[4910-13-U]

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

[Policy Statement Number ANM-99-2]

Guidance for Reviewing Certification Plans to Address Human Factors for Certification of Transport Airplane Flight Decks

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of policy statement; request for comments.

SUMMARY: This document announces an FAA general statement of policy that is applicable to the type certification process of transport category airplanes. This policy provides guidance to FAA Certification Teams that will enable them to conduct an effective review of an applicant's Human Factors Certification Plan or the human factors components of a general Certification Plan, when one is submitted at the beginning of a type certification (TC), supplemental type certification (STC), or amended type certificate (ATC) project. This guidance describes the sections of a Human Factors Certification Plan and the information that should be included in each section. The purpose of the plan is to facilitate the establishment early on of an effective working relationship and agreement between the FAA and the applicant about the means by which human factors issues will be addressed during a certification project. This notice is to advise the public of FAA policy and give all interested persons an opportunity to review and comment on the policy statement.

DATES: Comments must be received on or before November 5, 1999.

ADDRESS: Send all comments on this policy statement to the individual identified under "FOR FURTHER INFORMATION CONTACT."

FOR FURTHER INFORMATION CONTACT: Sharon Hecht, Federal Aviation Administration, Transport Airplane Directorate, Transport Standards Staff, Airplane & Flight Crew Interface Branch, ANM-111, 1601 Lind Avenue SW., Renton, Washington

98055-4056; telephone (425) 227-2398; facsimile (425) 227-1100; e-mail: 9-ANM-111-HUMAN FACTORS@faa.gov.

SUPPLEMENTARY INFORMATION:

Comments Invited

Interested persons are invited to submit written comments on this policy statement. Commenters should identify the Policy Statement Number of this policy statement, and submit comments, in duplicate, to the address specified above. All communications received on or before the closing date for comments will be considered by the Transport Standards Staff of the Transport Airplane Directorate.

Effect of General Statement of Policy

The general policy stated in this document is not intended to establish a binding norm; it does not constitute a new regulation, and the FAA would neither apply nor rely upon it as a regulation. The FAA Aircraft Certification Offices (ACO) that certify transport category airplanes and/or the flight deck systems installed on them should attempt to follow this policy, when appropriate. However, in determining compliance with certification standards, each FAA office has the discretion not to apply these guidelines where it determines that they are inappropriate.

Background

Recent aviation safety reports underscore the importance of addressing issues related to human factors and flightcrew error in system design and certification. Applicants have demonstrated the effectiveness of using a “Human Factors Certification Plan” to communicate their proposed approach to the identification and resolution of human factors issues. This type of plan has been used as a means by which the applicant and the FAA can establish an early and formal written agreement on the certification basis, the methods of compliance, and the schedules for completing the certification project. This approach has helped FAA Certification Teams address issues as early in the

certification process as possible, thereby decreasing the applicant's certification risk in cost or schedule.

An alternative approach to developing a stand-alone Human Factors Certification Plan is for the applicant to address the human factors issues as part of their general Certification Plan. Regardless of whether it is a stand-alone document or not, the trend has been for applicants to provide some specific information about their plans to address human factors issues for the certification project.

Because of the proven effectiveness of this type of approach, increasing numbers of applicants have asked for assistance from the FAA in developing Human Factors Certification Plans. Given this trend, the Transport Airplane Directorate has developed this policy to assist FAA Certification Team members in working with applicants who are attempting to develop Human Factors Certification Plans, as well as in reviewing these plans after they have been submitted.

Objective of This Policy

The objective of this policy is to provide guidance for the FAA Certification Team to use when reviewing the applicant's Human Factors Certification Plan or the human factors components of the general Certification Plan during a type certification (TC), supplemental type certification (STC), or amended type certificate (ATC) project for transport category airplanes. The policy is intended for use by all members of the Certification Team, which may include the following:

- aircraft evaluation group inspectors,
- avionics engineers,
- Certification Team project managers,
- flight test pilots and engineers,
- human factors specialists,
- propulsion engineers, and
- systems engineers.

While this policy is focused on providing guidance to these FAA team members, it may be of use to the applicant, as well. If the applicant develops a Certification Plan for a certification project, the information in this policy statement can be used as a basis for communicating the applicant's approach to addressing the human factors aspects of the project.

This policy is one portion of an overall FAA strategy for the development of policies related to human factors in the certification of flight decks on transport category airplanes. Future policy development will cover the following areas, related to showing compliance with regulatory requirements associated with human factors:

- Information on the recommended content of certification plans.
- Information on how to determine the adequacy of an applicant's proposed methods of compliance.
- Information on how to determine the adequacy of an applicant's proposed test plans intended to support certification.
- Information on how to determine pass-fail criteria for analyses and tests performed to support certification.

Relevant reference material can be found in Appendix B of this policy statement.

A checklist is included in Appendix D of this policy statement, which can be used as part of certification plan review. It covers all of the sections listed below.

GENERAL STATEMENT OF POLICY:

Guidance for Reviewing Certification Plans to Address Human Factors for Certification of Transport Airplane Flight Decks

The guidance provided in the following sections is intended to help the Certification Team members review a Human Factors Certification Plan submitted by an applicant. It is organized into nine sections, which are consistent with those suggested for a Certification Plan in FAA Advisory Circular (AC) 21-40, "Application Guide for Obtaining a Supplemental Type Certificate." Those sections are:

1. Introduction
2. System Description
3. Certification Requirements
4. Methods of Compliance
5. System Safety Assessments
6. Operational Considerations
7. Certification Documentation
8. Certification Schedule
9. Use of Designees and Identification of Individual DER/DAR

Guidance is provided in this general statement of policy concerning the information that would be appropriate to include in each of these sections for either a Human Factors Certification Plan or a general Certification Plan. A sample (hypothetical) Human Factors Certification Plan can be found in Appendix C of this general statement of policy. (**NOTE**: While Appendix C is included as part of this policy statement document, the FAA also plans to provide it as a separate web site on the Internet, where it can become a "living document" and be updated as new information, processes, and technology become available.)

1. INTRODUCTION

This section of the Certification Plan should provide a short overview of the certification project, the certification program in general, and the purpose of the Human Factors Certification Plan specifically.

2. SYSTEM DESCRIPTION

This section of the Certification Plan should describe the general features of the flight deck, system, or component being presented as part of a certification project. Because a human factors perspective of the flight deck includes the systems, the users (flightcrew members), and the ways in which they interact (e.g., crew procedures), this section of the Human Factors Certification Plan may include general descriptions of all

three. The applicant can use this section to ensure that the Certification Team and the applicant have a common understanding of the basic design concepts as well as the principles and operational assumptions that underlie the design of the flightcrew interfaces.

For the purposes of this policy, the term "flightcrew interface" is intended to cover both the design of the systems (hardware, software) and the tasks (physical, cognitive, perceptual, procedural) the pilots will perform when using the systems in the context of their overall responsibilities.

The applicant should give special attention to any new or unique features or functions and how the flightcrew will use them. Specifically, the following topic areas may be included:

2.a. Intended Function: The Human Factors Certification Plan should provide information describing the intended functions of the major flightcrew interfaces. For each, the applicant should identify the following items, as appropriate, focusing on new or unique features that affect the crew interface or the allocation of tasks between the pilot(s) and the airplane systems:

- The intended function of the system from the pilot's perspective.
- The role of the pilot relative to the system.
- The procedures (e.g., type of approach procedures) expected to be flown.
- The assumed airplane capabilities (e.g., communication, navigation, and surveillance).

