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Flight Simulation Training Device Qualification Standards for Extended Envelope and Adverse Weather Event Training Tasks; Final Rule

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

14 CFR Part 60

[Docket No.: FAA–2014–0391; Amdt. No. 60–4]

RIN 2120–AK08

Flight Simulation Training Device Qualification Standards for Extended Envelope and Adverse Weather Event Training Tasks

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Final rule.

SUMMARY: The FAA has determined this rule is necessary to amend the Qualification Performance Standards for flight simulation training devices (FSTDs) for the primary purpose of improving existing technical standards and introducing new technical standards for full stall and stick pusher maneuvers, upset recognition and recovery maneuvers, maneuvers conducted in airborne icing conditions, takeoff and landing maneuvers in gusting crosswinds, and bounced landing recovery maneuvers. These new and improved technical standards are intended to fully define FSTD fidelity requirements for conducting new flight training tasks introduced through recent changes to the air carrier training requirements, as well as to address various National Transportation Safety Board (NTSB) and Aviation Rulemaking Committee recommendations. This final rule also updates the FSTD technical standards to better align with the current international FSTD evaluation guidance and introduces a new FSTD level that expands the number of qualified flight training tasks in a fixed-base flight training device. These changes will ensure that the training and testing environment is accurate and realistic, will codify existing practice, and will provide greater harmonization with international guidance for simulation. The amendments will not apply to previously qualified FSTDs with the exception of the FSTD Directive, which codifies the new FSTD technical standards for specific training tasks.

DATES: Effective May 31, 2016. The compliance date of FSTD Directive No. 2 is March 12, 2019. After this date, any FSTD being used to conduct specific training tasks as defined in FSTD Directive No. 2 must be evaluated and qualified in accordance with the Directive.

ADDRESSES: For information on where to obtain copies of rulemaking documents and other information related to this final rule, see ''How To Obtain Additional Information'' in the **SUPPLEMENTARY INFORMATION** section of this document.

FOR FURTHER INFORMATION CONTACT: For technical questions concerning this action, contact Larry McDonald, Air Transportation Division/National Simulator Program Branch, AFS–205, Federal Aviation Administration, P.O. Box 20636, Atlanta, GA 30320; telephone (404) 474–5620; email *larry.e.mcdonald@faa.gov*.

SUPPLEMENTARY INFORMATION:

Authority for This Rulemaking

The Federal Aviation Administration's (FAA's) authority to issue rules on aviation safety is found in Title 49 of the United States Code. Subtitle I, Section 106(f) describes the authority of the FAA Administrator. Subtitle VII, Aviation Programs, describes in more detail the scope of the agency's authority.

This rulemaking is promulgated under the authority described in 49 U.S.C. 44701(a)(5), which requires the Administrator to promulgate regulations and minimum standards for other practices, methods, and procedures necessary for safety in air commerce and national security. This amendment to the regulation is within the scope of that authority because it prescribes an accepted method for testing and evaluating flight simulation training devices used to train and evaluate flightcrew members.

In addition, the Airline Safety and Federal Aviation Administration Extension Act of 2010 (Pub. L. 111–216) specifically required the FAA to conduct rulemaking to ensure that all flightcrew members receive flight training in recognizing and avoiding stalls, recovering from stalls, and recognizing and avoiding upset of an aircraft, as well as the proper techniques to recover from upset. This rulemaking is within the scope of the authority in Public Law 111–216 and is necessary to fully implement the training requirements recently adopted in the Qualification, Service, and Use of Crewmembers and Aircraft Dispatchers final rule (Crewmember and Aircraft Dispatcher Training final rule), RIN 2120–AJ00. See 78 FR 67800 (Nov. 12, 2013).

List of Abbreviations and Acronyms Frequently Used in This Document

AC Advisory Circular
AOA Angle of Attack
ARC Aviation Rulemaking Committee
AURTA Airplane Upset Recovery Training Aid
FFS Full Flight Simulator
FTD Flight Training Device
FSTD Flight Simulation Training Device
ICATEE International Committee on Aviation Training in Extended Envelopes
LOCART Loss of Control Avoidance and Recovery Training Working Group
NPRM Notice of Proposed Rulemaking
QPS Qualification Performance Standards
SOC Statement of Compliance
SNPRM Supplemental Notice of Proposed Rulemaking
SPAW ARC Stick Pusher and Adverse Weather Event Training Aviation Rulemaking Committee
UPRT Upset Prevention and Recovery Training

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I. Overview of Final Rule

This rulemaking defines simulator fidelity requirements for new training tasks to be conducted in Level A through D full flight simulators (FFS) that were mandated for air carrier training programs by Public Law 111–216 and incorporated into 14 CFR part 121. It also addresses the potential lack of simulator fidelity as identified in several NTSB safety recommendations. This final rule establishes new and updated FSTD technical evaluation standards for full stall and stick pusher maneuvers, upset prevention and recovery maneuvers, flight in airborne icing conditions, takeoff and landing maneuvers in gusting crosswinds, and bounced landing recovery maneuvers. This final rule also partially aligns the technical standards for Level C and D (fixed wing) FSTDs that are defined in 14 CFR part 60 with the current international FSTD evaluation guidelines published in the International Civil Aviation Organization (ICAO) document 9625, Edition 4, *Manual of Criteria for the Qualification of Flight Simulation Training Devices.*

This final rule will affect sponsors of previously qualified FSTDs if the devices will be used to conduct the specific training tasks defined in FSTD Directive No. 2. The FSTD sponsor has the discretion to determine if a device needs to be qualified based on whether it will be used for training the defined tasks in FSTD Directive No. 2. Additionally, because many of the technical FSTD evaluation standards in the final rule will become minimum requirements for some newly qualified FSTDs, this final rule will also affect sponsors of Level 7, Level C, and Level D FSTDs that are initially qualified after the effective date of the final rule. In addition to FSTD sponsors, this final rule will also affect data providers, FSTD manufacturers, and other entities that provide products and support to FSTD sponsors in the qualification of FSTDs for training. This final rule does not affect aviation training devices that are evaluated and approved for use outside of 14 CFR part 60.

A general summary of the applicability, compliance dates, and processes used to qualify FSTDs as defined in this rule are included in the following table:

Issue	Rule requirements
How does a sponsor determine if a previously qualified FSTD must be evaluated and qualified for stall, UPRT, engine and airframe icing, bounced landing recovery, and gusting crosswind training tasks as defined in FSTD Directive No. 2?	A previously qualified FSTD that will be used to obtain training, testing, or checking credit in an FAA approved flight training program, regardless of operational rule part, must be evaluated and qualified for the following maneuvers: Full Stall: Training maneuvers in the recognition cues and recovery procedures from a fully stalled flight condition (including recovery from a stick pusher activation) at angles of attack beyond the activation of the stall warning system.

Issue	Rule requirements
	UPRT: Upset recovery maneuvers and unusual attitude maneuvers that are intended to exceed the parameters of an aircraft upset as defined in the Airplane Upset Recovery Training Aid (pitch attitudes greater than 25 degrees nose up; pitch attitudes greater than 10 degrees nose down, and bank angles greater than 45 degrees). Engine and Airframe Icing: Flight training maneuvers that demonstrate the recognition cues and effects of engine and airframe ice accretion. Takeoff and Landing in Gusting Crosswinds. Bounced Landing Recovery Training.
How does a sponsor obtain qualification for stall, UPRT, icing, bounced landing recovery, or takeoff and landing in gusting crosswinds on a previously qualified FSTD?	FSTD Directive No. 2 contains all of the evaluation requirements for the qualification of these individual tasks on previously qualified FSTDs. FSTD sponsors will conduct the evaluations and modifications as described in the Directive and submit any required Statements of Compliance and objective testing results to the National Simulator Program (NSP) using the standard FSTD modification/notification process. The NSP will issue additional FSTD qualification for these tasks once compliance with the applicable sections of the Directive are verified and any necessary FSTD evaluations have been conducted.
How do you determine what portions of the updated qualification performance standards (QPS) appendices are applicable to previously qualified FSTDs?	As described in § 60.17(a), unless specified by an FSTD Directive, previously qualified (grandfathered) FSTDs will retain their original qualification basis under which they were originally evaluated, regardless of sponsor. All retroactive evaluation requirements for previously qualified FSTDs in this final rule are fully described in FSTD Directive No. 2.
What are the compliance dates associated with this final rule for previously qualified FSTDs?	After March 12, 2019, any FSTD being used to conduct the specific training maneuvers (as described in FSTD Directive No. 2) in an FAA approved training program must be issued additional FSTD qualification in accordance with the Directive.
How do you determine what changes in this final rule are applicable to new FSTDs that will be initially qualified after the final rule becomes effective?	With the exception of the full stall evaluation requirements, all FSTDs that are initially qualified or upgraded in qualification level after the effective date of the final rule must meet all new standards in this final rule as applicable for the particular FSTD qualification level requested. The qualification of full stall training tasks will be optional as requested by the sponsor to support FAA approved training being conducted in the FSTD. The qualification of full stall training tasks will be included as part of the list of qualified tasks on the FSTD's Statement of Qualification (SOQ).
What is the compliance date associated with this final rule for new FSTDs that will be initially qualified after the rule becomes effective?	In general, all changes to the part 60 QPS will be effective for all FSTDs that are initially qualified after the effective date of the final rule except as permitted by § 60.15(c).
What is the process to qualify an FSTD using another standard in lieu of the part 60 QPS as permitted by the deviation authority in § 60.15?	Requests for deviation from the part 60 QPS are made to the National Simulator Program Manager (NSPM) and must include justification that demonstrates an equivalent level of safety as compared to the FSTD evaluation requirements of the part 60 QPS. Approved deviations and the supporting evaluation standards will become a part of the permanent qualification basis of the FSTD.

The FAA estimates that it will cost $72.7 million to make the necessary modifications to previously qualified FSTDs which will enable training required by the new Crewmember and Aircraft Dispatcher Training final rule. The training cost for the Crewmember and Aircraft Dispatcher Training final rule provides rental revenue to simulator sponsors which will fully compensate them for their FSTD modification expenses. These simulator revenues were accounted for as costs of the additional training and were fully justified by the benefits in that final rule. The FAA estimates it will cost $1.3 million for the evaluation and modification of engine and airframe icing models which will enhance existing training requirements. If these modifications prevent only one severe injury the benefits will exceed the costs. The estimated cost of $6.9 million to align standards with ICAO will result in improved safety and cost savings.

The costs and benefits of this rule are presented in the table below.

		Present value at a 7% rate	Present value at a 3% rate
FSTD Modifications for New Training Requirements:			
Cost	$72,716,590	$63,610,049	$68,562,049
Benefits	Rational simulator owner will choose to comply.		
Icing provisions:			
Cost	$1,256,250	$1,098,926	$1,184,476

		Present value at a 7% rate	Present value at a 3% rate
Benefits	Only one prevented severe injury valued at $2.5 million makes the icing benefits exceed the costs.		
Aligning Standards with ICAO: Cost	$6,875,000	$5,356,979	$6,132,690
Benefits	Improved safety and cost savings.		
Total Cost	$80,847,840	$70,065,954	$75,879,215

II. Background

A. Statement of the Problem

In order to mitigate aircraft loss of control accidents and to comply with the requirements of Public Law 111–216, the FAA has issued new and revised flight training requirements in the Crewmember and Aircraft Dispatcher Training final rule for flight maneuvers such as full stall and upset recovery training. In support of this effort, the FAA participated in a number of collaborative industry and government working groups that examined loss of control training requirements and the flight simulation training device (FSTD) fidelity needed to support such training. These working groups included the International Committee on Aviation Training in Extended Envelopes (ICATEE), the Industry Stall and Stick Pusher Working Group, the Stick Pusher and Adverse Weather Event Training Aviation Rulemaking Committee (SPAW ARC), and the Loss of Control Avoidance and Recovery Training (LOCART) Working Group.

Through participation in these working groups and in consideration of the formal recommendations received from the SPAW ARC, the FAA determined that many existing FSTDs that could be used by air carriers to conduct such training may not adequately represent the simulated aircraft for the required training tasks. Additionally, the FAA evaluated several recent air carrier accidents and associated NTSB accident reports and determined that low FSTD fidelity or the lack of ability for an FSTD to adequately conduct certain training tasks may have been a contributing factor in these accidents.[1] A potential lack of simulator fidelity could contribute to inaccurate or incomplete training on new training tasks that are required by the Crewmember and Aircraft Dispatcher Training final rule, which could lead to a safety risk.

Furthermore, since the initial publication of the part 60 final rule in 2008, the international FSTD qualification guidance published in the ICAO 9625 document has been updated to incorporate general improvements to new aircraft and simulation technology and the introduction of new FSTD levels that better align FSTD fidelity with required training tasks. The ICAO 9625 document is an internationally recognized set of FSTD evaluation guidelines that was developed by government and industry experts on flight simulation training and technology and has been used as a basis for national regulation and guidance material for FSTD evaluation in many countries. Internationally aligned FSTD standards facilitate cost savings for FSTD operators because they can reduce the number of different FSTD designs, as well as reduce the amount of redundant supporting documentation that are required to meet multiple national regulations and standards for FSTD qualification.

This final rule was developed using recommendations from the SPAW ARC[2] and the international FSTD qualification guidelines that are published in ICAO 9625, Edition 3 and the newly published ICAO 9625, Edition 4.[3] The requirements in this final rule are primarily directed at improving the fidelity of FSTDs that will be used in air carrier pilot training to conduct extended envelope training tasks, but will also have an added benefit of improving the fidelity of all FSTDs initially qualified after the final rule becomes effective.

B. National Transportation Safety Board (NTSB) Recommendations

This proposal will incorporate changes into part 60 that address, at least in part, the following NTSB Safety Recommendations through improved FSTD evaluation standards to support required training tasks:

1. Stall training and/or stick pusher training (Recommendations A–10–22, A–10–23, A–97–47, A–07–3, and A–10–24);
2. Upset Recognition and recovery training (Recommendations A–04–62 and A–96–120);
3. Engine and airframe icing training (Recommendations A–11–46 and A–11–47)
4. Takeoff and landing training in gusting crosswind conditions (Recommendations A–10–110 and A–10–111); and
5. Bounced landing training (Recommendations A–00–93 and A–11–69).

C. Airline Safety and Federal Aviation Administration Extension Act of 2010 (Pub. L. 111–216) and the Crewmember and Aircraft Dispatcher Training Final Rule

On August 1, 2010, President Obama signed into law Public Law 111–216. In addition to extending the FAA's authorization, Public Law 111–216 included provisions to improve airline safety and pilot training. Specifically, section 208 of Public Law 111–216, Implementation of NTSB Flight Crewmember Training Recommendations, pertains directly to this rulemaking in that stall training and upset recovery training were mandated for part 121 air carrier flightcrew members.

On November 12, 2013, the FAA published the Crewmember and Aircraft Dispatcher Training final rule, adding the training tasks required by Public Law 111–216 that specifically target extended envelope training, recovery from bounced landings, enhanced runway safety training, and enhanced training on crosswind takeoffs and landings with gusts, which further requires that these maneuvers be completed in an FSTD. As a result, revisions to all part 121 training programs will be necessary prior to March 12, 2019 and the revisions to part

[1] Some of these accidents include the 1996 Airborne Express DC–8–63 loss of control accident, the 2001 American Airlines flight 587 A300 loss of control accident, the 2009 Colgan Air flight 3407 DHC–8–400 loss of control accident, and the 2008 Continental flight 1404 Boeing 737–500 runway excursion accident.

[2] A copy of the SPAW ARC final report has been placed in the docket for this rulemaking.

[3] International Civil Aviation Organization (ICAO) publications can be located on their public internet site at: *http://www.icao.int/*.

60 in this final rule are required to ensure FSTDs are properly evaluated in order to fully implement the flight training required in the Crewmember and Aircraft Dispatcher Training final rule.

D. Summary of the Notice of Proposed Rulemaking (NPRM)

On July 10, 2014, the FAA published an NPRM (79 FR 39461), proposing changes to the flight simulation training device (FSTD) technical evaluation standards. The primary purpose of the NPRM was to establish and update FSTD technical evaluation standards to address new training tasks required by the Crewmember and Dispatcher Training final rule, including full stall training, upset prevention and recovery training, and other new training tasks. Additionally, the NPRM proposed the incorporation of FSTD evaluation criteria as defined in the International Civil Aviation Organization (ICAO) 9625, *Manual of Criteria for the Qualification of Flight Simulation Training Devices* (Edition 3) document. Significant changes to the part 60 qualification performance standards (QPS) were proposed in the following areas:

1. *Full Stall Evaluation:* Minimum requirements were introduced to include aerodynamic modeling of a full stall and stick pusher activation (where equipped) up to ten degrees of angle of attack (AOA) beyond the stall AOA, subject matter expert (SME) pilot evaluation of the FSTD's stall characteristics, and improved objective testing to validate the FSTD's performance and handling qualities in the stall maneuver.

2. *Upset Recognition and Recovery:* New requirements were proposed for the qualification of upset recognition and recovery training tasks including the evaluation of a minimum set of upset recovery maneuvers against the defined FSTD validation envelope, providing a means to record and playback upset recovery maneuvers conducted in the FSTD, and providing the instructor with a minimum set of feedback tools on the instructor operating station (IOS) that gives information on the FSTD's expected fidelity, aircraft operational limitations, and student flight control inputs.

3. *Engine and Airframe Icing:* Modifications were proposed to the existing part 60 Level C and Level D FSTD qualification requirements for engine and airframe icing. The proposed amendments included requirements for ice accretion models based upon aircraft original equipment manufacturer (OEM) data or other analytical methods that incorporate the aerodynamic effects of icing as well as objective tests on the FSTD that demonstrate the effects of icing.

4. *Takeoff and Landing in Gusting Crosswinds:* New amendments were proposed that would require that realistic gusting crosswind profiles must be available to the instructor and the profiles must be tuned in intensity and variation to require pilot intervention to avoid runway departure during takeoff or landing roll. A Statement of Compliance (SOC) would be required to describe the source data used to develop the crosswind profiles.

5. *Bounced Landing Recovery:* New requirements were proposed to complement existing part 60 ground reaction requirements to support bounced landing recovery training. The updated requirements added that the effects of a bounced landing must be modeled and evaluated and include the effects of nosewheel exceedances and tail strike where appropriate.

6. *ICAO 9625 Alignment:* In the NPRM, the FAA proposed alignment with the updated ICAO 9625, Edition 3, FSTD evaluation document for similar FSTD levels that are defined in the part 60 QPS (Appendices A and B). This included incorporating updated technical standards for Level C and Level D FSTDs to align with that of the ICAO Type VII FSTD and creating a new high fidelity fixed-base flight training device (the Level 7 FTD) that is based upon the similar Type V device as defined in the ICAO document. This alignment also included adopting the ICAO language and numbering format for some of the technical requirements tables as well as integrating the existing legacy part 60 FSTD levels into these tables to maintain continuity with the current part 60 defined hierarchy of FSTD levels.

In general, the proposed amendments to the part 60 QPS would only be applicable to FSTDs that are initially qualified or upgraded in qualification level after the final rule becomes effective. Because many previously qualified FSTDs will likely be used to accomplish the training tasks required by the Crewmember and Dispatcher Training final rule, the FAA also proposed an FSTD Directive in order to retroactively apply evaluation requirements for those previously qualified FSTDs that will be used to conduct certain training tasks, including full stall, upset prevention and recovery training, engine and airframe icing, takeoff and landing in gusting crosswinds, and bounced landing recovery training.

On September 16, 2014, the FAA extended the comment period of the NPRM for an additional 90 days (79 FR 55407). The comment period closed on January 6, 2015. The FAA received approximately 675 individual comments in response to the NPRM. Commenters included air carriers, simulator training providers, FSTD data providers, FSTD manufacturers, the NTSB, labor organizations, trade associations, aircraft manufacturers, and individuals.

E. Differences Between the NPRM and the Final Rule

As a result of the comments received on the NPRM, the FAA made several changes to the final rule. A summary of significant changes as a result of comments are highlighted in the following table:

Issue	Significant changes
Full Stall Evaluation	(a) Improved the definition of the stall AOA for the purposes of defining the required aerodynamic modeling range. Clarifies specific issues concerning stick pusher equipped aircraft and envelope protected aircraft. (b) Made clarifications concerning acceptable source data for stall aerodynamic models. Clarified that data sources other than the aircraft manufacturer may be acceptable if they meet the modeling and SME pilot evaluation requirements. (c) Improved the qualification requirements for subject matter expert (SME) pilots that subjectively evaluate the stall model. Adds deviation authority if an acceptable SME pilot cannot be located. Allows for SME evaluation to be conducted on an engineering or development simulator where objective proof-of-match test cases are provided that verifies the model implementation on the FSTD. (d) Removed the proposed requirement for all newly qualified FSTDs to be evaluated and qualified for full stall training tasks. Full stall qualification will only be required for FSTDs that will be used to conduct this training as requested by the FSTD sponsor.

Issue	Significant changes
	(e) (Previously qualified FSTDs) Removed the proposed objective testing requirements for stall maneuvers where validation data may not exist for some older FSTD data packages (cruise and turning flight stall). These conditions will still require aerodynamic modeling and subjective evaluation by a SME pilot.
Upset Prevention and Recovery Training (UPRT) Evaluation.	(a) Removed the proposed minimum FSTD evaluation requirements for Level A and Level B FSTDs. (b) Removed the proposed specific requirements for features and malfunctions necessary to drive upset scenarios. (c) Removed the proposed requirement for audio and video record/playback functionality. (d) Improved the definition of required instructor operating station (IOS) parameters and feedback mechanisms. Allows for methods other than graphical displays to be used where the required parameters are provided to support the training program. (e) Expands the definition of UPRT to include unusual attitude training in which scenarios are introduced that are intended to exceed the defined parameters of an aircraft upset. This change better differentiates UPRT from the existing part 60 unusual attitude evaluation requirement in Table A1B.
Engine and Airframe Icing Evaluation.	(a) Clarified that specific icing effects are only required to be introduced where such effects are representative of the particular aircraft being simulated. (b) Revised the existing part 60 engine and airframe icing special effects test (Table A3F) to remove references to gross weight increments and to better align with the updated requirements. (c) Clarified that flight test data is not necessarily required for the development of icing models. Engineering and analytical methods may be used to develop representative icing models. (d) Added provisions to allow for supplemental tuning of icing models using an SME pilot assessment.
Gusting Crosswind Evaluation.	(a) Removed references to the windshear training aid for gusting crosswind model development. Recommend use of gusting crosswind profiles provided by the FAA in guidance material. (b) Removed the proposed minimum qualification requirement for Level A and Level B FSTDs.
Bounced Landing Recovery Evaluation.	(a) Removed the proposed ground reaction requirement to compute nosewheel exceedances. (b) Clarified the requirements to emphasize the effects and indications of ground contact due to landing in an abnormal aircraft attitude and that aircraft dynamics in a bounced landing recovery maneuver are already adequately covered in the existing part 60 rule.
Alignment with the ICAO 9625 Document.	(a) Restored the general requirements table (Tables A1A and B1A) format, numbering system, and content to the existing part 60 versions. Appended the proposed ICAO 9625 (Edition 3) requirements from the NPRM into their applicable sections. (b) Restored the existing part 60 visual system field of view (180°x40°) and system geometry requirements for Level C and Level D FSTDs. (c) Adopted the less restrictive visual system lightpoint brightness tolerance (5.8 ft.-lamberts) from the updated ICAO 9625, Edition 4, document. (d) Adopted the less restrictive transport delay tolerances (100 ms for instrument and motion system response; 120 ms for visual system response) from the updated ICAO 9625, Edition 4, document. (e) Modified the objective motion cueing test (OMCT) description to not require testing for continuing qualification evaluations, removed minimum tolerances, and further moved much of the technical test details into guidance material. (f) Aligned language where practical for similar stall, UPRT, and icing requirements from the ICAO 9625, Edition 4, document. (g) Added deviation authority for the FAA to accept alternate FSTD evaluation standards where no adverse impact to the fidelity of the FSTD can be demonstrated. (h) Reorganized the flight training device (FTD) requirements in Appendix B to restore the existing part 60 table structure and better separate requirements for the new Level 7 FTD and the legacy part 60 FTD levels. (i) Clarified the Level 7 FTD's minimum qualified training tasks in Table B1B to better align with the ICAO 9625 guidelines. (j) Removed minimum requirements for extended envelope training tasks for the Level 7 FTD that are not included in the ICAO 9625, Edition 4 document for the Type V device.

F. Related Actions

As a result of information gathered from various working groups, the FAA has taken action on loss of control training and simulator fidelity deficiencies by issuing the following voluntary guidance material:

1. FAA Safety Alert for Operators (SAFO 10012)—Possible Misinterpretation of the Practical Test Standards (PTS) Language ''Minimal Loss of Altitude.'' The purpose of this alert bulletin is to clarify the meaning of the approach to stall evaluation criteria as it relates to ''minimal loss of altitude'' in the Airline Transport Pilot PTS;

2. FAA Information for Operators Bulletin (InFO 10010)—Enhanced Upset Recovery Training. This information bulletin recommends the incorporation of the material in the AURTA into flightcrew training. The AURTA contains guidance for upset recovery training programs for air carrier flightcrews, as well as the evaluation guidance for FSTDs used in such training;

3. FAA Information for Operators Bulletin (InFO 15004)—Use of Windshear Models in FAA Qualified Flight Simulation Training Devices (FSTDs);

4. FAA National Simulator Program (NSP) Guidance Bulletin No. 11–04—FSTD Modeling and Evaluation Recommendations for Engine and Airframe Icing;

5. FAA National Simulator Program (NSP) Guidance Bulletin No. 11–05—FSTD Evaluation Recommendations for Upset Recovery Training Maneuvers;

6. FAA National Simulator Program (NSP) Guidance Bulletin No. 14–01—FSTD Evaluation Guidelines for Full Stall Training Maneuvers;

7. AC 120–109A—Stall and Stick Pusher Training;

8. AC 120–111—Upset Prevention and Recovery Training; and

9. Airline Transport Pilot Practical Test Standards (Change 4).

Portions of the above guidance material provide FSTD operators with recommended evaluation methods to improve FSTD fidelity for selected training tasks. To ensure that all FSTDs used to conduct such training are evaluated and modified to a consistent standard, the applicable part 60 technical requirements must be modified as described in this final rule.

III. Discussion of Public Comments and Final Rule

A. Evaluation Requirements for Full Stall Training Tasks

The existing FSTD evaluation requirements for stall maneuvers are generally limited to the evaluation of stall speeds with little emphasis on the actual aircraft performance and handling characteristics as the aircraft exceeds the stall warning AOA. As a result, FSTDs used for such training may not provide the necessary cues and associated performance degradation needed to train flight crews in the recognition of an impending stall as well as training the techniques needed to recover from a stalled flight condition. In the NPRM, the FAA proposed updated general requirements, objective testing requirements, and functions and subjective testing requirements for the evaluation of full stall training maneuvers to support air carrier training as required in the Crewmember and Aircraft Dispatcher Training final rule.

1. *Aerodynamic Modeling Range*

a. Aerodynamic Modeling Beyond the Stall AOA

In order to support the required training objectives, the proposal included requirements for the modeling and evaluation of the FSTD's stall characteristics up to 10 degrees beyond the stall AOA.

CAE, Inc. (CAE) commented that the 10 degrees beyond the stall AOA requirement should be further reviewed, since application of the recovery should immediately lead to a reduction in AOA and therefore is inappropriate to relate the requirement to the 10 degrees beyond the stall AOA. CAE recommended that the 10 degree requirement be removed where rationale is provided for the upper limit of AOA modeling in the required SOC.

The NTSB is generally supportive of the modeling requirements, citing that a peak AOA growth of about 10 degrees beyond the stall is typical for most incidents and accidents it has investigated. However, it did note that stick pusher response dynamics could cause a higher AOA overshoot and this dynamic behavior is a ''critical cue to a stall, which pilots must be trained to recognize.'' The NTSB also noted in its comments that the Colgan flight 3407 accident resulted in an AOA that extended to 13 degrees beyond the stall AOA.[4] In addition, the NTSB stated that the required aerodynamic modeling for aircraft equipped with a stick pusher should not be limited to that of the stick pusher activation and that the aerodynamic modeling range include the flight dynamics that may occur where a pilot resists the stick pusher in training.

The FAA disagrees with CAE that the 10 degree requirement be removed in select cases. The 10 degree AOA range was initially recommended by the SPAW ARC as necessary to accomplish full stall training. Furthermore, this 10 degree AOA range is currently a recommended practice for simulator aerodynamic modeling in the International Air Transport Association (IATA) Flight Simulation Training Device Design and Performance Data Requirements document[5] and has been a recommended practice since the second edition of the IATA document that was published in 1986. Finally, the FAA notes that an unpublished simulator investigation conducted by ICATEE in conjunction with NASA on their Enhanced Upset Recovery model showed that the 10 degree AOA range should be sufficient to capture most overshoots in AOA during various stall recovery maneuvers.

The FAA agrees with the NTSB that pilots can benefit from experiencing the aircraft dynamics involved in a stick pusher activation and recovery maneuver in training. The FAA has reviewed the NTSB accident reports and supporting data on two loss of control accidents in which pilots resisted the activation of a stick pusher and encountered an aerodynamic stall. In the Pinnacle Airlines Flight 3701 accident, the initial stick pusher activation occurred at approximately 10.5 degrees AOA at the start of the aircraft upset and the AOA subsequently oscillated from approximately −6 degrees to +14 degrees over three successive stick pusher activations with some instability evident in the roll axis.[6] Only until just before the fourth activation of the stick pusher system (approximately eleven seconds after the initial stick pusher activation) did the AOA exceed the proposed aerodynamic modeling range (of 10 degrees beyond the stall AOA) for FSTD evaluation purposes.[7]

In the Colgan 3407 accident, aerodynamic stall occurred before the stick pusher activation[8] at approximately 14 degrees AOA which included an initial roll off to about 50 degrees of bank angle. After the initial stick pusher activation at about 17.5 degrees AOA, the subsequent AOA overshoot remained within 24 degrees as the aircraft rolled through 100 degrees of bank angle in the opposite direction of the initial roll off. The peak AOA value of approximately 27 degrees (10 degrees of AOA beyond the stick pusher activation where stall identification should have occurred) was not recorded until after multiple incorrect column responses by the pilot against the stick pusher over a time period of 30 seconds after the pilot's initial incorrect response to the stall warning.

The FAA considered the comments and based on a review of industry recommendations and best practices, has determined that aerodynamic modeling to at least 10 degrees beyond the stall AOA is necessary so that the modeling does not abruptly end should the pilot overshoot the stall recognition and recovery in training. The FAA recognizes that the 10 degree AOA range may not be sufficient to capture all of the flight dynamics involved with multiple severe divergent pitch oscillations where the pilot repeatedly resists a stick pusher system; however, training should not normally be allowed to continue significantly beyond the point where a trainee initially resists the stick pusher before recognizing the stall identification cues and executing the recovery procedures. As demonstrated by the AOA oscillations experienced in the Colgan and Pinnacle accidents, the FAA has determined that aerodynamic modeling to 10 degrees beyond the stall AOA should be sufficient to capture aircraft dynamics in instances where a pilot initially resists the stick pusher activation in training. The data from these accidents suggests that the 10 degree AOA aerodynamic modeling requirement would adequately cover an

[4] See NTSB accident report, Loss of Control on Approach, Continental Connection Flight 3407, February 12, 2009, NTSB Accident Report, NTSB/AAR–10/01; page 87, ''After the stall, the AOA oscillated between 10 deg and 27 deg . . . .''.

[5] International Air Transport Association (IATA) Flight Simulation Training Device Design and Performance Data Requirements Document, 7th Edition (2009), sections 3.1.1.2 and 3.1.1.3 addresses stall entry and recovery as well as required angle of attack ranges for supporting data.

[6] See NTSB accident report, Crash of Pinnacle Airlines Flight 3701, October 14, 2004, NTSB Accident Report, NTSB/AAR–07/01 and supporting flight data recorder factual report on the NTSB public docket (NTSB accident identification number DCA05MA003).

[7] For this aircraft, since the aerodynamic stall occurs after the stick pusher is designed to activate, the stall identification is provided by the stick pusher system activation and aerodynamic modeling would be required up to at least 20.5 degrees AOA for this configuration.

[8] According to the NTSB accident report, the stick pusher on this aircraft is designed to activate after the aerodynamic stall.

AOA range that includes several seconds of inappropriate pilot responses to a stick pusher activation. The FAA has determined this range is sufficient to meet the training objective of teaching a pilot to not resist a stick pusher system activation.

b. Definition of the Stall AOA

In the NPRM, the FAA defined the required aerodynamic model validity range for full stall qualification as 10 degrees of AOA beyond the stall/critical AOA and not as a function of when the stall identification cues are present.

Airbus commented that the definition of stall or full stall should emphasize ''heavy buffet'' as an important cue. Airbus further cited the ICAO 9625, Edition 4, document [9] states that a stalled flight condition may be recognized by continuous stall warning activation accompanied by at least one of the following: (1) Buffeting, which could be heavy at times; (2) lack of pitch authority and/or roll control; or (3) inability to arrest the descent rate.

The FAA concurs with Airbus' comment that heavy buffet can be an important cue of a stall. The FAA has further considered the definition of stall as described in the ICAO 9625 document to determine an appropriate definition for stall with respect to the modeling requirements necessary to support the training objectives. The FAA does not fully agree, however, with the ICAO 9625 definition of stall; specifically the criteria of ''lack of pitch authority and/or roll control'' to define the stall since the part 25 airplane certification requirements state that the pilot must be able to control the aircraft in pitch and roll up to the stall. While control effectiveness can be reduced, it would be incorrect to say that it is lacking for certified airplanes.

Two fundamental objectives of the stall training requirements are to train pilots to recognize the cues of an impending stall as well as to reinforce to pilots that the stall recovery procedures learned during stall prevention training are the same recovery procedures needed to recover from an unintentional full stall. To determine the extent of FSTD aerodynamic modeling necessary to conduct this training, the stall identification AOA must be defined as the point in which the pilot should recognize that the aircraft has stalled and that the stall recovery procedures must be initiated. The FAA has considered both the aircraft certification (part 25) definition of a ''clear and distinctive'' indication of a stall, as well as the ICAO 9625, Edition 4, stall definition. In order to provide a more consistent definition of the stall AOA to ensure that the required aerodynamic modeling range covers potential overshoots in AOA during stall training, the FAA has amended the final rule to better define stall identification:

i. No further increase in pitch occurs when the pitch control is held on the aft stop for 2 seconds, leading to an inability to arrest descent rate;

ii. An uncommanded nose down pitch that cannot be readily arrested, which may be accompanied by an uncommanded rolling motion;

iii. Buffeting of a magnitude and severity that is a strong and effective deterrent to further increase in AOA; and

iv. The activation of a stick pusher.

Since AOA awareness is a fundamental element of stall training, the instructor must be provided with feedback at the IOS concerning the aircraft's current AOA as well as the stall identification AOA. This feedback will not only provide the instructor with additional awareness concerning the aircraft's current AOA and proximity to the stall, but will also assist the instructor in determining when the aircraft has stalled and that the stall recognition cues have been provided as necessary to support the training objectives. In the final rule, the FAA has amended the IOS feedback requirements for upset prevention and recovery training to include AOA and stall identification AOA parameters.

The FAA further notes that the stall identification cues exhibited by an aircraft can, and often do, vary depending upon the aircraft's configuration (*e.g.* weight, center of gravity, and flap setting) and how the stall is entered (turning flight or wings level stall entry). Where differing stall identification cues are present on the aircraft, the FSTD's aerodynamic model should be capable of providing these cues and variation of stall characteristics for training purposes. The FAA also points out that, while this requirement was implied in the stall model evaluation requirements in the NPRM, ICAO 9625, Edition 4, further clarifies this issue with additional language which states that ''. . . the model should be capable of capturing the variations seen in the stall characteristics of the aeroplane (*e.g.,* the presence or absence of a pitch break).'' The FAA has determined that the ability to show these variations would be valuable in training and has included similar clarifying language in Table A1A, section 2.m. of the final rule.

2. *Envelope Protected Aircraft*

a. Model Validity Ranges and Associated Objective Testing

In the NPRM, the FAA included provisions that did not specifically require objective validation testing at an AOA beyond the activation of a stall identification (stick pusher) system through recovery. The primary purpose of including this provision was to not require the collection of flight test validation data at an AOA that could result in an unrecoverable and dangerous stalled flight condition.

Empresa Brasileira de Aeronautica S.A. (Embraer), Airbus, and an individual commenter questioned why computer controlled aircraft with stall envelope protection systems are treated differently from aircraft equipped with stick pusher systems with respect to model validity ranges and associated objective testing. Delta Airlines, Inc. (Delta) further questioned whether such modeling and testing will be required for an Airbus A350 aircraft that has part 25 special conditions on stall testing for airplane certification.

The FAA notes that Public Law 111–216 and the Crewmember and Aircraft Dispatcher Training final rule require training to be conducted to a stall. The primary purpose for the training is to provide flight crews with experience in recognizing the cues of an impending stall, as well as reinforcing the recovery techniques learned in stall prevention training. To expose flight crews to these stall identification cues, envelope protections systems must typically be disabled in training. Unlike most envelope protection systems, stick pushers are typically installed to either compensate for an inability of the aircraft to meet the part 25 stalling definitions in § 25.201 or the stall characteristics requirements in § 25.203. Where a stick pusher is installed to meet the stall identification requirements of § 25.201, the activation of the stick pusher provides the pilot with a clear and distinctive indication to cease any further increase in AOA. This ''clear and distinctive'' indication of a stall is necessary to accomplish the training objectives and simply reaching the AOA limits of the envelope protection or ''alpha floor'' on an envelope protected aircraft will not provide the stall recognition cues that a pilot needs to learn to prevent and recover from a full stall in the event that the envelope protection systems fail. The accident and incident record contains multiple instances of stall envelope protection

[9] See section III.F.3 concerning changes made to address the recently published ICAO 9625, Edition 4 document.

system failures in the past, some of which progressed into a full stall situation where recognition cues of the stall were not identified by the flight crews.[10]

The FAA further notes that the FSTD qualification requirement for objective and subjective testing of the stall is not new with this rulemaking. The part 60 standard published in 2008 contains both objective and subjective testing of the stall to include the ''g-break'' and is required for computer controlled aircraft in a non-normal operational mode.[11] Furthermore, the FAA's FSTD qualification standards dating back to AC 121–14C (1980) have also had both objective and subjective testing requirements for stall.[12] As a result, virtually all of the currently qualified Level C and Level D FSTDs for transport category aircraft have objective testing already in place for stall maneuvers in their FAA approved Master Qualification Test Guide (MQTG) and most of these objective tests are validated against flight test data collected up to and including the stall. The FAA finds that reducing these requirements would not support the full stall training requirements in the Crewmember and Aircraft Dispatcher Training final rule and therefore maintains that the requirements set forth in this final rule are necessary.

b. Validation of Stall Characteristics Using Flight Test Data

In the NPRM, the FAA proposed objective testing of stall characteristics for computer controlled aircraft in both normal mode and non-normal mode flight conditions up to the full stall through recovery to normal flight.

Embraer commented that during the developmental flight test campaign, full aerodynamic stalls that are considered hazardous or impractical can only be done if the aircraft is equipped with additional safety features, such as a tail parachute or other equivalent device, and those features obviously change the aircraft behavior during stall recovery if they are employed. Additionally, Embraer emphasized that for safety reasons in the certification flight test campaign, depending upon the aircraft's aerodynamic characteristics during stalls; full aerodynamic stall flight tests are not done in control states in which the stall protection system is not available. Embraer recommended that flight testing for validation should not be required for objective testing in non-normal control states where the stall protection system is not available.

As previously stated, the non-normal control mode objective testing to a full stall has been required in the existing part 60 stall characteristics objective tests as well as in previous FSTD evaluation standards dating back several years and the FAA has not significantly changed this requirement in this rulemaking. The FAA agrees with Embraer that aerodynamic stall flight testing may be hazardous or impractical to conduct in some circumstances (on both envelope protected and non-envelope protected aircraft) and this rulemaking has not specifically required additional flight test validation data to be collected at an AOA beyond where it is reasonably safe to do so.

As described in the NPRM, the FAA has included allowances for aerodynamic stall models to be developed and validated using engineering and analytical methods. While the FAA agrees with the commenter that some airplane certification flight test data collected in a stall maneuver may not be suitable for simulator modeling and validation purposes (such as where a tail parachute has been deployed as mentioned by the commenter), other flight testing conducted to investigate the stall characteristics of the airplane during the aircraft certification program may be used to develop engineering simulator models. Where significant safety issues would prevent flight testing at an AOA beyond the activation of a stall protection system, engineering simulator validation data will be acceptable for FSTD objective testing purposes. The FAA has made amendments in the final rule to make this clarification.

c. Required AOA Range for Normal Mode Objective Testing

In the NPRM, the FAA did not specify a particular AOA range to support the normal mode testing requirements for stall characteristics on computer controlled aircraft.

Delta and Airlines for America (A4A) requested clarification on what will be the required AOA range for objective testing on aircraft with highly automated systems where the aircraft does not reach aerodynamic stall in ''normal control state.''

The FAA has not specified a particular AOA range to support the normal mode testing requirements in this final rule, as this will be a subset of the AOA range required for non-normal mode testing. Public Law 111–216 and part 121, subparts N and O, require training for recoveries from stalls and stick pusher activations, if equipped. In order to conduct stall recovery training, the protections of an envelope-protected aircraft must be disabled. As such, aerodynamics outside of the envelope protections up to ten degrees beyond the stall AOA must be considered to allow for stall recovery training in the event the envelope protections fail.

3. Data Sources for Model Development and Validation

a. Define Best Available Data

In the NPRM, the FAA proposed that where limited data is available to model and validate the stall characteristics of the aircraft, the data provider is expected to develop a stall model through analytical methods and the utilization of the ''best available data''.

Bihrle Applied Research (Bihrle), A4A, and an anonymous commenter stated that the term, ''best available data'' (with regards to the aerodynamic data used to model and validate the stall model) is ambiguous and open to interpretation. American Airlines (American), FlightSafety International (FlightSafety), A4A, JetBlue Airways (JetBlue), and Delta further requested clarification from the FAA on whether a ''non-OEM'' provided source of data would be acceptable to the FAA to meet the representative stall model requirements.

The FAA notes that there is not a specific requirement currently in part 60, nor has a new requirement been introduced in this final rule that mandates FSTD sponsors use the original equipment [aircraft] manufacturer's (OEM) data to develop and validate the aerodynamic and flight control models in qualified FSTDs. As described in § 60.13(b), ''The validation data package may contain flight test data from a source in addition to or independent of the aircraft manufacturer's data in support of an FSTD qualification . . .'' There are

[10] One such example is the June 2009 crash of Air France flight 447, an Airbus A330–203 that experienced failure of the high angle of attack (stall) protection system due to the loss of airspeed data as a result of pitot probe blockage. See ''Final report on the accident on 1 June 2009 to the Airbus A330–203 registered F–GZCP operated by Air France flight AF 447 Rio de Janeiro—Paris''; Bureau d'Enquêtes et d'Analyses (BEA); Paris, France. Another example is the December 2014 crash of Indonesia Air Asia flight 8501, an Airbus A320–216, where flightcrew actions to correct a malfunctioning flight augmentation system resulted in the loss of stall protection. See ''Aircraft Accident Investigation Report; PT. Indonesia Air Asia; Airbus A320–216; PK–AXC''; Komite Nasional Keselamatan Transportasi (KNKT), Republic of Indonesia 2015.

[11] See 14 CFR part 60 (2008), Appendix A, Table A2A, test 2.c.8 (Stall Characteristics) and Table A3A, test 6.a. (High angle of attack, approach to stalls, stall warning, buffet, and g-break . . . .''.

[12] Advisory Circular (AC) 121–14C (1980), ''Aircraft Simulator and Visual System Evaluation and Approval''.

numerous FSTDs that have been qualified up through Level D where the FSTD manufacturer or other third party data provider has instrumented and flight tested an aircraft in order to collect flight test data to develop and validate their own aerodynamic and flight control models to support FSTD evaluation and qualification.

The FAA has considered the issues involved with requiring aircraft OEM data to develop and validate stall models for the purpose of conducting full stall training. While flight test data collected by the aircraft manufacturer will generally be the preferred source of data to model and validate FSTDs for training, the FAA has determined that ''non-OEM'' sources of aerodynamic data must be considered for the following reasons:

i. Restricting the development of stall models to that of the airplane manufacturers could impose a high cost on the FSTD sponsors and may not be possible in some instances where the airplane manufacturer does not support a simulator data package or is no longer in existence;

ii. Recommendations by the SPAW ARC, ICATEE, and other working groups have supported the use of analytically developed ''type representative'' stall models for training purposes; and

iii. An FAA simulator study [13] has supported the SPAW ARC's findings and found that analytically derived ''type representative'' stall models that are developed by third party data sources and thoroughly evaluated by a SME pilot can be effectively used to support stall training tasks in a simulator.

For these reasons, the FAA finds that it would not be practical to require FSTD sponsors to use an aircraft manufacturer's high AOA/stall model to meet the requirements of this final rule and other source data may be acceptable. Furthermore, Boeing, A4A, and an anonymous commenter stated that ''flight test data should be noted as the preferred source of data, if available, with other data sources to be used if acceptable to the FAA.'' The FAA concurs with this statement. To manage unknown risks, an aircraft manufacturer provided stall model developed with flight test data will generally be the preferred source of data; however, the FAA has concluded that there is not sufficient evidence to warrant mandating a particular source of data for model development. The FAA acknowledges that the term, ''best available data'' is ambiguous and has removed that language in the final rule.

b. Post Stall ''Type Representative'' Modeling

In the NPRM, FAA indicated that flight crews should be provided with practical experience in recognizing a full stall should the stall warning system become ineffective. To support this objective, the FSTD must provide critical aircraft type-specific stall recognition cues to enable the crew to recognize the onset of a stalled flight condition. Where data limitations and aircraft behavior may prevent conducting precise objective validation of post-stall behavior in the FSTD, the FAA included provisions in the proposal for ''type representative'' modeling and validation. To distinguish between the objectively validated ''type specific'' pre-stall modeling and post-stall modeling that may be developed through engineering analysis and SME pilot evaluation, the FAA used the term ''type representative'' in the NPRM.

Delta, FlightSafety, and A4A requested that the FAA better define the term, ''type representative'' with regards to post stall model fidelity.

In defining the FSTD fidelity requirements for full stall behavior, the FAA considered the primary training objectives for such training. The first objective of stall training is to provide flight crews with practical experience in recognizing a full stall should the stall warning system become ineffective (either through malfunction or human error). To support this objective, the FSTD must provide critical aircraft ''type specific'' recognition cues of an impending stall. Examples include cues such as reduced lateral/directional stability, deterrent stall buffet, and reduced pitch control if the particular aircraft has these cues.

The second objective of stall training is to reinforce to flight crews that the recovery procedures learned during stall prevention training are the same procedures needed to recover from a full stall. From an aerodynamic modeling standpoint, this presents a more significant challenge for two reasons. First, aircraft behavior in an aerodynamic stall may not be stable and is often sensitive to initial conditions, which creates the impression of non-repeatable chaotic behavior. Second, because this occurs in a flight regime with reduced stability, there can be practical limitations on the amount of flight test data that can be safely collected for simulator modeling and validation purposes. It is for these reasons that objectively validated ''type specific'' behavior at an AOA beyond the aerodynamic stall may not be a reasonable goal for defining fidelity in a training simulator.

The FAA has determined that the primary training objective for stall training is to have a pilot learn the proper stall recovery procedure in response to the variety of stall cues that a particular aircraft presents. Owing to the reduced stability, unsteady aerodynamics, and surface and rigging variations that occur with use, an aircraft will respond differently from stall to stall. However, the physics of what can happen in a stall are known, accepting that they can differ from aircraft to aircraft. The FAA has concluded that if a pilot can demonstrate applying the stall recovery technique for the general characteristics of what might occur for an aircraft type, the precise characteristics are not required. That is, if an airplane typically rolls 10 degrees left or 20 degrees right in a stall does not matter as long as the pilot does not incorrectly apply the stall recovery technique by responding to that roll before reducing AOA. What is important is to present roll if an aircraft has rolling tendencies to ensure that a pilot responds properly.

In order to avoid confusion with other uses of the word ''representative'' with respect to simulator fidelity, and to remain consistent with the ICAO 9625 definitions, the FAA has changed the description of the post-stall fidelity requirements to ''sufficiently exemplar of the airplane being simulated to allow successful completion of the stall entry and recovery training tasks.'' For the purposes of stall maneuver evaluation, the term ''exemplar'' is defined as a level of fidelity that is type-specific of the simulated airplane to the extent that the training objectives can be satisfactorily accomplished.

c. Use of Flight Test Data and Availability

In consideration of the recommendations of the SPAW ARC as well as the results of the FAA stall study, the FAA proposed that the necessary levels of simulator fidelity (including type specific pre-stall behavior and type representative post-stall behavior) can be achieved through a combination of engineering analysis, SME pilot assessment, and improved pre-stall objective testing through the use of existing stall flight test data that is already required by part 60 and

[13] Schroeder, J.A., Burki-Cohen, J., Shikany, D.A., Gingras, D.R., & Desrochers, P. (2014). An Evaluation of Several Stall Models for Commercial Transport Training. *AIAA Modeling and Simulation Technologies Conference.*

previous simulator standards.[14] Furthermore, the FAA proposed additional objective testing requirements for stall characteristics to include turning flight stall and high altitude cruise stall. In the proposal, these tests were also included in the FSTD Directive as applicable to previously qualified FSTDs.

Dassault Aviation (Dassault) commented on the availability of full stall flight tests and that flight test points may not be available for some conditions where aircraft certification does not require them. Dassault further commented that corresponding flight test points might be implemented in the devices where partial data is available; however, no extension or extrapolation should be considered as type representative because this might lead to a very different behavior. An anonymous commenter made similar comments in that ''unless there is a source of flight test data in every possible combination of conditions that might exist in a full stall, a demonstration of recovery techniques in a given set of conditions is the only plausible solution.''

FlightSafety further questioned whether there would be a release from liability should a stall model developed through engineering judgment and analytical methods prove to be inadequate.

As stated in previous sections, the FSTD qualification standards have had objective testing requirements for flight maneuvers up to and including full stall since 1980, so nearly all currently qualified full flight simulators (FFS) already have full stall flight test points that are used for simulator validation purposes. For previously qualified FSTDs, this data could be used to further improve existing stall models to meet the requirements of this final rule. The FAA does recognize, as Dassault points out, that additional flight test validation data may not readily exist to validate the new stall maneuvers introduced in the objective testing requirements (*e.g.,* cruise stall and turning flight stall). To address this concern, the FAA has amended the FSTD Directive for previously qualified FSTDs to remove the objective testing requirements for both the cruise condition and the turning flight stall condition and replaced them with subjective evaluation by an SME pilot. The remaining required objective testing stall characteristics tests (second segment climb and approach or landing conditions) are already required under the existing part 60 rule and should have existing validation data that can be used to meet the new objective testing requirements. Where limitations exist in the stall aerodynamic model due to the lack of data or reliable analytical methods, the data provider may declare these limitations as part of the required aerodynamic modeling SOC for the purposes of restricting the FSTD to certain stall maneuvers.

In response to FlightSafety's comment, the FAA notes that engineering judgment and analytical methods are used extensively in other areas of a simulation model besides stall and these models are used for training in conditions and situations that vary from the flight conditions used to validate the model. This practice has proven satisfactory, as known physical principles are used by FSTD manufacturers and data providers to represent the training conditions that vary from the flight-validated conditions. The FAA issues standards for FSTD evaluation, but generally does not prescribe specific methods for developing simulation models. The FAA does not have the authority to declare a release from liability.

4. Qualification on FSTD Levels Other Than Level C and Level D

In the NPRM, the FAA proposed modifications to the Level A and Level B stall qualification requirements to include stick pusher system force objective testing and updated objective and subjective testing requirements for the approach to stall flight conditions for newly qualified FSTDs.

Boeing, Delta, and A4A commented that while the FAA proposed modifications to the Level A and Level B stall qualification requirements, the Crewmember and Aircraft Dispatcher Training final rule does not permit such training in these devices and therefore these requirements should be removed. Delta and Boeing had additional comments concerning new requirements proposed for the ''approach to stall'' objective tests on Level A and Level B simulators (including additional configurations, tolerances, and subjective testing of the autoflight/stall protection systems) with one commenter stating that there is no apparent explanation why the approach to stall characteristics objective test has changed for Level A and Level B simulators and it should remain unchanged to be consistent with the ICAO 9625 document.

The FAA concurs with the commenters in that § 121.423 requires extended envelope training be conducted in a Level C or Level D simulator and has removed the associated minimum requirements for full stall on Level A and Level B simulators. However, the FAA notes that such devices are qualified to conduct stall prevention training at AOAs below that of the activation of the stall warning system and improving the validation of these FSTDs in the approach to stall flight condition would be beneficial to this training. Where new testing requirements were proposed for Level C and Level D simulators for AOAs below the activation of the stall warning system, these testing requirements were carried over to Level A and Level B simulators to provide better validation of the simulator to conduct stall prevention training tasks. The FAA further notes that these requirements for Level A and Level B simulators are not retroactive requirements defined in the FSTD Directive and will only be required for Level A and Level B simulators that are initially qualified after this final rule becomes effective. The FAA does not believe these changes for Level A and Level B FSTDs will have an impact on the alignment with the ICAO document since the Level A and Level B FSTD levels in part 60 have no equivalent ICAO device level.

5. Motion Cueing System Limitations

In the NPRM, the FAA included provisions to allow the FSTD manufacturer to limit the maximum buffet based on ''motion platform capabilities and limitations'' (see Table A2A, Entry No. 2.c.8). A similar provision was also included in the ICAO 9625, Edition 4.

The FAA received several comments that the FSTD sponsors, in addition to the device manufacturers, should be allowed to limit maximum buffet based upon motion platform capabilities and limitations. Furthermore, Delta, Boeing, FlightSafety, A4A, JetBlue, and United Parcel Service (UPS) commented that FSTD sponsors should have the ability to tune down or otherwise reduce motion vibrations due to maintenance and reliability aspects, personnel safety, and limitations of other simulator components, such as visual display systems and other hardware onboard the simulator. Boeing additionally commented that other simulator systems, such as the visual system, may also limit the buffet levels.

With regards to reducing or otherwise limiting motion vibrations that are within the motion platform's capabilities and limitations, the FAA has determined not to include specific

[14] 14 CFR part 60 (2008) currently requires stall characteristics objective testing that extends to the full stall and ''g-break''. Similar requirements exist for grandfathered simulator standards dating back to AC 121–14C (1980).

provisions to allow for arbitrary reductions in stall buffet from the levels that are evaluated through SME pilot assessment or objective testing. On many aircraft, the stall buffet is an important cue of an impending stall and, in some cases, may be the only distinctive cue a pilot will receive before or during an actual stall. In an FAA stall study on its B737–800 simulator [15] in which the magnitude of the stall buffet cues had been modified and increased significantly, all ten of the participating test pilots who had stalled the B737 noted the importance of accurately presenting the strong buffet cues as a stall progresses. Furthermore, the importance of stall buffet in training has been emphasized numerous times by the various working groups that provided recommendations to the FAA on stall training and associated simulator fidelity. As such, the FAA has determined that to accomplish the intended training objectives to provide flight crews with accurate recognition cues of an impending stall, the stall buffet characteristics should be provided in the FSTD at a level that is representative of the aircraft as evaluated by an SME pilot.

Furthermore, as cited in A4A's and American's comments, Schroeder did acknowledge in his paper that buffet levels are sometimes reduced in a simulator to extend component life; however, no such reduction in stall buffet was implemented for this experiment. In fact, overall buffet gains were increased by a factor of 2.5 in the simulator with no adverse effects noted after the completion of the five week experiment.[16]

The FAA acknowledges that the potential exists for increased maintenance and reliability issues due to the repeated exposure of the FSTD to stall buffet. The FAA concurs with Boeing's comment in that other simulator systems (*e.g.,* visual systems) may limit the maximum buffet levels that are possible in a simulator and the FAA has made changes in the final rule to reflect this. Particularly with visual display systems, notch filters are frequently employed to reduce the vibration output of the motion platform at or around a resonant frequency that would cause damage to visual system components such as a Mylar mirror. These methods have been employed in the past and will continue to be permissible to protect the simulator and its occupants from known system limitations where damage is likely to occur or occupant safety may be compromised.

Furthermore, given that these standards may be applied to previously qualified FSTDs where the original FSTD manufacturer may not be accomplishing and evaluating the modifications of the FSTD, the FAA agrees with the commenters that the ability to limit the maximum buffet due to motion platform and other simulator system capabilities and limitations should be extended to the FSTD sponsor. The FAA has amended the final rule to allow for the FSTD manufacturer or the FSTD sponsor to limit the maximum motion buffet levels as described in this section.

6. Subject Matter Expert Pilot Evaluation and Qualification

a. SME Qualifications and Experience

In the NPRM the FAA proposed that the SME pilot who conducts the subject evaluation of the FSTD's stall characteristics must have ''. . . acceptable supporting documentation and/or direct experience of the stall characteristics of the aircraft being simulated'' and have ''knowledge of the training requirements to conduct the stall training tasks.'' The additional requirements proposed in Attachment 7 of the NPRM further stated that that the SME pilot must have experience in conducting stalls in the type of aircraft being simulated and, where not available, experience in an aircraft with similar stall characteristics.

The FAA received several comments concerning the experience and qualification requirements for SME pilots. American, A4A, Delta, and FlightSafety requested clarification on whether the required SME must be a pilot who has flown a full stall in the airplane or a pilot who only has knowledge of training requirements to conduct the stall tasks. Delta and A4A also questioned whether there are any other SME experience requirements beyond conducting stalls in the aircraft being simulated, or in an aircraft with similar stall characteristics. A4A, Delta, and FlightSafety, further requested clarification on whether an SME pilot can gain the necessary stall experience in an audited engineering simulator or on another Level D FFS that has already been qualified for stall maneuvers.

The FAA maintains that the subjective evaluation of the aerodynamic stall model is a critical component in ensuring that the FSTD's stall characteristics are representative of the aircraft and support the training objectives. The FAA further maintains that for such a subjective assessment to have credibility, the pilot must have direct experience in conducting stall maneuvers in the aircraft being simulated or in a similar aircraft that is expected to share the same general stall characteristics.

The FAA acknowledges that the SME requirements in the NPRM were not clearly defined and has revised Attachment 7 of Appendix A of the final rule to better define these requirements. In particular, rather than just stating the stall experience must be in the ''type of aircraft being simulated'', the FAA clarified this by stating that the experience must be ''. . . direct experience in conducting stall maneuvers in an airplane that shares a common type rating with the simulated aircraft.'' In instances where the stall experience is in a different make, model, and series of aircraft within a common type rating, the FAA clarified that differences in aircraft specific stall recognition cues and handling characteristics must be addressed using available documentation such as aircraft operating manuals, aircraft manufacturer flight test reports, or other documentation that describes the stall characteristics of the aircraft.

Particularly for aircraft that are no longer in production, the FAA recognizes that there may be practical limits in finding SME pilots with the required experience to conduct the stall model evaluations. In instances where an acceptable SME cannot be reasonably located, the FAA has included deviation authority in the final rule for a sponsor to propose alternate methods in conducting the SME pilot evaluation of an FSTD's stall model.

In response to the comments concerning whether the SME pilot is required to have experience in the stall characteristics of the aircraft or knowledge of the training requirements to conduct the stall training tasks, the FAA has determined that the SME pilot must have both aircraft experience and knowledge of the training requirements, with the exceptions on experience as noted previously. While an important element of the subjective assessment is the comparison of the FSTD's performance against that of the aircraft, knowledge of the training tasks to be conducted in the FSTD should be

[15] Schroeder, J.A., Burki-Cohen, J., Shikany, D.A., Gingras, D.R., & Desrochers, P. (2014). An Evaluation of Several Stall Models for Commercial Transport Training. AIAA Modeling and Simulation Technologies Conference.

[16] The FAA's CAE simulator was operated for an average of 8 hours per day for five weeks to conduct approximately 700 stall maneuvers which had significant buffet levels. The FAA estimated that this simulator was exposed to approximately 67 total minutes of stall buffet over this five week period of time, which is comparable to what a typical part 121 carrier's simulator may be exposed to over an entire year under the new training rule. There were no reports of equipment damage after the completion of the experiment.

considered when conducting these evaluations. The recognition cues and handling qualities of an airplane can change significantly as a function of the aircraft configuration and how the stall is entered. To ensure the model can support the training objectives as well as to communicate any known or potential deficiencies in the model, the SME pilot conducting this subjective evaluation should focus the evaluation on those general aircraft configurations and stall entry methods that will likely be used in training. The FAA has clarified this language in the SME pilot evaluation requirements in Attachment 7.

The FAA has considered whether an SME pilot can gain experience in an audited engineering simulator or another Level D FFS that has been qualified for full stall maneuvers and has concerns that the effectiveness of an SME pilot evaluation may be diminished when making such comparisons from simulator to simulator without an objective measure to ensure that the aerodynamic model from the engineering simulator has been properly implemented on the training simulator. For these reasons, the FAA maintains that the SME pilot conducting the subjective evaluation of the FSTD or associated stall model must have direct experience of the stall in the aircraft. A pilot cannot gain the necessary aircraft experience required to be a SME in an engineering simulator or another FFS that has been qualified for full stalls.

b. Model Validation Conducted by the Data Provider

Boeing and Airbus commented that in lieu of an SME pilot evaluation being conducted on the individual FSTDs for initial and recurrent evaluations, the model validation with the SME pilot can be conducted by the data provider where objective stall data is provided to validate the individual FSTDs. Delta and A4A made similar comments. The FAA agrees with the commenters and notes that provisions to conduct the SME pilot evaluation on an engineering simulator were included in the proposal in Attachment 7 to Appendix A. The FAA maintains that where objective proof of match tests are provided to verify the models have been properly implemented on the training FSTD (including stall characteristics and stall buffet objective testing), the FAA will accept an SOC from the data provider that confirms the integrated stall model has been evaluated by an SME pilot on an engineering simulator or other simulator acceptable to the FAA. Furthermore, there is no intent to require that this SME evaluation be conducted annually, and the SOC that confirms this SME assessment has taken place will remain valid as long as the stall model remains unmodified.

c. NSPM Process for Evaluating and Accepting an SME Pilot

In the NPRM, the FAA proposed that an SOC be provided to the FAA that confirms that the FSTD has been evaluated by an SME pilot. This requirement was proposed to apply to both newly qualified FSTDs as well as previously qualified FSTDs that are evaluated under the requirements of FSTD Directive No. 2.

Delta and A4A requested clarification on this process that the NSPM follows to evaluate and accept an SME pilot.

As described in FSTD Directive No. 2 and Attachment 7 to Appendix A, the process for the qualification of stall maneuvers requires that the sponsor submit an SOC to the NSPM confirming that the FSTD has been evaluated by a SME pilot with the required experience. The NSPM will review this SOC to verify that the evaluating SME pilot has the required experience as specified in the rule before issuing additional qualification for full stall training tasks. Additionally, requests for deviation from the SME experience requirements as described in Attachment 7 should be submitted to the NSPM when requesting additional qualification for full stall training tasks. Where specific questions arise, the NSPM will contact the sponsor or data provider directly for clarification.

7. Alignment With ICAO 9625, Edition 4, on Stall and Stick Pusher Requirements

The FAA's proposal for the stall and stick pusher requirements were primarily based upon the recommendations from the SPAW ARC, as well as other working groups such as ICATEE and the LOCART working group. After the FAA first initiated this rulemaking, the ICATEE recommendations that were considered by the FAA in developing the proposal were also considered by ICAO for updating the ICAO 9625 document to include FSTD evaluation standards for stall and upset prevention and recovery training.

The FAA received numerous comments that some of the general requirements and objective testing requirements in the proposal did not align with the ICAO 9625, Edition 4 requirements, which became available following the publication of the NPRM. A4A, Boeing, and an anonymous commenter indicated that the stick pusher requirements (Table A1A, Entry No. 2.1.7.S) in the NPRM should be relocated to the flight controls section where they are more applicable. Boeing and A4A also commented that the stall buffet onset measurements in the stall characteristics objective tests (Table A2A, Entry No. 2.c.8) are based upon speed rather than AOA like ICAO 9625, Edition 4. Delta, A4A, and an anonymous commenter indicated that the control force tolerances in the stall characteristics test should be applicable only to aircraft with reversible flight control systems. Finally, A4A and Boeing commented that the required test conditions for the stall buffet motion characteristics test (test 3.f.8 in Table A2A of the NPRM) do not include the same conditions as ICAO 9625, Edition 4.

