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Role and Selection of Pilots for Scenario-Based Human Factors Evaluations & Tests

A Report from the GAMA Flight Deck Human Factors Working Group

Submitted to

Federal Aviation Administration of the United States

European Union Aviation Safety Agency

Transport Canada Civil Aviation Directorate

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Contents

1. Abstract

A core best practice in the field of Human Factors is the inclusion and consideration of representative end users in analyses and assessments of human-machine interaction. GAMA Publication #21, “Boeing 737 MAX Related Reports & Recommendations and their Impact on Human Factors”, developed by the GAMA Flight Deck Human Factors Working Group (FDHFWG) recommends that: “Industry should develop a methodology to define the role of the different types of pilots (e.g., flight test pilots, production test pilots, and certification authority pilots) and to identify what an appropriate representation of a qualified flightcrew should be for scenario-based Human Factors (HF) evaluations and tests.”

However, current industry guidance material lacks detailed selection criteria to ensure that designs are evaluated and tested using a representative set of pilots. Based on the GAMA recommendation, this whitepaper, informed by GAMA, sets out best practices for defining and selecting qualified flightcrew for scenario-based HF assessments.

It should be noted that for the purposes of this document the terms “evaluation” and “tests” are consistent with definitions in AC 25.1302 and AMC 25.1302. Tests are executed toward the end of a program for certification credit in the presence of certification authorities. Evaluations are typically performed during the development phase for requirements definition and validation. However, evaluations may also be conducted later in the program and serve as a path to showing compliance.

2. Background

This whitepaper was developed as a result of the GAMA Flight Deck Human Factors Working Group's (FDHFWG) comprehensive analysis of the 737 MAX accident recommendations, which was released as "GAMA Publication #21, Boeing 737 MAX Related Reports & Recommendations and their Impact on Human Factors."

This whitepaper provides industry best practices and considerations for the selection of representative pilots for scenario-based Human Factors (HF) evaluations and tests. It is not intended to be prescriptive or mandatory. Rather, it is intended to be used by certification applicants to inform their development and certification efforts, and to facilitate discussions with regulators regarding compliance with HF-related regulations.

The purpose of this whitepaper is to provide additional guidance to applicants for GAMA Publication #21 Recommendation #3, as written below.

GAMA Recommendation #3

Industry should develop a methodology to define the role of the different types of pilots (e.g., flight test pilots, production test pilots, and certification authority pilots) and to identify what an appropriate representation of a qualified flightcrew should be for scenario-based human factors evaluations and tests.

GAMA Recommendation #3 was motivated by the Report of the Special Committee to Review the FAA's Aircraft Certification Process, which recommended "Test and evaluation should include multiple failure mode scenarios and involve trained pilots who reflect the anticipated end-users of the product."

Existing regulatory guidance (CATA CWI EASA-003 25.1302, AMC 25.1302 Amendment 28, AC 25.1302-1, AC 25.1523-1, and PS-ACE100-2001-004) establishes the need to use a representative set of pilots when assessing flight deck designs, including potential flightcrew errors or responses. It also assumes these pilots to be appropriately trained and proficient in the aircraft or the system to be assessed. However, there is no other detailed industry or regulatory guidance on the selection criteria for ensuring that a design has been assessed using a representative set of pilots.

For the purposes of this document the terms "evaluation" and "tests" are consistent with definitions in AC 25.1302 and AMC 25.1302. For example, AC 25.1302-1 states "the applicant may use a wide variety of part-task to full-installation representations of the product/system or flightdeck for evaluations. All of these have two characteristics in common. First, the representation of the human interface and the system interface do not necessarily conform to the final documentation. Second, the certification official is generally not present."

In contrast, tests are “means of compliance conducted in a manner very similar to evaluations described above, with one significant difference. Tests require an actual conforming product/system and system interface. A test may be conducted on a bench, in a laboratory, in a simulator, or on an airplane.”

Evaluations are typically performed during the development phase for requirements definition. However, evaluations may also be conducted later in the program and serve as a path to showing compliance. Throughout this document, the term “assessment” is meant to include both evaluations and tests.

The GAMA FDHFWG recommends that a set of pilots, representative of the future end users of the aircraft and/or system under development, should also be used to assess designs as soon as practical, e.g., during the development phase. The goal is to evaluate HF aspects early enough to inform the design. Early representative pilot-in-the-loop assessments help avoid late and costly design changes as the design matures.

Obtaining a representative set of pilots can be logistically challenging and costly, making it difficult to represent all the relevant characteristics of the future end-user pilot population. Nevertheless, the methodology provided in this whitepaper will focus on defining and selecting a representative pilot sample that factors in the target end-user pilot characteristics (language, cultural diversity, anthropometric dimensions, etc.) and experience (e.g., flight experience or training), as intended for assessing the design of the aircraft or subsystem.