2.b. Flight Deck Layout Drawings: Drawings of the flight deck layout, even if they are only preliminary, can be very beneficial for providing an understanding of the intended overall flight deck arrangement (controls, displays, sample display screens, seating, stowage, etc.). The applicant should be encouraged to provide scheduled updates to the drawings, so that the Certification Team's knowledge of the layout progresses as

the design matures. Special attention should be given to any of the following that are novel or unique:

- Arrangements of the controls, displays, or other flight deck features or equipment.
- Controls, such as a cursor control device, or new applications of existing control technologies.
- Display hardware technology.

For the items identified above, sketches of the crew interfaces for the specific systems can be helpful in providing an early understanding of the features that may have certification issues. The applicant should include with the drawings descriptions of interface, button, knob function, anticipated system response, alerting mechanism, mode annunciation, etc., so that the documentation adequately covers each component or system that the pilot must interact with.

2.c. Underlying Principles for Automation Logic: For designs that involve significant automation, the way the automation operates and communicates that operation to the pilot can have significant effects on safety. Key topics could include the following:

- Operating modes
- Principles underlying mode transitions
- Mode annunciation scheme
- Automation engagement/disengagement principles
- Preliminary logic diagrams, if available

2.d. Underlying Principles for Crew Procedures: Because the design of the systems and the development of the associated procedures are interrelated, it is useful to describe the underlying guidelines or principles that form the basis for the crew procedures. Key topics could include the following:

- The expected use of memorized procedures with confirmation checklists vs. read-and-do procedures/checklists.

- Crew interactions during procedure/checklist accomplishment.
- Automated support for procedures/checklists, if available.

2.e. Assumed Pilot Characteristics: The applicant may choose to include a description of the pilot group that the manufacturer expects will use the flight deck design. This description could include assumptions about the following:

- Previous flying experience (e.g., ratings, flying hours).
- Experience with similar or dissimilar flight deck designs and features, including automation.
- Expected training that the pilots will receive on this flight deck design, or assumptions regarding expected training.

3. CERTIFICATION REQUIREMENTS

This section should list and describe the human factors-related regulations and other requirements that are being addressed by the applicant's Human Factors Certification Plan. This section also may include the applicant's compliance checklist for these requirements.

The Certification Team should expect to see a matrix from the applicant with all of the pertinent regulations listed, with specific references to the detailed subparagraphs that will be covered by the Human Factors Certification Plan.

Table 1, below, provides a partial list of regulations contained in 14 CFR part 25 that may be considered for inclusion in a Human Factors Certification Plan. These regulations were selected for the list because they typically require that the applicant carefully consider a number of human factors issues when showing compliance with them.

Appendix B of this document also lists these regulations, along with a brief discussion of some of the human factors issues that may affect the chosen methods of compliance. (**NOTE**: While Appendix B is included as part of this policy statement document, the FAA also plans to provide it as a separate web site on the Internet, where it

can become a “living document” and be updated as new information, processes, and technology become available.)

TABLE 1.

Selected Listing of Regulations in 14 CFR Part 25
Related to Flightcrew Human Factors

FAR SECTION ***[Current Amdt. Level]***	**REQUIREMENT** ***(In some cases, the content of the subparagraphs has been paraphrased for clarity. Actual Human Factors Certification Plans should use the exact wording of the regulations.)***
General Human Factors (HF) Requirements	
§ 25.771(a) *[amdt. 25-4]*	Each pilot compartment and its equipment must allow the minimum flightcrew to perform their duties without unreasonable concentration or fatigue.
§ 25.771(e) *[amdt. 25 -4]*	Vibration and noise characteristics of cockpit equipment may not interfere with safe operation of the airplane.
§ 25.773(a)(1) *[amdt. 25 -72]*	Each pilot compartment must be arranged to give the pilots sufficiently extensive, clear, and undistorted view, to enable them to safely perform any maneuvers within the operating limitations of the airplane, including takeoff, approach, and landing.
§ 25.773(a)(2) *[amdt. 25 -72]*	Each pilot compartment must be free of glare and reflections that could interfere with the normal duties of the minimum flightcrew.
§ 25.777(a) *[amdt. 25 -46]*	Each cockpit control must be located to provide convenient operation and to prevent confusion and inadvertent operation.
§ 25.777(c) *[amdt. 25 -46]*	The controls must be located and arranged, with respect to the pilot’s seats, so that there is full and unrestricted movement of each control without interference from the cockpit structure or the clothing of the minimum flightcrew when any member of this flightcrew, from 5’2” to 6’3” in height, is seated with the seat belt and shoulder harness fastened.
§ 25.1301(a) *[original amdt.]*	Each item of installed equipment must be of a kind and design appropriate to its intended function.
§ 25.1309(b)(3) *[amdt. 25 -41]*	. . . Systems, controls, and associated monitoring and warning means must be designed to minimize crew errors that could create additional hazards.

§ 25.1321(a) *[amdt. 25 -41]*	. . . Each flight, navigation, and powerplant instrument for use by any pilot must be plainly visible to him from his station with the minimum practicable deviation from his normal position and line of vision when he is looking forward along the flight path.
§ 25.1321(e) *[amdt. 25 -41]*	If a visual indicator is provided to indicate malfunction of an instrument, it must be effective under all probable cockpit lighting conditions.
§ 25.1523 *[amdt. 25 -3]*	The minimum flightcrew must be established so that it is sufficient for safe operation, considering (a) the workload on individual crewmembers; (b) the accessibility and ease of operation of necessary controls by the appropriate crewmember; and (c) the kind of operation authorized under § 25.1525. The criteria used in making the determinations required by this section are set forth in Appendix D.
§ 25.1543(b) *[amdt. 25 -72]*	Each instrument marking must be clearly visible to the appropriate crewmember.
System-Specific HF Requirements	
§ 25.785(g) *[amdt. 25 -88]*	Each seat at a flight deck station must have a restraint system… that permits the flight deck occupant, when seated with the restraint system fastened, to perform all of the occupant's necessary flight deck functions.
§ 25.785(l) *[amdt. 25 -88]*	The forward observer's seat must be shown to be suitable for use in conducting the necessary enroute inspections.
§ 25.1141(a) *[amdt. 25 -72]*	Powerplant controls: Each control must be located so that it cannot be inadvertently operated by persons entering, leaving, or moving normally in the cockpit.
§ 25.1357(d) *[original amdt.]*	If the ability to reset a circuit breaker or replace a fuse is essential to safety in flight, that circuit breaker or fuse must be located and identified so that it can be readily reset or replaced in flight.
§ 25.1381(a)(2) *[amdt. 25 -72]*	The instrument lights must be installed so that (ii) no objectionable reflections are visible to the pilot.
Specific Crew Interface Requirements	
§ 25.773(b)(2)(i) *[amdt. 25 -72]*	The first pilot must have a window that is openable … and gives sufficient protection from the elements against impairment of the pilot's vision.

§ 25.1322 *[amdt. 25 -38]*	If warning, caution, or advisory lights are installed in the cockpit, they must, unless otherwise approved by the Administrator, be: (a) Red, for warning lights (lights indicating a hazard which may require immediate corrective action); (b) Amber, for caution lights (lights indicating the possible need for future corrective action); (c) Green for safe operation lights; and (d) Any other color, including white, for lights not described in paragraphs (a) through (c) of this section, provided the color differs sufficiently from the colors prescribed in paragraphs (a) through (c) of this section to avoid possible confusion.

