CIVIL AVIATION AUTHORITY, PAKISTAN

Air Navigation Order
No. : 91.0023
Date : 2nd September 2009
Issue : Two

CRITERIA FOR THE QUALIFICATION OF FLIGHT SIMULATORS

CONTENTS

SECTIONS

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1. AUTHORITY

1.1. This Air Naviagation Order is issued by the Director General of the Civil Aviation Authority (CAA) in pursuance of the powers vested under Rule 4, Civil Aviation Rules 1994 (CARs 94).

2. PURPOSE

2.1 The ANO is intended to provide guidance and means for PCAA to qualify a flight simulator, subsequent to a request by an applicant, through initial and recurrent evaluations of the flight simulator. Further, the ANO is intended to provide the means for the authorities of other States to accept the qualifications granted by PCAA which conducted the initial and recurrent evaluation of a flight simulator, without repetitive evaluations, when considering approval of the use of that flight simulator by applicants from their own State.

3. SCOPE

3.1 This ANO establishes the performance and documentation requirements for the evaluation of aeroplane flight simulators used for training and checking of flight crew members. This ANO also addresses the use of flight simulators representing aeroplanes. It does not consider the use of flight simulators in association with other types of aircraft, nor does this ANO consider the use of synthetic flight training devices other than flight simulators equipped with, at minimum, a visual system and the equivalent of a six degree-of-freedom motion system.

3.2 It applies to all simulators/training devices used by Pakistani operators wherever located. Specific approval/validation by PCAA is required for each Pakistani operator for each simulator before it can be used by the operator for any training or checking

4. DEFINITION

4.1 The terms used in this manual have the following meanings:

1) Aeroplane performance data. Performance data published by the aeroplane manufacturer in documents such as the Aeroplane Flight Manual, Operations Manual, Performance Engineering Manual or equivalent;

2) Automatic testing. Flight simulator testing wherein all stimuli are under computer control;

3) Breakout. The force required at the pilot's primary controls to achieve initial movement of the control position;

4) Closed loop testing. A test method for which the input stimuli are generated by controllers which drive the flight simulator to follow a defined target response;

5) Computer controlled aeroplane. An aeroplane where pilot inputs to the control surfaces are transferred and augmented via computers;

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

7) Convertible flight simulator. A flight simulator in which hardware and software can be changed so that the flight simulator becomes a replica of a different model, usually of the

same type aeroplane. The same flight simulator platform, flight deck shell, motion system, visual system, computers and necessary peripheral equipment can thus be used in more than one simulation;

8) Critical engine parameter. The engine parameter that is the most appropriate measure of propulsive force;

9) Damping
   a) Critical damping. That minimum damping of a second order system such that no overshoot occurs in reaching a steady state value after being displaced from a position of equilibrium and released. This corresponds to a relative damping ratio of 1.0;
   b) Overdamped. That damping of a second order system such that it has more damping than is required for critical damping as described above. This corresponds to a relative damping ratio of more than 1.0;
   c) Underdamped. That damping of a second order system such that a displacement from the equilibrium position and free release results in one or more overshoots or oscillations before reaching a steady state value. This corresponds to a relative damping ratio of less than 1.0.

10) Daylight visual. A visual system capable of meeting, as a minimum, the system brightness and contrast ratio requirements as identified in Appendix B. The system, when used in training, should provide full-colour presentations and sufficient surfaces with appropriate textural cues to successfully accomplish a visual approach, landing and airport movement (taxi). Surface shading effects should be consistent with simulated sun position. Total scene content comparable in detail to that produced by 10 000 visible textured surfaces and 6,000 visible lights and sufficient system capacity to display 16 simultaneously moving objects;

11) Deadband. The amount of movement of the input for a system for which there is no reaction in the output or state of the system observed;

12) Driven. A test method where the input stimulus or variable is driven or deposited by automatic means, generally a computer input. The input stimulus or variable should not necessarily be an exact match to the flight test comparison data, but simply driven to certain predetermined values;

13) Engineering simulator validation data. Validation data generated by an engineering simulation or engineering simulator;

14) Evaluation. The careful appraisal of a flight simulator by the authority to ascertain whether or not the standards required for a specified qualification level are met;

15) Flight simulator. A full-size replica of a specific type or make, model and series of aeroplane flight deck, including the assemblage of equipment and computer programmes necessary to represent the aeroplane in ground and flight operations, a visual system providing an out-of-the-flight-deck view and a force cueing motion system. It is in compliance with the minimum standards for flight simulator qualification;

16) Flight simulator approval. The extent to which a flight simulator of a specified qualification level may be used by an operator or training organization as agreed by the authority. It takes account of differences between aeroplanes and flight simulators and the operating and training ability of the organization;

17) Flight simulator data. The various types of data used by the flight simulator manufacturer and the applicant to design, manufacture and test the flight simulator;

18) Flight simulator operator. The person, organization or enterprise directly responsible to the authority for requesting and maintaining the qualification of a particular flight simulator;

19) Flight simulator qualification level. The level of technical capability of a flight simulator.

20) Flight test data. Actual aeroplane data obtained by the aeroplane manufacturer (or other approved supplier of data) during an aeroplane flight test programme;

21) Free response. The response of the aeroplane after completion of a control input or disturbance;

22) Frozen/locked. A test condition where a variable is held constant with time;

23) Full sweep. Movement of the controller from neutral to a stop, usually the aft or right stop, to the opposite stop and then to the neutral position;

24) Functional performance. An operation or performance that can be verified by objective data or other suitable reference material that may not necessarily be flight test data;

25) Functions test. A quantitative assessment of the operation and performance of a flight simulator by a suitably qualified evaluator. The test should include verification of correct operation of controls, instruments and systems of the simulated aeroplane under normal and non-normal conditions;

26) Ground effect. The change in aerodynamic characteristics due to modification of the airflow past the aeroplane, caused by proximity to the ground;

27) Hands-off. A test manoeuvre conducted or completed without pilot control inputs;

28) Hands-on. A test manoeuvre conducted or completed with pilot control inputs as required;

29) Highlight brightness. The area of maximum displayed brightness which satisfies the brightness test;

30) Icing accountability; Refers to changes from normal (as applicable to the individual aeroplane design) in take-off, climb (en route, approach, landing) or landing operating procedures or performance data, in accordance with the Aeroplane Flight Manual, for flight in icing conditions or with ice accumulation on unprotected surfaces;

31) Integrated testing. Testing of the flight simulator such that all aeroplane system models are active and contribute appropriately to the results. None of the aeroplane system models should be substituted with models or other algorithms intended for testing purposes only. This should be accomplished by using controller displacements as the input. These controllers shall represent the displacement of the pilot's controls and shall have been calibrated;

32) Irreversible control system. A control system in which movement of the control surface will not backdrive the pilot's control on the flight deck;

33) Latency. The additional time, beyond that of the basic perceivable response time of the aeroplane, due to the response of the flight simulator;

34) Manual testing. Flight simulator testing wherein the pilot conducts the test without computer inputs except for initial set-up. All modules of the simulation shall be active;

35) Master qualification test guide (MQTG). The authority approved test guide that incorporates the results of tests witnessed by the authorities. The MQTG serves as the reference for future evaluations;

36) Night visual. A visual system capable of producing, as a minimum, all features applicable to the twilight scene (see Twilight (dusk/dawn) visual) with the exception of the need to portray reduced ambient intensity which removes ground cues that are not self-illuminating or illuminated by ownship lights (e.g. landing lights). Night scene content should be comparable in detail to that produced by 10 000 visible textured surfaces and 15 000 visible lights and sufficient capacity to display 16 simultaneously moving objects;

37) Non-normal control. A state where one or more of the intended control, augmentation or protection functions are not fully available. Used in reference to computer-controlled aeroplanes;

Note: Specific terms such as alternate, direct, secondary or back-up, etc., may be used to define an actual level of degradation used in reference to computer-controlled aeroplanes.

38) Normal control. A state where the intended control, augmentation and protection functions are fully available. Used in reference to computer-controlled aeroplanes;

39) Objective test. A quantitative assessment based on comparison to data;

40) Operator. A person, organization or enterprise engaged in or offering to engage in an aeroplane operation;

41) Protection functions. Systems functions designed to protect an aeroplane from exceeding its flight and manoeuvre limitations;

42) Pulse input. A step input to a control followed by an immediate return to the initial position;

43) Qualification test guide (QTG). The primary reference document used for the evaluation of a flight simulator. It contains test results, statements of compliance and other information to enable the evaluator to assess if the flight simulator meets the test criteria described in this manual;

44) Reversible control system. A control system in which movement of the control surface will backdrive the pilot's control on the flight deck;

45) Robotic test. A basic performance check of a system's hardware and software components. Exact test conditions are defined to allow for repeatability. The components are tested in their normal operational configuration and may be tested independently of other system components;

46) Snapshot. Presentation of one or more variables at a given instant in time;

47) Statement of compliance. Certification that specific requirements have been met;

48) Step input. An abrupt input held at a constant value;

49) Subjective test. A qualitative assessment based on established standards as interpreted by a suitably qualified person;

50) Throttle lever angle. The angle of the pilot's primary engine control lever(s) on the flight deck, which also may be referred to as TLA or power lever or throttle;

51) Time history. Presentation of the change of a variable with respect to time;

52) Transport delay. The total flight 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 and is independent of the characteristic delay of the aeroplane simulated;

53) Twilight (dusk/dawn) visual. A visual system capable of producing, as a minimum, full-colour presentations of reduced ambient intensity, sufficient surfaces with appropriate textural cues that include self-illuminated objects such as road networks, ramp lighting and airport signage. Scenes should also include a definable horizon and typical terrain characteristics such as fields, roads and bodies of water and surfaces illuminated by representative ownship lighting (e.g. landing lights)sufficient to successfully accomplish visual approach, landing and airport movement (taxi);

54) Upgrade. The improvement or enhancement of a flight simulator for the purpose of achieving a higher qualification;

55) Validation data. Data used to prove that the flight simulator performance corresponds to that of the aeroplane;

56) Validation flight test data. Performance, stability and control, and other necessary test parameters electrically or electronically recorded in an aeroplane using a calibrated data acquisition system of sufficient resolution and verified as accurate to establish a reference set of relevant parameters to which like flight simulator parameters can be compared;

57) Validation test. A test by which flight simulator parameters can be compared to the relevant validation data;

58) Visual ground segment test. Test designed to assess items impacting the accuracy of the visual scene presented to the pilot at decision height (DH) on an ILS approach;

59) Visual system response time. 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.

