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# COVER SHEET
## Access 5 Project Deliverable

**Deliverable Number**: *HSI009*

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**Abstract:**

This document provides guidance to the FAA on important human factors considerations that can be used to support the certification of a UAS Aircraft Control Station (ACS). This document provides a synopsis of the human factors analysis, design and test activities to be performed to provide a basis for FAA certification. The data from these analyses, design activities, and tests, along with data from certification/qualification tests of other key components should be used to establish the ACS certification basis. *It is expected that this information will be useful to manufacturers in developing the ACS Certification Plan,, and in supporting the design of their ACS.*

**Status**:

| **Document Status Work in Progress** |
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**Limitations on use:**

This document assumes the UAS pilot will be required to monitor and control a single UAS; control of multiple UASs from a single control station is not considered in the document. Differences in Level of Autonomy (LOA) for various UASs were not in the scope of in this document. In this document, a low level of autonomy/automation was assumed. For example, where a low level of autonomy may require pilot skills to perform a required maneuver, a higher level of autonomy may require the pilot to monitor the maneuver for correct execution. In application it will be incumbent on the manufacturer to describe the LOA planned for their UAS and to indicate how the automation impacts the requirements specified in this document. This document only addresses requirements for an internal UAS pilot. Requirements for an external UAS pilot are out of scope of this effort, but could be included in a document update if specified by the Access 5 System Engineering and Integration Team. The information described in this report applies to all phases of flight, and not just to operations at or above FL 430.

# Human Systems Integration
# Unmanned Aircraft Control Station
# Certification Plan Guidance

## Access 5
## December, 2005



*The following document was prepared by a collaborative team through the noted work package. This was a funded effort under the Access 5 Project.*

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**CERTIFICATION PLAN GUIDANCE**
**(Version 3)**

# 1. INTRODUCTION

## 1.1 BACKGROUND

An Unmanned Aircraft System (UAS) consists of an air vehicle, an Aircraft Control Station (ACS), and links for command and control between the Unmanned Aircraft (UA), and the control station, and a communication link between the UA pilot and Air Traffic Control (ATC). This document provides guidance to aid manufacturers in developing a plan to certify the control station element of a UAS.

This document is modeled after the FAA's Guidance for Reviewing Certification Plans to Address Human Factors for Certification of Transport Airplane Flight Decks (FAA Policy Statement Number ANM-99-2). The objective of this document is to provide guidance that can be used the FAA Certification Team to review an 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). This document can be used as a stand-alone document to support ACS certification, or can be integrated into an overall UAS airworthiness certification plan

## 1.2 SCOPE

This document provides guidance to enable an applicant to develop a plan that addresses all of the important human factors considerations that are applicable for the certification of a UAS Aircraft Control Station (ACS). This document provides a synopsis of the human factors analysis, design and test activities required to provide a basis for FAA certification. The data from these analyses, design activities, and tests, along with data from certification/qualification tests of other key components should be used to establish the ACS certification basis. *It is expected that this information will be useful to manufacturers in developing the ACS Certification Plan, and in supporting ACS design*.

It is understood that the physical configuration of the ACS may vary widely from application to application. The design of the ACS may vary from a laptop to a UA control center that has the responsibility for monitoring/controlling multiple UAs. In addition, the location of the ACS may vary from ground, air or ship-based applications. The guidelines provided in this document should be tailored to meet the unique characteristics of the ACS under consideration.

Appendix A describes procedures aimed to aid the manufacturer perform the tasks required to obtain the data required to serve as the certification basis for an ACS.

## 1.3 ASSUMPTIONS

Assumptions made in the development of this document include:

- The UA pilot will be required to monitor and control a single Unmanned Aircraft (UA). Control of multiple UAs from a single ACS will be investigated in future studies.
- Differences in Level of Autonomy (LOA) for various UAs will not be considered in this document. For the purpose of this document a low level of autonomy/ automation will be assumed. Where a low level of autonomy may require pilot skills to perform a required maneuver, a higher level of autonomy may require the pilot to monitor the maneuver for correct execution. It is incumbent on the manufacturer to describe the LOA planned for their UA and to indicate how the automation impacts the requirements specified in this document.
- This document only addresses requirements for an internal UA pilot. Requirements for an external UA pilot are out of scope of this effort, but could be included in a document update if specified by the Access 5 System Engineering and Integration Team (SEIT).
- The information described in this report applies to all phases of flight, and not just to operations at or above FL 430.

## 1.4 REPORT ORGANIZATION

Section 2 provides guidelines for developing the System Description Section for the ACS Human Factors Certification Plan

Section 3 provides information for defining ACS Human Factors Certification Requirements

Section 4 provides information on various human factors Methods of Compliance

Section 5 provides information for describing the Operational Considerations related to human factors and ACS certification

Section 6 summarizes required Certification Documentation

Section 7 provides guidance on developing an ACS Certification Schedule

Section 8 summarizes procedures for using Designated Engineering Representatives (DERs), or other designees during the certification process.

