Transcript of the

Joint FAA/Industry Symposium

on

Level B Airplane Simulator Aeromodel Validation Requirements

To the Memory of Daryl Schueler

Part 7 of 7

Appendix:

Longridge, T., Ray, P., Boothe, E., & Bürki-Cohen, J. (1996). Initiative towards more affordable flight simulators for U.S. commuter airline training. *Royal Aeronautical Society Conference on Training - Lowering the Cost, Maintaining the Fidelity* (pp. 2.1-2.17), London, UK

Washington Dulles Airport Hilton
March 13 - 14, 1996

INITIATIVE TOWARDS MORE AFFORDABLE FLIGHT SIMULATORS FOR U.S. COMMUTER AIRLINE TRAINING

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Abstract

Recent regulatory action, coupled to a policy of encouraging commuter airlines to conduct all pilot training and checking activities in ground based equipment, has created an impetus to consider how best to ameliorate the conditions which have discouraged the use of such equipment for pilot recurrent training by commuter airlines in the United States. This paper compares the relative merits of permitting additional recurrent training credit for enhanced flight training devices versus revising the qualification standards for Level B full flight simulators to achieve enhanced affordability. The current status of an ongoing Level B flight simulator qualification standards review, results to date, and future plans, including plans for the development of a comprehensive applied research program, are discussed.

Background

The use of flight simulators for initial and recurrent pilot training by U.S. major airlines is universal, and its effectiveness is well recognized. However, the use of such equipment by smaller U.S. commuter airlines is mixed. While many commuter airlines use approved simulator resources available from aircraft manufacturers and training centers for initial pilot certification, smaller airlines frequently do not make use of such equipment for recurrent pilot training, due to various considerations, such as cost, convenience, and flight simulator availability. For airlines employing small aircraft, the per hour cost of operating an aircraft for training may compare favorably with the cost of contracting for simulator time. For some commuter aircraft, simulator resources may be very limited in availability, and they may be inconveniently located geographically for U.S. operators.

On 20 December 1995, the Federal Aviation Administration (FAA) issued a new regulation (Ref 1) applicable to all airlines that operate scheduled air carrier service in airplanes having ten or more passenger seats. This new regulation, Part 119 of Title 14, Code of Federal Regulations (14 CFR), encompasses all scheduled commuter airlines that operate airplanes of 10 or more seats under 14 CFR, Part 135. Among its provisions, it requires all such airlines to conduct pilot training and evaluation in accordance with the same provisions of the Federal Aviation Regulations (FAR) that apply to major airlines, namely 14 CFR, Part 121. These changes are intended to encourage one standard of safety for all air carriers, regardless of the size of their aircraft or the range of their flight operations. In concert with these new rules, the FAA has adopted a policy of encouraging commuter airlines to transition their pilot training programs out of the aircraft and into ground-based training equipment. However, it is likely the effective realization of this policy will not occur until the major obstacles which have historically restricted access of commuter airlines to such equipment, namely cost, convenience, and availability, are removed. If this is to occur on a timely basis, the FAA must act proactively in meeting the needs of the commuter airlines for affordable training equipment. The FAA has also concluded that for any such effort to be successful without compromising safety, it must be accomplished without degradation in the qualification standards for such equipment.

The FAA qualification requirements for a flight training device (FTD) are defined by Advisory Circular (AC) 120-45A (Ref 2), which defines seven levels of such equipment. The credit permitted for a corresponding FTD level is proscribed as an appendix to the FAA Practical Test Standards, as revised (Ref 3). Within the U.S., the Regional Airline Association has proposed that the FAA consider expanded options for the use of FTDs, a proposal which has also been enthusiastically endorsed by those equipment manufacturers for whom FTDs constitute a principle product line. The proposed strategy would entail an upgraded Level 5 or Level 6 FTD, consisting of an enhanced aeromodeling package and the addition of some type of visual image generation and display system. In some proposals, the addition of a low cost, small throw, three or four degree-of-freedom motion platform has also been discussed, although design specifications and associated capabilities have yet to be clearly defined. This enhanced FTD alternative is considered appealing by its proponents, because, provided the FAA were to agree to allow full credit for the use of such equipment in recurrent training and checking, it appears that this proposal would have the potential of addressing all of the major obstacles discussed above.

