Transcript of the

Joint FAA/Industry Symposium

on

Level B Airplane Simulator Motion Requirements

Part 8 of 9

Appendix 2:

Proposed Revision to Level B Standards Contained in AC120-40C (Draft)

Washington Dulles Airport Hilton
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PROPOSED REVISION TO LEVEL B STANDARDS
CONTAINED IN AC120-40C (DRAFT)

AIRPLANE SIMULATOR QUALIFICATION

PURPOSE. In March and June of 1996 the FAA Advanced Qualification Program(AQP) Manager and the National Simulator Program (NSP) Manager convened workshops of Subject Matter Experts on flight simulator aerodynamic programming and on motion systems to specifically address Level B flight simulator standards. The objective was to identify Level B flight simulator characteristics specific to the needs of regional air carriers for recurrent training. For the AQP, the Level B simulator will totally support a Line Oriented Evaluation. Of course, once the standards for Level B simulators are agreed and promulgated, they will be applicable to any user of Level B simulators in an FAA approved flight training program.

The proposed revision contained herein reflects the results of the Level B Flight Simulator SME Workshops. Changes to Appendix 1, Simulator Standards, and Appendix 2, Simulator Validation Tests, of Advisory Circular (AC)120-40C (Draft) are proposed as indicated in the following tables. These tables would replace, or revise as indicated, the pertinent sections of the AC tables. The aerodynamic programming workshop addressed data sources and flight testing techniques. Those results are in Appendix 7.

APPENDIX 1. **SIMULATOR STANDARDS Changes**

SIMULATOR STANDARDS	SIMULATOR LEVEL				COMMENTS
	A	B	C	D	
2. GENERAL					
v. Relative responses of the motion system, visual system , and cockpit instruments shall be coupled closely to provide integrated sensory cues. These systems shall respond to abrupt pitch, roll, and yaw inputs *for levels A, C, and D, and to abrupt pitch, roll and* ***sway inputs for Level B*** at the pilot's position within 150/300 milliseconds of time, but not before the time, when the airplane would respond under the same conditions. Visual scenes ...	X				For Level A response must be within 300 milliseconds
		X	X	X	For Levels B, C and D response must be within 150 milliseconds
3. MOTION SYSTEM.	X	X	X	X	
a. Motion (force) cues...					
b. A motion system having a minimum of three degrees of freedom.	X				
c. A motion system having a minimum of four degrees of freedom which must be at least pitch, roll, sway and heave		X			
d. re-designate "c.", "d."			X	X	
e. re-designate "d.", "e."	X	X	X	X	

APPENDIX 2. TABLE OF VALIDATION TESTS Changes:

There is a disagreement between Appendices 1 and 2. Appendix 1, Item 3.e. requires motion special effects for Level B, Appendix 2, Item 3.e. does not. Therefore, at least App. 2 Item 3.e. (2) through (6) and (8) and (9) should be marked as applicable to Level B.

Appendix 2, Item 3.a., b., and c. Should be unmarked for Level B and a comment added that Level B is listed separately.

Following is a proposed revision to the Table of Validation tests for Motion.

TABLE OF VALIDATION TESTS

I = Initial Evaluation
R = Recurrent Evaluation

TESTS	TOLERANCE	FLIGHT CONDITION	QUALIFICATION REQUIREMENT				COMMENTS
			A	B	C	D	
3. MOTION SYSTEM							
a. Frequency Response	As specified by operator for simulator acceptance	N/A	IR		IR	IR	Appropriate test to demonstrate frequency response required
b. Leg Balance	As specified by operator for simulator acceptance		IR		IR	IR	Appropriate test to demonstrate leg balance required
Leg Balance	Design dependent			I			See Appendix 7
c. Turn Around Check	As specified by operator for simulator acceptance		IR		IR	IR	Appropriate test to demonstrate smooth turn around required
Turn Around Check				I			See Appendix 7
e. Motion Excursion		N/A					See appendix 7 for a full description of Level B motion requirements and recommendations.
(1) sway 45 in	-0 + as desired			I			Total minimum usable non-simultaneous excursions about a single reference point. See Appendix 7
(2) heave 40 in	-0 + as desired			I			
(3) pitch 40°	-0 + as desired			I			
(4) roll 40°	-0 + as desired			I			
f. Accelerations							See Appendix 7 for systems having more than four degrees of freedom
(1) sway ± 0.6g	-0 + as desired			I			
(2) heave ± 0.6g	-0 + as desired			I			
g. Velocity							See Appendix 7 for systems having more than four degrees of freedom
(1) sway 20 in/s	-0 + as desired			I			
(2) heave 20 in/s	-0 + as desired			I			
h. Bandwidth: phase lag at 0 - 4 hertz	not to exceed 45°						See Appendix 7
i. Crosstalk				I			See Appendix 7
j. Smoothness				I			See Appendix 7