5. FLIGHT SIMULATOR QUALIFICATION

5.1 Introduction.

5.1.1 The availability of advanced technology has permitted greater use of flight simulators for training and checking of flight crew members. The complexity, costs and operating environment of modern aeroplanes also have encouraged broader use of advanced simulation. Flight simulators can provide more in-depth training than can be accomplished in aeroplanes and provide a safe and suitable learning environment. Fidelity of modern flight simulators is sufficient to permit pilot assessment with assurance that the observed behaviour will transfer to the aeroplane. Fuel conservation and reduction in adverse environmental effects are important by-products of flight simulator use.

5.1.2 While dealing with flight simulators, authorities differentiate between the technical criteria of the flight simulator and its use for training/testing and checking. The initial evaluation of the flight simulator and subsequent recurrent evaluations are designed to qualify the flight simulator as an acceptable replication of the aeroplane.

5.1.3 Qualification is achieved by comparing the flight simulator performance against the criteria specified in the Qualification Test Guide (QTG). Once the flight simulator has been qualified, PCAA may decide what training tasks can be carried out on the flight simulator. This determination is based on the flight simulator qualification,

a) The experience of the operator (the applicant),
b) The training programme in which the flight simulator is to be used and the experience, and qualifications of the pilots to be trained. This process results in the approved use of a flight simulator within an approved training programme.

5.1.4 This ANO deals specifically with criteria for the highest level of flight simulator. This level of flight simulator has the capability for and is used by many States for zero flight time training. To enable a comparison, the flight simulator defined in this ANO may be equated to the Federal Aviation Administration (FAA) and the European Joint Aviation Authorities (JAA) Level D. Appendices A, B and C to this ANO describe the minimum requirements for qualifying aeroplane flight simulators to the highest international level.

6. TESTING FOR FLIGHT SIMULATOR QUALIFICATION

6.1 The flight simulator shall be assessed in those areas which are essential to completing the flight crew member training and checking process. This includes the flight simulator's longitudinal and lateral-directional responses; performance in take-off, climb, cruise, descent, approach and landing; all-weather operations; control checks; and pilot, flight engineer and instructor station functions checks. The motion, visual and sound systems will be evaluated to ensure their proper operation.

6.2 The intent will be to evaluate the flight simulator as objectively as possible. Pilot acceptance, however, is also an important consideration. Therefore, the flight simulator will be subjected to the validation tests listed in Appendix B of this ANO and the functions and subjective tests in Appendix C. Validation tests are used to compare objectively flight simulator and aeroplane data to ensure that they agree within specified tolerances. Functions and subjective tests provide a basis for evaluating flight simulator capability to perform over a typical training period and to verify correct operation of the flight simulator.

6.3 Tolerances listed for parameters in Appendix B should not be confused with flight simulator design tolerances and are the maximum acceptable for flight simulator qualification.

6.4 For initial evaluation of flight simulators, the aeroplane manufacturer's validation flight test data is preferred. Data from other sources may also be used, subject to the review and concurrence of PCAA.

6.5 In the case of new aeroplane programmes, the aeroplane manufacturer's data, partially validated by flight test data, may be used in the interim qualification of the flight simulator. However, the flight simulator shall be requalified following the release of the manufacturer's data resulting from final airworthiness approval of the aeroplane. The requalification schedule shall be as agreed by the authority, the flight simulator operator, the flight simulator manufacturer and the aeroplane manufacturer. For additional information, refer to Attachment A.

6.6 Flight simulator operators seeking initial or upgrade evaluation of a flight simulator should be aware that performance and handling data for older aeroplanes may not be of sufficient quality to meet some of the test standards contained in this manual. In this instance it may be necessary for a flight simulator operator to acquire additional flight test data.

6.7 During flight simulator evaluation, if a problem is encountered with a particular validation test, the test may be repeated to ascertain if test equipment or personnel error caused the problem. Following this, if the test problem persists, a flight simulator operator should be prepared to offer alternative test results which relate to the test in question.

6.8 Validation tests which do not meet the test criteria should be rectified and satisfactorily retaken.

7. QUALIFICATION TEST GUIDE (QTG)

7.1 The QTG is the primary reference document used for the evaluation of a flight simulator. It contains flight simulator test results, statements of compliance and other information to enable the evaluator to assess if the flight simulator meets the test criteria described in this manual.

7.2 The applicant should submit a QTG which includes:

a) A title page with blocks for the signatures of both the applicant and the authority;
b) A flight simulator information page (for each configuration in the case of convertible flight simulators) providing:
   i) Flight simulator identification number;
   ii) Aeroplane model and series being simulated;
   iii) Aerodynamic data revision;
   iv) Engine model and its data revision;
   v) Flight control data revision;
   vi) Avionic equipment system identification and revision level where the revision level affects the training and checking capability of the flight simulator;
   vii) Flight simulator model and manufacturer;
   viii) Date of flight simulator manufacture;
   ix) Flight simulator computer identification;
   x) Visual system type and manufacturer; and
   xi) Motion system type and manufacturer;
c) Table of contents;

d) Log of revisions and/or list of effective pages;
e) Listing of all reference and source data;
f) Glossary of terms and symbols used;
g) Statement of compliance (SOC) with certain requirements; SOCs should refer to sources of information and show compliance rationale to explain how the referenced material is used, applicable mathematical equations and parameter values and conclusions reached. Refer to the "Comments" column of Appendices A and B for SOC requirements;
h) Recording procedures and required equipment for the validation tests;
i) The following items for each validation test designated in Appendix B of this manual:
   i) Test title
   ii) Test objective
   iii) Demonstration procedure
   iv) Initial conditions
   v) Manual test procedures
   vi) Automatic test procedures
   vii) Evaluation criteria
   viii) Expected result(s)
   ix) Test result
   x) Source data
   xi) Comparison of results
j) A statement of compliance covering the functions and subjective tests designated in Appendix C.

8. MASTER QUALIFICATION TEST GUIDE (MQTG)

8.1 The MQTG is the document which results from the evaluation and qualification of the flight simulator.

8.2 The MQTG is then available as the document to use for recurrent or special evaluations and is also the document that any authority can use as proof of an evaluation and current qualifications of a flight simulator when approval for the use of the particular flight simulator is requested for a specific training task.

9. CONFIGURATION MANAGEMENT

9.1 A configuration management system shall be established and maintained to ensure the continued integrity of the hardware and software as from the original qualification standard.

10. TYPES OF EVALUATIONS

10.1 An initial evaluation is the first evaluation of a flight simulator to qualify it for use. It consists of a technical review of the QTG and a subsequent on-site validation of the flight simulator to ensure it meets all the requirements of this manual.

10.2 Recurrent evaluations are those evaluations accomplished periodically to ensure that the flight simulator continues to meet its qualification level.

10.3 Special evaluations are those that may be accomplished resulting from any of the following circumstances:
a) A major hardware and/or software change which may affect the handling qualities, performance or systems representations of the flight simulator;
b) A request for an upgrade for a higher qualification level; and
c) The discovery of a situation that indicates the flight simulator is not performing at its initial qualification standard.

11. CONDUCT OF EVALUATIONS

11.1 Initial flight simulator evaluations

11.1.1 An applicant seeking evaluation of an aeroplane flight simulator should make the request to the authority which has jurisdiction over the applicant's training programme.

11.1.2 The request for evaluation should provide the QTG and also include a statement that the flight simulator has been thoroughly tested and that it meets the criteria described in this manual. The applicant should further certify that all the QTG tests for the requested qualification level have been achieved and that the flight simulator is representative of the aeroplane.

11.1.3 A copy of the flight simulator's QTG, marked with test results, should accompany the request. Any QTG deficiencies raised by the authority should be corrected prior to the start of the evaluation.

11.2 Modification of flight simulators, motion and visual systems

11.2.1 Modifications to the simulator hardware and software which affect flight, ground handling and performance or any major modifications to the motion or visual system should be evaluated to determine the impact on the original QTG criteria. If necessary, QTG amendments should be prepared for any affected validation tests.

11.2.2 The authority holding jurisdiction should be advised in advance of any major changes to a flight simulator to determine if a special evaluation of the flight simulator may be necessary prior to returning it to active status following the modification.

11.2.3 In the case of a flight simulator upgrade, validation tests for all areas affected by the upgrade or required by a requested higher qualification level should be run. Validation test results offered in a QTG for previous initial or upgrade evaluations should not be used to validate flight simulator performance in a QTG offered for a requested upgrade.

11.3 Temporary deactivation of a currently qualified flight simulator

11.3.1 In the event it is planned to remove a flight simulator from active status for prolonged periods, the appropriate authority should be notified and suitable controls established for the period the flight simulator is inactive.

11.3.2 An understanding should be arranged with the authority to ensure that the flight simulator can be restored to active status at its originally qualified level.

11.4 Moving a flight simulator to a new location

11.4.1 In instances where a flight simulator is to be moved to a new location, the appropriate authority should be advised of the planned activity and provided with a schedule of events related thereto.

