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MANUAL OF CRITERIA FOR THE , QUALIFICATION OF FLIGHT SIMULATORS

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AMENDMENTS

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RECORD OF AMENDMENTS AND CORRIGENDA

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Foreword

This manual 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 manual 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.

The methods, procedures and testing standards contained in this manual are the result of the experience and expertise of State civil aviation authorities, operators, aircraft manufacturers and simulator manufacturers.

From 1989 to 1992 a specially convened international working group held several meetings with the stated purpose of establishing common test criteria that would be recognized internationally. The criteria that resulted from the work of the working group were presented to a conference held in London, United Kingdom, in January 1992.

These criteria are contained in the appendices to this manual. Appendix A describes the minimum requirements for qualifying Level I or II flight simulators. The validation and functions tests associated with a particular level of flight simulator are contained in Appendices B and C.

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GLOSSARY OF TERMS AND ABBREVIATIONS

1.1 GLOSSARY OF TERMS

The terms used in this manual have the following meanings:

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

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

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

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

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.

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

Critical engine parameter. The engine parameter which is the most appropriate measure of propulsive force.

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.

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.

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, may not necessarily be an exact match to the flight test comparison data, but simply driven to certain predetermined values.

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

Flight simulator. A full-size replica of a specific type or make, model and series of aircraft flight deck, including the assemblage of equipment and computer programmes necessary to represent the aircraft 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 simulator qualification.

a) ***Level I flight simulator.*** A six-axis motion system must be provided. The sound simulation must include the sounds of precipitation and other significant aircraft noises perceptible to the pilot and must be able to reproduce the sounds of a crash landing. The response to control inputs must not be greater than 150 milliseconds more than that experienced in the aircraft. Wind shear simulation must be provided.

b) ***Level II flight simulator.*** The highest level of simulated performance. In addition to the requirements for Level I flight simulators, a full daylight/dusk/night visual system is required and there must be complete fidelity of sounds and motion buffets.

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 competent authority. It takes account of differences between aircraft and flight simulators and the operating and training ability of the organization.

Flight simulator da&z. The various types of data used by the flight simulator manufacturer and the applicant to design, manufacture and test the flight simulator.

Flight simulator operator. That person, organization or enterprise directly responsible to the competent authority for requesting and maintaining the qualification of a particular flight simulator.

Flight simulator qualification level. The level of technical capability of a flight simulator as described in this manual.

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

Free response. The response of the aircraft after completion of a control input or disturbance.

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

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.

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.

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

Ground effect. The change in aerodynamic characteristics due to modification of the air flow past the aircraft, caused by proximity to the ground.

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

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

Highlight brightness. The area of maximum displayed brightness which satisfies the brightness test in Appendix A, 3 1) 2).

Icing accountability. A demonstration of minimum required performance, whilst operating in maximum and intermittent maximum icing conditions, of the applicable airworthiness requirement.

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

International qualification test guide (ZQTG). 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 simulator meets the test criteria described in this manual.

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

Latency. The additional time beyond that of the basic perceivable response time of the aircraft due to the response of the flight simulator.

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

Master international qualification test guide (MIQTG). The regulatory authority approved test guide which incorporates the results of tests witnessed by the regulatory authorities. The MIQTG serves as the reference for future evaluations.

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

Non-normal control. A state where one or more of the intended control, augmentation or protection functions are not fully available.

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

Objective test. A quantitative assessment based on comparison to data.

Operator. A person, organization or enterprise engaged in or offering to engage in an aircraft operation.

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

Predicted data. Data derived from sources other than flight test.

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

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

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

Snapshot. Presentation of one or more variables at a given instant of time.

Statement of compliance. Certification that specific requirements have been met.

Step input. An abrupt input he!d at a constant value.

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

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

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 over-all time delay incurred from signal input until output response and does not include the characteristic delay of the aeroplane simulated.

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

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

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.

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

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.

1.2 ABBREVIATIONS AND UNITS

The abbreviations and units used in this manual have the following meaning:

AGL	Above ground level (m or ft)
airspeed	Calibrated airspeed unless otherwise specified (knots)
altitude	Pressure-altitude (m or ft) unless otherwise specified
AOA	Angle of attack (degrees)

A_d	Total initial displacement of pilot controller (initial displacement to final resting amplitude)
A_n	Sequential amplitude of overshoot after initial X-axis crossing, e.g. A, = first overshoot
bank	Bank/roll angle (degrees)
CCA	Computer controlled aeroplane
cd/m^2	Candela/metre^2 (3.4263 candela/m* = I ft-lambert)
cm(s)	Centimetre(s)
daN	DecaNewtons
EPR	Engine pressure ratio
ft	Foot (I ft = 0.304801 m)
ft-lambert	Foot-lambert (I ft-lambert = 3.4263 candela/m*)
fuel used	Mass of fuel used (kilos or pounds)
g	Acceleration due to gravity (m or ft/s^2) (I g = 9.8 I m/s^2 or 32.2 ft/s^2)
G/S	Glideslope
height	Height above ground = AGL (m or ft)
ILS	Instrument landing system
IQTG	International qualification test guide
km	Kilometres (I km = 0.62 I37 statute miles)
kPa	KiloPascal (KiloNewton/m^2) (I psi = 6.89476 kPa)
kt	Knots calibrated airspeed unless otherwise specified (I knot = 0.5 I48 m/s or I .689 ft/s)
lb	Pound(s)
m	Metres (I m = 3.28083 ft)
MCTM	Maximum certificated take-off mass (kilos/pounds)
medium	Normal operational weight for flight segment
min	Minutes
MIQTG	Master international qualification test guide
MLG	Main landing gear
MPa	MegaPascals (I psi = 6894.76 pascals)
ms	Millisecond(s)
NM	Nautical mile (I NM = 6 084 ft)
nominal	Normal operational weight, configuration, speed, etc.. for the flight segment specified
N I	Low-pressure rotor revolutions per minute
N2	High-pressure rotor revolutions per minute
NWA	Nosewheel angle (degrees)
n	sequential period of a full cycle of oscillation
PAPI	Precision approach path indicator system
pitch	Pitch angle (degrees)
PLA	Power lever angle
P_0	Time from pilot controller release until initial X-axis crossing (X-axis defined by the resting amplitude)
P_1	First full cycle of oscillation after the initial X-axis crossing
P_2	Second full cycle of oscillation after the initial X-axis crossing
P_n	Sequential period of oscillation
P_t	Impact or feel pressure
PLF	Power for level flight
psi	Pounds per square inch
RAE	Royal Aerospace Establishment
REIL	Runway end identifier lights
R/C	Rate of climb (m/s or ft/min)
R/D	Rate of descent (m/s or ft/min)
RVR	Runway visual range (m or ft)
s	Second(s)
sideslip	Sideslip angle (degrees)
sm	Statute miles (I statute mile = 5 280 ft)
SOC	Statement of compliance
T(A)	Tolerance applied to amplitude
T(P)	Tolerance applied to period
T/O	Take-off
T_f	Total time of the flare manoeuvre duration
T_i	Total time from initial throttle movement until a IO per cent response of a critical engine parameter
T_t	Total time from T, to a 90 per cent increase or decrease in the power level specified
VASI	Visual approach slope indicator system
VGS	Visual ground segment

V_{mc}	Minimum control speed (air)
V_{mcl}	Minimum control speed (landing)
V_r	Rotate speed
V_s	Stall speed or minimum speed in the stall
WAT	Weight, altitude. temperature

I st segment	That portion of the take-off profile from lift-off to gear retraction
2nd segment	That portion of the take-off profile from after gear retraction to initial flap/slat retraction
3rd segment	That portion of the take-off profile after flap/slat retraction is complete

Chapter 1

INTRODUCTION

1.1 PURPOSE

1 .1 .I This manual establishes the performance and documentation requirements for the evaluation of aeroplane flight simulators used for training and checking of tlight crew members. These test standards and methods of compliance were derived from extensive experience of regulatory authorities and industry.

I.1.2 The manual is intended to provide the means for a State civil aviation authority to qualify a flight simulator, subsequent to a request by an applicant, through initial and recurrent evaluations of the flight simulator. Further, the manual is intended to provide the means for the civil aviation authorities of other States to accept the qualifications granted by the State which conducted the initial and recurrent evaluation of a tlight simulator, without repetitive evaluations, when considering approval of the use of that flight simulator by applicants from their own State.

1.2 BACKGROUND

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 modem 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 tlight simulator use.

1.3 RELATED READING MATERIAL

1.3. I Applicants desiring evaluation, qualification and approval for use of aeroplane flight simulators should refer to related documents published by the International Civil Aviation Organization (ICAO) and the International Air Transport Association (IATA) dealing with the use of tlight simulators and to technical and operational requirements relevant to simulator data and design. Applicable rules and regulations pertaining to the use of flight simulators in the State for which the simulator qualification and approval is requested must also be consulted.

13.2 The related international documents which formed the basis of the criteria set out in this manual were:

Australia	FSD I, *Operational Standards and Requirements, Approved Flight Simulators*
Canada	TP9685, *Aeroplane and Rotorcraft Simulator Manual*
France	*Projet d'arrêté relatif à l'agrément des simulateurs de vol — 1988*
United Kingdom	CAP *453, Aeroplane Flight Simulators: Approval Requirements*
United States	Advisory Circular 120-40B, *Airplane Simulator Qualification*

1.4 LEVELS OF SIMULATOR QUALIFICATION

1.4.1 In dealing with flight simulators, State regulatory 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 tlight simulator as an acceptable replication of the aircraft. Qualification is achieved by comparing the flight simulator performance against the criteria specified in the International Qualification Test Guide (IQTG). Once the simulator has been qualified. the State authority responsible for supervision of the activities of the applicant for the use of the flight simulator can decide what training tasks can be carried out on the tlight simulator. This determination must be based on the flight simulator qualification, the experience of the operator (the applicant), the training programme in which the simulator is to be used and the experience and qualifications of the pilots to be trained. This latter process results in the approved use of a flight simulator within an approved training programme.

1.4.2 This manual deals specifically with criteria for Level I and Level II flight simulators. Both of these types of flight simulators have the capability for and are used by one or more States for zero flight time training. To enable a comparison. the Level I flight simulator defined in this manual may be equated to the United States Federal Aviation Administration (FAA) and the European Joint Airworthiness Authority (JAA) Level C and the United Kingdom Civil Aviation Authority (CAA) Level 3. The Level II flight simulator defined in this manual may be equated to the United States FAA and the European JAA Level D and the United Kingdom CAA Level 4.

1.4.3 Appendices A, B and C describe the minimum requirements for qualifying International Level I and II aeroplane flight simulators.

1.5 TESTING FOR SIMULATOR QUALIFICATION

1.5.1 The flight simulator must be assessed in those areas which are essential to completing the flight crew member training and checking process. This includes the simulator's longitudinal and lateral-directional responses; performance in take-off. climb, cruise, descent, approach, landing; all-weather operations; control checks; pilot, flight engineer and instructor station functions checks and certain additional requirements depending on the complexity or qualification level of the simulator. The motion system and visual system will be evaluated to ensure their proper operation.

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

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

1.5.4 For initial qualification testing of simulators, the aeroplane manufacturer's validation flight test data is preferred. Data from other sources may be used, subject to the review and concurrence of the regulatory authority responsible for the qualification.

1.5.5 In the case of new aeroplane programmes, the aeroplane manufacturer's predicted data, partially validated by flight test data, may be used in the provisional initial qualification of the simulator. However, the simulator must be revalidated following the release of the manufacturer's data resulting from final airworthiness approval of the aeroplane. The schedule shall be as agreed by the regulatory authority, simulator operator, simulator manufacturer and aeroplane manufacturer.