4. METHODS OF COMPLIANCE

The Certification Team should request the detailed plans for showing compliance as the plans evolve with the program. It is recommended that coordination meetings with the applicant and Certification Team be held several times during the certification program to review the compliance checklist in detail and the associated test plans, as they are developed. This will help all parties reach agreement on how the tests, demonstrations, and other data-gathering efforts will be sufficient to show compliance. Of special importance is ensuring that the methods proposed by the applicant will provide enough fidelity to identify human factors issues early enough to avoid adversely affecting the certification schedule.

A suggested format for the compliance checklist is contained in FAA Advisory Circular (AC) 21-40, "Application Guide for Obtaining a Supplemental Type Certificate," dated May 6, 1998. An example of a checklist can be found in Appendix D of this policy statement. (**NOTE**: While Appendix D is included as part of this policy statement document, the FAA also plans to provide it as a separate web site on the Internet, where it can become a "living document" and be updated as new information, processes, and technology become available.)

In this section of the Human Factors Certification Plan, the applicant should delineate the methods that will be used to demonstrate compliance with the relevant regulations. The review and discussion of the methods of compliance is an opportunity for the FAA and the applicant to work together to identify potential human factors issues early in the certification program.

The methods of compliance are not mutually exclusive. The applicant may choose to include any or all of these methods of compliance in its Human Factors Certification Plan. All of the methods of compliance included in the Human Factors Certification Plan should be described in enough detail to give the Certification Team confidence that the results of the chosen method will provide the necessary information for finding compliance. Examples of methods to demonstrate compliance are as follows:

4.a. Drawings: Layout drawings and/or engineering drawings that show the geometric arrangement of hardware or display graphics.

4.b. Configuration Description: A description of the layout, arrangement, direction of movement, etc., or a reference to similar documentation.

4.c. Statement of Similarity: A description of the system to be approved and a previously approved system, which details their physical, logical, and operational similarities, with respect to compliance with the regulations.

4.d. Evaluations, Assessments, Analyses: Evaluations conducted by the applicant or others (not the FAA or a designee), who provides a report to the FAA. These include:

- **Engineering Evaluations or Analyses**: These assessments can involve a number of techniques, including such things as procedure evaluations (complexity, number of steps, nomenclature, etc); reach analysis via computer modeling; time-line analysis for assessing task demands and workload; or other methods, depending on the issue being considered.
- **Mock-up Evaluations:** These types of evaluations use physical mock-ups of the flight deck and/or components. They are typically used for

assessment of reach and clearance; thus, they demand a high degree of geometric accuracy.

- **Part-Task Evaluations:** These types of evaluations use devices that emulate (using flight hardware, simulated systems, or combinations) the crew interfaces for a single system or a related group of systems. Typically, these evaluations are limited by the extent to which acceptability may be affected by other flight deck tasks.
- **Simulator Evaluations:** These types of evaluations use devices that present an integrated emulation (using flight hardware, simulated systems, or combinations) of the flight deck and the operational environment. They also can be "flown," with response characteristics that replicate, to some extent, the responses of the airplane. Typically, these evaluations are limited by the extent to which the simulation is a realistic, high fidelity representation of the airplane, the flight deck, the external environment, and crew operations. The types of pilots (test, instructor, airline) used in the evaluations and the training they receive may significantly affect the results and their utility.
- **In-Flight Evaluations:** These types of evaluations use the actual airplane. Typically, these evaluations are limited by the extent to which the flight conditions of particular interest (e.g., weather, failures, unusual attitudes) can be located/generated and then safely evaluated in flight. The types of pilots (test, instructor, airline) used in the evaluations and the training they receive may significantly affect the results and their utility.

4.e. Demonstrations: Similar to evaluations (described above), but conducted by the applicant with participation by the FAA or its designee. The applicant provides a report, requesting FAA concurrence on the findings. Examples of demonstrations include:

- **Mock-up Demonstrations.**
- **Part-Task Demonstration.**
- **Simulator Demonstration.**

4.f. Inspection: A review by the FAA or its designee, who will be making the compliance finding.

4.g. Tests: Evaluations conducted by the FAA or a designee, which may encompass:

- **Bench Tests:** These are tests of components in a laboratory environment. This type of testing is usually confined to showing that the components perform as designed. Typical bench testing may include measuring physical characteristics (e.g., forces, luminance, format) or logical/dynamic responses to inputs, either from the user or from other systems (real or simulated).
- **Ground Tests:** These are tests conducted in the actual airplane, while it is stationary on the ground. In some cases, specialized test equipment may be employed to allow the airplane systems to behave as though the airplane was airborne.
- **Simulator Tests:** (See simulator evaluations, above.)
- **Flight Tests:** These are tests conducted in the actual airplane. The on-ground portions of the test (e.g., preflight, engine start, taxi) are typically considered flight test rather than ground test.

The methods identified above cover a wide spectrum: from documents that simply describe the product, to partial approximations, to methods that replicate the actual airplane and its operation with great accuracy. Features of the product being certified and the types of human factors issues to be evaluated are key considerations when selecting which method is to be used. The characteristics described below can be

used to help in coming to agreement regarding what constitutes the minimum acceptable method(s) of compliance for any individual requirement.

When a product needs to meet multiple requirements, some requirements may demand more complex testing while others can be handled using simple descriptive measures. It is important to note that the following characteristics are only general principles. They are intended to form the basis for discussions regarding acceptable methods of compliance for a specific product with respect to a requirement.

4.h. Other Considerations:

- **Degree of Integration/Independence:** If the product to be approved is a stand-alone piece of equipment that does not interact with other aspects of the crew interface, less integrated methods of compliance may be acceptable. However, if the product is tightly tied to other systems in the flight deck, either directly or by the ways crews use them, it may be necessary to use methods that allow the testing of those interactions.
- **Novelty/Past Experience:** If the technology is mature and well understood, less rigorous methods may be appropriate. More rigorous methods may be called for if the technology is new, is used in some new application, is new for the particular applicant, or is unfamiliar to the certification personnel.
- **Complexity/Level of Automation:** More complex and automated systems typically require test methods that will reveal how that complexity will manifest itself to the pilot, in normal and backup or reversionary modes of operation.
- **Criticality:** Systems that are central to the interface design may require testing in the most realistic environments (high-quality simulation or flight test), because any problems are likely to have serious consequences.

- **Dynamics:** If the control and display features of the product are highly dynamic, the compliance methods should be capable of replicating those dynamic conditions.
- **Level of Training Required:** If the product is likely to require a significant amount of training to operate, the interfaces may need to be evaluated in an environment that replicates the full spectrum of activities in which the pilot may be involved.
- **Subjectivity of Acceptance Criteria:** Requirements that have specific, objectively measurable criteria can often employ simpler methods for demonstrating compliance. As the acceptance criteria become more subjective, more integrated test methods are needed, so that the evaluations take into account the aspects of the integrated flight deck that may affect those evaluations.

The main objective is to carefully match the method to the product and the underlying human factors issues. It is also important for the Certification Team to recognize that several methods may be acceptable for any given requirement and applicants should be allowed to select among the acceptable methods, choosing the ones that best fit their compliance strategy, schedule, and cost considerations.

