APPENDIX 1. SIMULATOR STANDARDS

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

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

SIMULATOR STANDARDS —Continued	SIMULATOR LEVEL A	B	C	D	COMMENTS
f. In addition to the flight crewmember stations, two suitable seats for the Instructor/Check Airman and FAA Inspector. The NSPM will consider options to this standard based on unique cockpit configurations. These seats must provide adequate vision to the instrument panel and visual system. These seats need not represent those found in the helicopter but must be equipped with positive restraint devices similar to those found in the helicopter.		X	X	X	
g. Simulator systems must simulate the applicable helicopter system operation, both on the ground and in flight. Three systems must be operative to the extent that normal, abnormal, and emergency operating procedures appropriate to the simulator application can be accomplished.		X	X	X	
h. Instructor controls to enable the instructor to control all required system variables and insert abnormal or emergency conditions into the helicopter systems.		X	X	X	
i. Static control forces and control travel which correspond to that of the replicated helicopter. Control forces should react in the same manner as in the helicopter under the same flight conditions.		X	X	X	
j. Significant cockpit sounds which result from pilot actions corresponding to those of the helicopter.		X	X	X	
k. Sound of precipitation, windshield wipers, and other significant helicopter noises perceptible to the pilot during normal operations and the sound of a crash when the simulator is landed in excess of landing gear limitations.			X	X	Statement of Compliance. For Level D, appropriate weather related sounds shall be coordinated with the weather representations specified in Appendix 3, "Functions and Subjective Tests," paragraph 2.o.
l. Realistic amplitude and frequency of cockpit noises and sounds, including engine, transmission, rotor, and airframe sounds.				X	Tests required for noises and sounds that originate from the helicopter or helicopter systems.
m. Ground handling and aerodynamic programming to include the following: (1) Ground effect--for example: flare, and touchdown from a running landing as well as in ground effect (IGE) hover programming.		X	X	X	Statement of Compliance. Tests required. Level B does not require hover programming.

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

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

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

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

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

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

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

APPENDIX 2. SIMULATOR VALIDATION TESTS

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

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

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

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

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

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

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

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

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

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

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

TABLE OF VALIDATION TESTS

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

TABLE OF VALIDATION TESTS—Continued

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

TABLE OF VALIDATION TESTS—Continued

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

TABLE OF VALIDATION TESTS—Continued

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

TABLE OF VALIDATION TESTS—Continued

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

TABLE OF VALIDATION TESTS—Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS A	B	C	D	COMMENTS
(4) Autorotational Landing	Torque - ±3% Rotor Speed - ±3% Vertical Velocity - ±100 fpm (0.50 m/sec) or 10 % Pitch Attitude - ±2° Bank Attitude - ±2° Heading - ±5° Longitudinal Control Position - ±10% Lateral Control Position - ±10% Directional Control Position - ±10% Collective Control Position - ±10%	Approach/Landing			X	X	Time history of autorotational deceleration and landing from a stabilized autorotational descent.
2. Handling Qualities **a. Control System Mechanical Characteristics**							
(1) Cyclic**	Breakout ±.25 lb (0.1 12 daN) or 25% Force ±0.5 lb (0.224 daN) or 10%	Ground/Static Trim On/Off Friction Off Augmentation On/Off		X	X	X	Uninterrupted control sweeps. Does not apply to aircraft hardware modular controllers.
(2) Collective/Pedals**	Breakout ±0.5 lb (0.224 daN) or 10% Force ±1.0 lb (0.448 daN) or 10%	Ground/Static Trim On/Off Friction Off Augmentation On/Off		X	X	X	Uninterrupted control sweeps.
(3) Brake Pedal Force vs. Position	±5 lb (2.224 daN) or 10%	Ground/Static		X	X	X	Simulator computer output results may be used to show compliance.
(4) Trim System Rate (all applicable axes)	Rate - ±10%	Ground/Static Trim On Friction Off		X	X	X	Tolerance applies to recorded value of trim rate.
(5) Control Dynamics (all axes)	±10% of time for first zero crossing and ±10 (N+1)% of period thereafter	Hover/Cruise Trim On Friction Off			X	X	Control dynamics for irreversible control systems may be evaluated