11.4.2 Prior to returning the flight simulator to service at the new location, at least one third of the validation and functional tests from the QTG should be performed to ensure that the flight simulator performance meets its original qualification standard. A copy of the test documentation should be retained with the flight simulator records for review by the appropriate authority.

11.5 Composition of an evaluation team

11.5.1 An evaluation team led by a pilot from the authority usually conducts the flight simulator evaluations. Engineers and type qualified pilot inspectors will assist the team leader.

11.5.2 The applicant should provide technical assistance in the operation of the flight simulator and the required test equipment. The applicant should make available a pilot or training captain to assist the evaluation team as required.

11.5.3 On an initial evaluation the flight simulator manufacturer and/or aeroplane manufacturer should have technical staff available to assist as required.

11.6 Flight simulator qualification basis

11.6.1 Following satisfactory completion of the initial evaluation and qualification tests, a periodic check system should be established to ensure that flight simulators continue to maintain their initially qualified performance, functions and other characteristics.

11.6.2 The authority having jurisdiction over the flight simulator will establish the time required for the recurrent evaluation.

12. EVALUATION HANDBOOK

12.1 The “Airplane Flight Simulator Evaluation Handbook” is a useful source of guidance for conducting the tests required to establish that the flight simulator under evaluation complies with the criteria set out in this manual. This two volume document can be obtained through the Royal Aeronautical Society.

13. REFERENCES

13.1 ICAO Annex 6 Part 1

13.2 ICAO Document 9625 Edition 2

15. IMPLEMENTATION

15.1 This Air Navigation Order shall be implemented with immediate effect and supersedes ANO 91-0023 Issue 1.

--S/d--

(M. JUNAID AMEEN)
Air Commodore (Retd.)
Director General,
Pakistan Civil Aviation Authority

Dated: 2nd September, 2009

Appendix A

FLIGHT SIMULATOR CRITERIA

Introduction: This appendix describes the minimum flight simulator requirements for qualifying flight simulators to the highest international level. The validation and functions tests listed in Appendices B and C shall also be consulted when determining the requirements of a flight simulator qualified to the highest international level. Certain requirements included in this appendix shall be supported with a statement of compliance (SOC) and, in some designated cases, an objective test. The SOC will describe how the requirement was met, such as gear modelling approach, coefficient of friction sources, etc. The test results should show that the requirement has been attained. In the following tabular listing of flight simulator criteria, requirements for SOCs are indicated in the comments column.

Requirements	Comments
1. General	
1.1 Flight deck, a full-scale replica of the aeroplane simulated. Direction of movement of controls and switches identical to that in the aeroplane. Equipment for operation of the cockpit windows should be included in the flight simulator, but the actual windows need not be operable. Note:- The flight deck, for flight 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 flight crew member duty stations and those required bulkheads aft of the pilots' seats are also considered part of the flight deck and shall replicate the aeroplane.	Flight deck observer seats are not considered to be additional flight crew member duty stations and may be omitted (See 1.6.) Bulkheads containing items such as switches, circuit breakers, supplementary radio panels, etc., to which the flight crew may require access during any event after pre-flight cockpit preparation is complete are considered essential and may not be omitted. Bulkheads containing only items such as landing gear pin storage compartments, fire axes or extinguishers, spare light bulbs, aircraft document pouches, etc., are not considered essential and may be omitted. Such items, or reasonable facsimile, shall still be available in the flight simulator but may be relocated to a suitable location as near as practical to the original position. Fire axes and any similar purpose instruments need only be represented in silhouette.

Requirements	Comments
1.2 Circuit breakers that affect procedures and/or result in observable flight deck indications properly located and functionally accurate.	
1.3 Flight dynamics model that accounts for various combinations of drag and thrust normally encountered in flight corresponding to actual flight conditions, including the effect of change in aeroplane attitude, thrust, drag, altitude, temperature, gross mass, moments of inertia, centre of gravity location and configuration.	
1.4 All relevant instrument indications involved in the simulation of the applicable aeroplane to automatically respond to control movement by a flight crew member or external disturbance to the simulated aeroplane, i.e. turbulence or wind shear.	Numerical values shall be presented in accordance with ICAO Annex 5.
1.5 Communications, navigation, and caution and warning equipment corresponding to that installed in the applicant's aeroplane with operation within the tolerances prescribed for the applicable airborne equipment.	
1.6 In addition to the flight crew member duty stations, three suitable seats for the instructor/observer and authority inspector. The authority will consider options to this requirement based on unique flight deck configurations. The location of these seats shall provide an adequate view of the pilots' panels and forward windows. Observer seats need not represent those found in the aeroplane but shall be adequately secured to the floor of the flight simulator, fitted with positive restraint devices and of sufficient integrity to safely restrain the occupant during any known or predicted motion system excursion.	
1.7 Flight simulator systems to simulate the applicable aeroplane system operation, both on the ground and in flight. Systems shall be operative to the extent that all normal, abnormal and emergency operating procedures can be accomplished.	
1.8 Instructor controls to enable the operator to control all required system variables and insert abnormal or emergency conditions into the aeroplane systems.	

Requirements	Comments
1.9 Control forces and control travel which correspond to that of the replicated aeroplane. Control forces should react in the same manner as in the aeroplane under the same flight conditions.	
1.10 Ground handling and aerodynamic programming to include: 1.10.1 Ground effect. For example: round-out, flare and touchdown. This requires data on lift, drag, pitching moment, trim and power in ground effect. 1.10.2 Ground reaction. Reaction of the aeroplane 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. 1.10.3 Ground handling characteristics. Steering inputs to include crosswind, braking, thrust reversing, deceleration and turning radius.	SOC required. Tests required.
1.11 Wind shear models which provide training in the specific skills required for recognition of wind shear phenomena and execution of required manoeuvres. Such models shall 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 take-off rotation; 2) at lift-off; 3) during initial climb; 4) short final approach.	Tests required. See Appendix B, 2.g (wind shear).
1.12 Representative crosswinds and instructor controls for wind speed and direction.	
1.13 Representative stopping and directional control forces for at least the following runway conditions based on aeroplane related data: 1) dry; 2) wet; 3) icy; 4) patchy wet; 5) patchy icy; 6) wet on rubber residue in touchdown zone.	SOC required. Objective tests required for 1), 2) and 3). Subjective check for 4), 5) and 6). See Appendix B, 1.e (stopping).
1.14 Representative brake and tire failure dynamics (including antiskid) and decreased braking efficiency due to brake temperatures based on aeroplane related data.	SOC required. Subjective tests required for decreased braking efficiency.
1.15 A means for quickly and effectively conducting daily testing of flight simulator programming and hardware.	SOC required.
1.16 Flight simulator computer capacity, accuracy, resolution and dynamic response to fully support the overall flight simulator fidelity.	SOC required.
1.17 Control feel dynamics which replicate the aeroplane simulated.Free response of the controls shall match that of the aeroplane within tolerance given in Appendix B. Initial and upgrade evaluations will include control-free response (pitch, roll and yaw controllers) measurements recorded at the controls. The measured responses shall correspond to those of the aeroplane in take-off, cruise and landing configurations. 1.17.1 For aeroplanes 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 aeroplane manufacturer rationale shall be submitted as justification to ground test or to omit a configuration. 1.17.2 For simulators requiring static and dynamic tests at the controls, special test fixtures will not be required during initial evaluations if the QTG shows both test fixture results and alternate test method results, such as computer data plots, which were obtained concurrently. Repeat of the alternate method during initial evaluation may then satisfy this requirement.	Tests required. See Appendix B, 2.b.1 through 2.b.3 (dynamic control checks). See Appendix B, paragraphs 3.2 and 3.3 for a discussion of acceptable methods of validating control dynamics.

Requirements	Comments
1.18 Relative response of the visual system, flight deck instruments and initial motion system coupled closely to provide integrated sensory cues. Visual scene changes from steady state disturbance (i.e. the start of the scan of the first video field containing different information) shall occur within the system dynamic response limit of 150 milliseconds (ms). Motion onset shall also occur within the system dynamic response limit of 150 ms. While motion onset should occur before the start of the scan of the first video field containing different information, it must occur before the end of the scan of the same video field. The test to determine compliance with these requirements shall include simultaneously recording the output from the pilot's pitch, roll and yaw controllers, the output from the accelerometer attached to the motion system platform located at an acceptable location near the pilots' seats, the output signal to the visual system display (including visual system analog delays) and the output signal to the pilot's attitude indicator or an equivalent test approved by the authority. The following two methods are acceptable means to prove compliance with the above requirement:	Test required See Appendix B, 4.a
1.18.1 Transport delay: A transport delay test may be used to demonstrate that the flight simulator system response does not exceed 150 ms. This test shall measure all the delays encountered by a step signal migrating from the pilot's control through the control loading electronics and interfacing through all the simulation software modules in the correct order, using a handshaking protocol, finally through the normal output interfaces to the motion system, to the visual system and instrument displays. A recordable start time for the test should be provided by a pilot flight control input. The test mode shall permit normal computation time to be consumed and shall not alter the flow of information through the hardware/software system. The transport delay of the system is then the time between the control input and the individual hardware responses. It need only be measured once in each axis.	
1.18.2 Latency: The visual system, flight deck instruments and initial motion system response shall respond to abrupt pitch, roll and yaw inputs from the pilot's position within 150 ms of the time, but not before the time, when the aeroplane would respond under the same conditions. The objective of the test is to compare the recorded response of the flight simulator to that of the actual aeroplane data in the take-off, cruise and landing configuration for rapid control inputs in all three rotational axes.	
1.19 Aerodynamic modelling, that includes, for aeroplanes issued an original type certificate after June 1980, low altitude level flight ground effect, Mach effect at high altitude, normal and reverse dynamic thrust effect on control surfaces, aeroelastic effect and representations of non-linearities due to side-slip based on aeroplane flight test data provided by the aeroplane manufacturer.	SOC required. See Appendix B, 2.f. The SOC shall address each of these items. Separate tests for thrust effects and an SOC are required.
1.20 Modelling that includes the effects of airframe and engine icing.	SOC shall be provided
1.21 Aerodynamic and ground reaction modelling for the effects of reverse thrust on directional control.	SOC required. Tests required.
1.22 Realistic implementation of aeroplane mass properties, including mass, centre of gravity and moments of inertia as a function of payload and fuel loading.	SOC required with a range of tabulated target
1.23 Self-testing for simulator hardware and programming to determine compliance with the simulator performance tests as prescribed in Appendix B. Evidence of testing must include flight simulator number, date, time, conditions, tolerances and the appropriate dependent variables portrayed in comparison to the aeroplane data.	SOC required. Tests required
1.24 Timely permanent update of flight simulator hardware and programming subsequent to aeroplane modification.	
1.25 Daily pre-flight documentation either in the daily log or in a location easily accessible for review.	