5. SYSTEM SAFETY ASSESSMENTS

Typically, system safety assessments [i.e., Functional Hazard Assessment (FHA), Failure Modes and Effects Analysis (FMEA), Fault Tree Analysis, etc.] are accomplished by the applicant's engineering group that is responsible for each system. However, for each assessment planned, the applicant should describe how any human factors elements will be addressed (such as crew responses to failure conditions) and other assumptions that must be made about crew behavior. These assumptions should be reviewed by the full Certification Team to ensure that no assumptions are being made that will require the flightcrew to compensate for failures beyond their expected capabilities. These human

factors considerations can be documented in the individual system safety assessments, or the applicant may elect to describe them in the Human Factors Certification Plan, with references to the associated system safety assessments.

6. OPERATIONAL CONSIDERATIONS

The applicant may have specific goals associated with the operational certification of the airplane or system that could influence the design and its evaluation. In this section, the applicant will typically describe how these operational considerations will be integrated into the part 25 aspects of the certification project. It would be useful to identify operational requirements that have been factored into the type design. For example, the Traffic Alert and Collision Avoidance System (TCAS) is mandated as a rule change in part 121 rather than in part 25.

This section of the Certification Plan also may include how the operational certification, as captured in the following documents, will influence the methods of compliance:

- Airplane Flight Manual (AFM),
- Master Minimum Equipment List (MMEL)
- Flightcrew Operating Manual (FCOM), and
- Quick Reference Handbook (QRH).

Shown below are two examples of how the operational and airworthiness considerations may be interdependent:

Example 1. The applicant may desire MMEL dispatch relief for certain systems. In order to ensure that the desired dispatch relief will be approved, it may be advantageous to conduct certification testing of those configurations (including the next most significant failures), to ensure that they are acceptable for normal operations.

Example 2. In order to help ensure acceptance of the FCOM, it may be advantageous to conduct certification testing using the procedures and other relevant information that will be included in the FCOM. This will enable the members of the

Airplane Evaluation Group (AEG) to have a high degree of confidence that there will be no human factors problems associated with their use.

The AEG, Flight Standards Operations representatives, and Human Factors Specialists on the Certification Team should be involved in the review of this section of the Human Factors Certification Plan.

7. CERTIFICATION DOCUMENTATION

The Human Factors Certification Plan should indicate the types of documentation that will be submitted to show compliance or otherwise document the progress of the certification program. This section may list the specific documentation (test report number, analysis report number, etc.) that will be used to support compliance with the subject regulation. They may also be indicated in the compliance matrix.

8. CERTIFICATION SCHEDULE

This section of a Human Factors Certification Plan should include the major milestones of the certification program. This may include:

8.a. Certification Plan Submittals: The Certification Team should expect periodic updates to the Human Factors Certification Plan as the certification program progresses. The applicant should be encouraged to submit the first Human Factors Certification Plan as soon as possible after the start of the program. The applicant should be reassured that draft, preliminary information is acceptable and appropriate, provided that it is updated and finalized in a timely manner (as documented in the schedule and agreed to jointly by the FAA and the applicant).

8.b. Flight Deck Reviews, Early Prototype Reviews, Simulator Reviews, and Flight Test Demonstrations: The Human Factors Certification Plan can document planned design reviews. Even in cases where the reviews are not directly associated with finding compliance, they can be very helpful in the following ways:

- Providing the Certification Team with an accurate and early understanding of the crew interface tradeoffs and design proposals.

- Allow the certification team to provide the applicant with early feedback on any potential certification issues.
- Support cooperative teaming between the applicant and the certification team, in a manner consistent with the Certification Process Improvement initiative.

8.c. Coordination meetings: Coordination meetings with other certification authorities, or meetings with other FAA Aircraft Certification Offices on components of the same certification project or related projects, should be documented in the schedule.

The Certification Team can use the information in the schedule to determine if sufficient coordination and resources are planned for the certification program.

9. USE OF DESIGNEES AND IDENTIFICATION OF INDIVIDUAL DER/DAR

This section should describe how the applicant will make use of Designated Engineering Representatives (DER), Designated Airworthiness Representatives (DAR), or other designees during the certification program.

APPENDIX A

APPENDIX A

Partial List of Part 25 Regulations Related to Human Factors Issues

The following list of regulations is divided into the following three categories:

1. General Human Factors Requirements: Rules that deal with the acceptability of the flight deck and crew interfaces across a variety of systems/features.

2. Specific Human Factors Requirements: Rules that deal with the acceptability of a specific feature or function in the flight deck.

3. Specific Crew Interface Requirements: Rules that mandate a specific system feature, which must be implemented in an acceptable manner.

This list is not intended to include all regulations associated with flightcrew interfaces. However, these represent some of the requirements for which demonstrating compliance can be problematic. In some cases, where only subparagraphs are noted, they have been paraphrased for clarity; the applicant should use the exact wording of the regulation in all plans and compliance documents.

In many cases, there may be no precise standard of acceptability. Therefore, it is in the applicant's best interest to carefully consider and describe how they plan to come to agreement with the FAA with respect to compliance. The highlighted words identify the key issues that are central to finding compliance and that could be addressed using various methods. Following each regulatory requirement are notes intended to help the applicant select an appropriate method of compliance. Typically, the Certification Plan would only identify and generally describe the methods to be used. Detailed descriptions of analyses and tests would be documented separately (e.g., in test plans), subsequent to an agreed-upon Certification Plan. However, the applicant should sufficiently develop the plans to assure themselves and the FAA that the selected methods are appropriate and adequate.

1. **General Human Factors Requirements:**

- **§ 25.771(a) [at amdt. 25-4]:**

  Each pilot compartment and its equipment must allow the minimum flightcrew to perform their duties without unreasonable concentration or fatigue.

  Discussion: The applicant should carefully consider the aspects of the flightcrew interface that might require significant or sustained mental or physical effort, or might otherwise result in fatigue. Other factors affecting fatigue, such as noise and seat comfort, also may need to be evaluated. Methods of compliance should be selected based on the potential concentration demands and sources of fatigue for the flightcrew. Comparisons to previously certificated designs are often a useful method, although testing may be warranted for new designs.

- **§ 25.771(e) [at amdt. 25-4]:**

  Vibration and noise characteristics cockpit equipment may not interfere with safe operation of the airplane.

  Discussion: When determining the method of compliance, the applicant should carefully consider the types/magnitudes of the vibration and noise that may be present under both normal and abnormal conditions. Then, tasks that may be affected by vibration (e.g., display legibility and the operation of controls) and noise (e.g., communication and identification of aural alerts) should be identified, as well as the methods that could be employed to determine whether or not the vibration or noise will unacceptably interfere with safe operation of the airplane.

- **§ 25.773(a)(1) [at amdt. 25-72]:**

  Each pilot compartment must be arranged to give the pilots sufficiently extensive, clear, and undistorted view, to enable them

to safely perform any maneuvers within the operating limitations of the airplane, including takeoff, approach, and landing.

Discussion: The applicant should carefully consider the method of compliance described in FAA Advisory Circular (AC) 25.773-1, "Pilot Compartment View for Transport Category Airplanes."

- **§ 25.773(a)(2) [at amdt. 25-72]:**

  Each pilot compartment must be free of glare and reflections <u>that could interfere</u> with the normal duties of the minimum flightcrew.