3. Motion System continued

k. Motion Cue Repeatability l. Special Effects	Use AC120-63 procedure *Re-designate "e" to "l"*			R			Use procedure from AC120-63 or the IATA Procedure
6. Simulator Systems a. Visual, Motion and Cockpit Instrument Display	 *Change Level B from 300 to 150 milliseconds*						

<u>APPENDIX 7</u>. Level B Motion and Aerodynamics Tests Requirements

The Level B motion criteria and the aerodynamic data sources and test techniques contained in this Appendix are intended to replace those given in Appendix 2 and elsewhere in this AC.

1. DISCUSSION. In March of 1996 the FAA Advanced Qualification Program (AQP) Manager and the National Simulator Program (NSP) Manager convened a workshop of Subject Matter Experts to address and attempt to simplify the aerodynamic data and flight testing requirements for Level B flight simulators. The results of that effort are tabulated in this Appendix.

In June of 1996 the FAA AQP and NSP convened an additional workshop of Subject Matter Experts on flight simulator motion systems to specifically address the Level B flight simulator. The objective was to identify the characteristics of a motion system applicable to Level B simulators to specifically address the needs of regional air carriers for recurrent training. More specifically, for the AQP, the Level B simulator will totally support a Line Oriented Evaluation. Of course, once the standards for Level B simulators are agreed and promulgated, they will be applicable to any user of Level B simulators in an FAA approved flight training program

For the first time, a table of motion objectives was provided prior to the meeting. Although the motion objectives were not discussed in detail during the SME workshop, they were deemed to be descriptive of the contribution of motion to pilot certification and training activities. An edited version of the table of motion objectives is, therefore, included in this appendix.

2. LEVEL B MOTION CHARACTERISTICS

a. Transport Delay/Cue Synchronization

Transport Delay**:** 150 milliseconds is the maximum permitted. The time delay may also be measured as a “latency” or lag of the response of the motion, visual or instruments following the input when compared to the airplane response time.

Motion/Visual Phase Relationship: motion response must lead visual response. There is no specified amount of lead . When measured to assure that motion does not lag visual, motion acceleration is measured and visual displacement is measured.

b. Degrees of Freedom

At least four degrees of freedom are necessary to satisfy the motion objectives of critical pilot certification and training tasks. The following degrees of freedom are necessary:

Pitch, Roll, Heave and Sway.

c. Motion Platform Excursions

Acceptable usable, non-simultaneous excursions are the minimum limits of movement about a single specified reference point. Usable excursions are those actually used by the simulator in normal training mode without exceeding any safety limits. <u>Total</u> minimum excursions, which may be split to best advantage (for example pitch could be + 10 and - 30 or other split values), must be measurable about a common reference point as follows:

Lateral (sway)	45 inches
Vertical (heave)	40 inches

Pitch	40 degrees
Roll	40 degrees

If the motion system provides six degrees of freedom the following additional minimum excursions will apply:

Longitudinal (surge)	50 inches
Yaw	45 degrees

These six excursions are the undistorted displacements that can be achieved by driving one degree of freedom at a time.

d. Accelerations

Accelerations of the motion platform shall be measured about the same platform reference point about which excursions are measured. Minimum accelerations are:

Lateral (sway)	± 0.6 g
Vertical (heave)	± 0.6 g
Pitch	not specified
Roll	not specified

If the motion system provides six degrees of freedom the following additional minimum acceleration will apply:

