

The Definitive Guide to Aeroplane Flight Simulator Evaluation: RAeS Handbook & International Standards

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In the high-stakes world of aviation, the transition from theory to the cockpit is mediated by one of the most sophisticated pieces of engineering known to man: the Flight Simulation Training Device (FSTD). To ensure that these devices provide a training environment that accurately reflects the behavior of a real aircraft, the aviation industry relies on rigorous evaluation protocols. Central to these protocols is the **Aeroplane Flight Simulator Evaluation Handbook**, published by the Royal Aeronautical Society (RAeS). This handbook serves as the international benchmark for qualifying flight simulators, ensuring that pilots are trained on devices that meet strict fidelity requirements. This article provides an in-depth technical analysis of the standards, methodologies, and regulatory frameworks defined within the RAeS evaluation handbooks and their synergy with ICAO and EASA standards.

The Evolution of Flight Simulator Evaluation Standards

The history of flight simulation evaluation is a journey from rudimentary mechanical trainers to high-fidelity, full-motion systems. In the early days, simulator qualification was subjective, relying heavily on the opinions of experienced pilots. However, as the complexity of aircraft increased, so did the need for objective, data-driven validation. The **Royal Aeronautical Society (RAeS)**, based in Great Britain, took a leading role in the 1990s by forming an international working group to harmonize simulator standards. This led to the publication of the **Aeroplane Flight Simulator Evaluation Handbook**, now in its fourth edition.

The handbook was designed to be a companion to the **International Civil Aviation Organization (ICAO) Manual (Doc 9625)**. While ICAO provides the broad regulatory framework, the RAeS Handbook offers the technical "how-to," detailing the specific tests, tolerances, and data requirements necessary to certify an FSTD. The evolution from the Second Edition (1995) to the Third Edition (2005) and the Fourth Edition (2009) reflects advancements in computer processing, visual system resolution, and motion cueing algorithms.

The Regulatory Framework: EASA CS-FSTD(A) and ICAO Doc 9625

To understand the application of the Evaluation Handbook, one must understand the regulatory ecosystem. Regulatory bodies such as the **European Union Aviation Safety Agency (EASA)** and the **Federal Aviation Administration (FAA)** use these handbooks to define their own Certification Specifications (CS). For instance, **CS-FSTD(A)** is the EASA standard that governs the qualification of aeroplane flight simulation training devices. It explicitly references the RAeS Handbook for objective and subjective testing procedures.

The core philosophy of these regulations is based on **Level D** qualification—the highest tier of flight simulation. A Level D simulator must provide a "Zero Flight Time" (ZFT) capability, meaning a pilot can transition to a new aircraft type based entirely on simulator training without ever having flown the actual aircraft in a non-revenue environment. Achieving this requires the simulator to pass hundreds of objective tests documented in the **Qualification Test Guide (QTG)**.

Volume 1: Objective Testing and Technical Validation

Volume 1 of the Aeroplane Flight Simulator Evaluation Handbook is dedicated to objective testing. This is the quantitative side of simulator qualification, where the performance of the simulator is measured against actual flight test data provided by the aircraft manufacturer (the OEM).

The Validation Data Roadmap (VDR)

Objective testing begins with the **Validation Data Roadmap (VDR)**. This document outlines the source of all data used to program the simulator. The primary sources of data include:

- Flight Test Data: Recorded during actual test flights of the aircraft.
- Engineering Data: Derived from aerodynamic models and wind tunnel testing.
- Supplier Data: Information regarding specific components like engines, avionics, and flight control systems.

Key Objective Test Areas

The handbook categorizes objective tests into several domains. Each test has a specific **tolerance**—a range within which the simulator's performance must match the aircraft's performance. Common test domains include:

1. Performance: This includes takeoff ground roll, climb rates (all engines operating and engine-out), and landing distances. For example, the tolerance for a takeoff roll might be $\pm 5\%$ of the distance or ± 200 feet, whichever is greater.
2. Handling Qualities: These tests assess the simulator's response to pilot inputs. This includes static stability, dynamic stability (such as phugoid and Dutch roll oscillations), and flight control system characteristics.
3. Motion System: Tests ensure the motion platform provides accurate cues without excessive latency or "washout" (the process of returning the platform to center without the pilot noticing).
4. Visual System: Evaluates field of view, resolution, and Transport Delay—the time it takes for a pilot's input to be reflected in the visual display.