The FAA was unable to fully participate in the ICAO deliberations due to ex parte concerns as the agency was engaged in this rulemaking proceeding. The FAA has had an opportunity to review the final release of the ICAO 9625, Edition 4, document and has found that only minor differences exist with regards to the stall qualification requirements as compared to the final rule. As such, in order to maintain alignment with the ICAO document as identified by the commenters, the FAA has incorporated the ICAO language into the final rule to the maximum extent possible. The FAA has amended the final rule by adopting much of the ICAO language for high AOA/stall modeling minimum requirements (Table A1A, Entry No. 2.m. in the final rule) as well as the stall characteristics objective test tolerances and flight conditions (Table A2A, Entry No. 2.c.8.a in the final rule).

The FAA did not, however, amend the required conditions for the stall buffet tests to align with the ICAO 9625 standard. As recommended by the SPAW ARC report, stall buffet evaluation should include a broader range of flight conditions than what is currently evaluated. The FAA has determined that the inclusion of the second segment climb condition is important to evaluate the differences in stall buffet vibrations at high power settings, particularly for turboprop airplanes. As a result, the FAA has maintained this is as a required condition for the stall buffet characteristic vibrations test (Table A2A, Entry No. 3.f.5).

While the FAA has aligned a majority of the general requirements and the objective testing requirements with the ICAO document, specific differences must be maintained in the final rule to address comments received on the proposal as well as retroactive FSTD evaluation requirements that are required to support the mandated training for United States (U.S.) air carriers.

8. Requirements for Previously Qualified FSTDs

a. Stall Buffet Objective Testing

In the proposal, the retroactive requirements for previously qualified FSTDs, as described in FSTD Directive No. 2., did not include objective testing for stall buffets.

Boeing, Delta, A4A, and an anonymous commenter stated that the general requirement and objective testing requirements (Table A1A and Table A2A, respectively) for stall buffet vibration measurement state that these tests are required for all FSTDs qualified for stall training tasks. This is in conflict with the proposed FSTD Directive No. 2, which specifically states that stall buffet objective vibration testing is not required for previously qualified FSTDs.

In recognizing the potentially high cost of gathering additional flight test validation data for stall buffets, the FAA did not include this requirement in the proposed FSTD Directive No. 2 retroactive requirements for previously qualified FSTDs. Since changes to the QPS tables are not typically applicable to previously qualified FSTDs, changes to Table A1A or Table A2A are not necessary since all of the retroactive requirements are defined in FSTD Directive No. 2. The FAA has added language in FSTD Directive No. 2 in the final rule to clarify the retroactive testing requirements.

b. FSTD Directive No. 2 and Grandfather Rights

In FSTD Directive No. 2, previously qualified FSTDs that will be used to conduct full stall, UPRT, and other specific training tasks will be required to meet certain sections of the general requirements, objective testing requirements, and subjective testing requirements of the updated QPS tables in order to obtain qualification for these training tasks.

A4A requested clarification on whether FSTDs that are ''upgraded'' to provide extended envelope training would also have to comply with the proposed ICAO alignment requirements as well (such as the new visual display system requirements). American and A4A further noted that some sections within the QPS tables appear to have been mistakenly applied to all simulators instead of those qualified after the effective date of the final rule.

The FAA notes that the only new QPS requirements applicable for previously qualified FSTDs are those that are described in FSTD Directive No. 2. As described in § 60.17 and paragraph 13 of Appendix A, previously qualified FSTDs will continue to hold grandfather rights and the changes to the QPS tables will not generally be applicable to previously qualified devices unless specifically stated in an FSTD Directive. The FAA has reviewed FSTD Directive No. 2 and made amendments in the final rule to clarify which sections of the QPS appendices will be applicable to previously qualified devices.

The FAA further notes that an ''upgrade,'' as defined by part 60, is an ''improvement or enhancement of an FSTD for the purpose of achieving a higher qualification level.'' FSTDs that are upgraded in qualification level will generally have to comply with the standard that is in effect at the time of the upgrade. It is important to note, however, that compliance with FSTD Directive No. 2 does not require a change in qualification level and is not considered an ''upgrade'' under part 60. As a result, the other changes made to the QPS appendices, including the general changes made to align with the ICAO document, will not be applicable to previously qualified FSTDs unless upgrading in FSTD qualification level.

9. Applicability of Stall and UPRT Requirements on Newly Qualified FSTDs

In the NPRM, the FAA proposed that the minimum requirements for the evaluation of full stall maneuvers and UPRT maneuvers would be applicable for all fixed wing Level C and Level D FSTDs that are initially qualified after the final rule becomes effective.

Dassault commented that while UPRT and full stall training will become mandatory for part 121 operators, it is not clear if this applies to part 135 and part 91 operators as well. Dassault further questioned whether the objective testing requirements for full stall maneuvers would be required for an FSTD that will not be used for full stall training. Finally, Dassault commented that they would prefer the requirements to be applied to new or modified aircraft types instead of new FSTDs since this would allow collecting necessary data at the time of the type certification flight tests.

CAE made similar comments that point out that the FSTD Directive (for previously qualified devices) is only applicable for those FSTDs that will be used to conduct such (UPRT and stall) training, however, the requirements in the QPS appendices are mandatory for newly qualified FSTDs regardless of whether they are used in an air carrier or a non-air carrier training program. CAE recommended that operators of newly qualified FSTDs (that are initially qualified after the final rule becomes effective) who are not subject to the Crewmember and Aircraft Dispatcher Training final rule should also be given the same option on whether or not to invest in the additional features that support extended envelope and other tasks as required under the final rule. CAE further stated that this would provide an option to those operators who may have multiple devices to limit such updates to certain equipment that will be utilized to conduct such training.

FAA agrees with the commenters that the requirement for FSTD modifications and data collection should not be imposed on sponsors who will not use those FSTDs to conduct full stall training and have no mandate to conduct such training. Similar to the FSTD Directive for previously qualified FSTDs, the FAA has amended the final rule to make the qualification of full stall maneuvers optional for newly qualified FSTDs. This will allow flexibility for operators to decide how many FSTDs need to be evaluated for full stall maneuvers to support training requirements.

FAA has, however, maintained the minimum requirements for UPRT evaluation on newly qualified Level C and Level D FFSs. The FAA has estimated that the addition of such IOS feedback tools to support UPRT would add little to no incremental cost to that of a newly qualified FSTD and will enhance instructor awareness in support of the existing part 60 unusual attitude qualification requirement.[17]

In order to ensure that only FFSs that are evaluated and qualified for stall training tasks are used for such training, compliance with the stall and UPRT evaluation requirements will be tracked by the FAA through modifications to the FSTD's Statement of Qualification (SOQ).

10. General Comments on Stall Requirements

a. Testing and Checking of Stall Maneuvers

Boeing commented that stall training beyond the stick shaker activation does not require testing or checking in part 121 and references made to testing and checking in FSTD Directive No. 2 should be removed.

[17] 14 CFR part 60, Appendix A, Table A1B, Entry No. 3.f., ''Recovery From Unusual Attitudes''. This minimum qualification requirement covers maneuvers that are ''within the normal flight envelope supported by applicable simulation validation data.''

FAA agrees with Boeing's comment and has modified the language in FSTD Directive No. 2 accordingly.

b. Interim FSTD Qualification for Stall Training

A4A commented that the FSTD Directive (for previously qualified FSTDs) requires evaluation by the NSPM for additional qualification and should allow a draft SOQ to be issued until the next scheduled evaluation.

FAA notes that FSTD Directive No. 2 does not require an update to the FSTD's permanent SOQ before stall training can be conducted in an FAA approved training program. A positive response from the NSPM to the FSTD modification notification confirming that the requirements of the Directive have been met will, in most cases, serve as an interim update to the FSTD's SOQ until the next scheduled FSTD evaluation. In some instances, however, additional FSTD evaluations conducted by the FAA may be required before the modified FSTD is placed into service. FAA has added clarifying language to the FSTD Directive that this response will serve as interim FSTD qualification for stall training tasks until the next scheduled FSTD evaluation where additional FSTD evaluations conducted by the FAA have been determined to not be required.

c. Aerodynamic Modeling Considerations

Frasca International (Frasca) commented that AOA rate is a significant contributor to stall behavior and should be considered as part of the requirement for aerodynamic stall modeling. FAA agrees with Frasca's comment and has added AOA rate to the list of aerodynamic modeling considerations in Attachment 7.

B. Evaluation Requirements for Upset Prevention and Recovery Training Tasks

In order to support UPRT that was introduced in the Crewmember and Aircraft Dispatcher Training final rule, the FAA proposed new FSTD evaluation requirements for these training tasks. The proposed requirements were based upon recommendations from the LOCART and ICATEE working groups as well as from the guidance in the Airplane Upset Recovery Training Aid (AURTA), and included new standards to better define the FSTD's aerodynamic validation envelope. The proposal also included requirements to improve the feedback at the instructor operating station (IOS) concerning the FSTD validation envelope limits, aircraft operational limits, and flight control inputs by the trainee.

1. UPRT Qualification on Lower Level FSTDs

In the NPRM, the FAA proposed minimum qualification requirements for full stall and UPRT in the newly defined Level 7 flight training device (FTD) (Table B1A of Appendix B).

TRU Simulation and A4A commented that the proposal requires extended envelope modeling for the Level 7 FTD, but the part 121 training requirements have a minimum requirement that this training must be conducted in a Level C or higher simulator. In addition, A4A commented that this is inconsistent with ICAO 9625, Edition 4, where UPRT training is only qualified on a Type VII device. Finally, Air Line Pilots Association, International (ALPA) commented that training could be negatively impacted if allowed to be conducted on a Level A or Level B FFS as the proposal states and this is inconsistent with the recommendations of the SPAW ARC.

FAA agrees with A4A and TRU Simulation regarding UPRT qualification on a Level 7 FTD. This was an error in the proposal and the FAA has amended the final rule to remove minimum qualification requirements for both full stall and UPRT on the Level 7 FTD.

The FAA has reconsidered the qualification of Level A and Level B FFSs for UPRT tasks that involve no bank angle excursions, such as nose-high or nose-low upsets, as defined in the NPRM, and amended the final rule by removing references to full stall and UPRT evaluation requirements for Level A and Level B FFSs in the FSTD Directive.

The FAA notes that the primary differences between the Level A and Level B minimum qualification requirements compared to the Level C and Level D qualification requirements are generally limited to ground reaction modeling, visual system field of view requirements, and minimum motion cueing requirements. The ground reaction modeling requirements have no impact on UPRT or stall training given that training is typically conducted well outside of ground effect. There are significant differences in the motion cueing abilities between Level A and Level B FFSs versus Level C and Level D FFSs that impact the ability for effective full stall and upset training to be conducted in the lower level devices. Level A and Level B FFSs have a 3 degree-of-freedom (DOF) motion cueing system compared to the 6–DOF motion cueing requirement for Level C and Level D FFSs. Typically, a 3–DOF motion cueing system includes motion cues in the pitch, roll, and heave axes.[18] For wings-level maneuvers, such as the nose-high or nose-low upsets, the dominant motion cues during the stimulation of such an upset will typically be limited to the pitch and heave axis with little activity in the other axes. Because there may be considerable variation in how each pilot responds to an upset in training, other cues may be introduced during the recovery maneuver that are outside of the capability of a Level A or Level B FFS. Furthermore, a wings-level stall entry may result in considerable lateral-directional accelerations on airplanes that are unstable at the stall. These cues will generally be outside the capability for a Level A or Level B FFS with a 3–DOF motion cueing platform to reproduce; therefore, evaluation of full stall and upset in these devices would not be appropriate in most cases.

FAA adds that while the qualification of extended envelope training tasks will generally be applicable only to Level C and Level D simulators, operators of other FFSs have the option to apply for FAA consideration of a deviation from the use of a Level C or Level D simulator for extended envelope training tasks as described in § 121.423(e). Since the approval of such a deviation will be linked to the training program and the alternate means that are proposed to achieve the required learning objectives, approvals to deviate from the Level C or higher requirements in § 121.423 will have to be reviewed on a case-by-case basis under the deviation authority.

2. Record and Playback Requirements for UPRT

In its proposal, the FAA included minimum requirements for a means to record and playback audio and video as well as a means to record and playback certain parameters for the qualification of UPRT maneuvers.

American, Boeing, Delta, A4A, FedEx, JetBlue, and an anonymous commenter stated that the requirement for record and playback functionality is outside the scope of the part 60 rule and does not provide additional benefits to the training scenario. While the commenters generally agreed with having parameters available to the instructor during the scenario, such as the aerodynamic validation envelope and the aircraft operational limits, the recording and playback of parameters, particularly the recording and playback of audio and video, should be left to the discretion of the operator. Both ALPA and A4A further commented that there are union and collective bargaining agreements to

[18] See 14 CFR part 60, Table A1A, entry 5.b.

consider with videotaping flight crews in training. Additionally, several commenters noted that there is a high cost burden with requiring the audio and video playback functionality and the requirement should be removed.

The FAA has reconsidered the instructor feedback requirements and agrees with the commenters that effective UPRT can be conducted without audio and video playback capabilities or with the use of an instructor off-board debriefing system located outside of the simulator for the purposes of replaying the training scenario after its conclusion. While the use of off-board debriefing tools and audio/video playback may enhance such training, the FAA recognizes that operators can still conduct effective training without them and has amended the final rule to remove the audio and video record and playback requirements.

3. Instructor Operating Station (IOS) Requirements

In the NPRM, the FAA proposed minimum requirements for a feedback mechanism, located on the IOS and available to the instructor, that provides a minimum set of parameters to display to determine expected FSTD fidelity, aircraft structural/performance limitations, and student flight control inputs. The FAA provided example IOS feedback displays in the information section of Attachment 7 to Appendix A. The proposal also included requirements for features or malfunctions to support the training of crew awareness, recognition, and recovery from an aircraft upset.

American and A4A commented that the UPRT requirements for upset ''awareness'' and ''recognition'' features and/or malfunctions are outside of the scope of the rule and emphasis should be placed on recovery from an upset. JetBlue made similar comments on this topic. Boeing further commented that how the training requirements are met should be at the discretion of the training program and is not pertinent to FSTD qualification. Since these features are not prescribed, they should appear in the information/notes column and not in the requirements column of Table A1A. Frasca additionally questioned what would be some examples of relevant data sources with respect to externally driven upset scenarios.

Regarding the IOS requirement to display ''Cl-max'', A4A, Boeing, and an anonymous commenter stated that ''Cl-max'' is not an explicit output of most aerodynamic models and is not available for plotting on the IOS display. Similar comments concerning the use of ''Cl-max'' as an example of a limit were made by the NTSB. Boeing and FlightSafety also recommended changing the IOS feedback requirement from showing ''aircraft structural/performance limitations'' to showing ''aircraft operating limits''. FlightSafety further commented that aircraft structural and performance limitations are not likely to be known or provided to simulator manufacturers or operators. Delta commented that as an alternative to the record and playback functionality, enhancing existing IOS functionality to include ''FSTD crash'' and freeze when g-load or control input parameters are exceeded would provide immediate information to the instructor. UPS made similar comments in that a flag could be added to the IOS for envelope excursion and a maximum load indication and that other feedback mechanisms are cost prohibitive and not needed.

The FAA agrees with the commenters in that mandating specific features and malfunctions to drive upset scenarios is generally outside the scope of part 60 and has removed these requirements in the final rule. The FAA further notes that specific guidance material on developing UPRT scenarios has been published as part of Advisory Circular (AC) 120–111, Upset Prevention and Recovery Training.

The FAA maintains that minimum feedback requirements have been found necessary to provide meaningful information to the instructor in training and evaluating pilots in UPRT maneuvers. The FAA recognizes that FSTD sponsors and operators may have other means to display this information and the example IOS displays provided in Attachment 7 are included in an information section as guidance material and are intended to be examples that could be used if desired. Digital or discrete IOS feedback mechanisms may prove to be acceptable for some or all parameters as Delta and UPS have suggested and, consequently, the FAA has not mandated a particular solution. The FAA has amended the final rule to allow FSTD sponsors the discretion to determine a feedback mechanism design that provides the required parameters needed for UPRT and supports their particular training programs and FSTD capabilities.

The FAA has further amended the final rule to remove the ''structural/performance limitations'' terminology and replaced it with ''aircraft operational limitations'' as suggested by the commenters. Additionally, the FAA has removed the feedback parameter, ''Cl-max'' as suggested by the commenters and replaced it with ''stall speed'' and ''stall identification angle of attack'' since these are more useful parameters for instructors to directly provide feedback to crew members when conducting UPRT and stall maneuvers.

4. Aerodynamic Source Data and Range of the FSTD Validation Envelope

a. FSTD Validation Envelope and Training Maneuvers

In the NPRM, the FAA proposed requirements to define the limits of the FSTD's validation envelope and test the FSTD against a minimum set of standard upset recovery maneuvers as defined in the AURTA.

Boeing, A4A, and an anonymous commenter stated that the term ''extended envelope'' in the general requirements is redundant because ''modeling to the extent necessary. . . .'' defines the requirement adequately. Boeing further commented that this phrase is a misnomer and implies that the flight model may need to be extended. For some upset recovery training, the existing model may be sufficient to support the training needs. A4A made similar comments stating that its experience has shown that the current data appears to be sufficient for conducting upset recovery training.

Airbus further commented that the evaluation of the FSTD should take into consideration the training practices recommended by the aircraft OEM. An anonymous commenter additionally stated that it is imperative that the validation limits are defined by the aerodynamic data provider since they are the only credible source for these limits.

FAA agrees that the term, ''extended envelope'' may be redundant in this particular context and has amended the final rule accordingly. The FAA recognizes that many aerodynamic models on existing FSTDs may currently be capable of conducting UPRT maneuvers within their AOA versus sideslip validation envelope with no need to be extended further as the commenters suggest. However, the range of validation envelopes can vary significantly between FSTDs as a function of the extent of flight test data, wind tunnel data, and other data used to develop the model. Since those validation envelopes have not been transmitted by the data providers to the FSTD operators in most cases, the FAA has determined that the comments are unsupported and have concluded that operators need to obtain the validation envelopes and ensure that their training maneuvers remain within them.

The FAA agrees with Airbus in that the evaluation of the FSTD should consider the training that will be conducted in the device. However, this rulemaking only addresses FSTD qualification standards and the FSTD evaluation requirements were primarily developed to support training as required by the Crewmember and Aircraft Dispatcher Training final rule and public law. In developing the FSTD evaluation standards for UPRT, the SPAW ARC recommendations, as well as the AURTA recommendations, were reviewed to define a standard set of upset recovery maneuvers that were needed to minimally qualify an FSTD for such training. This set of maneuvers is considered to be the minimum required for FSTD qualification that will provide a baseline evaluation of the FSTD's capabilities to conduct UPRT, but in no way limits an FSTD sponsor's decisions concerning which upset recovery maneuvers they incorporate into their training programs.

The FAA further notes that the qualification requirements for UPRT in this final rule exceeds the current part 60 FSTD qualification requirement for ''recoveries from unusual attitudes'' which limits maneuvers to ''within the normal flight envelope supported by applicable simulation validation data.''[19] If a training provider, regardless of operational rule part, performs unusual attitude training[20] maneuvers that exceed the parameters that define an aircraft upset, that FSTD must be evaluated and qualified for UPRT. The FAA does not believe this will impose an additional cost burden on sponsors of previously qualified FSTDs since UPRT qualification is only required if the training provider chooses to conduct unusual attitude training that exceeds the defined upset conditions.

The FAA generally agrees that the validation limits are best defined by the aerodynamic data provider and has provided clarification in Attachment 7 in Appendix A of the final rule; however, there may be instances where the original aerodynamic data provider cannot directly provide this information (the original data provider is either no longer in business or no longer supports the model) and the FSTD sponsor must determine the validation envelope using data supplied with the original aerodynamic data package. The FSTD sponsor will be required to define such aerodynamic data sources in the required SOC.

b. Expansion of the FSTD Validation Envelope Using Existing Flight Test Data

In the existing part 60 rule, the objective testing requirements found in Attachment 2 of Appendix A requires that testing be conducted in weights and centers of gravity (CG) conditions that are typical of normal operations. Furthermore, where such testing is conducted at one extreme weight or CG condition, a second test must be provided at ''mid-conditions'' or as close as possible to the other extreme condition.

Airbus and Boeing commented that the existing part 60 requirement for objective testing to be predominately conducted in mid-weight/mid-CG flight conditions is outdated and a wider coverage of the alpha/beta (*e.g.,* AOA versus sideslip) envelope may be accomplished using critical flight conditions testing during aircraft certification at extreme weight and CG combinations. Boeing additionally stated that while the current regulation supports this, it requires testing at the opposite extreme conditions which increases the burden on the sponsor. Airbus additionally commented that there is no need to have a global requirement for this because the weight/CG requirements can be specified for each test where relevant. CAE made similar comments on this issue.

FAA agrees with the commenters and supports allowing flexibility in providing the best range of data to support not only extended envelope training, but all training conducted in an FSTD. Where weight and CG configuration is critical for validating a particular flight maneuver (such as in some of the takeoff objective tests), those conditions are described as a test requirement for that particular test. In general, the FAA recognizes that weight and CG effects on the aerodynamic model are well known and requiring redundant test conditions at varying weight and CG ranges has questionable benefit for FSTD validation in some required objective tests. The FAA has amended the final rule as recommended by the commenters to allow for greater flexibility in determining appropriate weight and CG conditions for some of the required objective tests that do not have specific requirements contained within Table A2A.

5. General Comments on UPRT

a. FSTD Qualification and FAA Oversight

ALPA commented that while they support the requirements associated with the simulator providing feedback to the instructors and evaluators, they believe that only simulators that can perform all aspects of the new training required in the Crewmember and Aircraft Dispatcher Training final rule should be qualified. In addition, ALPA further stated that since the proposed rule only requires FSTD evaluation for those FSTDs used to conduct the additional training tasks, a robust oversight system will be needed to ensure that only the simulators qualified for this training are used in the required training.

In developing the proposed requirements in the NPRM, the FAA considered the economic costs and benefits of mandating FSTD modifications and evaluations to support training requirements. With the considerable cost in the implementation of new aerodynamic stall models on previously qualified FSTDs, the FAA could not justify imposing this cost on FSTD sponsors who currently do not have a mandate to conduct such training. Furthermore, the FAA determined that some FSTD sponsors that do have a training mandate for stall and UPRT may realize some cost savings by not having to qualify all of their FSTDs where the training can be accomplished on a lesser number of devices. Finally, with the large number of FSTDs that will require evaluation to meet the part 121 compliance date of March 2019, this may provide some practical relief in having to qualify all FSTDs within a relatively short amount of time.

The FAA appreciates ALPA's concern for proper FAA oversight to ensure that the FSTDs are evaluated and qualified before extended envelope training is conducted. The FAA notes that an oversight system to track FSTD qualifications is already in place with the list of qualified tasks that is currently required on the part 60 required SOQ for all FAA qualified FSTDs.[21] In the final rule, the FAA maintained the requirement in FSTD Directive No. 2 that the individual training tasks are to be reflected on the FSTD's SOQ once qualified. The FSTD's SOQ will then serve as a tracking mechanism to ensure the FSTD has been properly evaluated and qualified by the FAA NSP to conduct the individual training tasks. Furthermore, the FAA

[19] 14 CFR part 60, Appendix A, Table A1B, Entry No. 3.f., ''Recovery From Unusual Attitudes''.

[20] Unusual attitude training is required training for an instrument rating, an airline transport pilot certificate, and an aircraft type rating.

[21] See § 60.17(b)

will coordinate internally with Principal Operations Inspectors (POIs) to ensure that only FSTDs that are qualified in accordance with FSTD Directive No. 2 are approved for use in training those specific tasks as part of an FAA approved training program.

b. Maintenance Concerns

A4A commented that further testing is needed to ensure that the reliability and availability of FSTDs due to maintenance issues is unchanged with the addition of UPRT training.

The potential for stall vibrations to cause FSTD maintenance issues has been acknowledged and discussed in a previous section on stall buffet. The FAA acknowledges that conducting UPRT maneuvers in an FSTD can produce significant motion system excursions, however, the FAA is not aware of any evidence that the addition of general UPRT maneuvers will introduce significant maintenance issues that would affect the overall reliability and availability of an FSTD beyond what is normally seen in existing training. As with motion system tuning in general, the FAA expects that FSTD sponsors will employ limits and protections within their motion system hardware and software that will protect the FSTD from dangerous excursions that could damage the FSTD's equipment or injure its occupants. The exposure to stall buffet likely has the greatest potential for affecting an FSTD's reliability and the FAA has addressed this issue in the stall requirements sections.

C. Evaluation Requirements for Engine and Airframe Icing Training Tasks

In the NPRM, the FAA proposed changes to the general requirements for engine and airframe icing qualification as well as adding a new objective demonstration test for ice accretion effects for newly qualified FSTDs. The changes were based upon new icing requirements in the ICAO 9625 document, as well as recommendations made by the SPAW ARC, and were intended to improve upon the existing engine and airframe icing requirements in part 60. The proposed changes focused on requirements for improved ice accretion models that represent the aerodynamic effects of icing rather than estimating icing effects through gross weight increments.

1. Objective Demonstration Testing

a. Objective Demonstration Testing for Previously Qualified FSTDs

In the proposal, the FAA introduced new objective testing requirements for the demonstration of icing effects on Level C and Level D FFSs. The objective tests are intended to demonstrate that the aerodynamic effects of ice accretion are present in the simulation with the icing model active as compared to the simulation where no ice is present. Due to the potential cost impact for previously qualified FSTDs, these tests were not retroactively required in FSTD Directive No. 2.

Boeing commented that the objective demonstration test for engine and airframe icing is not required in FSTD Directive No. 2 (for previously qualified FSTDs) and recommended that text should be added to Table A2A (Entry No. 2.i.) to clarify that this test is not required for previously qualified FSTDs.

FAA agrees with Boeing in that this demonstration test for engine and airframe icing is not required for previously qualified FSTDs and has added clarifying language in FSTD Directive No. 2. As with comments in previous sections concerning stall buffet testing, previously qualified FSTDs will maintain grandfather rights and the modifications to Table A2A will generally not be applicable to previously qualified FSTDs unless specified in an FSTD Directive. As a result, FAA has not added additional text in Table A2A concerning previously qualified FSTDs because it will be adequately addressed in the FSTD Directive.

b. Icing Effects and Recognition Cues

In the proposed icing effects objective demonstration test, the FAA included specific icing effects that may be present and evaluated as applicable to the particular airplane type. This list included both aerodynamic effects of ice accretion as well as engine effects that may also be present with the icing model activated in the simulation.

Boeing commented that the objective demonstration test for icing includes engine effects, but the general requirement for icing does not specifically identify engine effects and this should be removed from the objective testing requirement. An anonymous commenter stated that it may be necessary to show engine effects and airframe effects of icing separately because the test will not differentiate between thrust losses and drag increases. Another anonymous commenter pointed out that changes in control effectiveness and control forces are limited mainly to reversible systems on certain airframe configurations and the FSTD should only introduce these changes when they are representative of the specific make and model of aircraft. Additionally, an anonymous commenter stated that there is ''very little guidance on what engine icing effects should be represented and most manufacturers state there are little effects on engine indications for current turbofans. Based upon the data we do have for engine inlet icing, the effects are often very subtle, yet the requirements seem to ask for something more dramatic. If we modify our icing models to favor dramatic effects, do we risk training pilots to miss looking for the subtle indications?''

Concerning Boeing's comment, the general requirement for engine and airframe icing (Table A1A, Entry No. 2.j.) does include modeling the effects of icing on the engine, where appropriate, as does the current requirement in part 60. While the information section in the demonstration test does state ''aerodynamic parameters,'' the intent of the test is to demonstrate the effects of the icing model integrated into the simulation. If the sponsor designated icing model used for the demonstration test has an effect on relevant engine parameters (such as thrust reduction or other effects), these effects should also be shown as part of the test. FAA has amended the test details in the table to clarify this. Other icing models that may be optionally developed by the FSTD sponsor to train recognition of engine effects due to icing will not require separate objective demonstration testing.

The FAA agrees that icing effects should only be introduced where representative of the specific make and model of aircraft and has clarified this in Table A2A (test 2.i.) and Attachment 7 of the final rule. The FAA does not intend for a simulator operator to artificially insert dramatic icing effects that are not representative of the aircraft. While the FAA is aware that the cues of ice accretion can vary significantly depending upon the nature of the icing event and the aircraft's characteristics, the icing models developed for simulation and training purposes should support the general recognition of icing cues that are typical for the aircraft being simulated.

2. Requirements for Lower Level FTDs

In the NPRM, the FAA proposed general requirements and objective demonstration testing for engine and airframe icing as part of the new Level 7 FTD requirements in Appendix B.

TRU Simulation commented that in the proposal for ICAO 9625, Edition 4, only a Type VII is allowed for use in UPRT and this item (icing) is identified as only being required on devices where UPRT will be trained. TRU Simulation requested that the FAA confirm applicability on a Level 7 FTD and remove the requirement if not. TRU Simulation and A4A further commented that the objective demonstration test for icing is not required for an ICAO 9625 Type V device and should be removed from the Level 7 FTD requirements. TRU Simulation and A4A additionally commented that a new requirement for Level 6 FTD was introduced to have the anti-icing system operate with appropriate effects upon ice formation on airframe, engines, and instrument sensors.

FAA reviewed ICAO 9625 Edition 4 and found that the general requirement for the modeling of icing (Appendix A, Entry No. 2.1.S.e.) is a minimum requirement for an ICAO 9625 Type V device and has therefore maintained this requirement for the FAA Level 7 FTD. FAA confirms that the objective demonstration testing for icing is not required for an ICAO 9625 Type V device and therefore has removed this requirement for the FAA Level 7 FTD in Table B2A to maintain consistency with the ICAO document.

Regarding the addition of anti-icing effects to a Level 6 FTD, FAA has removed the ICAO numbering system in the general requirements table that was published with the NPRM and restored the existing part 60 requirements for Level 6 FTDs. The FAA notes, however, that the existing part 60 functions and subjective testing requirements for Level 6 FTDs includes ''operations during icing conditions'' and ''effects of airframe/engine icing'' in Table B3A of Appendix B. The FAA has not changed these requirements in the final rule.

3. Existing Engine and Airframe Icing Requirements in Part 60

In the existing part 60, the subjective evaluation requirements in Appendix A includes a table of special effects (Table A3F) that contains additional requirements for the qualification of engine and airframe icing. In the NPRM, the FAA maintained this table with no changes to it.

Boeing, A4A, and NTSB commented that the requirements for icing evaluation in Table A3F (special effects) include the evaluation of increased gross weight due to ice accumulation. The commenters noted that the pilot has no means to recognize if the simulated aircraft's weight has increased and an increased gross weight due to ice accumulation is typically an insignificant effect of icing. Boeing further commented that this test requires a ''nominal altitude and cruise airspeed and is likely to result in a flight condition where icing does not occur for large commercial transport category airplanes. This flight condition will also likely result in trimming at a low AOA where the effects of ice, even with the anti-ice system deactivated, are small (a few tenths change in pitch attitude or a few percent change in thrust to maintain level flight). In the lower AOA range, the aerodynamic effects of ice are relatively small. For large commercial transports one might expect to see a few tenths of a degree change in pitch attitude or a few percent change in thrust to maintain level flight with the addition of ice. This proposed new test will likely result in generating unnecessary questions when the expected (larger) results are not seen.''

FAA agrees with the commenters and has removed references to increased gross weight in the final rule as that table entry for icing special effects (Table A3F, Entry No. 2) was inadvertently retained in the proposal. Furthermore, the FAA has amended this table to remove the ''nominal altitude and cruise airspeed'' requirement and made additional changes to better align this section with the general requirements for engine and airframe icing in Table A1A, Entry No. 2.j.

4. Applicability in Training Programs

In the NPRM, the proposed updated requirements for engine and airframe icing were applied to all Level C and Level D FFSs, regardless of the type of aircraft or operator. This is consistent with the engine and airframe icing requirements in the existing part 60 and previous FSTD evaluation standards. The FAA notes that ''engine and airframe icing'' simulation is not a new FSTD qualification requirement that was introduced by this rulemaking. In fact, the ''effects of airframe icing'' has been a minimum FSTD qualification requirement for Level D (Phase III) FFSs since the publication of AC 121–14C, Aircraft Simulator and Visual System Evaluation and Approval, published in 1980. Similarly, the ''effects of airframe and engine icing'' is currently an FSTD qualification requirement in the existing part 60 rule (published in 2008) for Level C and Level D FFSs.

Delta commented that the de-icing and anti-icing systems are very effective on turbojet airplanes. The accidents referenced in NTSB reports are turboprops with significantly less performance available. Delta added there are no useful training objectives to be taught to pilots of commercial turbojet airplanes in icing conditions. A4A commented that stall ice effects are not required by Public Law 111–216 or the Crewmember and Aircraft Dispatcher Training final rule and should be deleted from this final rule. Delta, A4A, and FlightSafety further questioned whether the FAA has a specific list of airframes that are impacted by icing or are vulnerable to a specific type of ice accretion.

The FAA points out that Section 208(b)(1) of Public Law 111–216 addressed increasing the familiarity of flight crewmembers with, and improving the response of flight crewmembers to icing conditions. However, irrespective of statutory direction, the FAA believes the understanding of the effects of icing on aircraft performance is essential for professional crewmembers particularly as it relates to stall AOA.

The FAA agrees with Delta that de-icing and anti-icing systems are generally very effective on turbojet airplanes. However, every airplane is susceptible to icing to some extent and therefore, there are useful training objectives to be taught to pilots of turbojet aircraft. While the FAA recognizes that turboprop airplanes are generally more susceptible to ice accretion, accidents and incidents on turbojet aircraft have occurred in the past. In the case of the Circuit City Cessna 560 (a turbojet aircraft) accident in Pueblo, Colorado on February 16, 2005,[22] the flight crew did not comply with de-icing procedures during approach which led to an aerodynamic stall from which they did not recover. While it is unknown if the crew recognized the effects of icing before the aerodynamic stall occurred, enhanced simulator training on de-icing and/or anti-icing procedures with representative effects of ice accretion may have increased their awareness that ice accretion was occurring.

With respect to engines, while turboprop and propeller aircraft engines are generally more susceptible to the effects of ice accretion than turbojet engines, power loss events due to core icing have been known to occur on multiple models of aircraft and engines (including large turbojet aircraft). In research conducted in 2009, it was found that engine power loss events due to ice accretion were occurring at a rate of about one event every 4 months.[23] While these events often occurred in conditions that pilots considered benign with no airframe ice accreted, there were recognition cues present and it was noted that each engine appeared to

[22] Crash During Approach to Landing; Circuit City Stores, Inc.; Cessna Citation 560, Pueblo, Colorado, February 16, 2005. Accident Report NTSB/AAR–07/02. National Transportation Safety Board.

[23] Mason, J., ''Current Perspectives on Jet Engine Power Loss in Ice Crystal Conditions: Engine Icing,'' Presentation at 2008 AIAA Atmospheric and Space Environments, June 23rd, 2009.

have a different manifestation of the icing event. While this final rule does not require specific engine icing models such as these, providing flight crews with representative cues of engine icing, where present during a typical in-flight ice accretion event, could aid in its recognition during line operations.

The FAA has not prescribed specific types of ice accretion models to be implemented in the final rule. The intent is to provide flight crews with representative recognition cues of ice accretion for the aircraft being simulated. Where the accident and incident record indicates that a particular airframe may be susceptible to a particular type of ice accretion, the simulation of the cues associated with that type of icing should be considered when developing a representative icing model. While the accident record has some general examples of this (such as supercooled large droplet icing or tailplane icing on some aircraft), the aircraft manufacturer will likely be the best source of information as to a particular type of icing scenario that may enhance training in recognizing and exiting icing conditions for that aircraft.

5. Data Sources and Tuning of Ice Accretion Models

In the proposal, the FAA introduced updated engine and airframe icing requirements that included a requirement to use ''aircraft OEM data or other acceptable analytical methods'' to develop ice accretion models.

An anonymous commenter stated that the cost of purchasing icing data, if it exists, could be prohibitive. Due to the availability of SME's who have flown the subject aircraft in icing conditions, the requirement should allow SME pilot validation of icing models. Both A4A and CAE made similar comments that some SME pilot tuning and validation of icing models should be allowed in the requirements.

Dassault further commented that flight test data obtained through the aircraft certification process is limited with larger amounts of ice accretion. Engineering tests might be conducted in those conditions; however, Dassault claimed it would be unable to provide an SOC because there is no flight test data to support it.

The FAA maintains that icing models may be developed using analytical or other engineering methods, incorporating flight test data where available. This process may include supplemental SME pilot assessment to tune and subjectively validate the models. Furthermore, the objective demonstration test does not require the use of flight test data or other data to validate the model. The demonstration test is for the purpose of demonstrating that the expected icing recognition cues are present as compared to the simulation with no ice present. The FAA has added clarifying language in Table A1A and Attachment 7.

The FAA agrees with Dassault that flight test data gathered during the aircraft certification process will generally be limited to ice shape testing conducted to demonstrate performance limits. Like the current part 60 requirements for the simulation of airframe and engine icing, engineering and analytical methods may be used to develop representative icing models that support the intended training objectives. While the use of flight test data would certainly assist in developing such models, engineering analysis supported with subjective assessment and tuning of the icing models for the expected recognition cues will be acceptable in lieu of flight test developed models and should not be as costly.

D. Evaluation Requirements for Takeoff and Landing in Gusting Crosswinds

In order to support the new gusting crosswind training requirements in the Crewmember and Aircraft Dispatcher Training final rule, the FAA proposed new minimum requirements for Levels A, B, C, and D FFSs to include the programming of realistic gusting crosswind profiles. The FAA notes that in the existing part 60 and previous FSTD evaluation standards, there is no requirement for any FSTD to simulate gusting crosswinds. These proposed requirements also included updated ground handling characteristics to be evaluated with crosswinds and gusting crosswinds up to the aircraft's maximum demonstrated crosswind component. The FAA further included guidance material in the information section of the proposal that recommended the use of the Windshear Training Aid or other acceptable source data in the development of the gusting crosswind profiles.

1. Applicability on Lower Level FSTDs

In the proposal, FSTD evaluation requirements for gusting crosswind profiles were made applicable for all FFS levels in Appendix A as well as the Level 7 FTD defined in Appendix B.

TRU Simulation and A4A commented that a new gusting crosswind requirement was added for the Level 7 FTD and questioned whether this was appropriate for a Level 7 FTD. Boeing additionally commented that the requirement for gusting crosswinds are proposed for Levels A, B, C, and D FFSs, but crosswind takeoff and landing tasks are not minimum requirements for Level A simulators in Table A1B. Finally, A4A and Delta commented that gusting crosswind requirements have been added for both Level A and B simulators, but should be removed due to lack of alignment with the ICAO 9625 FSTD device type categories.

With regards to the Level 7 FTD, FAA has examined the ICAO 9625 requirements for the Type V device and found that instructor control of ''surface wind speed, direction, and gusts'' is a minimum requirement for this device level (see ICAO 9625, Appendix A, section 11.4.R,G). In order to maintain consistency and alignment with the similar ICAO device, FAA has maintained this requirement in the general requirements and functions and subjective testing tables for the Level 7 FTD, but removed the more detailed requirement for realistic gusting crosswind profiles and the associated SOC that was proposed in the NPRM.

FAA agrees with Boeing's comment concerning the qualification of the Level A simulator for takeoff and landing tasks and has removed this requirement in the final rule. Additionally, due to the lack of required side force motion cueing in a Level B simulator that would enhance the simulation of a realistic and dynamic gusting crosswind scenario, the FAA has also removed this minimum requirement for Level B simulators in the final rule.

2. Gusting Crosswind Profile Data Sources

In the NPRM, the FAA proposed requirements for FSTD sponsors to develop a realistic gusting crosswind profile for use in training. The FAA was not prescriptive in this requirement and only required that the profile be ''realistic'' and ''tuned in intensity and variation to require pilot intervention to avoid runway departure during takeoff or landing roll.'' The FAA additionally provided guidance in the information column of the proposal recommending the use of the Windshear Training Aid or other acceptable data sources to develop the gusting crosswind profiles.

The FAA received several comments concerning the data sources needed to develop realistic gusting crosswind profiles to meet the rule requirements. American, JetBlue, and A4A commented that FAA should provide an appropriate gusting crosswind model as recommended by the NTSB in its safety recommendation. Boeing commented that the Windshear Training Aid does not provide the necessary data to effectively model gusting crosswinds. Delta and A4A further commented that the FAA should define ''other acceptable source data'' to help sponsors be consistent in programming the gusting crosswind scenarios. Additionally, A4A commented that the FAA should permit carriers to use crosswinds with gust data from multiple sources because doing so will provide flexibility, more compliance options, and reduce compliance burdens. Finally, an anonymous commenter stated that all references in the NPRM to ''gusting crosswinds'' lack definition of what is considered a ''gust''. ''Without a definition such as ''10 percent increase over steady state wind speed for x seconds, repeated randomly'', this is an entirely subjective condition and as such is subject to every inspector's idea of what a wind gust should or could be. If the FAA cannot provide subjective guidance similar to the Windshear Training Aid, which does not provide adequate information for this scenario, the gusting crosswind scenarios should be treated as 'demonstration only' and not for training credit.''

While the FAA would generally agree that a defined wind gust model could provide standardization for FSTD qualification purposes, such a generic model may not be realistic unless tuned for the particular aircraft and training scenario. Similar to the Windshear Training Aid's windshear profiles, subjective tuning would be required to adjust the model as a function of the aircraft type/configuration and ambient conditions to provide the cues and aircraft performance needed to accomplish the training objectives. In the proposal, the FAA required that such wind gust models be ''realistic'' and have been ''tuned in intensity and variation to require pilot intervention to avoid runway departure.'' Like many other areas in the simulator qualification standards, this allows for the FSTD sponsor to develop solutions that meet the needs of their particular training program without the FAA prescribing a specific solution. While realistic baseline wind gust models may be derived from aircraft operational data, meteorological data, or other data, a certain amount of subjective tuning will be required in many cases to ensure the gusts are adequate enough to require pilot intervention to avoid runway departure or otherwise do not exceed the crosswind capabilities of the simulated aircraft and supporting aerodynamic and ground model data. Due to the wide range of aircraft and associated crosswind capabilities, the FAA has found that specifying a certain gust characteristic for FSTD qualification would not be practical and has maintained the requirements as proposed.

In response to the NTSB safety recommendation [24] and commenters' requests for an FAA developed gusting crosswind model, the FAA conducted an analysis of the extracted wind data from the Continental (CO) 1404 accident [25] and developed two wind gust models that may be used by FSTD sponsors to meet the requirements for a realistic gusting crosswind model. The first model was developed using the CO 1404 accident data to closely replicate the wind gust that was experienced by the flight crew in that accident. While this model was tested by FAA on a Boeing B737–800 simulator and was found to provide a subjectively acceptable training scenario, it is expected that the model will need to be tuned by the sponsor for different aircraft and operator specific training scenarios.

A second model was developed using a simplified linear estimation of the CO 1404 accident data using maximum wind rates of change as referenced in the Windshear Training Aid and the Joint Airport Weather Studies (JAWS) [26]. Similar to the continuous wind gust model, this model may also require tuning by the sponsor for different aircraft and operator specific training scenarios.

FAA recognizes that sponsors may desire to implement their own wind models that may be more suitable for their particular training programs and has not mandated the above described wind gust models as a condition of FSTD qualification. These models will be provided with the final rule as guidance material in a National Simulator Program (NSP) Guidance Bulletin and may be used as one method to develop realistic gusting crosswind profiles to satisfy the requirements of the rule. As suggested by A4A, this will provide operators with flexibility to develop other wind gust models from multiple sources to meet the FSTD qualification requirements.

3. Maximum Demonstrated Crosswind

In the proposal, the FAA included general requirements for Level C and Level D FFSs that included ground handling characteristics for crosswinds and gusting crosswinds up to the aircraft's maximum demonstrated crosswind component.

Delta and A4A requested clarification if the maximum demonstrated crosswind value includes the gusting component, or is the intent to require the gusting component in addition to the maximum demonstrated crosswind value.

The FAA has not prescribed a specific wind magnitude and direction to be implemented in the gusting crosswind model requirements. The wind gust models that will be provided by the FAA in guidance material were designed to allow for tuning of the gust characteristics as needed for the particular training scenarios (such as steady state wind conditions and runway direction) and aircraft type being simulated. The tuning of gust models should be conducted in consideration of the maximum crosswind capabilities of the aircraft in order to provide operationally realistic scenarios that are survivable in training. The specific aircraft crosswind capabilities, to include the addition of gust factors, are determined by the aircraft OEM. If this information is not clear in the aircraft flight manual, the FSTD sponsor should consult with the aircraft OEM. Additionally, the FSTD sponsor should coordinate with the data provider to ensure that gust models do not exceed the capabilities of the simulator's aerodynamic and ground models. The FAA has added information material in Table A1A (entry no. 2.d.3) to the final rule for clarification.

4. Requirements for Previously Qualified FSTDs

In the proposal, the updated ground handling and ground reaction requirements in Table A1A included information that stated ''tests required'' for these particular sections. The FAA notes that this text was derived from the similar sections in the ICAO 9625 document as part of the alignment process.

Delta and A4A pointed out that the general requirement for gusting crosswind (Table A1A, Entry No. 3.1.S in the NPRM) states ''tests required'' and requested clarification if additional objective testing is required under the FSTD Directive for previously qualified FSTDs.

In the final rule, since the FAA restored the existing part 60 format for the general requirements table as compared to the ICAO format in the proposal (including sections for ground reaction and ground handling

[24] NTSB safety recommendation no. A–10–110.

[25] Runway Side Excursion During Attempted Takeoff in Strong and Gusty Crosswind Conditions, Continental Flight 1404, December 20, 2008, NTSB Final Report, NTSB/AAR–10/04.

[26] The maximum wind rates published in the Windshear Training Aid are based upon the Joint Airport Weather Studies (JAWS) and were calculated from accident flight data recorder and Doppler radar measurements of microburst events.

characteristics), the text for ''tests required'' was removed from the ground handling requirements in Table A1A, Entry No. 2.d.3. in the final rule. No additional objective testing for ground reaction and ground handling characteristics was intended for previously qualified FSTDs in FSTD Directive No. 2. The FAA further notes that all required objective testing is fully described in Table A2A, making any such ''tests required'' notations in the information column redundant.

E. Evaluation Requirements for Bounced Landing Recovery Training Tasks

In the proposal, the FAA included updated FSTD evaluation requirements for ground reaction characteristics to support the bounced landing recovery training task that is required in the Crewmember and Aircraft Dispatcher Training final rule. The new requirements included ground reaction modeling to simulate the effects of a bounced or skipped landing as well as the indications of a tail strike or nosewheel exceedances as appropriate for the simulated aircraft and conditions.

1. Applicability to Lower Level FSTDs

In the proposal, the new requirements for bounced landing recovery evaluation were included for Level C and Level D FSTDs in Appendix A as well as for the new Level 7 FTD in Appendix B.

TRU Simulation and A4A commented that the bounced landing requirements were added for the Level 7 FTD and questioned whether it was appropriate for this device.

Given the Crewmember and Aircraft Dispatcher Training final rule requirement that a Level C or higher FSTD be used to conduct bounced landing recovery training tasks, the FAA has removed the additional FSTD evaluation requirements in the final rule for bounced landing recovery from the Level 7 FTD minimum requirements in Appendix B.

2. Bounced Landing Modeling and Evaluation

a. Nosewheel Exceedences

As part of the bounced landing recovery requirements in the proposal, the FAA included requirements to include indications of a tail strike and nosewheel exceedances.

Boeing commented that the requirement for ''nosewheel exceedances'' needs to be more clearly defined (*e.g.,* limit, yield, or ultimate loads) and suggested changing the rule text to read ''effects and indications of ground contact. . .''. An anonymous commenter further stated that calculation of structural loads on the nose gear is not a common feature in current FSTDs. Any nose first landing is considered abnormal and could be flagged on the IOS.

The FAA agrees with the commenters and has removed the nosewheel exceedances requirement from the final rule as it is not necessary to accomplish the training objectives for bounced landing recovery training tasks. This language was replaced with ''the effects and indications of ground contact due to landing in an abnormal aircraft attitude . . .'' since information on aircraft attitude during the landing and go-around sequence will be more useful to the instructor in evaluating bounced landing recovery training tasks.

b. Use of Existing Ground Reaction Modeling

In the NPRM, the FAA proposed that ground reaction modeling must simulate ''. . . the effects of a bounced or skipped landing (to include indications of a tail strike or nosewheel exceedances) as appropriate for the simulated aircraft and conditions''.

Delta and A4A commented that the existing part 60 requires verification of ground reaction and ground effects by minimum unstick speed, ground effects, and takeoff and landing performance objective tests. An SOC from the data provider and an affirmation that the model has been implemented correctly should be adequate. There is no need for additional subjective verification by a qualified pilot. A4A further commented that at least one data provider has implied that their current data and model meets the proposed requirements. CAE commented that the strut system simulation (damper/spring) and its geometry are already properly modeled and should provide the appropriate forces and moments during a bounce.

As described in the proposal, the FAA agrees with the commenters that much of the aerodynamic and ground reaction modeling is currently required and validated in several required objective tests for FSTD qualification. As such, the FAA has not required any additional objective testing for the qualification of bounced landing recovery training tasks in this final rule. In order to support bounced landing recovery training, the FSTD must have the ability to provide the instructor with the effects and indications of ground contact as a result of the FSTD being landed or conducting a go-around at an improper aircraft attitude. In addition to pitch attitude information, other parameters such as indications of nosewheel contact and indications of a tailstrike would provide useful information to the instructor in evaluating a bounced landing recovery maneuver. FAA agrees with the commenters that the use of a qualified SME pilot to evaluate these indications may be of limited value because they may not have any direct experience in the indications of a tailstrike in the airplane to base such an evaluation on. The FAA does recognize, however, that a tailstrike and other indications of ground contact can be computed in software using the geometric dimensions of the airplane and these indications will provide the instructor with additional feedback to assist in determining whether the aircraft landed in or a go-around was attempted in an unusual aircraft attitude. These indications and the ability of the modified FSTD to perform the intended training tasks are what should be evaluated by the sponsor's designated pilot as described in the FSTD Directive and § 60.16(a)(1).

The FAA has reviewed the current part 60 ground reaction and ground handling requirements along with associated objective testing that are already required for Level B through Level D FFSs and has determined that adequate requirements already exist in part 60 to evaluate and validate the aircraft dynamics necessary to support bounced landing recovery training tasks.[27] In order to improve the instructor's evaluation of an abnormal aircraft attitude during the bounced landing recovery maneuver, the FAA has amended the current ground reaction requirement for Level B through Level D FFSs to include appropriate effects during bounced or skipped landings, including the effects and indications of ground contact due to landing in an abnormal aircraft attitude.

3. Alignment With Training Requirements

As noted in the NPRM, the FSTD evaluation requirements for bounced landing recovery maneuvers were introduced both to support new requirements in the Crewmember and Aircraft Dispatcher Training final rule as well as to address comments concerning potential deficiencies in FSTD fidelity in this flight regime.

An anonymous commenter stated that ''there is no bounced landing training task listed in Table A1B (Table of Tasks v. Simulator Level). It is agreed that a

[27] In addition to objective testing requirements for maneuvers such as takeoff, landing, minimum unstick speed, and ground effect, the current part 60 ground reaction general requirements (Table A1A, Entry No. 2.d.2.) already requires ground reaction modeling that generally supports bounced landing recovery training.

Level D simulation should produce a bounced landing if appropriate, however that does not translate into a training requirement. There is currently no approved pilot training program that includes bounced landing. At most, it could be a required demonstration element, but it should not be a required training maneuver.''

A4A commented that Boeing has already addressed the bounced landing recognition and recovery procedure in their operating manuals and in recurrent simulator training and that the FAA should review simulator data it currently receives to determine if recurrent training programs implemented due to the NTSB recommendations were effective. A4A and JetBlue further commented that ''the training final rule limits new training requirements to recovery from bounced landing because carrier training programs currently include bounced landing training as recommended in FAA's InFO 08029 . . . simulator modeling for this final rule should be limited to enhancement to train recovery methods; it should avoid introducing elements that might induce negative training associated with 'teaching to bounce'.'' In addition, CAE made similar comments concerning the potential of a transfer of negative training in introducing a bounced condition during landing.

The FAA notes that bounced landing recovery is a training requirement for air carriers under § 121.423. While the minimum qualified task list in Table A1B does not specifically list bounced landing tasks, the final rule will require an amendment to the FSTD's SOQ that the FSTD has been evaluated for bounced landing recovery training tasks. As addressed in the Crewmember and Aircraft Dispatcher Training final rule, the FAA is aware of the incorporation of bounced landing recovery training by operators in response to the FAA's InFO and SAFO bulletins. To support the new training requirements in § 121.423 for bounced landing recovery training, the FSTD qualification standards were revised in this rule to ensure the FSTDs used to conduct such training have been properly evaluated for the training tasks.

The FAA agrees with commenters in that the purpose of bounced landing recovery training is to train bounced landing recovery methods and not to teach a pilot how to bounce the aircraft. While the simulation should support the ability to reproduce a bounce where the flight conditions dictate, the primary objective of training is to train recovery techniques should the landing result in an inadvertent bounce. The FAA agrees with the commenters in that these recovery techniques can be taught without stimulating an actual bounce during the landing sequence and rather ''calling a bounce'' to initiate the recovery maneuver. The FAA has amended the final rule to emphasize that the FSTD evaluation requirements are on the aircraft dynamics resulting from the bounced landing recovery and not in stimulating a bounce during the landing sequence.

The FAA further emphasizes that the FSTD evaluation requirements in the final rule that support bounced landing recovery training tasks are essentially a consolidation of existing requirements within part 60 [28] and will further support the instructor evaluation of other landing training tasks where the simulator may be inadvertently landed in an abnormal aircraft attitude.

4. Requirements for Previously Qualified FSTDs

Delta, FlightSafety, and A4A pointed out that the general requirement for ground reaction modeling (Table A1A, Entry No. 3.1.S in the NPRM) states ''tests required'' and requested clarification if additional objective testing is required under the FSTD Directive for previously qualified FSTDs.

In the final rule, since the FAA restored the existing part 60 format for the general requirements table as compared to the ICAO format in the proposal (including sections for ground reaction and ground handling characteristics), the text for ''tests required'' was removed from the ground reaction requirements in Table A1A, Entry No. 2.d.2. No additional objective testing for ground reaction and ground handling characteristics was intended for previously qualified FSTDs in FSTD Directive No. 2. The FAA further notes that all required objective testing is fully described in Table A2A, making any such ''tests required'' notations in the information column redundant.

F. Alignment With the ICAO 9625 International FSTD Evaluation Document

In order to promote harmonization of FSTD evaluation standards with that of other national aviation authorities, the FAA proposed alignment of the part 60 Qualification Performance Standards (QPS) with the latest international FSTD evaluation guidance in the ICAO 9625, Edition 3, document. Unlike previous alignment efforts the FAA undertook with earlier versions of the ICAO 9625 document that only contained one level of FSTD, this alignment effort proved to be more complex because the Edition 3 document contained many other FSTD levels that do not share an equivalent fidelity level in part 60 and other FAA training regulations and guidance material. Furthermore, since the main purpose of this rulemaking was to define new FSTD evaluation standards for new training tasks introduced by the Crewmember and Aircraft Dispatcher Training final rule, practical time limits prevented the FAA from conducting the significant updates to other regulations and guidance material to support a complete change in the existing hierarchy of FSTD levels. For these reasons, a full alignment with all of the FSTD levels in the ICAO 9625 document was not proposed with this rulemaking and only portions of the technical guidance material from ICAO were incorporated where practical.

1. Partial Alignment With the ICAO 9625 Document

For reasons cited above, the FAA did not propose complete alignment with ICAO 9625, Edition 3. In lieu of conducting a full alignment, the FAA proposed partial alignment with the ICAO document where significant overlap existed between the FAA FSTD fidelity levels in the part 60 QPS and the ICAO document. This included alignment of the part 60 Level C and D FFS evaluation standards with that of the highest level of ICAO device (the Type VII device) as well as adding a new Level 7 FTD to align with the ICAO Type V device.

FAA received several general comments concerning the proposed partial alignment with the ICAO 9625 FSTD evaluation guidance document. A4A commented that the ''incorporation of 9625 is not required to meet §§ 121.423 and 121.434. We are not opposed to harmonizing part 60 with the international standards but this piecemeal approach to incorporating the ICAO STD does not provide additional benefits for flight training''. A4A further stated that ''the FAA should consider incorporating ICAO 9625 as the standard for flight training in its entirety. Until this approach for part 121 training can be adopted, incorporating pieces of the standard into part 60 is only providing additional burden without benefit.'' American and Alaska Airlines made similar comments that there is no training value in adopting the ICAO standard as presented and recommended that the FAA should not adopt the ICAO standard unless doing so in its entirety. ALPA generally

[28] See 14 CFR part 60 (2008), Appendix A: Table A1A, Entry No. 2.d.2 (ground reaction modeling); and Table A3D (motion system effects), Entry no. 7 (main and nose gear touchdown cues), and Entry No. 13 (tail strikes and engine pod strikes).

supported the incorporation of the ICAO 9625 guidance into part 60, but expressed concern regarding the introduction of a fixed-base (non-motion) FTD for flightcrew training. Also, ICAO generally supported the incorporation of the ICAO 9625 document and further noted that the fourth edition of the ICAO 9625 document was recently published on the ICAO internet site for regulatory authorities.

The FAA notes that the primary purpose of this rulemaking was to update the FSTD evaluation standards to address the new extended envelope training introduced by the Crewmember and Aircraft Dispatcher Training final rule. Because the FAA and industry were integrally involved in the development of the ICAO 9625 FSTD evaluation guidance material, and much of the current part 60 and grandfathered FSTD standards are based upon previous versions of the ICAO 9625 document, the FAA proposed updating the current part 60 standard for certain FSTD levels that overlapped with similar FSTD levels defined in the ICAO 9625 document. Unlike previous versions of the ICAO 9625 document, ICAO 9625, Edition 3, introduced several new FSTD levels that have no direct equivalent in the part 60 rule. Because of the time critical nature of the extended envelope training requirements, it was determined that redefining all of the FAA FSTD levels to align with the ICAO document would not be practical because of the numerous other training rules and guidance material that would be affected if we made significant changes to the part 60 qualification standards and FSTD level definitions.

The benefits of general ICAO alignment are not readily quantifiable since they primarily focus on improving the overall simulation environment and not on specific safety issues. From an international harmonization standpoint, FSTD manufacturers and data providers can benefit from developing FSTDs and supporting data packages that meet a single internationally recognized standard. Despite statements made by one commenter concerning ''illusory benefits from internationally aligned FSTD standards,'' the FAA believes there is anecdotal evidence that supports the benefits of international harmonization. Based upon past experience with the previous international alignment efforts, the FAA points out that over 250 FSTDs (including FSTDs qualified by A4A air carriers) were voluntarily qualified against the more stringent ICAO 9625, Edition 2, JAR–STD 1A, Amendment 3,[29] and Draft AC 120–40C internationally harmonized standards during the 1995 to 2008 timeframe before part 60 became effective in 2008.

Due to the time critical nature of the extended envelope training requirements, complete alignment with the ICAO 9625 document was not considered in this rulemaking. Most of the device levels defined in ICAO are not within the scope of part 60 (all but two FSTD levels in ICAO 9625 are for generic or representative devices that are not defined in part 60) and would require significant rulemaking and policy changes outside of part 60 to address a new hierarchy of device levels. The FAA considers the ICAO alignment conducted in this rulemaking as a significant step in maintaining harmonization with the international FSTD evaluation standards and will continue to look for opportunities to further expand the alignment with the ICAO 9625 document where practical.

2. New Requirements Introduced by the Proposed ICAO Alignment

Several commenters pointed out that some of the new requirements introduced in the proposed ICAO 9625 alignment would add to the cost of a new Level C or Level D FFS with no demonstrated value to training. The FAA partially agrees with the commenters in that it is difficult to quantify specific safety benefits from some of the new and updated standards introduced as a result of the ICAO alignment. Most of these changes in the ICAO alignment target the improvement of objective testing tolerances, the incorporation of testing requirements for new technology that is not currently addressed in the simulator standards, and improvement of the overall simulation environment.

a. Visual System Field of View

A4A, JetBlue, Delta, and an anonymous commenter stated that the increased visual system field of view requirement from 180 degree × 40 degree in the existing part 60 general requirements to 200 degree × 40 degree in the proposal would introduce significant cost to a new simulator and has no demonstrated benefit to crew training. In addition, A4A and JetBlue further commented that the justification for this proposal is harmonizing with ICAO standards; there is no statutory or regulatory requirement or NTSB recommendation on this topic. The increased field of view for newly qualified FSTDs does not demonstrate any improved training value; the existing field of view has been used successfully in training programs worldwide for well over a decade. Increasing the field by 10 degrees on each side would add no value in taxiing or on the circling approach and there is no data or industry trend to indicate that pilots are experiencing difficulty performing these maneuvers using the current systems. Most part 121 air carriers train to Visual Flight Rules (VFR) minimums for a circling approach and in fact most flight schools that offer Airline Transport Pilot qualification courses now require only demonstration at a VFR level. A simulator field of view expansion to 200 degrees would not change practices at other facilities.

Concerning the cost of this new requirement, A4A further commented that the expense associated with this field of view expansion would add an estimated 20 to 30 percent to the cost of a visual system for the purchasing of a newly qualified FSTD, depending on the manufacturer. In most cases this would require the addition of at least one and possibly two image generators, very similar to helicopter simulators. In addition, changing the field of view standard for newly qualified FSTDs will prevent carriers from obtaining existing simulators that reside outside the United States (U.S.) that have a 180 degree field of view, and have not yet been qualified in the U.S. This would force carriers to purchase new simulators instead of purchasing used simulators; it will cost more and impose less efficient training options.

The FAA concurs with the commenters in that little evidence suggests that increasing the visual system field of view requirements to 200 degrees (horizontal) will have a quantifiable safety benefit. In order to avoid incurring significant additional cost as a result of the ICAO 9625 alignment as identified by the commenters, the visual system field of view requirements will remain at the existing part 60 requirement of 180 degrees × 40 degrees for Level C and Level D FFSs in the final rule.

b. Visual System Lightpoint Brightness Testing

In the NPRM, the FAA proposed the addition of a new objective visual lightpoint brightness test as part of the ICAO 9625 alignment. The addition of this test addresses inherent system limitations in fixed matrix visual display systems (such as LCD systems) and their ability to display lightpoints as compared to older calligraphic display systems. American, A4A, and an

[29] JAR–STD 1A was a publication by the Joint Aviation Authorities that provided FSTD qualification standards for European countries.

anonymous commenter stated that the tolerance for this test should be reduced from the 8.8 foot-lamberts as proposed in the NPRM to 5.8 foot-lamberts as proposed in the updated ICAO 9625, Edition 4, document because it has no technical advantage and is not achievable with current technology over long periods of time. CAE further stated that this requirement cannot currently be met with light emitting diode (LED) based visual projectors and this issue has been subsequently addressed in ICAO 9625, Edition 4. Similar comments were made by TRU Simulation. Frasca commented that, with regards to the surface brightness test, a modern display system cannot boost the brightness for light points only. If the system just meets the display brightness requirement, it will not pass the light point brightness requirement. This would only be possible using calligraphic projectors, which are no longer in regular use for simulation.

The FAA concurs with the commenters and has reviewed the updated ICAO 9625, Edition 4, document as suggested. In that document, the light point brightness test tolerance has been amended to be less restrictive (5.8 foot-lamberts) as compared to the Edition 3 document due to the inherent limitations of solid state illuminators (such as LEDs). In these types of systems, the benefit of improved temporal stability justifies the inherently lower brightness that an LED can produce as compared to a standard lamp illuminator. To support the alignment of the part 60 technical requirements with the ICAO document, as well as to address the commenters concerns, the FAA has amended this objective test (Table A2A and Table B2A, Entry No. 4.a.7.) in the final rule as recommended by the commenters.

c. Transport Delay Testing

In the NPRM, the FAA proposed to reduce the transport delay tolerances from150 millisecond (ms) to a more restrictive 100 ms tolerance for the purposes of aligning with ICAO 9625, Edition 3 as well as improving the overall simulation environment with faster simulation induced response times. The FAA received many comments on this issue which generally recommended that the FAA should not adopt these tighter tolerances. Boeing, FedEx, Delta, A4A, and American commented that while ICAO 9625 Edition 3 recommends a more restrictive tolerance than what is currently in part 60, there appears to be no evidence that timing below 150 ms provides better crew training. Boeing further commented that those values have been hard to achieve in industry, costing substantial amounts of money to meet this requirement. A4A further commented that ''the FAA should not change the transport delay standard because there have been no reports of pilot induced oscillation due to a throughput (transport) delay tolerance being too high. The current transport delay tolerance of 150 ms has proven to be adequate for all Level D FFSs with no known problems to date. The tolerance has no impact on safety and is a technical limitation of the software and hardware. Carriers have operated with the 150 ms for decades with no measurable degradation in training. In addition, the ICAO standard is being revised and will change in 2015; an FAA change to 100 ms will result in misaligned U.S. and ICAO standards starting next year. Therefore, to require adjustment of the delay to 100 ms would provide no additional benefit to pilot training and it is recommended that 150 ms tolerance be retained.'' Frasca, American, Boeing, and CAE made similar comments concerning the less restrictive 120 ms tolerance that has been amended in ICAO 9625, Edition 4.