Additionally, the methodology defines the role of various pilots within the assessments, such as Original Equipment Manufacturer (OEM) pilots (e.g., Flight Test Pilots, Technical Pilots, Training Pilots, Production Test Pilots), Certification Authority Pilots, and other pilots more representative of the end-user pilots, commonly referred to as “operational” or “line” pilots (per AC 25.1523-1).

In the following sections, we first present an overview of the principal pilot categories that applicants may draw on for specific HF assessments. We then describe the roles and contributions of these pilot types in both developmental design evaluations and certification testing. Finally, we propose methods for selecting representative pilots for HF evaluations and certification testing, and highlight key considerations to guide that selection process.

3. Scope

Based on GAMA Recommendation #3, the scope of our recommended best practices is limited to the following two types of design assessment activities on all development and certification projects (e.g., new conventional aircraft; derivative aircraft; modifications to existing aircraft; new subsystems or modifications to subsystems, or new aircraft types):

- Scenario-based *evaluations* of the flightcrew interface and system behavior, typically during the conceptual and development phase
- Scenario-based certification *tests* of the flightcrew interface and system behavior during the certification phase.

This document references FAA 14 CFR Part 25 (EASA CS-25) airplanes; however, consideration should be given to the practical and appropriate application across Part (CS) 23, 27, and 29 aircraft (as well as aircraft that may not fit specifically in these parts, e.g., Powered-Lift).

The scenario-based approach is defined in Section 3.3.2 of AMC 25.1302 Amendment 28 (Methodological considerations applicable to HF assessments) and provides guidelines on how to implement it. Scenario-based evaluations and tests can be executed at the full-mission, part-mission, or part-task level, with the chosen level driven by the HF objectives and required fidelity. Part-task evaluations are those where only specific tasks, procedures, or interactions with a particular flight deck system(s) are assessed (e.g., information processing during early design). Applicants should align their regulatory requirements with their corresponding certification authority.

4. Pilot Categories

Early Human Factors assessments typically involve three general categories of pilots at different stages in the flightcrew interface development process: Company/Manufacturer Pilots, Operational Pilots (also known as customer or line pilots), and Certification Authority Pilots. The following section describes each of these pilot categories in more detail.

Pilots in these categories can assume several roles throughout aircraft and subsystem development starting from early conceptual design. Individual pilots can fulfill distinct roles and participate in diverse simulation or flight tests according to their organization's process and culture. The pilot roles will be described in Section 5.

4.1. Company/Manufacturer Pilots

This section defines the range of pilot types typically employed or contracted by OEMs and flight-deck equipment suppliers to support program phases from early concept design through certification.

Because their responsibilities are complex and distinct, pilots may be grouped into several types. Job titles may vary across organizations, and a given pilot may perform multiple roles or be assigned to more than one group depending on the task or flight. Common types of flight include development, certification, production, demonstration, and customer support.

4.1.1. Development Test Pilots

These are pilots frequently assigned by OEMs/avionics suppliers to earlier stages of concept design and development projects. They are also known as either Engineering Test Pilots or Experimental Test Pilots (these designations can vary across companies). Typically, they are graduates of a formal test pilot school where they have been exposed to multiple aircraft types. It is not uncommon for them to also be delegated Certification Authority Pilots (see Section 4.3).

They are trained in flight-test techniques and methodologies and trained to evaluate an aircraft's handling qualities, performance, systems functionality and Human Machine Interfaces (HMIs). Experimental Test Pilots generally conduct both holistic flight deck assessments as well as specific system/feature assessments. They are also trained to identify assumptions about the expected pilot responses by the anticipated end-user pilot population when testing aircraft performance and handling characteristics.

These test pilots are typically the only personnel trained and qualified to operate experimental aircraft during the initial phases of a flight-test program—particularly for new types—until the aircraft attains sufficient maturity to involve other pilot categories. Beyond developmental and certification flights, they may also conduct production flights, aircraft entry-into-service sorties, and occasional demonstration flights. As per Part 21 Appendix XII and EASA Part Flight Crew

Licensing (Part-FCL), these pilots are classified as Category 1 and 2. It is common for Experimental Test Pilots to receive foundational human factors training as part of their qualification, covering concepts such as workload, stress, fatigue, human–machine interface & usability assessment. This training enhances their ability to detect potential HF deficiencies in user-interface designs.

4.1.2. Production Test Pilots

A primary duty of Production Test Pilots is testing the airworthiness and the functionality of all aircraft systems on newly manufactured, type-certificated aircraft as they leave the production line. They conduct the aircraft's first flight(s) to confirm compliance with airworthiness regulations and company standards. This may include testing the aircraft before its airworthiness certificate is granted. These pilots routinely perform production and completion of acceptance flights, customer entry-into-service flights, and occasional demonstration flights. As per Part 21 Appendix XII, these pilots are classified as Category 3.