	Requirements	Comments
2.	**MOTION SYSTEM**	
2.1	Motion cues perceived by the pilot representative of aeroplane motions (e.g. touchdown cues should be a function of the simulated rate of descent).	
2.2	A motion system which produces cues at least equivalent to those of a six-degree-of-freedom synergistic platform motion system.	SOC required. Tests required.
2.3	A means of recording the motion response time as required.	
2.4	Motion effects programming to include:	
2.4.1	Effects of runway rumble, oleo deflections, ground speed, uneven runway, centre line lights and taxiway characteristics;	
2.4.2	Buffets on the ground due to spoiler/speed-brake extension and thrust reversal;	
2.4.3	Bumps associated with the landing gear;	
2.4.4	Buffet during extension and retraction of landing gear;	
2.4.5	Buffet in the air due to flap and spoiler/speed-brake extension;	
2.4.6	Approach-to-stall buffet;	
2.4.7	Touchdown cues for main and nose gear;	
2.4.8	Nosewheel scuffing;	
2.4.9	Thrust effect with brakes set;	
2.4.10	Mach and manoeuvre buffet;	
2.4.11	Tire failure dynamics;	
2.4.12	Engine malfunction and engine damage; and	
2.4.13	Tail and pod strike.	
2.5	Motion vibrations: Tests with recorded results that allow the comparison of relative amplitudes versus frequency are required.	SOC required. Tests required. See Appendix B, 3.g (characteristic motion vibrations) and paragraph 3.4.
2.5.1	Characteristic motion vibrations that result from operation of the aeroplane, in so far as vibration marks an event or aeroplane state that can be sensed at the flight deck, shall be present. The flight simulator shall be programmed and instrumented in such a manner that the characteristic vibration modes can be measured and compared to aeroplane data.	
2.5.2	Aeroplane data are also required to define flight deck motions when the aeroplane is subjected to atmospheric disturbances. General purpose disturbance models that approximate demonstrable flight test data are acceptable. Tests with recorded results that allow the comparison of relative amplitudes versus frequency are required.	
3.	**VISUAL SYSTEMS**	
3.1	Visual system capable of meeting all the standards of this appendix and Appendices B and C.	
3.2	Continuous, cross-cockpit, minimum collimated visual field of view providing each pilot with 180 degrees horizontal and 40 degrees vertical field of view. Application of tolerances requires the field of view to be not less than a total of 176 measured degrees horizontal field of view (including not less than ±88 measured degrees either side of the centre of the design eye point) and not less than a total of 36 measured degrees vertical field of view from the pilot's and co-pilot's eye points.	An SOC is acceptable in place of this test. Consideration should be given to optimizing the vertical field of view for the respective aeroplane cut-off angle.
3.3	A means of recording the visual response time for visual systems as required. See Appendix B, 4.a (system response time).	
3.4	Visual textural cues to assess sink rate and depth perception during take-off and landing.	SOC required.
3.5	Horizon and attitude correlated to the simulated attitude indicator.	SOC required containing calculations confirming
3.6	A min of ten levels of occulting. SOC required. See Appendix C, 2.g.4.	
3.7	Surface resolution demonstrated by a test pattern of objects shown to occupy a visual angle of not greater than 2 arc minutes in the visual display used on a scene from the pilot's eye point.	SOC required
3.8	Light-point size — not greater than 5 arc minutes..	

Requirements	Comments
3.9 Light-point contrast ratio — not less than 25:1. 3.10 Daylight, twilight (dusk/dawn) and night visual capability as defined by terms in the glossary section of this document (Chapter 1). A raster drawn test pattern filling the entire visual scene (three or more channels) shall consist of a matrix of black and white squares no larger than 10 degrees and no smaller than 5 degrees per channel with a white square in the centre of each channel.	SOC required. See Appendix B, 4.b.7 (light-point contrast ratio). System objective tests are required — see Appendix B, 4.b (visual scene quality).
4. SOUND SYSTEM	
4.1 Significant flight deck sounds corresponding to those of the aeroplane which result from pilot actions.	
4.2 Sound of precipitation, rain removal equipment and other significant aeroplane noises perceptible to the pilot during normal and abnormal operations and the sound of a crash when the simulator is landed in excess of limitations.	SOC required.
4.3 Comparable amplitude and frequency of flight deck noises, including engine and airframe sounds. The sounds shall be coordinated with the required weather.	See Appendix B, 5.a 5.b, 5.c and para 3.6
4.4 The volume control shall have an indication of sound level setting which meets all qualification requirements.	

Appendix B

FLIGHT SIMULATOR VALIDATION TESTS

1. INTRODUCTION

1.1 Flight simulator performance and system operation must be objectively evaluated by comparing the results of tests conducted in the flight simulator to aeroplane data, unless specifically noted otherwise. To facilitate the validation of the flight simulator, an appropriate recording device acceptable to the authority should be used to record each validation test result. These recordings should then be compared to the aeroplane source data.

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

1.3 The flight simulator QTG must describe clearly and distinctly how the flight simulator will be set-up and operated for each test. Use of a driver programme designed to automatically accomplish the tests is required. It is not the intent, nor is it acceptable, to test each flight simulator sub-system independently. Overall integrated testing of the flight simulator shall be accomplished to assure that the total flight simulator system meets the prescribed standards. A manual test procedure with explicit and detailed steps for completion of each test shall also be provided.

1.4 Submission for approval of data other than flight test shall include an explanation of validity with respect to available flight test information. Tests and tolerances in this appendix shall be included in the flight simulator QTG. For aeroplanes certificated after January 2002, the QTG shall be supported by a Validation Data Road Map (VDR) as described in Attachment D. Data providers are encouraged to supply a VDR for older aeroplanes.

1.5 The Table of Flight Simulator Validation Tests in this appendix indicates the required tests. Unless noted otherwise, flight simulator tests should represent aeroplane performance and handling qualities at operating mass and centre of gravity (cg) positions typical of normal operation. If a test is supported by aeroplane data at one extreme mass or cg position, another test supported by aeroplane data at mid-conditions or as close as possible to the other extreme should be included. Certain tests which are relevant only at one extreme mass or cg position need not be repeated at the other extreme. Tests of handling qualities shall include validation of augmentation devices.

1.6 For the testing of computer-controlled aeroplane (CCA) flight simulators, flight test data are required for both the normal (N) and non-normal (NN) control states, as indicated in the validation requirements of this appendix. Tests in the non-normal state will always include the least augmented state. Tests for other levels of control state degradation may be required as detailed by the authority at the time of definition of a set of specific aeroplane tests for flight simulator data. Where applicable, flight test data shall record:

a) pilot controller deflections or electronically generated inputs including location of input; and
b) flight control surface positions unless test results are not affected by, or are independent of, surface positions.

1.7 The recording requirements of 1.6 a) and b) apply to both normal and non-normal states. All tests in the Table of Flight Simulator Validation Tests require test results in the normal control state unless specifically noted otherwise in the comments section following the CCA designation. However, if the test results are independent of control state, non-normal control data may be substituted.

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

2. TEST REQUIREMENTS

2.1 The ground and flight tests required for qualification are listed in the Table of Flight Simulator Validation Tests. Computer-generated flight simulator test results should be provided for each test. The results should be produced on an appropriate recording device acceptable to the authority. Time histories are required unless otherwise indicated in the Table of Flight Simulator Validation Tests.

2.2 Flight test data which exhibit rapid variations of the measured parameters may require engineering judgement when making assessments of flight simulator validity. Such judgement must not be limited to a single parameter. All relevant parameters related to a given manoeuvre or flight condition must be provided to allow overall interpretation. When it is difficult or impossible to match flight simulator to aeroplane data throughout a time history, differences shall be justified by providing a comparison of other related variables for the condition being assessed.

2.3 Parameters, tolerances and flight conditions. The Table of Flight Simulator Validation Tests describes the parameters, tolerances and flight conditions for flight simulator validation. When two tolerance values are given for a parameter, the less restrictive may be used unless indicated otherwise. Regardless, the test should exhibit correct trend. Flight simulator results shall be labelled using the tolerances and units given.

2.4 Flight condition verification. When comparing the parameters listed to those of the aeroplane, sufficient data shall also be provided to verify the correct flight condition. For example, to show the control force is within ±2.2 daN (5 lb) in a static stability test, data to show correct airspeed, power, thrust or torque, aeroplane 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 aeroplane, but airspeed, altitude, control input, aeroplane configuration, and other appropriate data shall also be given. All airspeed values shall be clearly annotated as to indicated, calibrated, etc., and like values used for comparison.