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

TABLE OF VALIDATION TESTS—Continued

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

TABLE OF VALIDATION TESTS—Continued

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

TABLE OF VALIDATION TESTS—Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(5) Landing Gear Operating Time	±1 sec	Takeoff (Retraction) Approach (Extension)		X	X	X	
d. Lateral and Directional Handling Qualities (1) Control Response							Two airspeeds to include at or near the minimum power required speed.
(a) Lateral	Roll Rate - ±10% or ±3°/sec Roll Attitude Change - ±10% or ±3°	Cruise Augmentation On/Off		X	X	X	Step control input. Off axis response must show correct trend for unaugmented cases.
(b) Directional	Yaw Rate - ±10% or ±2°/sec Yaw Attitude Change - ±10% or ±2°	Cruise Augmentation On/Off		X	X	X	Two airspeeds to include at or near the minimum power required speed. Step control input. Off axis response must show correct trend for unaugmented cases.
(2) Directional Static Stability	Lateral Control Position - ±10% of change from trim or ±0.25 in (6.3 mm) or Lateral Control Force - ±0.5 lb (0.223 daN) or 10% Roll Attitude - ±1.5° Directional Control Position - ±10% of change from trim or ±0.25 in (6.3 mm) or Directional Control Force - ±1 lb (0.448 daN) or 10% Longitudinal Control Position - ±10% of change from trim or ±0.25 in (6.3 mm) Vertical Velocity - ±100 fpm (0.50 m/sec) or 10%	Cruise or Climb/ Descent Augmentation On/Off		X	X	X	Steady heading sideslip. Minimum of two side-slip angles on either side of the trim point. Force may be a cross plot for irreversible control systems. May be a snapshot test.
(3) Dynamic Lateral and Directional Stability							

TABLE OF VALIDATION TESTS—Continued

TESTS	TOLERANCE	FLIGHT CONDITIONS	QUALIFICATION REQUIREMENTS				COMMENTS
			A	B	C	D	
(a) Lateral-Directional Oscillations	±0.5 sec or ±10% of Period ±10% of Time to 1/2 or Double Amplitude or ±.02 of Damping Ratio ±20% or ±1 sec of Time Difference Between Peaks of Bank and Side-slip	Cruise or Climb Augmentation On/Off		X	X	X	Two Airspeeds. Excite with cyclic or pedal doublet. Test should include six full cycles (12 overshoots after input completed) or that sufficient to determine time to 1/2 or double amplitude, whichever is less. For non-periodic response, time history should be matched.
(b) Spiral Stability	Correct Trend, ±2° Bank or ±10% in 20 sec	Cruise or Climb Augmentation On/Off		X	X	X	Time history of release from pedal only or cyclic only turns in both directions.
(c) Adverse/Proverse Yaw	Correct trend, ±2° transient sideslip angle	Cruise or Climb Augmentation On/Off		X	X	X	Time history of initial entry into cyclic only turns in both directions. Use moderate cyclic input rate.
3. Motion System**							
a. Motion Envelope							
(1) Pitch		N/A					
(a) Displacement ±TBD°				X			
±25°					X	X	
(b) Velocity ±TBD°/sec				X			
±20°/sec					X	X	
(c) Acceleration ±TBD°/sec^2				X			
±100°/sec^2					X	X	