Discussion: The applicant may be able to develop analytical techniques that identify potential sources of glare and reflections, as a means for reducing the risk of problems identified after the major structural features have been committed. Mock-ups also may be a useful means for early assessments. However, analysis results typically must be verified in an environment with a high degree of geometric and optical fidelity. Both internal (e.g., area and instrument lighting) and external (e.g., shafting sunlight) sources of reflections should be considered.

- **§ 25.777(a) [at amdt. 25-46]:**

  Each cockpit control must be located to provide <u>convenient operation</u> and to prevent <u>confusion and inadvertent operation</u>.

Discussion: The applicant may choose to use physical mock-ups for preliminary evaluations. Simulators, if available, provide a more powerful evaluation environment, because they allow the evaluation to take place in a flight scenario, which may influence convenience and inadvertent operation. Simulator evaluations may reduce the need for flight testing.

- **§ 25.777(c) [at amdt. 25-46]:**

  The controls must be located and arranged, with respect to the pilot's seats, so that there is full and unrestricted movement of each control without interference from the cockpit structure or the clothing of the minimum flightcrew when any member of this flightcrew, from 5'2" to 6'3" in height, is seated with the seat belt and shoulder harness fastened.

Discussion: The applicant may choose to use analytical methods, such as computer modeling of the flight deck and the pilots, for early risk reduction and to supplement certification evaluations using human subjects. Computer modeling allows for more control over the dimensions of the pilot model and, thus, may allow the assessment of otherwise unavailable combinations of body dimensions. The applicant should carefully consider the advantages and limitations of each of these methods.

- **§ 25.1301(a) [original amdt.]:**

  Each item of installed equipment must be of a kind and design appropriate to its intended function.

Discussion: The applicant may wish to consider a number of methods for showing compliance with this requirement, with respect to human factors. For example, service experience may be an effective means for assessing systems with well-understood, successful crew interfaces, assuming that other factors, such as changes in the operational environment, do not affect the relevance of that experience. Various requirements analysis techniques can be used to show that the information that the pilot needs to perform key tasks is available, usable, and timely. Simulation may be used to verify that properly trained pilots can adequately perform all required tasks, using the controls and displays provided by

the design, in realistic scenarios and timelines. Finally, flight tests can be used to investigate specific normal and abnormal operational scenarios.

- **§ 25.1309(b)(3) [at amdt. 25-41:**

  > . . . Systems, controls, and associated monitoring and warning means must be designed to minimize crew errors that could create additional hazards.

  Discussion: The applicant may wish to perform analyses of crew procedures in response to system faults. This can be especially important in cases where the applicant wishes to take certification credit (e.g., in a Fault Tree Analysis) for correct pilot response to a system failure. A crew procedure analysis could be supported by performing qualitative evaluations that compare actual procedures to procedure design philosophies, by developing measures of procedure complexity, or by accomplishing other techniques that focus on procedure characteristics that impact the likelihood of crew errors. Simulation testing, including the use of untrained (in the new design) line pilots, can be helpful in demonstrating that the design is not prone to crew errors. Finally, evaluations by highly experienced training and test pilots can be a valuable means of gathering information on the susceptibility to crew errors.

- **§ 25.1321(a) [at amdt. 25-41]:**

  > . . . Each flight, navigation, and powerplant instrument for use by any pilot must be plainly visible to him from his station with the minimum practicable deviation from his normal position and line of vision when he is looking forward along the flight path.

  Discussion: The applicant may wish to perform analyses of the visual angles to each of the identified instruments. Final assessments of the acceptability of the

visibility of the instruments may require a simulator with a high degree of geometric fidelity and/or the airplane.

- **§ 25.1321(e) [at amdt. 25-41]:**

  If a visual indicator is provided to indicate malfunction of an instrument, it must be effective under all probable cockpit lighting conditions.

  Discussion: Demonstrations and tests intended to show that these indications of instrument malfunctions, along with other indications and alerts, are visible under the expected lighting conditions will typically employ the use of production quality hardware and careful control of lighting conditions (e.g., dark, bright forward field, shafting sunlight). Simulators and aircraft are often used, although supporting data from laboratory testing also may be useful.

- **§ 25.1523 [at amdt. 25-3]:**

  The minimum flightcrew must be established so that it is sufficient for safe operation, considering:

  (a) the workload on individual crewmembers;

  (b) the accessibility and ease of operation of necessary controls by the appropriate crewmember; and

  (c) the kind of operation authorized under § 25.1525.

  Discussion: (The factors considered in making the determinations required by this section are set forth in Appendix D of this general statement of policy.) The applicant may choose to use workload analyses (such as time-line analysis) to evaluate certain workload issues. Other evaluations of workload typically involve trained pilots in either a high fidelity simulation or in actual airplanes. There are a number of possible workload assessment techniques that can be successfully employed. An efficient means for selecting test conditions is to focus on those

operational and/or failure scenarios that are likely to result in the highest workload conditions. Dispatch under the Minimum Equipment List (MEL) also should be considered, in combination with other failures that are likely to result in significantly increased workload. Since no objective standard for workload is available, applicants may wish to compare the workload in the new/modified airplane with that in a well-understood, previously certificated airplane.

- **§ 25.1543(b) [at amdt. 25-72]:**

  > Each instrument marking must be clearly visible to the appropriate crewmember.

  Discussion: The applicant may choose to use computer modeling to provide preliminary analysis showing that there are no visual obstructions between the pilot and the instrument markings. Where head movement is necessary, such analyses also can be used to measure its magnitude. Other analysis techniques can be used to establish appropriate font sizes, based on research-based requirements. Mock-ups also can be helpful in some cases. The data collected in these analysis and assessments can be used to support final verification in the flight deck, using subjects with vision that is representative of the pilot population, in representative lighting conditions.

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2. Specific Human Factors Requirements:

- **§ 25.785(g) [at amdt. 25-88]:**

  > Each seat at a flight deck station must have a restraint system . . . that permits the flight deck occupant, when seated with the restraint system fastened, to perform all of the occupant's necessary flight deck functions.

Discussion: The applicant may choose to develop a list of what it considers to be necessary flight deck functions, under normal and abnormal conditions. Methods similar to those used to show compliance with § 25.777 also may be appropriate for demonstrating compliance with this paragraph, with the additional consideration of movement constraints imposed by the full restraint system.

- **§ 25.785(l) [at amdt. 25-88]:**

  The forward observer's seat must be shown to be suitable for use in conducting the necessary enroute inspections.

Discussion: The applicant may choose to develop a set of requirements (e.g., what must be seen and reached) based on the expected tasks to be performed by an inspector. Computer-based analysis and/or mock-ups can be used to develop supporting data; evaluation of enroute inspection scenarios can be used to verify that all required tasks can be performed. Since the geometric relationship between the observer's seat and the rest of the flight deck (including the pilots) is important, the evaluations often must occur in the actual airplane.

- **§ 25.1141(a) [at amdt. 25-72]:**

  Each powerplant control must be located so that it cannot be inadvertently operated by persons entering, leaving, or moving normally in the cockpit.

Discussion: This type of assessment typically requires at least a physical mock-up, due to limitations in the ability to adequately model "normal" movement in the cockpit. Evaluations should be designed to include cases in which the pilots must reach across the area surrounding the powerplant controls and to look for places where pilots will naturally place their hands and feet during ingress and egress, and during cruise.