Longitudinal (surge)	± 0.6 g
Yaw	not specified

e. Velocities

Velocities of the motion platform shall be measured about the same platform reference point about which excursions and accelerations are measured. Minimum velocities are:

Lateral (sway)	20 inches per second
Vertical (heave)	20 inches per second
Pitch	not specified
Roll	not specified

If the motion system provides six degrees of freedom the following additional minimum velocity will apply:

Longitudinal (surge)	20 inches per second
Yaw	not specified

f. Bandwidth

The motion base platform shall exhibit a maximum phase lag of 45 degrees at a frequency of 4 hertz. At lower frequencies the phase lag shall be 45 degrees or less. This characteristic shall be determined by injecting an acceleration command into the kinematic transformation equations and measuring the acceleration output of the motion platform. The response bandwidth shall be determined in each translational degree of freedom.

g. Crosstalk

Motion response in a given degree of freedom should not be perceptibly distorted by response in other degrees of freedom. For example, if the desired response is sway, there should be no perceptible roll or other responses. Crosstalk perceptibility is a subjective measure. Crosstalk shall be imperceptible to a trained observer during operational use of the flight simulator. The observer must be at the proper location, seated at the pilot station with the seat adjusted to the appropriate operational position, during crosstalk evaluations.

h. Smoothness

There shall be no perceptible "turnaround bump" as the direction of motion of any actuator of the system reverses with the simulator being "flown" normally.

i. Leg Balance

If a synergistic hexipod (6 degrees of freedom) or similar system is used to satisfy the Level B flight simulator requirements, no leg of the system shall lead or lag a selected reference leg by more than 1.5 degrees. This requirement shall apply to other system designs if more than one actuator is required to drive the system in any single degree of freedom.

j. Recurrent Evaluation Procedure

The "Motion Cue Repeatability Testing" procedure described in AC120-63 Helicopter Simulator Qualification or similar tests developed by the International Air transportation Association, when released and published, may be used for this procedure.

3. LEVEL B FLIGHT SIMULATOR MOTION OBJECTIVES

a. Training/Pilot Certification Events

Events are listed in the order of Appendix 3 of draft Advisory Circular 120-40C. The associated maneuver or disturbance is listed in the "Event" column under each pertinent event. The pertinent degrees of freedom (DOF) shown in column 2 apply to the group of training events or special effects shown in column 1. The training events (maneuver or disturbance) are grouped in column 1 when the same DOF apply to all maneuvers or disturbances in the group.

b. Level B Motion Objectives

Event maneuver or disturbance	Pertinent Degree(s) of Freedom	Motion Objective
1.b. **Surface Operations** (Pre-takeoff)		
(2) pushback/ powerback	sway	Provide the pilot with the sensation of aircraft movements, thrust effects and side motion. Avoid the effects of a"sterile"
	heave	motion environment that occurs with only visual stimulus
(3) Taxi		
(iii) ground handling	sway	Provide sensation of the effects of rapid steering inputs, roughness of taxiway/runway surface.
(iv) nosewheel scuffing	heave	Feedback to the pilot the effect of turns at excessive groundspeed causing the nose wheel tire(s) to lose sideforce friction and "scuff"
(v) brake operation (vi) brake fade	pitch	Familiarize pilot with braking technique appropriate for the sensitivity of the brakes and provide deceleration sensation. Less than expected deceleration with brakes
1.c. **Takeoff(s)**		
(1) normal (ii) acceleration	pitch	Provide the sensation of acceleration on a surface with some roughness, the pitch or heave sensation during takeoff rotation.
(iii) steering	sway	Effects of nosewheel and rudder inputs during the takeoff roll. These effects are usually side to side accelerations at the pilot station.
(iv) crosswind	heave	Effects of sidewise skipping on the ground if adequate wind compensation is not used.
(2) Abnorm/ Emergency	roll	Subject the pilot to the accelerations, and pitch over associated with maximum braking and with side accelerations associated with directional control.
(i) rejected (ii) engine failure		Induce the rapid sway accelerations, "the lead cue", that may occur at the pilot station when there is an engine failure.
(iv) windshear		Acquaint the pilot with the large accelerations that may be associated with windshear and impose the task difficulty that accompanies escape from an windshear encounter where there may be heavy turbulence.
1.d. **In-Flight Operation**		
(2) Cruise		
(v) High **M** handling/over-speed warning	sway	Provide the buffets and vibrations associated with speeds near. the critical Mach number
	heave	
(viii) approach to stalls	sway	Provide the buffets and vibrations associated with speeds.
	heave	approaching the stall speed
(x) engine inoperative	sway	Provide the accelerations resulting from a sudden change in thrust and the thrust asymmetry. Provide the lead cues of a
	roll	shutdown in the event of an unexpected engine failure
(3) Descent		
(ii) maximum rate	pitch	Familiarize the pilot with the pitch attitude and the accelerations associated with the large pitch change to effect an emergency descent.
1.e. **Approaches**		
(1)(ii)(B) missed approach engine inop	pitch	Familiarize the pilot with the pitch attitude, the large yawing moments and the accelerations associated with the large pitch change and large asymmetric thrust change to effect a missed
	sway	approach with a critical engine inoperative
	roll	

