$\pm$10% or $\pm$2°/sec. Roll Rate	Cruise and Approach or Landing					Test with normal wheel deflection (about 30%).

TABLE OF VALIDATION TESTS (Cont'd)

I = Initial Evaluation
R = Recurrent Evaluation

Test	Tolerance	Flight Condition	Qualification Requirement A	B	C	D	Comments
2. HANDLING QUALITIES (LATERAL DIRECTIONAL Con't)							
(3) Roll Response to Roll Controller Step Input	±10% or ±2°/sec. Roll Rate	Approach or Landing	IR	IR	IR	IR	Roll rate response.
(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.
(5) Engine Inoperative Trim	±1° Rudder Angle or ±1° Tab Angle or Equivalent Pedal ±2° Sideslip Angle	Second Segment 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.
(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.
(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	Approach or Landing	IR	IR	IR	IR	May be a series of Snapshot Tests.

TABLE OF VALIDATION TESTS (Cont'd)

I = Initial Evaluation
R = Recurrent Evaluation

Test	Tolerance	Flight Condition	Qualification Requirement A	B	C	D	Comments
2. **HANDLING QUALITIES (Con't)**							
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.
(2) 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 or Yaw Angle	Landing		IR	IR	IR	Test from a minimum of 200 ft. (61 Meters) AGL to Nosewheel Touchdown and rollout to 60 Kts. Use near maximum landing weight with same Relative Wind Profile as aircraft test.
(3) 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 or Yaw Angle	Landing		IR	IR	IR	Test from a minimum of 200 ft. (61 Meters) AGL to Nosewheel Touchdown.
(4) Directional Control (Rudder Effectiveness) With Reverse Thrust, Symmetric and Asymmetric	±5 Kts Airspeed	Landing		IR	IR	IR	Airplane test data required, however, airplane manufacturer's engineering simulator data may be used for reference data as last resort. Airplanes with demonstrated minimum speed for rudder effectiveness ±5 Kts. Others, test to verify simulator meets conditions demonstrated by airplane manufacturer.

TABLE OF VALIDATION TESTS (Cont'd)

I = Initial Evaluation
R = Recurrent Evaluation

Test	Tolerance	Flight Condition	Qualification Requirement A	B	C	D	Comments
2. HANDLING QUALITIES (Con't)							
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.
3. MOTION SYSTEM							
a. Frequency Response	As specified by operator for simulator acceptance.		IR	IR	IR	IR	Appropriate test to demonstrate Frequency Response required.
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 Motions	See Appendix 1, para 3.f.					IR	Compliance statement required. Test required.

TABLE OF VALIDATION TESTS (Cont'd)

I = Initial Evaluation
R = Recurrent Evaluation

Test	Tolerance	Flight Condition	Qualification Requirement A	B	C	D	Comments
4. VISUAL SYSTEM - (Note: Refer to Appendix 3 for additional visual tests.)							
a. Visual Ground Segment (VGS)	±20% Threshold lights must be visible if they are in the visual segment. (See example in Comments.)	Landing. Static at 100 ft. (30 Meters) Wheel Height Above Touchdown Zone on Glide Slope. Runway Visual Range = 1200 Ft. or 350 Meters.	IR	IR	IR	IR	The ATG 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. Visual System Color	Demonstration Model				IR	IR	
c. Visual RVR Calibration	Demonstration Model				IR	IR	
d. Visual Display Focus and Intensity	Demonstration Model				IR	IR	
e. Visual Attitude vs. Simulator Attitude Indicator (Pitch and Roll of Horizon)	Demonstration Model				IR	IR	
f. Demonstrate 10 Levels of Occulting Through Each Channel of System	Demonstration Model				IR	IR	May be requested for recurrent evaluation.

TABLE OF VALIDATION TESTS (Cont'd)

I = Initial Evaluation
R = Recurrent Evaluation

Test	Tolerance	Flight Condition	Qualification Requirement A	B	C	D	Comments
5. SIMULATOR SYSTEMS							
a. VISUAL, MOTION, AND COCKPIT INSTRUMENT RESPONSE							
Visual, Motion, and Instrument Systems response to an abrupt pilot controller input, compared to airplane response for a similar 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 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.
	300 milliseconds or less after airplane response.	Takeoff, Cruise, Approach or Landing	IR	IR			
or							
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.
b. SOUND							
Realistic amplitude and frequency of cockpit noises and sounds, including precipitation static, and 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.						IR	Test results must show a comparison of the amplitude and frequency content of the sounds that originate from the airplane or airplane systems.