1.5.6 Simulator operators seeking initial or upgrade evaluation of a 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 simulator operator to acquire additional flight test data.

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

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

1.6 INTERNATIONAL QUALIFICATION TEST GUIDE (IQTG)

1.6.1 The International Qualification Test Guide (IQTG) is the primary reference document used for the evaluation of a flight simulator. It contains simulator test results, statements of compliance and other information to enable the evaluator to assess if the simulator meets the test criteria described in this manual.

1.6.2 The applicant should submit an IQTG which includes:

a) a title page with blocks for the signatures of both the applicant and approval authority;

b) a simulator information page (for each configuration in the case of convertible simulators) providing:

1) simulator identification number;

2) aeroplane model and series being simulated;

3) aerodynamic data revision;

4) engine model and its data revision;

5) flight control data revision;

6) avionic equipment system identification where the revision level affects the training and checking capability of the simulator;

7) simulator model and manufacturer;

8) date of simulator manufacture;

9) simulator computer identification;

10) visual system type and manufacturer; and

11) 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) Statements 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. Kefer to Appendices A and B "Comments" column, for SOC requirements;

h) recording procedures and required equipment for the validation tests; and

i) the following items for each validation test designated in Appendix B of this manual:

1) *Test title.* This should be short and definitive, based on the test title referred to in Appendix B

2) *Test objective.* This should be a brief summary of what the test is intended to demonstrate.

3) *Demonstration procedure.* This is a brief description of how the objective is to be met.

4) *References.* These are the aeroplane data source documents including both the document number and the page/condition number.

5) *Initial conditions.* A full and comprehensive list of the simulator initial conditions is required.

6) *Manual test procedures.* Procedures should be sufficient to enable the test to be flown by a qualified pilot, using reference to flight deck instrumentation and without reference to other parts of the IQTG or flight test data.

7) *Automatic test procedures.* A Level II IQTG must include provisions for automatically conducting the test.

8) *Evaluation criteria.* Specify the main parameter(s) under scrutiny during the test.

9) *Expected* result(s). The aeroplane result, including tolerances and, if necessary, a further definition of the point at which the information was extracted from the source data.

10) *Test result.* Simulator validation test results obtained by the simulator operator from the simulator. Tests run on a computer which is independent of the simulator are not acceptable.

11) *Source data.* Copy of the aeroplane source data, clearly marked with the document, page number, issuing authority and the test number and title as specified in 1). Computer generated displays of flight test data overplotted with simulator data are insufficient on their own for this requirement.

12) *Comparison of results.* An acceptable means of easily comparing simulator test results to the data obtained on the aeroplane. The preferred method is over-plotting.

1.6.3 The simulator test results must be recorded on a multichannel recorder, line printer, or other appropriate recording media acceptable to the regulatory authority conducting the test. Simulator results should be labelled using terminology common to aeroplane parameters as opposed to computer software identifications. These results should be easily compared with the supporting data by employing cross plotting, overlay transparencies, or other acceptable means. Aeroplane data documents included in the IQTG may be photographically reduced only if such reduction will not alter the graphic scaling or cause difficulties in scale interpretation or resolution. Incremental scales on graphical presentations must provide resolution necessary for evaluation of the parameters shown in Appendix B. The test guide will provide the documented proof of compliance with the simulator validation tests in Appendix B. For tests involving time histories, flight test data sheets, or transparencies thereof, simulator test results should be clearly marked with appropriate reference points to ensure an accurate comparison between the simulator and aeroplane with respect to time. Where line printers are used to record time histories, information taken from line printer data output for cross plotting on the aeroplane data should be clearly marked. The cross plotting of the simulator data to aeroplane data is essential to verify simulator performance in each test. The evaluation serves to validate the simulator test results given in the IQTG.

1.7 MASTER INTERNATIONAL QUALIFICATION TEST GUIDE (MIQTG)

1.7.1 The Master International Qualification Test Guide (MIQTG) is the document which results from the evaluation and qualification of the flight simulator.

1.7.2 The MIQTG is then available as the document to use for recurrent or special evaluations and is also the document that any civil aviation regulatory 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.

1.8 CONFIGURATION CONTROL

A configuration control system shall be established and maintained to ensure the continued integrity of the hardware and software as originally qualified.

1.9 TYPES OF EVALUATIONS

1.9.1 An initial evaluation is the first evaluation of a simulator to qualify it for use. It consists of a technical review of the International Qualification Test Guide (IQTG) and a subsequent on-site validation of the simulator to ensure it meets all the requirements of the criteria.

1.9.2 Recurrent evaluations are those evaluations accomplished periodically to ensure that the simulator retains its status as initially qualified.

1.9.3 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 simulator; and

b) a situation discovered that indicates the simulator is not performing at its initial qualification standard.

1.10 CONDUCT OF EVALUATIONS

Initial flight simulator evaluations

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

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

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

Modification of flight simulators, motion and visual systems

1.10.4 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 IQTG criteria. If necessary, IQTG amendments should be prepared for any affected validation tests. The simulator should be tested to the new criteria.

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

1.10.6 In the case of a 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 test guide for previous initial or upgrade evaluations should not be used to validate simulator performance in a test guide offered for a requested upgrade.

Temporary deactivation of a currently qualified flight simulator

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

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

Moving a flight simulator to a new location

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

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

Composition of an evaluation group

1.10.11 The simulator evaluation is usually conducted by a team led by a pilot from the regulatory authority. Engineers and type qualified pilot inspectors will assist the team leader.

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

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

Simulator qualification basis

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

1.10.15 The time required for the periodic evaluations will be established by the regulatory authority having jurisdiction over the simulator.

1.11 EVALUATORS' HANDBOOK

The methods proposed for conduct of the tests required to establish that the criteria set out in this manual are complied with by the flight simulator under evaluation are published in an Evaluators' Handbook. The Evaluators' Handbook is an essential document and can be obtained through the Joint Aviation Authorities, the Royal Aeronautical Society or the International Air Transport Association, at the addresses below.

International Air Transport Association
2000 Peel Street
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Appendix A

FLIGHT SIMULATOR CRITERIA

INTRODUCTION

This appendix describes the minimum simulator requirements for qualifying Level I or II flight simulators. The validation and functions tests listed in Appendices B and C must also be consulted when determining the requirements of a specific level simulator. Certain simulator and visual system requirements included in this appendix must be supported with a statement of compliance (SOC) and, in some designated cases, an objective test. 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 simulator criteria, requirements for SOCs are indicated in the comments column.

Requirements	Simulator level I	Simulator level II	Comments
1. GENERAL			
a) Flight deck, a full-scale replica of the aeroplane simulated. Direction of movement of controls and switches identical to that in the aeroplane. The flight deck, for simulator purposes, consists of all that space forward of a cross section of the fuselage at the most extreme aft setting of the pilots' seats. Additional required flight crew member duty stations and those required bulkheads aft of the pilots' seats are also considered part of the flight deck and must replicate the aeroplane.	X	X	
b) Circuit breakers that affect procedures and/or result in observable flight deck indications properly located and functionally accurate.	X	X	
c) Effect of aerodynamic changes for various combinations of drag and thrust normally encountered in flight corresponding to actual flight conditions, including the effect of change in aeroplane attitude, thrust, drag, altitude, temperature, gross mass, centre of gravity location and configuration.	X	X	
d) All relevant instrument indications involved in the simulation of the applicable aeroplane automatically respond to control movement by a flight crew member or external disturbance to the simulated aeroplane, i.e. turbulence or wind shear.	X	X	Numerical values must be presented in accordance with the appropriate ICAO Table.
e) 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.	X	X	

Requirements	Simulator level I	Simulator level II	Comments
f) In addition to the flight crew member stations, two suitable seats for the instructor/observer and regulatory authority inspector. The regulatory authorities will consider options to this requirement based on unique flight deck configurations. These seats must provide adequate vision to the pilots' panels and forward windows. Observer seats need not represent those found in the aeroplane but must be equipped with similar positive restraint devices.	[X]	[X]	
g) Simulator systems must simulate the applicable aeroplane system operation, both on the ground and in flight. Systems must be operative to the extent that normal, abnormal and emergency operating procedures appropriate to the simulator application can be accomplished.	[X]	[X]	
h) Instructor controls to enable the operator to control all required system variables and insert abnormal or emergency conditions into the aeroplane systems.	[X]	[X]	
i) 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.	[X]	[X]	
j) Significant flight deck sounds which result from pilot actions corresponding to those of the aeroplane.	[X]	[X]	
k) Sound of precipitation, windshield wipers and other significant aeroplane noises perceptible to the pilot during normal operations and the sound of a crash when the simulator is landed in excess of limitations.	[X]	[X]	SOC required.
l) Realistic amplitude and frequency of flight deck noises and sounds, including precipitation, windshield wipers, engine and airframe sounds. The sounds shall be co-ordinated with the weather representations required by Appendix B, 4 f).	[ ]	[X]	Tests required for noises and sounds that originate from the aeroplane or aeroplane systems. See Appendix B, 5 c).
m) Ground handling and aerodynamic programming to include: 1) Ground effect. For example: roundout, flare and touchdown. This requires data on lift, drag, pitching moment, trim and power in ground effect. 2) *Ground* reaction. Reaction of the 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. 3) *Ground* handling characteristics. Steering inputs to include cross-wind, braking, thrust reversing, deceleration and turning radius.	[X]	E I	SOC required. Tests required.

Requirements	Simulator level *I*	Simulator level *II*	*Comments*
n) Wind shear models which provide training in the specific skills required for recognition of wind shear phenomena and execution of required manoeuvres. Such models must be representative of measured or accident derived winds, but may include simplifications which ensure repeatable encounters. For example, models may consist of independent variable winds in multiple simultaneous components. Wind models should be available for the following critical phases of flight: 1) prior to take-off rotation; 2) at lift-off; 3) during initial climb; 4) short final approach. The United States Federal Aviation Administration (FAA) Wind shear Training Aid, wind models from the United Kingdom Royal Aerospace Establishment (RAE), the Joint Airport Weather Studies (JAWS) Protect or other recognized sources may be implemented and must be supported and properly referenced in the IQTG. Wind models from alternative sources may also be used if supported by aeroplane related data and such data are properly supported and referenced in the IQTG. Use of alternative data must be coordinated with the regulatory authority prior to submission of the IQTG for approval.	X	X	Tests required. See Appendix B, 2h).
o) Representative cross-winds and instructor controls for wind speed and direction.	X	X	
p) 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.	X	X	SOC required. Objective tests required for 1), 2), 3). Subjective check for 4), 5), 6). See Appendix B, 1 e).
q) Representative brake and tire failure dynamics (including antiskid) and decreased braking efficiency due to brake temperatures based on aeroplane related data.	X	X	SOC required. Tests required for decreased braking efficiency due to brake temperature. See Appendix B, 2 g).