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

TABLE OF VALIDATION TESTS—Continued

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

TABLE OF VALIDATION TESTS—Continued

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

TABLE OF VALIDATION TESTS—Continued

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

TABLE OF VALIDATION TESTS—Continued

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

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

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

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

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

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

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

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

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

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

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

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

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

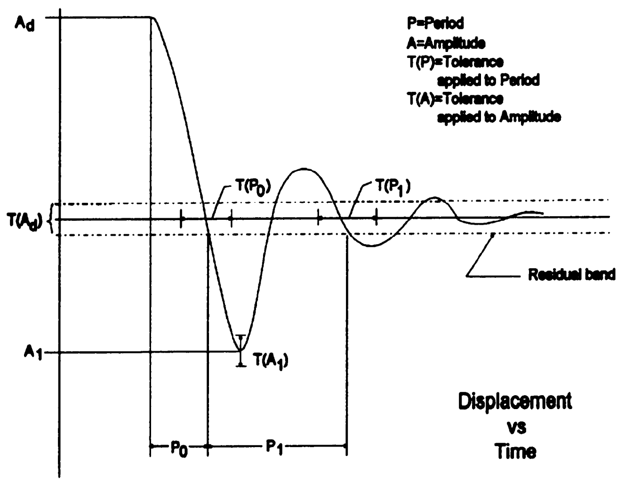

Figure 1. Underdamped Step Response

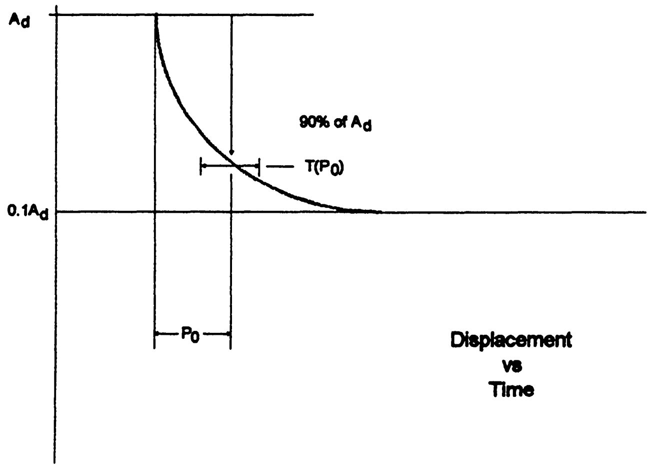

Figure 2. Critically Damped Step Response

4. MOTION TESTING.

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

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

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

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

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

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

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

Acceleration Test Signals

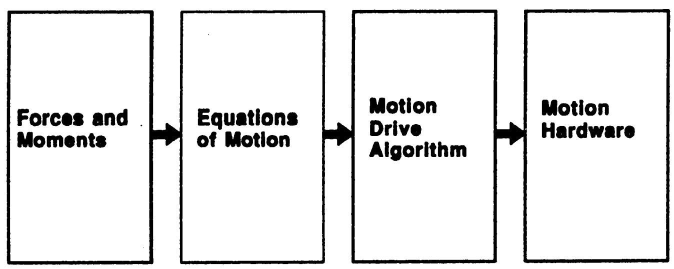

Figure 3

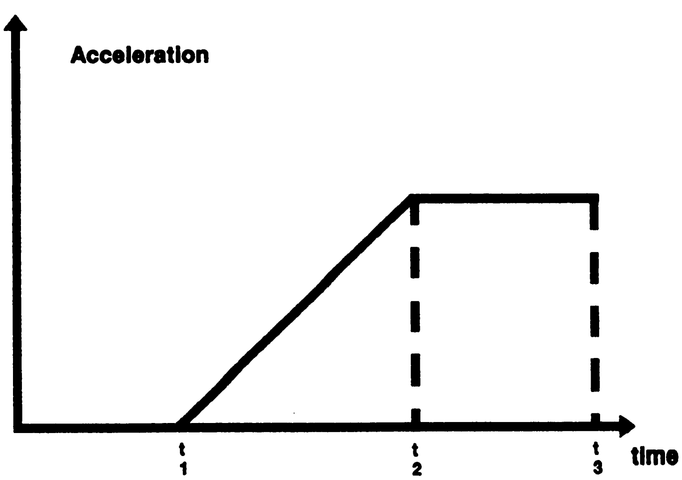

Figure 4

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

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

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

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

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

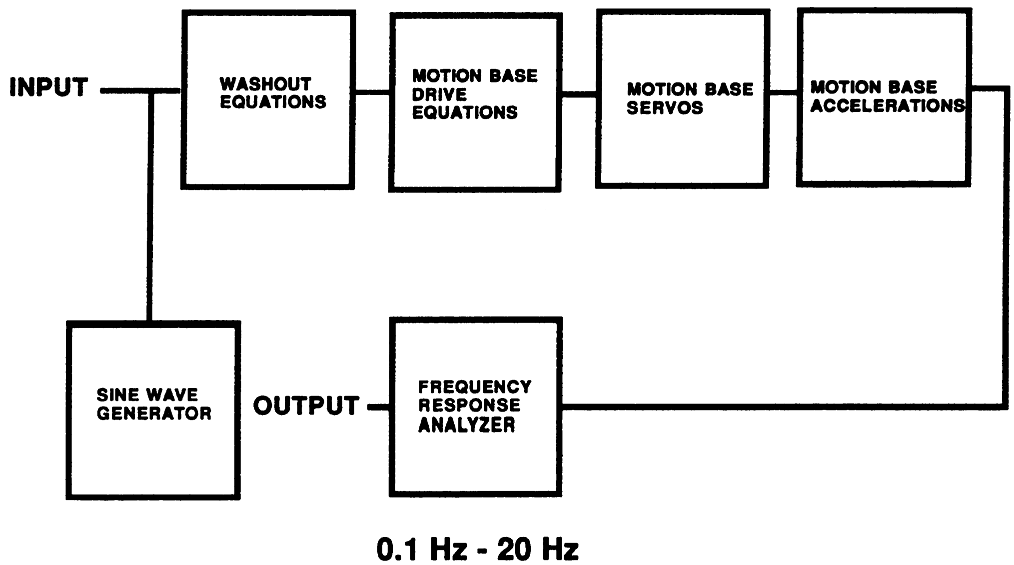

Figure 5