2.5 Flight condition definitions. The flight conditions specified in the Table of Flight Simulator Validation Tests, Sections 1 (Performance) and 2 (Handling Qualities) are defined as follows:

a) Ground — on ground, independent of aeroplane configuration;
b) Take-off — gear down with flaps in any certified take-off position;
c) Second segment climb — gear up with flaps in any certified take-off position;
d) Clean — flaps and gear up;
e) Cruise — clean configuration at cruise altitude and airspeed;
f) Approach — gear up or down with flaps at any normal approach position as recommended by the aeroplane manufacturer; and
g) Landing — gear down with flaps in any certified landing position.

3. INFORMATION FOR VALIDATION TESTS

3.1 Control dynamics

3.1.1 General. The characteristics of an aeroplane flight control system have a major effect on handling qualities. A significant consideration in pilot acceptability of an aeroplane is the “feel” provided through the flight controls. Considerable effort is expended on aeroplane feel system design so that pilots will be comfortable and will consider the aeroplane desirable to fly. In order for a flight simulator to be representative, it too shall present the pilot with the proper feel: that of the aeroplane being simulated. Compliance with this requirement shall be determined by comparing a recording of the control feel dynamics of the flight simulator to actual aeroplane measurements in the take-off, cruise and landing configurations.

3.1.1.1 Recordings such as free response to a pulse or step function are traditionally used to estimate the dynamic properties of electromechanical systems. In any case, the dynamic properties can only be estimated since the true inputs and responses are also only estimated. Therefore, it is imperative that the best possible data be collected since close matching of the flight simulator control loading system to the aeroplane systems is essential. The required control dynamics tests are indicated in 4.2.1 through 4.2.3 of the Table of Flight Simulator Validation Tests.

3.1.1.2 For initial and upgrade evaluations, it is required that control dynamics characteristics be measured at and recorded directly from the flight controls. This procedure is usually accomplished by measuring the free response of the controls using a step input or pulse input to excite the system. The procedure shall be accomplished in the take-off, cruise and landing flight conditions and configurations.

3.1.1.3 For aeroplanes 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 aeroplanes, take-off, cruise and landing configurations have like effects. Thus, one configuration may suffice. If either or both considerations apply, engineering validation or aeroplane manufacturer rationale shall be submitted as justification for ground tests or for eliminating a configuration. For flight simulators requiring static and dynamic tests at the controls, special test fixtures will not be required during initial and upgrade evaluations if the QTG shows both test fixture results and the results of an alternate approach, such as computer plots which were produced concurrently and show satisfactory agreement. Repeat of the alternate method during the initial evaluation would then satisfy this test requirement.

3.1.2 Control dynamics evaluation. The dynamic properties of control systems are often stated in terms of frequency, damping and a number of other traditional measurements which can be found in texts on control systems. In order to establish a consistent means of validating test results for flight simulator control loading, criteria are needed that will clearly define the interpretation of the measurements and the tolerances to be applied.

3.1.2.1 Tests to verify that control feel dynamics represent the aeroplane shall show that the dynamic damping cycles (free response of the controls) match those of the aeroplane within specified tolerances. The method of evaluating the response and the tolerance to be applied is described for the underdamped and critically damped cases.

a) 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 non-uniform periods in the response. Each period will be independently compared to the respective period of the aeroplane control system and, consequently, will enjoy the full tolerance specified for that period. Only oscillations outside the residual band are considered significant. When comparing flight simulator data to aeroplane data, the process should begin by overlaying or aligning the flight simulator and aeroplane steady state values and then comparing amplitudes of oscillation peaks, the time to the first zero crossing and individual periods of oscillation. The flight simulator should show the same number of significant overshoots to within one when compared against the aeroplane data;
b) Critically damped and overdamped response. Due to the nature of critically damped and overdamped responses (no overshoots), the time to reach 90 per cent of the steady state (neutral point) value should be the same as the aeroplane within ±10 per cent;
c) Special considerations. Control systems which exhibit characteristics other than traditional overdamped or underdamped responses should meet specified tolerances. In addition, special consideration should be given to ensure that significant trends are maintained.

3.1.2.2 Tolerances.

The following table summarizes the tolerances, T.

T(P0) ±10 per cent of P0
T(P1) ±20 per cent of P1
T(P2) ±30 per cent of P2
T(Pn) ±10(n+1) per cent of Pn
T(An) ±10 per cent of A1
T(Ad) ±5 per cent of Ad = residual band
Significant overshoots = first overshoot and ±1 subsequent overshoots

3.1.3 Alternate method for control dynamics evaluation.

One aeroplane manufacturer has proposed, and its authority has accepted, an alternate means for dealing with control dynamics. The method applies to aeroplanes 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.

3.1.3.1 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, take-off, cruise and landing conditions.

a) 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;
b) Slow dynamic test. Achieve a full sweep in approximately 10 seconds;
c) Fast dynamic test. Achieve a full sweep in approximately 4 seconds.

Note.— Dynamic sweeps may be limited to forces not exceeding 44.5 daN (100 lb).

3.1.3.2 Tolerances.

a) Static test. Items 4.1.1, 4.1.2 and 4.1.3 of the Table of Flight Simulator Validation Tests;
b) Dynamic test. ±0.9 daN (2 lb) or ±10 per cent on dynamic increment above static test.

3.1.3.3 Authorities are open to alternative means such as the one described in 3.1.3. Such alternatives shall, 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 aeroplanes with reversible control systems. Hence, each case shall be considered on its own merit on an ad hoc basis. Should the authority find that alternative methods do not result in satisfactory performance, then more conventionally accepted methods shall be used.

3.2 Ground effect

3.2.1 A flight simulator to be used for take-off and landing shall faithfully reproduce the aerodynamic changes which occur in ground effect. The parameters chosen for flight simulator validation shall be indicative of these changes. A dedicated test which will validate the aerodynamic ground effect characteristics should be undertaken. The choice of the test method and procedures to validate ground effect rests with the organization performing the flight tests; however, the duration of the flight test performed near the ground should be sufficient to validate the ground-effect model.

3.2.2 Acceptable tests for validation of ground effect include:

a) Level fly-bys. The level fly-bys should be conducted at a minimum of three altitudes within the ground effect, including one at no more than 10 per cent of the wingspan above the ground, one each at approximately 30 per cent and 50 per cent of the wingspan where height refers to main gear tire above the ground. In addition, one level-flight trim condition should be conducted out of ground effect, e.g. at 150 per cent of wingspan;
b) Shallow approach landing. The shallow approach landing should be performed at a glide slope of approximately one degree with negligible pilot activity until flare. If other methods are proposed, rationale shall be provided to conclude that the tests performed do validate the ground-effect model.

3.2.3 The lateral-directional characteristics are also altered by ground effect. For example, because of changes in lift, roll damping is affected. The change in roll damping will affect other dynamic modes usually evaluated for flight 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 side-slips will also be affected. These effects shall be accounted for in the simulator modelling. Several tests such as “crosswind landing”, “one engine inoperative landing” and “engine failure on take-off” serve to validate lateral-directional ground effect since portions of them are accomplished while transiting heights at which ground effect is an important factor.

3.3 Engineering simulator - validation data

3.3.1 When a fully flight-test validated simulation is modified as a result of changes to the simulated aeroplane configuration, a qualified aeroplane manufacturer may choose, with the prior agreement of the relevant authority, to supply validation data from an “audited” engineering simulator/simulation to selectively supplement flight test data. This arrangement is confined to changes that are incremental in nature and which are both easily understood and well defined.

3.3.2 To be qualified to supply engineering simulator validation data, an aeroplane manufacturer should:

a) Have a proven track record of developing successful data packages;
b) Have demonstrated high-quality prediction methods through comparisons of predicted and flight test validated data;
c) Have an engineering simulator that:
    1) has models which run in an integrated manner;
    2) Uses the same models as released to the training community (which are also used to produce stand-alone proof-of-match and checkout documents);
    3) Is used to support aeroplane development and certification.
d) use the engineering simulation to produce a representative set of integrated proof-of-match cases;
e) Have an acceptable configuration control system in place covering the engineering simulator and all other relevant engineering simulations.

3.3.3 Aeroplane manufacturers seeking to take advantage of this alternative arrangement should contact the authority at the earliest opportunity.

3.3.4 For the initial application, each applicant should demonstrate its ability to qualify to the satisfaction of the authority, in accordance with the means provided in this appendix.

3.4 Motion system

3.4.1 General. The objective validation tests presented in this appendix are intended to qualify the flight simulator motion cueing system from a mechanical performance standpoint. Additionally, the list of motion effects provides a representative sample of dynamic conditions that shall be present in the flight simulator. A list of representative training-critical manoeuvres that shall be recorded during initial qualification (but without tolerance) to indicate that the flight simulator motion cueing performance signature has been added to this document. These are intended to help to improve the overall standard of flight simulator motion cueing.

3.4.2 Motion system checks. The intent of tests as described in the Table of Flight Simulator Validation Tests, 3.a Frequency response, 3.b Leg balance and 3.c Turnaround check is to demonstrate the performance of the motion system hardware and to check the integrity of the motion set-up with regard to calibration and wear. These tests are independent of the motion cueing software and should be considered as robotic tests.

3.4.3 Motion cueing performance signature. The intent of this test is to provide quantitative time history records of motion system response to a selected set of automated QTG manoeuvres during initial qualification. This information describes a minimum set of manoeuvres and a guideline for determining the flight simulator's motion footprint. These tests can be run at any time deemed acceptable to the authority prior to or during the initial qualification. A priority (X) is given to each of these manoeuvres with the intent of placing greater importance on those manoeuvres that directly influence pilot perception and control of the aeroplane motions. For the manoeuvres designated with a priority, the flight simulator motion cueing system should have a high-tilt coordination gain, high rotational gain and high correlation with respect to the aeroplane simulation model.
The minimum list of parameters provided should allow for the determination of the flight simulator's motion cueing performance signature for the initial qualification. The following parameters are recommended as being acceptable to perform such a function:

a) Flight model acceleration and rotational rate commands at the pilot reference point;
b) Motion actuators position;
c) Actual platform position; and
d) Actual platform acceleration at pilot reference point.