TABLE OF VALIDATION TESTS (Cont'd)

I = Initial Evaluation
R = Recurrent Evaluation

Test	Tolerance	Flight Condition	Qualification Requirement A	B	C	D	Comments
c. DIAGNOSTIC TESTING							
(1) A means for quickly and effectively testing simulator programming and hardware. This could include an automated system which could be used for conducting at least a portion of the tests in the ATG.					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 FAR Part 121, Appendix H, Phase III (Level D) Simulator Requirement No. 5.						IR	

SIMULATOR VALIDATION TESTS (Cont'd)

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 FAR 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 FAR 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 ATG 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

SIMULATOR VALIDATION TESTS (Cont'd)

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.

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.

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

SIMULATOR VALIDATION TESTS (Cont'd)

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 must, 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 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.

4. GROUND EFFECT. During landing and takeoff, airplanes operate for brief time intervals close to the ground. The presence of the ground significantly modifies the air flow past the airplane and, therefore, 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).

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 $\pm 1^\circ$

Power for Level Flight (PLF) $\pm 5\%$

SIMULATOR VALIDATION TESTS (Cont'd)

Angle of Attack	$\pm 1^\circ$
Altitude/Height	$\pm 10\%$ or $\pm 5'$ (1.5 m.)
Airspeed	± 3 Knots
Pitch Attitude	$\pm 1^\circ$

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.

SIMULATOR VALIDATION TESTS (Cont'd)