Level B Motion Objectives continued

Event maneuver or disturbance	Pertinent Degree(s) of Freedom	Motion Objective
1.f. **Visual Segment and Landing**		
(1) Normal (i) crosswind	sway	Feedback to the pilot the proprioceptive cues associated with landing, especially touchdown sink rate and side forces which help inform the pilot of the "quality" of the landing. The side forces and associated rolling moments resulting from dragging a wheel sideways are essential to estimating the quality of a crosswind landing
	heave	
	pitch	
	roll	
(2) Abnormal (i) engine inoperative	sway	Same as for normal/crosswind
(ii) rejected	heave	Provide the sensation of quickly changing from large positive acceleration to the acceleration associated with maximum braking and high speed steering.
(iii) with windshear	pitch	Acquaint the pilot with the large accelerations that may be associated with windshear and impose the task difficulty that accompanies escape from an windshear encounter where there may be heavy turbulence.
(viii) with flight control system failures	roll	Same for normal/crosswind
1.g. **Surface Operations** (**Post Landing)**		
(ii) reverse thrust	sway	Provide lead information of asymmetric reverse thrust and the deceleration cues associated with reverse thrust
(v) brake and anti-skid	heave	Familiarize the pilot with the sensation of maximum brake operation
	pitch	
3. **SPECIAL EFFECTS**		
a. runway rumble	heave	Speed information and rough runway feedback
b. buffets, on ground	sway	Familiarize the pilot with the effects of spoilers, thrust reverse
	heave	
c. Bumps after lift off of nose and main gear	heave	Provide systems operations information
d. buffet, landing gear in transit	sway	Same as above
	heave	
e. flap, spoiler, speedbrake, stall buffet	sway	Familiarize the pilot with the characteristic buffets of in-flight deployment of spoilers and approach to stall buffet warning
	heave	

Level B Motion Objectives continued

f. touchdown cues, main and nose wheels	sway heave pitch roll	Same as landings
g. nosewheel scuffing	sway heave	Familiarize pilot with nose tire scuffing speed and characteristics
h. thrust effect w/ brakes set	sway heave	Provide information on thrust level and the associated vibrations.
Unusual Attitudes	sway heave pitch roll	Provide lead information on the development of a rapidly developing unusual attitude and the response of recovery control inputs
General and Continuous Atmospheric Disturbance	sway heave pitch roll	Remove the sterility of the smooth no motion environment. The real atmosphere contains frequent disturbances which continually induce minor upsets from the straight and level flight and flight during maneuvers

4. VALIDATION TEST DATA SOURCES AND TEST TECHNIQUES FOR LEVEL B FLIGHT SIMULATOR COMPLIANCE WITH (DRAFT) AC120-40C

***a*. DISCUSSION.** In March of 1996 the FAA AQP Manager and the NSP Manager convened a workshop of Subject Matter Experts to simplify the aerodynamic data and flight testing requirements for Level B flight simulators. The workshop resulted in the following table. These data sources and test techniques may be used in lieu of those otherwise contained in this AC.