Appendix A provides sample procedures for providing required data to support ACS Certification.

Appendix B provides a list of regulations in 14 CFR Part 23 related to ACS Human Factors and Certification

Appendix C provides an example ACS Compliance Matrix

Appendix D provides ACS Certification Issues and Validation Concepts

Appendix E presents a list of Abbreviations and Acronyms

Appendix F provides a Glossary of Terms

Appendix G provides a list of Related Documents

## 2. SYSTEM DESCRIPTION

This section of the ACS Human Factors Certification Plan should describe the general requirements and features of the ACS that are related to human factors considerations. Because a human factors perspective of the ACS includes: the systems, the pilot(s), and the ways in which they interact (pilot procedures), this section should 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 ACS Pilot interfaces.

The information in this section should provide an overview of the UA ACS and pilot procedures. The type of information to be provided is listed below:

The description of the aircraft should include:

- Size – Length, width and height dimensions should be provided, along with illustrations (e.g., side, plan, and top views) of the aircraft.
- Performance Capabilities – Speed, range, endurance, vertical velocity (climb and descent), etc.
- Unique Capabilities/Features - Description of any unique features of the air vehicle that will aid the Certification Teams' understanding of the air vehicle and its performance characteristics. This includes a description of the planned use of automation/level of autonomy.

The description of the ACS should include:

- Physical Arrangement – Location and arrangement of the pilot work station(s). Illustrations of the ACS layout should also be provided.
- Location – Description of the location of the ACS relative to the location of where the UA is based and its intended operational area(s).
- Operational Concept - Description of the intended use of the UA and how it is to be monitored/controlled by the UA pilot

The description of UA Pilot Procedures should include:

- Roles and Responsibilities – Primary roles and responsibilities for the Pilot-In-Command (PIC), and any other pilot within the ACS should be described.
- Pilot Rating Criteria – Description of proposed Pilot Ratings/Licenses, Medical and Training requirements.
- Normal and Abnormal Procedures – Procedures and PIC responsibilities for normal and abnormal procedures should be defined.
- Unique Pilot Procedures – Description of any unique/special responsibilities that the PIC may have in monitoring/controlling the specific UA.

2.1 INTENDED SYSTEM FUNCTIONSThe Human Factors Certification Plan should provide detailed information describing the PIC intended functions. UA Pilot interface description should cover both the design of the systems (hardware, software, and environment) and the tasks (perceptual, cognitive, and psychomotor) the pilot(s) have to perform to accomplish flight objectives. The document should give special attention to features or functions that are new or unique for an ACS compared to a manned flight deck and how the pilot interfaces with them. Specifically, the following topic areas should be addressed:

- Intended function of the system from the pilot's perspective
- The planned role of the pilot relative to the system
- General description of the procedures to be accomplished by the pilot for both normal and abnormal/emergency operations
- System capabilities (e.g., navigation, communication, hazard avoidance, etc.)
- Planned level of automation/autonomy

How the functions are planned to be allocated to systems or the UA pilot should be described to the detail available at the time of writing the plan. If allocation decisions are still to be made, those should be described.

A human-system engineering process should be used to support the design and validation of ACS Human System Interfaces (HSIs). Figure 1 shows a Human-Systems Engineering Methodology for deriving UA Pilot functions, and preliminary HSI information and control requirements. Procedural guidance on how to accomplish these tasks is provided in Appendix A.