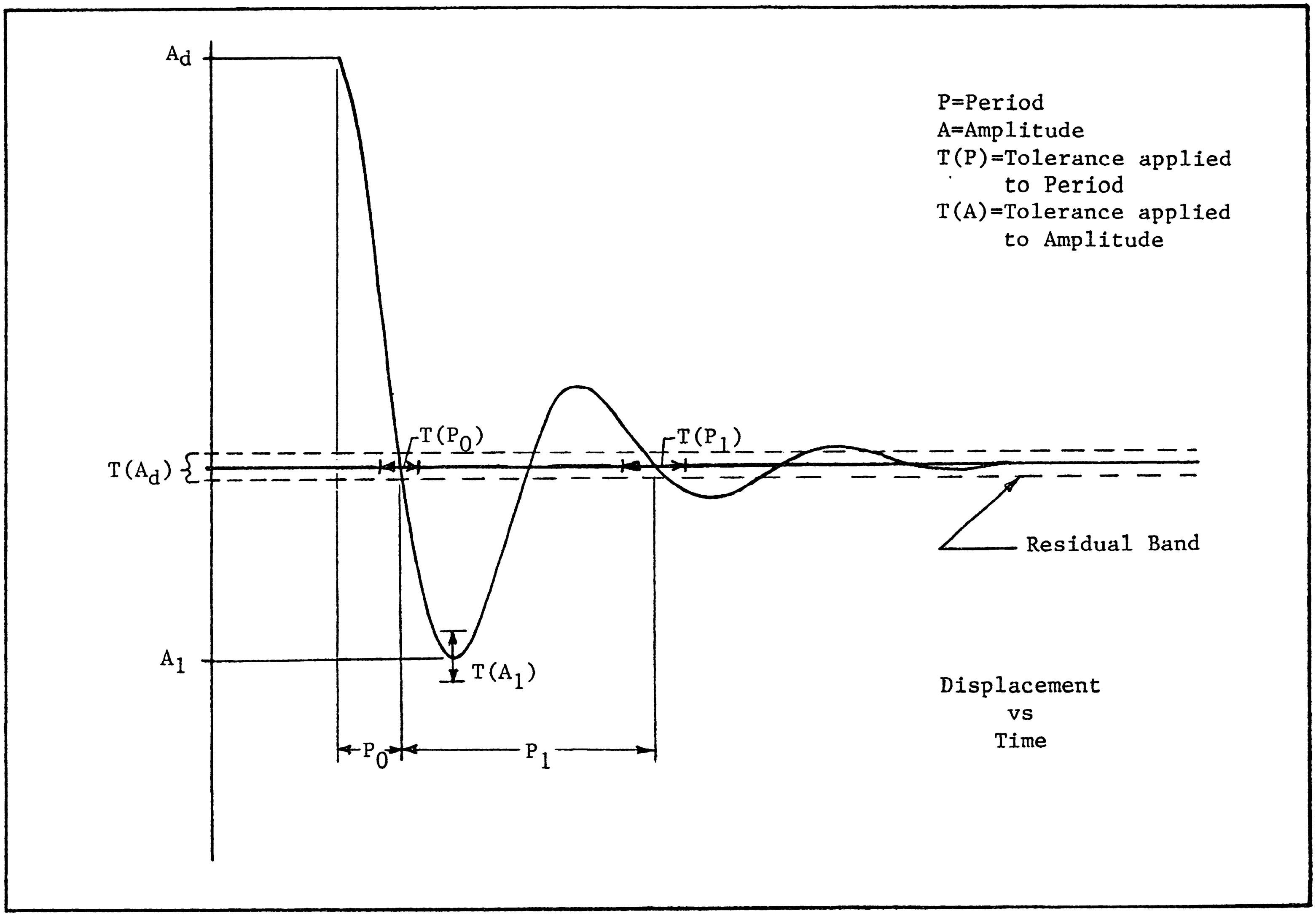

Figure 1. Under-damped Step Response

SIMULATOR VALIDATION TESTS (Cont'd)

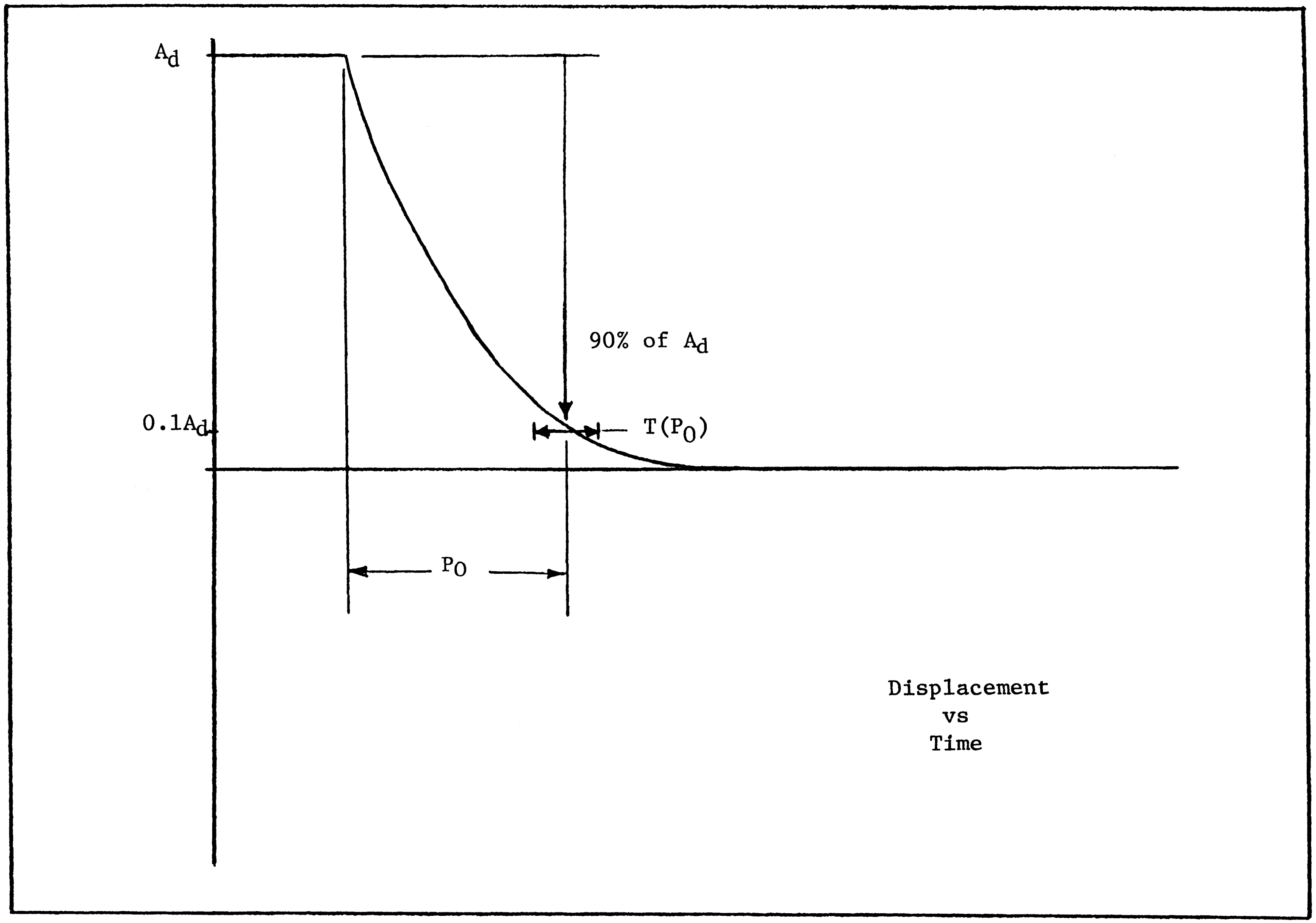

Figure 2. Critically-damped Step Response

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 FAA Simulator Evaluation Specialist qualified in the respective airplane.