While the FAA would concur that it is difficult to quantify transfer of training benefits with transport delay tolerances reduced to lower than 150 ms, it has been well established through multiple research studies that transport delay in simulation can significantly affect pilot performance. The FAA maintains that the proposed 100 ms tolerance is not a significant technical limitation of simulators and has, in fact, been a minimum FSTD qualification requirement for helicopter simulators since 1994.[30] Furthermore, the FAA conducted a random sampling of currently qualified FSTDs that were initially evaluated within the past 10 years and found that 44 percent of these FSTDs would have met the ICAO 9625, Edition 3, tolerance of 100 ms and 83 percent of these FSTDs would have met the ICAO 9625, Edition 4, tolerances (100 ms for motion/instrument and 120 ms for visual system response) with no modification.[31] These numbers generally support the commenters' concerns that the 100 ms transport delay tolerance in the NPRM may not be easily attainable with current technology that is implemented on previously qualified fixed wing FSTDs.

To address these concerns and to maintain consistency with the international guidance material, the FAA has amended the final rule to incorporate the updated ICAO 9625, Edition 4, transport delay tolerances of 100 ms for motion system/instrument response and 120 ms for visual system response as recommended by many commenters.

d. Objective Motion Cueing Fidelity Test

As part of the ICAO 9625 alignment proposed in the NPRM, the FAA included objective motion cueing fidelity testing (OMCT) as a minimum requirement for FSTD qualification.

The FAA received several comments on the adoption of the ICAO 9625 OMCT test. American commented that the OMCT in the ICAO 9625 document is still a work in progress with some testing details that are still under consideration as more experience is gained with conducting the test. American further questioned what source data was used to define the motion fidelity tolerances that are associated with the test as well as the lack of a time-domain test that was supposed to complement the frequency-domain test in the ICAO document. Additionally, American stated that the purpose of including an incomplete set of tests in the ICAO standard is to collect data and that a final rule is not appropriate vehicle to 'gather data'. Finally, American recommended against replacing the existing motion cueing signature (MCPS) tests with the OMCT, however, if it were to be adopted in the final rule, it should be limited to an SOC issued by the training device manufacturer stating compliance. A4A and JetBlue made similar comments opposing the adoption of the proposed OMCT.

The FAA agrees that the proposed OMCT from ICAO 9625, Edition 3, primarily consisted of a testing method with no specific fidelity standard applied to the test results. The FAA further notes that the recently published ICAO 9625, Edition 4, document has improved the OMCT method and has added recommended tolerances to the test results that were based upon ''. . . the statistical results of reliable OMCT measurements of eight Level D or Type VII FSTDs.'' The FAA maintains that a significant weakness in today's FSTD evaluation standards is the lack of a consistent method to measure and apply motion cueing in crew training

[30] See Advisory Circular (AC) 120–63, ''Helicopter Simulator Qualification'' (1994); Appendix 2, test 5.a.; and 14 CFR part 60 (2008), Appendix C, Table C2A, test 4.a.2.

[31] The FAA conducted a random sampling of transport delay test results from the Master Qualification Test Guides (MQTGs) of 18 currently qualified FSTDs that were initially evaluated within the past 10 years. Eight out the 18 FSTDs would have met the 100 ms transport delay tolerance for all axes. Fifteen of the 18 FSTDs would have met the 100/120 ms tolerance.

simulators. An industry-led group developed the objective motion cueing test, and it represents a marked improvement over today's subjective-only assessments. While the FAA concurs that a specific fidelity requirement needs development, applying the OMCT and comparing the results against representative responses will promote useful standardization and improvement of overall motion cueing.

To address the commenters concerns, the FAA has amended the final rule so as to not require OMCT results in the MQTG for annual continuing qualification evaluation purposes. Instead, OMCT results will only be required once during the initial qualification of the FSTD and included in an SOC from the FSTD manufacturer. Furthermore, the FAA will not require a specific tolerance to be met for this test and only require that the FSTD manufacturer use the OMCT to document the overall performance of the motion system and use its results to aid in the tuning of the motion cueing algorithms. Finally, because the technical details of this testing method are multifaceted and not suitable for inclusion in the final rule's text, the FAA will issue guidance material with the final rule on how to apply the OMCT to meet the part 60 requirements.

e. Sound Directionality Requirement

A4A commented that the directional sound requirements (incorporated from the ICAO 9625 document) are not cost/benefit justified and are not required to meet any existing or proposed training requirement.

The FAA notes that the requirement for ''sound directionality'' was introduced as part of the ICAO 9625 alignment proposed in the NPRM.[32] After review of this requirement, the FAA will maintain the proposed requirement in the final rule. FAA has found that it is essentially a codification of existing practice where FSTDs are subjectively evaluated for flight maneuvers, including engine failures and other malfunctions, which would result in directionally representative sound cueing in the FSTD. FAA further notes that the accident record has documented instances where flight crews have inadvertently shut down the wrong engine while diagnosing an engine malfunction in flight. This additional sound cueing in the simulator may enhance training in recognizing and verifying the cues of an actual engine failure in flight.

3. Alignment With the Recently Published ICAO 9625, Edition 4, Document

Concurrent with the development of the part 60 NPRM, an international working group was convened to review and update the ICAO 9625, Edition 3, document to incorporate FSTD evaluation requirements to address full stall training, UPRT, and icing. This working group was essentially operating in parallel with the part 60 rulemaking effort and used a similar set of recommendations issued from the ICATEE working group to incorporate FSTD evaluation standards into the ICAO 9625 document. In addition to the changes made to support UPRT and stall evaluation, this working group also made general changes to the ICAO 9625 document that addressed known issues with the Edition 3 document. These included changes that addressed technological improvements, changes that updated various test tolerances which were relieving in nature, as well as editorial changes to correct or clarify the requirements in the Edition 3 document. Since the FAA proposed alignment with ICAO 9625, Edition 3, many of the known issues identified with that document were also present in the NPRM.

The FAA received several comments, including various comments from A4A, Boeing, CAE, Frasca, ICAO, and TRU Simulation that recommended the use of the draft ICAO 9625, Edition 4, document in order to correct specific problems introduced from ICAO 9625, Edition 3, into the NPRM. Several commenters also recommended aligning the FAA requirements for the extended envelope training tasks with that of the updated ICAO document. Many of these comments have been discussed in previous sections of this document.

Since the publication of the NPRM and subsequent close of the comment period, ICAO has published the final version of the ICAO 9625, Edition 4, document. The FAA has reviewed its contents for potential incorporation of the changes into the final rule as recommended by several commenters and has found that the changes made to the ICAO document in the Edition 4 release were relatively limited in scope and have some overlap with the requirements published in the NPRM in the following areas:

1. Introduced ''extended envelope'' FSTD evaluation requirements for full stall, UPRT, and airframe icing.

2. Changes to testing requirements and tolerances to improve and correct issues in ICAO 9625, Edition 3, including transport delay testing tolerances, visual lightpoint brightness tolerances, objective motion cueing testing tolerances, and other changes that were generally less restrictive.

3. Other editorial and technical changes to improve the document and clarify existing requirements.

The FAA agrees with the commenters that alignment with the latest edition of the ICAO 9625 document would be desirable, particularly with evaluation requirements that have been found to be problematic in ICAO 9625, Edition 3. The FAA has incorporated many of these changes into the final rule; however, some differences were maintained to address public comments to the NPRM, as well as to address FAA specific training requirements and FSTD grandfathering rights. Where the more restrictive requirements were introduced in ICAO 9625, Edition 4, that were not included in the NPRM for public comment, the FAA included these in the final rule within non-regulatory ''information'' sections as recommended practices. The following table summarizes the sections that were modified in the final rule to incorporate changes made in ICAO 9625, Edition 4:

Change	ICAO 9625 Section	Final rule entry No.	Comments
General Requirements			
Appendix A (ICAO)/Table A1A			
Icing effects	2.1.S.e	2.j	Alignment of language with the equivalent ICAO section.

[32] ICAO 9625 (Edition 3), Part II, Appendix A, section 6.5.R requires that ''sound should be directionally representative.''

Change	ICAO 9625 Section	Final rule entry No.	Comments
High Angle of Attack Modeling	2.1.S.f 2.1.S.g	2.m	Alignment of language with the equivalent ICAO section.
Stick Pusher Systems	5.1.S.b	3.f	Alignment of language with the equivalent ICAO section.
Stall Buffet Sounds	6.1.R	7.c	Added to information column as recommended practice.
Stall Buffet Motion Effects (Buffet as first indication of stall or lack of stall buffet).	8.3.R(8)	5.e.1	Added to information column as recommended practice.
Stall Buffet Amplitude and Frequency Content	8.4.R(5)	8. (Table A3D)	Added to information column as recommended practice.
UPRT	13.2.1.S 13.2.2.S	2.n	Alignment of language with the equivalent ICAO section.
Transport Delay	13.8.S	2.g.2	Updates transport delay tolerance to less restrictive values.
Objective Testing			
Appendix B (ICAO)/Table A2A			
Static Flight Control Checks	2.a.	2.a	Moved test description text to ensure it is not improperly applied to dynamic control checks.
Stick Pusher Calibration	2.a.10	2.a.10	Alignment with equivalent ICAO test.
Stall Characteristics	2.c.8.a	2.c.8.a	Alignment with equivalent ICAO test.
Approach to Stall Characteristics	2.c.8.b	2.c.8.b	Alignment with equivalent ICAO test.
Engine and Airframe icing effects demonstrations	2.i.	2.i.	Alignment with equivalent ICAO test.
Stall Buffet	3.f.5	3.f.5	Alignment with equivalent ICAO test. (FAA retained three test conditions).
Visual Lightpoint Brightness	4.a.7	4.a.7	Updates tolerance to less restrictive value.
Transport Delay	6.a.1	6.a.1	Updates tolerance to less restrictive value.
Other			
Visual Model—Airport Clutter	2.a.12.c (Appendix C).	2.a.12.c (Table A3B).	Specific "gate clutter" requirement changed to "airport clutter".
Additional FSTD Evaluations Requirements for Stall, Upset Recovery, and Icing.	Attachment P	Attachment 7 (Appendix A).	Alignment with equivalent ICAO language.

4. Integration of ICAO Requirements With the Part 60 Table Structure

The FAA received several comments concerning the integration of the ICAO requirements within the tables of the part 60 QPS appendices. Several commenters pointed out that while there were requirements introduced into the tables for the purpose of aligning with the ICAO equivalent FSTD levels, many of these requirements were carried over to lower level FSTDs that were not specifically targeted in the alignment (*e.g.,* Level A and Level B FFSs that do not have an ICAO equivalent device). These differences were most apparent in the general requirements tables (Table A1A and Table B1A) where the ICAO format, language, and numbering system significantly differs from the existing part 60 format. Additionally, A4A commented that the incorporation of the ICAO format extends the overall structure of the document, is not value added, and creates repeated requirements.

The FAA agrees with the commenters in that the integration of the ICAO numbering system into some of the part 60 tables resulted in some overlapping requirements with FSTD levels that were not subject to the alignment. The main reason for this overlap was to avoid the addition of redundant table entries for the aligned Level C and Level D devices and the non-aligned Level A and Level B devices in cases where they substantially share the same requirement. Other changes were carried over to the Level A and Level B requirements simply because the requirements represented existing practice, and the FAA found it unlikely that a new FSTD would be initially qualified that could not meet these requirements. For example, one commenter noted that the requirement in Table A3B for taxiway edge lights to be of a correct color was a new requirement introduced for a Level A and Level B FFS. While this is a new requirement as compared to the current part 60, the FAA finds it very unlikely that any new FSTD would be initially qualified with a visual display system that could not produce taxiway edge lights of the correct color.

To address the commenters concerns as well as to reduce the overall complexity of the general requirements tables, the FAA has reverted back to the existing part 60 structure and format in the final rule for the general requirements tables in Appendix A and Appendix B (Tables A1A and A1B). Where specific changes were proposed in the ICAO alignment process, corresponding changes were made to the existing sections within the current part 60 general requirements tables for the appropriate FSTD levels. This will eliminate unintentional carryover of requirements into the other FSTD levels that were not subject to the proposed ICAO alignment.

Additionally, the FAA has examined other tables impacted by the ICAO alignment and has corrected other specific testing requirements as identified by the commenters that were unintentionally carried over to FSTD levels not subject to the ICAO alignment.

Finally, to address comments concerning the integration of the functions and subjective testing tables for all FTD levels in Appendix B, the FAA has separated the Level 7 FTD requirements into different tables and restored the functions and subjective testing tables for Levels 4, 5, and 6 FTDs back to their original format and contents in the final rule. This change will address commenters concerns and provide a clear distinction between the new Level 7 FTD requirements and the other FTD levels. The reorganized tables will be renumbered as follows in the final rule:

Tables of Functions and Subjective Testing

Table B3A (Level 6 FTD)
Table B3B (Level 5 FTD)
Table B3C (Level 4 FTD)
Table B3D (Level 7 FTD)

Level 7 FTD Specific Tables

Table B3E (Airport Modeling Requirements)
Table B3F (Sound System)
Table B3G (IOS Requirements)

5. Deviation From the Part 60 QPS Using the ICAO 9625 Document

CAE commented that the FAA should ''consider the adoption of the ICAO 9625 document technical standards through Incorporation by Reference as allowed by statute and in accordance with 1 CFR part 51, and allow for the qualification of devices using the ICAO technical standard as an Alternate Means of Compliance (AMOC).'' An individual commenter recommended that since the ''fast track'' process for part 60 QPS revisions has never come to fruition, the FAA should conduct separate rulemaking to remove the part 60 QPS appendices and replace them with an industry consensus standard.

The FAA notes that due to the high level of interest in this rulemaking with regards to supporting other significant rulemaking work and Public Law, it was determined that it would not be appropriate for the FAA to use the streamlined process as described by the commenter [33] and this particular part 60 rulemaking would have to proceed in accordance with the agency's normal rulemaking procedures. While the FAA agrees with the commenter that using a voluntary consensus standard may allow for faster changes to the FSTD evaluation standards, the incorporation of a consensus standard would be outside of the scope of this rulemaking. The FAA will consider this topic for future rulemaking as suggested by the commenter.

Regarding CAE's comment concerning the use of the ICAO 9625 document as an AMOC to the part 60 standards, the FAA agrees that allowing the use of other technical FSTD evaluation standards (such as ICAO 9625 or other FSTD evaluation standards issued by a national aviation authority) to initially qualify a new FSTD may allow for a more refined approach to incorporating future changes to the FSTD technical standards. The FAA agrees that where updated internationally recognized FSTD evaluation standards have been published and have been determined to provide an equivalent or higher level of safety (*e.g.* does not adversely impact the fidelity of the device) as compared to the part 60 standards, the voluntary use of these standards to initially qualify new FSTDs should be considered. Particularly with updates to the ICAO 9625 document, deliberations on changes to this document are conducted through international working groups with representation from many sectors of the training and simulation industry, including FSTD manufacturers, air carriers, training providers, aircraft manufacturers, government agencies, and other organizations. In addition to making changes to the FSTD evaluation standards that address safety related issues, other changes are made to improve the overall FSTD evaluation process, as well as addressing new simulation and aircraft technology that has not been adequately addressed in the existing standards.

Furthermore, the ability for the FAA to recognize equivalent FSTD evaluation standards issued by ICAO and national aviation authorities will support the qualification of FSTDs located in other countries and promote existing bilateral agreements which may result in cost savings for FSTD sponsors, manufacturers, and data providers. Particularly with FSTDs that are qualified by multiple national aviation authorities, the ability to recognize an equivalent international standard can reduce redundant testing requirements and documentation that would otherwise be needed to demonstrate compliance with multiple international standards. The FAA additionally points out that a similar process was successfully used prior to the initial publication of part 60 in 2008 where over 250 FSTDs were initially qualified on a voluntary basis using updated international FSTD evaluation standards (including ICAO and European FSTD evaluation standards) in lieu of the then current FAA evaluation standards in Advisory Circular (AC) 120–40B.

Where such new and updated standards are available, potential safety benefits, as well as cost savings, can be quickly realized through the recognition of new standards ahead of the formal rulemaking process. As with most of the past updates to the international standards, there are significant delays of months and even years in integrating updated ICAO standards into regulation. This results in a continuous lag between advances in simulation technology and the regulatory standards.

In order for the agency to be more responsive to changes in the international FSTD evaluation criteria as well as to provide additional options to sponsors of FSTDs that are qualified by multiple national aviation authorities, the FAA has included deviation authority in § 60.15(c) of the final rule to accept FSTD evaluation standards (such as ICAO 9625 or other FSTD evaluation standards issued by a national aviation authority). Such deviations must demonstrate that there will be no adverse impact to the fidelity or the capabilities of the FSTD as compared to the part 60 QPS. Deviations may be granted to an FSTD sponsor or to an FSTD manufacturer for application on multiple FSTDs. Where an FSTD has been initially qualified under the deviation authority, the evaluation standard will become a part of the FSTD's permanent qualification basis and recorded in the FSTD's MQTG and SOQ. The FAA will issue guidance material with this final rule in the form of an NSP guidance bulletin that explains the process for submitting and reviewing deviation requests under § 60.15(c).

6. Level 7 FTD Requirements and Usage in Training

As part of the ICAO 9625 alignment process, the FAA introduced a new FSTD level to the fixed wing FSTD evaluation standards in the NPRM. This FSTD level was based upon the ICAO 9625 Type V device and was intended to define requirements for a high fidelity, fixed-base FTD that could be used to conduct additional introductory training tasks beyond what the Level 6 FTD is currently qualified to do. Furthermore, the addition of this FTD level to the fixed wing standards in part 60 Appendix B would align with the current Level 7 helicopter FTD evaluation requirements that are already in Appendix D of part 60.

Boeing commented that the Level 7 FTD requirements exceed those for Level A and Level B FFSs. The Level 7 FTD will offer no additional training credit and appears to have no additional benefit to the industry. CAE further commented that while the Level 7 FTD is introduced and is based upon the ICAO Type V device, the applicable

[33] This streamlined process delegates the authority for final review and issuance of the part 60 QPS documents from the FAA Administrator to the Director of the Flight Standards Service (see 71 FR 63392).

flight crew licensing regulations should include provisions for training credits for this device.

The FAA notes that the corresponding ''Tasks vs. Simulator/FTD Level'' tables (Tables A1A and B1B) define the particular tasks that a particular FSTD level is qualified to conduct. Table B1B was updated in the NPRM to include the Level 7 FTD and adds several tasks that Level A and Level B FFSs are not currently qualified to conduct. The addition of this FSTD level was based upon the ICAO recommendations to create a high fidelity, fixed-base FTD in which introductory training could be conducted in lieu of a higher cost FFS. The part 60 FSTD qualification standards do not currently define such a high fidelity FTD [34] and the addition of the Level 7 FTD fills this gap. The FAA agrees with Boeing and CAE in that the FSTD qualification standards do not fully address the allowable training credit for this new FTD level and the FAA is currently reviewing supporting training guidance material to make corresponding updates to address this new FSTD level.

Furthermore, the FAA notes that a similar device level was introduced for helicopter training (a helicopter Level 7 FTD) with the initial publication of part 60 in 2008. The FAA has qualified several of these Level 7 helicopter FTDs since the initial publication of part 60 and these devices continue to be used within operator's training programs.

ALPA commented that while they support the incorporation of the ICAO 9625, Edition 3, guidance, they are concerned with the intention to increase use of non-motion devices at the expense of more realistic training in higher fidelity devices with motion. In addition, ALPA stated that they are ''concerned with the stated rationale for adopting the ICAO Doc 9625, Edition 3 Type V simulator guidance. The NPRM indicates this guidance will be used to introduce a new Level VII simulator for the purposes of increasing the opportunities to utilize fixed base, non-motion simulators. Some use of fixed based simulators is appropriate. However, the higher the simulator fidelity is, and the more realistic the training environment is, the better the transfer of learning to actual flight will be.''

ALPA went on to state that the ''highest-level flight simulators need to be used to the maximum extent possible. It is imperative that all end-level evaluations be conducted in full flight simulators (FFS) with six degree of freedom motion cues. Maneuver-based validation points required by airline-specific AQP documentation must be conducted in a FFS with six degree of freedom motion cues also. In addition, these FFSs should be used extensively in advance of evaluations and validation points to provide significant opportunity to prepare.''

The FAA notes that the concept of the Level 7 FTD was based primarily upon the recommendations made in the ICAO 9625 document. In this document, through the work of an industry and government working group, it was determined that the introduction of many training tasks could be conducted in a high fidelity, fixed-base FTD where the continuation and completion of that training task (training to proficiency) is conducted in a FFS with motion cueing. The FAA shares the commenter's concerns regarding the use of FFSs for end-level evaluations and in advance of evaluations and validations points. In the proposal, the FAA attempted to capture this ICAO concept in the ''Table of Tasks v. FTD Level'' (Table B1B), which defines the minimum qualified tasks for a specific FSTD level. The FAA has made additional amendments in the final rule to better define the differences in ''training'' and ''training to proficiency'' in Table B1B to maintain consistency with ICAO 9625.

Finally, the FAA notes that the part 60 FSTD qualification standards only define what training tasks an FSTD is qualified to conduct and does not define how the FSTD will be approved for use in a training program. The FAA is currently reviewing supporting training guidance material and will take these comments into consideration when making corresponding updates to address this new FSTD level.

G. General Comments

1. Compliance Period for Previously Qualified FSTDs

In the proposal, the FAA requested comment on the proposed three year compliance period for previously qualified FSTDs as described in the FSTD Directive. This request was to determine if the three year compliance period was adequate to conduct the necessary modifications to FSTDs in consideration of the March 2019 compliance date for the extended envelope provisions in the Crewmember and Aircraft Dispatcher Training final rule.

Delta, American, and A4A commented that the three year compliance date proposed in FSTD Directive No. 2 should be aligned with the air carrier training rule's compliance date of March 12, 2019, for the extended envelope training provisions. Delta and A4A additionally commented that there would not be enough lead time to develop supplemental data for legacy aircraft within the proposed three year compliance period and recommended that the compliance period be changed to a firm date of March 12, 2019, to align with the air carrier training rule. American and A4A also recommended that the due date of the FSTD Directive be 90 days prior to March 12, 2019, for incorporation and review by the local training authority.

The FAA agrees with the commenters in that the compliance period of the FSTD Directive should be changed to a firm date that aligns to the Crewmember and Aircraft Dispatcher Training final rule compliance date of March 12, 2019, and has made this change in the final rule. The FAA is aware that some aircraft manufacturers and third party data providers have already made substantial progress in the development of simulator data packages to meet the requirements of the proposed FSTD Directive and additional data packages will likely become available for many FSTD sponsors soon after the publication date of this final rule. Finally, it was not the intent of the FAA that all FSTDs must be modified and evaluated by the compliance dates proposed in this rule. As described in the proposal, only those FSTDs that will be used to conduct certain training tasks will require compliance with the FSTD Directive. This should provide FSTD sponsors with some flexibility in determining which FSTDs to modify as well as determining a timeline for the FSTD modifications that meets their training requirements.

2. Alternative Data Sources for Level 5 FTDs

TRU Simulation and A4A commented that the authorized performance range tables for Level 5 FTDs in Appendix B (Table B2B, B2C, B2D, and B2E) are incorrect for the change force maneuvers. For each maneuver, the stick force directions are reversed from the direction as needed to maintain airspeed as described. This error exists in the current part 60 and exists for all sets of aircraft. TRU Simulation and A4A further commented that the alternative data source tables for Level 5 FTDs are invaluable, especially when flight test data is difficult to come by. However, there are no data tables published in the current part 60 for turbofan/turbojet aircraft. These are the aircraft where such tables would have

[34] The current Level 6 FTD as defined in part 60 is not validated for most ground maneuvers (including takeoff and landing tasks) and does not require a visual system.

the biggest positive impact, since the flight test data gathering is the most expensive for those aircraft. Following the release of Change 1 (of part 60), there was a statement made that the only reason they were not included in Change 1 was that there was no time to prepare them.

The FAA concurs with the commenters and has amended the authorized performance range tables in Appendix B in the final rule to correct the stated errors in Tables B2B, B2C, B2D, and B2E. While the FAA agrees with the commenters that such additional alternative source data for turbofan/turbojet aircraft could provide for less expensive data collection and validation of Level 5 FTDs, the FAA did not propose modifications to these tables and making significant additions and modifications to these tables would be out of scope for this rulemaking.

3. *Objective Testing for Continuing Qualification*

CAE commented that the requirement for the objective test sequence that is part of the quarterly inspections requires that all of the objective tests as defined in the applicable QPS are included in the content of the complete annual evaluation. There are certain tests, however, such as visual geometry and motion frequency domain tests, that primarily serve to confirm or baseline the system performance at the initial evaluation. These tests are significantly time consuming to run and require special resources and equipment and do not necessarily provide value or benefit as part of the quarterly test sequence.

The FAA agrees with the commenter in that some tests specified in the table of objective tests may be time consuming and require special equipment to run on an annual basis as part of the quarterly test sequence. Concerning the objective motion cueing test as stated by the commenter, the FAA concurs that it would not be reasonable to conduct this test on an annual basis and has amended the final rule to only require this test be run at the initial evaluation.

With regards to the visual geometry test, the FAA has found that there is some benefit to verifying that the FSTD's visual system geometry has not been changed over time. As with the currently accepted practice for visual geometry testing, the FAA has not required FSTD sponsors to verify the visual system geometry on an annual basis using a theodolite since this requires special equipment and resources that most sponsors do not have. In lieu of conducting such detailed visual geometry testing on continuing qualification evaluations, provisions were added in the NPRM (Attachment 2, paragraph 18) that were consistent with the ICAO requirements allowing for the use of a ''hand-held optical checking device'' to check that the relative positioning is maintained. Due to this comment and other comments concerning the complexity of the visual system geometry test as well as the fact that the ICAO visual system geometry test was specified assuming a 200×40 degree field of view system, the FAA has maintained the existing part 60 existing visual geometry test in the final rule. The FAA has further added clarifying language in the test requirement (Table A2A, test 4.a.2) that allows for methods to quickly check the visual system geometry for continuing qualification evaluations.

4. Windshear Qualification Requirements

In the proposal, the FAA amended the windshear qualification requirements as a result of recommendations received from the SPAW ARC concerning improvements to windshear training. These proposed changes included requirements for complex windshear models to be available on the FSTD, the addition of realistic levels of turbulence associated with windshear, and requiring that all IOS selectable windshear profiles have a method to ensure the FSTD is properly configured for the selected windshear profile.

With regards to the updated windshear qualification requirements, A4A, Boeing, and an anonymous commenter stated that the proposal requires all required windshear models to be selectable and clearly labeled on the IOS. Additionally, they pointed out that all IOS selectable windshear models must employ a method, such as a simulator preset, to ensure that the FFS is properly configured for use in training. This method must address variables such as windshear intensity, aircraft configurations (weights, flap settings, etc.), and ambient conditions to ensure that the proper windshear recognition cues and training objectives are present as originally qualified. The commenters went on to state that this implies that all windshear training scenarios will have to be evaluated for some specific condition that is not specified and that this is a far reaching requirement and should be removed. The commenters suggested that a more definitive requirement to have a method to repeatedly establish a survivable and a non-survivable windshear scenario would make more sense and meet the desired requirement.

The FAA notes that this particular proposed change to the windshear qualification requirements was made to ensure that the windshear models which are available on the IOS are properly set up for use in training as recommended by the SPAW ARC. Specifically, the SPAW ARC recommended that all required windshear models should be selectable and clearly labeled on the IOS. The SPAW ARC determined that the labeling of available windshear models is not standardized in many FSTDs and instructors may lack the necessary information to ensure that the windshear recognition cues in a particular training scenario will occur as desired.

While the FAA agrees that the use of presets in the simulator should be at the discretion of the sponsor, there should be a method employed by the operator to ensure repeatability of the windshear training profiles if the instructor has the ability to change basic parameters of the aircraft or conditions that would affect the outcome of the windshear maneuver (*e.g.* aircraft gross weight, ambient conditions, etc.). As described in the Windshear Training Aid, most windshear profiles are tuned to produce specific recognition cues and performance characteristics for consistent training scenarios. If the basic aircraft configuration and ambient conditions are changed, the instructor cannot be guaranteed that the windshear recognition cues and performance during the escape maneuver will be present as originally evaluated and qualified. Since this rulemaking was originally proposed, the FAA has issued guidance material [35] to operators recommending the use of simulator presets or providing instructor guidance to ensure that windshear profiles are set up correctly in training. The FAA believes that the publication of this guidance material will sufficiently address this issue and has amended this section in the final rule, as suggested by the commenters, to recommend that a method to ensure the repeatability of the windshear required survivable and non-survivable scenarios be employed in the FSTD.

5. Miscellaneous Comments

a. Approved Location for Objective and Subjective Testing

With regards to the changes proposed for § 60.15(e), Delta, A4A, and an anonymous commenter noted that while

[35] Information for Operators (InFO) Number 15004, ''Use of Windshear Models in FAA Qualified Flight Simulation Training Devices'', published March 13, 2015.

the NPRM states that the subjective tests that form the basis for the statements described in paragraph (b) of this section and the objective tests referenced in paragraph (f) of this section must be accomplished at the FSTD's permanent location, except as provided for in the applicable QPS, we recommend changing FSTD's ''permanent location'' to FSTD's ''sponsor designated facility'' as an FSTD may be moved from one location to another over time. Frasca further commented that current FAA guidance allows for objective testing to be run at the FSTD manufacturer's facility as an option for submitting the required qualification test guide (QTG) prior to the initial evaluation.

The FAA concurs with the commenters and has amended the final rule to state that this testing ''must be accomplished at the sponsor's training facility or other sponsor designated location where training will take place, except as provided for in the applicable QPS.'' With regards to Frasca's comment, the ability to submit QTG test results conducted at the manufacturer's facility is defined in the applicable QPS (see Appendix A, paragraph 11.h.) and has not changed in this rulemaking. The submission of QTG test results in this manner will remain acceptable as described in the applicable QPS.

b. Increasing the Credit for Time in a Simulator

An individual commented that general aviation needs more extensive use of simulators rather than less. Reducing the number of hours a simulator can be used towards a private or instrument rating is bad for aviation and the flying community. Letters of authorization should increase the usage of simulator training allowed.

The FAA notes that this rulemaking has not reduced the number of hours that a FSTD can be used for a private pilot or instrument rating. The FAA believes the commenter is referring to training devices not covered under part 60. Those devices are referred to as aviation training devices. An approved aviation training device, if determined to meet the standards in AC 61–136A,[36] will receive a letter of authorization from the FAA, which specifies the amount of credit a pilot may take for training time in that specific device towards a pilot certificate or rating. Revising the amount of credit a pilot can take for training in any aviation training device or FSTD is outside the scope of this rulemaking.

H. Economic Evaluation

In July 2014, the FAA conducted a preliminary regulatory evaluation to estimate the costs and benefits of the provisions proposed in the NPRM. This regulatory evaluation was posted on the public docket with the NPRM. The agency received several comments on the NPRM from air carriers, FSTD manufacturers, and trade associations.

1. Cost of Aerodynamic Modeling and Implementation

An individual commenter questioned whether the FAA factored in the costs associated with the acquisition of OEM data needed to comply with the new requirements; the costs associated with obtaining licenses for third party implementation of data; and the costs associated with the loss of FFS utilization/revenue for the changes, design, implementation, installation, validation and actual FAA qualification activities. American, Delta, JetBlue, and A4A made similar comments on the basis of the simulator modification costs and how the FAA can provide an estimate if data licensing pricing and implementation costs are unknown. American and A4A additionally commented that the FAA needs to provide their assumptions used for the cost analysis. In addition, A4A further commented that the cost estimate for implementation of UPRT is not realistic, is understated, and will depend upon the host and software architecture of the device being updated. A4A also stated that once more definitive data is developed the FAA should prepare a supplemental regulatory impact analysis (RIA) to update the cost estimate for upgrading FSTDs and provide more detail on the assumptions used in the analysis.

The FAA notes that in the preliminary RIA, the estimated cost of aerodynamic model development included all modifications needed to meet the standards proposed for full stall, UPRT, and icing evaluation. This cost was estimated on a per model basis for grandfathered FSTDs and was further broken down into ''complex'' and ''simple'' projects that were based upon the likelihood that existing data was available to support the necessary modifications. This cost was estimated based upon feedback from an industry questionnaire which estimated the cost of a ''complex'' model development at $100,000 and a ''simple'' model development at $60,000. Since many FSTDs share a common aerodynamic model developed by a common source, it was assumed that the costs of aerodynamic model development would be distributed amongst the purchasers of the model. Section II.d. of the RIA that was published with the NPRM, fully explained the agency's assumptions and rationale used to develop the cost estimates.

With regards to implementation costs, the FAA calculated this separately from the aerodynamic model development costs on a per unit basis since implementation costs would impact individual FSTDs and not be distributed amongst several FSTDs. The FAA estimated the per unit costs as $77,307 per FSTD to include implementation costs, lost productivity/revenue, SME pilot testing, and hardware modifications. This estimate includes 45 hours of lost training time at $500 per hour to conduct these activities. This estimate was based upon the responses from an industry questionnaire and is fully explained in the RIA that was placed on the public docket with the NPRM. The FAA did not receive any cost estimates in the public comments concerning additional licensing fees for the implementation of data by a third party.

An individual commenter further questioned the cost basis for the icing modifications and that the summary is not based on any factual, verifiable analysis. The commenter further stated that assumptions are made that icing upgrades can be accomplished at the same time as non-icing upgrades and that there is no basis in fact for this statement and because of that, the costs are artificially low. A4A and American made similar comments concerning the cost of the required modifications for icing.

The FAA notes that the costs for the aerodynamic modeling development necessary for both the full stall requirements and the icing requirements were estimated based upon the responses from an industry questionnaire. Since most simulators for transport category aircraft currently use icing models that are supplied by a common source as that of the aerodynamic model, the FAA assumed the updated models for both full stall and icing would likely be developed concurrently by the data provider and subsequently installed by the FSTD sponsors as a package in most cases. The agency's rationale for the breakdown of aerodynamic modeling costs for both stall and icing are described in the regulatory evaluation that was published with the NPRM.

In response to these comments, the FAA has revised its cost estimates for the final rule to include additional

[36] Advisory Circular (AC) 61–136A, FAA Approval of Aviation Training Devices and Their Use for Training and Experience (2014).

information gathered from air carriers, FSTD manufacturers, and data providers to better estimate the cost of this rule. One aircraft OEM simulator data provider has indicated that the estimated cost of an enhanced stall model would be in the area of $25,000 per FSTD. Furthermore, this data provider stated that in order to support the installation of an enhanced stall model, FSTDs running certain versions of their data package would need to be brought up to the latest revision or blockpoint before this installation can take place. The FAA also obtained a cost estimate from a third party provider to implement its model on FSTDs.

As a result of this additional information as well as further analysis conducted on FAA FSTD qualification records, the FAA was able to group the FSTDs into seven different categories. The groups were based upon the estimated cost components to implement the modifications needed to meet the requirements of FSTD Directive No. 2. The estimated costs are separated by various factors such as the anticipated source of the aerodynamic data, whether the FSTD will need a standard data revision before further modifications can occur, whether the FSTD could potentially need a significant hardware update, and other factors that might affect the overall cost to meet the requirements of this final rule. This refined granularity for categorizing the FSTDs as well as the estimated cost for each category of FSTD is fully explained in the final RIA that is published with this final rule.

2. Cost of Instructor Operation Station (IOS) Replacement

American commented that the cost to bring an FSTD into compliance with FSTD Directive No. 2 is low by many orders of magnitude. Older simulators will need new IOSs since many FSTDs cannot support the required graphics capabilities and would have to be replaced. American further commented that they have a rough estimate from one vendor that it will cost $250,000 alone for IOS update/replacement. A4A made similar comments that older simulators would need IOS replacement at an estimated cost of $250,000 in order to meet the instructor feedback mechanism requirements for UPRT. A4A further commented that this underestimated cost is a concern because there is no benefit to this element of the proposal as there are other methods available to provide instructors with the information necessary to evaluate a pilot's skills during simulator sessions that are used successfully today. The record and playback function should be left as an option available to FSTD customers, but it should be removed from this proposed rule.

The FAA notes that the requirements for UPRT in the proposal and in the final rule do not specifically require the use of graphical displays to provide the necessary feedback. The FAA provided some example displays in Attachment 7 of Appendix A, but these examples are within an ''information'' section as recommendations, but are not regulatory. The FAA acknowledges that the instructor feedback that is necessary for UPRT could potentially be accomplished using methods other than graphical displays (such as numerical or discrete feedback at the IOS) and the agency has not been overly prescriptive in the final rule that requires a single solution. The FAA further notes that the requirement for video and audio recording and playback has been removed in the final rule as discussed in previous sections and this should provide some cost relief in meeting the requirements for UPRT. Finally, the FAA agrees with American and A4A in that there are a small number of older simulators still in operation which may have IOS display systems that cannot meet the requirements for UPRT without extensive modification or replacement. The FAA has made adjustments to the final RIA to account for the additional cost of replacing old IOS display systems for some older FSTDs.

3. Affected FSTDs and Sponsors

American commented that ''. . . the FAA indicates cost savings by Sponsors not modifying all FSTDs, just part of the fleet. This is not an option for [American] and we believe all sponsors. This would impose scheduling complexity. Cost and other factors should be reviewed in the context of modifying all part 121 flight simulators. It is not feasible to only modify part of a simulator fleet and efficiently schedule crews. Our plan is to modify all FSTDs in our fleet. This will drive the costs higher with increase data licenses, implementation costs, and training impact. This does not provide additional cost relief for the sponsors.'' Similar comments were made by A4A. An individual commenter stated that it appears that the effect on the industry could include a larger number of Level C and Level D FFSs than the 322 cited in the RIA and asked if the FAA calculated total costs if all currently FAA qualified Level C and Level D devices were to comply with FSTD Directive No. 2. This commenter further questioned whether the FAA calculated the cost to a sponsor if an FFS were to not comply with FSTD Directive No. 2.

The FAA notes that the cost estimates for FSTD Directive No. 2 included the cost to update and evaluate all Level C and Level D FFSs that could potentially be used to meet the part 121 extended envelope training requirements. The FAA assumed that all part 121 Level C and Level D FFSs would require updating and did not include any cost reductions in the RIA. These assumptions and the associated rationale were fully described in the RIA that was published with the NPRM.

The FAA further notes that the costs for previously qualified FSTDs were derived solely from the proposed FSTD Directive for full stall, upset recovery, icing, bounced landing recovery, and gusting crosswind FSTD evaluation requirements in the NPRM. Compliance with this Directive is only required for sponsors of FSTDs that will be used to deliver such training. The only operators required to conduct such training are air carriers operating under part 121. The estimated 322 FSTDs were derived from those currently qualified FSTDs that simulate an aircraft that is likely to be used in a U.S. part 121 air carrier's training program. Since the NPRM was published, the number of FSTDs that could be impacted by the air carrier training requirements has increased from 322 to 335 FSTDs. We assumed that the cost of modifying the previously qualified FSTDs that are not used in part 121 training are not a cost of this rule because these operators are not required to conduct such training for these particular tasks. If a sponsor chooses not to offer the training defined in the FSTD Directive, there are no additional requirements or costs imposed by this rule for previously qualified FSTDs.

American and A4A commented that the provisions included in the NPRM for Level A and Level B FFSs have no applied cost savings for sponsors since there are no Level A or Level B FFSs for part 121 sponsors.

The FAA notes that as of the close of the comment period of the NPRM, one Level A and one Level B FFS are still in operation and actively sponsored by part 121 operators. No cost savings were applied in the RIA for Level A and Level B FFSs as stated by the commenters.

Frasca commented that the NPRM stated that only sponsors are affected by this rule and FSTD sponsors are air carriers who own simulators to train their pilots or training centers that own simulators and sell simulator training time. Frasca went on to state that this statement assumes only part 119 and part 142 organizations, implying part

141 sponsors were not considered in the analysis. The FAA should consider reevaluating the analysis of small entities taking into consideration part 141 organizations that sponsor FSTDs. CAE further commented that FSTD manufacturers, aircraft OEMs and other data providers are also affected by these requirements.

The FAA acknowledges CAE's comment in that other entities beyond the FSTD sponsor may be indirectly affected by this rule; however, the part 60 requirements apply to FSTD sponsors and not directly to the FSTD manufacturers and data providers. The FAA concurs with Frasca's comment in that all affected FSTD sponsors should be considered in the cost analysis of the rule. The FAA points out that the cost estimates in the RIA considered all FSTDs and sponsors that may be affected by this rulemaking, regardless of the certificate held by the sponsor.[37] For previously qualified FSTDs that will have to meet the requirements of FSTD Directive No. 2 to conduct extended envelope training tasks, these estimates were based upon an analysis of FSTDs that could potentially be used in part 121 training programs to meet the air carrier training requirements, regardless of the sponsor's operating certificate. For newly qualified Level C and Level D FFSs that will be required to meet the updated requirements that were aligned with the ICAO 9625 document, this estimate was conducted using historical data on all new Level C and Level D FFSs that the FAA has initially qualified within the last 10 years. The specific impact on small entities was fully explained and accounted for in the RIA.

4. Costs and Benefits of ICAO Alignment

A4A commented that, in the NPRM, the FAA states that ''Internationally aligned FSTD standards facilitate cost savings for FSTD operators because they effectively reduce the number of different FSTD designs that are required.'' A4A further stated that ''We can find no simulator manufacturer information in the docket to substantiate this statement. The FAA should explain and provide the basis for this statement. Based on past experience, the A4A believes that simulator manufacturers will continue to differentiate their product features instead of adopting one design due to aligned standards. Unless simulator manufacturers can provide product pricing information that proves otherwise, there will be no savings for purchasers of FSTDs as a result of the alignment proposed in this rule. A final or supplemental RIA must therefore eliminate reference to or quantification of illusory benefits from internationally-aligned FSTD standards.''

The FAA notes that while the NPRM and RIA references qualitative benefits and potential cost savings due to internationally aligned FSTD evaluation standards, there were no quantified benefits included in the preliminary or final RIA. The FAA acknowledges that there will be a small cost associated with updating the part 60 FSTD evaluation standards to the latest ICAO 9625 document. In the RIA that was published with the NPRM, the FAA estimated the cost of compliance to initially qualify a new FSTD under the proposed standards that were aligned with ICAO 9625, Edition 3. Based upon the responses to a questionnaire that was distributed to industry for the purposes of determining these costs, the FAA estimated the recurring and non-recurring cost of compliance with the internationally aligned standards to be approximately $30,431.82 per FSTD. Considering that the cost of a new Level C or Level D FSTD can range from $8 million or more, the incremental cost of compliance with the internationally aligned standards will represent less than 0.5 percent of the cost of a new FSTD. Furthermore, as a result of the comments received on the NPRM as discussed in previous sections, the FAA has removed and/or modified some of the more costly requirements in the final rule which were introduced by the ICAO alignment (*e.g.,* the visual field-of-view requirement and the transport delay requirement). This will further reduce the estimated incremental cost of ICAO alignment that was estimated in the NPRM. The final rule estimate does not include these potential cost savings and therefore likely over estimates costs.

The FAA maintains that alignment with updated international FSTD evaluation standards benefits industry in a number of ways. Because updates made to the ICAO document are typically conducted by working groups with a significant amount of industry participation, many of those changes are made to correct problems with the existing standards that result in requirements that are sometimes less restrictive, deal with new technology that is not adequately addressed in existing standards, and clarifies requirements that are ambiguous in nature and left to subjective assessment. For example, in the current part 60, objective tests that are validated against engineering simulation data are generally required to meet tighter tolerances than that of objective tests that are validated against flight test data.[38] Due to practical issues with evaluating FSTDs against such tighter tolerances, ICAO 9625, Edition 3, provided relief to this requirement which now allows up to 40 percent of flight test tolerances to be used to evaluate engineering simulation validated objective tests. This is a less restrictive requirement that corrected an issue that was found to be problematic by FSTD sponsors, FSTD manufacturers, data providers, and regulators. As a result of the ICAO alignment, corresponding changes were proposed for the part 60 QPS. Several other examples exist in the ICAO 9625 alignment where less restrictive objective test tolerances were proposed or new objective evaluation requirements were introduced to replace subjective assessments (*e.g.,* standards for liquid crystal display (LCD) or liquid crystal on silicon (LCoS) visual display systems). In many cases, objective tolerances are preferable to industry because they eliminate the inherent variance amongst inspectors and evaluators when conducting a subjective assessment.

Additionally, international alignment can reduce redundant testing requirements and documentation for sponsors of FSTDs that are qualified by multiple national aviation authorities. A long standing requirement for the qualification of FSTDs by the FAA and many other national aviation authorities is the development of a MQTG which documents that the FSTD meets the evaluation requirements and any required objective testing of the FSTD as compared to flight test or other validation data. Where FSTDs are qualified by different countries and national aviation authorities under different standards, the FSTD sponsor is sometimes required to create redundant documentation and conduct additional testing to meet each individual qualification standard. This usually results in complex differences matrices and, in some cases, completely different MQTG documents for each qualifying authority. Where standards are aligned on an international basis, this redundant documentation and testing burden can be significantly reduced. Furthermore, because much of the flight test data needed to validate the individual objective test cases is supplied by common data sources, the burden on the simulation data providers can

[37] § 60.7(a) requires that an FSTD sponsors holds or is an applicant for a certificate under part 119, 141, or 142.

[38] 14 CFR part 60, Appendix A, Attachment 2, paragraph 11 ''Validation Test Tolerances'' recommends that 20% of the corresponding flight test tolerances should be used.

potentially be reduced through a reduction of flight test data collection needed to meet the requirements of multiple different FSTD evaluation standards.

Finally, as mentioned previously in this document, the FAA believes that a large portion of industry looks favorably on international alignment and has demonstrated a willingness to adopt such standards in the past. Since the publication of ICAO 9625, Edition 3, in 2009, the FAA has received numerous inquiries and requests from many sectors of the industry (including air carriers, trade associations, FSTD manufacturers, and FSTD data providers) requesting the adoption of this updated document. Prior to this rulemaking, previous versions of the FAA and European FSTD evaluation standards were developed and aligned with previous versions of the ICAO 9625 document. This included the FAA's (draft) AC 120–40C which was aligned with the ICAO 9625, Edition 1, document as well as the existing (2008) part 60 standard, which was aligned with the ICAO 9625, Edition 2, document. Further demonstrating industry's desire to maintain alignment with the latest international FSTD evaluation standards, during the time period between 1995 and 2010 before the initial part 60 rule became effective, industry requested and the FAA qualified over 250 FSTDs using more stringent internationally aligned FSTD evaluation standards on a completely voluntary basis.[39] The FAA believes this is strongly indicative that many sectors of the industry have found benefits in using internationally aligned FSTD evaluation standards to initially qualify new FSTDs.

IV. Regulatory Notices and Analyses

A. Regulatory Evaluation

Changes to Federal regulations must undergo several economic analyses. First, Executive Order 12866 and Executive Order 13563 direct that each Federal agency shall propose or adopt a regulation only upon a reasoned determination that the benefits of the intended regulation justify its costs. Second, the Regulatory Flexibility Act of 1980 (Pub. L. 96–354) requires agencies to analyze the economic impact of regulatory changes on small entities. Third, the Trade Agreements Act (Pub. L. 96–39) prohibits agencies from setting standards that create unnecessary obstacles to the foreign commerce of the United States. In developing U.S. standards, this Trade Act requires agencies to consider international standards and, where appropriate, that they be the basis of U.S. standards. Fourth, the Unfunded Mandates Reform Act of 1995 (Pub. L. 104–4) requires agencies to prepare a written assessment of the costs, benefits, and other effects of proposed or final rules that include a Federal mandate likely to result in the expenditure by State, local, or tribal governments, in the aggregate, or by the private sector, of $100 million or more annually (adjusted for inflation with base year of 1995). This portion of the preamble summarizes the FAA's analysis of the economic impacts of this final rule. We suggest readers seeking greater detail read the full regulatory evaluation, a copy of which we have placed in the docket for this rulemaking.

In conducting these analyses, the FAA has determined that this final rule: (1) Has benefits that justify its costs, (2) is not an economically ''significant regulatory action'' as defined in section 3(f) of Executive Order 12866, (3) is not ''significant'' as defined in DOT's Regulatory Policies and Procedures; (4) will not have a significant economic impact on a substantial number of small entities; (5) will not create unnecessary obstacles to the foreign commerce of the United States; and (6) will not impose an unfunded mandate on state, local, or tribal governments, or on the private sector by exceeding the threshold identified above. These analyses are summarized below.

Total Benefits and Costs of This Rule

The table below summarizes the estimated costs and benefits of this proposal.

		Present value at a 7% rate	Present value at a 3% rate
FSTD Modifications for New Training Requirements:			
Cost	$72,716,590	$63,610,049	$68,562,049
Benefits	Rational simulator owner will choose to comply.		
Icing provisions:			
Cost	$1,256,250	$1,098,926	$1,184,476
Benefits	Only one prevented severe injury valued at $2.5 million makes the icing benefits exceed the costs.		
Aligning Standards with ICAO:			
Cost	$6,875,000	$5,356,979	$6,132,690
Benefits	Improved safety and cost savings		
Total Cost	$80,847,840	$70,065,954	$75,879,215

Costs

Within each of the estimates we estimated three separate sets of costs, and later in the document provide separate benefit bases. These three sets include:

Modifications of Previously Qualified FSTDs for New Training Requirements. The first set of costs will be incurred to make the necessary modifications to the FSTDs to enable training required by the new Crewmember and Aircraft Dispatcher Training final rule. A potential lack of full flight simulator (FFS) fidelity could contribute to inaccurate or incomplete training for

[39] Before part 60 was initially published, the FAA authorized the use of other FSTD evaluation standards as an alternate means of compliance to AC 120–40B. The FAA initially qualified 166 FSTDs against the (draft) AC 120–40C and the ICAO 9625 (edition 2) documents. Another 90 FSTDs were initially qualified under the European JAR STD–1A (amendment 3) standard which was also substantially harmonized with the ICAO 9625 (edition 2) document.

''extended envelope'' training tasks in the new training rule, therefore FSTDs will require evaluation and modification as defined in the FSTD Directive of this part 60 final rule.

Icing Provisions. The second set of costs will be incurred for the evaluation and modification of engine and airframe icing models which will enhance existing training requirements for operations using anti-icing/de-icing equipment. This improvement is based on NTSB safety recommendations, recommendations from the International Committee on Aviation Training in Extended Envelopes (ICATEE) and the Stick Pusher and Adverse Weather Event Training Aviation Rulemaking Committee (SPAW ARC), and it aligns with the updated International Civil Aviation Organization (ICAO) 9625 standards. Most of the models that will be installed to update STDs for new training requirements will meet the icing requirements as well. However, the FAA estimates about 15 percent of all of the FSTDs may need additional icing updates to be compliant with the final rule and we estimate the costs of these additional updates.

Aligning Standards with ICAO. Lastly there are a set of changes to the part 60 Qualification Performance Standards (QPS) appendices which will align the FSTD standards for some FSTD levels with those of the latest ICAO FSTD evaluation guidance. This last set of changes will only apply to newly qualified FSTDs.

Assumptions:

A. Estimates are in 2012 $.

B. The estimated number of previously qualified FSTDs that will potentially be affected by the rule (335) includes all FSTDs that are capable of providing training for part 121 operations and as such are likely to be an overestimate of the number of FSTDs that will be affected by this rule, as some devices may not be used for the training.

C. As in the NPRM Regulatory Impact Analysis for newly qualified FSTDs, we expect minimal incremental cost to meet the standards for the new tasks in the Crewmember and Aircraft Dispatcher Training final rule and the standards for icing.

Who is Potentially Affected by This Rule?

Sponsors of flight simulation training devices.

Changes to Costs From the NPRM to the Final Rule

The FAA made two major changes in the final rule that might be cost relieving, although the FAA did not include these cost savings in the estimated costs.

A. Removal of audio/video record and playback capability requirement;

B. Removal/adjustment of the visual system field of view (FOV) and the transport delay requirements.

The FAA has also revised its cost estimates for the final rule to include additional information gathered from air carriers, FSTD manufacturers, and data providers to better estimate the cost of this rule. One aircraft OEM simulator data provider has indicated that the estimated cost of an enhanced stall model would be in the area of $25,000 per FSTD. Furthermore, this data provider stated that in order to support the installation of an enhanced stall model, FSTDs running certain versions of their data package would need to be brought up to the latest revision or blockpoint before this installation can take place. The FAA also obtained a cost estimate from a third party provider to implement its model on FSTDs. As a result of this additional information and data and comments received, the FAA has updated its cost estimates for the final rule. Details on the analysis can be found in the Regulatory Impact Analysis accompanying this final rule.

The table below shows the estimates derived during the NPRM phase, and the final rule updated cost estimate from data obtained after NPRM publication. The table indicates the three separate sets of costs incurred over a ten year period.

	NPRM Estimate	Final rule cost estimate	NPRM Present value at a 7% rate	Final rule cost estimate present value at a 7% rate	NPRM Present value at a 3% rate	Final rule cost estimate present value at a 3% rate
FSTD modifications for New Training Requirements:						
Cost	$45,215,480	$72,716,590	$32,286,867	$63,610,049	$39,014,931	$68,562,049
Icing provisions:						
Cost	468,000	1,256,250	334,183	1,098,926	403,822	1,184,476
Aligning Standards with ICAO:						
Cost	6,695,000	6,875,000	4,273,464	5,356,979	5,473,924	6,132,690
Total Cost	52,378,480	80,847,840	36,894,514	70,065,954	44,892,676	75,879,215

Benefits of This Rule

Modifying FSTDs To Support the Crewmember and Aircraft Dispatcher Training Final Rule

The best way to understand the benefits of this final rule is to view them in conjunction with the new Crewmember and Aircraft Dispatcher Training final rule. In that rule, the cost/benefit analysis assumed that the new extended envelope training tasks would be conducted in a FSTD capable of producing the flight characteristics of an aircraft in a stall or upset condition. The Crewmember and Aircraft Dispatcher Training final rule estimated a $500 hourly FSTD rental rate that included all modifications expected to be required by this final rule. Alternative sensitivity analyses used $550 and $600 hourly FSTD rates to reflect the possibility of additional costs for the modifications. The costs generated by either hourly rate were justified and captured by the benefits of that rule.

This final rule takes the next step to develop qualification standards for updating these FSTDs to ensure the extended envelope training provided is conducted in a realistic, accurate training environment. These modifications require FSTD owners [40] to purchase and install updated data packages, the costs of which are a cost of this rule. Revenues received by FSTD owners for providing a modified FSTD required by the new training tasks are

[40] We use the term owner here and elsewhere rather than sponsor because in isolated instances the FSTD sponsor may not be the owner of the device.

costs previously accounted for in the Crewmember and Aircraft Dispatcher Training final rule and justified by the benefits of that rule. This revenue over time exceeds the cost of this final rule.

The part 60 standards and FSTD modification expense supporting the new training is $72.7 million ($63.6 million in present value at 7 percent) and has been fully justified by the new Crewmember and Aircraft Dispatcher Training final rule.

Icing Provisions

The second area for benefits is for the icing update. Although this update is not in response to a new training requirement, it will enhance existing training requirements for operations involving anti-icing/de-icing equipment and further address NTSB, [41] [42] ICATEE and SPAW ARC recommendations to the FAA. It also aligns with the updated ICAO 9625 standards. These costs are minor at approximately $1.3 million dollars and are expected to comprise a small percentage of the total cost of compliance with the FSTD Directive. One avoided severe injury would justify the minor costs of complying with these icing requirements. We received no comments on this benefit discussed in the proposed rule.

Aligning Standards With ICAO

Lastly, we have not quantified benefits of aligning part 60 qualification standards with ICAO guidance, but we expect aligned FSTD standards to contribute to improved safety as they are developed by a broad coalition of experts with a combined pool of knowledge and experience. The FAA expects more realistic training to result from these changes. The changes are expected to improve overall FSTD fidelity by enhancing the evaluation standards for visual display resolution, system transport delay, sound direction, and motion cueing.

Furthermore, internationally aligned FSTD standards for FSTD sponsors can reduce the redundant testing and documentation that are required to meet multiple national regulations and standards for FSTD qualification, potentially resulting in cost savings.

The addition of the Level 7 FTD through the ICAO alignment will provide training providers with more options that do not exist today to conduct training at lower cost. If the sponsor chooses to qualify a level 7 FTD, it is because they expect the benefits to exceed the costs. We have not quantified these costs and benefits.

B. Regulatory Flexibility Determination

The Regulatory Flexibility Act of 1980 (Pub. L. 96–354) (RFA) establishes ''as a principle of regulatory issuance that agencies shall endeavor, consistent with the objectives of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the businesses, organizations, and governmental jurisdictions subject to regulation. To achieve this principle, agencies are required to solicit and consider flexible regulatory proposals and to explain the rationale for their actions to assure that such proposals are given serious consideration.'' The RFA covers a wide-range of small entities, including small businesses, not-for-profit organizations, and small governmental jurisdictions.

Agencies must perform a review to determine whether a rule will have a significant economic impact on a substantial number of small entities. If the agency determines that it will, the agency must prepare a regulatory flexibility analysis as described in the RFA.

However, if an agency determines that a rule is not expected to have a significant economic impact on a substantial number of small entities, section 605(b) of the RFA provides that the head of the agency may so certify and a regulatory flexibility analysis is not required. The certification must include a statement providing the factual basis for this determination, and the reasoning should be clear. The FAA made such a certification for the initial regulatory flexibility analysis, received no comments, and provides the factual basis below for such a determination in this final regulatory flexibility analysis.

Description and Estimate of the Number of Small Entities

Only FSTD sponsors are affected by this rule. FSTD sponsors are air carriers that own FSTDs to train their pilots or training centers that own FSTDs and sell FSTD training time. To identify FSTD sponsors that could be affected retroactively by the FSTD directive,[43] the FAA subjected the 876 FSTDs with an active qualification by the FAA to qualifying criteria designed to eliminate FSTDs not likely to be used in a part 121 training program for the applicable training tasks (*i.e.,* stall training, upset recovery training, etc.). The remaining list of 335 FSTDs (included in Appendix A of the regulatory evaluation), were sponsored by the 29 companies presented in the table below.

FSTD Sponsor	# of FSTDs
A.T.S. Inc.	1
ABX Air, Inc.	2
AIMS Community College	1
Airbus	6
Alaska Airlines	4
Allegiant Airlines	1
American Airlines	50
Atlas Air, Inc	3
Boeing Training and Flight Services	42
CAE SimuFlite Inc.	9
Compass Airlines, LLC	1
Delta Air Lines, Inc.	27
Embry Riddle Aeronautical Univ.	1
Endeavor Air	2
ExpressJet Airlines, Inc.	3
Federal Express Corp.	19
FlightSafety International	69
Global One Training Group, LLC	1
Hawaiian Airlines, Inc.	1
JetBlue Airways	6
Kalitta Air, LLC	2
Pan Am International Flight Academy	26
Sierra Academy of Aeronautics	2
Southwest Airlines	10
Spirit Airlines, Inc.	3
Strategic Simulation Solutions L.L.C.	3
Sun Country Airlines	1
United Airlines	31
United Parcel Service	8
Total	335

To determine which of the 29 organizations listed in the previous table are small entities, the FAA consulted the U.S. Small Business Administration Table of Small Business Size Standards Matched to North American Industry Classification System Codes.[44] For flight training (NAICS Code 611512) the threshold for small business is revenue of $25.5 million or less. The size standard for scheduled passenger air transportation (NAICS Code 481111) and scheduled freight air transportation (NAICS Code 481112) and non-scheduled charter passenger air transportation (NAICS Code 481211) is 1,500 employees. After consulting the World Aviation Directory, and other on-line sources, for employees and annual revenues, the FAA identified eight companies that are qualified as small entities. In this

[41] NTSB recommendations A–11–46 and A–11–47 address engine and airframe icing.

[42] *www.ntsb.gov.*

[43] Part 60 contains grandfather rights for previously qualified FSTD so the FAA would invoke an FSTD Directive to require modification of previously qualified devices. The FSTD Directive process has provisions for mandating modifications to FSTDs retroactively for safety of flight reasons. See 14 CFR part 60, § 60.23(b).

[44] *http://www.sba.gov/sites/default/files/files/Size_Standards_Table.pdf.*

instance, the FAA considers eight a substantial number of small entities.

Economic Impact

The economic impact of this rule applies differently to previously qualified FSTD sponsors than it would to newly qualified FSTD sponsors. Below is a summary of the two separate analyses performed. One determines the impact of the final rule on small entities that will have to update their previously qualified devices and the other analysis determines the impact on those that would have to purchase a newly qualified device.

Economic Impact of Upgrading Previously Qualified FSTDs

Five of the eight small entities are training providers. They are expected to offer this new required training as there would be increased demand for training time in their FSTDs because in addition to current requirements for training, all part 121 PICs and SICs must have two hours of additional training in the first year and additional training time in the future. The FAA found that costs that will be incurred by these small entities in order to train pilots in the tasks required by the new training rule, range from $122,300 to $335,842 [45] per FSTD and can be recovered by renting the FSTD for 245 hours [46] to 672 hours.[47] To recover modification costs within one year the training company would have to rent the most expensive modified FSTD for 7 two-hour sessions per week (14 hours/week) and 2 hour two-hour sessions per week (4 hours/week) in the case of the least expensive modification. In fact, the owners of these FSTDs will have guaranteed revenue for the life of the airplane used in part 121 operations. Therefore, the rule provides additional profit and would not impose a significant economic impact on these companies. Further, if the training company does not expect to recoup its costs in a reasonable amount of time for a particular FSTD it has the option not to offer the new part 121 training in that FSTD. Therefore, it will not have to incur the modification cost for that device.

[45] There are higher estimated per FSTD costs to update the FSTDs to meet the new training requirements, but these higher costs are for FSTDs owned by large entities.

[46] ($122,300 divided by $500 = 245 hours, resulting in 123 two hour sets—(245/2). If the training company offered 2 two hour sets per week it would recover its costs within a year (123/52 = 2).

[47] ($335,842/$500 = 672 hours, resulting in 336 two hour sets—(672/2). If the training company offered 6 two hour sets per week it would recover its costs within a year (336/52 = 6).

Three of the companies identified as small businesses are part 121 air carriers. They have to comply with the Crewmember and Aircraft Dispatcher Training final rule by training their pilots in FSTDs that meet the standards of this part 60 rule. The additional pilot training cost in a modified FSTD was accounted for and justified in that training final rule. This part 60 rule simply specifies how the FSTDs need to be modified such that the new training will be in compliance with the Crewmember and Aircraft Dispatcher Training final rule. These part 121 operators have two options. They can purchase training time for their pilots at a qualified training center. Alternatively they could choose to comply with the FSTD Directive by modifying their own FSTDs to train their pilots for the new training tasks. For these operators who already own FSTDs, the cost of complying with the FSTD Directive is estimated to be less than the cost of renting time at a training center to comply with the new requirements. Therefore, we expect that they will choose to modify their devices because it will be less costly to offer training in-house than to send pilots out to training centers. The cost to train pilots in the tasks required by the training rule is a cost of the training rule and not this rule. Thus, the rule will not impose a significant economic impact on these companies, because by modifying their FSTDs these operators will lower their costs.

An estimated 50 of the FSTDs (15 percent) may require additional modifications to comply with the icing requirements of the final rule. We do not know how many are small businesses however the estimated cost of these additional icing modifications ($25,000) are less than 0.3 percent of the estimated $10 million cost of a FSTD, which is not a significant impact.

Economics of Newly Qualified Devices

It is unknown how many sponsors of newly qualified FSTDs in the future may qualify as small entities, but we expect it will be a substantial number as it could include some or all of the eight identified above. The FAA expects the final rule requirements that address the new training tasks and modify the icing FSTD requirements to be included in future training packages, the revenues obtained from training will exceed the costs, and the cost will be minimal for a newly qualified FSTD. The requirement to align with ICAO guidance however, will result in some cost. The FAA does not know who in the future will be purchasing and qualifying FSTDs after the rule becomes effective. The FAA estimates that the incremental cost per newly qualified FSTD will be approximately $33,000. This is less than 0.5 percent of the cost of a new FSTD, which generally costs $10 million or more. Therefore we do not believe the final rule will have a significant economic impact on a substantial number of small entities that purchase newly qualified FSTDs after the rule is in effect.

Thus this final rule is expected to impact a substantial number of small entities, but not impose a significant negative economic impact. We made a similar determination in the initial regulatory flexibility analysis and received no comments. Therefore, as provided in section 605(b), the head of the FAA certifies that this rulemaking will not result in a significant economic impact on a substantial number of small entities.