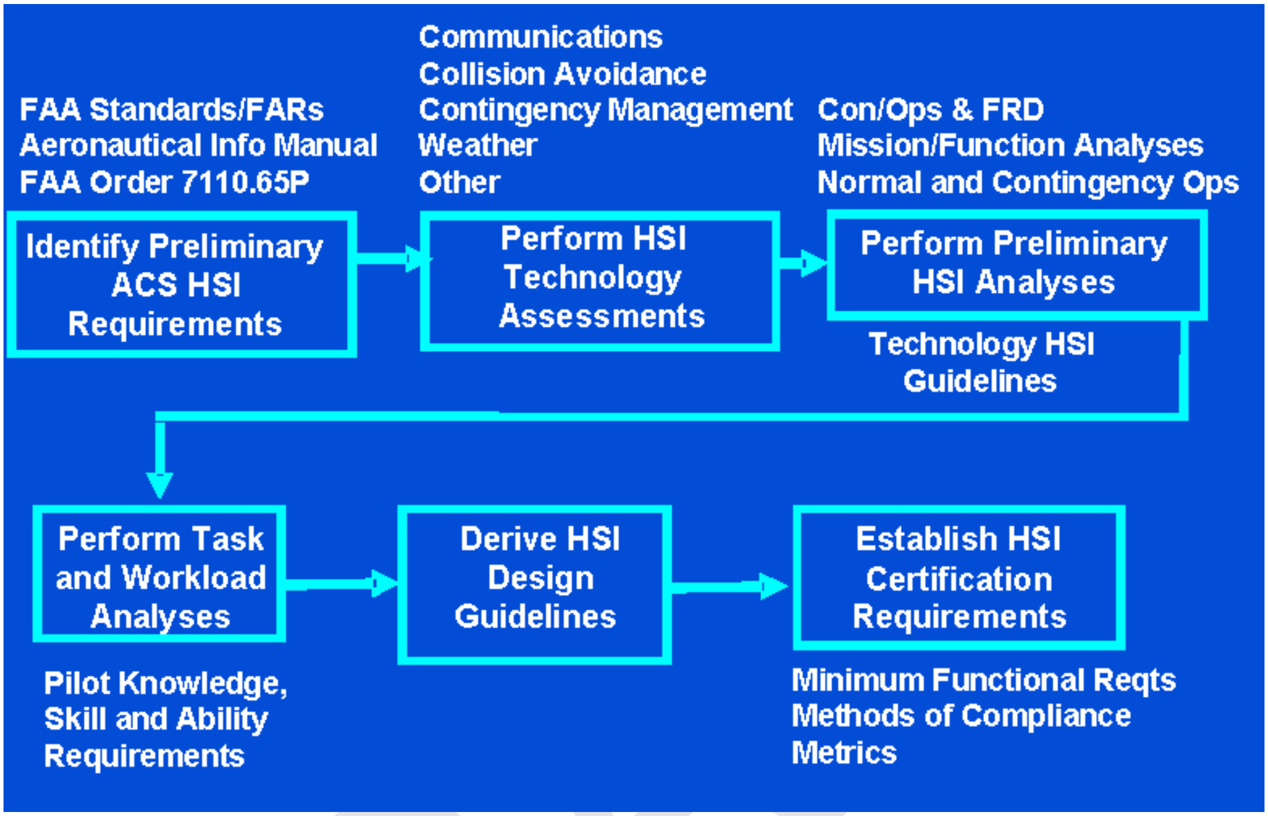


**FIGURE 1: PROCEDURE FOR IDENTIFYING UA PILOT FUNCTIONS, INFORMATION AND CONTROL REQUIREMENTS**

## 2.2 ACS LAYOUT

The ACS is where all information and controls required to safely and effectively monitor, and control a UA are provided. The required controls and displays depend upon specific mission requirements and UA capabilities. Specific areas of concern relate to the UA Level of Autonomy (LOA), and the resultant roles and responsibilities of the UA pilot.

This section should provide detailed drawings of the planned ACS layout. This information can be very beneficial for providing an understanding of the intended overall layout (controls, displays, sample display screens, etc.). The applicant should provide scheduled updates to the drawings so that the Certification Team's knowledge of the layout progresses as the design matures. This section should also describe the procedures that are going to be used to assess the anthropometric suitability of the ACS layout in terms of population accommodation (e.g., $5^{th}$% female to $95^{th}$% male, etc.).

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

- Arrangements of the controls, displays, and other ACS equipment

- Controls, such as a cursor control device, or new applications of existing technologies
- Display hardware technology

## 2.3 ACS CONTROLS AND DISPLAYS (DESIGN AND PERFORMANCE ISSUES)

This section of the Certification Plan should provide descriptions of the planned design, accessibility, and functionality of ACS controls and displays. Sufficient details should be provided to enable hardware and software engineers to proceed with all required HSI designs. This section should also include descriptions of:

- Color, symbol coding, and nomenclature conventions
- General rules for function allocation/automation and implementation
- Definition of function hierarchy (determination of function criticality, frequency and sequence of use)
- Default display schemes for various mission phases (planning, taxi, take-off, cruise, approach and landing, etc.)
- Definition of the concept for and implementation of an Integrated Caution and Warning System
- System health/status displays to aid the pilot maintain system awareness, especially with migration of control between pilots and another ACS
- Display schemes for both uplink and downlink status as well as provisions for link management (e.g., ability to work online versus offline and know affirmatively when commands have been uplinked from the ACS to the UA)
- Concept for displaying/affirming ACS is controlling the UA - important when migrating control between ACSs
- General rules for dealing with ACS failure (e.g., control transfer, redundant work stations, etc.)

## 2.4 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 addressed in the plan should include the following:

- Operating modes
- Principles underlying mode transitions (e.g., transition for one mode of automation to another, or transition from an automated mode to a manual mode of operation, etc.)

- Mode annunciation scheme (i.e. technique used to inform the pilot of the current mode of operation)
- Automation engagement/disengagement principles (i.e., procedures used to enter/exit a selected automation mode).
- Preliminary logic diagrams, if available

## 2.5 UNDERLYING PRINCIPLES FOR UA PILOT PROCEDURES

Because the design of the systems and the development of the associated procedures are interrelated, it is useful for the plan to describe the underlying guidelines or principles that will form the basis for the development of pilot procedures. Key topics could include the following:

- The expected use of memorized procedures with confirmation checklists vs. read and-do procedures/checklists
- Pilot interactions during procedure/checklist accomplishment
- Automated support for procedures/checklists, if planned
- Use of decision support tools
- Ability to conduct operations off-line and then uplink commands when desired. For example, planning to change the route of the UA after it has reached a certain destination prior to reaching the destination. Then uplinking the commands when the destination has been reached.