Req uiremenfs	Simulator level I	Simulator level II	***Comments***
r) A means for quickly and effectively testing simulator programming and hardware. This may include an automated system which could be used for conducting at least a portion of the tests in the IQTG.	[X]	[X]	SOC required.
s) Simulator computer capacity, accuracy, resolution and dynamic response sufficient for the qualification level sought.	[X]	[X]	SOC required.
t) 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 (control column, control wheel and rudder pedal) measurements recorded at the controls. The measured responses must correspond to those of the aeroplane in take-off, cruise and landing configurations. 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 must be submitted as justification to ground test or to omit a configuration. 2) For simulators requiring static and dynamic tests at the controls, special test fixtures will not be required during initial evaluations if the IQTG 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.	[X]	[X]	Tests required. See Appendix B, 2 b) 1) through 3) and 6 a).
u) Relative response of the visual system, flight deck instruments and initial motion system response shall be coupled closely to provide integrated sensory cues. These systems shall respond to abrupt pitch, roll and yaw inputs at the pilot's position within 150 milliseconds of the time, but not before the time, when the aeroplane would respond under the same conditions. Visual scene changes from steady state disturbance shall occur within the system dynamic response limit of 150 milliseconds but not before the resultant motion onset. The test to determine compliance with these requirements should include simultaneously recording the analog output from the pilot's control column, wheel and pedals, the output from 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 regulatory authorities. The test results in a comparison of a recording of the simulator response to actual aeroplane response data in the take-off, cruise and landing configuration. The intent is to verify that the simulator system transport delays, or time lags, are less than 150 milliseconds and that the motion and visual cues relate to actual aeroplane responses. For aeroplane response, acceleration in the appropriate rotational axis is preferred.	❑	[X]	Test required. See Appendix B, 4a).

Requirements	Simulator level *I*	Simulator level *II*	*Comments*
As an alternative, a transport delay test may be used to demonstrate that the simulator system does not exceed 150 milliseconds. This test shall measure all the delays encountered by a step signal migrating from the pilot's control through the control loading electronics and interfacing through all the simulation software modules in the correct order, using a handshaking protocol, finally through the normal output interfaces to the motion system, to the visual system and instrument displays. 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.			
v) 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, effects of airframe icing, normal and reverse dynamic thrust effect on control surfaces, aeroelastic effect and representations of nonlinearities due to side-slip based on aeroplane flight test data provided by the aeroplane manufacturer.	☐	☒	SOC required. See Appendix B, 2 f) and 6 b) for further information on ground effect. Mach effect, aeroelastic representations and nonlinearities due to side-slip are normally included in the simulator aerodynamic model. The SOC MUST address each of these items. Separate tests for thrust effects and an SOC and demonstration of icing effects are required.
w) Aerodynamic and ground reaction modelling for the effects of reverse thrust on directional control.	☒	☒	SOC required. Tests required. See Appendix B, 2 e) 7).
x) 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 simulator number, date, time, conditions, tolerances and the appropriate dependent variables portrayed in comparison to the aeroplane data. Automatic flagging of "out-of-tolerance" situations is encouraged.	☒	☒	SOC required. Tests required. For simulators on order prior to 1992, that otherwise qualify for Level I, an auto-test system may not be required.
y) Diagnostic analysis printouts of simulator malfunctions sufficient to determine compliance with the simulator component inoperative guide. These printouts shall be retained between recurrent simulator evaluations as part of the daily discrepancy log.	☐	☒	SOC required.
z) Timely permanent update of simulator hardware and programming subsequent to aeroplane modification.	☒	☒	
aa) Daily pre-flight documentation either in the daily log or in a location easily accessible for review.	☒	☒	

Requirements	*Simulator level* I	II	*Comments*
2. MOTION SYSTEM			
a) Motion cues perceived by the pilot representative of aeroplane motions, i.e. touchdown cues should be a function of the simulated rate of descent.	[X]	[X]	
b) 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.
c) A means of recording the motion response time for comparison with aeroplane data.	[ ]	[ ]	See 1 u) of this appendix.
d) Special effects programming to include:	[X]	[X]	
1) runway rumble, oleo deflections, effects of ground speed and uneven runway characteristics;			
2) buffets on the ground due to spoiler/speedbrake extension and thrust reversal;			
3) bumps after lift-off of nose and main gear;			
4) buffet during extension and retraction of landing gear;			
5) buffet in the air due to flap and spoiler/speedbrake extension;			
6) stall buffet to, but not necessarily beyond, the certified stall speed, V_8;			
7) representative touchdown cues for main and nose gear;			
8) nose-wheel scuffing and thrust effect with brakes set; and			
9) Mach buffet.			
e) Characteristic buffet motions that result from operation of the aeroplane (for example, high-speed buffet, extended landing gear, flaps, nose-wheel scuffing, stall) which can be sensed at the flight deck. The simulator must be programmed and instrumented in such a manner that the characteristic buffet modes can be measured and compared to aeroplane data. 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.	[ ]	[X]	SOC required. Tests required. See Appendix B, 3 e).

Requirements	Simulator level I	Simulator level II	Comments
3. VISUAL SYSTEMS			
a) Visual system capable of meeting all the standards of this appendix and Appendices B and C as applicable to the level of qualification requested by the applicant.	X	X	
b) Continuous minimum collimated visual field of view of 75 degrees horizontal and 30 degrees vertical per pilot seat. It must be possible to operate pilot seat visual systems simultaneously.	X	X	Wide angle systems providing cross flight deck viewing must provide a minimum of 150 degrees horizontal field of view; 75 degrees per pilot seat operated simultaneously.
c) A means of recording the visual response time for visual systems as required by Appendix B, 4 a).	X	X	
d) Verification of visual ground segment and visual scene content at a decision height on landing approach. The IQTG should contain appropriate calculations and a drawing showing the pertinent data used to establish the aeroplane location and visual ground segment. Such data should include, but are not limited to: 1) airport and runway used; 2) glide slope transmitter location for the specified runway; 3) position of the glide slope receiver antenna relative to the aeroplane main landing wheels; 4) approach and runway light intensity settings; and 5) aeroplane pitch angle. The above parameters should be presented for the aeroplane in the landing configuration and a main wheel height of 30 m (100 ft) above the touchdown zone. The visual ground segment and scene content should be determined for a runway visual range of 350 m (1 200 ft).	X	X	See Appendix B, 4) c).
e) Visual cues to assess sink rate and depth perception during take-off and landing.	X	X	
f) Test procedures to quickly confirm visual system colour, RVR, focus, intensity, level horizon and attitude as compared to the simulated attitude indicator.	X	X	SOC required. Tests required. See Appendix B, 4 b).
g) Dusk scene to enable identification of a visible horizon and typical terrain characteristics such as fields, roads and bodies of water.	X	X	SOC required. Tests required. See Appendix B, 4 e).

Requirements	Simulator level I	Simulator level II	Comments
h) A minimum of ten levels of occulting. This capability must be demonstrated by a visual model through each channel.	[X]	[X]	SOC required. Tests required. See Appendix B, 4 b).
i) Surface resolution will be demonstrated by a test pattern of objects shown to occupy a visual angle of 3 arc minutes in the visual used on a scene from the pilot's eyepoint. This should be confirmed by calculations in the statement of compliance.	[ ]	[X]	See Appendix B, 4 b). Where a night/dusk system is used on a Level I simulator, this test does not apply.
j) Lightpoint size — not greater than 6 arc minutes measured in a test pattern consisting of a single row of lightpoints reduced in length until modulation is just discernible. A row of 40 lights will form a 4-degree angle or less.	[ ]	[X]	See Appendix B, 4 b). This is equivalent to a lightpoint resolution of 3 arc minutes.
k) Lightpoint contrast ratio — not less than 25:1 when a square of at least 1 degree filled with lightpoints (i.e. lightpoint modulation is just discernible) is compared to the adjacent background.	[ ]	[X]	
l) Daylight, dusk and night visual scenes with sufficient scene content to recognize aerodrome, terrain and major landmarks around the aerodrome and to successfully accomplish a visual landing. The daylight visual scene must be part of a total daylight flight deck environment which at least represents the amount of light in the flight deck on an overcast day. Daylight visual system is defined as a visual system capable of producing, as a minimum, full colour presentations, scene content comparable in detail to that produced by 4 000 edges or 1 000 surfaces for daylight and 4 000 light points for night and dusk scenes, 20 cd/m^2 (6 ft-lamberts) of light measured at the pilot's eye position (highlight brightness) and a display which is free of apparent quantization and other distracting visual effects whilst the simulator is in motion. The flight deck ambient lighting shall be dynamically consistent with the visual scene displayed. For daylight scenes, such ambient lighting shall not "wash out" the displayed visual scene nor fall below 17 cd/m^2 (5 foot-lamberts) of light as reflected from an instrument approach chart at knee height at the pilot's station and' or 7 cd/m^2 (2 foot-lamberts) of light as reflected from the pilot's face. All brightness and resolution requirements must be validated by an objective test and will be retested at least annually. Testing may be accomplished more frequently if there are indications that the performance is degrading on an accelerated basis. Compliance with the brightness capability may be demonstrated with a test pattern of white light using a spot photometer. 1) Contrast ratio. A raster drawn test pattern filling the entire visual scene (three or more channels) shall consist of a matrix of black and white squares no larger than 10 degrees and no smaller than 5 degrees per channel with a white square in the centre of each channel.	[ ]	[X]	SOC required. Tests required. See Appendix B, 4 b).

Requirements	Simulator level I	Simulator level II	Comments
Measurement *shall be* made *on* the centre bright *square for each* channel *using a i-degree spot* photometer. This value *shall have* a minimum brightness *of* 7 *cd/m²* (2 *foot-lamberts). Measure* any adjacent dark squares. *The* contrast *ratio is* the bright *square value* divided *by the* dark *square value. Minimum test contrast ratio result is 5:1.*			
Note.- During contrast ratio testing, *flight deck ambient light /eve/s should be maintained as required in paragraph I) above.*			
2) Highlight brightness test. Maintaining the full test pattern described in paragraph 1) above, superimpose a highlight on the centre white square of each channel and measure the brightness using the l-degree spot photometer. Lightpoints are not acceptable. Use of calligraphic capabilities to enhance raster brightness is acceptable.			

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 simulator to aeroplane data unless specifically noted otherwise. To facilitate the validation of the simulator, a multichannel recorder, line printer, or other appropriate recording device acceptable to the regulatory authorities should be used to record each validation test result. These recordings should then be compared to the aeroplane source data.

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

1.3 The simulator IQTG must describe clearly and distinctly how the simulator will be set up and operated for each test. Use of a driver programme designed to automatically accomplish the tests is required for Level II simulators and Level I simulators on order after January 1992 and is encouraged for all simulators. It is not the intent, nor is it acceptable, to test each simulator subsystem independently. Over-all integrated testing of the simulator must be accomplished to assure that the total simulator system meets the prescribed standards. A manual test procedure with explicit and detailed steps for completion of each test must also be provided.

1.4 The tests and tolerances contained in this appendix must be included in the simulator IQTG. For aeroplanes certificated prior to January 1992, an applicant may, after reasonable attempts have failed to obtain suitable flight test data, indicate in the IQTG where flight test data are unavailable or unsuitable for a specific test. For such a test, alternative data should be submitted to the regulatory authority for approval. Submittal for approval of data other than flight test must include an explanation of validity with respect to available flight test information.

1.5 The Table of Flight Simulator Validation Tests in this appendix generally indicates the test results required. Unless noted otherwise, simulator tests should represent aeroplane performance and handling qualities at operating mass and centres 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 condition need not be repeated at the other extreme. Tests of handling qualities must include validation of augmentation devices.

1.6 For the testing of computer controlled aeroplane (CCA) 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 regulatory authorities at the time of definition of a set of specific aeroplane tests for simulator data. Where applicable, flight test data must record:

a) pilot controller deflections or electronically generated inputs including location of input; and

b) flight control surface positions unless test results are not effected by, or are independent of, surface positions.

1.7 The recording requirements of a) and b) above 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 computer controlled aeroplane designation (CCA).

1.8 Where tests in the performance section of the Table of Flight Simulator Validation Tests (paragraph 1 a) through f) of the table) require data in the normal control state, this indicates the preferred control state. However, if the test results are independent of control state, non-normal control data may be substituted.