C. International Trade Impact Assessment

The Trade Agreements Act of 1979 (Pub. L. 96–39), as amended by the Uruguay Round Agreements Act (Pub. L. 103–465), prohibits Federal agencies from establishing standards or engaging in related activities that create unnecessary obstacles to the foreign commerce of the United States. Pursuant to these Acts, the establishment of standards is not considered an unnecessary obstacle to the foreign commerce of the United States, so long as the standard has a legitimate domestic objective, such as the protection of safety, and does not operate in a manner that excludes imports that meet this objective. The statute also requires consideration of international standards and, where appropriate, that they be the basis for U.S. standards. The FAA has assessed the potential effect of this final rule and determined that the rule will provide improved safety training and will use international standards as its basis and does not create unnecessary obstacles to the foreign commerce of the United States, and the purpose of this rule is the protection of safety.

D. Unfunded Mandates Assessment

Title II of the Unfunded Mandates Reform Act of 1995 (Public Law 104–4) requires each Federal agency to prepare a written statement assessing the effects of any Federal mandate in a proposed or final agency rule that may result in an expenditure of $100 million or more (in 1995 dollars) in any one year by State, local, and tribal governments, in the aggregate, or by the private sector; such a mandate is deemed to be a ‘‘significant regulatory action.’’ The FAA currently uses an inflation-adjusted value of $155.0 million in lieu of $100 million.

E. Paperwork Reduction Act

The Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)) requires that the FAA consider the impact of paperwork and other information collection burdens imposed on the public. According to the 1995 amendments to the Paperwork Reduction Act (5 CFR 1320.8(b)(2)(vi)), an agency may not collect or sponsor the collection of information, nor may it impose an information collection requirement unless it displays a currently valid Office of Management and Budget (OMB) control number.

This final rule will impose the following amended information collection requirements. As required by the Paperwork Reduction Act of 1995 (44 U.S.C. 3507(d)), the FAA has submitted these information collection amendments to OMB for its review. Notice of OMB approval for this information collection will be published in a future **Federal Register** document.

Summary: As a result of this final rule, an increase in the currently approved information collection requirements [48] will be imposed on Sponsors of previously qualified FSTDs that require modification for the qualification of certain training tasks as defined in FSTD Directive No. 2. These Sponsors will be required to report FSTD modifications to the FAA as described in §§ 60.23 and 60.16, which would result in a one-time information collection. Additionally, because compliance with the FSTD Directive (for previously qualified FSTDs) and the new QPS requirements (for newly qualified FSTDs) will increase the overall amount of objective testing necessary to maintain FSTD qualification under § 60.19, a slight increase in annual information collection will be required to document such testing.

Additionally, the FAA added deviation authority to § 60.15(c)(5) in the final rule to allow for an FSTD sponsor to deviate from the technical requirements in the part 60 QPS. For FSTD sponsors requesting such a deviation, this will impose a small amount of additional information collection burden.

Public comments: The FAA did not receive any substantive comments on the amended information collection requirements as a result of this final rule.

Use: For previously qualified FSTDs, the information collection will be used to determine that the requirements of the FSTD Directive have been met. The FAA will use this information to issue amended SOQs for those FSTDs that have been found to meet those requirements and also to determine if the FSTDs annual inspection and maintenance requirements have been met as currently required by part 60.

For FSTD sponsors requesting a deviation as described in § 60.15(c)(5), the information collection will be used to evaluate and track the approval of deviations to support the initial evaluation of FSTDs.

Respondents (including number of): The additional information collection burden in this proposal is limited to those FSTD Sponsors that will require specific FSTD qualification for certain training tasks as defined in FSTD Directive 2. Approximately 335 previously qualified FSTDs [49] may require evaluation as described in the FSTD Directive to support the Crewmember and Aircraft Dispatcher Training final rule. The number of respondents would be limited to those Sponsors that maintain FSTDs which may require additional qualification in accordance with the FSTD Directive. Currently, there are 29 FSTD sponsors that may request additional FSTD qualification to support the training requirements in the Crewmember and Aircraft Dispatcher Training final rule.

Frequency: This additional information collection would include both a one-time event to report FSTD modifications as required by the FSTD Directive as well as a slight increase to the annual part 60 information collection requirements.

Annual Burden Estimate: The FAA estimates that for each additional qualified task required in accordance with FSTD Directive No. 2, the one-time information collection burden to each FSTD Sponsor would be approximately 0.85 hours per FSTD for each additional qualified task.[50] Assuming all five of the additional qualified tasks would be required for each of the estimated 335 FSTDs (including qualification for full stall training, upset recovery training, airborne icing training, takeoff and landing in gusting crosswinds, and bounced landing training), the cumulative one-time information collection burden would be approximately 1,424 hours. This collection burden would be distributed over a time period of approximately 3 years. This 3 year time period represents the compliance period of the proposed FSTD Directive.

The one-time information collection burden to the Federal government is estimated at approximately 0.6 hours per FSTD for each qualified task to include Aerospace Engineer review and preparation of an FAA response.[51] Assuming all five of the additional qualified tasks will be required for each of the estimated 335 FSTDs, the cumulative one-time information collection burden to the Federal government will be approximately 1,005 hours. The modification of the FSTD's SOQ would be incorporated with the FSTD's next scheduled evaluation, so this will not impose additional burden.

Because the number of objective tests required to maintain FSTD qualification would increase slightly with this proposal, the annual information collection burden would also increase under the FSTD inspection and maintenance requirements of § 60.19. This additional information collection burden is estimated by increasing the average number of required objective tests for Level C and Level D FFSs by four tests.[52] For the estimated 335 FSTDs that may be affected by the FSTD Directive, this will result in an additional 134 hours of annual information collection burden to FSTD Sponsors. This additional collection burden is based upon 0.1 hours [53] per test for a simulator technician to document as required by § 60.19. The additional information collection burden to the Federal government will also increase by approximately 45 hours [54] due to the additional tests that may be sampled and reviewed by the

[48] Office of Management and Budget (OMB) control number 2120–0680.

[49] The FAA estimated this from the number of previously qualified FSTDs that simulate aircraft which are currently used in U.S. part 121 air carrier operations. This number of FSTDs has increased from 322 to 335 since the publication of the NPRM.

[50] The 0.85 hour burden is derived from the existing Part 60 Paperwork Reduction Act supporting statement (OMB–2120–0680), Table 5 (§ 60.16) and includes estimated time for the FSTD Sponsor's staff to draft and send the letter as well as estimated time for updating the approved MQTG with new test results.

[51] The 0.6 hour burden on the Federal government is also derived from the existing Part 60 Paperwork Reduction Act supporting statement (OMB–2120–0680), Table 5 (§ 60.16).

[52] For previously qualified FSTDs, the requirements of FSTD Directive No. 2 will add a maximum of four additional objective test cases to the existing requirements.

[53] The 0.1 hour burden is derived from the existing Part 60 Paperwork Reduction Act supporting statement (OMB–2120–0680), Table 6 (§ 60.19) and includes estimated time for the FSTD Sponsor's staff to document the completion of required annual objective testing.

[54] This information collection burden is based upon 0.1 hours per test required for FAA personnel to review. These four additional tests are subject to the approximately 33% of which may be spot checked by FAA personnel on site during a continuing qualification evaluation.

FAA during continuing qualification evaluations.

For new FSTDs qualified after the proposal becomes effective, the changes to the QPS appendices proposed to align with ICAO 9625 as well as the new requirements for the evaluation of stall and icing training maneuvers would result in an estimated average increase of four objective tests [55] that would require annual documentation as described in § 60.19. For the estimated 23 new [56] Level C and Level D FFSs that may be initially qualified annually by the FAA, this will result in an additional 9 hours of annual information collection burden to FSTD Sponsors and an additional 3 hours of annual information collection burden to the Federal government. For newly qualified FSTDs, this proposal does not increase the frequency of reporting for FSTD sponsors.

The total additional information collection burden for FSTD sponsors as a result of this final rule is summarized in the following tables:

§ 60.16 Private sector burden (One-time cost)	Hours per notification	Hours	Hourly rate	Cost
Additional Tasks/Modifications.				
Number of notifications—1675.				
Management Rep hours to draft letter	0.5	838	$73.74	$61,794
Management Rep hours to make/insert MQTG change	0.25	419	73.74	30,897
Clerk hours to prepare/mail letter	0.1	168	29.70	4,990
Total		1425		97,681

§ 60.19 Private sector burden (Annual cost)	Hours	Hourly rate	Cost
Simulator technician (FSTD Directive No. 2)	134	$42.39	$5,680
Simulator technician (ICAO Alignment)	9	42.39	382
Total	143	42.39	6,062

The total additional information collection burden for the Federal government as a result of this final rule is summarized in the following tables:

§ 60.16 Federal burden (One-time cost)	Hours per notification	Hours	Hourly rate	Cost
Number of Notifications—1675.				
Engineer/Pilot (equivalent of GS14, Step 1)	0.5	838	$65.96	$55,274
Clerk (equivalent of GS10, Step 1)	0.1	168	35.64	5,988
Total		1006		61,262

§ 60.19 Federal burden (Annual cost)	Hours	Hourly rate	Cost
Federal Aviation Safety Inspector Review (FSTD Directive No. 2)	45	$65.96	$2,968
Federal Aviation Safety Inspector Review (ICAO Alignment)	3	65.96	198
Total	48	65.96	3,166

Additionally, as a result of public comments filed in response to the NPRM for this rule, the FAA added deviation authority to § 60.15(c)(5). The primary purpose for including this deviation authority is to allow for FSTD sponsors to initially qualify a new FSTD using internationally recognized FSTD evaluation standards, including those issued by the ICAO or another national aviation authority. This will improve international harmonization of FSTD evaluation standards as well as reduce redundant FSTD qualification documentation in instances where an FSTD is qualified by multiple national aviation authorities or evaluated under a bilateral agreement. Because an FSTD sponsor will have to submit a request to the FAA for the approval of a deviation, there will be an information collection burden for those FSTD sponsors or manufacturers that choose to request deviation authority. Since such deviations will generally be applicable only to those FSTDs that are undergoing an initial evaluation, and the total number of initial FSTD evaluations the FAA conducts averages around 50 per year, the burden for this information collection is expected to be very small. Furthermore, it is expected that most of these deviations will be submitted by FSTD manufacturers for the initial evaluation of multiple FSTDs as provisioned for in the deviation authority section of the final rule. As a result, the number of deviation requests received by the FAA will be mainly limited to a few FSTD manufacturers and will be result in a negligible information collection burden.

F. International Compatibility and Cooperation

(1) In keeping with United States (U.S.) obligations under the Convention on International Civil Aviation, it is FAA policy to conform to International

[55] These four additional tests were estimated through comparison between the current and proposed list of objective tests required for qualification (Table A2A). Note that the total number of tests can vary between FSTDs as a function of aircraft type, test implementation, and the employment of certain technologies that would require additional testing.

[56] Based upon internal records review, the FAA calculated the number of newly qualified fixed-wing Level C and Level D FSTDs at approximately 23 per year over a ten year period.

Civil Aviation Organization (ICAO) Standards and Recommended Practices to the maximum extent practicable. The FAA has determined that there are no ICAO Standards and Recommended Practices that correspond to these proposed regulations.

(2) Executive Order (EO) 13609, Promoting International Regulatory Cooperation, (77 FR 26413, May 4, 2012) promotes international regulatory cooperation to meet shared challenges involving health, safety, labor, security, environmental, and other issues and reduce, eliminate, or prevent unnecessary differences in regulatory requirements. The FAA has analyzed this action under the policy and agency responsibilities of Executive Order 13609, Promoting International Regulatory Cooperation. The agency has determined that this action would reduce differences between U.S. aviation standards and those of other civil aviation authorities by aligning the part 60 FSTD qualification standards with that of the latest international FSTD qualification guidance document (ICAO 9625) for equivalent FSTD levels.

(3) Harmonization. The FSTD evaluation standards that have been codified in this final rule were the result of numerous recommendations received from working groups that the FAA participated in on a collaborative basis. Many of these working groups had significant international presence from both industry and international regulatory authorities. Furthermore, much of the foundation of this final rule has been based upon the guidance material developed by the International Civil Aviation Organization which provides such material to promote international harmonization on aviation safety issues.

G. Environmental Analysis

FAA Order 1050.1F identifies FAA actions that are categorically excluded from preparation of an environmental assessment or environmental impact statement under the National Environmental Policy Act in the absence of extraordinary circumstances. The FAA has determined this rulemaking action qualifies for the categorical exclusion identified in paragraph 5–6.6.(f) and involves no extraordinary circumstances.

V. Executive Order Determinations

A. Executive Order 13132, Federalism

The FAA has analyzed this final rule under the principles and criteria of Executive Order 13132, Federalism. The agency determined that this action will not have a substantial direct effect on the States, or the relationship between the Federal Government and the States, or on the distribution of power and responsibilities among the various levels of government, and, therefore, does not have Federalism implications.

B. Executive Order 13211, Regulations that Significantly Affect Energy Supply, Distribution, or Use

The FAA analyzed this final rule under Executive Order 13211, Actions Concerning Regulations that Significantly Affect Energy Supply, Distribution, or Use (May 18, 2001). The agency has determined that it is not a ''significant energy action'' under the executive order and it is not likely to have a significant adverse effect on the supply, distribution, or use of energy.

VI. How To Obtain Additional Information

A. Rulemaking Documents

An electronic copy of a rulemaking document my be obtained by using the Internet—

1. Search the Federal eRulemaking Portal (*http://www.regulations.gov*);
2. Visit the FAA's Regulations and Policies Web page at *http://www.faa.gov/regulations_policies/* or
3. Access the Government Printing Office's Web page at *http://www.gpo.gov/fdsys/*.

Copies may also be obtained by sending a request (identified by notice, amendment, or docket number of this rulemaking) to the Federal Aviation Administration, Office of Rulemaking, ARM–1, 800 Independence Avenue SW., Washington, DC 20591, or by calling (202) 267–9680.

B. Comments Submitted to the Docket

Comments received may be viewed by going to *http://www.regulations.gov* and following the online instructions to search the docket number for this action. Anyone is able to search the electronic form of all comments received into any of the FAA's dockets by the name of the individual submitting the comment (or signing the comment, if submitted on behalf of an association, business, labor union, etc.).

C. Small Business Regulatory Enforcement Fairness Act

The Small Business Regulatory Enforcement Fairness Act (SBREFA) of 1996 requires FAA to comply with small entity requests for information or advice about compliance with statutes and regulations within its jurisdiction. A small entity with questions regarding this document, may contact its local FAA official, or the person listed under the FOR FURTHER INFORMATION CONTACT heading at the beginning of the preamble. To find out more about SBREFA on the Internet, visit *http://www.faa.gov/regulations_policies/rulemaking/sbre_act/*.

List of Subjects in 14 CFR Part 60

Air Carriers, Aircraft, Aviation safety, Reporting and recordkeeping requirements, Safety Transportation.

The Amendment

For the reasons set forth in the preamble, amend part 60 of title 14 of the Code of Federal Regulations as follows:

PART 60—FLIGHT SIMULATION TRAINING DEVICE INITIAL AND CONTINUING QUALIFICATION AND USE

■ 1. The authority citation for part 60 is revised to read as follows:

Authority: 49 U.S.C. 106(f), 106(g), 40113, and 44701; Pub. L. 111–216, 124 Stat. 2348 (49 U.S.C. 44701 note)

■ 2. Amend § 60.15 by adding paragraph (c)(5), revising paragraph (e), and adding paragraph (g)(7) to read as follows:

§ 60.15 Initial Qualification requirements.

* * * * *

(c) * * *

(5) An FSTD sponsor or FSTD manufacturer may submit a request to the Administrator for approval of a deviation from the QPS requirements as defined in Appendix A through Appendix D of this part.

(i) Requests for deviation must be submitted in a form and manner acceptable to the Administrator and must provide sufficient justification that the deviation meets or exceeds the testing requirements and tolerances as specified in the part 60 QPS or will otherwise not adversely affect the fidelity and capability of the FSTDs evaluated and qualified under the deviation.

(ii) The Administrator may consider deviation from the minimum requirements tables, the objective testing tables, the functions and subjective testing tables, and other supporting tables and requirements in the part 60 QPS.

(iii) Deviations may be issued to an FSTD manufacturer for the initial qualification of multiple FSTDs, subject to terms and limitations as determined by Administrator. Approved deviations will become a part of the permanent qualification basis of the individual FSTD and will be noted in the FSTD's Statement of Qualification.

(iv) If the FAA publishes a change to the existing part 60 standards as described in paragraph (c)(1) of this section or issues an FSTD Directive as described in § 60.23(b), which conflicts with or supersedes an approved deviation, the Administrator may terminate or revise a grant of deviation authority issued under this paragraph.

* * * * *

(e) The subjective tests that form the basis for the statements described in paragraph (b) of this section and the objective tests referenced in paragraph (f) of this section must be accomplished at the sponsor's training facility or other sponsor designated location where training will take place, except as provided for in the applicable QPS.

* * * * *

(g) * * *

(7) A statement referencing any deviations that have been granted and included in the permanent qualification basis of the FSTD.

* * * * *

■ 3. Amend § 60.17 by revising paragraph (a) to read as follows:

§ 60.17 Previously qualified FSTDs.

(a) Unless otherwise specified by an FSTD Directive, further referenced in the applicable QPS, or as specified in paragraph (e) of this section, an FSTD qualified before May 31, 2016 will retain its qualification basis as long as it continues to meet the standards, including the objective test results recorded in the MQTG and subjective tests, under which it was originally evaluated, regardless of sponsor. The sponsor of such an FSTD must comply with the other applicable provisions of this part.

* * * * *

■ 4. Amend § 60.19 by revising paragraphs (b)(4) through (6)to read as follows:

§ 60.19 Inspection, continuing qualification evaluation, and maintenance requirements.

* * * * *

(b) * * *

(4) The frequency of NSPM-conducted continuing qualification evaluations for each FSTD will be established by the NSPM and specified in the Statement of Qualification.

(5) Continuing qualification evaluations conducted in the 3 calendar months before or after the calendar month in which these continuing qualification evaluations are required will be considered to have been conducted in the calendar month in which they were required.

(6) No sponsor may use or allow the use of or offer the use of an FSTD for flight crewmember training or evaluation or for obtaining flight experience for the flight crewmember to meet any requirement of this chapter unless the FSTD has passed an NSPM-conducted continuing qualification evaluation within the time frame specified in the Statement of Qualification or within the grace period as described in paragraph (b)(5) of this section.

* * * * *

■ 5. Amend § 60.23 by revising paragraph (a)(2) to read as follows:

§ 60.23 Modifications to FSTDs.

(a) * * *

(2) Changes are made to either software or hardware that are intended to impact flight or ground dynamics; changes are made that impact performance or handling characteristics of the FSTD (including motion, visual, control loading, or sound systems for those FSTD levels requiring sound tests and measurements); or changes are made to the MQTG. Changes to the MQTG which do not affect required objective testing results or validation data approved during the initial evaluation of the FSTD are not considered modifications under this section.

* * * * *

■ 6. Amend Appendix A by:

■ A. Revising paragraph 1.b.;

■ B. Revising paragraph 1.d.(22);

■ C. Revising paragraph 1.d.(25);

■ D. Revising paragraph 1.d.(26);

■ E. Revising paragraph 11.b.(2);

■ F. Removing and reserving paragraph 11.e.(2);

■ G. Revising paragraph 11.h;

■ H. Revising paragraph 13.b; and

■ I. Revising paragraph 13.d.

The revisions read as follows:

Appendix A to Part 60—Qualification Performance Standards for Airplane Full Flight Simulators

* * * * *

1. Introduction.

* * * * *

b. Questions regarding the contents of this publication should be sent to the U.S. Department of Transportation, Federal Aviation Administration, Flight Standards Service, National Simulator Program Staff, AFS–205, P.O. Box 20636, Atlanta, Georgia, 30320. Telephone contact numbers for the NSP are: phone, 404–474–5620; fax, 404–474–5656. The NSP Internet Web site address is: *http://www.faa.gov/about/initiatives/nsp/*. On this Web site you will find an NSP personnel list with telephone and email contact information for each NSP staff member, a list of qualified flight simulation devices, advisory circulars (ACs), a description of the qualification process, NSP policy, and an NSP ''In-Works'' section. Also linked from this site are additional information sources, handbook bulletins, frequently asked questions, a listing and text of the Federal Aviation Regulations, Flight Standards Inspector's handbooks, and other FAA links.

* * * * *

d. * * *

(22) International Air Transport Association document, ''Flight Simulation Training Device Design and Performance Data Requirements,'' as amended.

* * * * *

(25) International Civil Aviation Organization (ICAO) Manual of Criteria for the Qualification of Flight Simulation Training Devices, as amended.

(26) Aeroplane Flight Simulation Training Device Evaluation Handbook, Volume I, as amended and Volume II, as amended, The Royal Aeronautical Society, London, UK.

* * * * *

11. Initial (and Upgrade) Qualification Requirements (§ 60.15).

* * * * *

b. * * *

(2) Unless otherwise authorized through prior coordination with the NSPM, a confirmation that the sponsor will forward to the NSPM the statement described in § 60.15(b) in such time as to be received no later than 5 business days prior to the scheduled evaluation and may be forwarded to the NSPM via traditional or electronic means.

* * * * *

h. The sponsor may elect to complete the QTG objective and subjective tests at the manufacturer's facility or at the sponsor's training facility (or other sponsor designated location where training will take place). If the tests are conducted at the manufacturer's facility, the sponsor must repeat at least one-third of the tests at the sponsor's training facility in order to substantiate FFS performance. The QTG must be clearly annotated to indicate when and where each test was accomplished. Tests conducted at the manufacturer's facility and at the sponsor's designated training facility must be conducted after the FFS is assembled with systems and sub-systems functional and operating in an interactive manner. The test results must be submitted to the NSPM.

* * * * *

13. Previously Qualified FFSs (§ 60.17).

* * * * *

b. Simulators qualified prior to May 31, 2016, are not required to meet the general simulation requirements, the objective test requirements or the subjective test requirements of attachments 1, 2, and 3 of this appendix as long as the simulator continues to meet the test requirements contained in the MQTG developed under the original qualification basis.

* * * * *

d. Simulators qualified prior to May 31, 2016, may be updated. If an evaluation is deemed appropriate or necessary by the NSPM after such an update, the evaluation will not require an evaluation to standards beyond those against which the simulator was originally qualified.

* * * * *

■ 7. Amend Attachment 1 to Appendix A:

■ A. By revising Table A1A;

■ B. In Table A1B, ''Table of Tasks vs. Simulator Level by:

■ i. Revising text of entry 3.b.;

■ ii. Adding entry 3.b.1;

■ iii. Adding entry 3.b.2; and

■ iv. Adding entry 3.g..

The revisions and additions read as follows:

Appendix A to Part 60—Qualification Performance Standards for Airplane Full Flight Simulators

* * * * *

Attachment 1 to Appendix A to Part 60—GENERAL SIMULATOR REQUIREMENTS

* * * * *

Table A1A – Minimum Simulator Requirements						
QPS REQUIREMENTS						INFORMATION
Entry Number	General Simulator Requirements	Simulator Levels				Notes
		A	B	C	D	
1. General Flight Deck Configuration.						
1.a.	The simulator must have a flight deck that is a replica of the airplane simulated with controls, equipment, observable flight deck indicators, circuit breakers, and bulkheads properly located, functionally accurate and replicating the airplane. The direction of movement of controls and switches must be identical to the airplane. Pilot seats must allow the occupant to achieve the design “eye position” established for the airplane being simulated. Equipment for the operation of the flight deck windows must be included, but the actual windows need not be operable. Additional equipment such as fire axes, extinguishers, and spare light bulbs must be available in the FFS but may be relocated to a suitable location as near as practical to the original position. Fire axes, landing gear pins, and any similar purpose instruments need only be represented in silhouette. The use of electronically displayed images with physical overlay or masking for simulator instruments and/or instrument panels is acceptable provided: (1) All instruments and instrument panel layouts are dimensionally correct with differences, if any, being imperceptible to the pilot; (2) Instruments replicate those of the airplane including full instrument functionality and embedded logic; (3) Instruments displayed are free of quantization (stepping); (4) Instrument display characteristics replicate those of the airplane including: resolution, colors, luminance, brightness, fonts, fill patterns, line styles and symbology; (5) Overlay or masking, including bezels and bugs, as applicable, replicates the airplane panel(s); (6) Instrument controls and switches replicate and operate with the same technique, effort, travel and in the same direction as those in the airplane; (7) Instrument lighting replicates that of the airplane and is operated from	X	X	X	X	For simulator purposes, the flight deck consists of all that space forward of a cross section of the flight deck at the most extreme aft setting of the pilots' seats, including additional required crewmember duty stations and those required bulkheads aft of the pilot seats. For clarification, bulkheads containing only items such as landing gear pin storage compartments, fire axes and extinguishers, spare light bulbs, and aircraft document pouches are not considered essential and may be omitted.

	the FSTD control for that lighting and, if applicable, is at a level commensurate with other lighting operated by that same control; and (8) As applicable, instruments must have faceplates that replicate those in the airplane; and					
	Level C and Level D only; (1) The display image of any three dimensional instrument, such as an electro-mechanical instrument, should appear to have the same three dimensional depth as the replicated instrument. The appearance of the simulated instrument, when viewed from the principle operator's angle, should replicate that of the actual airplane instrument. Any instrument reading inaccuracy due to viewing angle and parallax present in the actual airplane instrument should be duplicated in the simulated instrument display image. Viewing angle error and parallax must be minimized on shared instruments such and engine displays and standby indicators.			**X**	**X**	
1.b.	Those circuit breakers that affect procedures or result in observable flight deck indications must be properly located and functionally accurate.	**X**	**X**	**X**	**X**	
2. Programming.						
2.a.	A flight dynamics model that accounts for various combinations of drag and thrust normally encountered in flight must correspond to actual flight conditions, including the effect of change in airplane attitude, thrust, drag, altitude, temperature, gross weight, moments of inertia, center of gravity location, and configuration. An SOC is required.	**X**	**X**	**X**	**X**	The SOC should include a range of tabulated target values to enable a demonstration of the mass properties model to be conducted from the instructor's station. The data at a minimum should contain 3 weight conditions including zero fuel weight and maximum taxi weight with a least 2 different combinations of zero fuel weight, fuel weight and
	For Level C and Level D simulators, the effects of pitch attitude and of fuel slosh on the aircraft center of gravity must be simulated.			**X**	**X**	

						payload for each condition.
2.b.	The simulator must have the computer capacity, accuracy, resolution, and dynamic response needed to meet the qualification level sought. An SOC is required.	**X**	**X**	**X**	**X**	
2.c.	Surface operations must be represented to the extent that allows turns within the confines of the runway and adequate controls on the landing and roll-out from a crosswind approach to a landing.	**X**				
2.d.	Ground handling and aerodynamic programming must include the following:					
2.d.1.	Ground effect.		**X**	**X**	**X**	Ground effect includes modeling that accounts for roundout, flare, touchdown, lift, drag, pitching moment, trim, and power while in ground effect.
2.d.2.	Ground reaction. Ground reaction modeling must produce the appropriate effects during bounced or skipped landings, including the effects and indications of ground contact due to landing in an abnormal aircraft attitude (e.g. tailstrike or nosewheel contact). An SOC is required.		**X**	**X**	**X**	Ground reaction includes modeling that accounts for strut deflections, tire friction, and side forces. This is the reaction of the airplane upon contact with the runway during landing, and may differ with changes in factors such as gross weight, airspeed, or rate of descent on touchdown.
2.d.3.	Ground handling characteristics, including aerodynamic and ground reaction modeling including steering inputs, operations with crosswind, braking, thrust reversing, deceleration, and turning radius.		**X**	**X**	**X**	In developing gust models for use in training, the FSTD sponsor should coordinate with the data provider to ensure that

	Aerodynamic and ground reaction modeling to support training in crosswinds and gusting crosswinds up to the aircraft's maximum demonstrated crosswind component. Realistic gusting crosswind profiles must be available to the instructors that have been tuned in intensity and variation to require pilot intervention to avoid runway departure during takeoff or landing roll. An SOC is required describing source data used to construct gusting crosswind profiles.			X	X	the gust models do not exceed the capabilities of the aerodynamic and ground models.
2.e.	If the aircraft being simulated is one of the aircraft listed in § 121.358, Low-altitude windshear system equipment requirements, the simulator must employ windshear models that provide training for recognition of windshear phenomena and the execution of recovery procedures. Models must be available to the instructor/evaluator for the following critical phases of flight: (1) Prior to takeoff rotation; (2) At liftoff; (3) During initial climb; and (4) On final approach, below 500 ft AGL. The QTG must reference the FAA Windshear Training Aid or present alternate airplane related data, including the implementation method(s) used. If the alternate method is selected, wind models from the Royal Aerospace Establishment (RAE), the Joint Airport Weather Studies (JAWS) Project and other recognized sources may be implemented, but must be supported and properly referenced in the QTG. Only those simulators meeting these requirements may be used to satisfy the training requirements of part 121 pertaining to a certificate holder's approved low-altitude windshear flight training program as described in § 121.409. The addition of realistic levels of turbulence associated with each required windshear profile must be available and selectable to the instructor.			X	X	If desired, Level A and B simulators may qualify for windshear training by meeting these standards; see Attachment 5 of this appendix. Windshear models may consist of independent variable winds in multiple simultaneous components. The FAA Windshear Training Aid presents one acceptable means of compliance with simulator wind model requirements. The simulator should employ a method to ensure the required survivable and non-survivable windshear scenarios are repeatable in the training environment.

	In addition to the four basic windshear models required for qualification, at least two additional "complex" windshear models must be available to the instructor which represent the complexity of actual windshear encounters. These models must be available in the takeoff and landing configurations and must consist of independent variable winds in multiple simultaneous components. The Windshear Training Aid provides two such example "complex" windshear models that may be used to satisfy this requirement.					
2.f.	The simulator must provide for manual and automatic testing of simulator hardware and software programming to determine compliance with simulator objective tests as prescribed in Attachment 2 of this appendix. An SOC is required.			**X**	**X**	Automatic "flagging" of out-of-tolerance situations is encouraged.
2.g.	Relative responses of the motion system, visual system, and flight deck instruments, measured by latency tests or transport delay tests. Motion onset should occur before the start of the visual scene change (the start of the scan of the first video field containing different information) but must occur before the end of the scan of that video field. Instrument response may not occur prior to motion onset. Test results must be within the following limits:					The intent is to verify that the simulator provides instrument, motion, and visual cues that are, within the stated time delays, like the airplane responses. For airplane response, acceleration in the appropriate, corresponding rotational axis is preferred.
2.g.1.	300 milliseconds of the airplane response.	**X**	**X**			
2.g.2.	100 milliseconds of the airplane response (motion and instrument cues) 120 milliseconds of the airplane response (visual system cues)			**X**	**X**	
2.h.	The simulator must accurately reproduce the following runway conditions: (1) Dry; (2) Wet; (3) Icy;. (4) Patchy Wet; (5) Patchy Icy; and			**X**	**X**	

	(6) Wet on Rubber Residue in Touchdown Zone; An SOC is required.					
2.i.	The simulator must simulate: (1) brake and tire failure dynamics, including antiskid failure; and (2) decreased brake efficiency due to high brake temperatures, if applicable. An SOC is required			**X**	**X**	Simulator pitch, side loading, and directional control characteristics should be representative of the airplane.
2.j.	Engine and Airframe Icing Modeling that includes the effects of icing, where appropriate, on the airframe, aerodynamics, and the engine(s). Icing models must simulate the aerodynamic degradation effects of ice accretion on the airplane lifting surfaces including loss of lift, decrease in stall angle of attack, change in pitching moment, decrease in control effectiveness, and changes in control forces in addition to any overall increase in drag. Aircraft systems (such as the stall protection system and autoflight system) must respond properly to ice accretion consistent with the simulated aircraft. Aircraft OEM data or other acceptable analytical methods must be utilized to develop ice accretion models. Acceptable analytical methods may include wind tunnel analysis and/or engineering analysis of the aerodynamic effects of icing on the lifting surfaces coupled with tuning and supplemental subjective assessment by a subject matter expert pilot. SOC and tests required. See objective testing requirements (Attachment 2, test 2.i.).			**X**	**X**	SOC should be provided describing the effects which provide training in the specific skills required for recognition of icing phenomena and execution of recovery. The SOC should describe the source data and any analytical methods used to develop ice accretion models including verification that these effects have been tested. Icing effects simulation models are only required for those airplanes authorized for operations in icing conditions. See Attachment 7 of this Appendix for further guidance material.
2.k.	The aerodynamic modeling in the simulator must include:				**X**	See Attachment 2 of this

	(1) Low-altitude level-flight ground effect; (2) Mach effect at high altitude; (3) Normal and reverse dynamic thrust effect on control surfaces; (4) Aeroelastic representations; and (5) Nonlinearities due to sideslip. An SOC is required and must include references to computations of aeroelastic representations and of nonlinearities due to sideslip.					appendix, paragraph 5, for further information on ground effect.
2.l.	The simulator must have aerodynamic and ground reaction modeling for the effects of reverse thrust on directional control, if applicable. An SOC is required.		**X**	**X**	**X**	
2.m.	High Angle of Attack Modeling Aerodynamic stall modeling that includes degradation in static/dynamic lateral-directional stability, degradation in control response (pitch, roll, and yaw), uncommanded roll response or roll-off requiring significant control deflection to counter, apparent randomness or non-repeatability, changes in pitch stability, Mach effects, and stall buffet, as appropriate to the aircraft type. The aerodynamic model must incorporate an angle of attack and sideslip range to support the training tasks. At a minimum, the model must support an angle of attack range to ten degrees beyond the stall identification angle of attack. The stall identification angle of attack is defined as the point where the behavior of the airplane gives the pilot a clear and distinctive indication through the inherent flight characteristics or the characteristics resulting from the operation of a stall identification device (e.g., a stick pusher) that the airplane has stalled. The model must be capable of capturing the variations seen in the stall characteristics of the airplane (e.g., the presence or absence of a pitch break,			**X**	**X**	The requirements in this section only apply to those FSTDs that are qualified for full stall training tasks. Sponsors may elect to not qualify an FSTD for full stall training tasks; however, the FSTD's qualification will be restricted to approach to stall training tasks that terminate at the activation of the stall warning system. Specific guidance should be available to the instructor which clearly communicates the flight configurations and stall maneuvers that have been evaluated in the FSTD for use

	deterrent buffet, or other indications of a stall where present on the aircraft). The aerodynamic modeling must support stall training maneuvers in the following flight conditions: (1) Stall entry at wings level (1g); (2) Stall entry in turning flight of at least 25° bank angle (accelerated stall); (3) Stall entry in a power-on condition (required only for propeller driven aircraft); and (4) Aircraft configurations of second segment climb, high altitude cruise (near performance limited condition), and approach or landing. A Statement of Compliance (SOC) is required which describes the aerodynamic modeling methods, validation, and checkout of the stall characteristics of the FSTD. The SOC must also include verification that the FSTD has been evaluated by a subject matter expert pilot acceptable to the FAA. See Attachment 7 of this Appendix for detailed requirements. Where known limitations exist in the aerodynamic model for particular stall maneuvers (such as aircraft configurations and stall entry methods), these limitations must be declared in the required SOC. FSTDs qualified for full stall training tasks must also meet the instructor operating station (IOS) requirements for upset prevention and recovery training (UPRT) tasks as described in section 2.n. of this table. See Attachment 7 of this Appendix for additional requirements.					in training. See Attachment 7 of this Appendix for additional guidance material.
2.n.	Upset Prevention and Recovery Training (UPRT). Aerodynamics Evaluation: The simulator must be evaluated for specific upset recovery maneuvers for the purpose of determining that the combination of angle of attack and sideslip does not exceed the range of flight test validated data or wind tunnel/analytical data while performing the recovery maneuver.			**X**	**X**	This section generally applies to the qualification of airplane upset recovery training maneuvers or unusual attitude training maneuvers that exceed

	The following minimum set of required upset recovery maneuvers must be evaluated in this manner and made available to the instructor/evaluator. Other upset recovery scenarios as developed by the FSTD sponsor must be evaluated in the same manner: (1) A nose-high, wings level aircraft upset; (2) A nose-low aircraft upset; and (3) A high bank angle aircraft upset. Upset Scenarios: IOS selectable dynamic airplane upsets must provide guidance to the instructor concerning the method used to drive the FSTD into an upset condition, including any malfunction or degradation in the FSTD's functionality required to initiate the upset. The unrealistic degradation of simulator functionality (such as degrading flight control effectiveness) to drive an airplane upset is generally not acceptable unless used purely as a tool for repositioning the FSTD with the pilot out of the loop. Instructor Operating System (IOS): The simulator must have a feedback mechanism in place to notify the instructor/evaluator when the simulator's validated aerodynamic envelope and aircraft operating limits have been exceeded during an upset recovery training task. This feedback mechanism must include: (1) FSTD validation envelope. This must be in the form of an alpha/beta envelope (or equivalent method) depicting the "confidence level" of the aerodynamic model depending on the degree of flight validation or source of predictive methods The envelopes must provide the instructor real-time feedback on the simulation during a maneuver. There must be a minimum of a flaps up and flaps down envelope available; (2) Flight control inputs. This must enable the instructor to assess the					one or more of the following conditions: ▪ Pitch attitude greater than 25 degrees, nose up ▪ Pitch attitude greater than 10 degrees, nose down ▪ Bank angle greater than 45 degrees ▪ Flight at airspeeds inappropriate for conditions. FSTDs used to conduct upset recovery maneuvers at angles of attack above the stall warning system activation must meet the requirements for high angle of attack modeling as described in section 2.m. Special consideration should be given to the motion system response during upset prevention and recovery maneuvers. Notwithstanding the limitations of simulator motion, specific emphasis should be placed on tuning out motion system responses.

	pilot's flight control displacements and forces (including fly-by-wire as appropriate); and (3) Airplane operational limits. This must display the aircraft operating limits during the maneuver as applicable for the configuration of the airplane. Statement of Compliance (SOC): An SOC is required that defines the source data used to construct the FSTD validation envelope. The SOC must also verify that each upset prevention and recovery feature programmed at the instructor station and the associated training maneuver has been evaluated by a suitably qualified pilot using methods described in this section. The statement must confirm that the recovery maneuver can be performed such that the FSTD does not exceed the FSTD validation envelope, or when exceeded, that it is within the realm of confidence in the simulation accuracy.					Consideration should be taken with flight envelope protected airplanes as artificially positioning the airplane to a specified attitude may incorrectly initialize flight control laws. See Attachment 7 of this Appendix for further guidance material.
3. Equipment Operation.						
3.a.	All relevant instrument indications involved in the simulation of the airplane must automatically respond to control movement or external disturbances to the simulated airplane; e.g., turbulence or windshear. Numerical values must be presented in the appropriate units. For Level C and Level D simulators, instrument indications must also respond to effects resulting from icing.	**X**	**X**	**X**	**X**	
3.b.	Communications, navigation, caution, and warning equipment must be installed and operate within the tolerances applicable for the airplane. Instructor control of internal and external navigational aids. Navigation aids must be usable within range or line-of-sight without restriction, as applicable to the geographic area.	**X**	**X**	**X**	**X**	See Attachment 3 of this appendix for further information regarding long-range navigation equipment.
3.b.1.	Complete navigation database for at least 3 airports with corresponding precision and non-precision approach procedures, including navigational			**X**	**X**	

	database updates.					
3.b.2.	Complete navigation database for at least 1 airport with corresponding precision and non-precision approach procedures, including navigational database updates.	**X**	**X**			
3.c.	Simulated airplane systems must operate as the airplane systems operate under normal, abnormal, and emergency operating conditions on the ground and in flight. Once activated, proper systems operation must result from system management by the crew member and not require any further input from the instructor's controls.	**X**	**X**	**X**	**X**	Airplane system operation should be predicated on, and traceable to, the system data supplied by the airplane manufacturer, original equipment manufacturer or alternative approved data for the airplane system or component. At a minimum, alternate approved data should validate the operation of all normal, abnormal, and emergency operating procedures and training tasks the FSTD is qualified to conduct.
3.d.	The simulator must provide pilot controls with control forces and control travel that correspond to the simulated airplane. The simulator must also react in the same manner as in the airplane under the same flight conditions. Control systems must replicate airplane operation for the normal and any non-normal modes including back-up systems and should reflect failures of associated systems. Appropriate cockpit indications and messages must be replicated.	**X**	**X**	**X**	**X**	
3.e.	Simulator control feel dynamics must replicate the airplane. This must be			**X**	**X**	

	determined by comparing a recording of the control feel dynamics of the simulator to airplane measurements. For initial and upgrade qualification evaluations, the control dynamic characteristics must be measured and recorded directly from the flight deck controls, and must be accomplished in takeoff, cruise, and landing flight conditions and configurations.					
3.f.	For aircraft equipped with a stick pusher system, control forces, displacement, and surface position must correspond to that of the airplane being simulated. A Statement of Compliance (SOC) is required verifying that the stick pusher system has been modeled, programmed, and validated using the aircraft manufacturer's design data or other acceptable data source. The SOC must address, at a minimum, stick pusher activation and cancellation logic as well as system dynamics, control displacement and forces as a result of the stick pusher activation. Tests required.			**X**	**X**	See Appendix A, Table A2A, test 2.a.10 (stick pusher system force calibration) for objective testing requirements. The requirements in this section only apply to those FSTDs that are qualified for full stall training tasks.
4. Instructor or Evaluator Facilities.						
4.a.	In addition to the flight crewmember stations, the simulator must have at least two suitable seats for the instructor/check airman and FAA inspector. These seats must provide adequate vision to the pilot's panel and forward windows. All seats other than flight crew seats need not represent those found in the airplane, but must be adequately secured to the floor and equipped with similar positive restraint devices.	**X**	**X**	**X**	**X**	The NSPM will consider alternatives to this standard for additional seats based on unique flight deck configurations.
4.b.	The simulator must have controls that enable the instructor/evaluator to control all required system variables and insert all abnormal or emergency conditions into the simulated airplane systems as described in the sponsor's FAA-approved training program; or as described in the relevant operating manual as appropriate.	**X**	**X**	**X**	**X**	
4.c.	The simulator must have instructor controls for all environmental effects expected to be available at the IOS; e.g., clouds, visibility, icing,	**X**	**X**	**X**	**X**	

	precipitation, temperature, storm cells and microbursts, turbulence, and intermediate and high altitude wind speed and direction.					
4.d.	The simulator must provide the instructor or evaluator the ability to present ground and air hazards.			**X**	**X**	For example, another airplane crossing the active runway or converging airborne traffic.
5. Motion System.						
5.a.	The simulator must have motion (force) cues perceptible to the pilot that are representative of the motion in an airplane.	**X**	**X**	**X**	**X**	For example, touchdown cues should be a function of the rate of descent (RoD) of the simulated airplane.
5.b.	The simulator must have a motion (force cueing) system with a minimum of three degrees of freedom (at least pitch, roll, and heave). An SOC is required.	**X**	**X**			
5.c.	The simulator must have a motion (force cueing) system that produces cues at least equivalent to those of a six-degrees-of-freedom, synergistic platform motion system (i.e., pitch, roll, yaw, heave, sway, and surge). An SOC is required.			**X**	**X**	
5.d.	The simulator must provide for the recording of the motion system response time. An SOC is required.	**X**	**X**	**X**	**X**	
5.e.	The simulator must provide motion effects programming to include:					
5.e.1.	(1) Thrust effect with brakes set; (2) Runway rumble, oleo deflections, effects of ground speed, uneven runway, centerline lights, and taxiway characteristics; (3) Buffets on the ground due to spoiler/speedbrake extension and thrust reversal; (4) Bumps associated with the landing gear;		**X**	**X**	**X**	If there are known flight conditions where buffet is the first indication of the stall, or where no stall buffet occurs, this characteristic should be included in the model.

	(5) Buffet during extension and retraction of landing gear; (6) Buffet in the air due to flap and spoiler/speedbrake extension; (7) Approach-to-stall buffet and stall buffet (where applicable); (8) Representative touchdown cues for main and nose gear; (9) Nosewheel scuffing, if applicable; (10) Mach and maneuver buffet; (11) Engine failures, malfunctions, and engine damage (12) Tail and pod strike;					
5.e.2.	(13) Taxiing effects such as lateral and directional cues resulting from steering and braking inputs; (14) Buffet due to atmospheric disturbances (e.g. buffets due to turbulence, gusting winds, storm cells, windshear, etc.) in three linear axes (isotropic); (15) Tire failure dynamics; and (16) Other significant vibrations, buffets and bumps that are not mentioned above (e.g. RAT), or checklist items such as motion effects due to pre-flight flight control inputs.			**X**	**X**	
5.f.	The simulator must provide characteristic motion vibrations that result from operation of the airplane if the vibration marks an event or airplane state that can be sensed in the flight deck.				**X**	The simulator should be programmed and instrumented in such a manner that the characteristic buffet modes can be measured and compared to airplane data.
6. Visual System.						
6.a.	The simulator must have a visual system providing an out-of-the-flight deck view.	**X**	**X**	**X**	**X**	
6.b.	The simulator must provide a continuous collimated field-of-view of at least 45° horizontally and 30° vertically per pilot seat or the number of degrees necessary to meet the visual ground segment requirement, whichever is greater. Both pilot seat visual systems must be operable simultaneously. The minimum horizontal field-of-view coverage must be plus and minus one-half	**X**	**X**			Additional field-of-view capability may be added at the sponsor's discretion provided the minimum fields of view are retained.

	(½) of the minimum continuous field-of-view requirement, centered on the zero degree azimuth line relative to the aircraft fuselage. An SOC is required and must explain the system geometry measurements including system linearity and field-of-view.					
6.c.	(Reserved)					
6.d.	The simulator must provide a continuous collimated visual field-of-view of at least176° horizontally and 36° vertically or the number of degrees necessary to meet the visual ground segment requirement, whichever is greater. The minimum horizontal field-of-view coverage must be plus and minus one-half (½) of the minimum continuous field-of-view requirement, centered on the zero degree azimuth line relative to the aircraft fuselage. An SOC is required and must explain the system geometry measurements including system linearity and field-of-view.			**X**	**X**	The horizontal field-of-view is traditionally described as a 180º field-of-view. However, the field-of-view is technically no less than 176º. Additional field-of-view capability may be added at the sponsor's discretion provided the minimum fields of view are retained.
6.e.	The visual system must be free from optical discontinuities and artifacts that create non-realistic cues.	**X**	**X**	**X**	**X**	Non-realistic cues might include image "swimming" and image "roll-off," that may lead a pilot to make incorrect assessments of speed, acceleration, or situational awareness.
6.f.	The simulator must have operational landing lights for night scenes. Where used, dusk (or twilight) scenes require operational landing lights.	**X**	**X**	**X**	**X**	
6.g.	The simulator must have instructor controls for the following: (1) Visibility in statute miles (km) and runway visual range (RVR) in ft.(m); (2) Airport selection; and (3) Airport lighting.	**X**	**X**	**X**	**X**	

6.h.	The simulator must provide visual system compatibility with dynamic response programming.	**X**	**X**	**X**	**X**	
6.i.	The simulator must show that the segment of the ground visible from the simulator flight deck is the same as from the airplane flight deck (within established tolerances) when at the correct airspeed, in the landing configuration, at the appropriate height above the touchdown zone, and with appropriate visibility.	**X**	**X**	**X**	**X**	This will show the modeling accuracy of RVR, glideslope, and localizer for a given weight, configuration, and speed within the airplane's operational envelope for a normal approach and landing.
6.j.	The simulator must provide visual cues necessary to assess sink rates (provide depth perception) during takeoffs and landings, to include: (1) Surface on runways, taxiways, and ramps; and (2) Terrain features.		**X**	**X**	**X**	
6.k.	The simulator must provide for accurate portrayal of the visual environment relating to the simulator attitude.	**X**	**X**	**X**	**X**	Visual attitude vs. simulator attitude is a comparison of pitch and roll of the horizon as displayed in the visual scene compared to the display on the attitude indicator.
6.l.	The simulator must provide for quick confirmation of visual system color, RVR, focus, and intensity. An SOC is required.			**X**	**X**	
6.m.	The simulator must be capable of producing at least 10 levels of occulting.			**X**	**X**	
6.n.	Night Visual Scenes. When used in training, testing, or checking activities, the simulator must provide night visual scenes with sufficient scene content to recognize the airport, the terrain, and major landmarks around the airport. The scene content must allow a pilot to successfully accomplish a visual landing. Scenes must include a definable horizon and typical terrain characteristics such as fields, roads and bodies of water and surfaces illuminated by airplane landing lights.	**X**	**X**	**X**	**X**	

6.o.	Dusk (or Twilight) Visual Scenes. When used in training, testing, or checking activities, the simulator must provide dusk (or twilight) visual scenes with sufficient scene content to recognize the airport, the terrain, and major landmarks around the airport. The scene content must allow a pilot to successfully accomplish a visual landing. Dusk (or twilight) scenes, as a minimum, must provide full color presentations of reduced ambient intensity, sufficient surfaces with appropriate textural cues that include self-illuminated objects such as road networks, ramp lighting and airport signage, to conduct a visual approach, landing and airport movement (taxi). Scenes must include a definable horizon and typical terrain characteristics such as fields, roads and bodies of water and surfaces illuminated by airplane landing lights. If provided, directional horizon lighting must have correct orientation and be consistent with surface shading effects. Total night or dusk (twilight) scene content must be comparable in detail to that produced by 10,000 visible textured surfaces and 15,000 visible lights with sufficient system capacity to display 16 simultaneously moving objects. An SOC is required.			**X**	**X**	
6.p.	Daylight Visual Scenes. The simulator must provide daylight visual scenes with sufficient scene content to recognize the airport, the terrain, and major landmarks around the airport. The scene content must allow a pilot to successfully accomplish a visual landing. Any ambient lighting must not "washout" the displayed visual scene. Total daylight scene content must be comparable in detail to that produced by 10,000 visible textured surfaces and 6,000 visible lights with sufficient system capacity to display 16 simultaneously moving objects. The visual display must be free of apparent and distracting quantization and other distracting visual effects while the simulator is in motion. An SOC is required.			**X**	**X**	
6.q.	The simulator must provide operational visual scenes that portray physical			**X**	**X**	For example: short runways,

	relationships known to cause landing illusions to pilots.					landing approaches over water, uphill or downhill runways, rising terrain on the approach path, unique topographic features.
6.r.	The simulator must provide special weather representations of light, medium, and heavy precipitation near a thunderstorm on takeoff and during approach and landing. Representations need only be presented at and below an altitude of 2,000 ft. (610 m) above the airport surface and within 10 miles (16 km) of the airport.			**X**	**X**	
6.s.	The simulator must present visual scenes of wet and snow-covered runways, including runway lighting reflections for wet conditions, partially obscured lights for snow conditions, or suitable alternative effects.			**X**	**X**	
6.t.	The simulator must present realistic color and directionality of all airport lighting.			**X**	**X**	
6.u.	The following weather effects as observed on the visual system must be simulated and respective instructor controls provided. (1) Multiple cloud layers with adjustable bases, tops, sky coverage and scud effect; (2) Storm cells activation and/or deactivation; (3) Visibility and runway visual range (RVR), including fog and patchy fog effect; (4) Effects on ownship external lighting; (5) Effects on airport lighting (including variable intensity and fog effects); (6) Surface contaminants (including wind blowing effect); (7) Variable precipitation effects (rain, hail, snow); (8) In-cloud airspeed effect; and (9) Gradual visibility changes entering and breaking out of cloud.			**X**	**X**	Scud effects are low, detached, and irregular clouds below a defined cloud layer. Atmospheric model should support representative effects of wake turbulence and mountain waves as needed to enhance UPRT training. The mountain wave model should support the atmospheric climb, descent, and roll rates which can be encountered in mountain wave and rotor conditions.

6.v.	The simulator must provide visual effects for: (1) Light poles; (2) Raised edge lights as appropriate; and (3) Glow associated with approach lights in low visibility before physical lights are seen,			**X**	**X**	Visual effects for light poles and raised edge lights are for the purpose of providing additional depth perception during takeoff, landing, and taxi training tasks. Three dimensional modeling of the actual poles and stanchions is not required.
7. Sound System.						
7.a.	The simulator must provide flight deck sounds that result from pilot actions that correspond to those that occur in the airplane.	**X**	**X**	**X**	**X**	
7.b.	The volume control must have an indication of sound level setting which meets all qualification requirements.	**X**	**X**	**X**	**X**	For Level D simulators, this indication should be readily available to the instructor on or about the IOS and is the sound level setting required to meet the objective testing requirements as described in Table A2A of this Appendix. For all other simulator levels, this indication is the sound level setting as evaluated during the simulator's initial evaluation.
7.c.	The simulator must accurately simulate the sound of precipitation, windshield wipers, and other significant airplane noises perceptible to the pilot during normal and abnormal operations, and include the sound of a crash (when the simulator is landed in an unusual attitude or in excess of the structural gear limitations); normal engine and thrust reversal sounds; and the sounds of flap,			**X**	**X**	For simulators qualified for full stall training tasks, sounds associated with stall buffet should be replicated if significant in the airplane.

	gear, and spoiler extension and retraction. Sounds must be directionally representative. A SOC is required.					
7.d.	The simulator must provide realistic amplitude and frequency of flight deck noises and sounds. Simulator performance must be recorded, compared to amplitude and frequency of the same sounds recorded in the airplane, and be made a part of the QTG. .				**X**	

* * * * * * * *						
3. Inflight Maneuvers.						
* * * * * * * *						
3.b.	High Angle of Attack Maneuvers					
3.b.1	Approaches to Stall	**X**	**X**	**X**	**X**	
3.b.2	Full Stall			**X**	**X**	Stall maneuvers at angles of attack above the activation of the stall warning system. Required only for FSTDs qualified to conduct full stall training tasks as indicated on the Statement of Qualification.
* * * * * * * *						
3.g.	Upset Prevention and Recovery Training (UPRT)			**X**	**X**	Upset recovery or unusual attitude training maneuvers within the FSTD's validation envelope that are intended to exceed pitch attitudes greater than 25 degrees nose up; pitch attitudes greater than 10 degrees nose down, and bank angles greater than 45 degrees.
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■ 8. Amend Attachment 2 to Appendix A by revising:

■ A. Paragraph 2.e.;

■ B. Table A2A;

■ C. Paragraph 6.b.;

■ D. Paragraph 6.d.;

■ E. Paragraph 11.a.(1);
■ F. Paragraph 11.b.(5);
■ G. Paragraph 12.a.;

The revisions read as follows:

Appendix A to Part 60—Qualification Performance Standards for Airplane Full Flight Simulators

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Attachment 2 to Appendix A to Part 60—FFS OBJECTIVE TESTS

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2. * * *

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e. It is not acceptable to program the FFS so that the mathematical modeling is correct only at the validation test points. Unless otherwise noted, simulator tests must represent airplane performance and handling qualities at operating weights and centers of gravity (CG) typical of normal operation. Simulator tests at extreme weight or CG conditions may be acceptable where required for concurrent aircraft certification testing. Tests of handling qualities must include validation of augmentation devices.

* * * * *

1. Performance.									
1.a.	**Taxi.**								
1.a.1	Minimum radius turn.	±0.9 m (3 ft) or ±20% of airplane turn radius.	Ground.	Plot both main and nose gear loci and key engine parameter(s). Data for no brakes and the minimum thrust required to maintain a steady turn except for airplanes requiring asymmetric thrust or braking to achieve the minimum radius turn.		X	X	X	
1.a.2	Rate of turn versus nosewheel steering angle (NWA).	±10% or ±2°/s of turn rate.	Ground.	Record for a minimum of two speeds, greater than minimum turning radius speed with one at a typical taxi speed, and with a spread of at least 5 kt.		X	X	X	
1.b.	**Takeoff.**			*Note.— All airplane manufacturer commonly-used certificated take-off flap settings must be demonstrated at least once either in minimum unstick speed (1.b.3), normal take-off (1.b.4), critical engine failure on take-off (1.b.5) or crosswind take-off (1.b.6).*					
1.b.1	Ground acceleration time and distance.	±1.5 s or ±5% of time; and ±61 m (200 ft) or ±5% of distance.	Takeoff.	Acceleration time and distance must be recorded for a minimum of 80% of the total time from brake release to V_r. Preliminary aircraft certification data may be used.	X	X	X	X	May be combined with normal takeoff (1.b.4.) or rejected takeoff (1.b.7.). Plotted data should be shown using appropriate scales for each portion of the maneuver.
1.b.2	Minimum control speed, ground (V_{mcg}) using aerodynamic controls only per applicable airworthiness requirement or alternative engine inoperative test to demonstrate ground control characteristics.	±25% of maximum airplane lateral deviation reached or ±1.5 m (5 ft). For airplanes with reversible flight control systems: ±2.2 daN (5 lbf) or ±10% of rudder pedal force.	Takeoff.	Engine failure speed must be within ±1 kt of airplane engine failure speed. Engine thrust decay must be that resulting from the mathematical model for the engine applicable to the FSTD under test. If the modeled engine is not the same as the airplane manufacturer's flight test engine, a further test may be run with the same initial conditions using the thrust from the flight test data as the driving parameter.	X	X	X	X	If a V_{mcg} test is not available, an acceptable alternative is a flight test snap engine deceleration to idle at a speed between V_1 and V_1-10 kt, followed by control of heading using aerodynamic control only and recovery should be achieved with the main gear on the ground. To ensure only aerodynamic control, nosewheel steering should be disabled (i.e. castored) or the nosewheel held slightly off the ground.
1.b.3	Minimum unstick speed (V_{mu}) or equivalent test to	±3 kt airspeed. ±1.5° pitch angle.	Takeoff.	Record time history data from 10 knots before start of rotation until at least 5 seconds after the occurrence of main gear lift-off.	X	X	X	X	V_{mu} is defined as the minimum speed at which the

	demonstrate early rotation take-off characteristics.								last main landing gear leaves the ground. Main landing gear strut compression or equivalent air/ground signal should be recorded. If a V_{mu} test is not available, alternative acceptable flight tests are a constant high-attitude takeoff run through main gear lift-off or an early rotation takeoff. If either of these alternative solutions is selected, aft body contact/tail strike protection functionality, if present on the airplane, should be active.
1.b.4	Normal take-off.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±6 m (20 ft) height. For airplanes with reversible flight control systems: ±2.2 daN (5 lbf) or ±10% of column force.	Takeoff.	Data required for near maximum certificated takeoff weight at mid center of gravity location and light takeoff weight at an aft center of gravity location. If the airplane has more than one certificated takeoff configuration, a different configuration must be used for each weight. Record takeoff profile from brake release to at least 61 m (200 ft) AGL.	**X**	**X**	**X**	**X**	The test may be used for ground acceleration time and distance (1.b.1). Plotted data should be shown using appropriate scales for each portion of the maneuver.
1.b.5	Critical engine failure on take-off.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±6 m (20 ft) height. ±2° roll angle. ±2° side-slip angle. ±3° heading angle. For airplanes with reversible flight control systems:	Takeoff.	Record takeoff profile to at least 61 m (200 ft) AGL. Engine failure speed must be within ±3 kt of airplane data. Test at near maximum takeoff weight.	**X**	**X**	**X**	**X**	

		±2.2 daN (5 lbf) or ±10% of column force; ±1.3 daN (3 lbf) or ±10% of wheel force; and ±2.2 daN (5 lbf) or ±10% of rudder pedal force.							
1.b.6	Crosswind takeoff.	± 3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±6 m (20 ft) height. ±2° roll angle. ±2° side-slip angle. ±3° heading angle. Correct trends at ground speeds below 40 kt for rudder/pedal and heading angle. For airplanes with reversible flight control systems: ±2.2 daN (5 lbf) or ±10% of column force; ±1.3 daN (3 lbf) or ±10% of wheel force; and ±2.2 daN (5 lbf) or ±10% of rudder pedal force.	Takeoff.	Record takeoff profile from brake release to at least 61 m (200 ft) AGL. This test requires test data, including wind profile, for a crosswind component of at least 60% of the airplane performance data value measured at 10 m (33 ft) above the runway. Wind components must be provided as headwind and crosswind values with respect to the runway.	**X**	**X**	**X**	**X**	In those situations where a maximum crosswind or a maximum demonstrated crosswind is not known, contact the NSPM.
1.b.7.	Rejected Takeoff.	±5% of time or ±1.5 s.	Takeoff.	Record at mass near maximum takeoff weight.	**X**	**X**	**X**	**X**	Autobrakes will be used

		±7.5% of distance or ±76 m (250 ft).		Speed for reject must be at least 80% of V_1. Maximum braking effort, auto or manual. Where a maximum braking demonstration is not available, an acceptable alternative is a test using approximately 80% braking and full reverse, if applicable. Time and distance must be recorded from brake release to a full stop.					where applicable.
1.b.8.	Dynamic Engine Failure After Takeoff.	±2°/s or ±20% of body angular rates.	Takeoff.	Engine failure speed must be within ±3 kt of airplane data. Engine failure may be a snap deceleration to idle. Record hands-off from 5 s before engine failure to +5 s or 30° roll angle, whichever occurs first. **CCA**: Test in Normal and Non-normal control state.			**X**	**X**	For safety considerations, airplane flight test may be performed out of ground effect at a safe altitude, but with correct airplane configuration and airspeed.
1.c.	**Climb.**								
1.c.1.	Normal Climb, all engines operating.	±3 kt airspeed. ±0.5 m/s (100 ft/ min) or ±5% of rate of climb.	Clean.	Flight test data are preferred; however, airplane performance manual data are an acceptable alternative. Record at nominal climb speed and mid initial climb altitude. FSTD performance is to be recorded over an interval of at least 300 m (1 000 ft).	**X**	**X**	**X**	**X**	
1.c.2.	One-engine-inoperative 2nd segment climb.	±3 kt airspeed. ±0.5 m/s (100 ft/ min) or ±5% of rate of climb, but not less than airplane performance data requirements.	2nd segment climb.	Flight test data is preferred; however, airplane performance manual data is an acceptable alternative. Record at nominal climb speed. FSTD performance is to be recorded over an interval of at least 300 m (1,000 ft). Test at WAT (weight, altitude or temperature) limiting condition.	**X**	**X**	**X**	**X**	

1.c.3.	One Engine Inoperative En route Climb.	±10% time, ±10% distance, ±10% fuel used	Clean	Flight test data or airplane performance manual data may be used. Test for at least a 1,550 m (5,000 ft) segment.			**X**	**X**	
1.c.4.	One Engine Inoperative Approach Climb for airplanes with icing accountability if provided in the airplane performance data for this phase of flight.	±3 kt airspeed. ±0.5 m/s (100 ft/ min) or ±5% rate of climb, but not less than airplane performance data.	Approach	Flight test data or airplane performance manual data may be used. FSTD performance to be recorded over an interval of at least 300 m (1,000 ft). Test near maximum certificated landing weight as may be applicable to an approach in icing conditions.	**X**	**X**	**X**	**X**	Airplane should be configured with all anti-ice and de-ice systems operating normally, gear up and go-around flap. All icing accountability considerations, in accordance with the airplane performance data for an approach in icing conditions, should be applied.
1.d.	**Cruise / Descent.**								
1.d.1.	Level flight acceleration	±5% Time	Cruise	Time required to increase airspeed a minimum of 50 kt, using maximum continuous thrust rating or equivalent. For airplanes with a small operating speed range, speed change may be reduced to 80% of operational speed change.	**X**	**X**	**X**	**X**	
1.d.2.	Level flight deceleration.	±5% Time	Cruise	Time required to decrease airspeed a minimum of 50 kt, using idle power. For airplanes with a small operating speed range, speed change may be reduced to 80% of operational speed change.	**X**	**X**	**X**	**X**	
1.d.3.	Cruise performance.	±.05 EPR or ±3% N1 or ±5% of torque. ±5% of fuel flow.	Cruise.	The test may be a single snapshot showing instantaneous fuel flow, or a minimum of two consecutive snapshots with a spread of at least 3 minutes in steady flight.			**X**	**X**	
1.d.4.	Idle descent.	±3 kt airspeed. ±1.0 m/s (200 ft/min) or ±5% of rate of descent.	Clean.	Idle power stabilized descent at normal descent speed at mid altitude. FSTD performance to be recorded over an interval of at least 300 m (1,000 ft).	**X**	**X**	**X**	**X**	
1.d.5.	Emergency descent.	±5 kt airspeed. ±1.5 m/s (300 ft/min) or ±5% of rate of descent.	As per airplane performance data.	FSTD performance to be recorded over an interval of at least 900 m (3,000 ft).	**X**	**X**	**X**	**X**	Stabilized descent to be conducted with speed brakes extended if applicable, at mid altitude and near V_{mo} or according to emergency

									descent procedure.
1.e.	**Stopping.**								
1.e.1.	Deceleration time and distance, manual wheel brakes, dry runway, no reverse thrust.	±1.5 s or ±5% of time. For distances up to 1,220 m (4, 000 ft), the smaller of ±61 m (200 ft) or ±10% of distance. For distances greater than 1,220 m (4, 000 ft), ±5% of distance.	Landing.	Time and distance must be recorded for at least 80% of the total time from touchdown to a full stop. Position of ground spoilers and brake system pressure must be plotted (if applicable). Data required for medium and near maximum certificated landing mass. Engineering data may be used for the medium mass condition.	**X**	**X**	**X**	**X**	
1.e.2.	Deceleration time and distance, reverse thrust, no wheel brakes, dry runway.	±1.5 s or ±5% of time; and the smaller of ±61 m (200 ft) or ±10% of distance.	Landing	Time and distance must be recorded for at least 80% of the total time from initiation of reverse thrust to full thrust reverser minimum operating speed. Position of ground spoilers must be plotted (if applicable). Data required for medium and near maximum certificated landing mass. Engineering data may be used for the medium mass condition.	**X**	**X**	**X**	**X**	
1.e.3.	Stopping distance, wheel brakes, wet runway.	±61 m (200 ft) or ±10% of distance.	Landing.	Either flight test or manufacturer's performance manual data must be used, where available. Engineering data, based on dry runway flight test stopping distance and the effects of contaminated runway braking coefficients, are an acceptable alternative.			**X**	**X**	
1.e.4.	Stopping distance, wheel brakes, icy runway.	±61 m (200 ft) or ±10% of distance.	Landing.	Either flight test or manufacturer's performance manual data must be used, where available. Engineering data, based on dry runway flight test stopping distance and the effects of contaminated runway braking coefficients, are an acceptable alternative.			**X**	**X**	
1.f.	**Engines.**								

1.f.1.	Acceleration.	±10% Ti or ±0.25 s; and ±10% Tt or ±0.25 s.	Approach or landing	Total response is the incremental change in the critical engine parameter from idle power to go-around power.	**X**	**X**	**X**	**X**	See Appendix F of this part for definitions of T_i, and T_t.
1.f.2.	Deceleration.	±10% Ti or ±0.25 s; and ±10% Tt or ±0.25 s.	Ground	Total response is the incremental change in the critical engine parameter from maximum takeoff power to idle power.	**X**	**X**	**X**	**X**	See Appendix F of this part for definitions of T_i, and T_t.
2. Handling Qualities.									
2.a.	**Static Control Tests.**								
	Note.1 — Testing of position versus force is not applicable if forces are generated solely by use of airplane hardware in the FSTD. *Note 2 — Pitch, roll and yaw controller position versus force or time should be measured at the control. An alternative method in lieu of external test fixtures at the flight controls would be to have recording and measuring instrumentation built into the FSTD. The force and position data from this instrumentation could be directly recorded and matched to the airplane data. Provided the instrumentation was verified by using external measuring equipment while conducting the static control checks, or equivalent means, and that evidence of the satisfactory comparison is included in the MQTG, the instrumentation could be used for both initial and recurrent evaluations for the measurement of all required control checks. Verification of the instrumentation by using external measuring equipment should be repeated if major modifications and/or repairs are made to the control loading system. Such a permanent installation could be used without any time being lost for the installation of external devices. Static and dynamic flight control tests should be accomplished at the same feel or impact pressures as the validation data where applicable.* *Note 3 — FSTD static control testing from the second set of pilot controls is only required if both sets of controls are not mechanically interconnected on the FSTD. A rationale is required from the data provider if a single set of data is applicable to both sides. If controls are mechanically interconnected in the FSTD, a single set of tests is sufficient.*								
2.a.1.a.	Pitch controller position versus force and surface position calibration.	±0.9 daN (2 lbf) breakout. ±2.2 daN (5 lbf) or ±10% of force. ±2° elevator angle.	Ground.	Record results for an uninterrupted control sweep to the stops.	**X**	**X**	**X**	**X**	Test results should be validated with in-flight data from tests such as longitudinal static stability, stalls, etc.
2.a.1.b.	**(Reserved)**								
2.a.2.a.	Roll controller position versus force and surface position calibration.	±0.9 daN (2 lbf) breakout. ±1.3 daN (3 lbf) or ±10% of force. ±2° aileron angle. ±3° spoiler angle.	Ground.	Record results for an uninterrupted control sweep to the stops.	**X**	**X**	**X**	**X**	Test results should be validated with in-flight data from tests such as engine-out trims, steady state side-slips, etc.
2.a.2.b.	**(Reserved)**								
2.a.3.a.	Rudder pedal position versus force and surface position	±2.2 daN (5 lbf) breakout.	Ground.	Record results for an uninterrupted control sweep to the stops.	**X**	**X**	**X**	**X**	Test results should be validated with in-flight data from tests such as engine-out

	calibration.	±2.2 daN (5 lbf) or ±10% of force. ±2° rudder angle.							trims, steady state side-slips, etc.
2.a.3.b.	**(Reserved)**								
2.a.4.	Nosewheel Steering Controller Force and Position Calibration.	±0.9 daN (2 lbf) breakout. ±1.3 daN (3 lbf) or ±10% of force. ±2° NWA.	Ground.	Record results of an uninterrupted control sweep to the stops.	X	X	X	X	
2.a.5.	Rudder Pedal Steering Calibration.	±2° NWA.	Ground.	Record results of an uninterrupted control sweep to the stops.	X	X	X	X	
2.a.6.	Pitch Trim Indicator vs. Surface Position Calibration.	±0.5° trim angle.	Ground.		X	X	X	X	The purpose of the test is to compare FSTD surface position and indicator against the flight control model computed value.
2.a.7.	Pitch Trim Rate.	±10% of trim rate (°/s) or ±0.1°/s trim rate.	Ground and approach.	Trim rate to be checked at pilot primary induced trim rate (ground) and autopilot or pilot primary trim rate in-flight at go-around flight conditions. For CCA, representative flight test conditions must be used.	X	X	X	X	
2.a.8.	Alignment of cockpit throttle lever versus selected engine parameter.	When matching engine parameters: ±5° of TLA. When matching detents: ±3% N1 or ±.03 EPR or ±3% torque, or equivalent. Where the levers do not have angular travel, a tolerance of ±2 cm (±0.8 in) applies.	Ground.	Simultaneous recording for all engines. The tolerances apply against airplane data. For airplanes with throttle detents, all detents to be presented and at least one position between detents/ endpoints (where practical). For airplanes without detents, end points and at least three other positions are to be presented.	X	X	X	X	Data from a test airplane or engineering test bench are acceptable, provided the correct engine controller (both hardware and software) is used. In the case of propeller-driven airplanes, if an additional lever, usually referred to as the propeller lever, is present, it should also be checked. This test may be a series of snapshot tests.
2.a.9.	Brake pedal position versus force and	±2.2 daN (5 lbf) or	Ground.	Relate the hydraulic system pressure to pedal	X	X	X	X	FFS computer output results may be used to show

	brake system pressure calibration.	±10% of force. ±1.0 MPa (150 psi) or ±10% of brake system pressure.		position in a ground static test. Both left and right pedals must be checked.					compliance.
2.a.10	Stick Pusher System Force Calibration (if applicable)	±10% or ±5 lb (2.2 daN)) Stick/Column force	Ground or Flight	Test is intended to validate the stick/column transient forces as a result of a stick pusher system activation. This test may be conducted in an on-ground condition through stimulation of the stall protection system in a manner that generates a stick pusher response that is representative of an in-flight condition.			**X**	**X**	Aircraft manufacturer design data may be utilized as validation data as determined acceptable by the NSPM. Test requirement may be met through column force validation testing in conjunction with the Stall Characteristics test (2.c.8.a.). This test is required only for FSTDs qualified to conduct full stall training tasks.
2.b.	**Dynamic Control Tests.**								
	Note.— Tests 2.b.1, 2.b.2 and 2.b.3 are not applicable for FSTDs where the control forces are completely generated within the airplane controller unit installed in the FSTD. Power setting may be that required for level flight unless otherwise specified. See paragraph 4 of this attachment..								
2.b.1.	Pitch Control.	**For underdamped systems**: $T(P_0)$ ±10% of P_0 or ±0.05 s. $T(P_1)$ ±20% of P_1 or ±0.05 s. $T(P_2)$ ±30% of P_2 or ±0.05 s. $T(P_n)$ ±10*(n+1)% of P_n or ±0.05 s. $T(A_n)$ ±10% of A_{max}, where A_{max} is the largest amplitude or ±0.5% of the total control travel	Takeoff, Cruise, and Landing.	Data must be for normal control displacements in both directions (approximately 25% to 50% of full throw or approximately 25% to 50% of maximum allowable pitch controller deflection for flight conditions limited by the maneuvering load envelope). Tolerances apply against the absolute values of each period (considered independently).			**X**	**X**	n = the sequential period of a full oscillation. Refer to paragraph 4 of this Attachment. For overdamped and critically damped systems, see Figure A2B of Appendix A for an illustration of the reference measurement.