## 2.6 ASSUMPTIONS ABOUT PILOT CHARACTERISTICS

This section should provide a description of the pilot group that the manufacturer/ operator plans to use to monitor/control the UA. The description of pilot capabilities should include developing assumptions concerning:

- Previous flying experience (e.g., ratings, flight hours)
- Experience with similar or dissimilar UA ACS designs and features, including automation
- Expected training that the pilots will receive, or assumptions regarding training, including currency
- Medical qualifications/limitations

## 2.7 ACS HABITABILITY AND PILOT ACCOMMODATIONS

- This section of the Certification Plan should describe ACS design features and habitability accommodations that are planned to be provided to support pilot comfort and performance. This section should describe the: Tasks that are to be accomplished to ensure that potential environmental stressors (e.g., lighting, noise, ventilation, cooling/heating, etc,) do not interfere with the safe operation of the UA, or negatively impact pilot performance, safety or health.

- ACS anthropometric accommodation features (e.g., seating, work console, if applicable, etc.) that are planned to be used to facilitate pilot performance and comfort
- Analyses, tests/demonstrations that are to be performed to verify/validate that the environment and the accommodations support pilot performance and comfort
- Provisions for controlling/limiting access to the ACS to enable the pilot to maintain a "sterile cockpit", and secure environment

## 3. CERTIFICATION REQUIREMENTS

This section of the ACS Human Factors Certification Plan should list and describe the human factors-related regulations and other requirements that will be addressed for certification. This section should also include the applicant's compliance matrix for these requirements. Appendix B provides a listing of Regulations in 14 CFR Part 23 related to ACS Human Factors. Current regulation text and how it is related to the ACS are provided. Appendix C provides an example compliance matrix.

# 4. METHODS OF COMPLIANCE

This section of the plan describes the methods that will be used to demonstrate compliance with human-factors-related certification requirements. The intent is to provide sufficient detail on the applicants' proposed approach to address key human factors certification issues.

## 4.1 METHODS OF COMPLIANCE

Methods of Compliance (MOC) are not mutually exclusive. The applicant may choose to include any one or a combination of MOCs to address any particular issue. The applicant should describe the methods in sufficient detail to give the FAA Certification Team confidence that the results obtained from the application of the selected methods will provide the information necessary for finding compliance. The following method descriptions obtained from ANM-01-03 provide a summary of human factors tools and methods that can be used to provide the required compliance data. Figure 2 illustrates the procedural steps that should be followed to provide the FAA Certification team with the data required to certify the ACS.