3.4.4 Motion system repeatability.
The intent of this test is to ensure that the motion system software and motion system hardware have not degraded or changed over time. This diagnostic test should be run during recurrent checks in lieu of the robotic tests. This will allow an improved ability to determine changes in the software or determine degradation in the hardware that have adversely affected the training value of the motion as was accepted during the initial qualification. The following information delineates the methodology that should be used for this test.

a) Conditions:
   1) One test case on-ground: to be determined by the operator; and
   2) One test case in-flight: to be determined by the operator.
b) Input. The inputs shall be such that both rotational accelerations/rates and linear accelerations are inserted before the transfer from aeroplane cg to pilot reference point with a minimum amplitude of 5 deg/sec/sec, 10 deg/sec and 0.3 g, respectively, to provide adequate analysis of the output.
c) Recommended output:
   1) Actual platform linear accelerations; the output will comprise accelerations due to both the linear and rotational motion acceleration; and
   2) Motion actuators position.

3.4.5 Motion vibrations.

3.4.5.1 Presentation of results. The characteristic motion vibrations are a means to verify that the flight simulator can reproduce the frequency content of the aeroplane when flown in specific conditions. As a minimum, the results along the dominant axes should be presented and a rationale for not presenting the other axes should be provided.

3.4.5.2 Interpretation of results. The overall trend of the PSD plot should be considered while focusing on the dominant frequencies. Less emphasis should be placed on the differences at the high frequency and low amplitude portions of the PSD plot. The amplitude should match aeroplane data as per the following description; however, if for subjective reasons the PSD plot was altered, a rationale should be provided to justify the change. If the plot is on a logarithmic scale, it may be difficult to interpret the amplitude of the buffet in terms of acceleration. A 1 × 10-3 grms2/Hz would describe a heavy buffet and may be seen in the deep stall regime. On the other hand, a 1 × 10-6 grms2/Hz buffet is almost not perceivable but may represent a flap buffet at low speed. The previous two examples differ in magnitude by 1 000. On a PSD plot this represents three decades (one decade is a change in order of magnitude of 10; two decades is a change in order of magnitude of 100; etc.).

3.5 Visual systems

3.5.1 General. Visual systems shall meet the following criteria:

a) Contrast ratio shall be demonstrated using a raster drawn test pattern filling the entire visual scene (three or more channels) consisting of a matrix of black and white squares no larger than 5 degrees per square with a white square in the centre of each channel. Measurement shall be made on the centre bright square for each channel using a 1-degree spot photometer. This value shall have a minimum brightness of 7 cd/m2 (2 ft-lamberts). The contrast ratio is the bright square value divided by the dark square value. Minimum test contrast ratio result is 5:1. Light-point contrast ratio shall be not less than 25:1 when a square of at least 1 degree filled (i.e. lightpoint modulation is just discernible) with light point is compared to the adjacent background.

b) Highlight brightness test. Shall be demonstrated by maintaining the full test pattern described in 3.5.1 a), then superimposing a highlight on the centre white square of each channel and measuring the brightness using the 1-degree spot photometer. The highlight brightness shall not be less than 6 ftlamberts. Light points are not acceptable. Use of calligraphic capabilities to enhance raster brightness is acceptable.

c) Resolution. Shall be demonstrated by a test of objects shown to occupy a visual angle of not greater than 2 arc minutes in the visual scene from the pilot's eye point. This should be confirmed by calculations in the SOC.

d) Light-point size. Not greater than 5 arc minutes shall be measured in a test pattern consisting of a single row of light points reduced in length until modulation is just discernible. A row of 48 lights will form a 4-degree angle or less.

3.5.2 Visual ground segment.

a) Altitude and RVR for the assessment have been selected in order to produce a visual scene that can be readily assessed for accuracy (RVR calibration) and where spatial accuracy (centre line and G/S) of the simulated aeroplane can be readily determined using approach/runway lighting and flight deck instruments.

b) The QTG should indicate the source of data, i.e. airport and runway used, ILS G/S antenna location (airport and aeroplane), pilot eye reference point, flight deck cut-off angle, etc., used to accurately make visual ground segment (VGS) scene content calculations.

c) Automatic positioning of the simulated aeroplane on the ILS is encouraged. If such positioning is accomplished, diligent care shall be taken to ensure that the correct spatial position and aeroplane attitude are achieved. Flying the approach manually or with an installed autopilot shall also produce acceptable results. An SOC shall be provided in the QTG indicating that ILS systems are accurately modelled (location and slope) for the airport models used.

3.6 Sound system

3.6.1 General.
The total sound environment in the aeroplane is very complex and changes with atmospheric conditions, aeroplane configuration, airspeed, altitude, power settings, etc. Thus, flight deck sounds are an important component of the flight deck operational environment and as such provide valuable information to the flight crew. For effective training, the flight simulator shall provide flight deck sounds that are perceptible to the pilot during normal and abnormal operations and that are comparable to those of the aeroplane. Accordingly, the flight simulator operator should carefully evaluate background noises in the location being considered.

3.6.2 Alternate propulsion. For flight simulators with multiple propulsion configurations, any condition listed in Appendix B, Section 5 that is identified by the aeroplane manufacturer as significantly different, due to a change in propulsion system (engine or propeller), shall be presented for evaluation as part of the QTG.

3.6.3 Data and data collection system. Information provided to the flight simulator manufacturer should contain calibration and frequency response data.

3.6.4 Playback equipment. Playback equipment and recordings of the QTG conditions according to Appendix B, Section 5, shall be provided during initial evaluations.

3.6.5 Background noise. Background noise includes the noise in the flight simulator due to the flight simulator's cooling and hydraulic systems that are not associated with the aeroplane and the extraneous noise from other locations in the building. Background noise can seriously impact the correct simulation of aeroplane sounds, so the goal should be to keep the background noise below the aeroplane sounds. In some cases, the sound level of the simulation can be increased to compensate for the background noise. However, this approach is limited by the specified tolerances and by the subjective acceptability of the sound environment to the evaluation pilot. The acceptability of the background noise levels is dependent upon the normal sound levels in the aeroplane being represented.

3.6.6 Frequency response. Frequency response plots for each channel shall be provided at initial certification. These plots may be rerun at the recurrent evaluation as per 3.6.8.

3.6.7 Initial and recurrent evaluations. If recurrent frequency response and flight simulator background noise results are within tolerance, respective to initial evaluation results, and the operator can prove that no software or hardware changes have occurred that will affect the aeroplane cases, then it is not required to rerun those cases during recurrent evaluations.

3.6.8 Validation testing. Deficiencies in aeroplane recordings should be considered when applying the specified tolerances to ensure that the simulation is representative of the aeroplane. Examples of typical deficiencies are:

a) Variation of data between tail numbers;
b) Frequency response of microphones;
c) Repeatability of the measurements.

Note: Refer to **Table of flight simulator validation tests** in ICAO Document 9625 edition 2

Appendix C

FUNCTIONS AND SUBJECTIVE TESTS

1. INTRODUCTION

1.1 Accurate replication of aeroplane systems functions should be checked at each flight crew member position. This includes procedures using the AFM and checklists. Handling qualities, performance and flight simulator systems operation will be subjectively assessed. Prior coordination with the authority responsible for the evaluation is essential to ensure that the functions tests are conducted in an efficient and timely manner and that any skills, experience or expertise required by the evaluation team are available.

1.2 At the request of an authority, the flight simulator may be assessed for a special aspect of a relevant training programme during the functions and subjective portion of an evaluation. Such an assessment may include a portion of a LOFT (line oriented flight training) scenario or special emphasis items in the training programme. Unless directly related to a requirement for the current qualification level, the results of such an evaluation would not affect the flight simulator's current status.

1.3 Functions tests should be run in a logical flight sequence at the same time as performance and handling assessments. This also permits the real time flight simulator to run for two to three hours, without repositioning of flight or position freeze, thereby permitting proof of reliability.

2. TEST REQUIREMENTS

2.1 The ground and flight tests and other checks required for qualification are listed in the following Table of Functions and Subjective Tests. The table includes man oeuvres and procedures to assure that the flight simulator functions and performs appropriately for use in pilot training and checking in the maneuvers and procedures normally required of a training and checking programme.

2.2 Man oeuvres and procedures are included to address some features of advanced technology aeroplanes and innovative training programmes. For example, "high angle of attack maneuverings" is included to provide an alternative to "approach-to-stalls". Such an alternative is necessary for aeroplanes employing flight envelope limiting technology.

2.3 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 man oeuvres or events within that flight phase. Systems are listed separately under "any flight phase" to assure appropriate attention to systems checks.

3. THE TESTS

3.1 FUNCTIONS AND MANOEUVRES

3.1.1 Preparation for flight

3.1.1.1 Pre-flight accomplish a functions check of all switches, indicators, systems and equipment at all crew members' and instructors' stations and determine that the flight deck design and functions are identical to that of the aeroplane simulated

3.1.2 Surface operations (pre-take-off)

3.1.2.1 Engine start

- i) Normal start
- ii) Alternate start procedures
- iii) Abnormal starts and shutdowns (hot start, hung start, etc.)