Transport Delay and Latency Analysis

One of the most critical technical metrics in Volume 1 is **Transport Delay**. In a modern simulator, the time between a control input (e.g., moving the sidestick) and the resulting change in the visual scene must be less than **100 milliseconds** for Level D qualification. Excessive latency leads to pilot-induced oscillations (PIO) and simulator sickness. The handbook details the mathematical methods for measuring this delay using high-speed cameras or software-based timing probes.

Volume 2: Subjective Testing and Pilot Evaluation

While Volume 1 focuses on numbers, **Volume 2 of the Evaluation Handbook** focuses on the "feel" of the simulator. Even if a simulator passes every objective test, a pilot may still feel that it does not "fly like the real airplane." Subjective testing is conducted by a **Qualification Test Pilot** or a highly experienced instructor pilot.

The Role of the Evaluator

The evaluator uses **Form F7** or similar guidance documents to check each item in the simulator. The focus is on the operational environment, including:

- Cockpit Fidelity: Are all switches, knobs, and displays identical in look, feel, and location to the real aircraft?
- Environmental Effects: Does the simulator accurately replicate rain on the windshield, runway lighting, and turbulence?
- Abnormal Operations: Does the simulator behave correctly during engine failures, hydraulic leaks, or electrical smoke?

Handling Qualities Rating Scales

Evaluators often use standardized scales, such as the **Cooper-Harper Rating Scale**, to quantify their subjective impressions. Although the RAeS handbook provides more specific checklists, the goal remains the same: ensuring the workload in the simulator matches the workload in the aircraft.

Comparison of FSTD Qualification Levels

Simulators are not all created equal. The following table illustrates the differences between various levels of qualification based on the standards derived from the RAeS Handbook and EASA CS-FSTD(A).

Feature	Level A / BITD	Level B	Level C	Level D
Motion System	None / Optional	3 Degrees of Freedom	6 Degrees of Freedom	6 Degrees of Freedom (High Fidelity)
Visual System	Night Only / None	Day/Night/Dusk	Day/Night/Dusk (75°; FOV)	Day/Night/Dusk (180°;x40°; FOV)
Transport Delay	< 300 ms	< 150 ms	< 100 ms	< 100 ms (Strict)
Sound Simulation	Basic	Representative	High Fidelity	Directional / 3D Spatial Audio
ZFT Capability	No	No	Partial	Yes

Technical Workflow: Preparing for an FSTD Evaluation

The evaluation process is a multi-year journey involving the simulator manufacturer (OEM), the operator (airline or training center), and the National Aviation Authority (NAA). The following procedural steps are standard in the industry:

1. Development of the MQTG

The **Master Qualification Test Guide (MQTG)** is the foundational document. It contains all the objective tests and their results from the factory. This document must be approved by the regulator before the simulator is shipped to its final location.

2. Data Validation and Aerodynamic Modeling

Engineers must integrate the **Data Package** into the simulator's flight model. This involves complex **Computational Fluid Dynamics (CFD)** and real-time integration of flight control laws. If the aircraft is a Fly-By-Wire (FBW) system, the simulator must run the exact same binary code as the aircraft's Flight Control Computers (FCC).

3. The On-Site Evaluation

Once the simulator is installed, an evaluation team from the NAA (e.g., FAA or EASA inspectors) arrives. The process typically takes 3-5 days and involves:

- Review of the QTG: Running a sample of objective tests (usually 1/3 of the total tests each year for recurrent evaluations).
- Subjective Flying: The inspectors fly various profiles, including steep turns, stalls, and CAT III autolands.
- Functional Checks: Testing the Instructor Operating Station (IOS) to ensure it can trigger all required malfunctions.