1.9 Where tests in other sections of the appendix require testing in the normal control state, this indicates the required control state.

1.10 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 simulator test results should be provided for each test. The results should be produced on a multichannel recorder, line printer or other appropriate recording device acceptable to the regulatory authorities. 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 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 over-all interpretation. When it is difficult or impossible to match simulator to aeroplane data throughout a time history, differences must 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 of this appendix describes the parameters, tolerances and flight conditions for simulator validation. When two tolerance values are given for a parameter, the less restrictive may be used unless indicated otherwise. If a flight condition or operating condition is shown which does not apply to the qualification level sought, it should be disregarded. Simulator results must be labelled using the tolerances and units given.

2.4 Flight condition verification. When comparing the parameters listed to those of the aeroplane, sufficient data must 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 must also be given. All airspeed values should be clearly annotated as to indicated, calibrated, etc., and like values used for comparison.

3. INFORMATION FOR VALIDATION TESTS

3.1 Control dynamics

3.1.1 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 simulator to be representative, it too must 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 simulator to actual aeroplane measurements in the take-off, cruise and landing configurations.

3.1.2 Recordings such as free response to a pulse or step function are classically 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 simulator control loading system to the aeroplane systems is essential. The required control dynamics tests are indicated in 2 b) 1) through 3) of the Table of Flight Simulator Validation Tests.

3.1.3 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 must be accomplished in the take-off, cruise and landing flight conditions and configurations.

3.1.4 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 may suffice for another. If either or both considerations apply, engineering validation or aeroplane manufacturer rationale must be submitted as justification for ground tests or for eliminating a configuration. For simulators requiring static and dynamic tests at the controls, special test fixtures will not be required during initial and upgrade evaluations if the IQTG 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.

3.2 Control dynamics evaluation

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

3.2.2 Tests to verify that control feel dynamics represent the aeroplane must 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.

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

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. Figure B-2 illustrates the procedure.

3.2.3 Tolerances. The following table summarizes the tolerances, T. See Figures B- 1 and B-2 for an illustration of the referenced measurements.

$T(P_0)$	±10% of P_0
$T(P_1)$	±20% of P_1
$T(P_2)$	±30% of P_2
$T(P_n)$	±10(n+1)% of P_n
$T(A_n)$	±10% of A,, ±20% of subsequent peaks
$T(A_d)$	±5% of A, = residual band
Overshoots	±1

3.3 Alternate method for control dynamics evaluation

3.3.1 One aeroplane manufacturer has proposed, and the regulatory authorities have 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.

3.3.2 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.

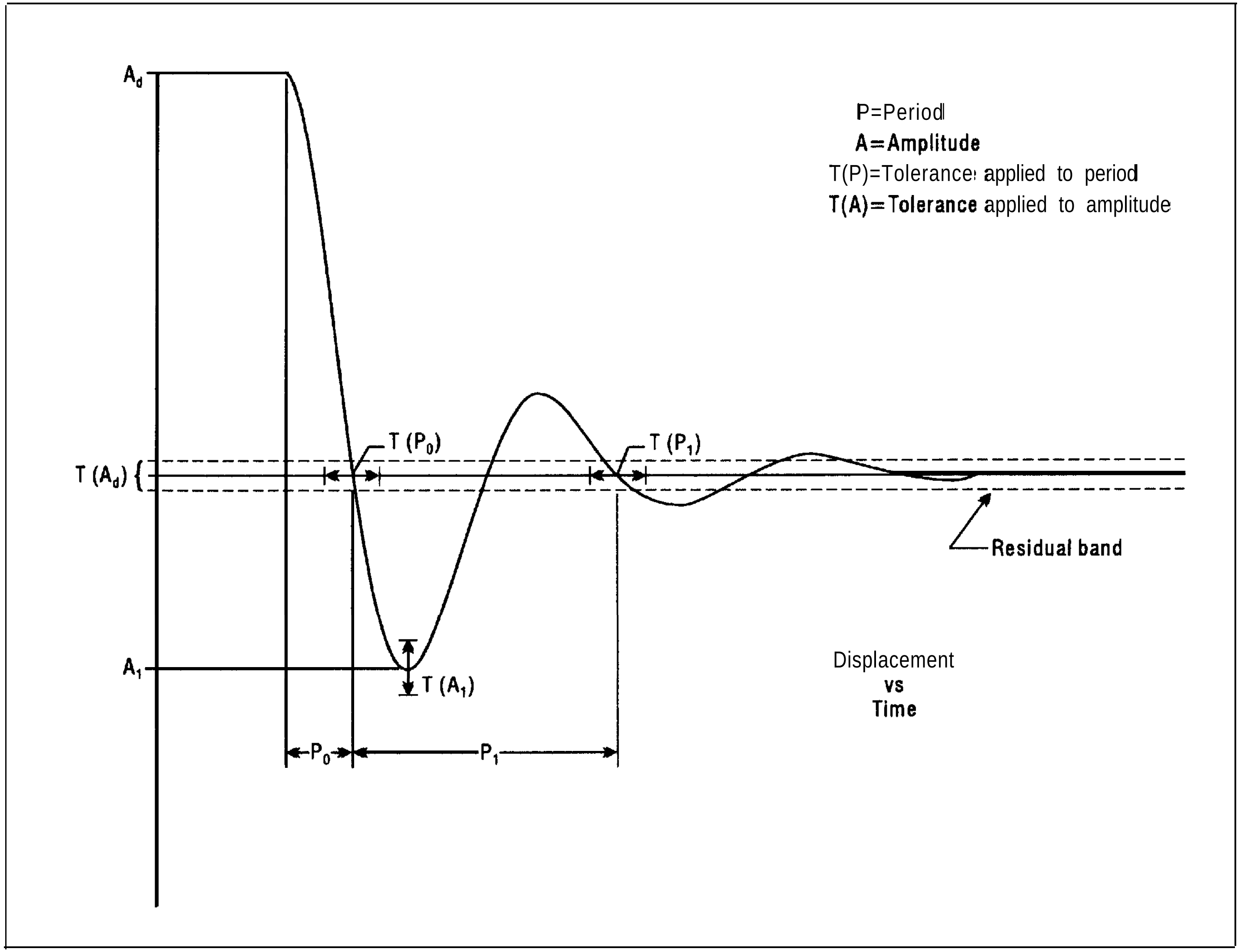

Figure B-l. Underdamped step response

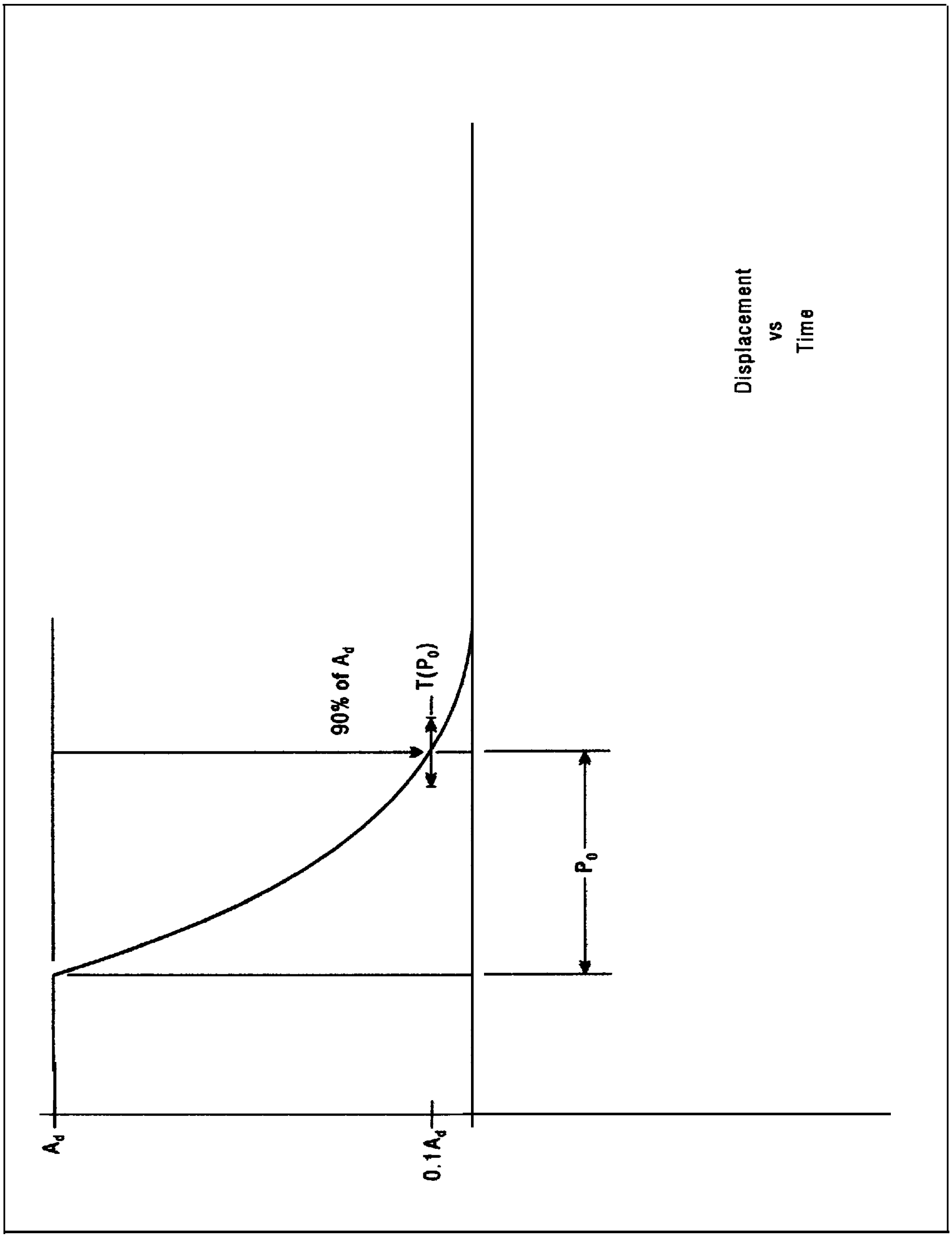

Figure B-2. Critically damped step response

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).

3.3.3 Tolerances.

a) *Static test.* Items 2 a) 1), 2) and 3) of the Table of Flight Validation Tests.

b) *Dynamic test.* ±0.9 daN (2 lb) or ±10 per cent on dynamic increment above static test.

3.3.4 The regulatory authorities are open to alternative means such as the one described above. Such alternatives must, however, be justified and appropriate to the application. For example, the method described here may not apply to all manufacturer's systems and certainly not to aeroplanes with reversible control systems. Hence, each case must be considered on its own merit on an *ad hoc* basis. Should the regulatory authority find that alternative methods do not result in satisfactory performance, then more conventionally accepted methods must be used

3.4 Ground effect

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

a) elevator or stabilizer angle to trim;

b) power (thrust) required for level flight;

c) angle of attack for a given lift coefficient;

d) height; and

e) airspeed.

This listing of parameters assumes that ground effect data is acquired by tests during "fly-bys" at several altitudes in ground effect. The test altitudes should, as a minimum, be at 10 per cent, 30 per cent and 70 per cent of the aeroplane wingspan and one altitude out of ground effect, e.g. 150 per cent of wingspan. Level I simulator evaluations may use methods other than the level fly-by method.