From a regulatory perspective, however, there are certain drawbacks to this proposed approach. The first such drawback concerns the need for standardization in equipment qualification, in order to maintain acceptable standards of safety for pilot training and checking. As the purposes for which the FAA established the category of equipment called FTD did not incorporate an intent to address the full spectrum of pilot training needs, the existing FTD qualifications standards are not applicable to the use of these devices for such broad purposes. FTDs were established for use within an overall air carrier pilot training curriculum, which must either employ a full flight simulator (FFS), or the aircraft itself, as an essential component. The FFS provides an FAA-qualified vehicle for training and testing the skill integration required for the full range of flight operations. The FTD provides an FAA-qualified vehicle for mastering the skills associated with individual flight tasks, particularly procedural skills. Use of an FTD better enables matching training objectives to training equipment, by virtue of permitting training on lower level enabling objectives to occur on lower level equipment.

This practice clearly permits more efficient use of FFS time, by concentrating use of the latter on those skills for which the FTD is not a suitable vehicle - namely, flight operations training and evaluation, in which the training equipment must be capable of presenting a full representive range of operational tasks, conditions, and contingencies. While the FAA has authorized training and checking credit for certain individual flight maneuvers to be accomplished in an FTD, the FAR also require that the demonstration of pilot proficiency for certain other tasks be completed in an appropriately qualified FFS, or in an aircraft, as part of the air carrier's approved overall training program. For recurrent pilot training proficiency checks, unless the landing maneuvers are accomplished in a Level B or higher FFS, evaluation of proficiency on these maneuvers must be conducted in the aircraft, typically accomplished by the satisfactory completion of at least two landings during the required operational (line) evaluation. In addition, 14 CFR Part 121 requires that recurrent windshear training be accomplished annually in a FFS.

In 1990 the FAA issued Special Federal Aviation Regulation (SFAR) 58, Advanced Qualification Program (AQP), which created a voluntary alternative to the traditional 14 CFR Part 121 requirements for pilot training and checking (Ref 4). SFAR 58 provides a regulatory mechanism on which basis the FAA may approve significant departures from traditional requirements, including the authorized use of equipment for training. It has been argued by some in the training development community that "..... qualification of ground-based devices for training needs to be based on their effectiveness for that purpose, not solely on their verisimilitude to an airplane" (Ref 5), and that ".....what an effective simulation requires is as many of the psychophysical, cockpit management and communications demands as possible, rather than technical, physical, or aerodynamic fidelity to a particular aircraft type. Suitable simulation devices thus need "functional" fidelity and the simulation scenario must ensure appropriate "operational" and "embodied" fidelity." (Ref 6). Under AQP it is possible to conduct pilot training which is fully consistent with this philosophy, and to obtain FAA approval for the use in an AQP curriculum of equipment based upon such functional considerations, rather than on engineering criteria. It is not possible, however, to conduct the evaluation of end-level pilot proficiency in such equipment.

In the U.S., as in many other countries today, regulations permit pilot training, qualification, and certification to be conducted entirely in ground-based equipment. Pilots qualified on such a basis are permitted to perform immediately as cockpit crewmembers in aircraft which fly passengers in revenue operations, albeit under the supervision of a check airman during the initial operating experience which follows upgrade or transition training. Recurrent training for continuing qualification of pilots can be accomplished entirely in ground-based equipment. Consequently, it is critical to safety that the ground-based equipment employed to evaluate end level proficiency for such purposes be qualified as replicating the aircraft over the full range of operational tasks, conditions, and contingencies.

Even in AQP, therefore, there are clear restraints on the use of equipment for assessing terminal proficiency. Such equipment must be qualified by the FAA, and it must be approved for its intended use as AQP proficiency evaluation media. AQP does offer considerably flexibility with respect to the use of FTDs for the progressive sign-off of proficiency on individual objectives, including training to proficiency on technical and/or cognitively oriented objectives. However, the final criterion for successful completion of an AQP curriculum is the formal evaluation of proficiency in realistic operational scenarios that test a diagnostic sample of technical and cognitive skills in a systematically developed Line Operational Evaluation (LOE), which is designed to test both sets of skills together. The FAA has determined that only a qualified FFS is an acceptable media for LOE.

Authorization of an "enhanced" FTD to accomplish recurrent training and checking, whether for credit on specific maneuvers under a traditional 14 CFR Part 121 program or under SFAR 58 with respect to evaluation on specific proficiency objectives, would require the development of appropriate equipment qualification standards for the modified configuration of devices to be employed for those purposes. Alternatively, it would necessitate the application of existing FFS qualification standards to the enhanced components of that equipment. It would also require modification to, or exemption from, the existing FAR pertaining to the requirements for FAA approval of an air carrier's pilot training program under Part 121. Since the enhancements to an FTD necessary to justify these actions would in effect be identical to those required to upgrade the device to a FFS, it is highly questionable whether this proposed course of action is warranted.