***b.* TABLE OF LEVEL B DATA SOURCES AND TEST TECHNIQUES**

120-40C test No	Test Name	Existing Data Source	**Test Objective (Obj)** Proposed Test Technique and Instrumentation	Comment
1. PERFORMANCE				
a. TAXI				
1.a.(1)	Min Rad turn	AFM/Ops Manual	**Obj: Verify ground handling and required ground maneuvering surface area.** None Required	NC
1.a.(2)	Rate of Turn vs Nosewheel Steering Angle		**Obj: Verify that steering is commensurate with airplane steering .** Tiller protractor and video of heading indicator during steady state turn or <u>full rudder pedal steady state turn</u> and video. If less than full rudder pedal is used, pedal position must be recorded. (A single test procedure may not be applicable to all airplane's steering systems, therefore appropriate measurement procedures should be devised and proposed for FAA concurrence.) If heading change rate and speed are constant, ground speed can be calculated, otherwise groundspeed must be measured by accepted methods.	Rev
b. TAKEOFF				
1.b.(1)	Ground Acceleration	Cert Data TIR AFM	**Obj: Confirm the simulator model ground performance during acceleration.** As currently permitted by 40B. Also, could use stop watch, calibrated A/S and rwy markers to acquire data during a takeoff with power set before brake release. Power settings hand recorded. If an inertial measurement system is installed, speed and distance may be derived from acceleration measurements.	Rev
1.b.(2)	Min Cont Spd, Grd	Cert Data TIR AFM	**Obj: Confirm the simulator on ground aerodynamic controls, thrust and control models.** Available in AFM, Required Certification Test	NC

1.b.(2)	Alternative to Min Cont Spd, Gnd	None	**Obj: Confirm the simulator on ground aerodynamic controls, thrust and control models.** Rapid throttle reductions at speeds near Vmcg recording yaw rate, control inputs etc. The nose wheel must be free to caster, or equivalently freed of sideforce generation. The applicant for simulator qualification must demonstrate that the simulator yawing moment due to asymmetric thrust and the rudder yawing moment to compensate are the same as those of the airplane. Inertial measurement system and cockpit control force and position measurement device.	** Rev
1.b.(3)	Min Unstick Speed	Cert Data TIR	**Obj: Confirm low speed elevator effectiveness in ground effect and confirm lift model at high angle of attack in ground effect.** Required speed definition for Part 25, not defined for Part. 23 Commuter Category. Rotate, using full elevator input, at a speed less than V_R, hold a constant attitude until lift off etc. The test and procedure are described in AC 25-7 para 10. B.(5) which should be consulted for the test procedure. An equivalent test may be used for Part 23 Commuter Category airplanes for which V_{MU} is not an airplane certification requirement. The elevator effectiveness and lift computation for the simulator must be verified by comparison to the airplane. Inertial measurement system and control input measurement devices.	** NC
1.b.(4)	Normal Takeoff	Cert - Performance Only	**Obj: Confirm the overall performance and handling of the simulator model during ground, lift off and transition through ground effect, and initial climb operations.** Calculate AOA from pitch attitude and flight path. Inertial measurement system, radio altimeter, video of calibrated aircraft instruments, Force and position measurement on cockpit controls.	** NC
1.b.(5)	Critical Engine Failure on Takeoff	Performance data available from certification	**Obj: Confirm simulator model response to a critical engine failure during the take off run, corrective control inputs, effect on takeoff distance, and initial climb with one engine inoperative.** Need is aircraft dynamic response to engine failure and control inputs required to correct flight path. Inertial measurement system and video system. Omit AOA measurement. Measure heading and lateral acceleration.	** Rev
1.b.(6)	Crosswind Takeoff	None, except limiting crosswind	**Obj: Confirm proper response of simulator model, including flight controls, to a crosswind during take off and post lift off.** Inertial measurement system, video of calibrated aircraft instruments, Control forces measurement device, Omit AOA. Measure heading and lateral acceleration. The wind profile should be specified. The 1/7 law to 10 meters is suggested as an acceptable wind profile model that is now in use.	** Rev
1.b.(7)	Rejected	None		Rev