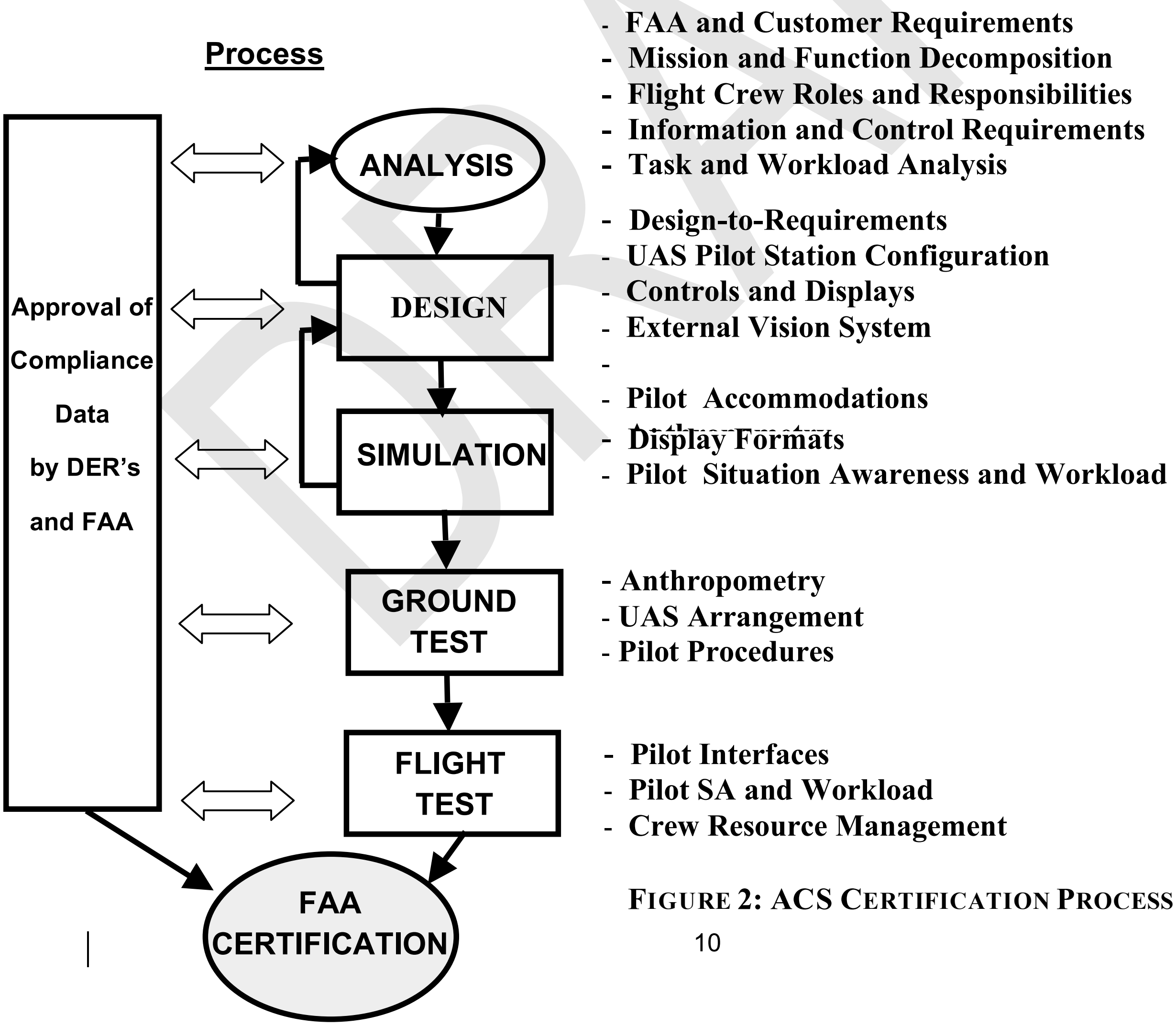


FIGURE 2: ACS CERTIFICATION PROCESS

**a.** **Drawings:** These are engineering drawings that show the geometric arrangement of hardware or display graphics. Drawings typically are used when demonstration of compliance can easily be reduced to simple geometry, arrangement, or presence of a given feature, on a technical drawing.

**b.** **Configuration Description**: This is a description of the layout, general arrangement, direction of movement, etc., of the regulated item, or a reference to similar documentation. For example, such a description could be used to show the relative locations of flight instruments, groupings of control functions, allocation of color codes to displays and alerts, etc. Configuration descriptions are generally less formalized than engineering drawings, and are developed to point out design features that are supportive of a finding of compliance. Configuration descriptions may illustrate how a design philosophy or concept is implemented in a consistent, easy-to-understand manner. In some cases, such configuration descriptions may provide sufficient information for a finding of compliance with a specific requirement; however, more often, these descriptions provide important background information requiring demonstrations, test, or other means to confirm compliance. The background information provided, however, may significantly reduce the complexity and/or risk associated with the demonstrations/tests.

**c.** **Statement of Similarity**: This is a description of the system to be approved and a description of a previously approved system. The description details the physical, logical, and operational similarities of the two systems in complying with the regulations. Past certification precedents are important; however, this method of compliance must be used with care because the ACS should be evaluated as a whole, rather than merely as a set of individual functions or systems. For example, two functions that have been previously approved on two different programs may be incompatible when combined within a single workstation. Also, changing one feature in the ACS may necessitate corresponding changes in other features, in order to maintain consistency and prevent confusion.

**d.** **Evaluations, Assessments and Analyses**: These are conducted by the applicant or others, who then provide a report of their results to the FAA. In cases, where human subjects are used when gathering data, the applicant should fully document the criteria used to select subjects, what data, and how the data will be collected. This will allow the FAA Certification Team to determine the extent to which the evaluations, assessments and analyses provide valid and relevant information with respect to finding compliance with the regulations. Specific examples of the evaluations/assessments/analyses could include:

**(1) Engineering Evaluations or Analyses –** These assessments can involve a number of techniques including:

- Procedure evaluations (complexity, number of steps, nomenclature, etc.)
- Vision, reach or strength analysis via computer modeling

- Time-line analysis for assessing task demands and workload
- Other methods, depending on the issue being considered

If analyses involve comparing measured characteristics to recommendations derived from pre-existing research, then the applicant may be asked to validate the use of this data derived from this research.

**(2) Mock-Up Evaluations**: These are evaluations using mock-ups of the ACS and/or components. Mock-ups are typically used for assessments of visual and reach accessibility, clearance, and therefore, they demand a high degree of geometry accuracy. Mock-ups are physical representations which allow evaluators to physically interact with designs. Using data extracted from Computer-Aided Design (CAD) systems, control panels can now be created in three-dimensional form. These computer mock-ups can allow precise evaluations of body clearances, visibility of labels, reach and visual access to controls and displays, etc.