4.1.3. Customer Support/Demonstration Pilots

These pilots perform mainly domestic and international operational flying, airshows, entry-into-service operations for new aircraft deliveries, customer accommodation flights, and provide logistical or maintenance-related assistance to customers. These pilots may also perform line training and may be responsible for the validation of the training syllabus with third-party training organizations (e.g. CAE or FlightSafety International). They can be valuable in the design process since they can anticipate pilot needs and/or behaviors due to their previous experience with pilots on similar aircraft.

4.1.4. Corporate Pilots

Some companies employ experienced type-rated pilots who typically fill the executive/ employee's transport role within a company/manufacturer. These pilots are similar to Operational Pilots. However, they are mostly used for unscheduled ("on-demand") service and are not necessarily experienced with the flight deck design or operational aspects of the aircraft under development.

4.1.5. Standards/Technical Pilots

These pilots are primarily responsible for maintaining or supporting, either in writing or checking, the procedures, checklists, and flight manuals for each model and derivative, and customer configuration.

4.1.6. Training/Instructor Pilots

These pilots are qualified to provide initial, transition, or recurrent aircraft type training. They may also provide dedicated training for specific operations. When developing or upgrading trainer aircraft, the use of a flight instructor is necessary.

4.2. Operational Pilots

These pilots typically hold an Airline Transport Pilot (ATP) certificate and are employed by operators (e.g., airlines) that may be current or prospective customers of the OEM or supplier. They bring operational knowledge of how the product is used in service and in the conditions and contexts unique to customers' operation. This includes operator-specific training, route structures, geographic and airspace considerations, and company procedures and checklists. Operational pilots from multiple customers can be selected to represent a diverse end-user population for design assessments, and they are generally the closest proxy for the end-user pilot population.

4.3. Certification Authority Pilots

Certification Authority flight test pilots (e.g., FAA, EASA, TCCA, ANAC) and their designees, (e.g., Designated Engineering Representative (DER) or Organization Designation Authorization (ODA) Authorized Representative (AR)/ Engineering Unit Members (E-UM)) are responsible for performing certification tests and/or making findings of compliance and approving or recommending approval of the compliance data.

They have extensive experience in multiple aircraft types and typically participate in flight test and flight simulator programs to verify that the minimum required standards have been met by the certification applicant, according to specific regulatory requirements. Note that in some cases, additional certification authority pilots may be recruited for evaluations and tests to provide additional data and breadth of experience, but do not have a direct role in finding compliance.

5. Pilot Roles

5.1. Overview

While acknowledging the variability in job titles and responsibilities across applicants, the three broad roles for pilots in HF assessments are:

1) design definition

2) design validation & verification

3) certification

Roles 1 and 2 are discussed below in “Pilot Roles in Development Evaluations” (Section 5.2) and role 3 is discussed in “Pilot Roles in Certification Testing (Section 5.3).

These are roles that are not exclusively linked to a pilot category as one pilot category may be involved in multiple roles depending on the OEM or supplier organization structure and/or their certification planning.

In the initial design, at earlier stages of concept design and development projects, OEMs/ avionics suppliers will assign Developmental Test Pilots to evaluate an aircraft’s handling characteristics, performance, as well as systems. They may be designated as Project Pilot. Project Pilots are often used to communicate flight crew needs and assess the implementation of the function.

They support requirements definition, review assumptions about pilot behavior (e.g., human-error analyses, problem reports, SFHA validations), and play a critical role across aircraft development and certification. Project Pilots act as the primary liaison among engineering, program management, and customers.

In addition, they work directly with system engineers, both from the OEM itself and sometimes from its sub-system suppliers, to identify, assess, and resolve operational and functional issues. This helps the implementation of solutions that facilitate successful fielding of the aircraft. They also serve as critical liaisons between the company, its flight test branch and the certifying authorities.

Finally, they contribute to the flight planning risk analysis process, ensuring that operational risks are properly understood and mitigated during elevated-risk testing.

Once an initial design has been developed, but before it is finalized, it can be beneficial for requirements validation and/or verification to be accomplished by either company/manufacturer pilots with limited exposure to a new design (i.e., those who have not participated in early design and development to avoid biases) or Operational Pilots (“line pilots” per AC 25.1523-1 guidelines) who are most familiar with how customers (i.e. end-user pilots) operate the aircraft or subsystem in service.

Test Pilots with significant prior experience as Operational Pilots can potentially serve as good surrogate representatives for current Operational Pilots. Engaging these pilots is critical for both development and certification activities, delivering practical advantages (reduced cost, schedule risk, and program complexity) and technical benefits (assumptions about the user population, cockpit philosophy hindsight, and cross-program/aircraft experience).

Operational pilots are familiar with how the aircraft and sub-systems are used in service. The pilot group participating in assessments of the design should be representative, to the extent possible, of the demographics intended for the final aircraft operation and be familiar with the recommended practices expected of the operational pilots in service.