		(stop to stop). $T(A_d)$ ±5% of A_d = residual band or ±0.5% of the maximum control travel = residual band. ±1 significant overshoots (minimum of 1 significant overshoot). Steady state position within residual band. *Note 1.— Tolerances should not be applied on period or amplitude after the last significant overshoot.* *Note 2.— Oscillations within the residual band are not considered significant and are not subject to tolerances.* **For overdamped and critically damped systems only**, the following tolerance applies: $T(P_0)$ ±10% of P_0 or ±0.05 s.							
2.b.2.	Roll Control.	Same as 2.b.1.	Takeoff, Cruise, and Landing.	Data must be for normal control displacement (approximately 25% to 50% of full throw or approximately 25% to 50% of maximum allowable roll controller deflection for flight conditions limited by the maneuvering load envelope).			**X**	**X**	Refer to paragraph 4 of this Attachment. For overdamped and critically damped systems, see Figure A2B of Appendix A for an illustration of the reference measurement.
2.b.3.	Yaw Control.	Same as 2.b.1.	Takeoff, Cruise, and	Data must be for normal control displacement			**X**	**X**	Refer to paragraph 4 of this

			Landing.	(approximately 25% to 50% of full throw).					Attachment. For overdamped and critically damped systems, see Figure A2B of Appendix A for an illustration of the reference measurement.
2.b.4.	Small Control Inputs – Pitch.	±0.15°/s body pitch rate or ±20% of peak body pitch rate applied throughout the time history.	Approach or Landing.	Control inputs must be typical of minor corrections made while established on an ILS approach (approximately 0.5 to 2°/s pitch rate). Test in both directions. Show time history data from 5 s before until at least 5 s after initiation of control input. If a single test is used to demonstrate both directions, there must be a minimum of 5 s before control reversal to the opposite direction. **CCA**: Test in normal and non-normal control state.			**X**	**X**	
2.b.5.	Small Control Inputs – Roll.	±0.15°/s body roll rate or ±20% of peak body roll rate applied throughout the time history.	Approach or landing.	Control inputs must be typical of minor corrections made while established on an ILS approach (approximately 0.5 to 2°/s roll rate). Test in one direction. For airplanes that exhibit non-symmetrical behavior, test in both directions. Show time history data from 5 s before until at least 5 s after initiation of control input. If a single test is used to demonstrate both directions, there must be a minimum of 5 s before control reversal to the opposite direction. **CCA**: Test in normal and non-normal control state.			**X**	**X**	
2.b.6.	Small Control Inputs – Yaw.	±0.15°/s body yaw rate or ±20% of peak body yaw rate applied throughout the time history.	Approach or landing.	Control inputs must be typical of minor corrections made while established on an ILS approach (approximately 0.5 to 2°/s yaw rate). Test in both directions.			**X**	**X**	

				Show time history data from 5 s before until at least 5 s after initiation of control input. If a single test is used to demonstrate both directions, there must be a minimum of 5 s before control reversal to the opposite direction. **CCA:** Test in normal and non-normal control state.					
2.c.	**Longitudinal Control Tests.**								
	Power setting is that required for level flight unless otherwise specified.								
2.c.1.	Power Change Dynamics.	±3 kt airspeed. ±30 m (100 ft) altitude. ±1.5° or ±20% of pitch angle.	Approach.	Power change from thrust for approach or level flight to maximum continuous or go-around power. Time history of uncontrolled free response for a time increment equal to at least 5 s before initiation of the power change to the completion of the power change + 15 s. **CCA:** Test in normal and non-normal control mode	X	X	X	X	
2.c.2.	Flap/Slat Change Dynamics.	±3 kt airspeed. ±30 m (100 ft) altitude. ±1.5° or ±20% of pitch angle.	Takeoff through initial flap retraction, and approach to landing.	Time history of uncontrolled free response for a time increment equal to at least 5 s before initiation of the reconfiguration change to the completion of the reconfiguration change + 15 s. **CCA:** Test in normal and non-normal control mode	X	X	X	X	
2.c.3.	Spoiler/Speedbrake Change Dynamics.	±3 kt airspeed. ±30 m (100 ft) altitude. ±1.5° or ±20% of pitch angle.	Cruise.	Time history of uncontrolled free response for a time increment equal to at least 5 s before initiation of the configuration change to the completion of the configuration change +15 s. Results required for both extension and retraction. **CCA:** Test in normal and non-normal control mode	X	X	X	X	
2.c.4.	Gear Change	±3 kt airspeed.	Takeoff (retraction), and	Time history of uncontrolled free response for a	X	X	X	X	

	Dynamics.	±30 m (100 ft) altitude. ±1.5° or ±20% of pitch angle.	Approach (extension).	time increment equal to at least 5 s before initiation of the configuration change to the completion of the configuration change + 15 s. **CCA:** Test in normal and non-normal control mode					
2.c.5.	Longitudinal Trim.	±1° elevator angle. ±0.5° stabilizer or trim surface angle. ±1° pitch angle. ±5% of net thrust or equivalent.	Cruise, Approach, and Landing.	Steady-state wings level trim with thrust for level flight. This test may be a series of snapshot tests. **CCA**: Test in normal or non-normal control mode, as applicable.	**X**	**X**	**X**	**X**	
2.c.6.	Longitudinal Maneuvering Stability (Stick Force/g).	±2.2 daN (5 lbf) or ±10% of pitch controller force. Alternative method: ±1° or ±10% of the change of elevator angle.	Cruise, Approach, and Landing.	Continuous time history data or a series of snapshot tests may be used. Test up to approximately 30° of roll angle for approach and landing configurations. Test up to approximately 45° of roll angle for the cruise configuration. Force tolerance not applicable if forces are generated solely by the use of airplane hardware in the FSTD. Alternative method applies to airplanes which do not exhibit stick-force-per-g characteristics. **CCA:** Test in normal or non-normal control mode	**X**	**X**	**X**	**X**	
2.c.7.	Longitudinal Static Stability.	±2.2 daN (5 lbf) or ±10% of pitch controller force. Alternative method: ±1° or ±10% of the change of elevator angle.	Approach.	Data for at least two speeds above and two speeds below trim speed. The speed range must be sufficient to demonstrate stick force versus speed characteristics. This test may be a series of snapshot tests. Force tolerance is not applicable if forces are generated solely by the use of airplane hardware in the FSTD.	**X**	**X**	**X**	**X**	

				Alternative method applies to airplanes which do not exhibit speed stability characteristics. **CCA:** Test in normal or non-normal control mode, as applicable.					
2.c.8.a	Stall Characteristics	±3 kt airspeed for stall warning and stall speeds. ±2.0° angle of attack for buffet threshold of perception and initial buffet based upon Nz component. Control inputs must be plotted and demonstrate correct trend and magnitude. Approach to stall: ±2.0° pitch angle; ±2.0° angle of attack; and ±2.0° bank angle Stall warning up to stall: ±2.0° pitch angle; ±2.0° angle of attack; and Correct trend and magnitude for roll rate and yaw rate. Stall Break and Recovery: SOC Required (see Attachment 7) Additionally, for those simulators with reversible flight control systems or equipped with stick pusher	Second Segment Climb, High Altitude Cruise (Near Performance Limited Condition), and Approach or Landing	Each of the following stall entries must be demonstrated in at least one of the three flight conditions: ▪ Stall entry at wings level (1g) ▪ Stall entry in turning flight of at least 25° bank angle (accelerated stall) ▪ Stall entry in a power-on condition (required only for propeller driven aircraft) The cruise flight condition must be conducted in a flaps-up (clean) configuration. The second segment climb flight condition must use a different flap setting than the approach or landing flight condition. Record the stall warning signal and initial buffet, if applicable. Time history data must be recorded for full stall through recovery to normal flight. The stall warning signal must occur in the proper relation to buffet/stall. FSTDs of airplanes exhibiting a sudden pitch attitude change or "g break" must demonstrate this characteristic. FSTDs of airplanes exhibiting a roll off or loss of roll control authority must demonstrate this characteristic. Numerical tolerances are not applicable past the stall angle of attack, but must demonstrate correct trend through recovery. See Attachment 7 for additional requirements and information concerning data sources and required angle of attack ranges. **CCA:** Test in normal and non-normal control states. For CCA aircraft with stall envelope protection systems, the normal mode testing is only required to an angle of attack range necessary to demonstrate the correct operation of the system. These tests may be used to satisfy the required			**X**	**X**	Buffet threshold of perception should be based on 0.03 g peak to peak normal acceleration above the background noise at the pilot seat. Initial buffet to be based on normal acceleration at the pilot seat with a larger peak to peak value relative to buffet threshold of perception (some airframe manufacturers have used 0.1 g peak to peak). Demonstrate correct trend in growth of buffet amplitude from initial buffet to stall speed for normal and lateral acceleration. The FSTD sponsor/FSTD manufacturer may limit maximum buffet based on motion platform capability/limitations or other simulator system limitations. Tests may be conducted at centers of gravity and weights typically required for airplane certification stall testing. This test is required only for FSTDs qualified to conduct full stall training tasks. In instances where flight test validation data is limited due to safety of flight considerations, engineering simulator validation data may

		systems: ±10% or ±5 lb (2.2 daN)) Stick/Column force (prior to the stall angle of attack).		(angle of attack) flight maneuver and envelope protection tests (test 2.h.6.). Non-normal control states must be tested through stall identification and recovery.					be used in lieu of flight test validation data for angles of attack that exceed the activation of a stall protection system or stick pusher system. Where approved engineering simulation validation is used, the reduced engineering tolerances (as defined in paragraph 11 of this appendix) do not apply.
2.c.8.b	Approach to Stall Characteristics	±3 kt airspeed for stall warning speeds. ±2.0° angle of attack for initial buffet. Control displacements and flight control surfaces must be plotted and demonstrate correct trend and magnitude. ±2.0° pitch angle; ±2.0° angle of attack; and ±2.0° bank angle Additionally, for those simulators with reversible flight control systems: ±10% or ±5 lb (2.2 daN)) Stick/Column force	Second Segment Climb, High Altitude Cruise (Near Performance Limited Condition), and Approach or Landing	Each of the following stall entries must be demonstrated in at least one of the three flight conditions: ▪ Approach to stall entry at wings level (1g) ▪ Approach to stall entry in turning flight of at least 25° bank angle (accelerated stall) ▪ Approach to stall entry in a power-on condition (required only for propeller driven aircraft) The cruise flight condition must be conducted in a flaps-up (clean) configuration. The second segment climb flight condition must use a different flap setting than the approach or landing flight condition. **CCA:** Test in Normal and Non-normal control states. For CCA aircraft with stall envelope protection systems, the normal mode testing is only required to an angle of attack range necessary to demonstrate the correct operation of the system. These tests may be used to satisfy the required (angle of attack) flight maneuver and envelope protection tests (test 2.h.6.).	**X**	**X**			Tests may be conducted at centers of gravity and weights typically required for airplane certification stall testing. Tolerances on stall buffet are not applicable where the first indication of the stall is the activation of the stall warning system (i.e. stick shaker).
2.c.9.	Phugoid Dynamics.	±10% of period. ±10% of time to one half or double amplitude or ±0.02 of damping ratio.	Cruise.	Test must include three full cycles or that necessary to determine time to one half or double amplitude, whichever is less. **CCA:** Test in non-normal control mode.	**X**	**X**	**X**	**X**	
2.c.10	Short Period Dynamics.	±1.5° pitch angle or ±2°/s pitch rate.	Cruise.	**CCA:** Test in normal and non-normal control mode.	**X**	**X**	**X**	**X**	

		±0.1 g normal acceleration							
2.c.11.	**(Reserved)**								
2.d.	**Lateral Directional Tests.**								
	Power setting is that required for level flight unless otherwise specified.								
2.d.1.	Minimum control speed, air (V_{mca}) or landing (V_{mcl}), per applicable airworthiness requirement or low speed engine-inoperative handling characteristics in the air.	±3 kt airspeed.	Takeoff or Landing (whichever is most critical in the airplane).	Takeoff thrust must be set on the operating engine(s). Time history or snapshot data may be used. **CCA**: Test in normal or non-normal control state, as applicable.	**X**	**X**	**X**	**X**	Minimum speed may be defined by a performance or control limit which prevents demonstration of V_{mca} or V_{mcl} in the conventional manner.
2.d.2.	Roll Response (Rate).	±2°/s or ±10% of roll rate. For airplanes with reversible flight control systems: ±1.3 daN (3 lbf) or ±10% of wheel force.	Cruise, and Approach or Landing.	Test with normal roll control displacement (approximately one-third of maximum roll controller travel). This test may be combined with step input of flight deck roll controller test 2.d.3.	**X**	**X**	**X**	**X**	
2.d.3.	Step input of flight deck roll controller.	±2° or ±10% of roll angle.	Approach or Landing.	This test may be combined with roll response (rate) test 2.d.2. **CCA**: Test in normal and non-normal control mode	**X**	**X**	**X**	**X**	With wings level, apply a step roll control input using approximately one-third of the roll controller travel. When reaching approximately 20° to 30° of bank, abruptly return the roll controller to neutral and allow approximately 10 seconds of airplane free response.
2.d.4.	Spiral Stability.	Correct trend and ±2° or ±10% of roll angle in 20 s. If alternate test is used: correct trend and ±2° aileron angle.	Cruise, and Approach or Landing.	Airplane data averaged from multiple tests may be used. Test for both directions. As an alternative test, show lateral control required to maintain a steady turn with a roll angle of approximately 30°.	**X**	**X**	**X**	**X**	

				CCA: Test in non-normal control mode.					
2.d.5.	Engine Inoperative Trim.	±1° rudder angle or ±1° tab angle or equivalent rudder pedal. ±2° side-slip angle.	Second Segment Climb, and Approach or Landing.	This test may consist of snapshot tests.	**X**	**X**	**X**	**X**	Test should be performed in a manner similar to that for which a pilot is trained to trim an engine failure condition. 2nd segment climb test should be at takeoff thrust. Approach or landing test should be at thrust for level flight.
2.d.6.	Rudder Response.	±2°/s or ±10% of yaw rate.	Approach or Landing.	Test with stability augmentation on and off. Test with a step input at approximately 25% of full rudder pedal throw. **CCA:** Test in normal and non-normal control mode	**X**	**X**	**X**	**X**	
2.d.7.	Dutch Roll	±0.5 s or ±10% of period. ±10% of time to one half or double amplitude or ±.02 of damping ratio. ±1 s or ±20% of time difference between peaks of roll angle and side-slip angle.	Cruise, and Approach or Landing.	Test for at least six cycles with stability augmentation off. **CCA:** Test in non-normal control mode.		**X**	**X**	**X**	
2.d.8.	Steady State Sideslip.	For a given rudder position: ±2° roll angle; ±1° side-slip angle; ±2° or ±10% of aileron angle; and	Approach or Landing.	This test may be a series of snapshot tests using at least two rudder positions (in each direction for propeller-driven airplanes), one of which must be near maximum allowable rudder.	**X**	**X**	**X**	**X**	

		±5° or ±10% of spoiler or equivalent roll controller position or force. For airplanes with reversible flight control systems: ±1.3 daN (3 lbf) or ±10% of wheel force. ±2.2 daN (5 lbf) or ±10% of rudder pedal force.							
2.e.	**Landings.**								
2.e.1.	Normal Landing.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±3 m (10 ft) or ±10% of height. For airplanes with reversible flight control systems: ±2.2 daN (5 lbf) or ±10% of column force.	Landing.	Test from a minimum of 61 m (200 ft) AGL to nosewheel touchdown. **CCA:** Test in normal and non-normal control mode, if applicable.		**X**	**X**	**X**	Two tests should be shown, including two normal landing flaps (if applicable) one of which should be near maximum certificated landing mass, the other at light or medium mass.
2.e.2.	Minimum Flap Landing.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±3 m (10 ft) or ±10% of height. For airplanes with	Minimum Certified Landing Flap Configuration.	Test from a minimum of 61 m (200 ft) AGL to nosewheel touchdown. Test at near maximum certificated landing weight.			**X**	**X**	

		reversible flight control systems: ±2.2 daN (5 lbf) or ±10% of column force.							
2.e.3.	Crosswind Landing.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±3 m (10 ft) or ±10% of height. ±2° roll angle. ±2° side-slip angle. ±3° heading angle. For airplanes with reversible flight control systems: ±2.2 daN (5 lbf) or ±10% of column force. ±1.3 daN (3 lbf) or ±10% of wheel force. ±2.2 daN (5 lbf) or ±10% of rudder pedal force.	Landing.	Test from a minimum of 61 m (200 ft) AGL to a 50% decrease in main landing gear touchdown speed. Test data is required, including wind profile, for a crosswind component of at least 60% of airplane performance data value measured at 10 m (33 ft) above the runway. Wind components must be provided as headwind and crosswind values with respect to the runway.		**X**	**X**	**X**	In those situations where a maximum crosswind or a maximum demonstrated crosswind is not known, contact the NSPM.
2.e.4.	One Engine Inoperative Landing.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±3 m (10 ft) or ±10% of height.	Landing.	Test from a minimum of 61 m (200 ft) AGL to a 50% decrease in main landing gear touchdown speed.		**X**	**X**	**X**	

		±2° roll angle. ±2° side-slip angle. ±3° heading angle.							
2.e.5.	Autopilot landing (if applicable).	±1.5 m (5 ft) flare height. ±0.5 s or ± 10% of Tf. ±0.7 m/s (140 ft/min) rate of descent at touchdown. ±3 m (10 ft) lateral deviation during roll-out.	Landing.	If autopilot provides roll-out guidance, record lateral deviation from touchdown to a 50% decrease in main landing gear touchdown speed. Time of autopilot flare mode engage and main gear touchdown must be noted.		**X**	**X**	**X**	See Appendix F of this part for definition of T_f.
2.e.6.	All-engine autopilot go-around.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA.	As per airplane performance data.	Normal all-engine autopilot go-around must be demonstrated (if applicable) at medium weight.		**X**	**X**	**X**	
2.e.7.	One engine inoperative go around.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±2° roll angle. ±2° side-slip angle.	As per airplane performance data.	Engine inoperative go-around required near maximum certificated landing weight with critical engine inoperative. Provide one test with autopilot (if applicable) and one without autopilot. **CCA**: Non-autopilot test to be conducted in non-normal mode.		**X**	**X**	**X**	
2.e.8.	Directional control (rudder effectiveness) with symmetric reverse thrust.	±5 kt airspeed. ±2°/s yaw rate.	Landing.	Apply rudder pedal input in both directions using full reverse thrust until reaching full thrust reverser minimum operating speed.		**X**	**X**	**X**	
2.e.9.	Directional control (rudder effectiveness) with asymmetric reverse thrust.	±5 kt airspeed. ±3° heading angle.	Landing.	With full reverse thrust on the operating engine(s), maintain heading with rudder pedal input until maximum rudder pedal input or thrust reverser minimum operation speed is reached.		**X**	**X**	**X**	
2.f.	**Ground Effect.**								

	Test to demonstrate Ground Effect.	±1° elevator angle. ±0.5° stabilizer angle. ±5% of net thrust or equivalent. ±1° AOA. ±1.5 m (5 ft) or ±10% of height. ±3 kt airspeed. ±1° pitch angle.	Landing.	A rationale must be provided with justification of results. **CCA:** Test in normal or non-normal control mode, as applicable.		X	X	X	See paragraph 5 of this Attachment for additional information.
2.g.	**Windshear.**								
	Four tests, two takeoff and two landing, with one of each conducted in still air and the other with windshear active to demonstrate windshear models.	See Attachment 5 of this appendix.	Takeoff and Landing.	Requires windshear models that provide training in the specific skills needed to recognize windshear phenomena and to execute recovery procedures. See Attachment 5 of this appendix for tests, tolerances, and procedures.			X	X	See Attachment 5 of this appendix for information related to Level A and B simulators.
2.h.	**Flight Maneuver and Envelope Protection Functions.**								
	Note. — The requirements of 2.h are only applicable to computer-controlled airplanes. Time history results of response to control inputs during entry into each envelope protection function (i.e. with normal and degraded control states if their function is different) are required. Set thrust as required to reach the envelope protection function.								
2.h.1.	Overspeed.	±5 kt airspeed.	Cruise.			X	X	X	
2.h.2.	Minimum Speed.	±3 kt airspeed.	Takeoff, Cruise, and Approach or Landing.			X	X	X	
2.h.3.	Load Factor.	±0.1g normal load factor	Takeoff, Cruise.			X	X	X	
2.h.4.	Pitch Angle.	±1.5° pitch angle	Cruise, Approach.			X	X	X	
2.h.5.	Bank Angle.	±2° or ±10% bank angle	Approach.			X	X	X	
2.h.6.	Angle of Attack.	±1.5° angle of attack	Second Segment Climb, and Approach or Landing.			X	X	X	
2.i.	**Engine and Airframe Icing Effects**								
2.i.	Engine and Airframe Icing Effects Demonstration (High Angle of Attack)		Takeoff or Approach or Landing [One flight condition –	Time history of a full stall and initiation of the recovery. Tests are intended to demonstrate representative aerodynamic effects caused by in-flight ice accretion. Flight test validation data is			X	X	Tests will be evaluated for representative effects on relevant aerodynamic and other parameters such as

			two tests (ice on and off)]	not required. Two tests are required to demonstrate engine and airframe icing effects. One test will demonstrate the FSTDs baseline performance without ice accretion, and the second test will demonstrate the aerodynamic effects of ice accretion relative to the baseline test. The test must utilize the icing model(s) as described in the required Statement of Compliance in Table A1A, Section 2.j. Test must include rationale that describes the icing effects being demonstrated. Icing effects may include, but are not limited to, the following effects as applicable to the particular airplane type: ▪ Decrease in stall angle of attack ▪ Changes in pitching moment ▪ Decrease in control effectiveness ▪ Changes in control forces ▪ Increase in drag ▪ Change in stall buffet characteristics and threshold of perception ▪ Engine effects (power reduction/variation, vibration, etc. where expected to be present on the aircraft in the ice accretion scenario being tested)					angle of attack, control inputs, and thrust/power settings. Plotted parameters must include: • Altitude • Airspeed • Normal acceleration • Engine power • Angle of attack • Pitch attitude • Bank angle • Flight control inputs • Stall warning and stall buffet onset
3. Motion System.									
3.a.	**Frequency response.**								
		As specified by the sponsor for FSTD qualification.	Not applicable.	Appropriate test to demonstrate required frequency response.	**X**	**X**	**X**	**X**	See paragraph 6 of this Attachment.
3.b.	**Turn-around check.**								
		As specified by the sponsor for FSTD qualification.	Not applicable.	Appropriate test to demonstrate required smooth turn-around.	**X**	**X**	**X**	**X**	See paragraph 6 of this Attachment.
3.c	**Motion effects.**				**X**	**X**	**X**	**X**	Refer to Attachment 3 of this Appendix on subjective testing.
3.d.	**Motion system repeatability.**								
	Motion system repeatability	±0.05 g actual platform linear accelerations.	None.		**X**	**X**	**X**	**X**	Ensure that motion system hardware and software (in normal FSTD operating

									mode) continue to perform as originally qualified. Performance changes from the original baseline can be readily identified with this information. See paragraph 6.c. of this Attachment.
3.e.	**Motion cueing fidelity**								
3.c.1.	Motion cueing fidelity – Frequency-domain criterion.	As specified by the FSTD manufacturer for initial qualification.	Ground and flight.	For the motion system as applied during training, record the combined modulus and phase of the motion cueing algorithm and motion platform over the frequency range appropriate to the characteristics of the simulated aircraft. This test is only required for initial FSTD qualification.			**X**	**X**	Testing may be accomplished by the FSTD manufacturer and results provided as a statement of compliance.
3.e.2.	Reserved								
3.f	Characteristic motion vibrations. The following tests with recorded results and an SOC are required for characteristic motion vibrations, which can be sensed at the flight deck where applicable by airplane type.	None.	Ground and flight.					**X**	The recorded test results for characteristic buffets should allow the comparison of relative amplitude versus frequency. See also paragraph 6.e. of this Attachment.
3.f.1.	Thrust effect with brakes set.	The FSTD test results must exhibit the overall appearance and trends of the airplane data, with at least three (3) of the predominant frequency “spikes” being present within ± 2 Hz of the airplane data.	Ground.	Test must be conducted at maximum possible thrust with brakes set.				**X**	
3.f.2.	Buffet with landing gear extended.	The FSTD test results must exhibit the overall appearance and trends of the airplane data,	Flight.	Test condition must be for a normal operational speed and not at the gear limiting speed.				**X**	

		with at least three (3) of the predominant frequency "spikes" being present within ± 2 Hz of the airplane data.							
3.f.3.	Buffet with flaps extended.	The FSTD test results must exhibit the overall appearance and trends of the airplane data, with at least three (3) of the predominant frequency "spikes" being present within ± 2 Hz of the airplane data.	Flight.	Test condition must be at a normal operational speed and not at the flap limiting speed.				**X**	
3.f.4.	Buffet with speedbrakes deployed.	The FSTD test results must exhibit the overall appearance and trends of the airplane data, with at least three (3) of the predominant frequency "spikes" being present within ± 2 Hz of the airplane data.	Flight.	Test condition must be at a typical speed for a representative buffet.				**X**	
3.f.5.	Stall buffet	The FSTD test results must exhibit the overall appearance and trends of the airplane data, with at least three (3) of the predominant frequency "spikes" being present within ± 2 Hz of the airplane data.	Cruise (High Altitude), Second Segment Climb, and Approach or Landing	Tests must be conducted for an angle of attack range between the buffet threshold of perception to the pilot and the stall angle of attack. Post stall characteristics are not required.			**X**	**X**	If stabilized flight data between buffet threshold of perception and the stall angle of attack are not available, PSD analysis should be conducted for a time span between initial buffet and the stall angle of attack. Test required only for FSTDs qualified for full stall training tasks or for those aircraft which exhibit stall buffet before the activation of the stall warning system.
3.f.6.	Buffet at high airspeeds or high Mach.	The FSTD test results must exhibit the overall appearance and trends of the airplane data, with at least three (3) of the predominant	Flight.					**X**	Test condition should be for high-speed maneuver buffet/wind-up-turn or alternatively Mach buffet.

		frequency "spikes" being present within ± 2 Hz of the airplane data.							
3.f.7.	In-flight vibrations for propeller driven airplanes.	The FSTD test results must exhibit the overall appearance and trends of the airplane data, with at least three (3) of the predominant frequency "spikes" being present within ± 2 Hz of the airplane data.	Flight (clean configuration).					**X**	Test should be conducted to be representative of in-flight vibrations for propeller-driven airplanes.
4. Visual System.									
4.a.	**Visual scene quality**								
4.a.1.	Continuous collimated cross-cockpit visual field of view.	Cross-cockpit, collimated visual display providing each pilot with a minimum of 176° horizontal and 36° vertical continuous field of view.	Not applicable.	Required as part of MQTG but not required as part of continuing evaluations.			**X**	**X**	Field of view should be measured using a visual test pattern filling the entire visual scene (all channels) consisting of a matrix of black and white 5° squares. Installed alignment should be confirmed in an SOC (this would generally consist of results from acceptance testing).
	Continuous collimated cross-cockpit visual field of view.	Continuous collimated field-of-view providing at least 45° horizontal and 30° vertical field-of-view for each pilot seat. Both pilot seat visual systems must be operable simultaneously.	Not applicable.	Required as part of MQTG but not required as part of continuing evaluations.	**X**	**X**			A vertical field-of-view of 30° may be insufficient to meet visual ground segment requirements.
4.a.2.	System geometry	5° even angular spacing within ±1° as measured from either pilot eye point and within 1.5° for adjacent squares.	Not applicable.	The angular spacing of any chosen 5° square and the relative spacing of adjacent squares must be within the stated tolerances.	**X**	**X**	**X**	**X**	The purpose of this test is to evaluate local linearity of the displayed image at either pilot eye point. System geometry should be measured using a visual test pattern filling the entire visual scene (all channels) with a matrix of black and white 5° squares

									with light points at the intersections. For continuing qualification testing, the use of an optical checking device is encouraged. This device should typically consist of a hand-held go/no go gauge to check that the relative positioning is maintained.
4.a.3	Surface resolution (object detection).	Not greater than 2 arc minutes.	Not applicable.	An SOC is required and must include the relevant calculations and an explanation of those calculations. This requirement is applicable to any level of simulator equipped with a daylight visual system.			**X**	**X**	Resolution will be demonstrated by a test of objects shown to occupy the required visual angle in each visual display used on a scene from the pilot's eyepoint. The object will subtend 2 arc minutes to the eye. This may be demonstrated using threshold bars for a horizontal test. A vertical test should also be demonstrated.
4.a.4	Light point size.	Not greater than 5 arc minutes.	Not applicable.	An SOC is required and must include the relevant calculations and an explanation of those calculations. This requirement is applicable to any level of simulator equipped with a daylight visual system.			**X**	**X**	Light point size should be measured using a test pattern consisting of a centrally located single row of white light points displayed as both a horizontal and vertical row. It should be possible to move the light points relative to the eyepoint in all axes. At a point where modulation is just discernible in each visual channel, a calculation should be made to determine the light spacing.
4.a.5	Raster surface contrast ratio.	Not less than 5:1.	Not applicable.	This requirement is applicable to any level of simulator equipped with a daylight visual system.			**X**	**X**	Surface contrast ratio should be measured using a raster

									drawn test pattern filling the entire visual scene (all channels). The test pattern should consist of black and white squares, 5° per square, with a white square in the center of each channel. Measurement should be made on the center bright square for each channel using a 1° spot photometer. This value should have a minimum brightness of 7 cd/m^2 (2 ft-lamberts). Measure any adjacent dark squares. The contrast ratio is the bright square value divided by the dark square value. *Note 1. — During contrast ratio testing, FSTD aft-cab and flight deck ambient light levels should be as low as possible.* *Note 2. — Measurements should be taken at the center of squares to avoid light spill into the measurement device.*
4.a.6	Light point contrast ratio.	Not less than 25:1.	Not applicable.	An SOC is required and must include the relevant calculations.			**X**	**X**	Light point contrast ratio should be measured using a test pattern demonstrating an area of greater than 1° area filled with white light points and should be compared to the adjacent background. *Note. — Light point*

									modulation should be just discernible on calligraphic systems but will not be discernable on raster systems. Measurements of the background should be taken such that the bright square is just out of the light meter FOV. *Note. — During contrast ratio testing, FSTD aft-cab and flight deck ambient light levels should be as low as practical.*
	Light point contrast ratio.	Not less than 10:1.	Not applicable.		X	X			
4.a.7	Light point brightness.	Not less than 20 cd/m^2 (5.8 ft-lamberts).	Not applicable.				X	X	Light points should be displayed as a matrix creating a square. On calligraphic systems the light points should just merge. On raster systems the light points should overlap such that the square is continuous (individual light points will not be visible).
4.a.8	Surface brightness.	Not less than 20 cd/m^2 (5.8 ft-lamberts) on the display.	Not applicable.	This requirement is applicable to any level of simulator equipped with a daylight visual system.			X	X	Surface brightness should be measured on a white raster, measuring the brightness using the 1° spot photometer. Light points are not acceptable. Use of calligraphic capabilities to enhance raster brightness is acceptable.
4.a.9	Black level and	Black intensity:	Not applicable.		X	X	X	X	All projectors should be

	sequential contrast.	Background brightness – Black polygon brightness < 0.015 cd/m² (0.004 ft-lamberts). Sequential contrast: Maximum brightness – (Background brightness – Black polygon brightness) > 2,000:1.							turned off and the cockpit environment made as dark as possible. A background reading should be taken of the remaining ambient light on the screen. The projectors should then be turned on and a black polygon displayed. A second reading should then be taken and the difference between this and the ambient level recorded. A full brightness white polygon should then be measured for the sequential contrast test. This test is generally only required for **light valve projectors**.
4.a.10	Motion blur.	When a pattern is rotated about the eyepoint at 10°/s, the smallest detectable gap must be 4 arc min or less.	Not applicable.		**X**	**X**	**X**	**X**	A test pattern consists of an array of 5 peak white squares with black gaps between them of decreasing width. The range of black gap widths should at least extend above and below the required detectable gap, and be in steps of 1 arc min. The pattern is rotated at the required rate. Two arrays of squares should be provided, one rotating in heading and the other in pitch, to provide testing in both axes. A series of stationary

									numbers identifies the gap number. *Note.— This test can be limited by the display technology. Where this is the case the NSPM should be consulted on the limitations.* This test is generally only required for **light valve projectors**.
4.a.11	Speckle test.	Speckle contrast must be < 10%.	Not applicable.	An SOC is required describing the test method.	**X**	**X**	**X**	**X**	This test is generally only required for **laser projectors**.
4.b	**Head-Up Display (HUD)**								
4.b.1	Static Alignment.	Static alignment with displayed image. HUD bore sight must align with the center of the displayed image spherical pattern. Tolerance +/- 6 arc min.	**N/A**				**X**	**X**	Alignment requirement applies to any HUD system in use or both simultaneously if they are used simultaneously for training.
4.b.2	System display.	All functionality in all flight modes must be demonstrated.	**N/A**				**X**	**X**	A statement of the system capabilities should be provided and the capabilities demonstrated
4.b.3	HUD attitude versus FSTD attitude indicator (pitch and roll of horizon).	Pitch and roll align with aircraft instruments.	Flight.				**X**	**X**	
4.c	**Enhanced Flight Vision System (EFVS)**								
4.c.1	Registration test.	Alignment between EFVS display and out of the window image must represent the alignment typical of the aircraft and system type.	Takeoff point and on approach at 200 ft.				**X**	**X**	*Note.— The effects of the alignment tolerance in 4.b.1 should be taken into account.*

4.c.2	EFVS RVR and visibility calibration.	The scene represents the EFVS view at 350 m (1,200 ft) and 1,609 m (1 sm) RVR including correct light intensity.	Flight.				X	X	Infra-red scene representative of both 350 m (1,200 ft), and 1,609 m (1 sm) RVR. Visual scene may be removed.
4.c.3	Thermal crossover.	Demonstrate thermal crossover effects during day to night transition.	Day and night.				X	X	The scene will correctly represent the thermal characteristics of the scene during a day to night transition.
4.d	**Visual ground segment**								
4.d.1	Visual ground segment (VGS).	Near end: the correct number of approach lights within the computed VGS must be visible. Far end: ±20% of the computed VGS. The threshold lights computed to be visible must be visible in the FSTD.	Trimmed in the landing configuration at 30 m (100 ft) wheel height above touchdown zone on glide slope at an RVR setting of 300 m (1,000 ft) or 350 m (1,200 ft).	This test is designed to assess items impacting the accuracy of the visual scene presented to a pilot at DH on an ILS approach. These items include: 1) RVR/Visibility; 2) glide slope (G/S) and localizer modeling accuracy (location and slope) for an ILS; 3) for a given weight, configuration and speed representative of a point within the airplane's operational envelope for a normal approach and landing; and 4) Radio altimeter. *Note. — If non-homogeneous fog is used, the vertical variation in horizontal visibility should be described and included in the slant range visibility calculation used in the VGS computation.*	X	X	X	X	
4.e	**Visual System Capacity**								
4.e.1	System capacity – Day mode.	Not less than: 10,000 visible textured surfaces, 6,000 light points, 16 moving models.	Not applicable.				X	X	Demonstrated through use of a visual scene rendered with the same image generator modes used to produce scenes for training. The required surfaces, light

									points, and moving models should be displayed simultaneously.
4.e.2	System capacity – Twilight/night mode.	Not less than: 10,000 visible textured surfaces, 15,000 light points, 16 moving models.	Not applicable.				X	X	Demonstrated through use of a visual scene rendered with the same image generator modes used to produce scenes for training. The required surfaces, light points, and moving models should be displayed simultaneously.
5. Sound System. The sponsor will not be required to repeat the airplane tests (i.e., tests 5.a.1. through 5.a.8. (or 5.b.1. through 5.b.9.) and 5.c., as appropriate) during continuing qualification evaluations if frequency response and background noise test results are within tolerance when compared to the initial qualification evaluation results, and the sponsor shows that no software changes have occurred that will affect the airplane test results. If the frequency response test method is chosen and fails, the sponsor may elect to fix the frequency response problem and repeat the test or the sponsor may elect to repeat the airplane tests. If the airplane tests are repeated during continuing qualification evaluations, the results may be compared against initial qualification evaluation results or airplane master data. All tests in this section must be presented using an unweighted 1/3-octave band format from band 17 to 42 (50 Hz to 16 kHz). A minimum 20 second average must be taken at the location corresponding to the airplane data set. The airplane and flight simulator results must be produced using comparable data analysis techniques.									
5.a.	**Turbo-jet airplanes.**								All tests in this section should be presented using an unweighted 1/3-octave band format from at least band 17 to 42 (50 Hz to 16 kHz). A measurement of minimum 20 s should be taken at the location corresponding to the approved data set. The approved data set and FSTD results should be produced using comparable data analysis techniques. Refer to paragraph 7 of this Attachment
5.a.1.	Ready for engine start.	Initial evaluation: ± 5 dB per 1/3 octave band.	Ground.	Normal condition prior to engine start. The APU should be on if appropriate.				X	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2

		Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.							that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.
5.a.2.	All engines at idle.	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Ground.	Normal condition prior to takeoff.				**X**	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.
5.a.3.	All engines at maximum allowable thrust with brakes set.	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent	Ground.	Normal condition prior to takeoff.				**X**	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation employs approved subjective

		evaluation results cannot exceed 2 dB.							tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.
5.a.4.	Climb	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	En-route climb.	Medium altitude.				X	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.
5.a.5.	Cruise	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Cruise.	Normal cruise configuration.				X	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.
5.a.6.	Speed brake/spoilers extended (as appropriate).	Initial evaluation: ± 5 dB per 1/3 octave band.	Cruise.	Normal and constant speed brake deflection for descent at a constant airspeed and power setting.				X	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB

		Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.							tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.
5.a.7	Initial approach.	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Approach.	Constant airspeed, gear up, flaps/slats as appropriate.				X	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.
5.a.8	Final approach.	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between	Landing.	Constant airspeed, gear down, landing configuration flaps.				X	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation

		initial and recurrent evaluation results cannot exceed 2 dB.							employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.
5.b	**Propeller-driven airplanes**								All tests in this section should be presented using an unweighted 1/3-octave band format from at least band 17 to 42 (50 Hz to 16 kHz). A measurement of minimum 20 s should be taken at the location corresponding to the approved data set. The approved data set and FSTD results should be produced using comparable data analysis techniques. Refer to paragraph 3.7 of this Appendix.
5.b.1.	Ready for engine start.	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Ground.	Normal condition prior to engine start. The APU should be on if appropriate.				**X**	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.

5.b.2	All propellers feathered, if applicable.	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Ground.	Normal condition prior to takeoff.				X	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.
5.b.3.	Ground idle or equivalent.	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Ground.	Normal condition prior to takeoff.				X	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.
5.b.4	Flight idle or equivalent.	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three	Ground.	Normal condition prior to takeoff.				X	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data,

		consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.							providing that the overall trend is correct. Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.
5.b.5	All engines at maximum allowable power with brakes set.	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Ground.	Normal condition prior to takeoff.				**X**	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.
5.b.6	Climb.	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	En-route climb.	Medium altitude.				**X**	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.

5.b.7	Cruise	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Cruise.	Normal cruise configuration.				X	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.
5.b.8	Initial approach.	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Approach.	Constant airspeed, gear up, flaps extended as appropriate, RPM as per operating manual.				X	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.
5.b.9	Final approach.	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the	Landing.	Constant airspeed, gear down, landing configuration flaps, RPM as per operating manual.				X	For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct.

		average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.							Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations.
5.c.	**Special cases.**	Initial evaluation: ± 5 dB per 1/3 octave band. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	As appropriate.					**X**	This applies to special steady-state cases identified as particularly significant to the pilot, important in training, or unique to a specific airplane type or model. For initial evaluation, it is acceptable to have some 1/3 octave bands out of ± 5 dB tolerance but not more than 2 that are consecutive and in any case within ± 7 dB from approved reference data, providing that the overall trend is correct. Where initial evaluation employs approved subjective tuning to develop the approved reference standard, recurrent evaluation tolerances should be used during recurrent evaluations
5.d	**FSTD background noise**	Initial evaluation: background noise levels must fall below the sound levels described in Paragraph 7.c (5) of this Attachment. Recurrent evaluation: ±3 dB per 1/3 octave band compared to initial evaluation.		Results of the background noise at initial qualification must be included in the QTG document and approved by the NSPM. The measurements are to be made with the simulation running, the sound muted and a dead cockpit.				**X**	The simulated sound will be evaluated to ensure that the background noise does not interfere with training. Refer to paragraph 7 of this Attachment. This test should be presented using an unweighted 1/3 octave band format from band 17 to 42 (50 Hz to 16 kHz).

5.e	**Frequency response**	Initial evaluation: not applicable. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Ground (static with all systems switched off)					**X**	Only required if the results are to be used during continuing qualification evaluations in lieu of airplane tests. The results must be approved by the NSPM during the initial qualification. This test should be presented using an unweighted 1/3 octave band format from band 17 to 42 (50 Hz to 16 kHz).
6	**SYSTEMS INTEGRATION**								
6.a.	**System response time**								
6.a.1	Transport delay.	Motion system and instrument response: 100 ms (or less) after airplane response. Visual system response: 120 ms (or less) after airplane response.	Pitch, roll and yaw.				**X**	**X**	One separate test is required in each axis. Where EFVS systems are installed, the EFVS response should be within + or - 30 ms from visual system response, and not before motion system response. *Note.— The delay from the airplane EFVS electronic elements should be added to the 30 ms tolerance before comparison with visual system reference.*
	Transport delay.	300 milliseconds or less after controller movement.	Pitch, roll and yaw.		**X**	**X**			

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6. Motion System.

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b. Motion System Checks. The intent of test 3a, Frequency Response, and test 3b, Turn-

Around Check, as described in the Table of Objective Tests, are to demonstrate the performance of the motion system hardware, and to check the integrity of the motion set-up with regard to calibration and wear. These tests are independent of the motion cueing software and should be considered robotic tests.

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d. Objective Motion Cueing Test—Frequency Domain

(1) Background. This test quantifies the response of the motion cueing system from the output of the flight model to the motion platform response. Other motion tests, such as the motion system frequency response, concentrate on the mechanical performance of the motion system hardware alone. The intent of this test is to provide quantitative frequency response records of the entire motion system for specified degree-of-freedom transfer relationships over a range of frequencies. This range should be representative of the manual control range for that particular aircraft type and the simulator as set up during qualification. The measurements of this test should include the combined influence of the motion cueing algorithm, the motion platform dynamics, and the transport delay associated with the motion cueing and control system implementation. Specified frequency responses describing the ability of the FSTD to reproduce aircraft translations and rotations, as well as the cross-coupling relations, are required as part of these measurements. When simulating forward aircraft acceleration, the simulator is accelerated momentarily in the forward direction to provide the onset cueing. This is considered the direct transfer relation. The simulator is simultaneously tilted nose-up due to the low-pass filter in order to generate a sustained specific force. The tilt associated with the generation of the sustained specific force, and the angular rates and angular accelerations associated with the initiation of the sustained specific force, are considered cross-coupling relations. The specific force is required for the perception of the aircraft sustained specific force, while the angular rates and accelerations do not occur in the aircraft and should be minimized.

(2) Frequency response test. This test requires the frequency response to be measured for the motion cueing system. Reference sinusoidal signals are inserted at the pilot reference position prior to the motion cueing computations. The response of the motion platform in the corresponding degree-of-freedom (the direct transfer relations), as well as the motions resulting from cross-coupling (the cross-coupling relations), are recorded. These are the tests that are important to pilot motion cueing and are general tests applicable to all types of airplanes.

(3) This test is only required to be run once for the initial qualification of the FSTD and will not be required for continuing qualification purposes. The FAA will accept test results provided by the FSTD manufacturer as part of a Statement of Compliance confirming that the objective motion cueing tests were used to assist in the tuning of the FSTD's motion cueing algorithms.

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11. Validation Test Tolerances

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a. * * *

(1) If engineering simulator data or other non-flight-test data are used as an allowable form of reference validation data for the objective tests listed in Table A2A of this attachment, the data provider must supply a well-documented mathematical model and testing procedure that enables a replication of the engineering simulation results within 40% of the corresponding flight test tolerances.

b. * * *

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(5) The tolerance limit between the reference data and the flight simulator results is generally 40 percent of the corresponding 'flight-test' tolerances. However, there may be cases where the simulator models used are of higher fidelity, or the manner in which they are cascaded in the integrated testing loop have the effect of a higher fidelity, than those supplied by the data provider. Under these circumstances, it is possible that an error greater than 40 percent may be generated. An error greater than 40 percent may be acceptable if simulator sponsor can provide an adequate explanation.

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12. Validation Data Roadmap

a. Airplane manufacturers or other data suppliers should supply a validation data roadmap (VDR) document as part of the data package. A VDR document contains guidance material from the airplane validation data supplier recommending the best possible sources of data to be used as validation data in the QTG. A VDR is of special value when requesting interim qualification, qualification of simulators for airplanes certificated prior to 1992, and qualification of alternate engine or avionics fits. A sponsor seeking to have a device qualified in accordance with the standards contained in this QPS appendix should submit a VDR to the NSPM as early as possible in the planning stages. The NSPM is the final authority to approve the data to be used as validation material for the QTG.

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■ 9. Amend Attachment 3 to Appendix A by revising:

■ A. Table A3A;

■ B. Table A3B;

■ C. Table A3D; and

■ D. Table A3F;

The revisions read as follows:

Appendix A to Part 60—Qualification Performance Standards for Airplane Full Flight Simulators

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Attachment 3 to Appendix A to Part 60—SIMULATOR SUBJECTIVE EVALUATION

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	Tasks in this table are subject to evaluation if appropriate for the airplane simulated as indicated in the SOQ Configuration List or the level of simulator qualification involved. Items not installed or not functional on the simulator and, therefore, not appearing on the SOQ Configuration List, are not required to be listed as exceptions on the SOQ.				
1.	**Preparation For Flight**				
1.a.	**Pre-flight.** Accomplish a functions check of all switches, indicators, systems, and equipment at all crew members' and instructors' stations and determine that:				
1.a.1	The flight deck design and functions are identical to that of the airplane being simulated.	**X**	**X**	**X**	**X**
1.a.2	Reserved				
1.a.3	Reserved				
2.	**Surface Operations (pre-flight).**				
2.a.	**Engine Start**				
2.a.1.	Normal start	**X**	**X**	**X**	**X**
2.a.2.	Alternate start procedures	**X**	**X**	**X**	**X**
2.a.3.	Abnormal starts and shutdowns (e.g., hot/hung start, tail pipe fire)	**X**	**X**	**X**	**X**
2.b.	**Taxi**				
2.b.1	Pushback/powerback		**X**	**X**	**X**
2.b.2.	Thrust response	**X**	**X**	**X**	**X**
2.b.3.	Power lever friction	**X**	**X**	**X**	**X**
2.b.4.	Ground handling	**X**	**X**	**X**	**X**
2.b.5.	Nosewheel scuffing			**X**	**X**
2.b.6.	Taxi aids (e.g. taxi camera, moving map)			**X**	**X**
2.b.7.	Low visibility (taxi route, signage, lighting, markings, etc.)			**X**	**X**
2.c.	**Brake Operation**				
2.c.1.	Brake operation (normal and alternate/emergency)	**X**	**X**	**X**	**X**
2.c.2.	Brake fade (if applicable)	**X**	**X**	**X**	**X**
2.d	**Other**				
3.	**Take-off.**				
3.a.	**Normal**				
3.a.1.	Airplane/engine parameter relationships, including run-up	**X**	**X**	**X**	**X**
3.a.2.	Nosewheel and rudder steering	**X**	**X**	**X**	**X**
3.a.3.a	Crosswind (maximum demonstrated)	**X**	**X**	**X**	**X**
3.a.3.b	Gusting crosswind			**X**	**X**
3.a.4.	Special performance				
3.a.4.a	Reduced V_1	**X**	**X**	**X**	**X**
3.a.4.b	Maximum engine de-rate	**X**	**X**	**X**	**X**
3.a.4.c	Soft surface			**X**	**X**
3.a.4.d	Short field/short take-off and landing (STOL) operations	**X**	**X**	**X**	**X**
3.a.4.e	Obstacle (performance over visual obstacle)			**X**	**X**
3.a.5.	Low visibility take-off	**X**	**X**	**X**	**X**
3.a.6.	Landing gear, wing flap leading edge device operation	**X**	**X**	**X**	**X**
3.a.7.	Contaminated runway operation			**X**	**X**
3.a.8.	Other				
3.b.	Abnormal/emergency				
3.b.1.	Rejected Take-off	**X**	**X**	**X**	**X**
3.b.2.	Rejected special performance (e.g., reduced V_1, max de-rate, short field operations)	**X**	**X**	**X**	**X**

3.b.3.	Rejected take-off with contaminated runway			**X**	**X**
3.b.4.	Takeoff with a propulsion system malfunction (allowing an analysis of causes, symptoms, recognition, and the effects on aircraft performance and handling) at the following points: (i) Prior to V1 decision speed; (ii) Between V1 and Vr (rotation speed); and (iii)Between Vr and 500 feet above ground level.	**X**	**X**	**X**	**X**
3.b.5.	Flight control system failures, reconfiguration modes, manual reversion and associated handling.	**X**	**X**	**X**	**X**
3.b.6.	Other				
4.	**Climb.**				
4.a.	Normal.	**X**	**X**	**X**	**X**
4.b.	One or more engines inoperative.	**X**	**X**	**X**	**X**
4.c.	Approach climb in icing (for airplanes with icing accountability).	**X**	**X**	**X**	**X**
4.d.	Other				
5.	**Cruise.**				
5.a.	**Performance characteristics (speed vs. power, configuration, and attitude)**				
5.a.1.	Straight and level flight.	**X**	**X**	**X**	**X**
5.a.2.	Change of airspeed.	**X**	**X**	**X**	**X**
5.a.3.	High altitude handling.	**X**	**X**	**X**	**X**
5.a.4.	High Mach number handling (Mach tuck, Mach buffet) and recovery (trim change).	**X**	**X**	**X**	**X**
5.a.5.	Overspeed warning (in excess of V_{mo} or M_{mo}).	**X**	**X**	**X**	**X**
5.a.6.	High IAS handling.	**X**	**X**	**X**	**X**
5.a.7.	Other				
5.b.	**Maneuvers**				
5.b.1.	High Angle of Attack				
5.b.1.a	High angle of attack, approach to stalls, stall warning, and stall buffet (take-off, cruise, approach, and landing configuration) including reaction of the autoflight system and stall protection system.	**X**	**X**		
5.b.1.b	High angle of attack, approach to stalls, stall warning, stall buffet, and stall (take-off, cruise, approach, and landing configuration) including reaction of the autoflight system and stall protection system.			**X**	**X**
5.b.2.	Slow flight			**X**	**X**
5.b.3.	Upset prevention and recovery maneuvers within the FSTD's validation envelope.			**X**	**X**
5.b.4.	Flight envelope protection (high angle of attack, bank limit, overspeed, etc.)	**X**	**X**	**X**	**X**
5.b.5.	Turns with/without speedbrake/spoilers deployed	**X**	**X**	**X**	**X**
5.b.6.	Normal and standard rate turns	**X**	**X**	**X**	**X**
5.b.7.	Steep turns	**X**	**X**	**X**	**X**
5.b.8.	Performance turn			**X**	**X**
5.b.9.	In flight engine shutdown and restart (assisted and windmill)	**X**	**X**	**X**	**X**
5.b.10.	Maneuvering with one or more engines inoperative, as appropriate	**X**	**X**	**X**	**X**
5.b.11.	Specific flight characteristics (e.g. direct lift control)	**X**	**X**	**X**	**X**

5.b.12.	Flight control system failures, reconfiguration modes, manual reversion and associated handling	**X**	**X**	**X**	**X**
5.b.13	Gliding to a forced landing			**X**	**X**
5.b.14	Visual resolution and FSTD handling and performance for the following (where applicable by aircraft type and training program):				
5.b.14.a	Terrain accuracy for forced landing area selection;			**X**	**X**
5.b.14.b	Terrain accuracy for VFR Navigation;			**X**	**X**
5.b.14.c	Eights on pylons (visual resolution);			**X**	**X**
5.b.14.d	Turns about a point; and			**X**	**X**
5.b.14.e	S-turns about a road or section line.			**X**	**X**
5.b.15	Other.				
6.	**Descent.**				
6.a.	Normal	**X**	**X**	**X**	**X**
6.b.	Maximum rate/emergency (clean and with speedbrake, etc.).	**X**	**X**	**X**	**X**
6.c.	With autopilot.	**X**	**X**	**X**	**X**
6.d.	Flight control system failures, reconfiguration modes, manual reversion and associated handling.	**X**	**X**	**X**	**X**
6.e.	Other				
7.	**Instrument Approaches And Landing.** Those instrument approach and landing tests relevant to the simulated airplane type are selected from the following list. Some tests are made with limiting wind velocities, under windshear conditions, and with relevant system failures, including the failure of the Flight Director. If Standard Operating Procedures allow use autopilot for non-precision approaches, evaluation of the autopilot will be included. Level A simulators are not authorized to credit the landing maneuver.				
7.a.	**Precision approach**				
7.a.1	CAT I published approaches.				
7.a.1.a	Manual approach with/without flight director including landing.	**X**	**X**	**X**	**X**
7.a.1.b	Autopilot/autothrottle coupled approach and manual landing.	**X**	**X**	**X**	**X**
7.a.1.c	Autopilot/autothrottle coupled approach, engine(s) inoperative.	**X**	**X**	**X**	**X**
7.a.1.d	Manual approach, engine(s) inoperative.	**X**	**X**	**X**	**X**
7.a.1.e	HUD/EFVS			**X**	**X**
7.a.2	CAT II published approaches.				
7.a.2.a	Autopilot/autothrottle coupled approach to DH and landing (manual and autoland).	**X**	**X**	**X**	**X**
7.a.2.b	Autopilot/autothrottle coupled approach with one-engine-inoperative approach to DH and go-around (manual and autopilot).	**X**	**X**	**X**	**X**
7.a.2.c	HUD/EFVS			**X**	**X**
7.a.3	CAT III published approaches.				
7.a.3.a	Autopilot/autothrottle coupled approach to landing and roll-out (if applicable) guidance (manual and autoland).	**X**	**X**	**X**	**X**
7.a.3.b	Autopilot/autothrottle coupled approach to DH and go-around (manual and autopilot).	**X**	**X**	**X**	**X**
7.a.3.c	Autopilot/autothrottle coupled approach to land and roll-out (if applicable) guidance with one engine inoperative	**X**	**X**	**X**	**X**

	(manual and autoland).				
7.a.3.d	Autopilot/autothrottle coupled approach to DH and go-around with one engine inoperative (manual and autopilot).	**X**	**X**	**X**	**X**
7.a.3.e	HUD/EFVS			**X**	**X**
7.a.4	Autopilot/autothrottle coupled approach (to a landing or to a go-around):				
7.a.4.a	With generator failure;	**X**	**X**	**X**	**X**
7.a.4.b.1	With maximum tail wind component certified or authorized;			**X**	**X**
7.a.4.b.2	With 10 knot tail wind;	**X**	**X**		
7.a.4.c.1	With maximum crosswind component demonstrated or authorized; and			**X**	**X**
7.a.4.c.2	With 10 knot crosswind.	**X**	**X**		
7.a.5	PAR approach, all engine(s) operating and with one or more engine(s) inoperative	**X**	**X**	**X**	**X**
7.a.6	MLS, GBAS, all engine(s) operating and with one or more engine(s) inoperative	**X**	**X**	**X**	**X**
7.b.	**Non-precision approach.**				
7.b.1	Surveillance radar approach, all engine(s) operating and with one or more engine(s) inoperative	**X**	**X**	**X**	**X**
7.b.2	NDB approach, all engine(s) operating and with one or more engine(s) inoperative	**X**	**X**	**X**	**X**
7.b.3	VOR, VOR/DME, TACAN approach, all engines(s) operating and with one or more engine(s) inoperative	**X**	**X**	**X**	**X**
7.b.4	RNAV / RNP / GNSS (RNP at nominal and minimum authorized temperatures) approach, all engine(s) operating and with one or more engine(s) inoperative	**X**	**X**	**X**	**X**
7.b.5	ILS LLZ (LOC), LLZ back course (or LOC-BC) approach, all engine(s) operating and with one or more engine(s) inoperative	**X**	**X**	**X**	**X**
7.b.6	ILS offset localizer approach, all engine(s) operating and with one or more engine(s) inoperative	**X**	**X**	**X**	**X**
7.c	**Approach procedures with vertical guidance (APV), e.g. SBAS, flight path vector**				
7.c.1	APV/baro-VNAV approach, all engine(s) operating and with one or more engine(s) inoperative			**X**	**X**
7.c.2	Area navigation (RNAV) approach procedures based on SBAS, all engine(s) operating and with one or more engine(s) inoperative			**X**	**X**
8.	**Visual Approaches (Visual Segment) And Landings.** Flight simulators with visual systems, which permit completing a special approach procedure in accordance with applicable regulations, may be approved for that particular approach procedure.				
8.a.	Maneuvering, normal approach and landing, all engines operating with and without visual approach aid guidance	**X**	**X**	**X**	**X**
8.b.	Approach and landing with one or more engines inoperative	**X**	**X**	**X**	**X**
8.c.	Operation of landing gear, flap/slats and speedbrakes (normal and abnormal)	**X**	**X**	**X**	**X**
8.d.1	Approach and landing with crosswind (max. demonstrated)	**X**	**X**	**X**	**X**