From an FAA perspective, a more rationale course of action would be to take the existing qualification standards for a Level B simulator as a starting point, and determine (a) whether more affordable means of meeting those equipment standards can be achieved, and (b) if certain revisions to those qualification standards can be accomplished which would enhance affordability without degrading the quality of equipment performance. AC 120-40B (Ref 7) defines four FFS levels - A, B, C, and D. Of these, Level B appears to be the most logical target for this endeavor, because it can be used for 100% of recurrent training, equipment for recurrent training use is among the most significant cost considerations for U.S. commuter airlines, and the engineering requirements for a Level B simulator are such that the likelihood of a successful outcome for this review is higher than would be the case for a Level C or D simulator. Most U.S. regional airlines are already using a Level C or D FFS for initial and transition pilot training. Their use for that purpose is recognized as cost effective, but the cost of purchasing or leasing access to that level of equipment for pilot recurrent training is not considered to be acceptable by many commuter airlines, which continue to find it financially advantageous to conduct recurrent training and checking in the aircraft. Few, if any, Level B (or Level A) simulators are presently available for use with commuter class aircraft in the U.S..

The choice of a Level B simulator as a target system is driven by the stated policy of the FAA to encourage commuter airlines to conduct all of their training in ground-based equipment, rather than in the aircraft. While a Level A simulator can be employed under 14 CFR Part 121 to accomplish most of the requirements for aircraft specific recurrent pilot training and checking, the regulations require that if limited to that level of equipment, then two landings under the observation of a check airman must also be accomplished in the aircraft within the due period of the proficiency check for a given pilot. As previously noted, the two landings are typically observed during the required operational (line) evaluation, thereby necessitating at least two flight segments. If a Level B simulator is utilized for the proficiency check, the line checking requirement may be satisfied with a single flight segment, thereby potentially reducing the workload on check airmen by 50%. Another consideration for choice of Level B as the starting point concerns the feasibility of generalizing between equipment levels. Downward extension from Level B to Level A would appear to be more practical than attempting to extrapolate in the opposite direction..

Accordingly, the FAA is undertaking a comprehensive review of the equipment qualification standards for Level B FFS. This effort constitutes the initial phase of a systematic, multi-year program of FAA-sponsored flight simulator applied research, intended to provide empirical data on the relationships between training equipment engineering characteristics, pilot cueing requirements, equipment cueing effectiveness, and equipment pilot training and evaluation effectiveness. As results become available, they will be presented by the FAA for discussion and potential application internationally.

FAA efforts regarding this issue are supportive of ongoing international initiatives to improve the quality of simulation and its use. The FAA actively supports the recently adopted international standards for Level I and II simulators, as exemplified by their incorporation into FAA Level C and D simulator qualification standards. This paper will describe the current status of the Level B flight simulator qualification standards review, progress to date, and future plans, including plans for the development of a comprehensive applied research program. The paper constitutes a description of work in progress.

Review of Level B Simulator Qualification Standards

The baseline for this review is AC120-40B and the simulator validation tables therein. The review is being conducted on a progressive basis, beginning with the data requirements for validation of the aeromodel for a Level B flight simulator, since this consideration is fundamental to the fidelity of the simulator's handling characteristics, and is crucial for pilot acceptance of such equipment as a substitute for the aircraft. The second priority for this review is Level B flight simulator motion cueing. The third priority is Level B flight simulator visual display technology. Although there are other considerations to simulator validation, the FAA has determined that these three priorities have the biggest potential for success relative to achieving increased flight simulator affordability. To date, however, only the aeromodel review has been initiated.

Aeromodel Validation

In initiating a review of those portions of AC120-40B pertaining to the validation of the aeromodeling for a Level B simulator, each test was examined with regard to the following questions: Given a commuter class aircraft with wing mounted turboprop engines, (a) what is the objective of this test? (b) is the test important to simulator fidelity from the perspective of what the pilot actually sees and feels in the cockpit? (c) are there modifications to the test that would reduce costs without seriously impacting simulator handling characteristics? and (d) are there modifications to the flight data instrumentation requirements that would reduce costs without seriously impacting the reliability and validity of the aeromodel verification process? A meeting of selected subject matter experts from industry, academia, and government in the disciplines of aerodynamic modeling, aircraft flight test instrumentation, simulator qualification, aircraft certification, and air carrier pilot training was convened to examine the tests in light of the above questions. The results of this review are summarized in Table I, and the verbatim transcript of the proceedings from this meeting has been documented (Ref 8).