Pilots who find compliance with regulations have extensive experience in multiple aircraft types and typically participate in large-scale flight test and flight simulator programs to verify that the minimum applicable requirements have been met by the certification applicant, according to specific regulatory requirements. These pilots are employed by regulatory agencies and receive extensive training in multiple aircraft types. If delegated by the certification authority, company/ manufacturer pilots with DER or ODA AR/ E-UM delegation may make findings of compliance to airworthiness regulations.

A separate team within the certification authority pilot organization focuses on the operational aspects with a particular focus on training requirements. That team approves the methods and training facility used for pilot training and helps vet the Airplane Flight Manual (AFM) for approval. In some cases, this group of pilots may also be called upon to participate in certification testing to increase the breadth and experience of the certification pilot pool.

5.2. Pilot Roles in Development Evaluations

This section provides a general description (non-exhaustive) of the roles that can be performed by different pilot categories during the development phase. Previous experience in any of the categories described in Section 4 should be considered when selecting a participant, not just the individual's current role and/or title.

5.2.1. Developmental Test Pilots

- Assigned as Project Pilot.
- Provide input based on their experience interacting with aircraft/system/equipment starting from the early developmental stages.
- Provide input when extensive familiarity and knowledge of aircraft/system/equipment are required or when a high level of proficiency or skill in the aircraft is desired.
- Provide input on the cumulative flight deck effects of single and multiple aircraft level and system failure modes.
- Identify and/or validate assumptions about the expected target end-user pilot responses.
- Participate in design reviews and pilot-in-the-loop evaluations.

- Propose or provide feedback on design changes or recommendations.
- Assist engineering personnel in design or redesign of flight deck/system/equipment based on test results.
- Propose or provide feedback on new flight manual changes.
- Identify and/or validate potential compliance issues.
- Support safety analyses.

5.2.2. Production Test Pilots

- Provide input based on their experience interacting with aircraft/ system/equipment after early developmental stages.
- Act as “naïve” pilots for a newer aircraft they have not yet flown or newer system/equipment they have not yet operated.
- Participate in design reviews and pilot-in-the-loop evaluations.
- Evaluate flight manual changes or new content.

5.2.3. Customer Support/Demonstration Pilots

- Provide insights into customer needs and functionality gaps (in the early design stages) based on familiarity and interactions with customer pilots and their operations.
- Provide input based on their experience interacting with aircraft/ system/equipment after early developmental stages when a more operational perspective is needed to ensure customer needs are met.
- Participate in design reviews and pilot-in-the-loop evaluations.
- Provide input during development if a naïve participant is needed.

Notes:

1. The use of these pilots may be limited during early conceptual stages due to lack of familiarity with aircraft/system/equipment under development. This will vary from project to project.
2. Depending on the requested expertise and the needs of the assessment, corporate and standards/technical pilots may be used as user representatives.

5.2.4. Operational Pilots

- Provide input based on their experience interacting with aircraft/system/equipment when operational expertise is needed to ensure that customer needs are being met and to assess system usability.
- Participate in design reviews and pilot-in-the-loop evaluations.
- Provide comments and suggestions during developmental stages if a naïve participant is needed.

Notes:

1. Use of Operational Pilots for early scenario-based evaluation phases may not be practicable due to cost or logistical issues, but there are significant benefits in early involvement of Operational Pilots during developmental stages.
2. When practical, this category of pilots should be included in activities to elicit end-user information and in design validations early during the development process. The goals of Operational Pilot engagement include supporting development of HMI requirements, establishing design assumptions, and informing initial flight-deck design early enough to enable necessary changes.

5.2.5. Certification Authority Pilots

- Typically engaged during the entire development process, the exact engagement points are usually a function of the scope of the project and organizational structure.
- Provide input based on their experience interacting with and certifying different aircraft/ system/equipment from various manufacturers.
- Evaluate potential compliance risks and issues.

Note:

1. Normally, Certification Authority Pilots are not traditionally used to collect data for scenario-based evaluations during internal developmental stages. However, to reduce the risk of late modifications required by the certification authority, it is highly recommended that they be involved with these early evaluations to acquire familiarity with the system/function and the certification process (the “early involvement” recommended in AMC 25.1302, CATA CWI EASA-003 – 25.1302).

5.3. Pilot Roles in Certification Testing

This section provides a general description of the roles that can be performed by the various pilots during the certification phase to show or find compliance with HF related regulations. As indicated in Section 5.2, previous experience in any of the categories described in Section 4 should be considered when selecting a participant, not just the individual's current role and/or title.

5.3.1. Developmental Test Pilots

- Work collaboratively with engineers to develop scenarios and test plans to be used during certification campaigns.
- Act as a liaison with the certifying authorities during certification testing in a manner consistent with the test plans.
- Provide input based on their experience interacting with aircraft/ system/equipment.