8.d.2	Approach and landing with gusting crosswind			**X**	**X**
8.e.	Approach and landing with flight control system failures, reconfiguration modes, manual reversion and associated handling (most significant degradation which is probable)	**X**	**X**	**X**	**X**
8.e.1.	Approach and landing with trim malfunctions	**X**	**X**	**X**	**X**
8.e.1.a	Longitudinal trim malfunction	**X**	**X**	**X**	**X**
8.e.1.b	Lateral-directional trim malfunction	**X**	**X**	**X**	**X**
8.f.	Approach and landing with standby (minimum) electrical/hydraulic power	**X**	**X**	**X**	**X**
8.g.	Approach and landing from circling conditions (circling approach)	**X**	**X**	**X**	**X**
8.h.	Approach and landing from visual traffic pattern	**X**	**X**	**X**	**X**
8.i.	Approach and landing from non-precision approach	**X**	**X**	**X**	**X**
8.j.	Approach and landing from precision approach	**X**	**X**	**X**	**X**
8.k.	Other				
9.	**Missed Approach.**				
9.a.	All engines, manual and autopilot.	**X**	**X**	**X**	**X**
9.b.	Engine(s) inoperative, manual and autopilot.	**X**	**X**	**X**	**X**
9.c.	Rejected landing			**X**	**X**
9.d.	With flight control system failures, reconfiguration modes, manual reversion and associated handling	**X**	**X**	**X**	**X**
9.e.	Bounced landing recovery			**X**	**X**
10.	**Surface Operations (landing, after-landing and post-flight).**				
10.a	**Landing roll and taxi**				
10.a.1	HUD/EFVS			**X**	**X**
10.a.2.	Spoiler operation	**X**	**X**	**X**	**X**
10.a.3.	Reverse thrust operation	**X**	**X**	**X**	**X**
10.a.4.	Directional control and ground handling, both with and without reverse thrust		**X**	**X**	**X**
10.a.5.	Reduction of rudder effectiveness with increased reverse thrust (rear pod-mounted engines)		**X**	**X**	**X**
10.a.6.	Brake and anti-skid operation				
10.a.6.a	Brake and anti-skid operation with dry, patchy wet, wet on rubber residue, and patchy icy conditions			**X**	**X**
10.a.6.b	Reserved				
10.a.6.c	Brake operation	**X**	**X**		
10.a.6.d	Auto-braking system operation	**X**	**X**	**X**	**X**
10.a.7	Other				
10.b	**Engine shutdown and parking**				
10.b.1	Engine and systems operation	**X**	**X**	**X**	**X**
10.b.2	Parking brake operation	**X**	**X**	**X**	**X**
10.b.3	Other				
11.	**Any Flight Phase.**				
11.a.	**Airplane and engine systems operation (where fitted)**				
11.a.1.	Air conditioning and pressurization (ECS)	**X**	**X**	**X**	**X**
11.a.2.	De-icing/anti-icing	**X**	**X**	**X**	**X**
11.a.3.	Auxiliary power unit (APU).	**X**	**X**	**X**	**X**
11.a.4.	Communications	**X**	**X**	**X**	**X**
11.a.5.	Electrical	**X**	**X**	**X**	**X**

11.a.6.	Fire and smoke detection and suppression	**X**	**X**	**X**	**X**
11.a.7.	Flight controls (primary and secondary)	**X**	**X**	**X**	**X**
11.a.8.	Fuel and oil	**X**	**X**	**X**	**X**
11.a.9.	Hydraulic	**X**	**X**	**X**	**X**
11.a.10.	Pneumatic	**X**	**X**	**X**	**X**
11.a.11.	Landing gear	**X**	**X**	**X**	**X**
11.a.12.	Oxygen	**X**	**X**	**X**	**X**
11.a.13.	Engine	**X**	**X**	**X**	**X**
11.a.14.	Airborne radar	**X**	**X**	**X**	**X**
11.a.15.	Autopilot and Flight Director	**X**	**X**	**X**	**X**
11.a.16.	Terrain awareness warning systems and collision avoidance systems (e.g. EGPWS, GPWS, TCAS)	**X**	**X**	**X**	**X**
11.a.17.	Flight control computers including stability and control augmentation	**X**	**X**	**X**	**X**
11.a.18.	Flight display systems	**X**	**X**	**X**	**X**
11.a.19.	Flight management computers	**X**	**X**	**X**	**X**
11.a.20.	Head-up displays (including EFVS, if appropriate)	**X**	**X**	**X**	**X**
11.a.21.	Navigation systems	**X**	**X**	**X**	**X**
11.a.22.	Stall warning/avoidance	**X**	**X**	**X**	**X**
11.a.23.	Wind shear avoidance/recovery guidance equipment	**X**	**X**	**X**	**X**
11.a.24.	Flight envelope protections	**X**	**X**	**X**	**X**
11.a.25.	Electronic flight bag			**X**	**X**
11.a.26.	Automatic checklists (normal, abnormal and emergency procedures)			**X**	**X**
11.a.27.	Runway alerting and advisory system			**X**	**X**
11.a.28.	Other				
11.b.	**Airborne procedures**				
11.b.1.	Holding	**X**	**X**	**X**	**X**
11.b.2.	Air hazard avoidance (traffic, weather, including visual correlation)			**X**	**X**
11.b.3.	Windshear				
11.b.3.a	Prior to take-off rotation			**X**	**X**
11.b.3.b	At lift-off			**X**	**X**
11.b.3.c	During initial climb			**X**	**X**
11.b.3.d	On final approach, below 150 m (500 ft) AGL			**X**	**X**
11.b.4.	Effects of airframe ice			**X**	**X**

This table specifies the minimum airport model content and functionality to qualify a simulator at the indicated level. This table applies only to the airport models required for simulator qualification; i.e., one airport model for Level A and Level B simulators; three airport models for Level C and Level D simulators.					
Begin QPS Requirements					
1.	**Functional test content requirements for Level A and Level B simulators.** The following is the minimum airport model content requirement to satisfy visual capability tests, and provides suitable visual cues to allow completion of all functions and subjective tests described in this attachment for simulators at Levels A and B.				
1.a.	A minimum of one (1) representative airport model. This model identification must be acceptable to the sponsor's TPAA, selectable from the IOS, and listed on the SOQ.	**X**	**X**		
1.b.	The fidelity of the airport model must be sufficient for the aircrew to visually identify the airport; determine the position of the simulated airplane within a night visual scene; successfully accomplish take-offs, approaches, and landings; and maneuver around the airport on the ground as necessary.	**X**	**X**		
1.c.	Runways:	**X**	**X**		
1.c.1.	Visible runway number.	**X**	**X**		
1.c.2.	Runway threshold elevations and locations must be modeled to provide sufficient correlation with airplane systems (e.g., altimeter).	**X**	**X**		
1.c.3.	Runway surface and markings.	**X**	**X**		
1.c.4.	Lighting for the runway in use including runway edge and centerline.	**X**	**X**		
1.c.5.	Lighting, visual approach aid and approach lighting of appropriate colors.	**X**	**X**		
1.c.6.	Representative taxiway lights.	**X**	**X**		
2.a.	**Additional functional test content requirements**				
2.a.1	**Airport scenes**				
2.a.1.a	A minimum of three (3) real-world airport models to be consistent with published data used for airplane operations and capable of demonstrating all the visual system features below. Each model should be in a different visual scene to permit assessment of FSTD automatic visual scene changes. The model identifications must be acceptable to the sponsor's TPAA, selectable from the IOS, and listed on the SOQ.			**X**	**X**
2.a.1.b	Reserved				
2.a.1.c	Reserved				
2.a.1.d	**Airport model content.** For circling approaches, all tests apply to the runway used for the initial approach and to the runway of intended landing. If all runways in an airport model used to meet the requirements of this attachment are not designated as "in use," then the "in use" runways must be listed on the SOQ (e.g., KORD, Rwys 9R, 14L, 22R). Models of airports with more than one runway must have all significant runways not "in-use" visually depicted for airport and runway recognition purposes. The use of white or off white light strings that identify the runway threshold, edges, and ends for twilight and night scenes are acceptable for this requirement.	**X**	**X**	**X**	**X**

	Rectangular surface depictions are acceptable for daylight scenes. A visual system's capabilities must be balanced between providing airport models with an accurate representation of the airport and a realistic representation of the surrounding environment. Airport model detail must be developed using airport pictures, construction drawings and maps, or other similar data, or developed in accordance with published regulatory material; however, this does not require that such models contain details that are beyond the design capability of the currently qualified visual system. Only one "primary" taxi route from parking to the runway end will be required for each "in-use" runway.				
2.a.2	**Visual scene fidelity.**				
2.a.2.a	The visual scene must correctly represent the parts of the airport and its surroundings used in the training program.	**X**	**X**	**X**	**X**
2.a.2.b	Reserved				
2.a.2.c	Reserved				
2.a.3	**Runways and taxiways.**				
2.a.3.a	Airport specific runways and taxiways.	**X**	**X**	**X**	**X**
2.a.3.b	Reserved				
2.a.3.c	Reserved				
2.a.4	If appropriate to the airport, two parallel runways and one crossing runway displayed simultaneously; at least two runways must be capable of being lit simultaneously.			**X**	**X**
2.a.5	Runway threshold elevations and locations must be modeled to provide correlation with airplane systems (e.g. HUD, GPS, compass, altimeter).			**X**	**X**
2.a.6	Slopes in runways, taxiways, and ramp areas must not cause distracting or unrealistic effects, including pilot eye-point height variation.			**X**	**X**
2.a.7	**Runway surface and markings for each "in-use" runway must include the following, if appropriate:**				
2.a.7.a	Threshold markings.	**X**	**X**	**X**	**X**
2.a.7.b	Runway numbers.	**X**	**X**	**X**	**X**
2.a.7.c	Touchdown zone markings.	**X**	**X**	**X**	**X**
2.a.7.d	Fixed distance markings.	**X**	**X**	**X**	**X**
2.a.7.e	Edge markings.	**X**	**X**	**X**	**X**
2.a.7.f	Center line markings.	**X**	**X**	**X**	**X**
2.a.7.g	Distance remaining signs.	**X**	**X**	**X**	**X**
2.a.7.h	Signs at intersecting runways and taxiways.	**X**	**X**	**X**	**X**
2.a.7.i	Windsock that gives appropriate wind cues.			**X**	**X**
2.a.8	**Runway lighting of appropriate colors, directionality, behavior and spacing for the "in-use" runway including the following:**				
2.a.8.a	Threshold lights.	**X**	**X**	**X**	**X**
2.a.8.b	Edge lights.	**X**	**X**	**X**	**X**
2.a.8.c	End lights.	**X**	**X**	**X**	**X**
2.a.8.d	Center line lights.	**X**	**X**	**X**	**X**
2.a.8.e	Touchdown zone lights.	**X**	**X**	**X**	**X**
2.a.8.f	Lead-off lights.	**X**	**X**	**X**	**X**
2.a.8.g	Appropriate visual landing aid(s) for that runway.	**X**	**X**	**X**	**X**

2.a.8.h	Appropriate approach lighting system for that runway.	**X**	**X**	**X**	**X**
2.a.9	**Taxiway surface and markings (associated with each "in-use" runway):**				
2.a.9.a	Edge markings	**X**	**X**	**X**	**X**
2.a.9.b	Center line markings.	**X**	**X**	**X**	**X**
2.a.9.c	Runway holding position markings.	**X**	**X**	**X**	**X**
2.a.9.d	ILS critical area markings.	**X**	**X**	**X**	**X**
2.a.9.e	All taxiway markings, lighting, and signage to taxi, as a minimum, from a designated parking position to a designated runway and return, after landing on the designated runway, to a designated parking position; a low visibility taxi route (e.g. surface movement guidance control system, follow-me truck, daylight taxi lights) must also be demonstrated at one airport model for those operations authorized in low visibilities. The designated runway and taxi routing must be consistent with that airport for operations in low visibilities. The qualification of surface movement guidance control systems (SMGCS) is optional at the request of the FSTD sponsor. For the qualification of SMGCS, a demonstration model must be provided for evaluation.				**X**
2.a.10	**Taxiway lighting of appropriate colors, directionality, behavior and spacing (associated with each "in-use" runway):**				
2.a.10.a	Edge lights.	**X**	**X**	**X**	**X**
2.a.10.b	Center line lights.	**X**	**X**	**X**	**X**
2.a.10.c	Runway holding position and ILS critical area lights.	**X**	**X**	**X**	**X**
2.a.11	**Required visual model correlation with other aspects of the airport environment simulation.**				
2.a.11.a	The airport model must be properly aligned with the navigational aids that are associated with operations at the runway "in-use".	**X**	**X**	**X**	**X**
2.a.11.b	The simulation of runway contaminants must be correlated with the displayed runway surface and lighting.				**X**
2.a.12	**Airport buildings, structures and lighting.**				
2.a.12.a	Buildings, structures and lighting:				
2.a.12.a.1	Airport specific buildings, structures and lighting.			**X**	**X**
2.a.12.a.2	Reserved				
2.a.12.a.3	Reserved				
2.a.12.b	At least one useable gate, set at the appropriate height (required only for those airplanes that typically operate from terminal gates).			**X**	**X**
2.a.12.c	Representative moving and static airport clutter (e.g. other airplanes, power carts, tugs, fuel trucks, additional gates).			**X**	**X**
2.a.12.d	Gate/apron markings (e.g. hazard markings, lead-in lines, gate numbering), lighting and gate docking aids or a marshaller.			**X**	**X**
2.a.13	**Terrain and obstacles.**				
2.a.13.a	Terrain and obstacles within 46 km (25 NM) of the reference airport.			**X**	**X**
2.a.13.b	Reserved				
2.a.14	**Significant, identifiable natural and cultural features and moving airborne traffic.**				
2.a.14.a	Significant, identifiable natural and cultural features within 46 km (25 NM) of the reference airport.			**X**	**X**

	Note.— This refers to natural and cultural features that are typically used for pilot orientation in flight. Outlying airports not intended for landing need only provide a reasonable facsimile of runway orientation.				
2.a.14.b	Reserved				
2.a.14.c	Representative moving airborne traffic (including the capability to present air hazards – e.g. airborne traffic on a possible collision course).			**X**	**X**
2.b	**Visual scene management.**				
2.b.1	All airport runway, approach and taxiway lighting and cultural lighting intensity for any approach must be capable of being set to six (6) different intensities (0 to 5); all visual scene light points should fade into view appropriately.			**X**	**X**
2.b.2	Airport runway, approach and taxiway lighting and cultural lighting intensity for any approach must be set at an intensity representative of that used in training for the visibility set; all visual scene light points should fade into view appropriately.	**X**	**X**		
2.b.3	The directionality of strobe lights, approach lights, runway edge lights, visual landing aids, runway center line lights, threshold lights, and touchdown zone lights on the runway of intended landing must be realistically replicated.	**X**	**X**	**X**	**X**
2.c	**Visual feature recognition.** *Note.— The following are the minimum distances at which runway features should be visible. Distances are measured from runway threshold to an airplane aligned with the runway on an extended 3-degree glide slope in suitable simulated meteorological conditions. For circling approaches, all tests below apply both to the runway used for the initial approach and to the runway of intended landing.*				
2.c.1	Runway definition, strobe lights, approach lights, and runway edge white lights from 8 km (5 sm) of the runway threshold.	**X**	**X**	**X**	**X**
2.c.2	**Visual approach aids lights.**				
2.c.2.a	Visual approach aids lights from 8 km (5 sm) of the runway threshold.			**X**	**X**
2.c.2.b	Visual approach aids lights from 4.8 km (3 sm) of the runway threshold.	**X**	**X**		
2.c.3	Runway center line lights and taxiway definition from 4.8 km (3 sm).	**X**	**X**	**X**	**X**
2.c.4	Threshold lights and touchdown zone lights from 3.2 km (2 sm).	**X**	**X**	**X**	**X**
2.c.5	Runway markings within range of landing lights for night scenes; as required by the surface resolution test on day scenes.	**X**	**X**	**X**	**X**
2.c.6	For circling approaches, the runway of intended landing and associated lighting must fade into view in a non-distracting manner.	**X**	**X**	**X**	**X**
2.d	**Selectable airport visual scene capability for:**				
2.d.1	Night.	**X**	**X**	**X**	**X**
2.d.2	Twilight.			**X**	**X**
2.d.3	Day.			**X**	**X**
2.d.4	Dynamic effects — the capability to present multiple ground and air hazards such as another airplane crossing the active runway or converging airborne traffic; hazards should be selectable via controls at the instructor station.			**X**	**X**

2.d.5	Illusions — operational visual scenes which portray representative physical relationships known to cause landing illusions, for example short runways, landing approaches over water, uphill or downhill runways, rising terrain on the approach path and unique topographic features. *Note.— Illusions may be demonstrated at a generic airport or at a specific airport.*				X
2.e	**Correlation with airplane and associated equipment.**				
2.e.1	Visual cues to relate to actual airplane responses.	X	X	X	X
2.e.2	**Visual cues during take-off, approach and landing.**				
2.e.2.a	Visual cues to assess sink rate and depth perception during landings.		X	X	X
2.e.2.b	Visual cueing sufficient to support changes in approach path by using runway perspective. Changes in visual cues during take-off, approach and landing should not distract the pilot.	X	X	X	X
2.e.3	Accurate portrayal of environment relating to airplane attitudes.	X	X	X	X
2.e.4	The visual scene must correlate with integrated airplane systems, where fitted (e.g. terrain, traffic and weather avoidance systems and HUD/EFVS).			X	X
2.e.5	The effect of rain removal devices must be provided.			X	X
2.f	**Scene quality.**				
2.f.1	**Quantization.**				
2.f.1.a	Surfaces and textural cues must be free from apparent quantization (aliasing).			X	X
2.f.1.b	Surfaces and textural cues must not create distracting quantization (aliasing).	X	X		
2.f.2	System capable of portraying full color realistic textural cues.			X	X
2.f.3	The system light points must be free from distracting jitter, smearing or streaking.	X	X	X	X
2.f.4	System capable of providing representative focus effects that simulate rain (e.g. reduced visibility and object resolution in the out the window view as a result of rain).			X	X
2.f.5	System capable of providing light point perspective growth (e.g. relative size of runway and taxiway edge lights increase as the lights are approached).			X	X
2.g	**Environmental effects.**				
2.g.1	The displayed scene must correspond to the appropriate surface contaminants and include runway lighting reflections for wet, partially obscured lights for snow, or suitable alternative effects.			X	X
2.g.2	Special weather representations which include the sound, motion and visual effects of light, medium and heavy precipitation near a thunderstorm on take-off, approach and landings at and below an altitude of 600 m (2 000 ft) above the airport surface and within a radius of 16 km (10 sm) from the airport.			X	X
2.g.3	One airport with a snow scene to include terrain snow and snow-covered taxiways and runways.			X	X
2.g.4	In-cloud effects such as variable cloud density, speed cues and ambient changes should be provided.			X	X
2.g.5	The effect of multiple cloud layers representing few, scattered, broken and overcast conditions giving partial or complete			X	X

	obstruction of the ground scene.				
2.g.6	Gradual break-out to ambient visibility/RVR, defined as up to 10% of the respective cloud base or top, 20 ft ≤ transition layer ≤ 200 ft; cloud effects should be checked at and below a height of 600 m (2 000 ft) above the airport and within a radius of 16 km (10 sm) from the airport. Transition effects should be complete when the IOS cloud base or top is reached when exiting and start when entering the cloud, i.e. transition effects should occur within the IOS defined cloud layer.			**X**	**X**
2.g.7	Visibility and RVR measured in terms of distance. Visibility/RVR must be checked at and below a height of 600 m (2 000 ft) above the airport and within a radius of 16 km (10 sm) from the airport.	**X**	**X**	**X**	**X**
2.g.8	Patchy fog (sometimes referred to as patchy RVR) giving the effect of variable RVR. The lowest RVR should be that selected on the IOS, ie. variability is only greater than the IOS RVR.			**X**	**X**
2.g.9	Effects of fog on airport lighting such as halos and defocus.			**X**	**X**
2.g.10	Effect of ownship lighting in reduced visibility, such as reflected glare, to include landing lights, strobes, and beacons.			**X**	**X**
2.g.11	Wind cues to provide the effect of blowing snow or sand across a dry runway or taxiway should be selectable from the instructor station.			**X**	**X**
	End QPS Requirement				

	Begin Information				
3.	An example of being able to "combine two airport models to achieve two "in-use" runways: One runway designated as the "in use" runway in the first model of the airport, and the second runway designated as the "in use" runway in the second model of the same airport. For example, the clearance is for the ILS approach to Runway 27, Circle to Land on Runway 18 right. Two airport visual models might be used: the first with Runway 27 designated as the "in use" runway for the approach to runway 27, and the second with Runway 18 Right designated as the "in use" runway. When the pilot breaks off the ILS approach to runway 27, the instructor may change to the second airport visual model in which runway 18 Right is designated as the "in use" runway, and the pilot would make a visual approach and landing. This process is acceptable to the FAA as long as the temporary interruption due to the visual model change is not distracting to the pilot, does not cause changes in navigational radio frequencies, and does not cause undue instructor/evaluator time.				
4.	Sponsors are not required to provide every detail of a runway, but the detail that is provided should be correct within the capabilities of the system. **End Information**				

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This table specifies motion effects that are required to indicate when a flight crewmember must be able to recognize an event or situation. Where applicable, flight simulator pitch, side loading and directional control characteristics must be representative of the airplane.						
1.	**Taxiing effects such as lateral, longitudinal, and directional cues resulting from steering and braking inputs. Runway contamination with associated anti-skid and taxiway characteristics.**			**X**	**X**	
2.	**Runway rumble, oleo deflection, ground speed, uneven runway, runway/taxiway centerline light characteristics:** Procedure: After the airplane has been pre-set to the takeoff position and then released, taxi at various speeds with a smooth runway and note the general characteristics of the simulated runway rumble effects of oleo deflections. Repeat the maneuver with a runway roughness of 50%, then with maximum roughness. Note the associated motion vibrations affected by ground speed and runway roughness.		**X**	**X**	**X**	Different gross weights can also be selected, which may also affect the associated vibrations depending on airplane type. The associated motion effects for the above tests should also include an assessment of the effects of rolling over centerline lights, surface discontinuities of uneven runways, and various taxiway characteristics.
3.	**Buffets on the ground due to spoiler/speedbrake extension and reverse thrust:** Procedure: Perform a normal landing and use ground spoilers and reverse thrust – either individually or in combination – to decelerate the simulated airplane. Do not use wheel braking so that only the buffet due to the ground spoilers and thrust reversers is felt.	**X**	**X**	**X**	**X**	
4.	**Bumps associated with the landing gear:** Procedure: Perform a normal take-off paying special attention to the bumps that could be perceptible due to maximum oleo	**X**	**X**	**X**	**X**	

	extension after lift-off. When the landing gear is extended or retracted, motion bumps can be felt when the gear locks into position.					
5.	**Buffet during extension and retraction of landing gear:** Procedure: Operate the landing gear. Check that the motion cues of the buffet experienced represent the actual airplane.	**X**	**X**	**X**	**X**	
6.	**Buffet in the air due to flap and spoiler/speedbrake extension:** Procedure: Perform an approach and extend the flaps and slats with airspeeds deliberately in excess of the normal approach speeds. In cruise configuration, verify the buffets associated with the spoiler/speedbrake extension. The above effects can also be verified with different combinations of spoiler/speedbrake, flap, and landing gear settings to assess the interaction effects.	**X**	**X**	**X**	**X**	
7.	**Buffet due to atmospheric disturbances** (e.g. buffet due to turbulence, windshear, proximity to thunderstorms, gusting winds, etc.).			**X**	**X**	
8.	**Approach to stall buffet and stall buffet (where applicable):** Procedure: Conduct an approach-to-stall with engines at idle and a deceleration of 1 knot/second. Check that the motion cues of the buffet, including the level of buffet increase with decreasing speed, are representative of the actual airplane.	**X**	**X**	**X**	**X**	For FSTDs qualified for full stall training tasks, modeling that accounts for any increase in buffet amplitude from initial buffet threshold of perception to critical angle of attack or deterrent buffet as a function of angle of attack. The stall buffet modeling should include effects of Nz, as well as Nx and Ny if relevant.

9.	**Touchdown cues for main and nose gear:** Procedure: Conduct several normal approaches with various rates of descent. Check that the motion cues for the touchdown bumps for each descent rate are representative of the actual airplane.	**X**	**X**	**X**	**X**	
10.	**Nosewheel scuffing:** Procedure: Taxi at various ground speeds and manipulate the nosewheel steering to cause yaw rates to develop that cause the nosewheel to vibrate against the ground ("scuffing"). Evaluate the speed/nosewheel combination needed to produce scuffing and check that the resultant vibrations are representative of the actual airplane.		**X**	**X**	**X**	
11.	**Thrust effect with brakes set:** Procedure: Set the brakes on at the take-off point and increase the engine power until buffet is experienced. Evaluate its characteristics. Confirm that the buffet increases appropriately with increasing engine thrust.	**X**	**X**	**X**	**X**	This effect is most discernible with wing-mounted engines.
12.	**Mach and maneuver buffet:** Procedure: With the simulated airplane trimmed in 1 g flight while at high altitude, increase the engine power so that the Mach number exceeds the documented value at which Mach buffet is experienced. Check that the buffet begins at the same Mach number as it does in the airplane (for the same configuration) and that buffet levels are representative of the actual airplane. For certain airplanes, maneuver buffet can also be verified for the same effects. Maneuver buffet can occur during turning flight at conditions greater than 1 g, particularly		**X**	**X**	**X**	

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	at higher altitudes.					
13.	**Tire failure dynamics:** Procedure: Simulate a single tire failure and a multiple tire failure.			**X**	**X**	The pilot may notice some yawing with a multiple tire failure selected on the same side. This should require the use of the rudder to maintain control of the airplane. Dependent on airplane type, a single tire failure may not be noticed by the pilot and should not have any special motion effect. Sound or vibration may be associated with the actual tire losing pressure.
14.	**Engine failures, malfunction, engine, and airframe structural damage:** Procedure: The characteristics of an engine malfunction as stipulated in the malfunction definition document for the particular flight simulator must describe the special motion effects felt by the pilot. Note the associated engine instruments varying according to the nature of the malfunction and note the replication of the effects of the airframe vibration.		**X**	**X**	**X**	
15.	**Tail strikes, engine pod/propeller, wing strikes:** Procedure: Tail-strikes can be checked by over-rotation of the airplane at a speed below V_r while performing a takeoff. The effects can also be verified during a landing. Excessive banking of the airplane during its take-off/landing roll can cause a pod strike.		**X**	**X**	**X**	The motion effect should be felt as a noticeable bump. If the tail strike affects the airplane angular rates, the cueing provided by the motion system should have an associated effect.

This table specifies the minimum special effects necessary for the specified simulator level.					
1.	**Braking Dynamics:** Representations of the dynamics of brake failure (flight simulator pitch, side-loading, and directional control characteristics representative of the airplane), including antiskid and decreased brake efficiency due to high brake temperatures (based on airplane related data), sufficient to enable pilot identification of the problem and implementation of appropriate procedures.			**X**	**X**
2.	**Effects of Airframe and Engine Icing:** **Required only for those airplanes authorized for operations in known icing conditions.** Procedure: With the simulator airborne, autopilot on and auto-throttles off, engine and airfoil anti-ice/de-ice systems deactivated; activate icing conditions at a rate that allows monitoring of simulator and systems response. Icing recognition will typically include airspeed decay, change in simulator pitch attitude, change in engine performance indications (other than due to airspeed changes), and change in data from pitot/static system. Activate heating, anti-ice, or de-ice systems independently. Recognition will include proper effects of these systems, eventually returning the simulated airplane to normal flight. See Table A1A, section 2.j. and Attachment 7 for additional requirements.			**X**	**X**

Appendix A to Part 60—Qualification Performance Standards for Airplane Full Flight Simulators—[Amended]

■ 10. Amend Attachment 4 to Appendix A by removing and reserving Figure A4H.

■ 11. Amend Attachment 6 to Appendix A by adding the text for FSTD Directive No. 2 in sequential order after FSTD Directive No. 1 to read as follows:

Appendix A to Part 60—Qualification Performance Standards for Airplane Full Flight Simulators

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Flight Simulation Training Device (FSTD) Directive

FSTD Directive 2. Applicable to all airplane Full Flight Simulators (FFS), regardless of the original qualification basis and qualification date (original or upgrade), used to conduct full stall training, upset recovery training, airborne icing training, and other flight training tasks as described in this Directive.

Agency: Federal Aviation Administration (FAA), DOT.

Action: This is a retroactive requirement for any FSTD being used to obtain training, testing, or checking credit in an FAA approved flight training program for the specific training maneuvers as defined in this Directive.

Summary: Notwithstanding the authorization listed in paragraph 13b in Appendix A of this Part, this FSTD Directive requires that each FSTD sponsor conduct additional subjective and objective testing, conduct required modifications, and apply for additional FSTD qualification under § 60.16 to support continued qualification of the following flight training tasks where training, testing, or checking credit is being sought in a selected FSTD being used in an FAA approved flight training program:

a. Recognition of and Recovery from a Full Stall
b. Upset Prevention and Recovery
c. Engine and Airframe Icing
d. Takeoff and Landing with Gusting Crosswinds
e. Recovery from a Bounced Landing

The FSTD sponsor may elect to apply for additional qualification for any, all, or none of the above defined training tasks for a particular FSTD. After March 12, 2019, any FSTD used to conduct the above training tasks must be evaluated and issued additional qualification by the National Simulator Program Manager (NSPM) as defined in this Directive.

Dates: FSTD Directive No. 2 becomes effective on May 31, 2016.

For Further Information Contact: Larry McDonald, Air Transportation Division/National Simulator Program Branch, AFS–205, Federal Aviation Administration, P.O. Box 20636, Atlanta, GA 30320; telephone (404) 474–5620; email *larry.e.mcdonald@faa.gov.*

Specific Requirements

1. Part 60 requires that each FSTD be:

a. Sponsored by a person holding or applying for an FAA operating certificate under Part 119, Part 141, or Part 142, or holding or applying for an FAA-approved training program under Part 63, Appendix C, for flight engineers, and

b. Evaluated and issued a Statement of Qualification (SOQ) for a specific FSTD level.

2. The evaluation criteria contained in this Directive is intended to address specific training tasks that require additional evaluation to ensure adequate FSTD fidelity.

3. The requirements described in this Directive define additional qualification criteria for specific training tasks that are applicable only to those FSTDs that will be utilized to obtain training, testing, or checking credit in an FAA approved flight training program. In order to obtain additional qualification for the tasks described in this Directive, FSTD sponsors must request additional qualification in accordance with § 60.16 and the requirements of this Directive. FSTDs that are found to meet the requirements of this Directive will have their Statement of Qualification (SOQ) amended to reflect the additional training tasks that the FSTD has been qualified to conduct. The additional qualification requirements as defined in this Directive are divided into the following training tasks:

a. Section I—Additional Qualification Requirements for Full Stall Training Tasks
b. Section II—Additional Qualification Requirements for Upset Prevention and Recovery Training Tasks
c. Section III—Additional Qualification Requirements for Engine and Airframe Icing Training Tasks
d. Section IV—Additional Qualification Requirements for Takeoff and Landing in Gusting Crosswinds
e. Section V—Additional Qualification Requirements for Bounced Landing Recovery Training Tasks

4. A copy of this Directive (along with all required Statements of Compliance and objective test results) must be filed in the MQTG in the designated FSTD Directive Section, and its inclusion must be annotated on the Index of Effective FSTD Directives chart. See Attachment 4, Appendix A for a sample MQTG Index of Effective FSTD Directives chart.

Section I—Evaluation Requirements for Full Stall Training Tasks

1. This section applies to previously qualified Level C and Level D FSTDs being used to obtain credit for stall training maneuvers beyond the first indication of a stall (such as stall warning system activation, stick shaker, etc.) in an FAA approved training program.

2. The evaluation requirements in this Directive are intended to validate FSTD fidelity at angles of attack sufficient to identify the stall, to demonstrate aircraft performance degradation in the stall, and to demonstrate recovery techniques from a fully stalled flight condition.

3. After March 12, 2019, any FSTD being used to obtain credit for full stall training maneuvers in an FAA approved training program must be evaluated and issued additional qualification in accordance with this Directive and the following sections of Appendix A of this Part:

a. Table A1A, General Requirements, Section 2.m. (High Angle of Attack Modeling)
b. Table A1A, General Requirements, Section 3.f. (Stick Pusher System) [where applicable]
c. Table A2A, Objective Testing Requirements, Test 2.a.10 (Stick Pusher Force Calibration) [where applicable]
d. Table A2A, Objective Testing Requirements, Test 2.c.8.a (Stall Characteristics)
e. Table A2A, Objective Testing Requirements, Test 3.f.5 (Characteristic Motion Vibrations—Stall Buffet) [See paragraph 4 of this section for applicability on previously qualified FSTDs]
f. Table A3A, Functions and Subjective Testing Requirements, Test 5.b.1.b. (High Angle of Attack Maneuvers)
g. Attachment 7, Additional Simulator Qualification Requirements for Stall, Upset Prevention and Recovery, and Engine and Airframe Icing Training Tasks (High Angle of Attack Model Evaluation)

4. For FSTDs initially qualified before May 31, 2016, including FSTDs that are initially qualified under the grace period conditions as defined in § 60.15(c):

a. Objective testing for stall characteristics (Table A2A, test 2.c.8.a.) will only be required for the (wings level) second segment climb and approach or landing flight conditions. In lieu of objective testing for the high altitude cruise and turning flight stall conditions, these maneuvers may be subjectively evaluated by a qualified subject matter expert (SME) pilot and addressed in the required statement of compliance.
b. Where existing flight test validation data in the FSTD's Master Qualification Test Guide (MQTG) is missing required parameters or is otherwise unsuitable to fully meet the objective testing requirements of this Directive, the FAA may accept alternate sources of validation, including subjective validation by an SME pilot with direct experience in the stall characteristics of the aircraft.
c. Objective testing for characteristic motion vibrations (Stall buffet—Table A2A, test 3.f.5) is not required where the FSTD's stall buffets have been subjectively evaluated by an SME pilot. For previously qualified Level D FSTDs that currently have objective stall buffet tests in their approved MQTG, the results of these existing tests must be provided to the FAA with the updated stall and stall buffet models in place.
d. As described in Attachment 7 of this Appendix, the FAA may accept a statement of compliance from the data provider which confirms the stall characteristics have been subjectively evaluated by an SME pilot on an engineering simulator or development simulator that is acceptable to the FAA. Where this evaluation takes place on an engineering or development simulator, additional objective ''proof-of-match'' testing for all flight conditions as described in tests 2.c.8.a. and 3.f.5.will be required to verify the implementation of the stall model and stall buffets on the training FSTD.

5. Where qualification is being sought to conduct full stall training tasks in accordance with this Directive, the FSTD Sponsor must conduct the required evaluations and modifications as prescribed in this Directive and report compliance to the NSPM in accordance with § 60.23 using the NSP's standardized FSTD Sponsor Notification Form. At a minimum, this form must be accompanied with the following information:

a. A description of any modifications to the FSTD (in accordance with § 60.23) necessary to meet the requirements of this Directive.
b. Statements of Compliance (High Angle of Attack Modeling/Stick Pusher System)—See Table A1A, Section 2.m., 3.f., and Attachment 7
c. Statement of Compliance (SME Pilot Evaluation)—See Table A1A, Section 2.m. and Attachment 7
d. Copies of the required objective test results as described above in sections 3.c., 3.d., and 3.e.

6. The NSPM will review each submission to determine if the requirements of this Directive have been met and respond to the FSTD Sponsor as described in § 60.23(c). Additional NSPM conducted FSTD evaluations may be required before the modified FSTD is placed into service. This response, along with any noted restrictions, will serve as interim qualification for full stall training tasks until such time that a permanent change is made to the Statement of Qualification (SOQ) at the FSTD's next scheduled evaluation.

Section II—Evaluation Requirements for Upset Prevention and Recovery Training Tasks

1. This section applies to previously qualified FSTDs being used to obtain training, testing, or checking credits for upset prevention and recovery training tasks (UPRT) as defined in Appendix A, Table A1A, Section 2.n. of this part. Additionally, FSTDs being used for unusual attitude training maneuvers that are intended to exceed the parameters of an aircraft upset must also be evaluated and qualified for UPRT under this section. These parameters include pitch attitudes greater than 25 degrees nose up; pitch attitudes greater than 10 degrees nose down, and bank angles greater than 45 degrees.

2. The requirements contained in this section are intended to define minimum standards for evaluating an FSTD for use in upset prevention and recovery training maneuvers that may exceed an aircraft's normal flight envelope. These standards include the evaluation of qualified training maneuvers against the FSTD's validation envelope and providing the instructor with minimum feedback tools for the purpose of determining if a training maneuver is conducted within FSTD validation limits and the aircraft's operating limits.

3. This Directive contains additional subjective testing that exceeds the evaluation requirements of previously qualified FSTDs. Where aerodynamic modeling data or validation data is not available or insufficient to meet the requirements of this Directive, the NSPM may limit additional qualification to certain upset prevention and recovery maneuvers where adequate data exists.

4. After March 12, 2019, any FSTD being used to obtain training, testing, or checking credit for upset prevention and recovery training tasks in an FAA approved flight training program must be evaluated and issued additional qualification in accordance with this Directive and the following sections of Appendix A of this part:

a. Table A1A, General Requirements, Section 2.n. (Upset Prevention and Recovery)
b. Table A3A, Functions and Subjective Testing, Test 5.b.3. (Upset Prevention and Recovery Maneuvers)
c. Attachment 7, Additional Simulator Qualification Requirements for Stall, Upset Prevention and Recovery, and Engine and Airframe Icing Training Tasks (Upset Prevention and Recovery Training Maneuver Evaluation)

5. Where qualification is being sought to conduct upset prevention and recovery training tasks in accordance with this Directive, the FSTD Sponsor must conduct the required evaluations and modifications as prescribed in this Directive and report compliance to the NSPM in accordance with § 60.23 using the NSP's standardized FSTD Sponsor Notification Form. At a minimum, this form must be accompanied with the following information:

a. A description of any modifications to the FSTD (in accordance with § 60.23) necessary to meet the requirements of this Directive.
b. Statement of Compliance (FSTD Validation Envelope)—See Table A1A, Section 2.n. and Attachment 7
c. A confirmation statement that the modified FSTD has been subjectively evaluated by a qualified pilot as described in § 60.16(a)(1)(iii).

6. The NSPM will review each submission to determine if the requirements of this Directive have been met and respond to the FSTD Sponsor as described in § 60.23(c). Additional NSPM conducted FSTD evaluations may be required before the modified FSTD is placed into service. This response, along with any noted restrictions, will serve as an interim qualification for upset prevention and recovery training tasks until such time that a permanent change is made to the Statement of Qualification (SOQ) at the FSTD's next scheduled evaluation.

Section III—Evaluation Requirements for Engine and Airframe Icing Training Tasks

1. This section applies to previously qualified Level C and Level D FSTDs being used to obtain training, testing, or checking credits in maneuvers that demonstrate the effects of engine and airframe ice accretion.

2. The requirements in this section are intended to supersede and improve upon existing Level C and Level D FSTD evaluation requirements on the effects of engine and airframe icing. The requirements define a minimum level of fidelity required to adequately simulate the aircraft specific aerodynamic characteristics of an in-flight encounter with engine and airframe ice accretion as necessary to accomplish training objectives.

3. This Directive contains additional subjective testing that exceeds the evaluation requirements of previously qualified FSTDs. Where aerodynamic modeling data is not available or insufficient to meet the requirements of this Directive, the NSPM may limit qualified engine and airframe icing maneuvers where sufficient aerodynamic modeling data exists.

4. After March 12, 2019, any FSTD being used to conduct training tasks that demonstrate the effects of engine and airframe icing must be evaluated and issued additional qualification in accordance with this Directive and the following sections of Appendix A of this part:

a. Table A1A, General Requirements, Section 2.j. (Engine and Airframe Icing)
b. Attachment 7, Additional Simulator Qualification Requirements for Stall, Upset Prevention and Recovery, and Engine and Airframe Icing Training Tasks (Engine and Airframe Icing Evaluation; Paragraphs 1, 2, and 3). Objective demonstration tests of engine and airframe icing effects (Attachment 2, Table A2A, test 2.i. of this Appendix) are not required for previously qualified FSTDs.

5. Where continued qualification is being sought to conduct engine and airframe icing training tasks in accordance with this Directive, the FSTD Sponsor must conduct the required evaluations and modifications as prescribed in this Directive and report compliance to the NSPM in accordance with § 60.23 using the NSP's standardized FSTD Sponsor Notification Form. At a minimum, this form must be accompanied with the following information:

a. A description of any modifications to the FSTD (in accordance with § 60.23) necessary to meet the requirements of this Directive;
b. Statement of Compliance (Ice Accretion Model)—See Table A1A, Section 2.j., and Attachment 7; and
c. A confirmation statement that the modified FSTD has been subjectively evaluated by a qualified pilot as described in § 60.16(a)(1)(iii).

6. The NSPM will review each submission to determine if the requirements of this Directive have been met and respond to the FSTD Sponsor as described in § 60.23(c). Additional NSPM conducted FSTD evaluations may be required before the modified FSTD is placed into service. This response, along with any noted restrictions, will serve as an interim update to the FSTD's Statement of Qualification (SOQ) until such time that a permanent change is made to the SOQ at the FSTD's next scheduled evaluation.

Section IV—Evaluation Requirements for Takeoff and Landing in Gusting Crosswind

1. This section applies to previously qualified FSTDs that will be used to obtain training, testing, or checking credits in takeoff and landing tasks in gusting crosswinds as part of an FAA approved training program. The requirements of this Directive are applicable only to those Level B and higher FSTDs that are qualified to conduct takeoff and landing training tasks.

2. The requirements in this section introduce new minimum simulator requirements for gusting crosswinds during takeoff and landing training tasks as well as additional subjective testing that exceeds the evaluation requirements of previously qualified FSTDs.

3. After March 12, 2019, any FSTD that is used to conduct gusting crosswind takeoff and landing training tasks must be evaluated and issued additional qualification in accordance with this Directive and the following sections of Appendix A of this part:

a. Table A1A, General Requirements, Section 2.d.3. (Ground Handling Characteristics);
b. Table A3A, Functions and Subjective Testing Requirements, test 3.a.3 (Takeoff, Crosswind—Maximum Demonstrated and Gusting Crosswind); and
c. Table A3A, Functions and Subjective Testing Requirements, test 8.d. (Approach and landing with crosswind—Maximum Demonstrated and Gusting Crosswind).

4. Where qualification is being sought to conduct gusting crosswind training tasks in accordance with this Directive, the FSTD Sponsor must conduct the required evaluations and modifications as prescribed in this Directive and report compliance to the NSPM in accordance with § 60.23 using the NSP's standardized FSTD Sponsor Notification Form. At a minimum, this form must be accompanied with the following information:

a. A description of any modifications to the FSTD (in accordance with § 60.23) necessary to meet the requirements of this Directive.
b. Statement of Compliance (Gusting Crosswind Profiles)—See Table A1A, Section 2.d.3.
c. A confirmation statement that the modified FSTD has been subjectively evaluated by a qualified pilot as described in § 60.16(a)(1)(iii).

5. The NSPM will review each submission to determine if the requirements of this Directive have been met and respond to the FSTD Sponsor as described in § 60.23(c). Additional NSPM conducted FSTD evaluations may be required before the modified FSTD is placed into service. This response, along with any noted restrictions, will serve as an interim qualification for gusting crosswind training tasks until such time that a permanent change is made to the Statement of Qualification (SOQ) at the FSTD's next scheduled evaluation.

Section V—Evaluation Requirements for Bounced Landing Recovery Training Tasks

1. This section applies to previously qualified FSTDs that will be used to obtain training, testing, or checking credits in bounced landing recovery as part of an FAA approved training program. The requirements of this Directive are applicable only to those Level B and higher FSTDs that are qualified to conduct takeoff and landing training tasks.

2. The evaluation requirements in this section are intended to introduce new evaluation requirements for bounced landing recovery training tasks and contains additional subjective testing that exceeds the evaluation requirements of previously qualified FSTDs.

3. After March 12, 2019, any FSTD that is used to conduct bounced landing training tasks must be evaluated and issued additional qualification in accordance with this Directive and the following sections of Appendix A of this Part:

a. Table A1A, General Requirements, Section 2.d.2. (Ground Reaction Characteristics)
b. Table A3A, Functions and Subjective Testing Requirements, test 9.e. (Missed Approach—Bounced Landing)

4. Where qualification is being sought to conduct bounced landing training tasks in accordance with this Directive, the FSTD Sponsor must conduct the required evaluations and modifications as prescribed in this Directive and report compliance to the NSPM in accordance with § 60.23 using the NSP's standardized FSTD Sponsor Notification Form. At a minimum, this form must be accompanied with the following information:

a. A description of any modifications to the FSTD (in accordance with § 60.23) necessary to meet the requirements of this Directive; and
b. A confirmation statement that the modified FSTD has been subjectively evaluated by a qualified pilot as described in § 60.16(a)(1)(iii).

5. The NSPM will review each submission to determine if the requirements of this Directive have been met and respond to the FSTD Sponsor as described in § 60.23(c). Additional NSPM conducted FSTD evaluations may be required before the modified FSTD is placed into service. This response, along with any noted restrictions, will serve as an interim qualification for bounced landing recovery training tasks until such time that a permanent change is made to the Statement of Qualification (SOQ) at the FSTD's next scheduled evaluation.

■ 12. In appendix A to part 60, add Attachment 7 to read as follows:

Appendix A to Part 60—Qualification Performance Standards for Airplane Full Flight Simulators

* * * * *

Attachment 7 to Appendix A to Part 60—Additional Simulator Qualification Requirements for Stall, Upset Prevention and Recovery, and Engine and Airframe Icing Training Tasks

Begin QPS Requirements

A. High Angle of Attack Model Evaluation (Table A1A, Section 2.m.)

1. Applicability: This attachment applies to all simulators that are used to satisfy training requirements for stall maneuvers that are conducted at angles of attack beyond the activation of the stall warning system. This attachment is not applicable for those FSTDs that are only qualified for approach to stall maneuvers where recovery is initiated at the first indication of the stall. The material in this section is intended to supplement the general requirements, objective testing requirements, and subjective testing requirements contained within Tables A1A, A2A, and A3A, respectively.

2. General Requirements: The requirements for high angle of attack modeling are intended to evaluate the recognition cues and performance and handling qualities of a developing stall through the stall identification angle-of-attack and recovery. Strict time-history-based evaluations against flight test data may not adequately validate the aerodynamic model in an unsteady and potentially unstable flight regime, such as stalled flight. As a result, the objective testing requirements defined in Table A2A do not prescribe strict tolerances on any parameter at angles of attack beyond the stall identification angle of attack. In lieu of mandating such objective tolerances, a Statement of Compliance (SOC) will be required to define the source data and methods used to develop the stall aerodynamic model.

3. Fidelity Requirements: The requirements defined for the evaluation of full stall training maneuvers are intended to provide the following levels of fidelity:

a. Airplane type specific recognition cues of the first indication of the stall (such as the stall warning system or aerodynamic stall buffet);

b. Airplane type specific recognition cues of an impending aerodynamic stall; and

c. Recognition cues and handling qualities from the stall break through recovery that are sufficiently exemplar of the airplane being simulated to allow successful completion of the stall recovery training tasks.

For the purposes of stall maneuver evaluation, the term ''exemplar'' is defined as a level of fidelity that is type specific of the simulated airplane to the extent that the training objectives can be satisfactorily accomplished.

4. Statement of Compliance (Aerodynamic Model): At a minimum, the following must be addressed in the SOC:

a. Source Data and Modeling Methods: The SOC must identify the sources of data used to develop the aerodynamic model. These data sources may be from the airplane original equipment manufacturer (OEM), the original FSTD manufacturer/data provider, or other data provider acceptable to the FAA. Of particular interest is a mapping of test points in the form of alpha/beta envelope plot for a minimum of flaps up and flaps down aircraft configurations. For the flight test data, a list of the types of maneuvers used to define the aerodynamic model for angle of attack ranges greater than the first indication of stall must be provided per flap setting. In cases where it is impractical to develop and validate a stall model with flight-test data (*e.g.,* due to safety concerns involving the collection of flight test data past a certain angle of attack), the data provider is expected to make a reasonable attempt to develop a stall model through the required angle of attack range using analytical methods and empirical data (*e.g.,* wind-tunnel data);

b. Validity Range: The FSTD sponsor must declare the range of angle of attack and sideslip where the aerodynamic model remains valid for training. For stall recovery training tasks, satisfactory aerodynamic model fidelity must be shown through at least 10 degrees beyond the stall identification angle of attack. For the purposes of determining this validity range, the stall identification angle of attack is defined as the angle of attack where the pilot is given a clear and distinctive indication to cease any further increase in angle of attack where one or more of the following characteristics occur:

i. No further increase in pitch occurs when the pitch control is held at the full aft stop for 2 seconds, leading to an inability to arrest descent rate;

ii. An uncommanded nose down pitch that cannot be readily arrested, which may be accompanied by an uncommanded rolling motion;

iii. Buffeting of a magnitude and severity that is a strong and effective deterrent to further increase in angle of attack; and

iv. Activation of a stick pusher.

The model validity range must also be capable of simulating the airplane dynamics as a result of a pilot initially resisting the stick pusher in training. For aircraft equipped with a stall envelope protection system, the model validity range must extend to 10 degrees of angle of attack beyond the stall identification angle of attack with the protection systems disabled or otherwise degraded (such as a degraded flight control mode as a result of a pitot/static system failure).

c. Model Characteristics: Within the declared range of model validity, the SOC must address, and the aerodynamic model must incorporate, the following stall characteristics where applicable by aircraft type:

i. Degradation in static/dynamic lateral-directional stability;

ii. Degradation in control response (pitch, roll, yaw);

iii. Uncommanded roll acceleration or roll-off requiring significant control deflection to counter;

iv. Apparent randomness or non-repeatability;

v. Changes in pitch stability;

vi. Stall hysteresis;

vii. Mach effects;

viii. Stall buffet; and

ix. Angle of attack rate effects.

An overview of the methodology used to address these features must be provided.

5. Statement of Compliance (Subject Matter Expert Pilot Evaluation): The sponsor must provide an SOC that confirms the FSTD has been subjectively evaluated by a subject matter expert (SME) pilot who is knowledgeable of the aircraft's stall characteristics. In order to qualify as an acceptable SME to evaluate the FSTD's stall characteristics, the SME must meet the following requirements:

a. Has held a type rating/qualification in the aircraft being simulated;

b. Has direct experience in conducting stall maneuvers in an aircraft that shares the same type rating as the make, model, and series of the simulated aircraft. This stall experience must include hands on manipulation of the controls at angles of attack sufficient to identify the stall (*e.g.,* deterrent buffet, stick pusher activation, etc.) through recovery to stable flight;

c. Where the SME's stall experience is on an airplane of a different make, model, and series within the same type rating, differences in aircraft specific stall recognition cues and handling characteristics must be addressed using available documentation. This documentation may include aircraft operating manuals, aircraft manufacturer flight test reports, or other documentation that describes the stall characteristics of the aircraft; and

d. Must be familiar with the intended stall training maneuvers to be conducted in the FSTD (*e.g.,* general aircraft configurations, stall entry methods, etc.) and the cues necessary to accomplish the required training objectives. The purpose of this requirement is to ensure that the stall model has been sufficiently evaluated in those general aircraft configurations and stall entry methods that will likely be conducted in training.

This SOC will only be required once at the time the FSTD is initially qualified for stall training tasks as long as the FSTD's stall model remains unmodified from what was originally evaluated and qualified. Where an FSTD shares common aerodynamic and flight control models with that of an engineering simulator or development simulator that is acceptable to the FAA, the FAA will accept an SOC from the data provider that confirms the stall characteristics have been subjectively assessed by an SME pilot on the engineering or development simulator.

An FSTD sponsor may submit a request to the Administrator for approval of a deviation from the SME pilot experience requirements in this paragraph. This request for deviation must include the following information:

a. An assessment of pilot availability that demonstrates that a suitably qualified pilot meeting the experience requirements of this section cannot be practically located; and

b. Alternative methods to subjectively evaluate the FSTD's capability to provide the stall recognition cues and handling characteristics needed to accomplish the training objectives.

B. Upset Prevention and Recovery Training (UPRT) Maneuver Evaluation (Table A1A, Section 2.n.)

1. Applicability: This attachment applies to all simulators that are used to satisfy training requirements for upset prevention and recovery training (UPRT) maneuvers. For the purposes of this attachment (as defined in the Airplane Upset Recovery Training Aid), an aircraft upset is generally defined as an airplane unintentionally exceeding the following parameters normally experienced in line operations or training:

a. Pitch attitude greater than 25 degrees nose up;

b. Pitch attitude greater than 10 degrees nose down;

c. Bank angles greater than 45 degrees; and

d. Within the above parameters, but flying at airspeeds inappropriate for the conditions.

FSTDs that will be used to conduct training maneuvers where the FSTD is either repositioned into an aircraft upset condition or an artificial stimulus (such as weather phenomena or system failures) is applied that is intended to result in a flightcrew entering an aircraft upset condition must be evaluated and qualified in accordance with this section.

2. General Requirements: The general requirement for UPRT qualification in Table A1A defines three basic elements required for qualifying an FSTD for UPRT maneuvers:

a. FSTD Training Envelope: Valid UPRT should be conducted within the high and moderate confidence regions of the FSTD validation envelope as defined in paragraph 3 below.

b. Instructor Feedback: Provides the instructor/evaluator with a minimum set of feedback tools to properly evaluate the trainee's performance in accomplishing an upset recovery training task.

c. Upset Scenarios: Where dynamic upset scenarios or aircraft system malfunctions are used to stimulate the FSTD into an aircraft upset condition, specific guidance must be available to the instructor on the IOS that describes how the upset scenario is driven along with any malfunction or degradation in FSTD functionality that is required to stimulate the upset.

3. FSTD Validation Envelope: For the purposes of this attachment, the term ''flight envelope'' refers to the entire domain in which the FSTD is capable of being flown with a degree of confidence that the FSTD responds similarly to the airplane. This envelope can be further divided into three subdivisions (see Appendix 3–D of the *Airplane Upset Recovery Training Aid*):

a. Flight test validated region: This is the region of the flight envelope which has been validated with flight test data, typically by comparing the performance of the FSTD against the flight test data through tests incorporated in the QTG and other flight test data utilized to further extend the model beyond the minimum requirements. Within this region, there is high confidence that the simulator responds similarly to the aircraft. Note that this region is not strictly limited to what has been tested in the QTG; as long as the aerodynamics mathematical model has been conformed to the flight test results, that portion of the mathematical model can be considered to be within the flight test validated region.

b. Wind tunnel and/or analytical region: This is the region of the flight envelope for which the FSTD has not been compared to flight test data, but for which there has been wind tunnel testing or the use of other reliable predictive methods (typically by the aircraft manufacturer) to define the aerodynamic model. Any extensions to the aerodynamic model that have been evaluated in accordance with the definition of an exemplar stall model (as described in the stall maneuver evaluation section) must be clearly indicated. Within this region, there is moderate confidence that the simulator will respond similarly to the aircraft.

c. Extrapolated: This is the region extrapolated beyond the flight test validated and wind tunnel/analytical regions. The extrapolation may be a linear extrapolation, a holding of the last value before the extrapolation began, or some other set of values. Whether this extrapolated data is provided by the aircraft or simulator manufacturer, it is a ''best guess'' only. Within this region, there is low confidence that the simulator will respond similarly to the aircraft. Brief excursions into this region may still retain a moderate confidence level in FSTD fidelity; however, the instructor should be aware that the FSTD's response may deviate from the actual aircraft.

4. Instructor Feedback Mechanism: For the instructor/evaluator to provide feedback to the student during UPRT maneuver training, additional information must be accessible that indicates the fidelity of the simulation, the magnitude of trainee's flight control inputs, and aircraft operational limits that could potentially affect the successful completion of the maneuver(s). At a minimum, the following must be available to the instructor/evaluator:

a. FSTD Validation Envelope: The FSTD must employ a method to display the FSTD's expected fidelity with respect to the FSTD validation envelope. This may be displayed as an angle of attack vs sideslip (alpha/beta) envelope cross-plot on the Instructor Operating System (IOS) or other alternate method to clearly convey the FSTD's fidelity level during the maneuver. The cross-plot or other alternative method must display the relevant validity regions for flaps up and flaps down at a minimum. This validation envelope must be derived by the aerodynamic data provider or derived using information and data sources provided by the original aerodynamic data provider.

b. Flight Control Inputs: The FSTD must employ a method for the instructor/evaluator to assess the trainee's flight control inputs during the upset recovery maneuver. Additional parameters, such as cockpit control forces (forces applied by the pilot to the controls) and the flight control law mode for fly-by-wire aircraft, must be portrayed in this feedback mechanism as well. For passive sidesticks, whose displacement is the flight control input, the force applied by the pilot to the controls does not need to be displayed. This tool must include a time history or other equivalent method of recording flight control positions.

c. Aircraft Operational Limits: The FSTD must employ a method to provide the instructor/evaluator with real-time information concerning the aircraft operating limits. The simulated aircraft's parameters must be displayed dynamically in real-time and also provided in a time history or equivalent format. At a minimum, the following parameters must be available to the instructor:

i. Airspeed and airspeed limits, including the stall speed and maximum operating limit airspeed (Vmo/Mmo);

ii. Load factor and operational load factor limits; and

iii. Angle of attack and the stall identification angle of attack. See section A, paragraph 4.b. of this attachment for additional information concerning the definition of the stall identification angle of attack. This parameter may be displayed in conjunction with the FSTD validation envelope.

End QPS Requirements

Begin Information

An example FSTD ''alpha/beta'' envelope display and IOS feedback mechanism are shown below in Figure 1 and Figure 2. The following examples are provided as guidance material on one possible method to display the required UPRT feedback parameters on an IOS display. FSTD sponsors may develop other methods and feedback mechanisms that provide the required parameters and support the training program objectives.

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Figure 1 – Example FSTD Alpha/Beta Envelope Plot

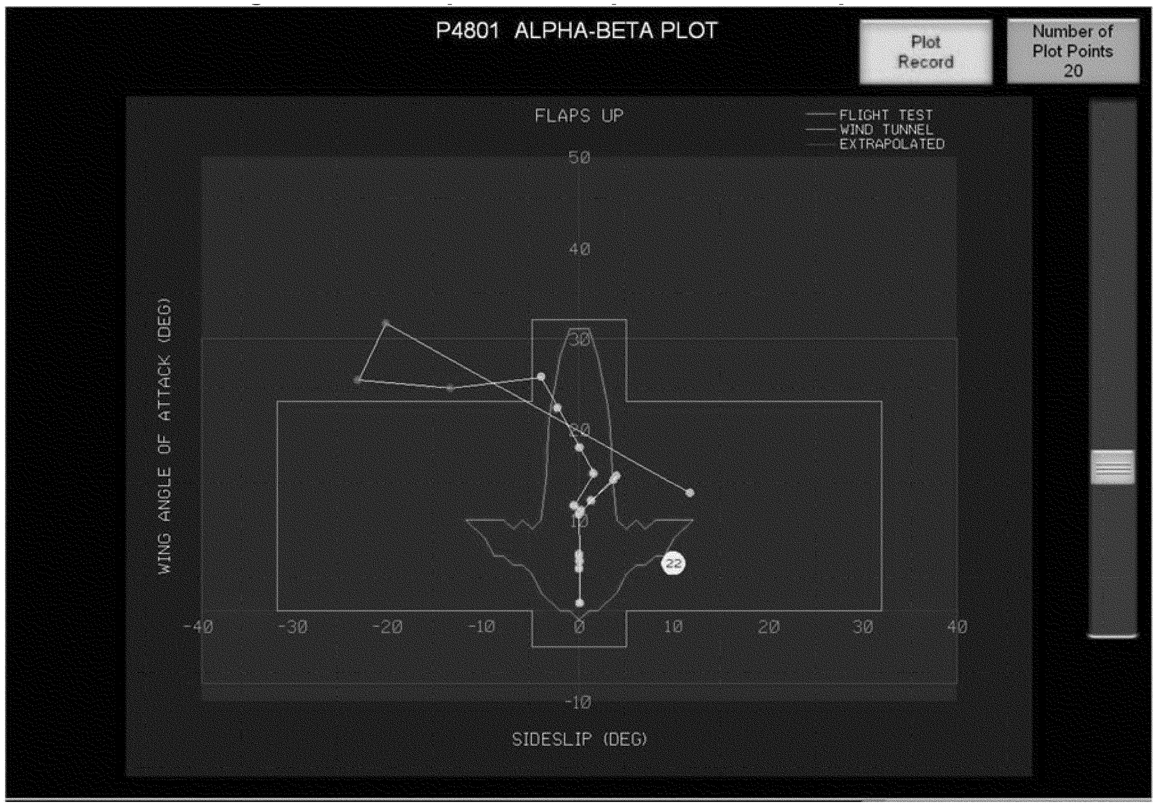
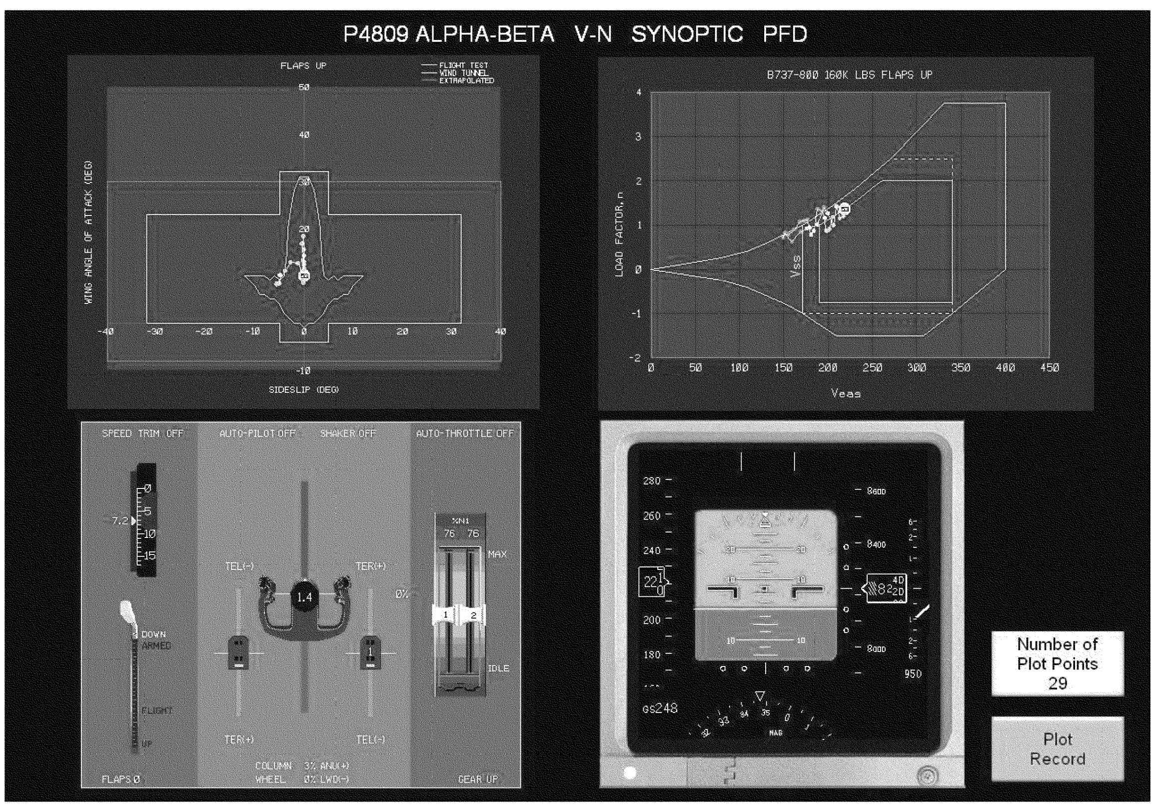


Figure 2 – Example IOS Instructor UPRT Feedback Display



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End Information

Begin QPS Requirements

C. Engine and Airframe Icing Evaluation (Table A1A, Section 2.j.)

1. Applicability: This section applies to all FSTDs that are used to satisfy training requirements for engine and airframe icing. New general requirements and objective requirements for simulator qualification have been developed to define aircraft specific icing models that support training objectives for the recognition and recovery from an in-flight ice accretion event.