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 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 assure that the simulator functions and performs appropriately for use in pilot training and checking in the maneuvers and procedures delineated in FAR Part 61 and FAR Part 121, Appendices E and F. It also contains tests to assure compliance with FAR 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 assure 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
(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

TABLE OF FUNCTIONS AND SUBJECTIVE TESTS (Cont'd)	SIMULATOR LEVEL A	B	C	D
(i) Engine parameter relationships.				
(ii) Acceleration characteristics.				
(iii) Nosewheel and rudder steering.				
(iv) Crosswind (maximum demonstrated).				
(v) Special performance.				
(vi) Instrument takeoff.				
(vii) Landing gear, wing flap, leading edge device operation.				
(viii) Other.				
(2) Abnormal/Emergency.	X	X	X	X
(i) Rejected.				
(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.				

TABLE OF FUNCTIONS AND SUBJECTIVE TESTS (Cont'd)	SIMULATOR LEVEL A	B	C	D
(2) Cruise.	X	X	X	X
(i) Performance characteristics (speed vs. power).				
(ii) Turns with/without spoilers (speed brake) deployed.				
(iii) High altitude handling.				
(iv) High speed handling.				
(v) Mach tuck and trim, overspeed warning.				
(vi) Normal and steep turns.				
(vii) Performance turns.				
(viii) Approach to stalls (stall warning, buffet, and g-break) cruise, takeoff, approach, and landing configuration.				
(ix) High angle of attack maneuvers (cruise, takeoff, approach, and landing).				
(x) Inflight engine shutdown and restart.				
(xi) Maneuvering with one engine inoperative.				
(xii) Specific flight characteristics.				
(xiii) Manual flight control reversion.				
(xiv) Flight control system failure modes.				
(xv) Other.				
(3) Descent.	X	X	X	X
(i) Normal.				

TABLE OF FUNCTIONS AND SUBJECTIVE TESTS (Cont'd)	SIMULATOR LEVEL A	B	C	D
(ii) Maximum rate.				
(iii) Manual flight control reversion.				
(iv) Flight control system failure modes.				
(v) Other.				
e. APPROACHES				
(1) Nonprecision.	X	X	X	X
(i) Approach procedure(s), one or more of the following. -- NDB -- VOR, RNAV, TACAN -- DME ARC -- LOC/BC -- AZI, LDA, LOC, SDF -- ASR				
(ii) Missed approach.				
(iii) All engines operating.				
(iv) One or more engines inoperative.				
(2) Precision.	X	X	X	X
(i) PAR.				
(ii) ILS.				
(A) Normal.				
(B) Engine(s) inoperative.				
(C) Category I published approach.				
1 Manually controlled with and without flight director to 100 ft. (30 m.) below CAT I minima.				

TABLE OF FUNCTIONS AND SUBJECTIVE TESTS (Cont'd)	SIMULATOR LEVEL A	B	C	D
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 generator failure.				
2 With 10 knot tailwind.				
3 With 10 knot crosswind.				
4 One engine inoperative.				
(iii) 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.				
f. VISUAL SEGMENT AND LANDING				
(1) Normal.				
(i) Crosswind (maximum demonstrated).		X	X	X
(ii) From VFR traffic pattern.	---(Reserved)---			

TABLE OF FUNCTIONS AND SUBJECTIVE TESTS (Cont'd)	SIMULATOR LEVEL A	B	C	D
(iii) From nonprecision approach.		X	X	X
(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 Section 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.				

TABLE OF FUNCTIONS AND SUBJECTIVE TESTS (Cont'd)	SIMULATOR LEVEL A	B	C	D
(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) Brake operation.				
(vii) Other.				
h. ANY FLIGHT PHASE				
(1) Airplane and powerplant systems operation.	X	X	X	X
(i) Air conditioning.				
(ii) Antiicing/deicing.				
(iii) Auxiliary powerplant.				
(iv) Communications.				
(v) Electrical.				
(vi) Fire detection and suppression.				
(vii) Flaps/slats/speed brakes				
(viii) Flight controls.				
(ix) Fuel and oil.				
(x) Hydraulic.				
(xi) Landing gear.				
(xii) Oxygen.				