As Table I indicates, changes were proposed to more than half of the existing tests. Of 48 total tests, 27 were changed, including two which were deleted entirely - (2.d.(2): Roll Response Rate, and 2.e.(4): Rudder Effectiveness with Reverse Thrust. The most significant change was the elimination of angle-of-attack and control-surface-position measurements from all flights tests. While these recommendations do not depart dramatically from the existing requirements of AC120-40B, it is estimated that the net effect of adopting these proposed changes would be a savings of at least 25% in the cost of flight simulator validation, by virtue of reduced requirements for certain flight test instrumentation. For example, for Crosswind Landing - 2.e.(2), and Engine Inoperative-2.e.(3), the replacement of angle-of-attack and sideslip measures with normal and lateral acceleration measures would result in a significant instrumentation savings. While all these proposed changes would simplify flight testing and thereby reduce costs, it was the consensus of the review team that the quality of Level B simulator performance would not be adversely affected for pilot recurrent training purposes.

In addition to a review of FAA simulator qualification requirements as embodied in the AC120-40B validation tables, consideration was given to the feasibility of using predictive modeling as a substitute for the flight test data typically required by the simulator manufacturer in order to tune an aeromodel to better match aircraft handling characteristics throughout the maneuver envelope. The use of flight data for this purpose is not a requirement of the objective tests specified in the FAA validation tables, which tend to reflect the acquisition of data taken from the middle of the flight envelope during steady state conditions. Nevertheless, simulator manufacturers have historically required flight data beyond that required for FAA objective tests, in order to refine the equations of motion so that simulation of aircraft dynamics is acceptable for the purposes of FAA-required subjective tests, and ultimately, for pilot acceptance. This requirement can add to the overall cost of the data package for a given flight simulator.

Considerable progress has been made in recent years in the use of predictive modeling techniques to generate estimated flight data. In conjunction with increased accessibility to very high-powered computer technology, these techniques have become quite sophisticated. Moreover, it has been possible to refine the precision of such models by comparisons of their output with actual flight data on an iterative basis over a period of years. Indeed, the use of such techniques has become standard practice for simulator manufacturers, as a means of establishing new simulator configurations pending the availability of actual flight test data. These techniques are also gaining acceptance as a means for transport category aircraft manufacturers to reduce the amount of actual flight testing required for certification of variants from a previously flight-tested aircraft make and model.

If predictive modeling can be successfully used to significantly reduce the requirement for flight data needed for aerodynamic model programming, it is estimated that an additional reduction of 25% in the cost of a simulator data package could be achieved. It was the consensus of the review team that this proposal has merit, and warrants further exploration, though it remains to be satisfactorily demonstrated that this approach would produce sufficiently accurate results for commuter class turboprop aircraft. The net cost savings for the flight test data package, which would result from the proposed validation table changes, and the use of predictive modeling as the primary source for supplemental flight data, is estimated to be 50%.

Motion Cueing

There is probably no topic in the domain of flight simulation in more dire need of a unified approach to the quantitative analysis of flight simulator cueing requirements than that of motion cueing. In the absence of tools for that purpose, the continuing controversy over motion extends to diametrically opposing arguments (Ref 9, 10, 11, and 12), resolution of which is unlikely to ever occur unless a systematic program of properly designed research is undertaken to develop the requisite methodologies and to conduct the necessary critical studies. Surprisingly little satisfactory progress has occurred toward that end in recent years.

The presently described FAA program is committed to the application of resources to address this need, but this effort is only in an early planning stage, and it remains to be determined whether such a program will be more successful than previous endeavors in this arena. In the meantime, the FAA must move forward to address the motion cueing considerations that would be applicable to updating the qualification requirements for a Level B flight simulator. Pending the availability of new scientific data, decisions in this regard must be based on the existing literature, and on best expert judgment.