2. General Requirements: The qualification of engine and airframe icing consists of the following elements that must be considered when developing ice accretion models for use in training:

a. Ice accretion models must be developed to account for training the specific skills required for recognition of ice accumulation and execution of the required response.

b. Ice accretion models must be developed in a manner to contain aircraft specific recognition cues as determined with aircraft OEM supplied data or other suitable analytical methods.

c. At least one qualified ice accretion model must be objectively tested to demonstrate that the model has been implemented correctly and generates the correct cues as necessary for training.

3. Statement of Compliance: The SOC as described in Table A1A, Section 2.j. must contain the following information to support FSTD qualification of aircraft specific ice accretion models:

a. A description of expected aircraft specific recognition cues and degradation effects due to a typical in-flight icing encounter. Typical cues may include loss of lift, decrease in stall angle of attack, changes in pitching moment, decrease in control effectiveness, and changes in control forces in addition to any overall increase in drag. This description must be based upon relevant source data, such as aircraft OEM supplied data, accident/incident data, or other acceptable data sources. Where a particular airframe has demonstrated vulnerabilities to a specific type of ice accretion (due to accident/incident history) which requires specific training (such as supercooled large-droplet icing or tailplane icing), ice accretion models must be developed that address the training requirements.

b. A description of the data sources utilized to develop the qualified ice accretion models. Acceptable data sources may be, but are not limited to, flight test data, aircraft certification data, aircraft OEM engineering simulation data, or other analytical methods based upon established engineering principles.

4. Objective Demonstration Testing: The purpose of the objective demonstration test is to demonstrate that the ice accretion models as described in the Statement of Compliance have been implemented correctly and demonstrate the proper cues and effects as defined in the approved data sources. At least one ice accretion model must be selected for testing and included in the Master Qualification Test Guide (MQTG). Two tests are required to demonstrate engine and airframe icing effects. One test will demonstrate the FSTDs baseline performance without icing, and the second test will demonstrate the aerodynamic effects of ice accretion relative to the baseline test.

a. *Recorded Parameters:* In each of the two required MQTG cases, a time history recording must be made of the following parameters:

i. Altitude;
ii. Airspeed;
iii. Normal Acceleration;
iv. Engine Power/settings;
v. Angle of Attack/Pitch attitude;
vi. Bank Angle;
vii. Flight control inputs;
viii. Stall warning and stall buffet onset; and
ix. Other parameters as necessary to demonstrate the effects of ice accretions.

b. *Demonstration maneuver:* The FSTD sponsor must select an ice accretion model as identified in the SOC for testing. The selected maneuver must demonstrate the effects of ice accretion at high angles of attack from a trimmed condition through approach to stall and ''full'' stall as compared to a baseline (no ice buildup) test. The ice accretion models must demonstrate the cues necessary to recognize the onset of ice accretion on the airframe, lifting surfaces, and engines and provide representative degradation in performance and handling qualities to the extent that a recovery can be executed. Typical recognition cues that may be present depending upon the simulated aircraft include:

i. Decrease in stall angle of attack;
ii. Increase in stall speed;
iii. Increase in stall buffet threshold of perception speed;
iv. Changes in pitching moment;
v. Changes in stall buffet characteristics;
vi. Changes in control effectiveness or control forces; and
vii. Engine effects (power variation, vibration, etc.);

The demonstration test may be conducted by initializing and maintaining a fixed amount of ice accretion throughout the maneuver in order to consistently evaluate the aerodynamic effects.

End QPS Requirements

13. Amend Appendix B by:

■ A. Revising paragraph 1.b.;
■ B. Revising paragraph 1.d.(21);
■ C. Revising paragraph 1.d.(24);
■ D. Revising paragraph 1.d.(25);
■ E. Revising paragraph 11.b.(2);
■ F. Removing and reserving paragraph 11.e.(2);
■ G. Revising paragraph 11.h.;
■ H. Revising paragraph 13.b.;
■ I. Revising paragraph 13.d.; and
■ J. Adding paragraph 24.a.(4)

The revisions and addition read as follows:

Appendix B to Part 60—Qualification Performance Standards for Airplane Flight Training Devices

* * * * *

1. Introduction

* * * * *

b. Questions regarding the contents of this publication should be sent to the U.S. Department of Transportation, Federal Aviation Administration, Flight Standards Service, National Simulator Program Staff, AFS–205, P.O. Box 20636, Atlanta, Georgia 30320. Telephone contact numbers for the NSP are: Phone, 404–474–5620; fax, 404–474–5656. The NSP Internet Web site address is: *http://www.faa.gov/about/initiatives/nsp/.* On this Web site you will find an NSP personnel list with telephone and email contact information for each NSP staff member, a list of qualified flight simulation devices, advisory circulars (ACs), a description of the qualification process, NSP policy, and an NSP ''In-Works'' section. Also linked from this site are additional information sources, handbook bulletins, frequently asked questions, a listing and text of the Federal Aviation Regulations, Flight Standards Inspector's handbooks, and other FAA links.

* * * * *

d. * * *

(21) International Air Transport Association document, ''Flight Simulation Training Device Design and Performance Data Requirements,'' as amended.

* * * * *

(24) International Civil Aviation Organization (ICAO) Manual of Criteria for the Qualification of Flight Simulation Training Devices, as amended.

(25) Aeroplane Flight Simulation Training Device Evaluation Handbook, Volume I, as amended and Volume II, as amended, The Royal Aeronautical Society, London, UK.

* * * * *

11. Initial (and Upgrade) Qualification Requirements (§ 60.15)

* * * * *

b. * * *

(2) Unless otherwise authorized through prior coordination with the NSPM, a confirmation that the sponsor will forward to the NSPM the statement described in § 60.15(b) in such time as to be received no later than 5 business days prior to the scheduled evaluation and may be forwarded to the NSPM via traditional or electronic means.

* * * * *

h. The sponsor may elect to complete the QTG objective and subjective tests at the manufacturer's facility or at the sponsor's training facility (or other sponsor designated location where training will take place). If the tests are conducted at the manufacturer's facility, the sponsor must repeat at least one-third of the tests at the sponsor's training facility in order to substantiate FTD performance. The QTG must be clearly annotated to indicate when and where each test was accomplished. Tests conducted at the manufacturer's facility and at the sponsor's designated training facility must be conducted after the FTD is assembled with systems and sub-systems functional and operating in an interactive manner. The test results must be submitted to the NSPM.

* * * * *

13. Previously Qualified FTDs (§ 60.17)

* * * * *

b. FTDs qualified prior to May 31, 2016, and replacement FTD systems, are not required to meet the general FTD requirements, the objective test requirements, and the subjective test requirements of Attachments 1, 2, and 3 of this appendix as long as the FTD continues to meet the test requirements contained in the MQTG developed under the original qualification basis.

* * * * *

d. FTDs qualified prior to May 31, 2016, may be updated. If an evaluation is deemed appropriate or necessary by the NSPM after such an update, the evaluation will not require an evaluation to standards beyond those against which the FTD was originally qualified.

* * * * *

24. Levels of FTD

* * * * *

a. * * *

(4) Level 7. A Level 7 device is one that has an enclosed airplane-specific flight deck and aerodynamic program with all applicable airplane systems operating and control loading that is representative of the simulated airplane throughout its ground and flight envelope and significant sound representation. All displays may be flat/LCD panel representations or actual representations of displays in the aircraft, but all controls, switches, and knobs must physically replicate the aircraft in control operation. It also has a visual system that provides an out-of-the-flight deck view, providing cross-flight deck viewing (for both pilots simultaneously) of a field-of-view of at least 180° horizontally and 40° vertically.

* * * * *

■ 14. In appendix B to part 60, amend Attachment 1 to Appendix B by revising Tables B1A and B1B to read as follows:

Appendix B to Part 60—Qualification Performance Standards for Airplane Flight Training Devices

* * * * *

Attachment 1 to Appendix B to Part 60—General FTD REQUIREMENTS

* * * * *

1. General Flight deck Configuration.						
1.a.	The FTD must have a flight deck that is a replica of the airplane simulated with controls, equipment, observable flight deck indicators, circuit breakers, and bulkheads properly located, functionally accurate and replicating the airplane. The direction of movement of controls and switches must be identical to that in the airplane. Pilot seat(s) must afford the capability for the occupant to be able to achieve the design "eye position." Equipment for the operation of the flight deck windows must be included, but the actual windows need not be operable. Fire axes, extinguishers, and spare light bulbs must be available in the flight FTD, but may be relocated to a suitable location as near as practical to the original position. Fire axes, landing gear pins, and any similar purpose instruments need only be represented in silhouette. The use of electronically displayed images with physical overlay or masking for FTD instruments and/or instrument panels is acceptable provided: (1) All instruments and instrument panel layouts are dimensionally correct with differences, if any, being imperceptible to the pilot; (2) Instruments replicate those of the airplane including full instrument functionality and embedded logic; (3) Instruments displayed are free of quantization (stepping); (4) Instrument display characteristics replicate those of the airplane including: resolution, colors, luminance, brightness, fonts, fill patterns, line styles and symbology; (5) Overlay or masking, including bezels and bugs, as applicable, replicates the airplane panel(s); (6) Instrument controls and switches replicate and operate with the same technique, effort, travel and in the same direction as those in the airplane; (7) Instrument lighting replicates that of the airplane and is operated from the FSTD control for that lighting and, if applicable, is at a level			X	X	For FTD purposes, the flight deck consists of all that space forward of a cross section of the fuselage at the most extreme aft setting of the pilots' seats including additional, required flight crewmember duty stations and those required bulkheads aft of the pilot seats. For clarification, bulkheads containing only items such as landing gear pin storage compartments, fire axes and extinguishers, spare light bulbs, aircraft documents pouches are not considered essential and may be omitted. For Level 6 FTDs, flight deck window panes may be omitted where non-distracting and subjectively acceptable to conduct qualified training tasks.

	commensurate with other lighting operated by that same control; and (8) As applicable, instruments must have faceplates that replicate those in the airplane; and Level 7 FTD only; The display image of any three dimensional instrument, such as an electro-mechanical instrument, should appear to have the same three dimensional depth as the replicated instrument. The appearance of the simulated instrument, when viewed from the principle operator's angle, should replicate that of the actual airplane instrument. Any instrument reading inaccuracy due to viewing angle and parallax present in the actual airplane instrument should be duplicated in the simulated instrument display image. Viewing angle error and parallax must be minimized on shared instruments such and engine displays and standby indicators.					
1.b.	The FTD must have equipment (e.g., instruments, panels, systems, circuit breakers, and controls) simulated sufficiently for the authorized training/checking events to be accomplished. The installed equipment must be located in a spatially correct location and may be in a flight deck or an open flight deck area. Additional equipment required for the authorized training/checking events must be available in the FTD, but may be located in a suitable location as near as practical to the spatially correct position. Actuation of equipment must replicate the appropriate function in the airplane. Fire axes, landing gear pins, and any similar purpose instruments need only be represented in silhouette.	**X**	**X**			
1.c.	Those circuit breakers that affect procedures or result in observable flight deck indications must be properly located and functionally accurate.				**X**	
2. Programming.						
2.a.1	The FTD must provide the proper effect of aerodynamic changes for the combinations of drag and thrust normally encountered in flight. This must include the effect of change in airplane attitude, thrust, drag, altitude, temperature, and configuration.		**X**	**X**		

	Level 6 additionally requires the effects of changes in gross weight and center of gravity. Level 5 requires only generic aerodynamic programming. An SOC is required.					
2.a.2	A flight dynamics model that accounts for various combinations of drag and thrust normally encountered in flight must correspond to actual flight conditions, including the effect of change in airplane attitude, thrust, drag, altitude, temperature, gross weight, moments of inertia, center of gravity location, and configuration. The effects of pitch attitude and of fuel slosh on the aircraft center of gravity must be simulated. An SOC is required.				**X**	
2.b.	The FTD must have the computer capacity, accuracy, resolution, and dynamic response needed to meet the qualification level sought. An SOC is required.	**X**	**X**	**X**	**X**	
2.c.1	Relative responses of the flight deck instruments must be measured by latency tests, or transport delay tests, and may not exceed 300 milliseconds. The instruments must respond to abrupt input at the pilot's position within the allotted time, but not before the time when the airplane responds under the same conditions. (1) Latency: The FTD instrument and, if applicable, the motion system and the visual system response must not be prior to that time when the airplane responds and may respond up to 300 milliseconds after that time under the same conditions. (2) Transport Delay: As an alternative to the Latency requirement, a transport delay objective test may be used to demonstrate that the FTD system does not exceed the specified limit. The sponsor must measure		**X**	**X**		The intent is to verify that the FTD provides instrument cues that are, within the stated time delays, like the airplane responses. For airplane response, acceleration in the appropriate, corresponding rotational axis is preferred. Additional information regarding Latency and Transport Delay testing may be found in Appendix A,

	all the delay encountered by a step signal migrating from the pilot's control through all the simulation software modules in the correct order, using a handshaking protocol, finally through the normal output interfaces to the instrument display and, if applicable, the motion system, and the visual system.					Attachment 2, paragraph 15.
2.c.2.	Relative responses of the motion system, visual system, and flight deck instruments, measured by latency tests or transport delay tests. Motion onset should occur before the start of the visual scene change (the start of the scan of the first video field containing different information) but must occur before the end of the scan of that video field. Instrument response may not occur prior to motion onset. Test results must be within the following limits: 100 ms for the motion (if installed) and instrument systems; and 120 ms for the visual system.				**X**	The intent is to verify that the FTD provides instrument, motion, and visual cues that are, within the stated time delays, like the airplane responses. For airplane response, acceleration in the appropriate, corresponding rotational axis is preferred.
2.d.	Ground handling and aerodynamic programming must include the following:					
2.d.1.	Ground effect.				**X**	Ground effect includes modeling that accounts for roundout, flare, touchdown, lift, drag, pitching moment, trim, and power while in ground effect.
2.d.2.	Ground reaction.				**X**	Ground reaction includes modeling that accounts for strut deflections, tire friction, and side forces. This is the reaction of the airplane upon contact with the runway during landing, and may differ with changes in factors such as gross weight, airspeed, or rate

						of descent on touchdown.
2.d.3.	Ground handling characteristics, including aerodynamic and ground reaction modeling including steering inputs, operations with crosswind, gusting crosswind, braking, thrust reversing, deceleration, and turning radius.				**X**	
2.e.	If the aircraft being simulated is one of the aircraft listed in § 121.358, Low-altitude windshear system equipment requirements, the FTD must employ windshear models that provide training for recognition of windshear phenomena and the execution of recovery procedures. Models must be available to the instructor/evaluator for the following critical phases of flight: (1) Prior to takeoff rotation; (2) At liftoff; (3) During initial climb; and (4) On final approach, below 500 ft AGL. The QTG must reference the FAA Windshear Training Aid or present alternate airplane related data, including the implementation method(s) used. If the alternate method is selected, wind models from the Royal Aerospace Establishment (RAE), the Joint Airport Weather Studies (JAWS) Project and other recognized sources may be implemented, but must be supported and properly referenced in the QTG. The addition of realistic levels of turbulence associated with each required windshear profile must be available and selectable to the instructor. In addition to the four basic windshear models required for qualification, at least two additional "complex" windshear models must be available to the instructor which represent the complexity of actual windshear encounters. These models must be available in the takeoff and landing configurations and must consist of independent variable winds in multiple simultaneous components. The Windshear Training Aid provides two such example "complex" windshear models that may be used to satisfy this requirement.				**X**	Windshear models may consist of independent variable winds in multiple simultaneous components. The FAA Windshear Training Aid presents one acceptable means of compliance with FTD wind model requirements. The FTD should employ a method to ensure the required survivable and non-survivable windshear scenarios are repeatable in the training environment. For Level 7 FTDs, windshear training tasks may only be qualified for aircraft equipped with a synthetic stall warning system. The qualified windshear profile(s) are evaluated to ensure the synthetic stall warning (and not the stall buffet) is first indication of the stall.
2.f.	The FTD must provide for manual and automatic testing of FTD hardware				**X**	Automatic "flagging" of out-

	and software programming to determine compliance with FTD objective tests as prescribed in Attachment 2 of this appendix. An SOC is required.					of-tolerance situations is encouraged.
2.g.	The FTD must accurately reproduce the following runway conditions: (1) Dry; (2) Wet; (3) Icy; (4) Patchy Wet; (5) Patchy Icy; and (6) Wet on Rubber Residue in Touchdown Zone. An SOC is required.				**X**	
2.h.	The FTD must simulate: (1) brake and tire failure dynamics, including antiskid failure; and (2) decreased brake efficiency due to high brake temperatures, if applicable. An SOC is required				**X**	FTD pitch, side loading, and directional control characteristics should be representative of the airplane.
2.i.	Engine and Airframe Icing Modeling that includes the effects of icing, where appropriate, on the airframe, aerodynamics, and the engine(s). Icing models must simulate the aerodynamic degradation effects of ice accretion on the airplane lifting surfaces including loss of lift, decrease in stall angle of attack, change in pitching moment, decrease in control effectiveness, and changes in control forces in addition to any overall increase in drag. Aircraft systems (such as the stall protection system and autoflight system) must respond properly to ice accretion consistent with the simulated aircraft. Aircraft OEM data or other acceptable analytical methods must be utilized to develop ice accretion models that are representative of the simulated aircraft's performance degradation in a typical in-flight icing encounter. Acceptable				**X**	SOC should be provided describing the effects which provide training in the specific skills required for recognition of icing phenomena and execution of recovery. The SOC should describe the source data and any analytical methods used to develop ice accretion models including verification that these effects have been tested.

	analytical methods may include wind tunnel analysis and/or engineering analysis of the aerodynamic effects of icing on the lifting surfaces coupled with tuning and supplemental subjective assessment by a subject matter expert pilot. SOC required.					Icing effects simulation models are only required for those airplanes authorized for operations in icing conditions. Icing simulation models should be developed to provide training in the specific skills required for recognition of ice accumulation and execution of the required response. See Attachment 7 of this Appendix for further guidance material.
2.j.	The aerodynamic modeling in the FTD must include: (1) Low-altitude level-flight ground effect; (2) Mach effect at high altitude; (3) Normal and reverse dynamic thrust effect on control surfaces; (4) Aeroelastic representations; and (5) Nonlinearities due to sideslip. An SOC is required and must include references to computations of aeroelastic representations and of nonlinearities due to sideslip.				**X**	See Attachment 2 of this appendix, paragraph 5, for further information on ground effect.
2.k.	The FTD must have aerodynamic and ground reaction modeling for the effects of reverse thrust on directional control, if applicable. An SOC is required.				**X**	
3. Equipment Operation.						
3.a.	All relevant instrument indications involved in the simulation of the airplane must automatically respond to control movement or external disturbances to the simulated airplane; e.g., turbulence or windshear. Numerical values must		**X**	**X**	**X**	

	be presented in the appropriate units. For Level 7 FTDs, instrument indications must also respond to effects resulting from icing.					
3.b.1.	Navigation equipment must be installed and operate within the tolerances applicable for the airplane. Levels 6 must also include communication equipment (inter-phone and air/ground) like that in the airplane and, if appropriate to the operation being conducted, an oxygen mask microphone system. Level 5 need have only that navigation equipment necessary to fly an instrument approach.		**X**	**X**		
3.b.2.	Communications, navigation, caution, and warning equipment must be installed and operate within the tolerances applicable for the airplane. Instructor control of internal and external navigational aids. Navigation aids must be usable within range or line-of-sight without restriction, as applicable to the geographic area.				**X**	See Attachment 3 of this appendix for further information regarding long-range navigation equipment.
3.b.3.	Complete navigation database for at least 3 airports with corresponding precision and non-precision approach procedures, including navigational database updates.				**X**	
3.c.1.	Installed systems must simulate the applicable airplane system operation, both on the ground and in flight. Installed systems must be operative to the extent that applicable normal, abnormal, and emergency operating procedures included in the sponsor's training programs can be accomplished. Level 6 must simulate all applicable airplane flight, navigation, and systems operation. Level 5 must have at least functional flight and navigational controls, displays, and instrumentation. Level 4 must have at least one airplane system installed and functional.	**X**	**X**	**X**		
3.c.2.	Simulated airplane systems must operate as the airplane systems operate				**X**	Airplane system operation

	under normal, abnormal, and emergency operating conditions on the ground and in flight. Once activated, proper systems operation must result from system management by the crew member and not require any further input from the instructor's controls.					should be predicated on, and traceable to, the system data supplied by the airplane manufacturer, original equipment manufacturer or alternative approved data for the airplane system or component. At a minimum, alternate approved data should validate the operation of all normal, abnormal, and emergency operating procedures and training tasks the FSTD is qualified to conduct.
3.d.	The lighting environment for panels and instruments must be sufficient for the operation being conducted.	**X**	**X**	**X**	**X**	Back-lighted panels and instruments may be installed but are not required.
3.e.	The FTD must provide control forces and control travel that corresponds to the airplane being simulated. Control forces must react in the same manner as in the airplane under the same flight conditions. For Level 7 FTDs, control systems must replicate airplane operation for the normal and any non-normal modes including back-up systems and should reflect failures of associated systems. Appropriate cockpit indications and messages must be replicated.			**X**	**X**	
3.f.	The FTD must provide control forces and control travel of sufficient precision to manually fly an instrument approach.		**X**			
3.e.	FTD control feel dynamics must replicate the airplane. This must be determined by comparing a recording of the control feel dynamics of the FTD				**X**	

	to airplane measurements. For initial and upgrade qualification evaluations, the control dynamic characteristics must be measured and recorded directly from the flight deck controls, and must be accomplished in takeoff, cruise, and landing flight conditions and configurations.					
4. Instructor or Evaluator Facilities.						
4.a.1.	In addition to the flight crewmember stations, suitable seating arrangements for an instructor/check airman and FAA Inspector must be available. These seats must provide adequate view of crewmember's panel(s).	**X**	**X**	**X**		These seats need not be a replica of an aircraft seat and may be as simple as an office chair placed in an appropriate position.
4.a.2.	In addition to the flight crewmember stations, the FTD must have at least two suitable seats for the instructor/check airman and FAA inspector. These seats must provide adequate vision to the pilot's panel and forward windows. All seats other than flight crew seats need not represent those found in the airplane, but must be adequately secured to the floor and equipped with similar positive restraint devices.				**X**	The NSPM will consider alternatives to this standard for additional seats based on unique flight deck configurations.
4.b.1.	The FTD must have instructor controls that permit activation of normal, abnormal, and emergency conditions as appropriate. Once activated, proper system operation must result from system management by the crew and not require input from the instructor controls.	**X**	**X**	**X**		
4.b.2.	The FTD must have controls that enable the instructor/evaluator to control all required system variables and insert all abnormal or emergency conditions into the simulated airplane systems as described in the sponsor's FAA-approved training program; or as described in the relevant operating manual as appropriate.				**X**	
4.c.	The FTD must have instructor controls for all environmental effects expected to be available at the IOS; e.g., clouds, visibility, icing, precipitation, temperature, storm cells and microbursts, turbulence, and intermediate and high altitude wind speed and direction.				**X**	
4.d.	The FTD must provide the instructor or evaluator the ability to present ground				**X**	For example, another airplane

	and air hazards.					crossing the active runway or converging airborne traffic.
5. Motion System.						
5.a.	The FTD may have a motion system, if desired, although it is not required. If a motion system is installed and additional training, testing, or checking credits are being sought on the basis of having a motion system, the motion system operation may not be distracting and must be coupled closely to provide integrated sensory cues. The motion system must also respond to abrupt input at the pilot's position within the allotted time, but not before the time when the airplane responds under the same conditions.		**X**	**X**	**X**	The motion system standards set out in part 60, Appendix A for at least Level A simulators is acceptable.
5.b.	If a motion system is installed, it must be measured by latency tests or transport delay tests and may not exceed 300 milliseconds. Instrument response may not occur prior to motion onset.			**X**	**X**	The motion system standards set out in part 60, Appendix A for at least Level A simulators is acceptable.
6. Visual System.						
6.a.	The FTD may have a visual system, if desired, although it is not required. If a visual system is installed, it must meet the following criteria:	**X**	**X**	**X**		
6.a.1.	The visual system must respond to abrupt input at the pilot's position. An SOC is required.		**X**	**X**		
6.a.2.	The visual system must be at least a single channel, non-collimated display. An SOC is required.	**X**	**X**	**X**		
6.a.3.	The visual system must provide at least a field-of-view of 18° vertical / 24° horizontal for the pilot flying. An SOC is required.	**X**	**X**	**X**		
6.a.4.	The visual system must provide for a maximum parallax of 10° per pilot. An SOC is required.	**X**	**X**	**X**		
6.a.5.	The visual scene content may not be distracting. An SOC is required.	**X**	**X**	**X**		
6.a.6.	The minimum distance from the pilot's eye position to the surface of a direct view					

	display may not be less than the distance to any front panel instrument. An SOC is required.					
6.a.7.	The visual system must provide for a minimum resolution of 5 arc-minutes for both computed and displayed pixel size. An SOC is required.	**X**	**X**	**X**		
6.b.	If a visual system is installed and additional training, testing, or checking credits are being sought on the basis of having a visual system, a visual system meeting the standards set out for at least a Level A FFS (see Appendix A of this part) will be required. A "direct-view," non-collimated visual system (with the other requirements for a Level A visual system met) may be considered satisfactory for those installations where the visual system design "eye point" is appropriately adjusted for each pilot's position such that the parallax error is at or less than 10° simultaneously for each pilot. An SOC is required.			**X**		Directly projected, non-collimated visual displays may prove to be unacceptable for dual pilot applications.
6.c.	The FTD must have a visual system providing an out-of-the-flight deck view.				**X**	
6.d.	The FTD must provide a continuous visual field-of-view of at least176° horizontally and 36° vertically or the number of degrees necessary to meet the visual ground segment requirement, whichever is greater. The minimum horizontal field-of-view coverage must be plus and minus one-half (½) of the minimum continuous field-of-view requirement, centered on the zero degree azimuth line relative to the aircraft fuselage. An SOC is required and must explain the system geometry measurements including system linearity and field-of-view. Collimation is not required but parallax effects must be minimized (not greater than 10° for each pilot when aligned for the point midway between the left and right seat eyepoints).				**X**	The horizontal field-of-view is traditionally described as a 180° field-of-view. However, the field-of-view is technically no less than 176°. Additional field-of-view capability may be added at the sponsor's discretion provided the minimum fields of view are retained.
6.e.	The visual system must be free from optical discontinuities and artifacts that create non-realistic cues.				**X**	Non-realistic cues might include image "swimming"

						and image “roll-off,” that may lead a pilot to make incorrect assessments of speed, acceleration, or situational awareness.
6.f.	The FTD must have operational landing lights for night scenes. Where used, dusk (or twilight) scenes require operational landing lights.				**X**	
6.g.	The FTD must have instructor controls for the following: (1) Visibility in statute miles (km) and runway visual range (RVR) in ft.(m); (2) Airport selection; and (3) Airport lighting.				**X**	
6.h.	The FTD must provide visual system compatibility with dynamic response programming.				**X**	
6.i.	The FTD must show that the segment of the ground visible from the FTD flight deck is the same as from the airplane flight deck (within established tolerances) when at the correct airspeed, in the landing configuration, at the appropriate height above the touchdown zone, and with appropriate visibility.				**X**	This will show the modeling accuracy of RVR, glideslope, and localizer for a given weight, configuration, and speed within the airplane's operational envelope for a normal approach and landing.
6.j.	The FTD must provide visual cues necessary to assess sink rates (provide depth perception) during takeoffs and landings, to include: (1) Surface on runways, taxiways, and ramps; and (2) Terrain features.				**X**	
6.k.	The FTD must provide for accurate portrayal of the visual environment relating to the FTD attitude.				**X**	Visual attitude vs. FTD attitude is a comparison of pitch and roll of the horizon as displayed in the visual scene compared to the display on the attitude indicator.

6.l.	The FTD must provide for quick confirmation of visual system color, RVR, focus, and intensity. An SOC is required.				**X**	
6.m.	The FTD must be capable of producing at least 10 levels of occulting.				**X**	
6.n.	Night Visual Scenes. When used in training, testing, or checking activities, the FTD must provide night visual scenes with sufficient scene content to recognize the airport, the terrain, and major landmarks around the airport. The scene content must allow a pilot to successfully accomplish a visual landing. Scenes must include a definable horizon and typical terrain characteristics such as fields, roads and bodies of water and surfaces illuminated by airplane landing lights.				**X**	
6.o.	Dusk (or Twilight) Visual Scenes. When used in training, testing, or checking activities, the FTD must provide dusk (or twilight) visual scenes with sufficient scene content to recognize the airport, the terrain, and major landmarks around the airport. The scene content must allow a pilot to successfully accomplish a visual landing. Dusk (or twilight) scenes, as a minimum, must provide full color presentations of reduced ambient intensity, sufficient surfaces with appropriate textural cues that include self-illuminated objects such as road networks, ramp lighting and airport signage, to conduct a visual approach, landing and airport movement (taxi). Scenes must include a definable horizon and typical terrain characteristics such as fields, roads and bodies of water and surfaces illuminated by airplane landing lights. If provided, directional horizon lighting must have correct orientation and be consistent with surface shading effects. Total night or dusk (twilight) scene content must be comparable in detail to that produced by 10,000 visible textured surfaces and 15,000 visible lights with sufficient system capacity to display 16 simultaneously moving objects. An SOC is required.				**X**	

6.p.	Daylight Visual Scenes. The FTD must provide daylight visual scenes with sufficient scene content to recognize the airport, the terrain, and major landmarks around the airport. The scene content must allow a pilot to successfully accomplish a visual landing. Any ambient lighting must not "washout" the displayed visual scene. Total daylight scene content must be comparable in detail to that produced by 10,000 visible textured surfaces and 6,000 visible lights with sufficient system capacity to display 16 simultaneously moving objects. The visual display must be free of apparent and distracting quantization and other distracting visual effects while the FTD is in motion. An SOC is required.				**X**	
6.q.	The FTD must provide operational visual scenes that portray physical relationships known to cause landing illusions to pilots.				**X**	For example: short runways, landing approaches over water, uphill or downhill runways, rising terrain on the approach path, unique topographic features.
6.r.	The FTD must provide special weather representations of light, medium, and heavy precipitation near a thunderstorm on takeoff and during approach and landing. Representations need only be presented at and below an altitude of 2,000 ft. (610 m) above the airport surface and within 10 miles (16 km) of the airport.				**X**	
6.s.	The FTD must present visual scenes of wet and snow-covered runways, including runway lighting reflections for wet conditions, partially obscured lights for snow conditions, or suitable alternative effects.				**X**	
6.t.	The FTD must present realistic color and directionality of all airport lighting.				**X**	
6.u.	The following weather effects as observed on the visual system must be simulated and respective instructor controls provided. (1) Multiple cloud layers with adjustable bases, tops, sky coverage and				**X**	Scud effects are low, detached, and irregular clouds below a defined cloud layer.

	scud effect; (2) Storm cells activation and/or deactivation; (3) Visibility and runway visual range (RVR), including fog and patchy fog effect; (4) Effects on ownship external lighting; (5) Effects on airport lighting (including variable intensity and fog effects); (6) Surface contaminants (including wind blowing effect); (7) Variable precipitation effects (rain, hail, snow); (8) In-cloud airspeed effect; and (9) Gradual visibility changes entering and breaking out of cloud.					
6.v.	The simulator must provide visual effects for: (1) Light poles; (2) Raised edge lights as appropriate; and (3) Glow associated with approach lights in low visibility before physical lights are seen,				**X**	Visual effects for light poles and raised edge lights are for the purpose of providing additional depth perception during takeoff, landing, and taxi training tasks. Three dimensional modeling of the actual poles and stanchions is not required.
7. Sound System.						
7.a.	The FTD must provide flight deck sounds that result from pilot actions that correspond to those that occur in the airplane.			**X**	**X**	
7.b.	The volume control must have an indication of sound level setting which meets all qualification requirements.				**X**	This indication is of the sound level setting as evaluated during the FTD's initial evaluation.
7.c.	The FTD must accurately simulate the sound of precipitation, windshield wipers, and other significant airplane noises perceptible to the pilot during normal and abnormal operations, and include the sound of a crash (when the				**X**	

	FTD is landed in an unusual attitude or in excess of the structural gear limitations); normal engine and thrust reversal sounds; and the sounds of flap, gear, and spoiler extension and retraction. Sounds must be directionally representative. An SOC is required.					
7.d.	The FTD must provide realistic amplitude and frequency of flight deck noises and sounds. FTD performance must be recorded, subjectively assessed for the initial evaluation, and be made a part of the QTG. .				**X**	

1. Preflight Procedures.						
1.a.	Preflight Inspection (flight deck only)	**A**	**A**	**X**	**X**	
1.b.	Engine Start	**A**	**A**	**X**	**X**	
1.c.	Taxiing				**T**	
1.d.	Pre-takeoff Checks	**A**	**A**	**X**	**X**	
2. Takeoff and Departure Phase.						
2.a.	Normal and Crosswind Takeoff				**T**	
2.b.	Instrument Takeoff				**T**	
2.c.	Engine Failure During Takeoff				**T**	
2.d.	Rejected Takeoff (requires visual system)			**A**	**X**	
2.e.	Departure Procedure		**X**	**X**	**X**	
3. Inflight Maneuvers.						
3.a.	Steep Turns		**X**	**X**	**X**	
3.b	Approaches to Stalls		**A**	**X**	**X**	Approach to stall maneuvers qualified only where the aircraft does not exhibit stall buffet as the first indication of the stall.
3.c.	Engine Failure—Multiengine Airplane		**A**	**X**	**X**	
3.d.	Engine Failure—Single-Engine Airplane		**A**	**X**	**X**	
3.e.	Specific Flight Characteristics incorporated into the user's FAA approved flight training program.	**A**	**A**	**A**	**A**	Level 4 FTDs have no minimum requirement for aerodynamic programming and are generally not qualified to conduct in-flight maneuvers.
3.f.	Windshear Recovery				**T**	For Level 7 FTD, windshear recovery may be qualified at the Sponsor's option. See Table B1A for specific requirements and limitations.
4. Instrument Procedures.						
4.a.	Standard Terminal Arrival / Flight Management System Arrivals Procedures		**A**	**X**	**X**	
4.b.	Holding		**A**	**X**	**X**	
4.c.	Precision Instrument					
4.c.1.	All engines operating.		**A**	**X**	**X**	e.g., Autopilot, Manual (Flt. Dir. Assisted), Manual (Raw Data)
4.c.2.	One engine inoperative.				**T**	e.g., Manual (Flt. Dir. Assisted), Manual (Raw Data)

4.d.	Non-precision Instrument Approach		**A**	**X**	**X**	e.g., NDB, VOR, VOR/DME, VOR/TAC, RNAV, LOC, LOC/BC, ADF, and SDF.
4.e.	Circling Approach (requires visual system)			**A**	**X**	Specific authorization required.
4.f.	Missed Approach					
4.f.1.	Normal.		**A**	**X**	**X**	
4.f.2.	One engine Inoperative.				**T**	
5. Landings and Approaches to Landings.						
5.a.	Normal and Crosswind Approaches and Landings				**T**	
5.b.	Landing From a Precision / Non-Precision Approach				**T**	
5.c.	Approach and Landing with (Simulated) Engine Failure – Multiengine Airplane				**T**	
5.d.	Landing From Circling Approach				**T**	
5.e.	Rejected Landing				**T**	
5.f.	Landing From a No Flap or a Nonstandard Flap Configuration Approach				**T**	
6. Normal and Abnormal Procedures.						
6.a.	Engine (including shutdown and restart)	**A**	**A**	**X**	**X**	
6.b.	Fuel System	**A**	**A**	**X**	**X**	
6.c.	Electrical System	**A**	**A**	**X**	**X**	
6.d.	Hydraulic System	**A**	**A**	**X**	**X**	
6.e.	Environmental and Pressurization Systems	**A**	**A**	**X**	**X**	
6.f.	Fire Detection and Extinguisher Systems	**A**	**A**	**X**	**X**	
6.g.	Navigation and Avionics Systems	**A**	**A**	**X**	**X**	
6.h.	Automatic Flight Control System, Electronic Flight Instrument System, and Related Subsystems	**A**	**A**	**X**	**X**	
6.i.	Flight Control Systems	**A**	**A**	**X**	**X**	
6.j.	Anti-ice and Deice Systems	**A**	**A**	**X**	**X**	
6.k.	Aircraft and Personal Emergency Equipment	**A**	**A**	**X**	**X**	
7. Emergency Procedures.						
7.a.	Emergency Descent (Max. Rate)		**A**	**X**	**X**	
7.b.	Inflight Fire and Smoke Removal		**A**	**X**	**X**	
7.c.	Rapid Decompression		**A**	**X**	**X**	
7.d.	Emergency Evacuation	**A**	**A**	**X**	**X**	
8. Postflight Procedures.						
8.a.	After-Landing Procedures	**A**	**A**	**X**	**X**	
8.b.	Parking and Securing	**A**	**A**	**X**	**X**	

Note 1: An “A” in the table indicates that the system, task, or procedure, although not required to be present, may be examined if the appropriate airplane system is simulated in the FTD and is working properly.

Note 2: Items not installed or not functional on the FTD and not appearing on the SOQ Configuration List, are not required to be listed as exceptions on the SOQ.

Note 3: A “T” in the table indicates that the task may only be qualified for introductory initial or recurrent qualification training. These tasks may not be qualified for proficiency testing or checking credits in an FAA approved flight training program.

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■ 15. Amend Attachment 2 to Appendix B as follows:

■ A. Revise paragraph 2.e.;

■ B. Revise Table B2A;

■ C. In Table B2B;
■ D. In Table B2C;
■ E. In Table B2D; and
■ F. In Table B2E,.

The revisions and additions read as follows:

Appendix B to Part 60—Qualification Performance Standards for Airplane Flight Training Devices

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Attachment 2 to Appendix B to Part 60—FFS OBJECTIVE TESTS

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2. * * *

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e. It is not acceptable to program the FTD so that the mathematical modeling is correct only at the validation test points. Unless otherwise noted, FTD tests must represent airplane performance and handling qualities at operating weights and centers of gravity (CG) typical of normal operation. FTD tests at extreme weight or CG conditions may be acceptable where required for concurrent aircraft certification testing. Tests of handling qualities must include validation of augmentation devices.

* * * * *

1. Performance.								
1.a.	**Taxi.**							
1.a.1	Minimum radius turn.	±0.9 m (3 ft) or ±20% of airplane turn radius.	Ground.	Plot both main and nose gear loci and key engine parameter(s). Data for no brakes and the minimum thrust required to maintain a steady turn except for airplanes requiring asymmetric thrust or braking to achieve the minimum radius turn.			**X**	
1.a.2	Rate of turn versus nosewheel steering angle (NWA).	±10% or ±2°/s of turn rate.	Ground.	Record for a minimum of two speeds, greater than minimum turning radius speed with one at a typical taxi speed, and with a spread of at least 5 kt.			**X**	
1.b.	**Takeoff.**			*Note.— For Level 7 FTD, all airplane manufacturer commonly-used certificated take-off flap settings must be demonstrated at least once either in minimum unstick speed (1.b.3), normal take-off (1.b.4), critical engine failure on take-off (1.b.5) or crosswind take-off (1.b.6).*				
1.b.1	Ground acceleration time and distance.	±1.5 s or ±5% of time; and ±61 m (200 ft) or ±5% of distance. For Level 6 FTD: ±1.5 s or ±5% of time.	Takeoff.	Acceleration time and distance must be recorded for a minimum of 80% of the total time from brake release to V_r. Preliminary aircraft certification data may be used.		**X**	**X**	May be combined with normal takeoff (1.b.4.) or rejected takeoff (1.b.7.). Plotted data should be shown using appropriate scales for each portion of the maneuver. For Level 6 FTD, this test is required only if RTO training credit is sought.
1.b.2	Minimum control speed, ground (V_{mcg}) using aerodynamic controls only per applicable airworthiness requirement or alternative engine inoperative test to demonstrate ground control characteristics.	±25% of maximum airplane lateral deviation reached or ±1.5 m (5 ft). For airplanes with reversible flight control systems: ±10% or ±2.2 daN (5 lbf) rudder pedal force.	Takeoff.	Engine failure speed must be within ±1 kt of airplane engine failure speed. Engine thrust decay must be that resulting from the mathematical model for the engine applicable to the FTD under test. If the modeled engine is not the same as the airplane manufacturer's flight test engine, a further test may be run with the same initial conditions using the thrust from the flight test data as the driving parameter.			**X**	If a V_{mcg} test is not available, an acceptable alternative is a flight test snap engine deceleration to idle at a speed between V_1 and V_1-10 kt, followed by control of heading using aerodynamic control only and recovery should be achieved with the main gear on the ground. To ensure only aerodynamic control, nosewheel steering must be disabled (i.e. castored) or the nosewheel held slightly off the ground.
1.b.3	Minimum unstick speed (V_{mu}) or	±3 kt airspeed. ±1.5° pitch angle.	Takeoff.	Record time history data from 10 knots before start of rotation until at least 5 seconds after the			**X**	V_{mu} is defined as the minimum speed at which the last main

	equivalent test to demonstrate early rotation take-off characteristics.			occurrence of main gear lift-off.				landing gear leaves the ground. Main landing gear strut compression or equivalent air/ground signal should be recorded. If a V_{mu} test is not available, alternative acceptable flight tests are a constant high-attitude takeoff run through main gear lift-off or an early rotation takeoff. If either of these alternative solutions is selected, aft body contact/tail strike protection functionality, if present on the airplane, should be active.
1.b.4	Normal take-off.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±6 m (20 ft) height. For airplanes with reversible flight control systems: ±2.2 daN (5 lbf) or ±10% of column force.	Takeoff.	Data required for near maximum certificated takeoff weight at mid center of gravity location and light takeoff weight at an aft center of gravity location. If the airplane has more than one certificated take-off configuration, a different configuration must be used for each weight. Record takeoff profile from brake release to at least 61 m (200 ft) AGL.			**X**	The test may be used for ground acceleration time and distance (1.b.1). Plotted data should be shown using appropriate scales for each portion of the maneuver.
1.b.5	Critical engine failure on take-off.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±6 m (20 ft) height. ±2° roll angle. ±2° side-slip angle. ±3° heading angle. For airplanes with reversible flight control systems:	Takeoff.	Record takeoff profile to at least 61 m (200 ft) AGL. Engine failure speed must be within ±3 kt of airplane data. Test at near maximum takeoff weight			**X**	

		±2.2 daN (5 lbf) or ±10% of column force; ±1.3 daN (3 lbf) or ±10% of wheel force; and ±2.2 daN (5 lbf) or ±10% of rudder pedal force.						
1.b.6	Crosswind take-off.	± 3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±6 m (20 ft) height. ±2° roll angle. ±2° side-slip angle. ±3° heading angle. Correct trends at ground speeds below 40 kt for rudder/pedal and heading angle. For airplanes with reversible flight control systems: ±2.2 daN (5 lbf) or ±10% of column force; ±1.3 daN (3 lbf) or ±10% of wheel force; and ±2.2 daN (5 lbf) or ±10% of rudder pedal force.	Takeoff.	Record takeoff profile from brake release to at least 61 m (200 ft) AGL. This test requires test data, including wind profile, for a crosswind component of at least 60% of the airplane performance data value measured at 10 m (33 ft) above the runway. Wind components must be provided as headwind and crosswind values with respect to the runway.			**X**	In those situations where a maximum crosswind or a maximum demonstrated crosswind is not known, contact the NSPM.
1.b.7.a.	Rejected Takeoff.	±5% of time or ±1.5 s.	Takeoff.	Record at mass near maximum takeoff weight.			**X**	Autobrakes will be used where

		±7.5% of distance or ±76 m (250 ft). For Level 6 FTD: ±5% of time or ±1.5 s.		Speed for reject must be at least 80% of V_1. Maximum braking effort, auto or manual. Where a maximum braking demonstration is not available, an acceptable alternative is a test using approximately 80% braking and full reverse, if applicable. Time and distance must be recorded from brake release to a full stop.				applicable.
1.b.7.b.	Rejected Takeoff.	±5% of time or ±1.5 s.	Takeoff	Record time for at least 80% of the segment from initiation of the rejected takeoff to full stop.		**X**		For Level 6 FTD, this test is required only if RTO training credit is sought.
1.b.8.	Dynamic Engine Failure After Takeoff.	±2°/s or ±20% of body angular rates.	Takeoff.	Engine failure speed must be within ±3 kt of airplane data. Engine failure may be a snap deceleration to idle. Record hands-off from 5 s before engine failure to +5 s or 30° roll angle, whichever occurs first. **CCA**: Test in Normal and Non-normal control state.			**X**	For safety considerations, airplane flight test may be performed out of ground effect at a safe altitude, but with correct airplane configuration and airspeed.
1.c.	**Climb.**							
1.c.1.	Normal Climb, all engines operating.	±3 kt airspeed. ±0.5 m/s (100 ft/ min) or ±5% of rate of climb.	Clean.	Flight test data are preferred; however, airplane performance manual data are an acceptable alternative. Record at nominal climb speed and mid initial climb altitude. FTD performance is to be recorded over an interval of at least 300 m (1, 000 ft).	**X**	**X**	**X**	For Level 5 and Level 6 FTDs, this may be a snapshot test result.
1.c.2.	One-engine-inoperative 2nd segment climb.	±3 kt airspeed. ±0.5 m/s (100 ft/ min) or ±5% of rate of climb, but not less than airplane performance data requirements.	2nd segment climb.	Flight test data is preferred; however, airplane performance manual data is an acceptable alternative. Record at nominal climb speed. FTD performance is to be recorded over an interval of at least 300 m (1,000 ft). Test at WAT (weight, altitude or temperature)			**X**	

				limiting condition.				
1.c.3.	One Engine Inoperative En route Climb.	±10% time, ±10% distance, ±10% fuel used	Clean	Flight test data or airplane performance manual data may be used. Test for at least a 1,550 m (5,000 ft) segment.			**X**	
1.c.4.	One Engine Inoperative Approach Climb for airplanes with icing accountability if provided in the airplane performance data for this phase of flight.	±3 kt airspeed. ±0.5 m/s (100 ft/ min) or ±5% rate of climb, but not less than airplane performance data.	Approach	Flight test data or airplane performance manual data may be used. FTD performance to be recorded over an interval of at least 300 m (1,000 ft). Test near maximum certificated landing weight as may be applicable to an approach in icing conditions.			**X**	Airplane should be configured with all anti-ice and de-ice systems operating normally, gear up and go-around flap. All icing accountability considerations, in accordance with the airplane performance data for an approach in icing conditions, should be applied.
1.d.	**Cruise / Descent.**							
1.d.1.	Level flight acceleration	±5% Time	Cruise	Time required to increase airspeed a minimum of 50 kt, using maximum continuous thrust rating or equivalent. For airplanes with a small operating speed range, speed change may be reduced to 80% of operational speed change.			**X**	
1.d.2.	Level flight deceleration.	±5% Time	Cruise	Time required to decrease airspeed a minimum of 50 kt, using idle power. For airplanes with a small operating speed range, speed change may be reduced to 80% of operational speed change.			**X**	
1.d.3.	Cruise performance.	±.05 EPR or ±3% N1 or ±5% of torque. ±5% of fuel flow.	Cruise.	The test may be a single snapshot showing instantaneous fuel flow, or a minimum of two consecutive snapshots with a spread of at least 3 minutes in steady flight.			**X**	
1.d.4.	Idle descent.	±3 kt airspeed. ±1.0 m/s (200 ft/min) or ±5% of rate of descent.	Clean.	Idle power stabilized descent at normal descent speed at mid altitude. FTD performance to be recorded over an interval of at least 300 m (1,000 ft).			**X**	
1.d.5.	Emergency descent.	±5 kt airspeed. ±1.5 m/s (300 ft/min) or ±5% of rate of descent.	As per airplane performance data.	FTD performance to be recorded over an interval of at least 900 m (3,000 ft).			**X**	Stabilized descent to be conducted with speed brakes extended if applicable, at mid altitude and near V_{mo} or

								according to emergency descent procedure.
1.e.	**Stopping.**							
1.e.1.	Deceleration time and distance, manual wheel brakes, dry runway, no reverse thrust.	±1.5 s or ±5% of time. For distances up to 1,220 m (4,000 ft), the smaller of ±61 m (200 ft) or ±10% of distance. For distances greater than 1,220 m (4,000 ft), ±5% of distance.	Landing.	Time and distance must be recorded for at least 80% of the total time from touchdown to a full stop. Position of ground spoilers and brake system pressure must be plotted (if applicable). Data required for medium and near maximum certificated landing weight. Engineering data may be used for the medium weight condition.			**X**	
1.e.2.	Deceleration time and distance, reverse thrust, no wheel brakes, dry runway.	±1.5 s or ±5% of time; and the smaller of ±61 m (200 ft) or ±10% of distance.	Landing	Time and distance must be recorded for at least 80% of the total time from initiation of reverse thrust to full thrust reverser minimum operating speed. Position of ground spoilers must be plotted (if applicable). Data required for medium and near maximum certificated landing weight. Engineering data may be used for the medium weight condition.			**X**	
1.e.3.	Stopping distance, wheel brakes, wet runway.	±61 m (200 ft) or ±10% of distance.	Landing.	Either flight test or manufacturer's performance manual data must be used, where available. Engineering data, based on dry runway flight test stopping distance and the effects of contaminated runway braking coefficients, are an acceptable alternative.			**X**	
1.e.4.	Stopping distance, wheel brakes, icy runway.	±61 m (200 ft) or ±10% of distance.	Landing.	Either flight test or manufacturer's performance manual data must be used, where available. Engineering data, based on dry runway flight test stopping distance and the effects of contaminated runway braking coefficients, are an acceptable alternative.			**X**	
1.f.	**Engines.**							
1.f.1.	Acceleration.	For Level 7 FTD:	Approach or landing	Total response is the incremental change in the	**X**	**X**	**X**	See Appendix F of this part for

		±10% Ti or ±0.25 s; and ±10% Tt or ±0.25 s. For Level 6 FTD: ±10% Tt or ±0.25 s. For Level 5 FTD: ±1 s		critical engine parameter from idle power to go-around power.				definitions of T_i and T_t.
1.f.2.	Deceleration.	For Level 7 FTD: ±10% Ti or ±0.25 s; and ±10% Tt or ±0.25 s. For Level 6 FTD: ±10% Tt or ±0.25 s. For Level 5 FTD: ±1 s	Ground	Total response is the incremental change in the critical engine parameter from maximum take-off power to idle power.	**X**	**X**	**X**	See Appendix F of this part for definitions of T_i and T_t.
2. Handling Qualities.								
2.a.	**Static Control Tests.**							
	Note.1 — Testing of position versus force is not applicable if forces are generated solely by use of airplane hardware in the FTD. *Note 2 — Pitch, roll and yaw controller position versus force or time should be measured at the control. An alternative method in lieu of external test fixtures at the flight controls would be to have recording and measuring instrumentation built into the FTD. The force and position data from this instrumentation could be directly recorded and matched to the airplane data. Provided the instrumentation was verified by using external measuring equipment while conducting the static control checks, or equivalent means, and that evidence of the satisfactory comparison is included in the MQTG, the instrumentation could be used for both initial and recurrent evaluations for the measurement of all required control checks. Verification of the instrumentation by using external measuring equipment should be repeated if major modifications and/or repairs are made to the control loading system. Such a permanent installation could be used without any time being lost for the installation of external devices. Static and dynamic flight control tests should be accomplished at the same feel or impact pressures as the validation data where applicable.* *Note 3 — (Level 7 FTD only) FTD static control testing from the second set of pilot controls is only required if both sets of controls are not mechanically interconnected on the FTD. A rationale is required from the data provider if a single set of data is applicable to both sides. If controls are mechanically interconnected in the FTD, a single set of tests is sufficient.*							
2.a.1.a.	Pitch controller position versus force and surface position calibration.	±0.9 daN (2 lbf) breakout. ±2.2 daN (5 lbf) or ±10% of force. ±2° elevator angle.	Ground.	Record results for an uninterrupted control sweep to the stops.		**X**	**X**	Test results should be validated with in-flight data from tests such as longitudinal static stability, stalls, etc.
2.a.1.b.	Pitch controller position versus force	±0.9 daN (2 lbf) breakout. ±2.2 daN (5 lbf) or ±10% of force.	As determined by sponsor	Record results during initial qualification evaluation for an uninterrupted control sweep to the stops. The recorded tolerances apply to subsequent comparisons on continuing qualification evaluations.	**X**			Applicable only on continuing qualification evaluations. The intent is to design the control feel for Level 5 to be able to manually fly an instrument approach; and not to compare results to flight test or other such data.

2.a.2.a.	Roll controller position versus force and surface position calibration.	±0.9 daN (2 lbf) breakout. ±1.3 daN (3 lbf) or ±10% of force. ±2° aileron angle. ±3° spoiler angle.	Ground.	Record results for an uninterrupted control sweep to the stops.		**X**	**X**	Test results should be validated with in-flight data from tests such as engine-out trims, steady state side-slips, etc.
2.a.2.b.	Roll controller position versus force	±0.9 daN (2 lbf) breakout. ±1.3 daN (3 lbf) or ±10% of force.	As determined by sponsor	Record results during initial qualification evaluation for an uninterrupted control sweep to the stops. The recorded tolerances apply to subsequent comparisons on continuing qualification evaluations.	**X**			Applicable only on continuing qualification evaluations. The intent is to design the control feel for Level 5 to be able to manually fly an instrument approach; and not to compare results to flight test or other such data.
2.a.3.a.	Rudder pedal position versus force and surface position calibration.	±2.2 daN (5 lbf) breakout. ±2.2 daN (5 lbf) or ±10% of force. ±2° rudder angle.	Ground.	Record results for an uninterrupted control sweep to the stops.		**X**	**X**	Test results should be validated with in-flight data from tests such as engine-out trims, steady state side-slips, etc.
2.a.3.b.	Rudder pedal position versus force	±2.2 daN (5 lbf) breakout. ±2.2 daN (5 lbf) or ±10% of force.	As determined by sponsor	Record results during initial qualification evaluation for an uninterrupted control sweep to the stops. The recorded tolerances apply to subsequent comparisons on continuing qualification evaluations.	**X**			Applicable only on continuing qualification evaluations. The intent is to design the control feel for Level 5 to be able to manually fly an instrument approach; and not to compare results to flight test or other such data.
2.a.4.a.	Nosewheel Steering Controller Force and Position Calibration.	±0.9 daN (2 lbf) breakout. ±1.3 daN (3 lbf) or ±10% of force. ±2° NWA.	Ground.	Record results of an uninterrupted control sweep to the stops.			**X**	
2.a.4.b.	Nosewheel Steering Controller Force	±0.9 daN (2 lbf) breakout. ±1.3 daN (3 lbf) or	Ground.	Record results of an uninterrupted control sweep to the stops.		**X**		

		±10% of force.						
2.a.5.	Rudder Pedal Steering Calibration.	±2° NWA.	Ground.	Record results of an uninterrupted control sweep to the stops.		**X**	**X**	
2.a.6.	Pitch Trim Indicator vs. Surface Position Calibration.	±0.5° trim angle.	Ground.			**X**	**X**	The purpose of the test is to compare FSTD surface position indicator against the FSTD flight controls model computed value.
2.a.7.	Pitch Trim Rate.	±10% of trim rate (°/s) or ±0.1°/s trim rate.	Ground and approach.	Trim rate to be checked at pilot primary induced trim rate (ground) and autopilot or pilot primary trim rate in-flight at go-around flight conditions. For CCA, representative flight test conditions must be used.			**X**	
2.a.8.	Alignment of cockpit throttle lever versus selected engine parameter.	When matching engine parameters: ±5° of TLA. When matching detents: ±3% N1 or ±.03 EPR or ±3% torque, or ±3% maximum rated manifold pressure, or equivalent. Where the levers do not have angular travel, a tolerance of ±2 cm (±0.8 in) applies.	Ground.	Simultaneous recording for all engines. The tolerances apply against airplane data. For airplanes with throttle detents, all detents to be presented and at least one position between detents/ endpoints (where practical). For airplanes without detents, end points and at least three other positions are to be presented.		**X**	**X**	Data from a test airplane or engineering test bench are acceptable, provided the correct engine controller (both hardware and software) is used. In the case of propeller-driven airplanes, if an additional lever, usually referred to as the propeller lever, is present, it should also be checked. This test may be a series of snapshot tests.
2.a.9.a.	Brake pedal position versus force and brake system pressure calibration.	±2.2 daN (5 lbf) or ±10% of force. ±1.0 MPa (150 psi) or ±10% of brake system pressure.	Ground.	Relate the hydraulic system pressure to pedal position in a ground static test. Both left and right pedals must be checked.			**X**	FTD computer output results may be used to show compliance.
2.a.9.b.	Brake pedal position versus force	±2.2 daN (5 lbf) or ±10% of force.	Ground.	Two data points are required: zero and maximum deflection. Computer output results may be used to show compliance.		**X**		FTD computer output results may be used to show compliance. Test not required unless RTO credit is sought.

2.b.	**Dynamic Control Tests.**							
	Note.— Tests 2.b.1, 2.b.2 and 2.b.3 are not applicable for FTDs where the control forces are completely generated within the airplane controller unit installed in the FTD. Power setting may be that required for level flight unless otherwise specified. See paragraph 4 of Appendix A, Attachment 2.							
2.b.1.	Pitch Control.	**For underdamped systems**: $T(P_0)$ ±10% of P_0 or ±0.05 s. $T(P_1)$ ±20% of P_1 or ±0.05 s. $T(P_2)$ ±30% of P_2 or ±0.05 s. $T(P_n)$ ±10*(n+1)% of P_n or ±0.05 s. $T(A_n)$ ±10% of A_{max}, where A_{max} is the largest amplitude or ±0.5% of the total control travel (stop to stop). $T(A_d)$ ±5% of A_d = residual band or ±0.5% of the maximum control travel = residual band. ±1 significant overshoots (minimum of 1 significant overshoot). Steady state position within residual band. *Note 1.— Tolerances should not be applied on period or amplitude after the last significant overshoot.*	Takeoff, Cruise, and Landing.	Data must be for normal control displacements in both directions (approximately 25% to 50% of full throw or approximately 25% to 50% of maximum allowable pitch controller deflection for flight conditions limited by the maneuvering load envelope). Tolerances apply against the absolute values of each period (considered independently).			**X**	n = the sequential period of a full oscillation. Refer to paragraph 4 of Appendix A, Attachment 2 for additional information. For overdamped and critically damped systems, see Figure A2B of Appendix A for an illustration of the reference measurement.