TABLE OF FUNCTIONS AND SUBJECTIVE TESTS (Cont'd)	SIMULATOR LEVEL A	B	C	D
(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.				
(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) Engine shutdown and parking.	X	X	X	X
(i) Engine and systems operation.				
(ii) Parking brake operation.				

TABLE OF FUNCTIONS AND SUBJECTIVE TESTS (Cont'd)	SIMULATOR LEVEL A	B	C	D
(5) 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 VASI lights from 5 statute miles (8 kilometers) of the runway threshold.				
(2) Runway centerline lights and taxiway definition from 3 statute miles (4.8 kilometers).				
(3) Threshold lights and touchdown zone lights from 2 statute miles (3.2 kilometers).				
(4) Runway markings within range of landing lights for night scenes; as required by 3 arc-minutes resolution on day scenes.				
c. Representative airport scene content including:	X	X	X	X
(1) Airport runways and taxiways.				
(2) Runway definition.				
(i) Runway surface and markings.				

TABLE OF FUNCTIONS AND SUBJECTIVE TESTS (Cont'd)	SIMULATOR LEVEL A	B	C	D
(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.				
d. Operational landing lights.	X	X	X	X
e. Instructor controls of:	X	X	X	X
(1) Cloudbase.				
(2) Visibility in statute miles (km) and RVR in feet (meters).				
(3) Airport selection.				
(4) Airport lighting.				
f. Visual system compatibility with aerodynamic programming.	X	X	X	X
g. Visual cues to assess sink rates and depth perception during landings.		X	X	X
(1) Surface on taxiways and ramps.				
(2) Terrain features.				
h. Dusk and night visual scene capability.			X	X
i. Minimum of three specific airport scenes.			X	X
(1) Surfaces on runways, taxiways, and ramps.				
(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 which correspond to an operator's Line-Oriented Flight Training and Line Oriented Simulator scenarios.				

TABLE OF FUNCTIONS AND SUBJECTIVE TESTS (Cont'd)	SIMULATOR LEVEL A	B	C	D
j. General terrain characteristics and significant landmarks.			X	X
k. At and below an altitude of 2,000 feet (610 m.) height above the airport and within a radius of 10 miles (16 kilometers) from the airport, weather representations, including the following:			X	X
(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.				
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 representative 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 feet (610 m.) above the airport surface and within a radius of 10 miles (16 kilometers) 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

TABLE OF FUNCTIONS AND SUBJECTIVE TESTS (Cont'd)	SIMULATOR LEVEL A	B	C	D
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
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 gear.		X	X	X
g. Nosewheel scuffing.		X	X	X
h. Thrust effect with brakes set.		X	X	X
i. Representative 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			X	X

TABLE OF FUNCTIONS AND SUBJECTIVE TESTS (Cont'd)	SIMULATOR LEVEL A	B	C	D
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.				
k. Effects of airframe icing.			X	X

APPENDIX 4. EXAMPLES

APPENDIX 4. EXAMPLES (Cont'd)

Name, POI, ______________________ (Operator)

FAA FSDO ________________________

Address

City, State, Zip

Dear Mr. ______________:

_____(Name)_________ Airlines 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 approval test guide (ATG). We have completed tests of the simulator and certify that it meets all applicable requirements of FAR Section 121.407 (or FAR Sections 135.335 or 125.297), FAR Part 121, Appendix H, and the guidance of AC 120-40B. Appropriate hardware and software configuration control procedures have been established. Our pilots have assessed the simulator and found that it conforms to the _________(Name)____________ Airlines ____ ___(Type)_____________ airplane cockpit configuration and that the simulated systems and subsystems function equivalently to those in the airplane. Our pilots have also assessed the performance and flying qualities of the simulator and find that it represents the respective airplane.

(Added comments as desired.)

Sincerely,

FIGURE 1. Application Letter

APPENDIX 4. EXAMPLES (Cont'd)

OPERATOR NAME

OPERATOR ADDRESS

FAA APPROVAL TEST GUIDE

(AIRPLANE MODEL)

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

(Simulator Location)

FAA Initial Evaluation
Date: ______________

(Operator Approval) ______ Date: ______

________________________ Date: ______
FAA, Manager, National
Simulator Program

FIGURE 2. Example ATG Cover Page

APPENDIX 4. EXAMPLES (Cont'd)

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

FIGURE 3. Simulator Information Page

APPENDIX 5. WINDSHEAR QUALIFICATION [RESERVED]

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