- Development Test Pilots with previous experience as Line/Customer Pilot may fill the role of a customer pilot, if needed and approved by the certification authority if test data is to be used for showing compliance.

Note:

1. When delegated by the certification authority, company/ manufacturer Test Pilots with DER or ODA AR/E-UM delegation may perform the certification tests and/or make findings of compliance with airworthiness regulations and approve or recommend approval of the test data on behalf of certification authority (e.g., FAA Order 8110.37F).
2. A Development Test Pilot who has participated in the design development, and/or scenario and test plan preparations with the engineers should not be selected as participant for the scenario-based HF assessments.

5.3.2. Production Test Pilots

- Provide inputs based on their experience interacting with aircraft/system/equipment.
- Production Pilots with previous experience as Operational Pilot may fill the role of a customer pilot, if needed and approved by the certification authority if test data is to be used for showing compliance.

5.3.3. Customer Support/Demonstration Pilots

- Provide input (possibly also on scenario and test plan development) based on their experience with customer pilots interacting with aircraft systems.

Notes:

1. They could potentially be used as test participants for HF scenario-based simulator testing, when using Operational Pilot availability is not possible/feasible.
2. Not all manufacturers have dedicated Customer Support Pilots, therefore Production Pilots with previous experience as Operational Pilot could also be considered.
3. Depending on the requested expertise and the needs of the testing, Corporate and Standards/Technical Pilots may be used as test participants/user representatives.
4. Instructor Pilots are normally used as end users when testing trainer aircraft.
5. Certification authority approval is normally required for the pilot pool that will be used for certification testing.

5.3.4. Operational Pilots

- Operational Pilots are the most representative of end users.
- Participate in scenario-based tests as test participants to support data collection on representative end user interaction with the design under varied operational and workload conditions.
- Provide input based on their experience interacting with similar aircraft/ system/equipment based on their professional in-service experience.

Note:

1. Extensive/prolonged use of Operational Pilots in simulator testing can have some drawbacks - special attention should be paid to the potential adverse effect resulting from participation in repeated demanding failure scenarios, e.g. pilot fatigue, risk associated with negative transfer from the test scenarios to flying duties on other aircraft where the same response may be inappropriate, risk of persistent spatial disorientation, reduction in pilot confidence after repeated demanding scenarios.
2. Note that the line-pilot feedback may conflict with certification requirements - manufacturers must weigh such input appropriately while retaining ultimate responsibility for design and regulatory compliance.

5.3.5. Certification Authority Pilots

- Verify that the HF scenarios and pilot test population are adequate to demonstrate that the aircraft/systems comply with requirements in scenario-based certification testing.
- Act as liaison with the applicant during certification testing planning consistent with the agreed test schedules.
- Approve the test data.
- Find compliance with the applicable regulations.
- May act as a “representative” pilot at the certification authority’s discretion or when sufficient representative pilots are not available, provided that they have not been involved in developing or verifying the test plan/scenarios being used.
- There are also some test conditions under which Certification Authority pilots may conduct scenarios together with manufacturer test pilots, with DER or ODA AR/E-UM delegation, to find compliance (for example, during flight test).

6. Methodology for Selecting Representative Pilots for Certification Testing

Having provided an overview of the types of pilots and their main roles during the aircraft development and certification processes, this section provides recommendations related to selecting representative pilots for scenario-based HF certification tests, as described in AMC 25.1302 Section 3.3.2.(d)(e)(h).

6.1. Number of Participants

For scenario-based HF certification testing (e.g., Type Certificate (TC), Supplement Type Certificate (STC)), applicants should include pilots who are representative of future users for the aspects relevant to the test objectives. Testing should target three to five flightcrews, including the certification authority, consistent with AMC 25.1302 Amendment 28 (Section 3.3.2.(e)) and CATA Worklist Item EASA-003. A ‘flightcrew’ represents the minimum certified (or proposed) crew complement for the aircraft."

In cases where the primary focus is on one pilot’s tasks and responses, it may be acceptable to adopt a ‘confederate’ pilot across multiple test crews. A confederate pilot briefed on the scenario purpose and script may be appropriate if additional control over the scenario is needed to create the test point of interest for the second pilot. Where this method is used, applicants should pair the confederate with three to five pilots and obtain certification authority approval for this approach.

Consideration should also be given to the function or feature being evaluated. The number of flightcrews should be commensurate with the level of scrutiny and the relevant aspects of future end users. Aspects of the flight deck design that require “high scrutiny” (i.e., have high degrees of novelty, complexity, or integration as per AC 23.1523, AC 25.1302-1, AC 27-1B MG 20, AC 29 MG 20) would benefit from the higher participant numbers described above (i.e., more than three crews).