3.1.2.2 Push back/power back

3.1.2.3 Taxi

- 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

3.1.3 Take-off

3.1.3.1 Normal
i) Parameter relationships
ii) Acceleration characteristics
iii) Nosewheel and rudder steering
iv) Crosswind (maximum demonstrated)
v)s Pecial performance
vi) Instrument take-off (low visibility)
vii) Landing gear, wing flap, leading edge device operation
viii) Other

3.1.3.2 Abnormal/emergency
i) Rejected
ii) Rejected special performance
iii) With failure of most critical engine at most critical point along take-off path, take-off
iv) Continued
v) With wind shear
vi) Flight control system failure modes
vii) Other

3.1.4 In-flight operation

3.1.4.1 Climb
i) Normal
ii) One or more engine(s) inoperative
iii) Other

3.1.4.2 Cruise
i) Performance characteristics (speed versus power)
ii) Turns with/without spoilers (speed brake) deployed
iii) High-altitude handling
iv) High-IAS handling
v) Mach tuck and trim, over-speed warning
vi) Normal and steep turns
vii) Performance turns
viii) Approach-to-stalls, stall warning, buffet and g-break (cruise, take-off, approach and landing configuration)
ix) In-flight engine shutdown and restart
x) Manoeuvring with one or more engine(s) inoperative, as appropriate
xi) Specific flight characteristics
xii) Manual flight control reversion
xiii) Flight control system failure modes
xiv) Other

3.1.4.3 Descent
i) Normal
ii) Maximum rate
iii) Manual flight control reversion
iv) Flight control system failure modes
v) Other

3.1.5 Approaches

3.1.5.1 Precision approach and landing procedures
i) PAR
ii) ILS/MLS/GBAS
  a) Normal
  b) Engine(s) inoperative
  c) Category I published approach
    - Manually controlled with and without flight director to 30 m (100 ft) below CAT I minima
    - With crosswind (maximum demonstrated)

- With wind shear

d) Category II published approach auto-coupled, auto-throttle, auto-land
- All engines operating missed approach

e) Category III published approach
- With generator failure
- With 10 kt tailwind
- With 10 kt crosswind
- One engine inoperative

3.1.5.2 Non-precision approach and landing procedures
- Landing gear, operation of flaps and speed brake
- All engines operating
- One or more engine(s) inoperative

i) NDB, VOR, DME, ARC, TACAN
ii) ILS LLZ only, BC"
iii) RNAV (GNSS, VOR/DME, DME/DME)
iv) ILS offset localizer
v) Direction-finding facility
vi) Surveillance radar

3.1.5.3 Missed approach procedures
- All engines operating
- One or more engine(s) inoperative (as applicable)

3.1.6 Visual segment and landing

3.1.6.1 Normal
i) Crosswind (maximum demonstrated)
ii) From VFR traffic pattern
iii) From non-precision approach
iv) From precision approach
v) From circling approach
vi) Without glide slope guidance

3.1.6.2 Abnormal/emergency
i) Engine(s) inoperative
ii) Rejected
iii) With wind shear
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) Abnormal wing flaps/slats
x) Other flight control system failure modes as dictated by the training programme
xi) Other

3.1.7 Surface operations (post-landing)

3.1.7.7 landing roll and taxi
i) Spoiler operation
ii) Reverse thrust operation
iii) Directional control and ground handling, both with and without reverse thrust
iv) Reduction of rudder effectiveness with increased reverse thrust (rear pod-mounted engines)
v) Brake and anti-skid operation with dry, wet and icy conditions
vi) Brake operation
vii) Other

3.1.8 Any flight phase

3.1.8.1 Aeroplane and power plant systems operation
i) Air conditioning
ii) De-icing/anti-icing
iii) Auxiliary power unit

iv) Communications
v) Electrical
vi) Fire and smoke detection and suppression
vii) Flaps and smoke detection and suppression
viii) Flight controls
ix) Fuel and oil
x) Hydraulic
xi)l Anding gear
xii) Oxygen
xiii) Pneumatic
xiv) Power plant
xv) Pressurization

3.1.8.2 Flight management and guidance systems
i) Airborne radar
ii) Automatic landing aids
iii) Autopilot
iv) Collision avoidance systems
v) Flight control computers
vi) Flight display systems
vii) Ground proximity warning systems
viii) Head-up displays
vix) Navigation systems
vx) Stall warning/avoidance
vxi) Stability and control augmentation
vxii) Wind shear avoidance equipment

3.1.8.3 Airborne procedures
i) Holding
ii) Air hazard avoidance
iii) Wind shear 1.h.4 engine shutdown and parking
iv) Engine and systems operation
v) Parking brake operation

4. VISUAL SYSTEM

4.1 Functional test content requirements
The intent of this visual scene content requirement description is to identify the content required to aid the pilot in making appropriate, timely decisions.

4.1.1 Two parallel runways and one crossing runway displayed simultaneously; at least two runways should be lit simultaneously.

4.1.2 Runway threshold elevations and locations shall be modelled to provide sufficient correlation with aeroplane systems (e.g. HGS, GPS, altimeter); slopes in runways, taxiways and ramp areas should not cause distracting or unrealistic effects, including pilot eye-point height variation.

4.1.3 Representative airport buildings, structures and lighting.

4.1.4 One usable gate, set at the appropriate height, for those aeroplanes that typically operate from terminal gates.

4.1.5 Representative moving and static gate clutter (e.g. other aeroplanes, power carts, tugs, fuel trucks, additional gates).

4.1.6 Representative gate/apron markings (e.g. hazard markings, lead-in lines, gate numbering) and lighting.

4.1.7 Representative runway markings, lighting and signage, including a wind sock that gives appropriate wind cues.

4.1.8 Representative taxiway markings, lighting and signage necessary for position identification, and to taxi from parking to a designated runway and return to parking: representative, visible taxi route signage shall be provided; a low-visibility taxi route (e.g. SMGCS, follow-me truck, daylight taxi lights) should also be demonstrated.

4.1.9 Representative moving and static ground traffic (e.g. vehicular and aeroplane).

4.1.10 Representative depiction of terrain and obstacles within 25 NM of the reference airport.

4.1.11 Representative depiction of significant and identifiable natural and cultural features within 25 NM of the reference airport.

Note.— This refers to natural and cultural features that are typically used for pilot orientation in flight. Outlying airports not intended for landing need only provide a reasonable facsimile of runway orientation.

4.1.12 Representative moving airborne traffic.

4.1.13 Appropriate approach lighting systems and airfield lighting for a VFR circuit and landing, non-precision approaches and landings, and Category I, II and III precision approaches and landings.

4.1.14 Representative gate docking aids or a marshaller.

4.2 Visual scene management

4.2.1 Runway and approach lighting intensity for any approach should be set at an intensity representative of that used in training for the visibility set; all visual scene light points should fade into view appropriately.

4.2.2 The directionality of strobe lights, approach lights, runway edge lights, visual landing aids, runway centre line lights, threshold lights and touchdown zone lights on the runway of intended landing should be realistically replicated.

4.3 Visual feature recognition

4.3.1 Runway definition, strobe lights, approach lights, white runway edge lights and visual landing aids from 8 km (5 sm) of the runway threshold.

4.3.2 Runway centre line lights and taxiway definition from 5 km (3 sm).

4.3.3 Threshold lights and touchdown zone lights from 3 km (2 sm).

4.3.4 Runway markings within range of landing lights for night/twilight scenes or as required by the surface resolution text on day scenes.

4.3.5 For circling approaches, the runway of intended landing and associated landing should fade into view in a non-distracting manner.

4.4 Airport model content

4.4.1 Terminal approach area accurate portrayal of airport features is to be consistent with published data used for aeroplane operations all depicted lights should be checked for appropriate colours, directionality, behaviour and spacing (e.g. obstruction lights, edge lights, centre line, touchdown zone, VASI, PAPI, REIL and strobes) depicted airport lighting should be selectable via controls at the instructor station as required for aeroplane operation selectable day, twilight and night airport visual scene capability at each model demonstrated.

4.4.2 Terrain appropriate terrain, geographic and cultural features.

4.4.3 Dynamic effects the capability to present multiple ground and air hazards such as another aeroplane crossing the active runway or converging airborne traffic; hazards should be selectable via controls at the instructor station.

4.4.4 Illusions operational visual scenes which portray representative physical relationships known to cause landing illusions, for example, short runways, landing approaches over water, uphill or downhill runways, rising terrain on the approach path and unique topographic features.

Note.— Illusions may be demonstrated at a generic airport or specific aerodrome.

4.5 Correlation with aeroplane and associated equipment

4.5.1 Visual system compatibility with aerodynamic programming.

4.5.2 Visual cues to assess sink rate and depth perception during landings.

4.5.3 Accurate portrayal of environment relating to flight simulator attitudes.

4.5.4 The visual scene should correlate with integrated aeroplane systems, where fitted (e.g. terrain, traffic and weather avoidance systems, HGS).

4.5.5 Representative visual effects for each visible, ownship, aeroplane external light.

4.5.6 The effect of rain removal devices should be provided.

4.6 Environmental effects

4.6.1 The displayed scene should correspond to the appropriate surface contaminants and include runway Lighting reflections for wet, partially obscured lights for snow, or suitable alternative effects.

4.6.2 Weather representations which include the sound, motion and visual effects of light, medium and heavy precipitation near a thunderstorm on take-off, approach and landings at and below an altitude of 600 m (2 000 ft) above the aerodrome surface and within a radius of 16 km (10 sm) from the airport.

4.6.3 In-cloud effects such as variable cloud density, speed cues and ambient changes should be provided.

4.6.4 The effect of multiple cloud layers representing few, scattered, broken and overcast conditions giving Partial or complete obstruction of the ground scene.

4.6.5 Gradual break-out to ambient visibility/RVR, defined as up to 10 per cent of the respective cloud base or top, 20 ft < transition layer <200 ft; cloud effects should be checked at and below a height of 600 m (2 000 ft) above the aerodrome and within a radius of 16 km (10 sm) from the airport.

4.6.6 Visibility and RVR measured in terms of distance. Visibility/RVR should be checked at and below a height of 600 m (2 000 ft) above the aerodrome and within a radius of 16 km (10 sm) from the airport.

4.6.7 Patchy fog giving the effect of variable RVR.

Note.— Patchy fog is sometimes referred to as patchy RVR.