When using computer models, care must be taken to determine if the model reasonably represents actual human movement capabilities, and the critical physical dimensions (e.g., seated eye height, functional reach, etc.) for the full range of the intended user population (e.g., 5$^{th}$ percentile female to 95$^{th}$ percentile male). It is important to note that this type of virtual mock-up should be used judiciously because they typically represent only certain features of the physical environment. For many of the compliance issues typically evaluated in a mock-up, a simulator may be required to produce the final compliance findings.

**(3) Part-Task Evaluations**: These evaluations use devices that emulate 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 ACS tasks. This MOC is most easily used with stand-alone systems. As the ACS becomes more integrated, part-task evaluations become less useful, although their utility as an engineering tool may increase. A typical example of a part-task demonstration for an integrated system would be an avionics suite installed in a mock-up of a UA ACS, with the main displays and autopilot controllers included. Such a tool may be valuable during development and for providing pilot system familiarization. However, in a highly integrated architecture, it may be difficult or impossible to assess how well the avionics system will fit into the overall ACS without a more complete simulation. Some part-task evaluations may be performed as part of seeking Technical Standard Order (TSO) approval. However, a TSO does not constitute installation approval, which usually requires evaluation in the overall ACS.

(4) **Simulator Evaluations**: These are evaluations using devices that present an integrated emulation (using flight hardware, simulated systems, or combinations of these) of the ACS and the operational environment. They can also be "flown" with response characteristics that replicate, to some extent, the responses of the UA. Typically, these evaluations are limited by the extent to which the simulation is a realistic, high fidelity representation of the airplane, the ACS, the external environment, and crew operations. It should be noted that not all aspects of the simulation must have a high level of fidelity for any given compliance issue. Rather, simulator fidelity requirements should be determined based upon the issue being evaluated.

(5) **Evaluations in ACS with Simulated UA Operation**: These are evaluations using the actual ACS so that interaction and integration of systems can be evaluated with real procedures. The airplane operations and response, and ATC communications are simulated for these evaluations. A high-fidelity model of the UA should be appropriate for the conduct of most required human factors studies. Assuming that the ACS is fully configured, the integration of the crew interface features can be evaluated in a flight environment, including communication tasks and interaction with the ATC environment. However, typically, these evaluations may be limited by the extent to which the critical flight conditions (for example, weather, failures, or unusual attitudes) can be simulated. Using the simulator, the applicant should be able to demonstrate crew performance in the event of specified system failures.

(6) **Evaluations in ACS with Actual UA Flight Operations**: These are evaluations using the actual ACS and UA with real flight and operational scenarios. This is equivalent to in-flight manned aircraft evaluations, which generally offer the most realistic and comprehensive environment for evaluating the ACS design, and pilot procedures in realistic scenarios.

**e. Demonstrations**: These are similar to evaluations (as described above), but these demonstrations are conducted by the applicant with participation by the FAA or its designee. The applicant may provide a report or summary, requesting FAA concurrence on the findings. In each case, the applicant should note the limitations of the demonstration and how those limitations relate to the compliance issues being considered. It is important to consider what FAA specialists will participate (e.g., pilots, human factors specialists, or systems engineers, etc.), what data will be collected (objective and/or subjective), and how the data will be collected. This is to ensure that the demonstration adequately addresses the compliance issues and that there is participation by the appropriate FAA evaluators.

f. **Inspection:** This is a review of a regulated item by the FAA or its designee, who will be making the compliance finding. This MOC is generally limited to those items for which compliance can be found simply by looking at (or listening to) the feature being considered (for example, the presence or absence of a placard, the direction of control movement, etc.).

g. **Tests:** These are tests conducted by the applicant or a designee. Types of tests include:

(1) **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, or format, etc.) or logical/dynamic responses to inputs, either from the user or from other systems (real or simulated). For most human factors evaluations, bench tests are insufficient to show compliance, but can provide useful supporting data in combination with other methods. For example, visibility of a display under the brightest of the expected lighting conditions might be shown with a bench test, provided there is supporting analysis to define the expected lighting conditions. This might include geometric analysis to show the potential directions from which the sun, or artificial lighting could shine on the display, along with calculations of expected viewing angles. These conditions might then be replicated in a laboratory.

(2) **Usability Evaluations** – Usability evaluations can be used to assess the adequacy of the design of the ACS Human Computer Interfaces (HCIs). The following techniques can be used to perform HCI usability assessments.

- **Heuristic Evaluations** - A heuristic evaluation is a method to inspect user interfaces based on a list of established principles or rules. Typically, heuristics evaluations are conducted by at least three, but not more than five usability specialists. In a heuristics review, design rules are reduced to a manageable number of high-level usability guidelines, or heuristics, such as: design to prevent error, to give users control, enhance situation awareness, and to prevent errors (among others). During a heuristic evaluation, independent human factors experts explore the interface focusing their attention on the heuristics, while at the same time allowing their prior experience with usability evaluations to help identify any potential usability problems.