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

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

elevator or stabilizer angle	±1°
power for level flight	±5%
angle of attack	±1°
height	±10% or ±1.5 m (5 ft)
airspeed	±3 kt
pitch attitude	±1°

3.4.4 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 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 must be accounted for in the simulator modelling. Several tests such as "cross-wind landing", "one engine inoperative landing" and "engine failure on take-off' serve to validate lateral-directional ground effect since portions of them are accomplished whilst transiting heights at which ground effect is an important factor.

3.5 Visual systems

Daylight visual systems must meet the following criteria:

a) *Contrast ratio.* A raster drawn test pattern filling the entire visual scene (three or more channels) shall consist of a matrix of black and white squares no larger than 10 degrees and no smaller than 5 degrees per square with a white square in the centre cf each channel.

Measurement shall be made on the centre bright square for each channel using a l-degree spot photometer. This value shall have a minimum brightness of 7 cd/m^2 (2 foot-lamberts). Measure any adjacent dark squares. The contrast ratio is the bright square value divided by the dark square value. Minimum test contrast ratio result is 5: 1.

Lightpoint contrast ratio shall be not less than 25: I when a square of at least 1 degree filled (i.e. lightpoint modulation is just discernible) with lightpoint is compared to the background adjacent.

b) *Highlight brightness test.* Maintaining the full test pattern described above, superimpose a highlight on the centre white square of each channel and measure the brightness using the l-degree spot photometer. Lightpoints are not acceptable. Use of calligraphic capabilities to enhance raster brightness is acceptable.

c) Resolution will be demonstrated by a test of objects shown to occupy a visual angle of 3 arc minutes in the visual scene from the pilot's eyepoint. This should be confirmed by calculations in the statement of compliance.

d) Lightpoint size — not greater than 6 arc minutes measured in a test pattern consisting of a single row of lightpoints reduced in length until modulation is just discernible. A row of 40 lights will form a 4-degree angle or less.

TABLE OF FLIGHT SIMULATOR VALIDATION TESTS

Test	*Tolerance*	*Flight* condition	*Comments*
1. PERFORMANCE			
a) Taxi			
1) minimum radius turn	M.9 m (3 ft) or ±20% of aeroplane turn radius	Ground/take-off	Plot both main and nose gear turning radius. Data for no brakes and minimum thrust except for aeroplanes requiring asymmetric thrust or braking to turn.
2) rate of turn versus nosewheel steering angle (NWA)	±10% or ±2°/s turn rate	Ground/take-off	Plot a minimum of two speeds, greater than minimum turning radius speed, with a spread of a least 5 kt.
b) Take-off			
1) ground acceleration time and distance	±5% time and distance or ±5% time and ±61 m (200 ft) of distance	Ground/take-off	Acceleration time and distance should be recorded for a minimum of 80% of the total time from brake release to V_r.
2) minimum control speed, ground (V,,) aerodynamic controls only per applicable airworthiness requirement or low speed, engine inoperative ground control characteristics	±25% of maximum aeroplane lateral deviation or f1.5 m (5ft)	Ground/take-off	Engine failure speed must be within ±1 k-t of aeroplane engine failure speed. Engine thrust decay must be that resulting from the mathematical model for the engine variant applicable to the simulator under test. If the modelled engine variant is not the same as the aeroplane manufacturers flight test engine, then a further test may be run with the same initial conditions using the thrust from the flight test data as the driving parameter. Aeroplanes with reversible flight control systems must also plot rudder pedal force [±10% or ±2.2 daN (5 lb)].
3) minimum unstick speed (V,,) or equivalent as provided by the aeroplane manufacturer	±3 kt airspeed ±1.5° pitch	Ground/take-off	V_{mu} is defined as that speed at which the last main landing gear leaves the ground. Main landing gear strut compression or equivalent air/ground signal should be recorded. Record, as a minimum, from 10 kt before start of rotation. Elevator input must precisely match aeroplane data.

Test	Tolerance	Flight condition	Comments
4) normal take-off	±3 kt airspeed ±1.5° pitch ±1.5° AOA ±6 m (20 ft) height	Ground/take-off and 1 st segment climb	Record take-off profile from brake release to at least 61 m (200 ft) AGL. Aeroplanes with reversible flight control systems must also plot control column force [±10% or ±2.2 daN (5 lb)].
5) critical engine failure on take-off	±3 kt airspeed ±1.5° pitch ±1.5° AOA ±6 m (20 fl) height ±2° bank and sideslip angle	Ground/take-off and 1 st segment climb	Record take-off profile to at least 61 m (200 ft) AGL. Engine failure speed must be within ±3 kt of aeroplane data. Test at near MCTM. Aeroplanes with reversible flight control systems must also plot control column force [±10% or ±2.2 daN (5 lb)], control wheel force [±10% or ±1 .3 daN (3 lb)], rudder pedal force [±1 0% or ±2.2 daN (5lb)]. CCA: Test in normal and non-normal control state.
6) cross-wind take-off	±3 kt airspeed ±1.5° pitch 11.5' AOA ±6 m (20 ft) height ±2° bank and side-slip angle	Ground/take-off and 1st segment climb	Record take-off profile to at least 61 m (200 ft) AGL. Requires test data, including wind profile, for a cross-wind component of at least 20 kt or the maximum demonstrated cross-wind, if available. Aeroplanes with reversible flight control systems must also plot control column force [±10% or ±2.2 daN (5 lb)], control wheel force [±10% or ±1.3 daN (3 lb)], rudder pedal force [±10% or ±2.2 daN (5lb)].
7) rejected take-off	±5% time or ±1.5 s ±7.5% distance or ±76 m (250ft)	Ground/take-off	Record near MCTM. Autobrakes will be used where applicable. Maximum braking effort, auto or manual. Time and distance should be recorded from brake release to a full stop.
8) dynamic engine failure after take-off	±20% body rates	1st segment climb	Engine failure speed must be within ±3 kt of aeroplane data. Engine failure may be a snap deceleration to idle. Record hands-off from 5 s before engine failure to t5 s or 30" bank, whichever occurs first and then hands-on until wings-level recovery. CCA: Test in normal and non-normal control state.
c) Climb			
1) normal climb all engines operating	±3 kt airspeed ±5% or M.5 m/s (100 ft/min) rate of climb	Initial climb	Manufacturer's gross climb gradient may be used for flight test data. Record at nominal climb speed and mid initial climb altitude. May be a snapshot test.

Test	Tolerance	Flight condition	Comments
2) one engine inoperative 2nd segment climb	± 3 kt airspeed ±5% or ±0.5 m/s (100 ft/min) rate of climb	2nd segment climb	Manufacturer's gross climb gradient may be used for flight test data and rate of climb cannot be less than flight manual values. Test at WAT (weight, altitude or temperature) limiting condition. May be a snapshot test.
3) one engine inoperative en-route climb	±10% time ±10% distance ±10% fuel used	En-route climb	Approved performance manual data may be used. Test for at least a 1 550 m (5 000 ft) segment.
4) one engine inoperative approach climb for aeroplanes with icing accountability if required by the flight manual	±3 kt airspeed ±5% or M.5 m/s (100 ft/min) rate of climb but not less than the approved flight manual rate of climb	Approach climb with one engine inoperative	Manufacturers' gross climb gradient may be used for flight test data. May be a snapshot test. Test near maximum certificated landing mass.
5) level acceleration and deceleration	±5% time	Cruise	Minimum of 50 kt speed change.
d) Cruise			
1) cruise performance	±.05 EPR ±5% of N1 and N2 ±5% torque ±5% fuel flow	Cruise	May be a minimum of two consecutive snapshots with a spread of at least 5 minutes.
e) Stopping			
1) deceleration time and distance, manual wheel brakes, dry runway, no reverse thrust	±5% of time For distances up to 1 220 m (4 000 ft) ±61 m (200 ft) or ±10%, whichever is the smaller, For distances greater than 1 220 m (4 000 ft) ±5% distance.	Landing	Time and distance should be recorded for at least 80% of the total time from touchdown to a full stop, Data required for medium, light and near maximum certificated landing mass. Engineering data may be used for the medium and light mass conditions. Brake system pressure should be available.

Test	Tolerance	Flight	Comments
2) deceleration time and distance, reverse thrust, no wheel brakes, dry runway	±5% time and the smaller of ±10% or ±61 m (200 ft) of distance	Landing	Time and distance should be recorded for at least 80% of the total time from initiation of reverse thrust to forward idle. Data required for medium, light and near maximum certificated landing mass. Engineering data may be used for the medium and light mass conditions.
3) stopping distance, wheel brakes, wet runway	±10% or ±61 m (200 ft) distance	Landing	Flight manual data must be used where available.
4) stopping distance, wheel brakes, icy runway	±10% or ±61 m (200 ft) distance	Landing	Flight manual data must be used where available.
f) Engines			
1) acceleration	±10% T_i ±10% T_t	Approach or landing	T_t = total time from T_i to 90% of go-around power. Critical engine parameter should be a measure of power (N1, N2, EPR, etc.). Plot from flight idle to go-around power for a rapid throttle movement.
2) deceleration	±10% T_i ±10% T_t	nd/t	T_t = total time from T_i to 90% decay of maximum take-off power. Plot from maximum take-off power to 90% decay of maximum take-off power for a rapid throttle movement.
2. HANDLING QUALITIES			
a) Static control checks			
Control column, control wheel and rudder pedal position versus force or time shall be measured at the control. An alternative method would be to instrument the simulator in an equivalent manner to the flight test aeroplane. The force and position data from this instrumentation can be directly recorded			

Test	Tolerance	Flight condition	Comments
and matched to the aeroplane data. Such a permanent installation could be used without any time for installation of external devices. See 3.1 of this appendix.			
1) control column position versus force and surface position calibration	±0.9 daN (2 lb) breakout ±2.2 daN (5 lb) or ±10% force ± 2° elevator angle	Ground (validated with flight data)	Uninterrupted control sweep to stops. Must be validated with in-flight data from tests such as longitudinal static stability, stalls, etc. Static and dynamic flight control tests should be accomplished at the same feel or impact pressures. **CCA**: Position versus force not applicable if aeroplane controller is used.
2) control wheel position versus force and surface position calibration	±0.9 daN (2 lb) breakout ±1.3 daN (3 lb) or ±10% force ±1° aileron angle ±3° spoiler angle	Ground (validated with flight data)	Uninterrupted control sweep to stops. Must be validated with in-flight data from tests such as engine-out trims, steady state side-slips, etc. Static and dynamic flight control tests should be accomplished at the same feel or impact pressures. **CCA**: Position versus force not applicable if aeroplane controller is used.
3) rudder pedal position versus force and surface position calibration	±2.2 daN (5 lb) breakout ±2.2 daN (5 lb) or ±10% force ±2° rudder angle	Ground (validated with flight data)	Uninterrupted control sweep to stops. Must be validated with in-flight data from tests such as engine-out trims, steady state side-slips, etc. Static and dynamic flight control tests should be accomplished at the same feel or impact pressures.
4) nosewheel steering force and position calibration	±0.9 daN (2 lb) breakout ±1.3 daN (3 lb) or ±10% force ±2° NWA	Ground	Uninterrupted control sweep to stops.
5) rudder pedal steering calibration	±2° NWA ±0.5° deadband	Ground	Uninterrupted control sweep to stops.
6) pitch trim calibration: indicator versus computed	±0.5° of computer trim angle ±10% trim rate (°/s)	Ground and go-around	Trim rate to be checked at pilot primary induced trim rate (ground) and autopilot or pilot primary trim rate in flight at go-around flight conditions.