- **§ 25.1357(d) [original amdt.]:**

  If the ability to reset a circuit breaker or replace a fuse is essential to safety during flight, that circuit breaker or fuse must be located and identified so that it can be readily reset or replaced in flight.

  Discussion: The applicant may choose to use methods similar to those employed for § 25.777 to demonstrate the ability of the pilot to reach the specific circuit protective device(s). The applicant also should consider how to evaluate the ability of the pilot to readily identify the device(s), whether they are installed on a circuit breaker panel or controlled using an electronic device (i.e., display screen on which the circuit breaker status can be displayed and controlled).

- **§ 25.1381(a)(2) [at amdt. 25-72]**:

  The instrument lights must be installed so that . . . (ii) no objectionable reflections are visible to the pilot.

  Discussion: See the discussion of § 25.773(a), above.

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3. Specific Crew Interface Requirements:

- **§ 25.773(b)(2)(i) [at amdt. 25-72]**:

  The first pilot must have a window that is openable . . . and gives sufficient protection from the elements against impairment of the pilot's vision.

  Discussion: While the applicant may perform analyses to show that the visual field through the openable window, due to the nature of the task (landing the airplane by looking out the opened window), it is likely that a flight test would be the most appropriate method of compliance. Assessment of the forces required to open the window under flight conditions may also be needed.

- **§ 25.1322 [at amdt. 25-38]**:

  If warning, caution, or advisory lights are installed in the cockpit, they must, unless otherwise approved by the Administrator, be:

  (a) Red, for warning lights (lights indicating a hazard which may require immediate corrective action);

  (b) Amber, for caution lights (lights indicating the possible need for future corrective action);

  (c) Green for safe operation lights; and

  (d) Any other color, including white, for lights not described in paragraphs (a) through (c) of this section, provided the color differs sufficiently from the colors prescribed in paragraphs (a) through (c) of this section to avoid possible confusion.

  Discussion: Compliance with this requirement is typically shown by a description of each of the warning, caution, and advisory lights. Evaluations may also be useful to verify the chromaticity (e.g., red looks red, amber looks amber) and discriminability (i.e., colors can be distinguished reliably from each other) of the colors being used, under the expected lighting levels. These evaluations can be affected by the specific display technology being used, so final evaluation with flight quality hardware is sometimes needed. A description of a well-defined color coding philosophy that is consistently applied across flight deck systems can be used to show how the design avoids "possible confusion."

APPENDIX B

APPENDIX B

Related Documents

1. **Williams, James H., "Description of the FAA Avionics Certification Process," FAA Document, April 23, 1997.**

   This document is a high level explanation of the FAA approach to certification of avionics. It addresses the major aspects of the certification process including:

   - design approvals under the Type Certificate (TC) or Supplemental Type Certificate (STC) approval process;
   - design approvals under the Technical Standard Order (TSO) approval process;
   - installation approvals for initial (new) avionics following a TSO approval;
   - installation approvals using the FAA Form 337 ("Major Repair and Alteration: Airframe, Powerplant, Propeller, or Appliance") process.

   This document will help the applicant become familiar with the FAA process to certify avionics. The certification process is laid out in a flowchart format. This document is available on the Internet at http://www.faa.gov/avr/air/air100/100home.htm.

2. **FAA Booklet, "The FAA Type Certification Process," Aircraft Certification Service, May 1996.**

   The FAA's Aircraft Certification Service issued this document for both internal use and industry guidance. It describes the important steps in the process leading to issuance of a type certificate. Discussion includes descriptions of roles, responsibilities, and job functions of participants in the process, and provides a listing of the "best practices" that the FAA can follow to do its job well. It also describes the

use of a Certification Plan as a key communication tool during the certification process.

3. **FAA Order 8110.4A, "Type Certification Process," March 2, 1995; and**
4. **FAA Order 8110.5, "Aircraft Certification Directorate Procedures," October 1, 1982.**

These Orders prescribe the responsibilities and procedures for FAA aircraft certification engineering and manufacturing personnel when accomplishing the evaluation and approval of aircraft type design data and changes to approved type design data. These Orders contain descriptions of Certification Plans and how FAA personnel can use them during the certification process. These documents are can be found on the Internet at:

http://www.mmac.jccbi.gov/afs/afs600/fdr/8110-4a.pdf

and

http://av-info.faa.gov/dst/8100-5.doc

5. **Advisory Circular (AC) 21-40, "Application Guide for Obtaining a Supplemental Type Certificate," May 6, 1998.**

This advisory circular contains guidance for preparing a Certification Plan for a supplemental type certification project. Figure 2-4 of the AC suggests that applicants use a specific format for the plan and provides a sample of it, which includes the following nine sections:

1. Introduction
2. System description
3. Certification requirements
   (a) Regulations
   (b) Special requirements, unique or novel design aspects
   (c) Compliance checklist

4. Methods of compliance
5. Functional hazard assessment summary
6. Operational considerations (if required)
7. Certification documentation
8. Certification schedule
9. Use of designees and identification of individual Designated Engineering Representatives (DER)/Designated Airworthiness Representatives (DAR)

These sections, and the material they contain, are appropriate for any applicant's Certification Plan. They also could be applied to the development of a Human Factors Certification Plan. This document can be found on the Internet at http://www.faa.gov/avr/air/acs/achome.htm.

6. Society of Aeronautical Engineers (SAE) Aerospace Recommended Practice 4033, "Pilot-System Integration," August 1995

This document provides a concept development guide to the human engineering specialist and the aircraft systems designer for pilot-system integration that will enhance safety, productivity, reduce certification risk, and improve cost effectiveness. It addresses the resulting processes of system development including aspects of interface design and automation philosophy. (SAE publications are available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001; telephone (412) 776-4970; or e-mail at publications@sae.org.)

APPENDIX C

APPENDIX C

Sample Human Factors Certification Plan

This sample plan is intended to provide examples of the types of information that could be included in the various sections. Keep the following in mind while reviewing it:

- It is based on a totally hypothetical certification program, and no connection to any real system or certification program is intended or implied.
- There are placeholders where the drawings and other figures could be inserted.
- This sample plan should not be considered to be comprehensive. The examples are intended to be illustrative, but do not necessarily include all of the issues, even for the hypothetical program.
- The methods of compliance are intended to show the methods that a hypothetical applicant might have chosen for the project. It should not be construed as describing the acceptable list of methods for any real program. These would have to be discussed and agreed upon within the context of a specific program.
- The Deliverable Products column in the compliance matrix identifies what the hypothetical applicant will produce to substantiate compliance. The titles of reports represent examples of how an applicant might choose to package the information.
- Finally, the sample plan is not intended to specify the format of the report, but rather, to provide guidance on the structure and content only.

[HYPOTHETICAL]

Human Factors Certification Plan
for the Electronic Approach Chart System (EACS)

1. INTRODUCTION.

This project seeks a Supplemental Type Certificate for the installation of an Electronic Approach Chart System (EACS) in Guerin Model 522 airplanes. The intent of the EACS is to provide an alternative to the use of paper approach charts. The EACS will be installed so that it will be physically and functionally integrated into the flight deck. System data will be loaded using existing on-board data loading capabilities. The EACS will be certified as a non-essential system. This Human Factors Certification Plan identifies the human factors-related regulations and the methods of compliance that will be used to show that all safety-related human factors issues have been fully addressed.