In light of the current state of knowledge (Refs 13, 14, 15, 16, and 17), the FAA has determined that both Level A and B full flight flight simulators must continue to be equipped with full-body-motion capability. Remaining at issue is whether the existing standards for motion platform performance for a Level B simulator should be left unchanged, or whether, in the interest of equal or better fidelity at reduced cost, modifications may be warranted. The objective tests in AC120-40B only directly address motion platform hardware performance, not motion drive software, which is only indirectly assessed by virtue of subjective acceptance testing. Consequently, there is presently no defined standard which validates that the motion system *per se* provides appropriate cueing. Nor is there a requirement for objective tests which specifically address acceptable phase lag relationships between flight simulator visual and motion systems, though there is ample data that the lack of simulator fidelity for onset cueing therein can not only impact motion perception (Refs 14, 15, and 17), but it can be a contributor to simulator sickness (Ref 18). While consideration of additional standards or guidelines along these lines might on the surface appear to risk increasing rather than reducing the costs for a Level B simulator, it is entirely possible that the establishment of such standards could enable increased regulatory flexibility with respect to approval criteria for alternative full-body-motion simulator system configurations. For this reason, these issues will be addressed as part of the FAA's comprehensive Level B simulator qualifications standards review.

Visual Image Generation & Display Technology

The existing requirements in AC120-40B for simulator visual image generation systems could be considered to be minimal, given the progress that has occurred in the capabilities of commercial off-the-shelf technology (COT), and the associated significant drop in the cost of such systems during the past decade. Not only are relatively inexpensive full-color, photo-texture-capable image generation systems suitable for Level B simulator use available in the marketplace, but user friendly, relatively inexpensive data base modeling systems are also available, as a result of which there does not appear to be any requirement to address image generation from either the perspective of the FAA Level B qualification standards review, or planned research. On the other hand, progress in the development of affordable visual system display technology, though evident, has been less dramatic. Until recently, there have been few alternatives to calligraphic displays, or to hybrid rastergraphic/calligraphic displays, suitable for meeting FAA Level B qualification standards for approach and runway lights. Similarly, although Level B standards do not explicitly call out a requirement for collimated optics, it is unlikely that a display system without such optics could qualify with respect to simultaneous field-of-view, sink rate cueing, and depth perception. Although Level B qualification standards only specify a requirement for a 45 H by 30 V degree field-of-view for each pilot, the provision of such displays systems can be relatively expensive. No change in the existing standards for Level B simulator display systems is contemplated. However, it is planned to seek the recommendations of subject matter experts concerning alternatives for more affordable display technology capable of meeting existing Level B standards.

Future Plans

Practical Applications

Plans for the immediate future include convening groups of recognized subject matter experts in the areas of simulator motion cueing, as well as simulator visual display technology, respectively, for the purposes of reviewing the existing AC120-40B qualification standards for Level B flight simulators in light of the considerations discussed above, and formulating recommendations to the FAA that could enhance simulator affordability without degrading quality of performance.

Following FAA review, collation, and integration of expert input on aeromodeling, motion systems, and visual display systems, the FAA will publish an addendum to AC120-40, as revised, which will incorporate any appropriate revisions to qualification standards for Level A and B full flight simulators.

Planned Research Program

Planning for an FAA-sponsored comprehensive simulator research program is still in development. The research plan will not be finalized until the recommendations from the remaining subject matter expert groups discussed above are available, and a presently ongoing review of the pertinent scientific literature in these areas has been completed. However, certain research priorities have already emerged for the immediate future. First, with regard to the use of predictive modeling as a substitute for the supplementary flight data used to tune the math model, the FAA will sponsor research to compare the results of predictive modeling with actual flight data for commuter class turboprop aircraft. Provided the results of that endeavor are positive, the characteristics of effective strategies for the use of predictive models to generate valid data estimates, and the properties of effective models for that purpose, will be documented. This information will be disseminated to industry. Concommitantly, the FAA will seek recommendations on whether guidelines for the application of such models to flight data estimation should be incorporated into agency advisory materials.