c. CLIMB				
1.c.(1)	Normal Climb, all engines	Certification data, TIR, AFM,	**Obj: Confirm simulator model climb performance.** As now permitted by 40B, could also do with stop watch and calibrated ships airspeed system	Rev
1.c.(2)	Second Segment Climb, One Engine Inoperative	Certification data, TIR, AFM	**Obj: Confirm simulator model climb performance in airplane take off configuration with one engine inoperative.** As now permitted by 40B, could also do with stop watch and ships calibrated airspeed system	Rev
1.c.(4)	Approach Climb, one engine inoperative	Certification data, TIR, AFM	**Obj: Confirm simulator model climb performance in airplane approach configuration with one engine inoperative.** As now permitted by 40B, could also do with stop watch and ships calibrated airspeed system	Rev
e. STOPPING				
1.d.(1)	Deceleration Time and Distance, Wheel Brakes	Certification data, landing distance tests, TIR, AFM	**Obj: Confirm simulator overall lift, drag and wheel braking model on the ground.** None Required if time to stop is available in certification data	Rev
1.d.(2)	Deceleration Time and Distance, Reverse Thrust	None	**Obj: Confirm simulator on ground overall lift, drag and thrust modeling with reverse thrust.** Landing Tests, stop watch, runway markers, video, calibrated aircraft instruments. Thrust control lever positions and engine output (pertinent parameters) must be recorded.	Rev
f. ENGINES				
1.e.(1)	Acceleration	None	**Obj: Demonstrate that the simulator engine model responds correctly during the specified condition.** Calibrated aircraft instruments, video with time read out.	Rev
1.e.(2)	Deceleration	None	As above	Rev
2. HANDLING QUALITIES				
a. STATIC CONTROL CHECKS				
2.a.(1)	Column Position vs Force	Maintenance Manual for surface to column calibration	**Obj: Confirm model of flight control system force, position and friction relationships.** Control force and position measurement device and x - y recorder needed. Surface position could be measured from FDR sensor or, if no FDR sensor, at selected column positions using a control surface protractor.	* Rev
2.a.(2)	Wheel Position vs Force	Maint Man as above	Same as above	* Rev
2.a.(3)	Pedal Position vs Force	Maint Man as above	Same as above	* Rev
2.a.(4)	Nosewheel Steering Force and Position	None	**Obj: Confirm important nosewheel steering metrics of the simulator model which are important to ground handling.** Use 45A. Measure breakout with hand held force gauge. Use hand held gauge to measure force after breakout for small arc. Predict remainder.	Rev

2.a.(5)	Rudder Pedal Steering Calibration	Acft Design Data	**Obj: Confirm important nosewheel steering metrics of the simulator model which are important to ground handling.** Force pads on pedals, pedal position measurement device, design data for nose wheel position. (Turn radius will be compared to AFM at full pedal, and possibly other, deflections also) [See 1.a.(2) above]	* Rev
2.a.(6)	Pitch Trim Calib. Indicate vs Compute	None	**Obj: Validate the simulator model pitch trim calculation.** Calculated	NC
2.a.(7)	Power Lever and other engine control levers Angle vs Engine Indication	None	**Obj: Confirm that given engine control lever positions result in the proper engine performance indications.** Fabricate scale to use on throttle quadrant. Video camera to record steady state instrument readings or hand record steady state engine performance readings	Rev
2.a.(8)	Brake Pedal Position vs Force	Acft Design Data	**Obj: Assure that the brake pedal produces the appropriate force feedback for a given brake pedal position.** Use design/predicted data. As for Level 6, measure only at 0 and maximum and use acft design data curve for deflections between extremes	* Rev
c. LONGITUDINAL				
2.c.(1)	Power Change Dynamics	None	**Obj: Confirm the correct simulator model dynamic response to an in flight airplane power or configuration change.** Do as per AC120-40B. Inertial measurement system would then be required. Transient data is needed therefore the dynamic case must be done.	** NC
2.c.(2)	Flap/Slat Change Dyn	None	Same as above	** NC
2.c.(3)	Spoiler/ Speedbrake Change Dyn	None	Same as above	** NC
2.c.(4)	Gear Change Dynamics	None	Same as above	** NC
2.c.(5)	Gear Flap Slat Operating Time	Design Data, Certification Tests	**Obj: Assure that the simulator model configuration change time increment corresponds to that of the airplane.** Measure in conjunction with acquisition of data for 2.c.(1), (2), (3), (4) above. Statement of compliance referencing an appropriate data source. [Such as design data, production flight test schedule, maintenance test specification etc.]	Rev
2.c.(6)	Longitudinal Trim	Certification Tests (limited)	**Obj: Confirm that simulator model parameters are correct in level flight steady state conditions.** Inertial measurement system for pitch attitude, cockpit controls position measurement equipment with a calibration of cockpit controls positions and surface positions, ships engine instruments, do a number of level runs in accordance with the guidance of AC120-40B.	** Rev