6.2. Training/Qualifications

In showing compliance with the HF requirements, the applicant may assume a qualified flightcrew is trained and checked in the use of the installed equipment (AC 25.1302-1 Section 3.3, and AMC 25.1302 Section 3.3.2). Therefore, at minimum, test participants must have either a valid Commercial or Airline Transport Pilot certificate, an appropriate or similar aircraft type rating related to the aircraft type certification under consideration and thus meet the requirements of the operating rules for similar category aircraft.

Sufficient briefing material and practical training (e.g., simulator, systems interaction) aimed at familiarization and operation of applicable systems and equipment must be provided to pilots (including any participating Certification Authority pilots) prior to testing. In this manner 'lack of training' can be excluded or minimized as a causal factor of any observed design-related human performance issue. The applicant should determine the appropriate amount of training based on factors such as the number, novelty, and complexity of the systems or features being tested and whether it is a completely new system/aircraft or a system/aircraft modification. The applicant's proposed training content and duration should be agreed with the certification authority and aligned with the certification test purpose.

Sufficient training must include an overview of the HF evaluation methodology and the assessment instruments (for example, rating scales) that will be used. Training should be designed, to the extent practicable, to avoid introducing bias into the test results e.g., overemphasizing a particular failure alert could lead flightcrews to anticipate that failure during testing. After completing the training, flightcrews are considered "qualified, trained, and checked' to participate in certification test data collection.

In the case of an all-new aircraft type, the training and qualification requirements are more challenging to define, since there is no existing type certification which can be used as a representative baseline for determining qualifications. Rather, pilot selection can be based on the qualifications for a similar aircraft. Relevant factors to be considered include:

- Same airworthiness Part (e.g., Part 23, 25);
- Same operational Part (e.g., Part 91, 121, and 135);
- Similar Type Certificate; and
- Similar flight deck features (e.g., number of pilot seats, flight controls, automation, cursor and touchscreen controls).

6.3. Diversity Dimensions

Several key diversity dimension factors that should be considered in selecting the most representative group of pilots for an assessment are presented below. The list is not exhaustive but covers some of the most important aspects of the selection. Selection criteria will vary depending on whether the project is a new type certification or a modification to an existing type. The necessary diversity depends on the assessment focus—for example, label effectiveness benefits from cultural/language diversity, while reach and accessibility require representative anthropometric variation. The methodology described below also considers whether or not the new project is associated with a previous aircraft model. For modification to an existing model, those aspects related to the modified areas should be considered.

Geographical/Cultural/Language

Selecting pilots from diverse geographical, cultural, and language backgrounds can improve the applicability of results to the global end-user population. However, this approach may be impractical due to cost and logistical complexity and therefore may not be feasible for all applicants. When the assessment objective is unaffected by geographical, cultural, or language factors (for example, reachability), sampling across those diversity dimensions is unnecessary. An effective approach is to select a diverse group of pilots drawn from operators of the fleet or model in question. Where practicable, the sample should also include pilots from at least two or three different geographical, cultural, or language backgrounds.

Even for a modification to a previously certified flight deck design, these aspects of cultural diversity may still need to be considered depending on whether the scope of the change is relevant to those aspects of the end user pilot population.

Flight Hours/Experience

As pilot experience influences decision making and interpretation of flight-deck effects, the pilot sample should include a range of flight and professional experience levels. Therefore, aim to include a subset of the pilots who are early in their careers and possess approximately the minimum flight hours required to operate the target aircraft type. In addition, where practical, include pilots with more than 3,000 total flight hours (irrespective of type ratings). While age can also be an interesting dimension as it relates to ‘comfort level’ with newer technologies, it tends to be covariant with experience, and selection based on age alone is not recommended.

Typically, level of experience is one of the most critical factors in selecting pilots for both new models and derivatives because it can impact errors and workload (e.g., different types of errors may be made by pilots with varying levels of experience). Selecting pilots with qualifications and training as described above, with representation from both the highest and lowest levels of flight hours/experience proposed, is recommended.

Also consider the experience such as Captain/Pilot-in-Command (PIC) and First Officer/ Second-in-Command (SIC) and select a mix between them. Where relevant to the assessment, consider other experience dimensions—such as night flying, instrument time, multiengine time, and flight instruction. For two-pilot flightcrew assessments, it is recommended that both pilots be drawn from the same operator to minimize differences arising from training and Standard Operating Procedures (SOPs).

Previous Aircraft

Depending on the assessment focus, prior experience or knowledge of the system/aircraft under test (for example, flight-deck automation, narrow vs wide-body aircraft) may be important. For

programs where no previous aircraft type exists, it may help to have knowledge and experience with similar systems, controls, or flight characteristics from other relevant aircraft types.

If the participant pilot does not have any previous systems experience on the target aircraft, adequate training is required before the assessment is conducted so that any observed issues with the design cannot be attributed to inadequate pre-test training (see Section 6.2).