Secondly, a research program to address the key unanswered issues in flight simulator motion cueing for transport category aircraft will be designed and initiated. Such a program must advance our state of knowledge regarding the critical interactions between the human visual/somatosensory/vestibular senses relating to motion, simulator hardware characteristics, simulator software-drive algorithms, and the transfer of pilot performance to the aircraft. As a minimum, this research must resolve the question of whether whole-body cueing information is needed for performance of particular flight tasks in the simulator, and if so, whether its presence or absence impacts transfer of pilot performance on those tasks from the simulator to the aircraft. If simulator motion is needed for particular maneuvers, then research must establish the nature of the translational, linear acceleration, and angular acceleration motion cueing required for those maneuvers. Since it is known that there exists a powerful interaction between visual perception and motion perception (Ref 9), if motion cueing is needed, then research must address the requirements for the synchronization between visual and motion cueing systems. Given that a Level B simulator only requires a 45 H by 30 V degree field-of-view per pilot eye point, the research must include consideration of field-of-view size effects on visually induced motion perception, and the associated interaction of visual field size with whole-body motion cueing. And in particular, since a flight simulator is restricted in its physical capacity to provide translational and acceleration motion cues, if motion cueing is warranted, research is needed on to how to optimize motion system design, so as to most effectively provide the essential cues, while minimizing false cues.

Though none of these questions are new, all of them remain controversial, despite the existing body of research literature. It is therefore appropriate that they should be reexamined in light of the most recent improvements in simulator visual and motion system technology, with a focus on better quantifying the relationships between the pertinent engineering and behavioral variables.

Conclusions

The FAA is undertaking a proactive effort to increase the accessibility of flight simulators to commuter airlines for use in recurrent pilot training in the United States. This strategy entails examining the qualification standards for a Level B simulator, to determine whether revisions which enhance affordability without degrading fidelity may be feasible. The most immediate product of this ongoing effort will be an update to AC120-40, as revised, addressing modified qualification standards for Level A and B flight simulators. It is hoped that this will serve as an enabling initiative for industry, by virtue of providing advance notice of FAA acceptance of more streamlined qualification criteria for such equipment. Whether such equipment will in fact ever be built must be determined by the marketplace. While the FAA encourages the use of FTDs as a means of increasing training efficiency, the FAA does not anticipate any change in the requirement to utilize an approved FFS for accomplishing certain pilot evaluation requirements. The FAA has no plans to authorize the use of an enhanced FTD to substitute for use of a FFS to accomplish those requirements.

In conjunction with its review of Level B qualification standards, the FAA is in the process of initiating a comprehensive program of flight simulator research. The short term goals for this program entail the acquisition of data needed to support the Level B initiative, such as the feasibility of using predictive modeling to generate estimated flight data suitable for use in tuning the simulator aeromodel. On a more long term basis, the research will address certain fundamental issues in flight simulation, such as the contribution of whole-body motion cueing to effective flight simulation training in transport category aircraft. Although still in an early planning stage, the FAA has elected to announce its intentions for such a program in the interest of soliciting suggestions on how it should best be formulated, and for the purpose of seeking partnerships in its execution. The FAA welcomes the recommendations and participation of interested parties to this endeavor.

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Table 1

PROPOSED
VALIDATION TEST DATA SOURCES
AND TEST TECHNIQUES
FOR LEVEL **B** FLIGHT SIMULATOR
(Multi-engine Turboprop Aircraft)

120-40B test No	Test Name	Existing Data Source	**Test Objective (Obj)** Proposed Test Technique and Instrumentation	Comment
PERFORMANCE				
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 full rudder pedal steady state turn 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
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

(Con't)

120-40B test No	Test Name	Existing Data Source	**Test Objective (Obj)** Proposed Test Technique and Instrumentation	Comment
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	**Obj: Confirm simulator model overall on ground performance and modeled wheel brake effectiveness during maximum wheel braking.** Use ground acceleration per 1.b.(1) and stopping per 1.d.(1) except that take off flap settings must be used which may effect the stopping distance.	Rev
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

(Con't)

120-40B test No	Test Name	Existing Data Source	**Test Objective (Obj)** Proposed Test Technique and Instrumentation	Comment
1.c.(3)	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
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
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
HANDLING QUALITIES				
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

(Con't)

120-40B test No	Test Name	Existing Data Source	**Test Objective (Obj)** Proposed Test Technique and Instrumentation	Comment
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
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

(Con't)

120-40B test No	Test Name	Existing Data Source	**Test Objective (Obj)** Proposed Test Technique and Instrumentation	Comment
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
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

(Con't)

120-40B test No	Test Name	Existing Data Source	**Test Objective (Obj)** Proposed Test Technique and Instrumentation	Comment
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 relationships 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
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.(2)	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.(3)	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.(4)	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
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 surfaces 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 AC120-40B.

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 AC120-40B 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

This paper was published in the Proceedings of the Royal Aeronautical Society Conference on Training - Lowering the Cost, Maintaining the Fidelity, 15-16 May 1996, London, UK, pages 2.1-2.17