2.c.(7)	Longitudinal Maneuver Stability	Certification Tests, TIR	**Obj: Confirm the simulator model longitudinal control force as a function of normal acceleration.** Ships calibrated airspeed indicator. Apply a temporary high resolution bank angle scale to attitude indicator, inertial measurement system and wheel/column force measurement device.	** NC
2.c.(8)	Longitudinal Static stability	Certification Tests TIR	**Obj: Confirm the simulator model longitudinal control force as a function of airspeed increments from trim airspeed.** Ships instruments, hand held force gauge	NC
2.c.(9)	Stick Shaker, Airframe Buffet, Stall Speeds	TIR, AFM	**Obj: Confirm that the simulator model produces stall at the correct airspeed and incorporates the appropriate warning modeling at airspeeds approaching the stall.** Acquire using stop watch, ships calibrated airspeed, and video, hand record flight condition and configuration. The speeds are available in the TIR and AFM. Consideration should also be given to stall characteristics	NC
2.c.(10)	Phugoid	None	**Obj: Confirm that the phugoid is correct as this mode is indicative of certain features of the longitudinal aerodynamic model and is very important to longitudinal trim ability.** Inertial measurement system is necessary to accurately measure this important response. Cockpit controller positions are also important, especially in cases where the dynamics of flight control system components alter the character of the response.	** NC
2.c.(11)	Short Period	None	**Obj: To assure that this primary longitudinal maneuvering mode is correctly produced by the simulator model.** Inertial measurement system, measuring primarily accelerations (normal), video	** NC
d. LATERAL DIRECTIONAL				
2.d.(1)	Minimum Control Speed, Air	Certification Tests, TIR,	**Obj: Confirm the minimum airspeed at which control can be maintained with one engine inoperative. Control force and deflection, asymmetric thrust and overall handling approaching and at the minimum control speed are important and should be recorded.** Inertia measurement system, cockpit control force and position measurement device. An alternative procedure to measuring just the minimum speed at which control can be maintained is to measure the needed control deflections and other parameters at several speeds as the speed approaches the minimum control speed and as close as possible to the minimum speed in order to develop several simulator validation points at progressively lower speeds	** NC
2.d.(2)	~~Roll Response (Rate)~~	~~None~~	~~Stop watch, ships calibrated instruments, high resolution scale on attitude indicator, FDR sensor for lateral control (wheel) deflection. Do roll in both directions using a number of wheel deflections and measure only the steady state rates. Video of instruments~~	* Delete