2. SYSTEM DESCRIPTION

a. Intended Function: The Electronic Approach Chart System uses a panel-mounted Active Matrix Liquid Crystal Display (AMLCD) to display approach charts for the pilots to use on the ground and in flight. The key functions include the following:

(1) **During the preflight preparation**:

(a) The pilot will use the system to call up and review the approach charts for the destination airport and selected alternates.

(b) The pilot will be able to “mark” the appropriate charts for quick retrieval later in the flight.

(c) If initiated by the pilot, the system will be able to query the Flight Management System (FMS) to pre-identify the appropriate charts, based on the flight plan.

(2) **During flight (normal operations):**

(a) The pilot will quickly access the preselected approach charts. Charts that were not preselected will also be accessible.

(b) The pilot will be able to manipulate the display of the chart to show only the information relative to the planned route of flight.

(c) The pilot will be able to select the appropriate approach parameters (transition, approach navigation aids, minimums, etc) using the EACS. Upon pilot initiation, the EACS will load these selections into the other systems on the airplane [e.g., approach navaids will be sent to the FMS for autotuning, decision height (DH) will be sent to altitude alerting system and display system]. For a complete list of EACS functions, see the EACS System Description Document.

(3) **During flight (non-normal operations, i.e., requiring an emergency diversion):** In addition to those functions available for normal operations, the EACS provides the following functionality to support emergency diversions.

(a) When the pilot selects the ALTERNATE AIRPORT function on the FMS, the FMS automatically identifies the five nearest airports that meet the landing requirements for the airplane. These airports will be automatically transmitted to the EACS, which will preselect them (mark them for quick retrieval).

(b) At the pilot's request, the EACS will display a listing of the diversion airports and allow the pilot to quickly review the approach charts and select the desired approach. As in normal operations, this selection will be automatically transmitted to the FMS and other using systems.

b. Flight Deck Layout Drawings:

(1) Figure 1 and Figure 2 are drawings showing the installation location for the EACS displays, on an angled panel just outboard of each pilot's main instrument panel and forward of the side console. [Figures 1 and 2 would be shown here.]

(2) Figure 3 is a drawing of the EACS display unit with integrated touch screen, function selection buttons, and brightness control. [Figure 3 would be shown here.]

(3) Display formats are still in development and will be provided according to the following schedule shown in Figure 4. [Schedule would be shown here.]

c. Underlying Principles for Crew Procedures

(1) **Normal operations:** The procedures for certain consistent navigation functions are imbedded in the FMS software, which walks the pilot through all necessary preflight and descent preparation steps. This is accomplished using a sequence of prompts, followed by a message when all required steps are completed. Wherever use of the EACS is called for in these existing sequences of tasks, the FMS software will be modified to include the appropriate prompts. Other ad hoc uses for the EACS will be at the pilots' discretion, as is the case with the other navigation and flight planning functions within the FMS.

(2) **Procedures for dealing with EACS and FMS failures:** Any such procedures will be driven by the following operational principles:

(a) The number of procedures and the number of steps in the procedures should be minimized.

(b) All diagnosis of system problems are to be accomplished by the system (i.e., there will be no crew procedures for diagnosing problems).

(c) There will be no crew procedures that require the use of the EACS circuit breaker.

(d) The pilots will not be required to learn alternative modes of interaction (i.e., if the touch screen fails, the pilots will not interact via a keyboard).

(e) If the FMS fails, the EACS should continue to operate normally, except for those functions associated with EACS-FMS data sharing. This continued operation should not be dependent on a pilot procedure.

d. User Pilot Description: The initial certification of this system will be in a transport category airplane and is expected to be used in both Part 121 and Part 135

operations. As a result, this program assumes that the pilot will have only the experience and training required for Part 135 operations.

(1) It is assumed that, as minimum qualifications, the pilots are multi-engine, instrument rated, commercial pilots. Minimum expected flying hours: 500. No time in type is assumed (first exposure to EACS may be during transition training).

(2) It is assumed that the pilots will have knowledge of existing paper approach charts, but no experience with electronic presentation of chart information.

(3) It is assumed that the pilots will receive sufficient information/training to allow them to operate the FMS. Additional information regarding the use of the EACS should be incorporated into the FMS training material.

(4) The system should be simple and intuitive to operate, so that the pilot can become proficient with either 30 minutes of computer-based training, or with written material plus 30 minutes of hands-on practice on the airplane (on the ground).

e. Description of the Operating Environment for the Airplane: The following is a partial description of the operating environment anticipated for the flight deck design:

(1) **Expected operational rules under which the airplane will be operated:** Part 121, Part 135.

(2) **Air Traffic Control (ATC) environment:** The system must be compatible with all currently planned FMS operations, including the following:

(a) Full area navigation (RNAV) capability,

(b) Required time of arrival (RTA),

(c) Required Navigation Performance (RNP), using GPS as the primary means of navigation.

(d) Aeronautical Telecommunications Network (ATN) Controller Pilot Datalink Communications

(3) **Airport types, conditions, facilities:** The system shall support any airport types suitable for transport category airplanes.

(4) **Geographic areas of operation and associated terrain and weather issues:** The system should support the display of any special terrain feature currently available on paper charts. However, that information may be displayed in a different way, appropriate for the selected display device.

3. COMPLIANCE MATRIX FOR PART 25 REGULATIONS RELATED TO FLIGHTCREW HUMAN FACTORS

SECTION [Amdt. Level]	GENERAL HUMAN FACTORS (HF) REQUIREMENTS	METHOD(S) OF COMPLIANCE	DELIVER-ABLE PRODUCT
§ 25.771(a) [at amdt. 25-4]	Each pilot compartment and its equipment must allow the minimum flightcrew to perform their duties without unreasonable concentration or fatigue.	Analysis, Simulator test, Flight test	Workload Certification Report
§ 25.771(e) [at amdt. 25-4]	Vibration and noise characteristics cockpit equipment may not interfere with safe operation of the airplane.	Bench test	Test report
§ 25.773(a)(1) [at amdt. 25-72]	Each pilot compartment must be arranged to give the pilots sufficiently extensive, clear, and undistorted view, to enable them to safely perform any maneuvers within the operating limitations of the airplane, including takeoff, approach, and landing.	Similarity	Vision Certification Report
§ 25.773(a)(2) [at amdt. 25. 72]	Each pilot compartment must be free of glare and reflections that could interfere with the normal duties of the minimum flightcrew.	Ground test	Lighting Certification Report
§ 25.777(a) [at amdt. 25-46]	Each cockpit control must be located to provide convenient operation and to prevent confusion and inadvertent operation.	Simulator test Flight test	Flight Deck Anthropometry Certification Report