4.6.8 Effects of fog on aerodrome lighting such as halos and defocus.

4.6.9 Effect of ownship lighting in reduced visibility, such as reflected flare, to include landing lights, strobes and beacons.

4.610 Wind cues to provide the effect of blowing snow or sand across a dry runway or taxiway should be selectable via controls at the instructor station.

4.7 Scene quality

4.7.1 Surfaces and textural cues should be free from apparent quantization (aliasing).

4.7.2 System capable of portraying full-colour realistic textural cues.

4.7.3 The system light points should be free from distracting jitter, smearing or streaking.

4.7.4 Demonstration of a minimum of ten levels of occulting through each channel of the system in an operational scene.

4.7.5 System capable of providing focus effects that simulate rain and light point perspective growth.

4.7.6 System capable of six discrete light step controls (0 – 5).

4.8 Instructor controls

4.8.1 Environmental effects: effects should be selectable via controls at the instructor station, e.g. cloud base, cloud effects, cloud density and visibility (kilometres/statute miles) and RVR (metres/feet).

4.8.2 Dynamic effects including ground and flight traffic.

4.8.3 Aerodrome selection.

4.8.4 Aerodrome lighting including variable intensity.

5. MOTION EFFECTS

5.1 Effects of runway rumble, oleo deflections, ground speed, uneven runway, centre line lights and **taxiway characteristics.**

5.1.1 After the aeroplane has been preset to the take-off position and then released, taxi at various **speeds,** first with a smooth runway, and note the general characteristics of the simulated runway rumble effects of oleo deflections. Next, repeat the manoeuvre with a runway roughness of 50 per cent then finally with maximum roughness. The associated motion vibrations should be affected by ground speed and runway roughness. If time permits, different gross weights can also be selected as this may also affect the associated vibrations depending on aeroplane type. The associated motion effects for the tests should also include an assessment of the effects of centre line lights, surface discontinuities of uneven runways, and various taxiway characteristics.

5.2 Buffets on the ground due to spoiler/speed brake extension and thrust reversal

5.2.1 Perform a normal landing and use ground spoilers and reverse thrust — either individually or in combi- nation with each other — to decelerate the simulated aeroplane. Do not use wheel braking so that only the buffet due to the ground spoilers and thrust reverser is felt.

5.3 Bumps associated with the landing gear

5.3.1 Perform a normal take-off paying special attention to the bumps that could be perceptible due to maximum oleo extension after lift-off. When the landing gear is extended or retracted, motion bumps could be felt when the gear locks into position**.**

5.4 Buffet during extension and retraction of landing gear

5.4.1 Operate the landing gear. Check that the motion cues of the buffet experienced are reasonably representative of the actual aeroplane.

5.6 Buffet in the air due to flap and spoiler/speed brake extension

5.6.1 First perform an approach and extend the flaps and slats, especially with airspeeds deliberately in excess of the normal approach speeds. In cruise configuration verify the buffets associated with the spoiler/speed brake extension. The effects could also be verified with different combinations of speed brake/flap/gear settings to assess the interaction effects.

5.7 Approach-to-stall buffet

5.7.1 Conduct an approach-to-stall with engines at idle and a deceleration of 1 kt/s. Check that the motion cues of the buffet, including the level of buffet increase with decreasing speed, are reasonably representative of the actual aeroplane.

5.8 Touchdown cues for main and nose gear

5.9 Nosewheel scuffing

5.9.1 Taxi the simulated aeroplane at various ground speeds and manipulate the nosewheel steering to cause yaw rates to develop which cause the nosewheel to vibrate against the ground (“scuffing”). Evaluate the speed/nosewheel combination needed to produce scuffing and check that the resultant vibrations are reasonably representative of the actual aeroplane.

5.10 Thrust effect with brakes set

5.10.1 With the simulated aeroplane set with the brakes on at the take-off point, increase the engine power until buffet is experienced and evaluate its characteristics. This effect is most discernible with wing-mounted engines. Confirm that the buffet increases appropriately with increasing engine thrust.

5.11 Mach and manoeuvre buffet

5.11.1 With the simulated aeroplane trimmed in 1 g flight while at high altitude, increase the engine power such that the Mach number exceeds the documented value at which Mach buffet is experienced. Check that the buffet begins at the same Mach number as it does in the aeroplane (for the same configuration) and that the buffet level is a reasonable representation of the actual aeroplane. In the case of some aeroplanes, manoeuvre buffet could also be verified for the same effects. Manoeuvre buffet can occur during turning flight at conditions greater than 1 g, particularly at higher altitudes.

5.12 Tire failure dynamics

5.12.1 Dependent on aeroplane type, a single tire failure may not necessarily be noticed by the pilot and therefore there should not be any special motion effects. There may possibly be some sound and/or vibration associated with the actual tire losing pressure. With a multiple tire failure selected on the same side, the pilot may notice some yawing which should require the use of the rudder to maintain control of the aeroplane.

5.13 Engine malfunction and engine damage

5.13.1 The characteristics of an engine malfunction as stipulated in the malfunction definition document for the particular flight simulator should describe the special motion effects felt by the pilot. The associated engine instruments should also vary according to the nature of the malfunction.

5.14 Tail and pod strikes

5.14.1 Tail strikes can be checked by over-rotation of the aeroplane at a speed below V_r while performing a takeoff. The effects can also be verified during a landing. The motion effect should be felt as a noticeable bump. Excessive banking of the aeroplane during its take-off/landing roll can cause a pod strike. The motion effect should be felt as a noticeable bump. If the tail and/or pod strike affects the aeroplane’s angular rates, the cueing provided by the motion system should have an associated effect.

6. SOUND SYSTEM

6.1 The following checks should be performed during a normal flight profile with motion:

6.1.1 Precipitation.

6.1.2 Rain removal equipment.

6.1.3 Significant aeroplane noises perceptible to the pilot during normal operations.

6.1.4 Abnormal operations for which there are associated sound cues including, but not limited to, engine mal- functions, landing gear/tire malfunctions, tail and engine pod strike and pressurization malfunction.

6.1.5 Sound of a crash when the flight simulator is landed in excess of limitations.

7. SPECIAL EFFECTS

7.1 Braking dynamics

7.1.1 Representative brake failure dynamics (including anti-skid) and decreased brake efficiency due to high brake temperatures based on aeroplane-related data. These representations should be realistic enough to cause pilot identification of the problem and implementation of appropriate procedures. Flight simulator pitch, side loading and directional control characteristics should be reasonably representative of the actual aeroplane.

7.2 Effects of airframe and engine icing
See Appendix A for information on requirements.

Appendix D

سول ایوی ایشن اتھارٹی	Simulator Qualification Approval Application Form (Flight Standards Directorate – PCAA)	DOC.NO:CAAD-624-… REV. NO: 00 DATED: … -09-2009

Note: Please read the instructions on last page carefully before filling and filing this Application Form. The quality and accuracy of information provided by you on these pages has a direct impact on the assessment and completion time of Simulator Qualification Approval process.

1. Company/Operator Name:

2. Name of the owner (s):

3. Address(es) with Tele., Fax No. and E-mail:

4. Complete Details/Definition of the Simulator:

5. Aircraft Type & Variant with Engine versions:

6. Master Qualification Test Guide Details :

7. Qualification Test Guide Details:

8. Type of flight simulator approval Required(Tick as applicable):

- **a) Initial Evaluation**
- **b) Recurrent Evaluation**
- **c) Modification of Flight Simulator**
- **d) Post Temporary De-activation**
- **e) Post Movement to New Location**

8. Testing Completion certificate with applicable details:

Flight simulator testing has been completed and it is declare that it meets the applicable requirements of ICAO Doc 9625 edition 2 and ANO 91-0023, except as noted below:

List of Test Discrepancies:

a) ..
b) ..
c) ..

Name and designation: Signature: Date:

9. Conformance to Aircraft Cockpit Configuration:

It is attested that this Flight Simulator conforms to the aircraft cockpit configuration of --------------(type of aircraft) and that the simulated systems and sub-systems function equivalently to those in that aircraft with the exception:

a) ----
b) ….
c) ….

Name and designation: Signature: Date:

10. Previous Assessment Record

a) Date of Assessment:
b) Name and designation of the Assessor:
c) Organization:

11. Additional Comments (if any)

Name and Designation: Signature: Date:

12. Application received at Flight Standards Directorate by:

Name and designation: Signature: Date:

Instructions related to the Application

1. It is important for you to know that CAA may refuse to consider an application or to consider it further from beyond a point while there are requirements that the applicant has not or cannot comply with. Rule 340 of CARs 94 is referred to which states:
   "(1) The Director-General may refuse to grant or to renew certificate on one or more of the following grounds:
   (a) The applicant has failed to satisfy a requirement prescribed by or specified under these rules in relation to the granting of the certificate;
   (b) The applicant has made a false or misleading statement in his application, or in connection with his application;
   (c) The applicant is the holder of a licence that is suspended;
   (d) The applicant was the holder of a licence that has been cancelled; or
   (e) The applicant is not a fit and proper person to have the responsibilities and to exercise the functions and duties of a holder of the certificate for which the application was made.
2. FSD, CAA strongly recommends that ICAO Document 9625 and ANO 91-0023 may be followed in true spirit. These documents provide comprehensive information on requirements and processes for flight simulator approval. Following the required procedures while complying with the requirements given therein shall expedite the whole process.
3. Application shall not be considered "complete" if all the information as specified is not provided at the time of its submission to FSD, CAA.
4. Application submission date shall be the day when completed application is submitted. Count down shall start from that date for further processes.
5. Application Form shall be signed either by the Head of Organization or the person authorised by CAA.
6. No column of this Application Form shall be left blank.
7. Reverse side of Form pages may be used for the data spillover.
8. Extra sheets may be used where required.
9. Where a copy of any document has to be attached, it shall be an attested true copy of the original.