2.d.(3)	Roll Response to Step Input	None	**Obj: Confirm that the simulator model properly produces this primary lateral-directional dynamic response mode and produces the correct steady state roll rate.** Inertial measurement system to obtain rates. Lateral control input measurement device, video . Cruise case in addition to flight conditions specified in AC120-40B	** Rev
2.d.(4)	Spiral Stability	None	**Obj: Confirm that the simulator model properly produces this primary lateral-directional dynamic response mode.** Stop watch, ships calibrated instruments, high resolution scale on attitude indicator or video	NC
2.d.(5)	Engine Inoperative Trim	None	**Obj: Validate simulator trim or control deflections required to counterbalance engine inoperative asymmetric forces and moments.** Apply high resolution scales to trim controls and perform a ground calibration using protractors on the control/trim surfaces (ignores airloads). Use control scales for in-flight measurements. Very system dependent, but similar methods for other controls. Alternatively measure cockpit control force and position, especially during second segment climb where trimming is not a certification requirement and not a task to be accomplished in flight until the proper altitude and conditions are satisfied.	Rev
2.d.(6)	Rudder Response	None	**Obj: Validate simulator model short term transient response to rudder inputs.** Inertial measurement system, Rudder pedal input position measurement device.	** NC
2.d.(7)	Dutch Roll	None, maybe TIR	**Obj: Confirm the lateral-directional simulator modeling as manifest by this coupled primary response mode.** Inertial measurement system. Record with and without yaw damper. Rudder pedal input position measurement device.	** NC
2.d.(8)	Steady State Sideslip	None, maybe TIR	**Obj: Confirm the relationship that exist between sideslip and rolling moment and secondarily the rudder and roll control power.** Use ground reference (a long straight path) for track and heading indicator for sideslip angle. Cockpit controller force and positions measurement device. If inertial measurement system is installed, measure lateral acceleration. Video. This test was not discussed during SME meeting. Revisions have been made based on the overall discussions.	* Rev
e. LANDINGS				
2.e.(1)	Normal Landing	None	**Obj: Confirm the overall performance and handling of the simulator model during descending flight near the ground, transition through ground effect, landing flair and touch down.** Inertial measurement system, cockpit control force and position measurement device	** NC

2.e.(3)	Crosswind Landings	None	**Obj: Confirm proper response of simulator model, including flight controls, to a crosswind during descending flight near the ground, transition through ground effect, decrab and touchdown/rollout.** Inertial measurement system, cockpit controller positions and forces, record normal and lateral acceleration in lieu of AOA and sideslip.	** NC
2.e.(4)	One Engine Inoperative Landing	None	**Obj: Confirm proper response of simulator model, including flight controls, with one engine inoperative during descending flight near the ground, transition through ground effect, touchdown and rollout.** Same as above	** NC
2.e.(7)	Rudder Effectiveness with Rev Thrust	None	**Obj: Demonstrate that the rudder effectiveness during reverse thrust on landing in the simulator is representative of the airplane.** No test recommended since the test was specific to airplanes with aft fuselage mounted engines	Delete
f. GROUND EFFECT				
2.f.(1)	Ground Effect Demonstrate G.E.	None	**Obj: Confirm the simulator modeling and proper aerodynamic modeling changes as a function of height and rate of change of height in ground effect.** Level fly-by trim runs. Use high resolution scale on elevator trim control. Ground calibrate Trim control with trim surface. Use ships calibrated flight instruments and engine instruments, video of trim controls and aircraft instruments. Or fly low angle constant pitch attitude approach and landing at constant power and record trim, control displacement and airspeed changes as ground is approached (not applicable to all airplanes). Inertial measurements system, cockpit controller force and positions, radio altitude and altitude rate are needed.	** Rev

Comments Legend

** tests for which an inertial data acquisition system is recommended - 20 tests
* tests for which some instrumentation less than inertial is recommended - 6 tests
Total number of tests requiring installation of instrumentation - 26
Total number of tests listed - 48

NC no change from the current AC120-40B guidance

Rev revision of the current AC120-40B guidance, usually by the use and acceptance of existing data sources or the use of more basic (less sophisticated and complex) flight test methods.

Notes:

1. Measurement of angle of attack and sideslip have been omitted for all tests. Also measurement of control surface positions is not required, however, cockpit controller positions must be measured where indicated and tolerances comparable to those for the control surface determined. These measurements alone result in revision to most Level B validation tests.

2. With the exception of the alternative, and in some cases relieving, techniques and instrumentation recommendations given above, all tests should be done to comply with the guidance of AC120-40C.

3. Measurements of control surface deflections/positions have been omitted in the above table, however, cockpit controller positions must be substituted and equivalent tolerances will have to be used when complying with AC120-40C Level B simulator qualification guidance.

4. To accommodate the recommended test methods and techniques, some measurements would be replaced with pilot's notes.

5. Certification/TIR data points are usually at the extremes of weight and CG, but still lie on the locus of a given parameter and are useful for model validation.

6. TIR data may be proprietary and should not be relied upon until known to be available.