Test	Tolerance	*Flight condition*	*Comments*
7) alignment of PLA versus selected engine parameter (EPR, N1, torque)	±5° of PLA	Ground	Simultaneous recording for all engines. The 5° tolerance applies against aeroplane data and between engines. May be a snapshot test.
Note.- In the case of propeller-driven aeroplanes, if an additional lever, usually referred to as the propeller lever, is present it must a/so be checked. Where these levers do not have angular *travel a tolerance of* ±2 cm (M.8 in) applies.			
8) brake pedal position versus force and brake system pressure calibration	±2.2 daN (5 lb) or 10% force ±1.0 MPa (150 psi) or ±10% brake system pressure	Ground	Simulator computer output results may be used to show compliance. Relate the hydraulic system pressure to pedal position in a ground static test.
b) Dynamic control checks			
1) pitch control	±10% of time for first zero crossing and ±10(n+1)% of period thereafter ±10% amplitude of first overshoot and ±20% amplitude for subsequent overshoots greater than 5% of initial displacement (A_d) ±1 overshoot	Take-off, cruise and landing	Data should be for normal control displacements in both directions (approximately 25% to 50% full throw). Tolerances apply against the absolute values of each period (considered independently). n = the sequential period of a full oscillation. Refer to 3.2 of this appendix. CCA: Test not applicable if aeroplane controller is installed in the simulator.
2) roll control	Same as 2 b) 1) above	Take-off, cruise and landing	Data should be for normal control displacement. (Approximately 25% to 50% of full throw). Refer to 3.2 of this appendix. CCA: Test not applicable if aeroplane controller is installed in the simulator.
3) yaw control	Same as 2 b) 1) above	Take-off, cruise and landing	Data should be for normal control displacement (Approximately 25% to 50% of full throw). Refer to 3.2 of this appendix.
4) small control inputs	±20% body rates	Cruise and approach	Small control inputs defined as 5% of total travel.

Test	*Tolerance*	*Flight condition*	*Comments*
c) Longitudinal			
1) power change dynamics	±3 kt airspeed ±30 m (100 ft) altitude ±1.5° or ±20% pitch	Approach to go-around	Time history of uncontrolled free response for a time increment equal to at least 5 s before initiation of the power change to completion of the power change t 15 s. CCA: Test in normal AND non-normal control state.
2) flap change dynamics	±3 kt airspeed ±30 m (100 ft) altitude ±1.5° or ±20% pitch	2nd to 3rd segment climb and approach to landing	Time history of uncontrolled free response for a time increment equal to at least 5 s before initiation of the reconfiguration change to the completion of the reconfiguration change t 15 s. 3rd segment = initial flap retraction after take-off. CCA: Test in normal AND non-normal control state.
3) spoiler/speed brake change dynamics	±3 kt airspeed ±30 m (100 ft) altitude ±1.5° or 20% pitch	Cruise	Time history of uncontrolled free response for a time increment equal to at least 5 s before initiation of the configuration change to completion of the configuration change t 15 s. Results required for both extension and retraction. CCA: Test in normal AND non-normal control state.
4) gear change dynamics	±3 kt airspeed ±30 m (100 ft) altitude ±1.5° or 20% pitch	1st to 2nd segment climb and approach to landing	Time history of uncontrolled free response for a time increment equal to at least 5 s before initiation of the configuration change to completion of the configuration change t 15 s. CCA: Test in normal AND non-normal control state.
5) gear and flap/slat operating times	±1 s or ±10% of time	Take-off and approach (air loaded)	Normal and alternate flaps — data for extend and retract. Normal gear-data for extend and retract. Alternate gear-data for extend only. All data for full range (intermediate increment times not required). Tabular data from production aeroplanes are acceptable.
6) longitudinal trim	±1° pitch control (elevator and stabilizer) ±1° pitch ±5% net thrust or equivalent	Cruise, approach and landing	May be a series of snapshot tests. CCA: Test in normal AND non-normal control state.

Test	Tolerance	Flight condition	Comments
7) longitudinal manoeuvring stability (stick force/g)	±2.2 daN (5 lb) or ±10% control column force or equivalent surface	Cruise, approach and landing	Test at approximately 20° and 30° of bank for approach and landing configurations. Test at approximately 20°, 30° and 45° of bank for the cruise configuration. May be a series of snapshot tests. **CCA**: Test in normal AND non-normal control state.
8) longitudinal static stability	±2.2 daN (5 lb) or ±10% column force or equivalent surface	Approach	Data for at least two speeds above and two speeds below trim speed. May be a series of snapshot tests. **CCA**: Test in normal OR non-normal control state.
9) stick shaker, airframe buffet, stall speeds	±3 kt airspeed ± 2° bank for speeds greater than stick shaker or initial buffet	2nd segment climb and approach or landing	Stall warning signal should be recorded and must occur in the proper relation to stall. Aeroplanes exhibiting a sudden pitch attitude change or "g break" must demonstrate this characteristic. Aeroplanes with reversible flight control systems must also plot control column force [±10% or ±2.2 daN (5 lb)]. **CCA:** Test in normal AND non-normal control state.
10) phugoid dynamics	±10% period ±10% time to 1/2 or double amplitude or ±0.02 of damping ratio	Cruise	Test should include three full cycles or that necessary to determine time to 1/2 or double amplitude, whichever is less. **CCA**: Test in non-normal control state.
11) short period	±1.5° pitch or ±2°/s pitch rate ±0.1 g normal acceleration	Cruise	**CCA**: Test in normal AND non-normal control state.
d) Lateral directional			
1) minimum control speed, air (V_{mc} or V_{mcl}), per applicable airworthiness requirement or low speed engine inoperative handling characteristics in the air.	±3 kt airspeed	Take-off or landing (whichever is most critical in the aeroplane)	V_{mc} or V_{mcl} may be defined by a performance or control limit which prevents demonstration of V_{mc} or V_{mcl} in the conventional manner. **CCA**: Test in normal OR non-normal control state.
2) roll response (rate)	±10% or ±2°/s roll rate	Cruise and approach or landing	Test with normal control wheel deflection (about 30% of maximum control wheel). Aeroplanes with reversible flight control systems must also plot control wheel force [±10% or ±1.3 daN (3 lb)].

Test	*Tolerance*	*Flight condition*	Comments
3) step input of flight deck roll controller	±10% or ±2°/s roll rate	Approach or landing	CCA: Test in normal AND non-normal control state.
4) spiral stability	Correct trend and ±2° or ±10% bank in 20 s	Cruise	Aeroplane data averaged from multiple tests may be used. Test for both directions. CCA: Test in non-normal control state.
5) engine inoperative trim	±1° rudder angle or ±1° tab angle or equivalent rudder pedal ±2° side-slip	2nd segment climb and approach or landing	May be snapshot tests.
6) rudder response	±2°/s or ±10% yaw rate	Approach or landing	Test with stability augmentation ON and OFF. Test with a step input at approximately 25% of full rudder pedal throw. CCA: Test in normal AND non-normal control state.
7) dutch roll (yaw damper OFF)	M.5 s or ± 10% of period ±10% of time to 1/2 or double amplitude or ±0.02 of damping ratio ±20% or ±1 s of time difference between peaks of bank and side-slip	Cruise and approach or landing	Test for at least six cycles with stability augmentation OFF. CCA: Test in non-normal control state.
6) steady state side-slip	For a given rudder position: ±2° bank ±1° side-slip ±10% or ±2° aileron ±10% or ±5° spoiler or equivalent control wheel position or force	Approach or landing	May be a series of snapshot tests using at least two rudder positions (in each direction for propeller driven aeroplanes). Aeroplanes with reversible flight control systems must also show control wheel force [±10% or ±1.3 daN (3 lb)] and rudder pedal force [±10% or f2.2 daN (5 lb)].

Test	Tolerance	*Flight condition*	*Comments*
e) Landings			
1) normal landing	±3 kt airspeed ±1.5° pitch ±1.5° AOA ±3 m (10 ft) or ±10% of height	Normal landing	Test from a minimum of 61 m (200 ft) AGL to nosewheel touchdown. Derotation may be shown as a separate segment from the time of main landing gear touchdown. Medium, light and near maximum certificated landing mass must be shown. Aeroplanes with reversible flight control systems must also plot control column force [±10% or ±2.2 daN (5 lb)]. CCA: Test in normal AND non-normal control state.
2) minimum/no flap landing	±3 kt airspeed ±1.5° pitch ±1.5° AOA ±3 m (10 ft) or ±10% of height	Minimum certificated landing flap configuration	Test from a minimum of 61 m (200 ft) AGL to nosewheel touchdown. Derotation may be shown as a separate segment from the time of main landing gear touchdown. Test at near maximum certificated landing mass. Aeroplanes with reversible flight control systems must also plot control column force [±10% or ±2.2 daN (5 lb)].
3) cross-wind landing	±3 kt airspeed ±1.5° pitch ±1.5° AOA ±3 m (10 ft) or ±10% height ±2° bank angle ±2° side-slip angle	Landing	Test from a minimum of 60 m (200 ft) AGL to a 50% decrease in main landing gear touchdown speed. Requires test data, including wind profile, for a cross-wind component of at least 20 kt or the maximum demonstrated cross-wind, if available. Aeroplanes with reversible flight control systems must also plot control wheel force [±10% or ±1.3 daN (3 lb) and rudder pedal force [±10% or ±2.2 daN (5 lb)].
4) one engine inoperative landing	±3 kt airspeed ±1.5° pitch ±1.5° AOA ±3 m (10 ft) or ±10% height ±2° bank angle ±2° side-slip angle	Landing	Test from a minimum of 60 m (200 ft) AGL to a 50% decrease in main landing gear touchdown speed.
5) autoland (if applicable)	±1.5 m (5 ft) flare height ±0.5 s T_f ±0.7 m/s (140 ft/min) R/D at touchdown ±3 m (10 ft) lateral deviation from maximum demonstrated cross-wind (autoland) deviation	Landing	This test is not a substitute for the ground effects test requirement. Plot lateral deviation from touchdown to autopilot disconnect. T_f = duration of flare.

Test	Tolerance	Flight condition	Comments
6) go-around	±3 kt airspeed ±1.5° pitch ±1.5° AOA	Go-around	Engine inoperative go-around required near maximum certificated landing mass with critical engine(s) inoperative. Normal all-engine autopilot go-around must be demonstrated (if applicable) at medium mass. CCA: Test in normal AND non-normal control state.
7) directional control (rudder effectiveness) with reverse thrust (symmetric and asymmetric)	±5 kt airspeed	Landing	Aeroplane test data required. However, aeroplane manufacturer's engineering simulator data may be used for reference data as a last resort. Aeroplanes with demonstrated minimum speed for rudder effectiveness: ±5 kt. Others, test to verify simulator meets conditions demonstrated by the aeroplane manufacturer.
f) Ground effect			
1) a test to demonstrate ground effect	±1° elevator or stabilizer angle ±5% net thrust or equivalent ±1° AOA ±1.5 m (5 ft) or ±10% height ±3 kt airspeed ±1° pitch	Landing	See 3.4 of this appendix. A rationale must be provided with justification of results.
g) Brake fade			
1) A test to demonstrate decreased braking efficiency due to brake temperature	None	Take-off or landing	SOC required. The test must show decreased braking efficiency due to brake temperature based on aeroplane related data.
h) Wind shear			
1) a test to demonstrate wind shear models	None	Take-off and landing	Wind shear models are required which provide training in the specific skills required for recognition of wind shear phenomena and execution of recovery manoeuvres.