- **Cognitive Walk-Through (CWT)** - A cognitive walk-through is a review of a technical HCI by applicant and Certification Team human factors and subject matter experts. The team evaluates the proposed implementation within the context of task oriented goals and objectives. The purpose of the CWT is to uncover problems with a design rather than validate a design. It can be used to evaluate a design, a set of specifications for a design or preliminary design concepts before a prototype or complete design is available.

**(3)** **ACS Simulator Tests** – As stated earlier, human factors tests that emulate the type of testing accomplished for ACS ground and flight test evaluations can be accomplished in the actual ACS, or in a high-fidelity ACS simulator. These tests can be accomplished without requiring an actual UA to be present. These tests should include evaluations of pilot procedures for accomplishing normal and realistic contingency operations.

**(4)** **Tests in ACS with Simulated UA Operation** – These are tests using the actual ACS so that interaction and integration of systems can be evaluated with real procedures. The airplane operations and response, and ATC communications are simulated for these tests. A high-fidelity model of the UA should be appropriate for the conduct of most required human factors studies. Assuming that the ACS is fully configured, the integration of the pilot interface features can be evaluated in a flight environment, including communication tasks and interaction with the ATC environment. However, typically, these evaluations may be limited by the extent to which the critical flight conditions (for example, weather, failures, or unusual attitudes) can be simulated. Using the simulator, the applicant should be able to demonstrate pilot performance in the event of specified system failures. These tests should also include evaluations of anthropometric suitability (reach and visual access to controls and displays), and assessments of the physical environment and its impact on pilot performance and comfort.

**(5)** **Tests in ACS with Actual UA Operation** – These are evaluations using the actual ACS and UA with real flight and operational scenarios. This is equivalent to in-flight evaluations in the manned aircraft, which generally offer the most realistic and comprehensive environment for evaluating the HCI design, pilot procedures, and the ACS physical environment in realistic scenarios.

## 4.2 COMPLIANCE VS. DESIGN OPTIMIZATION

The FAA personnel evaluating proposed methods of compliance for regulations related to human factors should keep in mind there may be a number of pilot interface design features that are compliant with the applicable regulations, but could be improved. However, applicants are under no legal obligation to conduct assessments to show that a compliant design is the best that they could implement among feasible alternatives (i.e., is the HCI "optimized").

## 4.3 IDENTIFICATION OF DESIGN-SPECIFIC HUMAN FACTORS ISSUES

The MOCs identified above cover a wide spectrum, from documents that simply describe the product, to partial approximations of the system(s), to methods that replicate the actual ACS 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 a method for use. The characteristics described below can be used to help in coming to agreement on 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 MOCs for a specific product with regard to a requirement.

a. **Degree of Integration/Independence:** If the product to be evaluated for compliance is a stand-alone piece of equipment that does not interact with other aspects of the crew interface, a less integrated MOC may be acceptable. However, if the product is a complete ACS or is a single system that is tightly tied to other systems in the ACS, either directly or by the way that pilot uses them, then it may be necessary to use methods that allow the testing of those interactions

b. **Novelty/past experience:** If the technology is mature and well understood then less rigorous methods may be appropriate. More rigorous methods may be called for if the technology is:

- New
- Used in some new application
- New for the particular applicant, or
- Unfamiliar to the certification personnel.

c. **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, backup, or reversionary modes of operation.

d. **Criticality:** For those systems where a consistently high level of pilot performance is essential to safety, testing in the most realistic environments (high quality simulation or flight test) may be necessary, because problems are more likely to have serious consequences.

e. **Dynamics:** If the control and display features of the product are highly dynamic (e.g., primary flight parameters), the compliance methods should be capable of replicating those dynamic conditions.

f. **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.

g. **Subjectivity of Acceptance Criteria:** If a requirement has specific, objectively measurable criteria, the applicant can often use simpler methods to demonstrate compliance. As the acceptance criteria become more subjective, the applicant will need to use more integrated test methods, so that the evaluations take into account the aspects of the integrated ACS that may affect those evaluations.

The central point is to carefully match the method to the product and the underlying human factors issues.

## 4.4 Identification of Regulation-Specific Human Factors Issues

The following eight steps outline a strategy for identifying the human factors issues associated with applicable regulations. These steps should be accomplished early in the certification process to ensure that the Certification Team is aware of important HF issues and the applicant's proposed approach for addressing these issues.

1. Identify key human factors issues related applicable regulations. While regulations may focus on a single concept, there may be underlying components that must be considered to evaluate identified issues
2. Identify systems, components, and features that are potentially affected by the regulations
3. Look for aspects of those systems, components, and features that need to be evaluated in order to show compliance with the regulation (for example, forces required, readability of legends/labels, and number of discrete steps required to accomplish a given task, etc.) These aspects are likely to vary by system, component, feature, and by regulation.
4. For modifications to existing ACSs or new type designs that are based on or derived from an existing designs, look for ways in which new aspects of the design may compromise compliance with previously certified designs.