		Note 2.—Oscillations within the residual band are not considered significant and are not subject to tolerances. **For overdamped and critically damped systems only**, the following tolerance applies: $T(P_0)$ ±10% of P_0 or ±0.05 s.						
2.b.2.	Roll Control.	Same as 2.b.1.	Takeoff, Cruise, and Landing.	Data must be for normal control displacement (approximately 25% to 50% of full throw or approximately 25% to 50% of maximum allowable roll controller deflection for flight conditions limited by the maneuvering load envelope).			**X**	Refer to paragraph 4 of Appendix A, Attachment 2 for additional information. For overdamped and critically damped systems, see Figure A2B of Appendix A for an illustration of the reference measurement.
2.b.3.	Yaw Control.	Same as 2.b.1.	Takeoff, Cruise, and Landing.	Data must be for normal control displacement (approximately 25% to 50% of full throw).			**X**	Refer to paragraph 4 of Appendix A, Attachment 2 for additional information. For overdamped and critically damped systems, see Figure A2B of Appendix A for an illustration of the reference measurement.
2.b.4.	Small Control Inputs – Pitch.	±0.15°/s body pitch rate or ±20% of peak body pitch rate applied throughout the time history.	Approach or Landing.	Control inputs must be typical of minor corrections made while established on an ILS approach (approximately 0.5 to 2°/s pitch rate). Test in both directions. Show time history data from 5 s before until at least 5 s after initiation of control input. If a single test is used to demonstrate both directions, there must be a minimum of 5 s before			**X**	

				control reversal to the opposite direction. **CCA**: Test in normal and non-normal control state.				
2.b.5.	Small Control Inputs – Roll.	±0.15°/s body roll rate or ±20% of peak body roll rate applied throughout the time history.	Approach or landing.	Control inputs must be typical of minor corrections made while established on an ILS approach (approximately 0.5 to 2°/s roll rate). Test in one direction. For airplanes that exhibit non-symmetrical behavior, test in both directions. Show time history data from 5 s before until at least 5 s after initiation of control input. If a single test is used to demonstrate both directions, there must be a minimum of 5 s before control reversal to the opposite direction. **CCA**: Test in normal and non-normal control state.			**X**	
2.b.6.	Small Control Inputs – Yaw.	±0.15°/s body yaw rate or ±20% of peak body yaw rate applied throughout the time history.	Approach or landing.	Control inputs must be typical of minor corrections made while established on an ILS approach (approximately 0.5 to 2°/s yaw rate). Test in both directions. Show time history data from 5 s before until at least 5 s after initiation of control input. If a single test is used to demonstrate both directions, there must be a minimum of 5 s before control reversal to the opposite direction. **CCA:** Test in normal and non-normal control state.			**X**	
2.c.	**Longitudinal Control Tests.**							
	Power setting is that required for level flight unless otherwise specified.							
2.c.1.a.	Power Change Dynamics.	±3 kt airspeed. ±30 m (100 ft) altitude. ±1.5° or ±20% of pitch angle.	Approach.	Power change from thrust for approach or level flight to maximum continuous or go-around power. Time history of uncontrolled free response for a			**X**	

				time increment equal to at least 5 s before initiation of the power change to the completion of the power change + 15 s. **CCA:** Test in normal and non-normal control mode				
2.c.1.b.	Power Change Force.	±5 lb (2.2 daN) or, ±20% pitch control force.	Approach.	May be a series of snapshot test results. Power change dynamics test as described in test 2.c.1.a. will be accepted. **CCA:** Test in Normal and Non-normal control mode.	**X**	**X**		
2.c.2.a.	Flap/Slat Change Dynamics.	±3 kt airspeed. ±30 m (100 ft) altitude. ±1.5° or ±20% of pitch angle.	Takeoff through initial flap retraction, and approach to landing.	Time history of uncontrolled free response for a time increment equal to at least 5 s before initiation of the reconfiguration change to the completion of the reconfiguration change + 15 s. **CCA:** Test in normal and non-normal control mode			**X**	
2.c.2.b.	Flap/Slat Change Force.	±5 lb (2.2 daN) or, ±20% pitch control force.	Takeoff through initial flap retraction, and approach to landing.	May be a series of snapshot test results. Flap/Slat change dynamics test as described in test 2.c.2.a. will be accepted. **CCA:** Test in Normal and Non-normal control mode.	**X**	**X**		
2.c.3.	Spoiler/Speedbrake Change Dynamics.	±3 kt airspeed. ±30 m (100 ft) altitude. ±1.5° or ±20% of pitch angle.	Cruise.	Time history of uncontrolled free response for a time increment equal to at least 5 s before initiation of the configuration change to the completion of the configuration change +15 s. Results required for both extension and retraction. **CCA:** Test in normal and non-normal control mode			**X**	
2.c.4.a.	Gear Change Dynamics.	±3 kt airspeed. ±30 m (100 ft) altitude. ±1.5° or ±20% of pitch angle.	Takeoff (retraction), and Approach (extension).	Time history of uncontrolled free response for a time increment equal to at least 5 s before initiation of the configuration change to the completion of the configuration change + 15 s. **CCA:** Test in normal and non-normal control mode			**X**	
2.c.4.b.	Gear Change Force.	±5 lb (2.2 daN) or,	Takeoff (retraction) and	May be a series of snapshot test results. Gear	**X**	**X**		

		±20% pitch control force.	Approach (extension).	change dynamics test as described in test 2.c.4.a. will be accepted. **CCA:** Test in Normal and Non-normal control mode.				
2.c.5.	Longitudinal Trim.	±1° elevator angle. ±0.5° stabilizer or trim surface angle. ±1° pitch angle. ±5% of net thrust or equivalent.	Cruise, Approach, and Landing.	Steady-state wings level trim with thrust for level flight. This test may be a series of snapshot tests. Level 5 FTD may use equivalent stick and trim controllers in lieu of elevator and trim surface. **CCA**: Test in normal or non-normal control mode, as applicable.	**X**	**X**	**X**	
2.c.6.	Longitudinal Maneuvering Stability (Stick Force/g).	±2.2 daN (5 lbf) or ±10% of pitch controller force. Alternative method: ±1° or ±10% of the change of elevator angle.	Cruise, Approach, and Landing.	Continuous time history data or a series of snapshot tests may be used. Test up to approximately 30° of roll angle for approach and landing configurations. Test up to approximately 45° of roll angle for the cruise configuration. Force tolerance not applicable if forces are generated solely by the use of airplane hardware in the FTD. Alternative method applies to airplanes which do not exhibit stick-force-per-g characteristics. **CCA:** Test in normal or non-normal control mode		**X**	**X**	
2.c.7.	Longitudinal Static Stability.	±2.2 daN (5 lbf) or ±10% of pitch controller force. Alternative method: ±1° or ±10% of the change of elevator angle.	Approach.	Data for at least two speeds above and two speeds below trim speed. The speed range must be sufficient to demonstrate stick force versus speed characteristics. This test may be a series of snapshot tests. Force tolerance is not applicable if forces are generated solely by the use of airplane hardware in the FTD. Alternative method applies to airplanes which do not exhibit speed stability characteristics.	**X**	**X**	**X**	

				Level 5 must exhibit positive static stability, but need not comply with the numerical tolerance. **CCA:** Test in normal or non-normal control mode, as applicable.				
2.c.8.a.	Approach to Stall Characteristics	±3 kt airspeed for initial buffet, stall warning, and stall speeds. Control inputs must be plotted and demonstrate correct trend and magnitude. ±2.0° pitch angle ±2.0° angle of attack ±2.0° bank angle ±2.0° sideslip angle Additionally, for those simulators with reversible flight control systems: ±10% or ±5 lb (2.2 daN)) Stick/Column force (prior to “g break” only).	Second Segment Climb, High Altitude Cruise (Near Performance Limited Condition), and Approach or Landing	Each of the following stall entry methods must be demonstrated in at least one of the three required flight conditions: ▪ Stall entry at wings level (1g) ▪ Stall entry in turning flight of at least 25° bank angle (accelerated stall) ▪ Stall entry in a power-on condition (required only for turboprop aircraft) The required cruise condition must be conducted in a flaps-up (clean) configuration. The second segment climb and approach/landing conditions must be conducted at different flap settings. For airplanes that exhibit stall buffet as the first indication of a stall, for qualification of this task, the FTD must be equipped with a vibration system that meets the applicable subjective and objective requirements in Appendix A of this Part.			**X**	Tests may be conducted at centers of gravity typically required for airplane certification stall testing.
2.c.8.b.	Stall Warning (actuation of stall warning device.)	±3 kts. airspeed, ±2° bank for speeds greater than actuation of stall warning device or initial buffet.	Second Segment Climb, and Approach or Landing.	The stall maneuver must be entered with thrust at or near idle power and wings level (1g). Record the stall warning signal and initial buffet if applicable. **CCA:** Test in Normal and Non-normal control states.	**X**	**X**		
2.c.9.a.	Phugoid Dynamics.	±10% of period. ±10% of time to one half or double amplitude or ±0.02 of damping ratio.	Cruise.	Test must include three full cycles or that necessary to determine time to one half or double amplitude, whichever is less. **CCA:** Test in non-normal control mode.		**X**	**X**	
2.c.9.b.	Phugoid Dynamics.	±10% period, Representative damping.	Cruise.	The test must include whichever is less of the following: Three full cycles (six overshoots after the input is completed), or the number of cycles sufficient to determine representative damping.	**X**			

				CCA: Test in non-normal control mode.				
2.c.10	Short Period Dynamics.	±1.5° pitch angle or ±2°/s pitch rate. ±0.1 g normal acceleration	Cruise.	**CCA:** (Level 7 FTD) Test in normal and non-normal control mode. (Level 6 FTD) Test in non-normal control mode.		**X**	**X**	
2.c.11.	**(Reserved)**							
2.d.	**Lateral Directional Tests.**							
	Power setting is that required for level flight unless otherwise specified.							
2.d.1.	Minimum control speed, air (V_{mca}) or landing (V_{mcl}), per applicable airworthiness requirement or low speed engine-inoperative handling characteristics in the air.	±3 kt airspeed.	Takeoff or Landing (whichever is most critical in the airplane).	Takeoff thrust must be set on the operating engine(s). Time history or snapshot data may be used. **CCA**: Test in normal or non-normal control state, as applicable.			**X**	Minimum speed may be defined by a performance or control limit which prevents demonstration of V_{mca} or V_{mcl} in the conventional manner.
2.d.2.	Roll Response (Rate).	±2°/s or ±10% of roll rate. For airplanes with reversible flight control systems (Level 7 FTD only): ±1.3 daN (3 lbf) or ±10% of wheel force.	Cruise, and Approach or Landing.	Test with normal roll control displacement (approximately one-third of maximum roll controller travel). This test may be combined with step input of flight deck roll controller test 2.d.3.	**X**	**X**	**X**	
2.d.3.	Step input of flight deck roll controller.	±2° or ±10% of roll angle.	Approach or Landing.	This test may be combined with roll response (rate) test 2.d.2. **CCA:** (Level 7 FTD) Test in normal and non-normal control mode. (Level 6 FTD) Test in non-normal control mode.		**X**	**X**	With wings level, apply a step roll control input using approximately one-third of the roll controller travel. When reaching approximately 20° to 30° of bank, abruptly return the roll controller to neutral and allow approximately 10 seconds of airplane free response.
2.d.4.a.	Spiral Stability.	Correct trend and ±2° or ±10% of roll angle in 20 s.	Cruise, and Approach or Landing.	Airplane data averaged from multiple tests may be used.			**X**	

		If alternate test is used: correct trend and ±2° aileron angle.		Test for both directions. As an alternative test, show lateral control required to maintain a steady turn with a roll angle of approximately 30°. **CCA:** Test in non-normal control mode.				
2.d.4.b.	Spiral Stability.	Correct trend and ±3° or ±10% of roll angle in 20 s.	Cruise	Airplane data averaged from multiple tests may be used. Test for both directions. As an alternative test, show lateral control required to maintain a steady turn with a roll angle of approximately 30°. **CCA:** Test in non-normal control mode.		**X**		
2.d.4.c.	Spiral Stability.	Correct trend	Cruise	Airplane data averaged from multiple tests may be used. **CCA:** Test in non-normal control mode.	**X**			
2.d.5.	Engine Inoperative Trim.	±1° rudder angle or ±1° tab angle or equivalent rudder pedal. ±2° side-slip angle.	Second Segment Climb, and Approach or Landing.	This test may consist of snapshot tests.			**X**	Test should be performed in a manner similar to that for which a pilot is trained to trim an engine failure condition. 2nd segment climb test should be at takeoff thrust. Approach or landing test should be at thrust for level flight.
2.d.6.a.	Rudder Response.	±2°/s or ±10% of yaw rate.	Approach or Landing.	For Level 7 FTD: Test with stability augmentation on and off. Test with a step input at approximately 25% of full rudder pedal throw. Not required if rudder input and response is shown in Dutch Roll test (test 2.d.7). **CCA:** Test in normal and non-normal control mode		**X**	**X**	
2.d.6.b.	Rudder Response.	Roll rate ±2°/sec, bank angle ±3°.	Approach or Landing.	May be roll response to a given rudder deflection.	**X**			May be accomplished as a yaw response test, in which case the

				CCA: Test in Normal and Non-normal control states.				procedures and requirements of test 2.d.6.a. will apply.
2.d.7.	Dutch Roll	±0.5 s or ±10% of period. ±10% of time to one half or double amplitude or ±.02 of damping ratio. (Level 7 FTD only): ±1 s or ±20% of time difference between peaks of roll angle and side-slip angle.	Cruise, and Approach or Landing.	Test for at least six cycles with stability augmentation off. **CCA:** Test in non-normal control mode.		**X**	**X**	
2.d.8.	Steady State Sideslip.	For a given rudder position: ±2° roll angle; ±1° side-slip angle; ±2° or ±10% of aileron angle; and ±5° or ±10% of spoiler or equivalent roll controller position or force. For airplanes with reversible flight control systems (Level 7 FTD only): ±1.3 daN (3 lbf) or ±10% of wheel force. ±2.2 daN (5 lbf) or ±10% of rudder pedal force.	Approach or Landing.	This test may be a series of snapshot tests using at least two rudder positions (in each direction for propeller-driven airplanes), one of which must be near maximum allowable rudder. (Level 5 and Level 6 FTD only): Sideslip angle is matched only for repeatability and only on continuing qualification evaluations.	**X**	**X**	**X**	

2.e.	**Landings.**							
2.e.1.	Normal Landing.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±3 m (10 ft) or ±10% of height. For airplanes with reversible flight control systems: ±2.2 daN (5 lbf) or ±10% of column force.	Landing.	Test from a minimum of 61 m (200 ft) AGL to nosewheel touchdown. **CCA:** Test in normal and non-normal control mode, if applicable.			**X**	Two tests should be shown, including two normal landing flaps (if applicable) one of which should be near maximum certificated landing mass, the other at light or medium mass.
2.e.2.	Minimum Flap Landing.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±3 m (10 ft) or ±10% of height. For airplanes with reversible flight control systems: ±2.2 daN (5 lbf) or ±10% of column force.	Minimum Certified Landing Flap Configuration.	Test from a minimum of 61 m (200 ft) AGL to nosewheel touchdown. Test at near maximum certificated landing weight.			**X**	
2.e.3.	Crosswind Landing.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±3 m (10 ft) or ±10% of height. ±2° roll angle.	Landing.	Test from a minimum of 61 m (200 ft) AGL to a 50% decrease in main landing gear touchdown speed. It requires test data, including wind profile, for a crosswind component of at least 60% of airplane performance data value measured at 10 m (33 ft) above the runway. Wind components must be provided as headwind			**X**	In those situations where a maximum crosswind or a maximum demonstrated crosswind is not known, contact the NSPM.

		±2° side-slip angle. ±3° heading angle. For airplanes with reversible flight control systems: ±2.2 daN (5 lbf) or ±10% of column force. ±1.3 daN (3 lbf) or ±10% of wheel force. ±2.2 daN (5 lbf) or ±10% of rudder pedal force.		and crosswind values with respect to the runway.				
2.e.4.	One Engine Inoperative Landing.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±3 m (10 ft) or ±10% of height. ±2° roll angle. ±2° side-slip angle. ±3° heading angle.	Landing.	Test from a minimum of 61 m (200 ft) AGL to a 50% decrease in main landing gear touchdown speed.			**X**	
2.e.5.	Autopilot landing (if applicable).	±1.5 m (5 ft) flare height. ±0.5 s or ± 10% of Tf. ±0.7 m/s (140 ft/min) rate of descent at touchdown.	Landing.	If autopilot provides roll-out guidance, record lateral deviation from touchdown to a 50% decrease in main landing gear touchdown speed. Time of autopilot flare mode engage and main gear touchdown must be noted.			**X**	See Appendix F of this part for definition of T_f.

		±3 m (10 ft) lateral deviation during roll-out.						
2.e.6.	All-engine autopilot go-around.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA.	As per airplane performance data.	Normal all-engine autopilot go-around must be demonstrated (if applicable) at medium weight.			**X**	
2.e.7.	One engine inoperative go around.	±3 kt airspeed. ±1.5° pitch angle. ±1.5° AOA. ±2° roll angle. ±2° side-slip angle.	As per airplane performance data.	Engine inoperative go-around required near maximum certificated landing weight with critical engine inoperative. Provide one test with autopilot (if applicable) and one without autopilot. **CCA**: Non-autopilot test to be conducted in non-normal mode.			**X**	
2.e.8.	Directional control (rudder effectiveness) with symmetric reverse thrust.	±5 kt airspeed. ±2°/s yaw rate.	Landing.	Apply rudder pedal input in both directions using full reverse thrust until reaching full thrust reverser minimum operating speed.			**X**	
2.e.9.	Directional control (rudder effectiveness) with asymmetric reverse thrust.	±5 kt airspeed. ±3° heading angle.	Landing.	With full reverse thrust on the operating engine(s), maintain heading with rudder pedal input until maximum rudder pedal input or thrust reverser minimum operation speed is reached.			**X**	
2.f.	**Ground Effect.**							
	Test to demonstrate Ground Effect.	±1° elevator angle. ±0.5° stabilizer angle. ±5% of net thrust or equivalent. ±1° AOA. ±1.5 m (5 ft) or ±10% of height. ±3 kt airspeed. ±1° pitch angle.	Landing.	A rationale must be provided with justification of results. **CCA:** Test in normal or non-normal control mode, as applicable.			**X**	See paragraph on Ground Effect in this attachment for additional information.

2.g.	**Reserved**							
2.h.	**Flight Maneuver and Envelope Protection Functions.**							
	Note. — The requirements of 2.h are only applicable to computer-controlled airplanes. Time history results of response to control inputs during entry into each envelope protection function (i.e. with normal and degraded control states if their function is different) are required. Set thrust as required to reach the envelope protection function.							
2.h.1.	Overspeed.	±5 kt airspeed.	Cruise.				**X**	
2.h.2.	Minimum Speed.	±3 kt airspeed.	Takeoff, Cruise, and Approach or Landing.				**X**	
2.h.3.	Load Factor.	±0.1g normal load factor	Takeoff, Cruise.				**X**	
2.h.4.	Pitch Angle.	±1.5° pitch angle	Cruise, Approach.				**X**	
2.h.5.	Bank Angle.	±2° or ±10% bank angle	Approach.				**X**	
2.h.6.	Angle of Attack.	±1.5° angle of attack	Second Segment Climb, and Approach or Landing.				**X**	
3. Reserved								
4. Visual System.								
4.a.	**Visual scene quality**							
4.a.1.	Continuous cross-cockpit visual field of view.	Visual display providing each pilot with a minimum of 176° horizontal and 36° vertical continuous field of view.	Not applicable.	Required as part of MQTG but not required as part of continuing evaluations.			**X**	Field of view should be measured using a visual test pattern filling the entire visual scene (all channels) consisting of a matrix of black and white 5° squares. Installed alignment should be confirmed in an SOC (this would generally consist of results from acceptance testing).
4.a.2.	System Geometry	Geometry of image should have no distracting discontinuities.					**X**	
4.a.3	Surface resolution (object detection).	Not greater than 4 arc minutes.	Not applicable.				**X**	Resolution will be demonstrated by a test of objects shown to occupy the required visual angle in each visual display used on a scene from the pilot's eyepoint. The object will subtend 4 arc minutes to the eye. This may be demonstrated using threshold bars for a horizontal

								test. A vertical test should also be demonstrated. The subtended angles should be confirmed by calculations in an SOC.
4.a.4	Light point size.	Not greater than 8 arc minutes.	Not applicable.				**X**	Light point size should be measured using a test pattern consisting of a centrally located single row of white light points displayed as both a horizontal and vertical row. It should be possible to move the light points relative to the eyepoint in all axes. At a point where modulation is just discernible in each visual channel, a calculation should be made to determine the light spacing. An SOC is required to state test method and calculation.
4.a.5	Raster surface contrast ratio.	Not less than 5:1.	Not applicable.				**X**	Surface contrast ratio should be measured using a raster drawn test pattern filling the entire visual scene (all channels). The test pattern should consist of black and white squares, 5° per square, with a white square in the center of each channel. Measurement should be made on the center bright square for each channel using a 1° spot photometer. This value should have a minimum brightness of 7 cd/m^2 (2 ft-lamberts). Measure any adjacent dark squares.

								The contrast ratio is the bright square value divided by the dark square value. *Note 1. — During contrast ratio testing, FTD aft-cab and flight deck ambient light levels should be as low as possible.* *Note 2. — Measurements should be taken at the center of squares to avoid light spill into the measurement device.*
4.a.6	Light point contrast ratio.	Not less than 10:1.	Not applicable.				**X**	Light point contrast ratio should be measured using a test pattern demonstrating an area of greater than 1° area filled with white light points and should be compared to the adjacent background. *Note. — Light point modulation should be just discernible on calligraphic systems but will not be discernable on raster systems.* Measurements of the background should be taken such that the bright square is just out of the light meter FOV. *Note. — During contrast ratio testing, FTD aft-cab and flight deck ambient light levels should be as low as practical.*
4.a.7	Light point brightness.	Not less than 20 cd/m^2 (5.8 ft-lamberts).	Not applicable.				**X**	Light points should be displayed as a matrix creating a square. On calligraphic systems the light points should just merge.

								On raster systems the light points should overlap such that the square is continuous (individual light points will not be visible).
4.a.8	Surface brightness.	Not less than 14 cd/m^2 (4.1 ft-lamberts) on the display.	Not applicable.				**X**	Surface brightness should be measured on a white raster, measuring the brightness using the 1° spot photometer. Light points are not acceptable. Use of calligraphic capabilities to enhance raster brightness is acceptable.
4.b	**Head-Up Display (HUD)**							
4.b.1	Static Alignment.	Static alignment with displayed image. HUD bore sight must align with the center of the displayed image spherical pattern. Tolerance +/- 6 arc min.					**X**	Alignment requirement only applies to the pilot flying.
4.b.2	System display.	All functionality in all flight modes must be demonstrated.					**X**	A statement of the system capabilities should be provided and the capabilities demonstrated
4.b.3	HUD attitude versus FTD attitude indicator (pitch and roll of horizon).	Pitch and roll align with aircraft instruments.	Flight				**X**	Alignment requirement only applies to the pilot flying.
4.c	**Enhanced Flight Vision System (EFVS)**							
4.c.1	Registration test.	Alignment between EFVS display and out of the window image must represent the alignment typical of the aircraft	Takeoff point and on approach at 200 ft.				**X**	Alignment requirement only applies to the pilot flying. *Note.— The effects of the alignment tolerance in 4.b.1*

		and system type.						*should be taken into account.*
4.c.2	EFVS RVR and visibility calibration.	The scene represents the EFVS view at 350 m (1,200 ft) and 1,609 m (1 sm) RVR including correct light intensity.	Flight				**X**	Infra-red scene representative of both 350 m (1,200 ft), and 1,609 m (1 sm) RVR. Visual scene may be removed.
4.c.3	Thermal crossover.	Demonstrate thermal crossover effects during day to night transition.	Day and night				**X**	The scene will correctly represent the thermal characteristics of the scene during a day to night transition.
4.d	**Visual ground segment**							
4.d.1	Visual ground segment (VGS).	Near end: the correct number of approach lights within the computed VGS must be visible. Far end: ±20% of the computed VGS. The threshold lights computed to be visible must be visible in the FTD.	Trimmed in the landing configuration at 30 m (100 ft) wheel height above touchdown zone on glide slope at an RVR setting of 300 m (1,000 ft) or 350 m (1,200 ft).	This test is designed to assess items impacting the accuracy of the visual scene presented to a pilot at DH on an ILS approach. These items include: 1) RVR/Visibility; 2) glide slope (G/S) and localizer modeling accuracy (location and slope) for an ILS; 3) for a given weight, configuration and speed representative of a point within the airplane's operational envelope for a normal approach and landing; and 4) Radio altimeter. *Note. — If non-homogeneous fog is used, the vertical variation in horizontal visibility should be described and included in the slant range visibility calculation used in the VGS computation.*			**X**	Pre-position for this test is encouraged but may be achieved via manual or autopilot control to the desired position.
4.e	**Visual System Capacity**							
4.e.1	System capacity – Day mode.	Not less than: 10,000 visible textured surfaces, 6,000 light points, 16 moving models.	Not applicable				**X**	Demonstrated through use of a visual scene rendered with the same image generator modes used to produce scenes for training. The required surfaces, light points, and moving models

								should be displayed simultaneously.
4.e.2	System capacity – Twilight/night mode.	Not less than: 10,000 visible textured surfaces, 15,000 light points, 16 moving models.	Not applicable				**X**	Demonstrated through use of a visual scene rendered with the same image generator modes used to produce scenes for training. The required surfaces, light points, and moving models should be displayed simultaneously.
5. Sound System. The sponsor will not be required to repeat the operational sound tests (i.e., tests 5.a.1. through 5.a.8. (or 5.b.1. through 5.b.9.) and 5.c., as appropriate) during continuing qualification evaluations if frequency response and background noise test results are within tolerance when compared to the initial qualification evaluation results, and the sponsor shows that no software changes have occurred that will affect the FTD's sound system. If the frequency response test method is chosen and fails, the sponsor may elect to fix the frequency response problem and repeat the test or the sponsor may elect to repeat the operational sound tests. If the operational sound tests are repeated during continuing qualification evaluations, the results may be compared against initial qualification evaluation results. All tests in this section must be presented using an unweighted 1/3-octave band format from band 17 to 42 (50 Hz to 16 kHz). A minimum 20 second average must be taken at a common location from where the initial evaluation sound results were gathered.								
5.a.	**Turbo-jet airplanes.**							All tests in this section should be presented using an unweighted 1/3-octave band format from at least band 17 to 42 (50 Hz to 16 kHz). A measurement of minimum 20 s should be taken at the location corresponding to the approved data set. Refer to paragraph 7 of Appendix A, Attachment 2.
5.a.1.	Ready for engine start.	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the	Ground.	Normal condition prior to engine start. The APU must be on if appropriate.			**X**	

		average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.						
5.a.2.	All engines at idle.	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Ground.	Normal condition prior to takeoff.			**X**	
5.a.3.	All engines at maximum allowable thrust with brakes set.	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Ground.	Normal condition prior to takeoff.			**X**	
5.a.4.	Climb	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the	En-route climb.	Medium altitude.			**X**	

		average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.						
5.a.5.	Cruise	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Cruise.	Normal cruise configuration.			**X**	
5.a.6.	Speed brake/spoilers extended (as appropriate).	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Cruise.	Normal and constant speed brake deflection for descent at a constant airspeed and power setting.			**X**	
5.a.7	Initial approach.	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the	Approach.	Constant airspeed, gear up, flaps/slats as appropriate.			**X**	

		average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.						
5.a.8	Final approach.	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Landing.	Constant airspeed, gear down, landing configuration flaps.			**X**	
5.b	**Propeller-driven airplanes**							All tests in this section should be presented using an unweighted 1/3-octave band format from at least band 17 to 42 (50 Hz to 16 kHz). A measurement of minimum 20 s should be taken at the location corresponding to the approved data set. Refer to paragraph 7 of Appendix A, Attachment 2.
5.b.1.	Ready for engine start.	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute	Ground.	Normal condition prior to engine start. The APU must be on if appropriate.			**X**	

		differences between initial and recurrent evaluation results cannot exceed 2 dB.						
5.b.2	All propellers feathered, if applicable.	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Ground.	Normal condition prior to take-off.			**X**	
5.b.3.	Ground idle or equivalent.	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Ground.	Normal condition prior to takeoff.			**X**	
5.b.4	Flight idle or equivalent.	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute	Ground.	Normal condition prior to takeoff.			**X**	

		differences between initial and recurrent evaluation results cannot exceed 2 dB.						
5.b.5	All engines at maximum allowable power with brakes set.	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Ground.	Normal condition prior to takeoff.			**X**	
5.b.6	Climb.	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	En-route climb.	Medium altitude.			**X**	
5.b.7	Cruise	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute	Cruise.	Normal cruise configuration.			**X**	

		differences between initial and recurrent evaluation results cannot exceed 2 dB.						
5.b.8	Initial approach.	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Approach.	Constant airspeed, gear up, flaps extended as appropriate, RPM as per operating manual.			**X**	
5.b.9	Final approach.	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.	Landing.	Constant airspeed, gear down, landing configuration flaps, RPM as per operating manual.			**X**	
5.c.	**Special cases.**	Initial evaluation: Subjective assessment of 1/3 octave bands. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute	As appropriate.				**X**	This applies to special steady-state cases identified as particularly significant to the pilot, important in training, or unique to a specific airplane type or model.

		differences between initial and recurrent evaluation results cannot exceed 2 dB.						
5.d	**FTD background noise**	Initial evaluation: background noise levels must fall below the sound levels described in Appendix A, Attachment 2, Paragraph 7.c (5). Recurrent evaluation: ±3 dB per 1/3 octave band compared to initial evaluation.		Results of the background noise at initial qualification must be included in the QTG document and approved by the NSPM. The measurements are to be made with the simulation running, the sound muted and a dead cockpit.			**X**	The simulated sound will be evaluated to ensure that the background noise does not interfere with training. Refer to paragraph 7 of this Appendix A, Attachment 2. This test should be presented using an unweighted 1/3 octave band format from band 17 to 42 (50 Hz to 16 kHz).
5.e	**Frequency response**	Initial evaluation: not applicable. Recurrent evaluation: cannot exceed ±5 dB difference on three consecutive bands when compared to initial evaluation and the average of the absolute differences between initial and recurrent evaluation results cannot exceed 2 dB.					**X**	Only required if the results are to be used during continuing qualification evaluations in lieu of airplane tests. The results must be approved by the NSPM during the initial qualification. This test should be presented using an unweighted 1/3 octave band format from band 17 to 42 (50 Hz to 16 kHz).
6	**SYSTEMS INTEGRATION**							
6.a.	**System response time**							
6.a.1	Transport delay.	Instrument response: 100 ms (or less) after airplane response. Visual system response: 120 ms (or less) after airplane response.	Pitch, roll and yaw.				**X**	One separate test is required in each axis. Where EFVS systems are installed, the EFVS response should be within + or - 30 ms from visual system response,

* * * * *

								and not before motion system response. *Note.— The delay from the airplane EFVS electronic elements should be added to the 30 ms tolerance before comparison with visual system reference.*
6.a.2	Transport delay.	300 milliseconds or less after controller movement.	Pitch, roll and yaw.		**X**	**X**		If transport delay is the chosen method to demonstrate relative responses, the sponsor and the NSPM will use the latency values to ensure proper FTD response when reviewing those existing tests where latency can be identified (e.g., short period, roll response, rudder response).

1.	**Performance.**	
1.c	**Climb.**	
1.c.1.	Normal climb with nominal gross weight, at best rate-of-climb airspeed.	Climb rate = 500 - 1200 fpm (2.5 - 6 m/sec).
1.f.	**Engines.**	
1.f.1.	Acceleration; idle to takeoff power.	2 - 4 Seconds.
1.f.2.	Deceleration; takeoff power to idle.	2 - 4 Seconds.
2.	**Handling Qualities.**	
2.c.	**Longitudinal Tests.**	
2.c.1.	Power change force.	
	(a) Trim for straight and level flight at 80% of normal cruise airspeed with necessary power. Reduce power to flight idle. Do not change trim or configuration. After stabilized, record column force necessary to maintain original airspeed.	5 - 15 lbs (2.2 - 6.6 daN) of force (Push).
	OR	
	(b) Trim for straight and level flight at 80 percent of normal cruise airspeed with necessary power. Add power to maximum setting. Do not change trim or configuration. After stabilized, record column force necessary to maintain original airspeed.	5 - 15 lbs (2.2 - 6.6 daN) of force (Pull).
2.c.2.	Flap/slat change force.	
	(a) Trim for straight and level flight with flaps fully retracted at a constant airspeed within the flaps-extended airspeed range. Do not adjust trim or power. Extend the flaps to 50 percent of full flap travel. After stabilized, record stick force necessary to maintain original airspeed.	5 - 15 lbs (2.2 - 6.6 daN) of force (Push).
	OR	
	b) Trim for straight and level flight with flaps extended to 50% of full flap travel, at a constant airspeed within the flaps-extended airspeed range. Do not adjust trim or power. Retract the flaps to zero. After stabilized, record stick force necessary to maintain original airspeed.	5 - 15 lbs (2.2 - 6.6 daN) of force (Pull).
2.c.4.	Gear change force.	

	(a) Trim for straight and level flight with landing gear retracted at a constant airspeed within the landing gear-extended airspeed range. Do not adjust trim or power. Extend the landing gear. After stabilized, record stick force necessary to maintain original airspeed.	2 - 12 lbs (0.88 - 5.3 daN) of force (Push).
	OR	
	(b) Trim for straight and level flight with landing gear extended, at a constant airspeed within the landing gear-extended airspeed range. Do not adjust trim or power. Retract the landing gear. After stabilized, record stick force necessary to maintain original airspeed.	2 - 12 lbs (0.88 - 5.3 daN) of force (Pull).
2.c.5.	Longitudinal trim.	Must be able to trim longitudinal stick force to “zero” in each of the following configurations: cruise; approach; and landing.
2.c.7.	Longitudinal static stability.	Must exhibit positive static stability.
2.c.8.	Stall warning (actuation of stall warning device) with nominal gross weight; wings level; and a deceleration rate of not more than three (3) knots per second.	
	a) Landing configuration.	40 - 60 knots; ± 5° of bank.
	b) Clean configuration.	Landing configuration speed + 10 - 20%.
2.c.9.b.	Phugoid dynamics.	Must have a phugoid with a period of 30 - 60 seconds. May not reach ½ or double amplitude in less than 2 cycles.
2.d.	**Lateral Directional Tests.**	
2.d.2.	Roll response (rate). Roll rate must be measured through at least 30 degree of roll. Aileron control must be deflected 1/3 (33.3 percent) of maximum travel.	Must have a roll rate of 4° - 25°/second.
2.d.4.b.	Spiral stability. Cruise configuration and normal cruise airspeed. Establish a 20 degree - 30 degree bank. When stabilized, neutralize the aileron control and release. Must be completed in both directions of turn.	Initial bank angle (± 5°) after 20 seconds.
2.d.6.b.	Rudder response. Use 25 percent of maximum rudder deflection. (Applicable to approach or landing configuration.)	2° - 6° /second yaw rate.
2.d.8.	Steady state sideslip. Use 50 percent rudder deflection. (Applicable to approach and landing configurations.)	2 percent – 10 percent of bank; 4 percent - 10 percent of sideslip; and 2 percent -10 percent of aileron.

6.	FTD System Response Time.	
6.a.	Flight deck instrument systems response to an abrupt pilot controller input. One test is required in each axis (pitch, roll, yaw).	300 milliseconds or less.

1.	**Performance.**	
1.c	**Climb.**	
1.c.1.	Normal climb with nominal gross weight, at best rate-of-climb airspeed.	Climb airspeed = 95 – 115 knots. Climb rate = 500 – 1500 fpm (2.5 – 7.5 m/sec)
1.f.	**Engines.**	
1.f.1.	Acceleration; idle to takeoff power.	2 - 5 Seconds.
1.f.2.	Deceleration; takeoff power to idle.	2 - 5 Seconds.
2.	**Handling Qualities.**	
2.c.	**Longitudinal Tests.**	
2.c.1.	Power change force.	
	(a) Trim for straight and level flight at 80 percent of normal cruise airspeed with necessary power. Reduce power to flight idle. Do not change trim or configuration. After stabilized, record column force necessary to maintain original airspeed.	10 - 25 lbs (2.2 - 6.6 daN) of force (Push).
	OR	
	(b) Trim for straight and level flight at 80 percent of normal cruise airspeed with necessary power. Add power to maximum setting. Do not change trim or configuration. After stabilized, record column force necessary to maintain original airspeed.	5 - 15 lbs (2.2 - 6.6 daN) of force (Pull).
2.c.2.	Flap/slat change force.	
	(a) Trim for straight and level flight with flaps fully retracted at a constant airspeed within the flaps-extended airspeed range. Do not adjust trim or power. Extend the flaps to 50 percent of full flap travel. After stabilized, record stick force necessary to maintain original airspeed.	5 - 15 lbs (2.2 - 6.6 daN) of force (Push).
	OR	
	(b) Trim for straight and level flight with flaps extended to 50 percent of full flap travel, at a constant airspeed within the flaps-extended airspeed range. Do not adjust trim or power. Retract the flaps to zero. After stabilized, record stick force necessary to maintain original airspeed.	5 - 15 lbs (2.2 - 6.6 daN) of force (Pull).
2.c.4.	Gear change force.	

	(a) Trim for straight and level flight with landing gear retracted at a constant airspeed within the landing gear-extended airspeed range. Do not adjust trim or power. Extend the landing gear. After stabilized, record stick force necessary to maintain original airspeed.	2 - 12 lbs (0.88 - 5.3 daN) of force (Push).
	OR	
	(b) Trim for straight and level flight with landing gear extended, at a constant airspeed within the landing gear-extended airspeed range. Do not adjust trim or power. Retract the landing gear. After stabilized, record stick force necessary to maintain original airspeed.	2 - 12 lbs (0.88 - 5.3 daN) of force (Pull).
2.c.5.	Longitudinal trim.	Must be able to trim longitudinal stick force to “zero” in each of the following configurations: cruise; approach; and landing.
2.c.7.	Longitudinal static stability.	Must exhibit positive static stability.
2.c.8.	Stall warning (actuation of stall warning device) with nominal gross weight; wings level; and a deceleration rate of not more than three (3) knots per second.	
	(a) Landing configuration.	60 - 90 knots; ± 5 degree of bank.
	(b) Clean configuration.	Landing configuration speed + 10 - 20%.
2.c.9.b.	Phugoid dynamics.	Must have a phugoid with a period of 30 - 60 seconds. May not reach ½ or double amplitude in less than 2 cycles.
2.d.	**Lateral Directional Tests.**	
2.d.2.	Roll response. Roll rate must be measured through at least 30 degree of roll. Aileron control must be deflected 1/3 (33.3 percent) of maximum travel.	Must have a roll rate of 4- 25 degree /second.
2.d.4.b.	Spiral stability. Cruise configuration and normal cruise airspeed. Establish a 20 degree – 30 degree bank. When stabilized, neutralize the aileron control and release. Must be completed in both directions of turn.	Initial bank angle (± 5 degree) after 20 seconds.
2.d.6.b.	Rudder response. Use 25 percent of maximum rudder deflection. (Applicable to approach or landing configuration.)	3 - 6 degree /second yaw rate.
2.d.8.	Steady state sideslip.	2 - 10 degree of bank; 4 - 10 degrees of sideslip; and

	Use 50 percent rudder deflection. (Applicable to approach and landing configurations.)	2 - 10 degree of aileron.
6.	**FTD System Response Time.**	
6.a.	Flight deck instrument systems response to an abrupt pilot controller input. One test is required in each axis (pitch, roll, yaw).	300 milliseconds or less.

1.	**Performance.**	
1.c	**Climb.**	
1.c.1.	Normal climb with nominal gross weight, at best rate-of-climb airspeed.	Climb airspeed = 95 – 115 knots. Climb rate = 800 – 1800 fpm (4 - 9 m/sec)
1.f.	**Engines.**	
1.f.1.	Acceleration; idle to takeoff power.	4 - 8 Seconds.
1.f.2.	Deceleration; takeoff power to idle.	3 - 7 Seconds.
2.	**Handling Qualities.**	
2.c.	**Longitudinal Tests.**	
2.c.1.	Power change force.	
	a) Trim for straight and level flight at 80 percent of normal cruise airspeed with necessary power. Reduce power to flight idle. Do not change trim or configuration. After stabilized, record column force necessary to maintain original airspeed.	8 lbs (3.5 daN) of Push force – 8 lbs (3.5 daN) of Pull force.
	OR	
	b) Trim for straight and level flight at 80 percent of normal cruise airspeed with necessary power. Add power to maximum setting. Do not change trim or configuration. After stabilized, record column force necessary to maintain original airspeed.	12 - 22 lbs (5.3 – 9.7 daN) of force (Pull).
2.c.2.	Flap/slat change force.	
	a) Trim for straight and level flight with flaps fully retracted at a constant airspeed within the flaps-extended airspeed range. Do not adjust trim or power. Extend the flaps to 50 percent of full flap travel. After stabilized, record stick force necessary to maintain original airspeed.	5 - 15 lbs (2.2 - 6.6 daN) of force (Push).
	OR	
	b) Trim for straight and level flight with flaps extended to 50 percent of full flap travel, at a constant airspeed within the flaps-extended airspeed range. Do not adjust trim or power. Retract the flaps to zero. After stabilized, record stick force necessary to maintain original airspeed.	5 - 15 lbs (2.2 - 6.6 daN) of force (Pull).
2.c.4.	Gear change force.	

	a) Trim for straight and level flight with landing gear retracted at a constant airspeed within the landing gear-extended airspeed range. Do not adjust trim or power. Extend the landing gear. After stabilized, record stick force necessary to maintain original airspeed.	2 - 12 lbs (0.88 - 5.3 daN) of force (Push).
	OR	
	b) Trim for straight and level flight with landing gear extended, at a constant airspeed within the landing gear-extended airspeed range. Do not adjust trim or power. Retract the landing gear. After stabilized, record stick force necessary to maintain original airspeed.	2 - 12 lbs (0.88 - 5.3 daN) of force (Pull).
2.c.5.	Longitudinal trim.	Must be able to trim longitudinal stick force to “zero” in each of the following configurations: cruise; approach; and landing.
2.c.7.	Longitudinal static stability.	Must exhibit positive static stability.
2.c.8.	Stall warning (actuation of stall warning device) with nominal gross weight; wings level; and a deceleration rate of not more than three (3) knots per second.	
	a) Landing configuration.	60 - 90 knots; ± 5 degree of bank.
	b) Clean configuration.	Landing configuration speed + 10 - 20 percent.
2.c.9.b.	Phugoid dynamics.	Must have a phugoid with a period of 30 - 60 seconds. May not reach ½ or double amplitude in less than 2 cycles.
2.d.	**Lateral Directional Tests.**	
2.d.2.	Roll response. Roll rate must be measured through at least 30° of roll. Aileron control must be deflected 1/3 (33.3 percent) of maximum travel.	Must have a roll rate of 4 - 25 degree /second.
2.d.4.c.	Spiral stability. Cruise configuration and normal cruise airspeed. Establish a 20° - 30° bank. When stabilized, neutralize the aileron control and release. Must be completed in both directions of turn.	Initial bank angle (± 5 degree) after 20 seconds.
2.d.6.b.	Rudder response. Use 25 percent of maximum rudder deflection. (Applicable to approach or landing configuration.)	3 - 6 degree /second yaw rate.
2.d.8.	Steady state sideslip. Use 50 percent rudder deflection. (Applicable to approach and landing configurations.)	2 - 10 degree of bank; 4 - 10 degree of sideslip; and 2 - 10 degree of aileron.
6.	**FTD System Response Time.**	

6.a.	Flight deck instrument systems response to an abrupt pilot controller input. One test is required in each axis (pitch, roll, yaw).	300 milliseconds or less.

1.	**Performance.**	
1.c	**Climb.**	
1.b.1.	Normal climb with nominal gross weight, at best rate-of-climb airspeed.	Climb airspeed = 120 – 140 knots. Climb rate = 1000 – 3000 fpm (5 - 15 m/sec)
1.f.	**Engines.**	
1.f.1.	Acceleration; idle to takeoff power.	2 - 6 Seconds.
1.f.2.	Deceleration; takeoff power to idle.	1 - 5 Seconds.
2.	**Handling Qualities.**	
2.c.	**Longitudinal Tests.**	
2.c.1.	Power change force.	
	a) Trim for straight and level flight at 80 percent of normal cruise airspeed with necessary power. Reduce power to flight idle. Do not change trim or configuration. After stabilized, record column force necessary to maintain original airspeed.	8 lbs (3.5 daN) of Push force to 8 lbs (3.5 daN) of Pull force.
	OR	
	b) Trim for straight and level flight at 80 percent of normal cruise airspeed with necessary power. Add power to maximum setting. Do not change trim or configuration. After stabilized, record column force necessary to maintain original airspeed.	12 - 22 lbs (5.3 – 9.7 daN) of force (Pull).
2.c.2.	Flap/slat change force.	
	a) Trim for straight and level flight with flaps fully retracted at a constant airspeed within the flaps-extended airspeed range. Do not adjust trim or power. Extend the flaps to 50 percent of full flap travel. After stabilized, record stick force necessary to maintain original airspeed.	5 - 15 lbs (2.2 - 6.6 daN) of force (Push).
	OR	
	b) Trim for straight and level flight with flaps extended to 50 percent of full flap travel, at a constant airspeed within the flaps-extended airspeed range. Do not adjust trim or power. Retract the flaps to zero. After stabilized, record stick force necessary to maintain original airspeed.	5 - 15 lbs (2.2 - 6.6 daN) of force (Pull).
2.c.4.	Gear change force.	

	a) Trim for straight and level flight with landing gear retracted at a constant airspeed within the landing gear-extended airspeed range. Do not adjust trim or power. Extend the landing gear. After stabilized, record stick force necessary to maintain original airspeed.	2 - 12 lbs (0.88 - 5.3 daN) of force (Push).
	OR	
	b) Trim for straight and level flight with landing gear extended, at a constant airspeed within the landing gear-extended airspeed range. Do not adjust trim or power. Retract the landing gear. After stabilized, record stick force necessary to maintain original airspeed.	2 - 12 lbs (0.88 - 5.3 daN) of force (Pull).
2.c.5.	Longitudinal trim.	Must be able to trim longitudinal stick force to “zero” in each of the following configurations: cruise; approach; and landing.
2.c.7.	Longitudinal static stability.	Must exhibit positive static stability.
2.c.8.	Stall warning (actuation of stall warning device) with nominal gross weight; wings level; and a deceleration rate of not more than three (3) knots per second.	
	a) Landing configuration.	80 - 100 knots; ± 5° of bank.
	b) Clean configuration.	Landing configuration speed + 10 - 20 percent.
2.c.9.b.	Phugoid dynamics.	Must have a phugoid with a period of 30 - 60 seconds. May not reach ½ or double amplitude in less than 2 cycles.
2.d.	**Lateral Directional Tests.**	
2.d.2.	Roll response. Roll rate must be measured through at least 30 degree of roll. Aileron control must be deflected 1/3 (33.3 percent) of maximum travel.	Must have a roll rate of 4 - 25 degree /second.
2.d.4.b.	Spiral stability. Cruise configuration and normal cruise airspeed. Establish a 20 - 30 dgree bank. When stabilized, neutralize the aileron control and release. Must be completed in both directions of turn.	Initial bank angle (± 5°) after 20 seconds.
2.d.6.b.	Rudder response. Use 25 percent of maximum rudder deflection. (Applicable to approach or landing configuration.)	3 - 6 degree /second yaw rate.
2.d.8.	Steady state sideslip. Use 50 percent rudder deflection.	2 - 10 degree of bank; 4 - 10 degree of sideslip; and

	(Applicable to approach and landing configurations.)	2 -10 degree of aileron.
6.	**FTD System Response Time.**	
6.a.	Flight deck instrument systems response to an abrupt pilot controller input. One test is required in each axis (pitch, roll, yaw).	300 milliseconds or less.

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■ 16. Amend Attachment 3 to Appendix B by adding Tables B3D, B3E, B3F, and B3G to read as follows:

Appendix B to Part 60—Qualification Performance Standards for Airplane Flight Training Devices

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Attachment 3 to Appendix B to Part 60—Flight Training Device (FTD) Subjective Evaluation

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	Tasks in this table are subject to evaluation if appropriate for the airplane simulated as indicated in the SOQ Configuration List or the level of FTD qualification involved. Items not installed or not functional on the FTD and, therefore, not appearing on the SOQ Configuration List, are not required to be listed as exceptions on the SOQ.
1.	**Preparation For Flight**
1.a.	**Pre-flight.** Accomplish a functions check of all switches, indicators, systems, and equipment at all crew members' and instructors' stations and determine that:
1.a.1	The flight deck design and functions are identical to that of the airplane simulated.
2.	**Surface Operations (pre-flight).**
2.a.	**Engine Start.**
2.a.1.	Normal start.
2.a.2.	Alternate start procedures.
2.a.3.	Abnormal starts and shutdowns (e.g., hot/hung start, tail pipe fire).
2.b.	**Taxi.**
2.b.1	Pushback/powerback
2.b.2.	Thrust response.
2.b.3.	Power lever friction.
2.b.4.	Ground handling.
2.b.5.	Reserved
2.b.6.	Taxi aids (e.g. taxi camera, moving map)
2.b.7.	Low visibility (taxi route, signage, lighting, markings, etc.)
2.c.	**Brake Operation**
2.c.1.	Brake operation (normal and alternate/emergency).
2.c.2.	Brake fade (if applicable).
3.	**Take-off.**
3.a.	**Normal.**
3.a.1.	Airplane/engine parameter relationships, including run-up.
3.a.2.	Nosewheel and rudder steering.
3.a.3.	Crosswind (maximum demonstrated and gusting crosswind).
3.a.4.	Special performance
3.a.4.a	Reduced V_1
3.a.4.b	Maximum engine de-rate.
3.a.4.c	Soft surface.
3.a.4.d	Short field/short take-off and landing (STOL) operations.
3.a.4.e	Obstacle (performance over visual obstacle).
3.a.5.	Low visibility take-off.
3.a.6.	Landing gear, wing flap leading edge device operation.
3.a.7.	Contaminated runway operation.
3.b.	Abnormal/emergency.
3.b.1.	Rejected Take-off.
3.b.2.	Rejected special performance (e.g., reduced V_1, max de-rate, short field operations).
3.b.3.	Rejected take-off with contaminated runway.

3.b.4.	Takeoff with a propulsion system malfunction (allowing an analysis of causes, symptoms, recognition, and the effects on aircraft performance and handling) at the following points: . (iii) Prior to V1 decision speed. (iv) Between V1 and Vr (rotation speed). (iii)Between Vr and 500 feet above ground level.
3.b.5.	Flight control system failures, reconfiguration modes, manual reversion and associated handling.
4.	**Climb.**
4.a.	Normal.
4.b.	One or more engines inoperative.
4.c.	Approach climb in icing (for airplanes with icing accountability).
5.	**Cruise.**
5.a.	**Performance characteristics (speed vs. power, configuration, and attitude)**
5.a.1.	Straight and level flight.
5.a.2.	Change of airspeed.
5.a.3.	High altitude handling.
5.a.4.	High Mach number handling (Mach tuck, Mach buffet) and recovery (trim change).
5.a.5.	Overspeed warning (in excess of V_{mo} or M_{mo}).
5.a.6.	High IAS handling.
5.b.	**Maneuvers.**
5.b.1.	High Angle of Attack
5.b.1.a	High angle of attack, approach to stalls, stall warning, and stall buffet (take-off, cruise, approach, and landing configuration) including reaction of the autoflight system and stall protection system.
5.b.1.b	Reserved
5.b.2.	Slow flight
5.b.3.	Reserved
5.b.4.	Flight envelope protection (high angle of attack, bank limit, overspeed, etc.).
5.b.5.	Turns with/without speedbrake/spoilers deployed.
5.b.6.	Normal and standard rate turns.
5.b.7.	Steep turns
5.b.8.	Performance turn
5.b.9.	In flight engine shutdown and restart (assisted and windmill).
5.b.10.	Maneuvering with one or more engines inoperative, as appropriate.
5.b.11.	Specific flight characteristics (e.g., direct lift control).
5.b.12.	Flight control system failures, reconfiguration modes, manual reversion and associated handling.
5.b.13	Gliding to a forced landing.
5.b.14	Visual resolution and FSTD handling and performance for the following (where applicable by aircraft type and training program):
5.b.14.a	Terrain accuracy for forced landing area selection.
5.b.14.b	Terrain accuracy for VFR Navigation.
5.b.14.c	Eights on pylons (visual resolution).
5.b.14.d	Turns about a point.
5.b.14.e	S-turns about a road or section line.
6.	**Descent.**
6.a.	Normal.

6.b.	Maximum rate/emergency (clean and with speedbrake, etc.).
6.c.	With autopilot.
6.d.	Flight control system failures, reconfiguration modes, manual reversion and associated handling.
7.	**Instrument Approaches And Landing.** Those instrument approach and landing tests relevant to the simulated airplane type are selected from the following list. Some tests are made with limiting wind velocities, under windshear conditions, and with relevant system failures, including the failure of the Flight Director. If Standard Operating Procedures allow use autopilot for non-precision approaches, evaluation of the autopilot will be included.
7.a.	**Precision approach**
7.a.1	CAT I published approaches.
7.a.1.a	Manual approach with/without flight director including landing.
7.a.1.b	Autopilot/autothrottle coupled approach and manual landing.
7.a.1.c	Autopilot/autothrottle coupled approach, engine(s) inoperative.
7.a.1.d	Manual approach, engine(s) inoperative.
7.a.1.e	HUD/EFVS
7.a.2	CAT II published approaches.
7.a.2.a	Autopilot/autothrottle coupled approach to DH and landing (manual and autoland).
7.a.2.b	Autopilot/autothrottle coupled approach with one-engine-inoperative approach to DH and go-around (manual and autopilot).
7.a.2.c	HUD/EFVS
7.a.3	CAT III published approaches.
7.a.3.a	Autopilot/autothrottle coupled approach to landing and roll-out (if applicable) guidance (manual and autoland).
7.a.3.b	Autopilot/autothrottle coupled approach to DH and go-around (manual and autopilot).
7.a.3.c	Autopilot/autothrottle coupled approach to land and roll-out (if applicable) guidance with one engine inoperative (manual and autoland).
7.a.3.d	Autopilot/autothrottle coupled approach to DH and go-around with one engine inoperative (manual and autopilot).
7.a.3.e	HUD/EFVS
7.a.4	Autopilot/autothrottle coupled approach (to a landing or to a go-around):
7.a.4.a	With generator failure.
7.a.4.b.1	With maximum tail wind component certified or authorized.
7.a.4.b.2	Reserved
7.a.4.c.1	With maximum crosswind component demonstrated or authorized.
7.a.4.c.2	Reserved
7.a.5	PAR approach, all engine(s) operating and with one or more engine(s) inoperative.
7.a.6	MLS, GBAS, all engine(s) operating and with one or more engine(s) inoperative.
7.b.	**Non-precision approach.**
7.b.1	Surveillance radar approach, all engine(s) operating and with one or more engine(s) inoperative.
7.b.2	NDB approach, all engine(s) operating and with one or more engine(s) inoperative.

7.b.3	VOR, VOR/DME, TACAN approach, all engines(s) operating and with one or more engine(s) inoperative.
7.b.4	RNAV / RNP / GNSS (RNP at nominal and minimum authorized temperatures) approach, all engine(s) operating and with one or more engine(s) inoperative.
7.b.5	ILS LLZ (LOC), LLZ back course (or LOC-BC) approach, all engine(s) operating and with one or more engine(s) inoperative.
7.b.6	ILS offset localizer approach, all engine(s) operating and with one or more engine(s) inoperative.
7.c	**Approach procedures with vertical guidance (APV), e.g. SBAS, flight path vector.**
7.c.1	APV/baro-VNAV approach, all engine(s) operating and with one or more engine(s) inoperative.
7.c.2	Area navigation (RNAV) approach procedures based on SBAS, all engine(s) operating and with one or more engine(s) inoperative.
8.	**Visual Approaches (Visual Segment) And Landings.** Flight simulators with visual systems, which permit completing a special approach procedure in accordance with applicable regulations, may be approved for that particular approach procedure.
8.a.	Maneuvering, normal approach and landing, all engines operating with and without visual approach aid guidance.
8.b.	Approach and landing with one or more engines inoperative.
8.c.	Operation of landing gear, flap/slats and speedbrakes (normal and abnormal).
8.d.	Approach and landing with crosswind (max. demonstrated and gusting crosswind).
8.e.	Approach and landing with flight control system failures, reconfiguration modes, manual reversion and associated handling (most significant degradation which is probable).
8.e.1.	Approach and landing with trim malfunctions.
8.e.1.a	Longitudinal trim malfunction.
8.e.1.b	Lateral-directional trim malfunction.
8.f.	Approach and landing with standby (minimum) electrical/hydraulic power.
8.g.	Approach and landing from circling conditions (circling approach).
8.h.	Approach and landing from visual traffic pattern.
8.i.	Approach and landing from non-precision approach.
8.j.	Approach and landing from precision approach.
9.	**Missed Approach.**
9.a.	All engines, manual and autopilot.
9.b.	Engine(s) inoperative, manual and autopilot.
9.c.	Rejected landing
9.d.	With flight control system failures, reconfiguration modes, manual reversion and associated handling.
9.e.	Reserved
10.	**Surface Operations (landing, after-landing and post-flight).**
10.a	**Landing roll and taxi.**
10.a.1	HUD/EFVS.
10.a.2.	Spoiler operation.
10.a.3.	Reverse thrust operation.
10.a.4.	Directional control and ground handling, both with and without reverse thrust.

10.a.5.	Reduction of rudder effectiveness with increased reverse thrust (rear pod-mounted engines).
10.a.6.	Brake and anti-skid operation
10.a.6.a	Brake and anti-skid operation with dry, patchy wet, wet on rubber residue, and patchy icy conditions.
10.a.6.b	Reserved
10.a.6.c	Reserved
10.a.6.d	Auto-braking system operation.
10.b	**Engine shutdown and parking.**
10.b.1	Engine and systems operation.
10.b.2	Parking brake operation.
11.	**Any Flight Phase.**
11.a.	**Airplane and engine systems operation (where fitted).**
11.a.1.	Air conditioning and pressurization (ECS).
11.a.2.	De-icing/anti-icing.
11.a.3.	Auxiliary power unit (APU).
11.a.4.	Communications.
11.a.5.	Electrical.
11.a.6.	Fire and smoke detection and suppression.
11.a.7.	Flight controls (primary and secondary).
11.a.8.	Fuel and oil
11.a.9.	Hydraulic
11.a.10.	Pneumatic
11.a.11.	Landing gear.
11.a.12.	Oxygen.
11.a.13.	Engine.
11.a.14.	Airborne radar.
11.a.15.	Autopilot and Flight Director.
11.a.16.	Terrain awareness warning systems and collision avoidance systems (e.g. EGPWS, GPWS, TCAS).
11.a.17.	Flight control computers including stability and control augmentation.
11.a.18.	Flight display systems.
11.a.19.	Flight management computers.
11.a.20.	Head-up displays (including EFVS, if appropriate).
11.a.21.	Navigation systems
11.a.22.	Stall warning/avoidance
11.a.23.	Wind shear avoidance/recovery guidance equipment
11.a.24.	Flight envelope protections
11.a.25.	Electronic flight bag
11.a.26.	Automatic checklists (normal, abnormal and emergency procedures).
11.a.27.	Runway alerting and advisory system.
11.b.	**Airborne procedures.**
11.b.1.	Holding.
11.b.2.	Air hazard avoidance (traffic, weather, including visual correlation).
11.b.3.	Windshear.
11.b.3.a	Prior to take-off rotation.
11.b.3.b	At lift-off
11.b.3.c	During initial climb.
11.b.3.d	On final approach, below 150 m (500 ft) AGL.

11.b.4.	Reserved

This table specifies the minimum airport model content and functionality to qualify a simulator at the indicated level. This table applies only to the airport models required for FTD qualification.	
Begin QPS Requirements	
1.	**Reserved**
2.a.	**Functional test content requirements**
2.a.1	**Airport scenes**
2.a.1.a	A minimum of three (3) real-world airport models to be consistent with published data used for airplane operations and capable of demonstrating all the visual system features below. Each model should be in a different visual scene to permit assessment of FSTD automatic visual scene changes. The model identifications must be acceptable to the sponsor's TPAA, selectable from the IOS, and listed on the SOQ.
2.a.1.b	Reserved
2.a.1.c	Reserved
2.a.1.d	**Airport model content.** For circling approaches, all tests apply to the runway used for the initial approach and to the runway of intended landing. If all runways in an airport model used to meet the requirements of this attachment are not designated as "in use," then the "in use" runways must be listed on the SOQ (e.g., KORD, Rwys 9R, 14L, 22R). Models of airports with more than one runway must have all significant runways not "in-use" visually depicted for airport and runway recognition purposes. The use of white or off white light strings that identify the runway threshold, edges, and ends for twilight and night scenes are acceptable for this requirement. Rectangular surface depictions are acceptable for daylight scenes. A visual system's capabilities must be balanced between providing airport models with an accurate representation of the airport and a realistic representation of the surrounding environment. Airport model detail must be developed using airport pictures, construction drawings and maps, or other similar data, or developed in accordance with published regulatory material; however, this does not require that such models contain details that are beyond the design capability of the currently qualified visual system. Only one "primary" taxi route from parking to the runway end will be required for each "in-use" runway.
2.a.2	**Visual scene fidelity.**
2.a.2.a	The visual scene must correctly represent the parts of the airport and its surroundings used in the training program.
2.a.2.b	Reserved
2.a.2.c	Reserved
2.a.3	**Runways and taxiways.**
2.a.3.a	Reserved
2.a.3.b	Representative runways and taxiways.
2.a.3.c	Reserved
2.a.4	Reserved
2.a.5	Runway threshold elevations and locations must be modeled to provide correlation with airplane systems (e.g. HUD, GPS, compass, altimeter).
2.a.6	Reserved
2.a.7	**Runway surface and markings for each "in-use" runway must include the following, if appropriate:**
2.a.7.a	Threshold markings.
2.a.7.b	Runway numbers.
2.a.7.c	Touchdown zone markings.
2.a.7.d	Fixed distance markings.

2.a.7.e	Edge markings.
2.a.7.f	Center line markings.
2.a.7.g	Reserved
2.a.7.h	Reserved
2.a.7.i	Windsock that gives appropriate wind cues.
2.a.8	**Runway lighting of appropriate colors, directionality, behavior and spacing for the "in-use" runway including the following:**
2.a.8.a	Threshold lights.
2.a.8.b	Edge lights.
2.a.8.c	End lights.
2.a.8.d	Center line lights.
2.a.8.e	Touchdown zone lights.
2.a.8.f	Lead-off lights.
2.a.8.g	Appropriate visual landing aid(s) for that runway.
2.a.8.h	Appropriate approach lighting system for that runway.
2.a.9	**Taxiway surface and markings (associated with each "in-use" runway):**
2.a.9.a	Edge markings
2.a.9.b	Center line markings.
2.a.9.c	Runway holding position markings.
2.a.9.d	ILS critical area markings.
2.a.9.e	Reserved
2.a.10	**Taxiway lighting of appropriate colors, directionality, behavior and spacing (associated with each "in-use" runway):**
2.a.10.a	Edge lights.
2.a.10.b	Center line lights.
2.a.10.c	Runway holding position and ILS critical area lights.
2.a.11	**Required visual model correlation with other aspects of the airport environment simulation.**
2.a.11.a	The airport model must be properly aligned with the navigational aids that are associated with operations at the runway "in-use".
2.a.11.b	Reserved
2.a.12	**Airport buildings, structures and lighting.**
2.a.12.a	Buildings, structures and lighting:
2.a.12.a.1	Reserved
2.a.12.a.2	Representative airport buildings, structures and lighting.
2.a.12.a.3	Reserved
2.a.12.b	Reserved
2.a.12.c	Representative moving and static airport clutter (e.g. other airplanes, power carts, tugs, fuel trucks, additional gates).
2.a.12.d	Reserved
2.a.13	**Terrain and obstacles.**
2.a.13.a	Reserved
2.a.13.b	Representative depiction of terrain and obstacles within 46 km (25 NM) of the reference airport.
2.a.14	**Significant, identifiable natural and cultural features.**
2.a.14.a	Reserved
2.a.14.b	Representative depiction of significant and identifiable natural and cultural features within 46 km (25 NM) of the reference airport. *Note.— This refers to natural and cultural features that are typically used for pilot orientation*

	in flight. Outlying airports not intended for landing need only provide a reasonable facsimile of runway orientation.
2.a.14.c	Representative moving airborne traffic (including the capability to present air hazards – e.g. airborne traffic on a possible collision course).
2.b	**Visual scene management.**
2.b.1	Reserved
2.b.2	Airport runway, approach and taxiway lighting and cultural lighting intensity for any approach should be set at an intensity representative of that used in training for the visibility set; all visual scene light points must fade into view appropriately.
2.b.3	Reserved
2.c	**Visual feature recognition.** *Note.— The following are the minimum distances at which runway features should be visible. Distances are measured from runway threshold to an airplane aligned with the runway on an extended 3-degree glide slope in suitable simulated meteorological conditions. For circling approaches, all tests below apply both to the runway used for the initial approach and to the runway of intended landing.*
2.c.1	Runway definition, strobe lights, approach lights, and runway edge white lights from 8 km (5 sm) of the runway threshold.
2.c.2	**Visual approach aids lights.**
2.c.2.a	Reserved
2.c.2.b	Visual approach aids lights from 4.8 km (3 sm) of the runway threshold.
2.c.3	Runway center line lights and taxiway definition from 4.8 km (3 sm).
2.c.4	Threshold lights and touchdown zone lights from 3.2 km (2 sm).
2.c.5	Reserved
2.c.6	For circling approaches, the runway of intended landing and associated lighting must fade into view in a non-distracting manner.
2.d	**Selectable airport visual scene capability for:**
2.d.1	Night.
2.d.2	Twilight.
2.d.3	Day.
2.d.4	Dynamic effects — the capability to present multiple ground and air hazards such as another airplane crossing the active runway or converging airborne traffic; hazards must be selectable via controls at the instructor station.
2.d.5	Reserved
2.e	**Correlation with airplane and associated equipment.**
2.e.1	Visual cues to relate to actual airplane responses.
2.e.2	**Visual cues during take-off, approach and landing.**
2.e.2.a	Visual cues to assess sink rate and depth perception during landings.
2.e.2.b	Reserved
2.e.3	Accurate portrayal of environment relating to airplane attitudes.
2.e.4	The visual scene must correlate with integrated airplane systems, where fitted (e.g. terrain, traffic and weather avoidance systems and HUD/EFVS).
2.e.5	Reserved
2.f	**Scene quality.**
2.f.1	**Quantization.**
2.f.1.a	Surfaces and textural cues must be free from apparent quantization (aliasing).
2.f.1.b	Reserved
2.f.2	System capable of portraying full color realistic textural cues.
2.f.3	The system light points must be free from distracting jitter, smearing or streaking.

2.f.4	Reserved
2.f.5	System capable of providing light point perspective growth (e.g. relative size of runway and taxiway edge lights increase as the lights are approached).
2.g	**Environmental effects.**
2.g.1	Reserved
2.g.2	Reserved
2.g.3	Reserved
2.g.4	Reserved
2.g.5	Reserved
2.g.6	Reserved
2.g.7	Visibility and RVR measured in terms of distance. Visibility/RVR must be checked at and below a height of 600 m (2 000 ft) above the airport and within a radius of 16 km (10 sm) from the airport.
2.g.8	Reserved
2.g.9	Reserved
2.g.10	Reserved
2.g.11	Reserved
	End QPS Requirement

	Begin Information
3.	An example of being able to “combine two airport models to achieve two “in-use” runways: One runway designated as the “in use” runway in the first model of the airport, and the second runway designated as the “in use” runway in the second model of the same airport. For example, the clearance is for the ILS approach to Runway 27, Circle to Land on Runway 18 right. Two airport visual models might be used: the first with Runway 27 designated as the “in use” runway for the approach to runway 27, and the second with Runway 18 Right designated as the “in use” runway. When the pilot breaks off the ILS approach to runway 27, the instructor may change to the second airport visual model in which runway 18 Right is designated as the “in use” runway, and the pilot would make a visual approach and landing. This process is acceptable to the FAA as long as the temporary interruption due to the visual model change is not distracting to the pilot, does not cause changes in navigational radio frequencies, and does not cause undue instructor/evaluator time.
4.	Sponsors are not required to provide every detail of a runway, but the detail that is provided should be correct within the capabilities of the system. **End Information**

The following checks are performed during a normal flight profile.	
1.	Precipitation.
2.	Reserved
3.	Significant airplane noises perceptible to the pilot during normal operations.
4.	Abnormal operations for which there are associated sound cues including, engine malfunctions, landing gear/tire malfunctions, tail and engine pod strike and pressurization malfunction.
5.	Sound of a crash when the flight simulator is landed in excess of limitations.

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Table B3G - Functions and Subjective Tests Level 7 FTD	
QPS REQUIREMENTS	
Entry Number	**Instructor Operating Station (IOS) Requirements**
	Functions in this table are subject to evaluation only if appropriate for the airplane and/or the system is installed on the specific FTD.
1.	**Simulator Power Switch(es)**
2.	**Airplane conditions.**
2.a.	Gross weight, center of gravity, fuel loading and allocation
2.b.	Airplane systems status.
2.c.	Ground crew functions (e.g., ext. power, push back)
3.	**Airports.**
3.a.	Number and selection.
3.b.	Runway selection.
3.c.	Runway surface condition (e.g., rough, smooth, icy, wet)
3.d.	Preset positions (e.g., ramp, gate, #1 for takeoff, takeoff position, over FAF)
3.e.	Lighting controls.
4.	**Environmental controls.**
4.a	Visibility (statute miles (kilometers)).
4.b.	Runway visual range (in feet (meters)).
4.c.	Temperature.
4.d.	Climate conditions (e.g., ice, snow, rain).
4.e.	Wind speed and direction.
4.f.	Windshear.
4.g.	Clouds (base and tops).
5.	**Airplane system malfunctions** (Inserting and deleting malfunctions into the simulator).
6.	**Locks, Freezes, and Repositioning.**
6.a.	Problem (all) freeze / release.
6.b.	Position (geographic) freeze / release.
6.c.	Repositioning (locations, freezes, and releases).
6.d.	Ground speed control.
7.	Remote IOS. (if installed)
8.	**Sound Controls.** On / off / adjustment
9.	**Control Loading System.**
9.a.	On / off / emergency stop.
10.	**Observer Seats / Stations.** Position / Adjustment

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Michael P. Huerta,

Administrator.

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