Note.- Wind shear *models must be* representative *of measured or accident derived winds, but* may *be 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*** fake-off rotation;
2) at ***lift-off;***
3) during initial climb; and
4) *shorf* ***final*** *approach.*

The United ***States*** *Federal Aviation Administration (FAA) Wind* shear Training *Aid, wind models* from ***the United*** Kingdom Royal Aerospace Establishment *(RAE),* ***the*** United *States Joint Aerodrome Weather Studies {JAWS)* Project *or other recognized sources may* be implemented *and must be supported and properly referenced in fhe* ***IQTG.*** *Wind models from alternate sources may also be used if supported by aeroplane related data and such data are properly supported and* referenced in ***the IQTG.*** *Use of alternate data must be co-ordinated with the* regulatory authorities prior *to submission* of *the* ***IQTG*** *for approval.*

Test	Tolerance	Night *condition*	Comments
i) Flight and manoeuvre envelope protection functions			
1) overspeed	±5 kt airspeed	Cruise	The requirements of this paragraph are only applicable to computer controlled aeroplanes. Time history results are required of simulator response to control inputs during entry into protection envelope limits, Flight test data must be provided for both normal and non-normal control states.
2) minimum speed	±3 kt airspeed	Take-off, cruise and approach or landing	
3) load factor	±0.1 g normal acceleration	Take-off, cruise	
4) pitch angle	±1.5' pitch	Cruise, go-around	
5) bank angle	±2' or ±1 0% bank	Approach	
6) angle of attack	±1.5' AOA	2nd segment and approach or landing	

Test	Tolerance	Flight condition	Comments
3. MOTION SYSTEM			
Certain tests in the following sections for motion, visual and sound (3, 4 and 5) do not require the test to be accomplished for a Level I flight simulator approval. These will be noted in the comments section, e.g. 3 e) 1).			
a) Frequency response	As specified by the applicant for simulator qualification	Not applicable	Appropriate test to demonstrate frequency response required.
b) Leg balance	As specified by the applicant for simulator qualification	Not applicable	Appropriate test to demonstrate leg balance required.
c) Turn-around check	As specified by the applicant for simulator qualification	Not applicable	Appropriate test to demonstrate smooth turn-around required.
d) Special effects			
1) thrust effects with brakes set	None	Take-off	Qualitative assessment to determine that the effect is representative.
2) runway rumble, oleo deflections, effects of ground speed and uneven runway characteristics	None	Take-off	Qualitative assessment to determine that the effect is representative.
3) bumps after lift-off of nose and main landing gear	None	Take-off	Qualitative assessment to determine that the effect is representative.
4) buffet during retraction and extension of landing gear	None	Climb	Qualitative assessment to determine that the effect is representative.
5) buffet in air due to flap and spoiler/speedbrake extension and approach-to-stall	None	Approach	Qualitative assessment to determine that the effect is representative.

Test	*Tolerance*	*Flight condition*	*Comments*
6) touchdown cues for main and nose landing gear	None	Landing	Qualitative assessment to determine that the effect is representative.
7) buffet on the ground due to spoiler/ speedbrake extension and thrust reversal	None	Landing	Qualitative assessment to determine that the effect is representative.
8) nosewheel scuffing	None	Ground	Qualitative assessment to determine that the effect is representative.
9) Mach buffet	None	Flight	Qualitative assessment to determine that the effect is representative.
e) Characteristic buffet motions			
1) a test with recorded results and an SOC are required for characteristic buffet motions which can be sensed at the flight deck. Examples of such motion buffets are high speed buffet, landing gear extension, flaps operation, atmospheric disturbance, nosewheel scuffing and approach-to-stall.	None	Ground and flight	NOT REQUIRED FOR LEVEL I FLIGHT SIMULATORS. For atmospheric disturbance testing, general purpose disturbance models that approximate demonstrable flight test data are acceptable. The recorded test results for characteristic buffets must allow the comparison of relative amplitude versus frequency.
4. VISUAL SYSTEM			
a) visual, motion and instrument systems response to an abrupt pilot controller input, compared to aeroplane response for a similar input	150 milliseconds or less after aeroplane response	Take-off, cruise, and approach or landing	One test is required in each axis (pitch, roll and yaw) for each of the three conditions compared to aeroplane data for a similar input. A total of nine tests are required unless invoking the provisions of Appendix A, u).
or			
transport delay	15 milliseconds or less after controller movement	Pitch, roll and yaw	One test is required in each axis (total three tests).

		condition	Co	
Note.— Visual change may si before motion response, but moti acceleration must occur before completion of the visual scan of t video field containing different information.				
Display system tests				
1) visual system colour	Demonstration model	Not applicable	Refer to 3.2.3 of this appendix for system requirements.	of visual
2) visual display focus and intensity	Demonstration model	Not applicable		
3) visual attitude versus simulator attitude indicator (pitch and roll horizon)	Demonstration model	Not applicable		
4) demonstrate ten levels of occulting through each channel of the system	Demonstration model	Not applicable		
5) daylight scene display brightness of 20 cd/m² (6 foot-lamberts) on the display and 17 cd/m² (5 foot-lamberts) at an approach plate positioned at the pilot's knee	Demonstration model	Not applicable	**NOT REQUIRED FOR LEVEL I FLIGHT SIMULATORS.**	
6) contrast ratio 5:1	Demonstration model	Not applicable	**NOT REQUIRED FOR LEVEL I FLIGHT SIMULATORS.**	
7) surface resolution three arc minutes	Demonstration model	Not applicable	Where a night/dusk system is used on a Level I simulator, this test does not apply.	
8) lightpoint size — not greater than six arc minutes	Demonstration model	Not applicable	This is equivalent to a lightpoint resolution of three arc minutes.	

lest	*Tolerance*	*Flight* condition	Comments
c) Visual ground segment			
1) visual ground segment	± 20% Threshold lights must be visible if they are in the visual segment. (See example under comments)	Trimmed in the landing configuration at 30 m (100 ft) wheel height above touchdown zone on glide slope at an RVR setting of 350 m (1 200 ft).	The IQTG should indicate the source of data, i.e. ILS G/S antenna location, pilot eye reference point, flight deck cut-off angle, etc., used to make visual scene ground segment (VGS) scene content calculations. Example: if the calculated VGS for the aeroplane is 256 m (840 ft), the 20% tolerance of 51 m (168 ft) may be applied at the near or far end of the simulator VGS or may be split between both, as long as the total of 51 m (168 ft) is not exceeded.
d) Visual feature recognition			Within final picture resolution, the distances at which features are visible for tests 1) through 4) should not be less than those indicated in the specified test. Applicants should indicate the light intensity level used for the test.
1) runway definition, strobe lights, runway edge white lights and VASI lights	8 km (5 sm) minimum from the runway threshold	Approach	
2) runway centre line lights	5 km (3 sm) minimum from the runway threshold	Approach	
3) threshold lights and touchdown zone lights	3 km (2 sm) minimum from the runway threshold	Approach	
4) runway markings	Night/dusk scenes within range of landing lights. Day scene as required by three arc minutes resolution.	Approach	
e) Visual scene content			For Tests 1) through IO) the demonstration models can be a sampling of specific models used in the training programme or a generic aerodrome model. A minimum of three specific aerodromes is required.
1) aerodrome runways and taxiways	Demonstration model	Ground or flight	

Test	*Tolerance*	*Flight condition*	*Comments*
2) surfaces on runways, taxiways and ramps	Demonstration model	Ground	
3) lighting for the runway in use	Demonstration model	Ground or flight	All lights associated with the test runway should be checked for appropriate colours (e.g. edge lights, centre line, touchdown zone, VASI, PAPI, REIL).
4) ramps and terminal buildings	Demonstration model	Ground	
5) dusk and night visual scene capability	Demonstration model	Flight	Dusk scene environment should include visible horizon and recognition of cultural features on the ground.
6) general terrain characteristics and significant landmarks	Demonstration model	Flight	
7) capability to present ground and air hazards such as another aeroplane crossing the active runway or converging airborne traffic	Demonstration model	Ground or flight	
8) operational visual scenes which portray representative physical relationships known to cause landing illusions on short runways, landing approaches over water, uphill or downhill runways, rising terrain on the approach path and unique topographic features	Demonstration model	Approach and landing	**NOT REQUIRED FOR LEVEL I FLIGHT SIMULATORS.** May be a generic airport model or specific aerodromes.
9) realistic colour and directionality of aerodrome lighting	Demonstration model	Ground or flight	**NOT REQUIRED FOR LEVEL I FLIGHT SIMULATORS.**
10) freedom from apparent quantization (aliasing)	Demonstration model	Ground	

Test	*Tolerance*	*Flight condition*	*Comments*
f) Weather effects			
1) special weather representations of light, medium and heavy precipitation near a thunderstorm on take-off, approach and landings at and below an altitude of 610 m (2 000 ft) above the aerodrome surface and within a radius of 16 km (10 sm) from the aerodrome	Demonstration model	Flight	**NOT REQUIRED FOR LEVEL I FLIGHT SIMULATORS.**
2) wet and snow-covered runways including runway lighting reflections for wet, partially obscured lights for snow or suitable alternative effects	Demonstration model	Ground	**NOT REQUIRED FOR LEVEL I FLIGHT SIMULATORS.**
3) weather radar presentations in aeroplanes where radar information is presented on the pilot's navigation instruments. Radar returns should correlate to the visual scene.	Demonstration model	Flight	**NOT REQUIRED FOR LEVEL I FLIGHT SIMULATORS.**
4) variable cloud density	Demonstration model	Approach	Weather effects described in tests 4) through 8) should be selectable via controls at the instructor station such as cloud base, cloud effects and visibility (kilometres/statute miles) and RVR (metres/feet).
5) partial obscuration of ground scenes: the effect of a scattered-to-broken cloud deck	Demonstration model	Approach	
6) gradual break-out	Demonstration model	Approach	Visibility and cloud effects should be checked at and below a height of 610 m (2 000 ft) above the aerodrome and within a radius of 16 km (10 sm) from the airport.
7) patchy fog	Demonstration model	Approach or take-off	
8) the effect of fog on aerodrome lighting	Demonstration model	Approach or take-off	

Test	Tolerance	Flight condition	Comments
g) Flight compatibility			
1) visual system compatibility with aerodynamic programming	Not applicable	Ground and flight	Qualitative tests to verify the validity of latency, throughput and visual attitude versus simulator attitude tests.
2) visual cues to assess sink rate and depth perception during landings	Not applicable	Approach and landing	Qualitative test to confirm that terrain features, surfaces on taxiways and ramps and other cultural features provide cues for landing the aeroplane.
3) accurate portrayal of environment relating to simulator attitudes	Not applicable	Flight	
5. SOUND SYSTEMS			
a) significant flight deck sounds, which result from pilot actions, corresponding to those of the aeroplane	Not applicable	Flight and ground	Statement of compliance or demonstration of representative sounds.
b) sound of precipitation, windshield wipers, and other significant aeroplane noises perceptible to the flight crew during normal operations and the sound of a crash related in some logical manner to landing in an unusual attitude or in excess of the structural gear limitations of the aeroplane	Not applicable	Flight and ground	Statement of compliance or demonstration of representative sounds. Significant aeroplane noises should include noises such as engine, flap, gear and spoiler extension and retraction and thrust reversal to a comparable level as that found in the aeroplane.
c) realistic amplitude and frequency of flight deck noises and sounds including engine, airframe and precipitation sounds. The sounds shall be co-ordinated with weather representations which are required to be displayed in the visual scene.	Not applicable	Flight and ground	NOT REQUIRED FOR LEVEL I FLIGHT SIMULATORS. Test results must show a comparison of the amplitude and frequency content of the sounds.