Physical Attributes/Anthropometrics

Anthropometrics of the pilot population are usually considered during flight deck design, and assessment is made using physical mockups or digital modeling tools. For scenario-based certification tests, this aspect should be considered if the applicable airworthiness requirements for the test require the applicant to consider physical attributes of the test participants. In other words, if the goal of a scenario is to validate accessibility, reach, clearance, or similar requirements while pilots interact with the flight deck in an operational environment, then anthropometric criteria should be included in the pilot selection as described below.

For Part 25, when practical and possible, it is recommended that pilots who are representative of the boundary stature size of 5’ 2” and 6’ 3” (14 CFR 25.777(c)) be included. For Part 23, 27, and 29 similar guidance applies depending on the intended anthropometric accommodation envelope defined in the requirements. Where practical, consider all anthropometric dimensions that may affect reach, accessibility, clearance, and other factors relevant to the planned aircraft mission.

Practical & Logistical Considerations and Limitations

Pilot selection for an HF assessment always involves practical and logistical aspects. The overall objective is always to collect data with diverse representative users to allow observation of the variability of interactions (sometimes unexpected) with the flight deck design. However, this objective will always need to be balanced against availability, confidentiality, cost, training, and other issues which can arise in the recruitment of pilot participants. These trade-offs are not uncommon and should be discussed with the certification authority.

7. Step-by-Step Guide for Selecting Pilots for Scenario-Based HF Evaluations and Tests

The intention of this Section is to summarize all the information provided above into simple guidelines on how to proceed (step-by-step) with pilot selection for scenario-based HF evaluations and tests.

It is important to highlight that for upgrading/modification in an existing aircraft/system, the pilot selection criteria may be more flexible and may allow for some pilot selection criteria to be relaxed. Each certification project should be evaluated based on the new aspects/changes and level of scrutiny. The relevant pilot characteristics based on those aspects should be identified. The entire process should be coordinated with the corresponding certification authority.

Below is a sequence of steps and considerations that can help guide an applicant as they prepare to select pilot participants for HF evaluations and tests.

I. Plan pilot selection: attempt to use a pool of pilots that are representative of the end users by encompassing as many pilot characteristics as practical that are relevant to the flight deck aspects being evaluated/tested.
    a. Evaluate the type of pilot characteristics that are important regarding the assessment purpose, while considering the practical and logistical considerations and limitations:
        i. Training/qualifications;
        ii. Geographical/cultural/language background;
        iii. Flight hours/experience/roles rather than pilot title;
        iv. Previous aircraft or system experience;
        v. Experience as Captain and First Officer; and
        vi. Anthropometry and gender.
    b. For a given aircraft type, it is recommended to use both low-time and highly experienced pilots:
        i. For low-time pilots, the pilots should be at the beginning of their careers and as close to the minimum number of flight hours accepted to operate the evaluation aircraft type.
        ii. For experienced pilots, as practical as possible, consider pilots with more than 3,000 total flight hours.
    c. Determine if the design aspect to be evaluated or tested is impacted by anthropometric considerations for accessibility, reach, clearance, strength, etc.
        i. If anthropometric considerations are not a key factor in the assessment, this aspect is not required to be considered in pilot selection.
        ii. If anthropometric considerations are a key component of the assessment:
            1. For Part 25, when practical, the test sample should include pilot representatives at or near the boundary stature sizes of 5 ft 2 in and 6 ft 3 in, per 14 CFR 25.777(c).

2. For Parts 23, 27, and 29, pilot selection should reflect the anthropometric accommodation envelope defined in the certification plan. When practical, the test sample should include pilots representative of the full accommodation envelope.

d. When deciding between participant categories, consider the following order as an example of the contrasting priorities between early development phases and certification of a mature design. In practice, pilot selection should be defined on a case-by-case basis to best satisfy the human-factors assessment requirements. For example, the participant needs for a global evaluation of a new flight deck will differ from those for an assessment of a minor functional update.
   i. For evaluation (engineering development):
      1. Developmental Test Pilots;
      2. Production Test Pilots;
      3. Production Test Pilots with previous experience as Operational Pilots;
      4. Customer Support Pilots;
      5. Operational Pilots (If the goal is to validate HMI requirements and assumptions in the early stages of design, this priority will likely be higher).
   ii. For certification testing:
      1. Operational Pilots;
      2. Customer Support Pilots;
      3. Production Test Pilots with previous experience as Operational Pilots;
      4. Production Test Pilots;
      5. Developmental Test Pilots.

      Note:
      1. In the case of flight tests, at least one Test Pilot will be required to ensure the safety of flight.
      2. For a trainer aircraft, flight instructors should be used during development, evaluation and certification processes.
      3. The participation of a certification authority pilot should be coordinated with the corresponding certification authority.