§ 25.777(c) [at amdt. 25-46]	The controls must be located and arranged, with respect to the pilot's seats, so that there is full and unrestricted movement of each control without interference from the cockpit structure or the clothing of the minimum flightcrew when any member of this flightcrew, from 5'2" to 6'3" in height, is seated with the seat belt and shoulder harness fastened.	Ground test	Flight Deck Anthropometry Certification Report
§ 25.1301(a) [original amdt.]]	Each item of installed equipment must be of a kind and design appropriate to its intended function.	System description Simulator demonstration Flight test	System Description Document Demonstration Report Flight Test Report
§ 25.1309(b)(3) [at amdt. 25-41]	. . . Systems, controls, and associated monitoring and warning means must be designed to minimize crew errors that could create additional hazards.	Hazard assessment Simulator demonstration	Fault tree analyses Demonstration Report
§ 25.1321(a) [at amdt. 25-41]	. . . Each flight, navigation, and powerplant instrument for use by any pilot must be plainly visible to him from his station with the minimum practicable deviation from his normal position and line of vision when he is looking forward along the flight path.	System description Analysis Flight test	Installation drawings Vision Certification Report Flight Test report
§ 25.1321(e) [at amdt. 25-41]	If a visual indicator is provided to indicate malfunction of an instrument, it must be effective under all probable cockpit lighting conditions.	Similarity Ground test	System description and Statement of Similarity Flight Test report

§ 25.1523 [at amdt. 25-3]	The minimum flightcrew must be established so that it is sufficient for safe operation, considering: a) the workload on individual crewmembers; b) the accessibility and ease of operation of necessary controls by the appropriate crewmember; and c) the kind of operation authorized under § 25.1525. The criteria used in making the determinations required by this section are set forth in Appendix D.	Simulator test Flight test	Demonstration report Flight Test report
§ 25.1543(b) [at amdt. 25-72]	Each instrument marking must be clearly visible to the appropriate crewmember.	Analysis Simulator test	Vision certification report Demonstration report
SYSTEM-SPECIFIC HF REQUIREMENTS			
§ 25.1381(a)(2) [at amdt. 25-72]	The instrument lights must be installed so that (ii) no objectionable reflections are visible to the pilot.	Ground test	Flight Test report
SPECIFIC CREW INTERFACE REQUIREMENTS			
§ 25.773(b)(2)(i) [at amdt. 25-72]	The first pilot must have a window that is openable . . . and gives sufficient protection from the elements against impairment of the pilot's vision.	Ground test (to verify no interference with window opening)	Flight Test report

§ 25.1322 [at amdt. 25-38]	If warning, caution, or advisory lights are installed in the cockpit, they must, unless otherwise approved by the Administrator, be -- (a) Red, for warning lights (lights indicating a hazard which may require immediate corrective action); (b) Amber, for caution lights (lights indicating the possible need for future corrective action); (c) Green for safe operation lights; and (d) Any other color, including white, for lights not described in paragraphs (a) through (c) of this section, provided the color differs sufficiently from the colors prescribed in paragraphs (a) through (c) of this section to avoid possible confusion.	Similarity	System Description Document

4. SYSTEM SAFETY ASSESSMENTS

Each Fault Tree that includes a pilot response to a failure condition will include an assessment in accordance with AC 25.1309. In addition, any specific design features intended to increase the likelihood of correct pilot response will be noted in the system safety assessment.

5. OPERATIONAL CONSIDERATIONS

The EACS is intended to replace the routine use of paper charts during all expected operations. It should be noted that design of this system is predicated on the assumption that if the system experiences a total failure, the pilots will revert to the use of paper charts. Because of this and the need to minimize the training burden, basic flight operations for the airplane will be unaffected by the incorporation of this system (no change in airplane capability or interaction with the airspace). Changes in pilot activities will be restricted to the way in which approach chart information is selected, accessed,

and viewed. The following documents are expected to be modified as a result of the incorporation of EACS:

- Master Minimum Equipment List (MMEL)
- Flightcrew Operating Manual (FCOM).
- Flightcrew Training Manual

6. CERTIFICATION DOCUMENTATION: Several documents will be produced that are intended to summarize the certain major human factors certification topics:

a. Workload-related issues [§ 25.771(a) and § 25.1523] will be covered in the Workload Certification Report. This will contain procedure analysis, timeline analysis, Pilot Subjective Evaluation results, and an overall summary of the workload considerations, as described in 14 CFR part 25, Appendix D.

> **NOTE**: Workload related data gathering during flight test is expected to be conducted concurrently with other scheduled flight tests (i.e., no dedicated workload test flights).

b. Internal and External Vision issues [§ 25.773(a)(1), § 25.1321(a), § 25.1543(b), § 25.785(l)] will be covered in the Vision Certification Report. This report will contain internal and external vision analyses, and a summary of pilot assessments.

c. Flight deck lighting issues [§ 25.773(a)(2), § 25.1321(e), § 25.1381(a)(2)] will be covered in the Lighting Certification Report. This report will include the results of reflection measurements and pilot assessments from ground tests and flight tests.

d. Issues associated with the physical arrangement of the flight deck with respect to pilot reach, clearance, and interference [§ 25.777(a) and (c)], will be covered in the Flight Deck Anthropometry Certification Report.

> **NOTE:** No computer modeling is planned. Testing will be done using human subjects with representative body dimensions.

e. Other documentation cited in the compliance matrix will be finalized as the testing plans develop. For most of the flight testing, during which human factors

certification tests will be conducted concurrently with other planned testing, the human factors results will be documented in the overall test report.

7. CERTIFICATION SCHEDULE

The following schedule (Figure 5) indicates the approximate timing of the major human factors analysis/demonstration/test activities, planned updates to the Human Factors Certification Plan, and planned coordination meetings for the discussion of human factors certification issues. This schedule will be refined and adjusted as the certification program develops.

Figure 5: Flight Crew Operations Certification Schedule

Start Date: 8/1/1999
End Date: 4/15/2000

Milestone	1999		2000	
	Quarter 3	Quarter 4	Quarter 1	Quarter 2
Initial FAA Project Concept Discussion Meeting	6/1			
Certification Plan Submittals	8/1			
Initial FAA Project Familiarization - draft drawings, etc.	9/1			
FAA Simulator Demonstrations	9/15			
FAA Simulator Demonstrations		10/10		
FAA Procedures Simulator Demos		10/30		
Workload Compliance Demonstrations		11/15		
List of Dispatch Conditions and Might Failures		11/15		

Flight Test Program		12/15		
Certification Document Submittals			1/5	
Draft Crew Ops Cert Document			3/1	
Workload 8110 Cert Report				4/1
Final Crew Ops Cert. Document				4/15

8. <u>USE OF DESIGNEES AND IDENTIFICATION OF INDIVIDUAL DER/DAR</u>:

The applicant recommends that the majority of the findings of compliance be delegated to the pilot DER. Final assessment of compliance with § 25.1523 should include FAA participation in flight test involving specific high workload scenarios. The FAA should also participate in ground testing for display legibility.

APPENDIX D

APPENDIX D

Quick Reference Guide for Reviewing Human Factors Certification Plans

This form can be used when reviewing an applicant's Certification Plan.

	yes	no	n/a
1. Introduction			
2. System description			
a. Intended function from pilot's perspective			
b. Flight deck layout drawings			
c. Underlying principles for crew procedures			
d. Assumed pilot characteristics			
e. Description of the operating environment for the airplane			
3. Certification requirements			
a. Regulations			
b. Special requirements, unique or novel design aspects			
c. Compliance checklist			
4. Methods of compliance			
5. System safety assessment			
6. Operational considerations			

7. Certification documentation			
8. Certification schedule			
9. Use of designees and identification of individual Designated Engineering Representative (DER)/Designated Airworthiness Representative (DAR)			

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/s/

Vi L. Lipski, Acting Manager
Transport Airplane Directorate
Aircraft Certification Service