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 aircraft operating manuals and checklists. Handling qualities, performance and simulator systems operation will be subjectively assessed. Prior co-ordination with the regulatory 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 a regulatory authority, the 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 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 real time simulator running for two to three hours, without repositioning or 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 Table of Functions and Subjective Tests. The table includes manoeuvres and procedures to assure that the simulator functions and performs appropriately for use in pilot training and checking in the manoeuvres and procedures normally required of a training and checking programme.

2.2 Manoeuvres and procedures are included to address some features of advanced technology aeroplanes and innovative training programmes. For example, "high angle of attack manoeuvring" 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 manoeuvres or events within that flight phase. Systems are listed separately under "any flight phase" to assure appropriate attention to systems checks.

TABLE OF FUNCTIONS AND SUBJECTIVE TESTS

	Simulator level I	Simulator level II
1. FUNCTIONS AND MANOEUVRES		
a) Preparation for flight		
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	X	X
b) Surface operations (pre-take-off)		
1) engine start	X	X
i) normal start		
ii) alternate start procedures		
iii) abnormal starts and shutdowns (hot start, hung start, etc.)		
2) pushback/powerback	X	X
3) taxi	X	X
i) thrust response		
ii) power lever friction		
iii) ground handling		
iv) nose-wheel scuffing		
v) brake operation (normal and alternate/emergency)		
vi) brake fade (if applicable)		
vii) other		
c) Take-off		
1) normal take-off	X	X
i) parameter relationships		
ii) acceleration characteristics		
iii) nose-wheel and rudder steering		
iv) cross-wind (maximum demonstrated)		
v) special performance		
vi) instrument take-off		
vii) landing gear, wing flap, leading edge device operation		
viii) other		
2) abnormal/emergency	X	X
i) rejected take-off		
ii) rejected special performance		
iii) with failure of most critical engine at most critical point along take-off path (continued take-off)		
iv) with wind shear		
v) flight control system failure modes		
vi) other		
d) In-flight operation		
1) climb	X	X

	Simulator level I	II
i) normal		
ii) one engine inoperative		
iii) other		
2) cruise	X	X
i) performance characteristics (speed vs power)		
ii) turns with/without spoilers (speedbrake) deployed		
iii) high altitude handling		
iv) high speed handling		
v) Mach tuck and trim, overspeed warning		
vi) normal and steep turns		
vii) performance turns		
viii) approach to stalls, stall warning, buffet and g-break (cruise, take-off, approach and landing configuration)		
ix) high angle of attack manoeuvres (cruise, take-off, approach and landing configuration)		
x) in-flight engine shutdown and restart		
xi) manoeuvring with one engine inoperative		
xii) specific flight characteristics		
xiii) manual flight control reversion		
xiv) flight control system failure modes		
xv) other		

	Simulator level I	II
3) descent	X	X
i) normal		
ii) maximum rate		
iii) manual flight control reversion		
iv) flight control system failure modes		
v) other		
e) Approaches		
1) non-precision approach and landing procedures — NDB — VOR, RNAV, TACAN — DMEARC — ILS/LOC/BC* — ILS offset localizer — direction finding facility — surveillance radar	X	X
i) manoeuvring with all engines operating		
ii) landing gear, operation of flaps and speed brake		
iii) all engines operating		
iv) one or more engines inoperative		
v) missed approach procedures — all engines operating — one or more engines inoperative (as applicable)		

* ILS localiser/back course approaches are not included in PANS-OPS **(Doc 8168)**

	Simulator level I	II
2) precision approach and landing procedures	[X]	[X]
i) PAR		
ii) ILS/MLS		
— normal		
— engine(s) inoperative		
— Category I published approach		
• manually controlled with and without flight director to 30 m (100 fl) below CAT I minima		
• with cross-wind (maximum demonstrated)		
• with wind shear		
— Category II published approach		
• auto-coupled, autothrottle, autoland		
• all engines operating missed approach		
— Category III published approach		
• with generator failure		
• with 10 knot tail wind		
• with 10 knot cross-wind		
• one engine inoperative		
3) visual approach and landing	[X]	[X]
i) abnormal wing flaps/slats		
ii) without glide slope guidance		
f) Visual segment and landing		
1) normal	[X]	[X]
i) cross-wind (maximum demonstrated)		
ii) from VFR traffic pattern		
iii) from non-precision approach		
iv) from precision approach		
v) from circling approach		

Note.— Simulators with visual systems which permit completing a circling approach in accordance with applicable regulations may be approved for that particular circling approach procedure.

	Simulator level I	II
2) abnormal/emergency	[X]	[X]
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) other flight control system failure modes as dictated by the training programme		
x) other		

	Simulator level I	Simulator level II
g) Ground operations (post landing)		
1) landing roll and taxi	X	X
i) spoiler operation		
ii) reverse thrust operation		
iii) directional control and ground handling, both with and without reverse thrust		
iv) reduction of rudder effectiveness with increased reverse thrust (rear pod-mounted engines)		
v) brake and anti-skid operation with dry, wet and icy conditions		
vi) brake operation		
vii) other		
h) Any flight phase		
1) aeroplane and powerplant systems operation	X	X
i) air conditioning		
ii) anti-icing/de-icing		
iii) auxiliary power unit		
iv) communications		
v) electrical		
vi) fire detection and suppression		
vii) flaps		
viii) flight controls		
ix) fuel and oil		
x) hydraulic		
xi) landing gear		
xii) oxygen		
xiii) pneumatic		
xiv) powerplant		
xv) pressurization		
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		
ix) navigation systems		
x) stall warning/avoidance		
xi) stability and control augmentation		
xii) wind shear avoidance equipment		
3) airborne procedures	X	X
i) holding		
ii) air hazard avoidance		
iii) wind shear		
4) engine shutdown and parking	X	X

	Simulator level I	Simulator level II
i) engine and systems operation		
ii) parking brake operation		
2. VISUAL SYSTEM		
a) Accurate portrayal of environment relating to simulator attitudes	[X]	[X]
b) The distance at which runway features are visible should not be less than those listed below. Distances are measured from runway threshold to an aeroplane aligned with the runway on an extended 3-degree glide slope	[X]	[X]
1) runway definition, strobe lights, approach lights, white runway edge lights and VASI from 8 km (5 sm) of the runway threshold		
2) runway centre line lights and taxiway definition from 5 km (3 sm)		
3) threshold lights and touchdown zone lights from 3 km (2 sm)		
4) runway markings within range of landing lights for night scenes; as required by 3 arc-minute resolution on day scenes		
c) Representative aerodrome scene content including:	[X]	[X]
1) aerodrome runways and taxiways		
2) runway definition		
i) runway surface and markings		
ii) lighting for the runway in use including runway edge and centre line lighting, touchdown zone, VASI and approach lighting of appropriate colours		
iii) taxiway lights		
d) Operational landing lights	[X]	[X]
e) Instructor controls of:	[X]	[X]
1) cloud base		
2) visibility in kilometres/statute miles and RVR in metres/feet		
3) aerodrome selection		
4) aerodrome lighting		
f) Visual system compatibility with aerodynamic programming	[X]	[X]
g) Visual cues to assess sink rates and depth perception during landings	☐	☐
1) surface on taxiways and ramps		
2) terrain features		
h) Dusk and night visual scene capability	☐	☐
i) Minimum of three specific aerodrome scenes	[X]	[X]
1) surfaces on runways, taxiways and ramps		
2) lighting of appropriate colourfor all runways including runway edge, centre line, VASI and approach lighting for the runway in use		
3) aerodrome taxiway lighting		
4) ramps and terminal buildings which correspond to specified line oriented flight training (LOFT) and line oriented simulator (LOS) scenarios		
j) General terrain characteristics and significant landmarks	[X]	[X]

	Simulator level I	Simulator level II
k) At and below an altitude of 610 m (2 000 ft) height above the aerodrome and within a radius of 16 km (IO sm) from the aerodrome, weather representations, including the following: 1) variable cloud density 2) partial obscuration of ground scenes; the effect of a scattered-to-broken cloud deck 3) graduai break-out 4) patchy fog 5) the effect of fog on aerodrome lighting	X	X
l) A capability to present ground and air hazards such as another aeroplane crossing the active runway or converging airborne traffic	X	X
m) Operational visual scenes which portray representative physical relationships known to cause landing illusions, such as short runways, landing approaches over water, uphill or downhill runways, rising terrain on the approach path and unique topographic features		X
n) Special weather representations which include the sound, visual and motion effects of entering light, medium and heavy precipitation near a thunderstorm on take-off, approach and landings at and below an altitude of 610 m (2 000 ft) above the aerodrome surface and within a radius of 16 km (10 sm) from the aerodrome		X
o) Wet and snow-covered runways including runway lighting reflections for wet, partially obscured lights for snow or suitable alternative effects		X
p) Realistic colour and directionality of aerodrome lighting		X
q) Weather radar presentations in aeroplanes where radar information is presented on the pilot's navigation instruments. Radar returns should correlate to the visual scene		X
r) Freedom from apparent quantization (aliasing)		X

3. SPECIAL EFFECTS

	Simulator level I	Simulator level II
a) Runway rumble, oleo deflections, effects of ground speed and uneven runway characteristics	X	X
b) Buffets on the ground due to spoiler/ speedbrake extension and thrust reversal	X	X
c) Bumps after lift-off of nose and main gear	X	X
d) Buffet during extension and retraction of landing gear	X	X
e) Buffet in the air due to flap and spoiler/ speedbrake extension and approach-to-stall buffet	X	X
f) Touchdown cues for main and nose gear	X	X
g) Nose-wheel scuffing	X	X
h) Thrust effect with brakes set	X	X
i) Mach buff et	X	X
j) Representative brake and tire 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		

		Simulator level I	Simulator level II		Simulator level I	Simulator level II
	the problem and implementation of appropriate procedures Simulator pitch, side loading and directional control characteristics should be representative of the aeroplane	X	X			
k)	Sound of precipitation and significant aeroplane noises perceptible to the pilot during normal operations and the sound of a crash when the simulator is landed in excess of landing gear limitations. Significant aeroplane noises should include noises such as engine, flap, gear and spoiler extension and retraction and thrust reversal to a comparable level as that found in the aeroplane. The sound of a crash should be related in some logical manner to landing in an unusual attitude or in excess of the structural gear limitations of the aeroplane	X	X			
l)	Effects of airframe icing	X	X			

— END —

ICAO TECHNICAL PUBLICATIONS

The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series. such as the Aeronautical Chart Catalogue *or the* Meteorological Tables for International Air Navigation.

International Standards and Recommended Practices are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience. as Annexes to the Convention. The uniform application by Contracting States of the specifications contained in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has. in fact, an obligation, under Article 38 of the Convention. to notify the Council of any differences. Knowledge of difference:, from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto. the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

Procedures for Air Navigation Services (PANS) are approved by the Council for world-wide application. They contain, for the most part. operating procedures regarded as not yet having attained a sufficient degree of maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome.

Regional Supplementary Procedures (SUPPS) have a status similar to that of PANS in that they are approved by the Council. but only for application in the respective regions. They are prepared in consolidated form, since certain of the procedures apply to overlapping regions or are common to two or more regions.

The following publications are prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.

Technical Manuals provide guidance and information in amplification of the international Standards. Recommended Practices and PANS, the implementation of which they are designed to facilitate.

Air Navigation Plans detail requirements for facilities and services for international air navigation in the respective ICAO Air Navigation Regions. They are prepared on the authority of the Secretary General on the basis of recommendations of regional air navigation meetings and of the Council action thereon. The plans are amended periodically to reflect changes in requirements and in the status of implementation of the recommended facilities and services.

ICAO Circulars make available specialized information of interest to Contracting States. This includes studies on technical subjects.

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