II. Proceed with pilot recruitment
   a. Review pilot roles for aiding the selection process.
   b. Select pilot types according to the evaluation or test objectives.
   c. Target use of at least three to five flightcrews corresponding to the minimum certified crew complement for the aircraft (or proposed to be certified).
   d. Define the pilot qualification needed for the evaluation or test objectives.
      i. Pilot(s) with little or no previous experience with a new system/design may be necessary (primarily during development stages).

Appendix A. References and Bibliography

Authority, Organization	Regulations, Guidelines, and Industry Standards	Relevant Paragraphs
EASA	Installed Systems and Equipment for Use by the Flight Crew, AMC 25.1302 Amdt. 28	3.3.2. Methodological considerations applicable to human factors assessments
EASA	AMC 25.1329 Amdt. 28	All
EASA	CATA Worklist Item (CWI) EASA-003 – 25.1302	V. Implementation of the scenario-based approach
EASA	Part 21, Annex I, Appendix XII – Categories of flight tests and associated flight test crew qualifications	C(3). Categories of flight tests
EASA	EASA Part Flight Crew Licensing (Part-FCL)	FCL 820 (a), (b) and (c)
FAA	Installed Systems and Equipment for Use by the Flightcrew, AC 25.1302-1	3-3 Flightcrew Capabilities
FAA	AC 27-1B CHG 9	MG 20
FAA	AC 29-2C CHG 9	MG 20
FAA	AC 25.1329-1C	100.b.(3) Pilot recognition 100.b.(4) Pilot reaction time 103 Assessment of human factors
FAA	Minimum Flightcrew, AC 25.1523-1	5.c. Testing (1)
FAA	Minimum Flightcrew, AC 23.1523	2.b.
FAA	Guidance for Reviewing Certification Plans to Address Human Factors for Certification of Part 23 Small Airplanes, PS- ACE100-2001-004	Appendix A
FAA	Order 8110.37F Designated Engineering Representative (DER) Handbook	All
GAMA	Boeing 737 MAX Related Reports & Recommendations and their Impact on Human Factors, GAMA Publication #21, May 2023	All

Appendix B. List of Abbreviations and Acronyms

AC	Advisory Circular
AFM	Airplane Flight Manual
AMC	Acceptable Means of Compliance
ANAC	Agência Nacional de Aviação Civil (National Civil Aviation Agency of Brazil)
AR	Authorized Representative
ATP	Airline Transport Pilot
CATA	Certification Authorities for Large Transport Aircraft
CFR	Code of Federal Regulations
CWI	CATA Worklist Item
DER	Designated Engineering Representative
EASA	European Union Aviation Safety Agency
E-UM	Engineering Unit Member
FAA	Federal Aviation Administration
FCL	Flight Crew Licensing
FDHFWG	Flight Deck Human Factors Working Group
GAMA	General Aviation Manufacturers Association
HF	Human Factors
HMI	Human Machine Interface
ODA	Organization Designation Authorization
OEM	Original Equipment Manufacturer
PIC	Pilot-in-Command
SIC	Second-in-Command
SOP	Standard Operating Procedure
STC	Supplemental Type Certificate
TC	Type Certificate
TCCA	Transport Canada Civil Aviation

Appendix C. Glossary

Term	Definition
Assessment	The process of finding and interpreting evidence to be used by the applicant in order to establish compliance with a specification. For the purposes of this paper, this term may refer to a range of means of compliance, such as mock-ups, design reviews, laboratory reviews, analyses, evaluations and tests. Evaluations are intended to be conducted using partially representative test means, whereas tests make use of conformed test articles (CATA Worklist Item EASA-00325. – 1302, Annex 1, 4.I.a, EASA AMC 25.1302 - Amdt 28).
Development	The iterative process of analyzing, designing, prototyping, and evaluating a solution to ensure that it meets company and certification requirements.
Evaluation	Evaluations are a design development activity and/or a means of compliance where the representation of the human interface and the system interface do not necessarily conform to the final documentation, and the certification official is generally not present. The applicant may use a wide variety of part-task to full-installation representations of the product/system or flightdeck for evaluations. Mock-ups, part-task simulations, full simulations, and in-flight evaluations typically make up this group of compliance means. (AC 25.1302-1)
Naïve Pilot	**If the assessment involves a system**, a naïve pilot is defined as one who has no prior knowledge of the evaluation/test plan content before participating in the assessment and was not involved in the development of the system. **If the assessment involves an aircraft**, a naïve pilot is one who has no prior knowledge of the evaluation/test plan content before participating in the assessment, has not previously flown the specific (newer) aircraft being assessed and was not involved in the development.
Tests	Tests are means of compliance conducted in a manner very similar to evaluations described above, with one significant difference. Tests require an actual conforming product/system and system interface. A test may be conducted on a bench, in a laboratory, in a simulator, or on an airplane. (AC 1302-1)

Appendix D. Contributors

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