Challenges in Simulation: Motion and Visual Cueing

One of the most technically difficult aspects discussed in the RAeS Handbook is the synchronization of motion and visual cues. If a pilot sees the horizon tilt but doesn't feel the corresponding lateral acceleration for several milliseconds, the brain detects a mismatch. This is known as **Simulator Sickness**.

The Washout Algorithm

Since a simulator has limited travel (it cannot move infinitely in one direction), it must use a **washout algorithm**. When a pilot initiates a turn, the motion system provides an initial acceleration cue. As the turn continues, the platform slowly and imperceptibly returns to a neutral position while the pilot's inner ear is "tricked" by a slight tilt of the platform (gravity-based cueing). The RAeS Handbook provides guidance on ensuring these filters are tuned correctly to prevent "false cues."

Common Failure Modes and Troubleshooting in Evaluations

During a formal evaluation, several common technical issues can lead to a "finding" or a failure to qualify. Understanding these is vital for simulator technicians.

QTG Parameter Mismatch

If an objective test shows a deviation beyond the tolerance (e.g., the roll rate is 2 degrees/second too slow), the engineering team must determine the cause. Is it a software bug in the flight model, or is the control loading system (the motors providing feedback to the pilot's yoke) out of calibration?

Visual System Latency

As visual systems move to 4K or 8K resolution, the processing power required increases. If the Image Generator (IG) takes too long to render a frame, the simulator will fail the Transport Delay test. Solutions often involve optimizing the **Shaders** or reducing the complexity of the airport scenery models.

Sound Pressure Level (SPL) Deviations

The simulator must accurately replicate the decibel levels of the cockpit at different engine settings. If the sound levels are off by more than ± 3 dB, the simulator may fail Volume 2 subjective checks. This requires precise acoustic tuning and sometimes the replacement of high-frequency speakers.

The Future of Simulator Evaluation: VR, AR, and AI

The fourth edition of the RAeS handbook was written before the widespread adoption of **Virtual Reality (VR)** and **Mixed Reality (MR)** in professional flight training. The next frontier for the RAeS and ICAO is defining how to evaluate a simulator that doesn't have a traditional screen but uses a headset. Key questions include:

- How do we measure visual latency in a VR headset?
- Can a simulator without a motion platform (using only visual "vection" cues) be qualified for certain tasks?
- How does Artificial Intelligence (AI)-driven Air Traffic Control (ATC) in the simulator affect the subjective workload evaluation?

Synthesizing the Path Forward

The Aeroplane Flight Simulator Evaluation Handbook remains the "gold standard" for a reason. It bridges the gap between pure aeronautical engineering and the practical needs of pilot training. By adhering to the rigorous objective standards of Volume 1 and the nuanced subjective requirements of Volume 2, simulator operators ensure that the pilots who fly millions of passengers every day have been trained in an environment that is as close to reality as humanly possible.

As technology progresses, the principles of the handbook—**accuracy, repeatability, and pilot-centric fidelity**—will continue to guide the development of next-generation training devices. Whether it is an eVTOL (electric Vertical Takeoff and Landing) simulator or a commercial airliner, the methodology for evaluation remains rooted in the technical excellence established by the Royal Aeronautical Society. Ensuring a simulator passes its evaluation is

not just a regulatory hurdle; it is a fundamental commitment to aviation safety and the integrity of the pilot's skillset.

Baca Juga (Artikel Terkait)

- [The Definitive Technical Guide to the Lycoming O-235 Series: Engineering Architecture, Operational Performance, and Maintenance Optimization](#)

URL: <http://alaskawriters.com/lycoming-o-235-engine-technical-guide.pdf>

- [The Ultimate Technical Guide to the Cessna 206 and T206 Series: Maintenance, Documentation, and Engineering Architecture](#)

URL: <http://alaskawriters.com/cessna-206-t206-technical-maintenance-guide.pdf>

- [Comprehensive Technical Guide to Boeing 737 Maintenance Manuals: Operational Procedures and System Standards](#)

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- [Comprehensive Technical Analysis of Boeing 737 Next Generation \(NG\) Maintenance and Operational Documentation](#)

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