5. Review past precedents. In this context, precedents should be reviewed to assess novelty of the design, because novelty will often affect the selection of an appropriate MOC. Similarity to a previous certified design does not necessarily mean that the new product will be certified. Rather, that similarity may result in fewer unknowns and a commensurate reduction in the rigor of the evaluations. It is important to assess whether or not there are new issues or interactions that were not present in previously certified installations. Because it is the installation (in the ACS) that is certificated, not the equipment itself, it is important to look for installation-unique issues when evaluating the relevance of precedents.

6. Assess design novelty. In addition, the need to fully determine their compliance with existing rules, novel designs may require more rigorous evaluations to ensure that their novel features (maybe not be covered by current regulations) do not result in any new safety problems. NOTE: Any evaluations intended to identify potential new safety problems, which might require the development of Special Conditions, should be accomplished as early in the project as possible. This will allow the FAA Certification Team and the applicant time to reach a common understanding of the issues, and to allow the applicant sufficient time to show compliance with any resultant Special Condition.

7. Review the proposed MOCs for each human factors regulation and determine if, taken together, they adequately address the compliance issues that have been identified for the relevant systems. There is no formula for this determination. It is based on the judgment of the FAA Certification Team. It is important to note that this step is not intended to determine if all potential human factors issues have been fully addressed. Instead, it is concerned only with determining if the proposed MOCs address the regulatory compliance issues, including those associated with any Special Condition.

8. If the proposed MOCs do not fully address the human factors issues associated with compliance, determine if the level of effort needed for the MOC preferred by the FAA Certification Team is commensurate with the level of safety risk and the compliance uncertainty. The applicant and the FAA Certification Team should carefully consider the regulation-specific issues and the design-specific issues to ensure that costly, time-consuming MOCs are not demanded for simple, low-risk designs. The MOCs should focus on compliance and safety issues, rather than on design optimization. However, applicants should be allowed to select (and justify) efficient and low cost MOCs when appropriate and adequate for showing compliance with requirements. The applicant and the FAA Certification Team should strive to reach a consensus on the MOCs

## 5. SYSTEM SAFETY ASSESSMENTS

The ACS Human Factors Certification Plan should describe the system safety assessments [i.e., Functional Hazard Assessment (FHA), Failure Modes and Effects Analysis (FMEA), Fault Tree Analysis, etc.] that are going to be accomplished to address human factors elements (such as crew responses to failure conditions) and other assumptions that must be made about pilot behavior. These assumptions should be reviewed by the full Certification Team to ensure that no assumptions are being made that will require the pilot to compensate for failures beyond their expected capabilities. If the assessments are described in detail in other assessment planning documents, those should be referenced in the ACS Human Factors Certification Plan.

## 6. OPERATIONAL CONSIDERATIONS

The applicant may have specific goals associated with the operational certification of the ACS that could influence the design and its evaluation. In this section, the applicant should describe how these operational considerations will be integrated into the ACS certification project. It is useful to identify operational requirements that have been factored into the design.

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:

- Pilot Operating Manual
- Airplane Flight Manual (AFM), or equivalent
- Master Minimum Equipment List (MMEL), or equivalent
- Quick Reference Handbook (QRH), or equivalent
- Other documents or checklists, as appropriate

In order to help ensure acceptance of the UA Pilot Operating Manual, it may be advantageous to conduct certification testing using the procedures and other relevant information that will be included in this document. This will enable the members of the FAA Aircraft Evaluation Group (AEG), who approve the procedures, to have a high degree of confidence that there will be no human factors problems associated with the use of the Operating Manual.

## 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. These reports should be indicated in the compliance matrix.

Documentation may include:

- Design Criteria
- Engineering Drawings
- Installation Drawings
- HSI designs
- Workload Assessment Report
- Flight Display Endorsement Plan and Report
- Test Plans and Reports
- Vision Certification Report

- Lighting Certification Report
- ACS Anthropometry Certification Report
- System Description Document
- Simulation and Demonstration Reports
- Minimum Flight Crew Demo/Test Plan and Results Reports
- Ground and Flight Test Plan and Report
- Fault Tree Analysis
- Failure Mode and Effects Analysis Report
- Environmental Criteria and Test Results

Other documentation that might be provided to the FAA Certification Team could include:

- **Human Engineering Program Plan**. This plan describes all of the analysis, design and T&E tasks that will be accomplished to support the design and validation of all aspects of the ACS. It also describes the qualifications of the employees that will be used to conduct the required tasks, program milestones and schedule, and resources required to accomplish required tasks.

- **Human Engineering Systems Analysis Report (HESAR)** – This document describes the methodology used to define the roles and responsibilities for the UA Pilot, and the accomplishment of mission, function, function allocation, task and workload analyses to define pilot information and control requirements. This document provides the required traceability to support design decisions that are used to support the design of the ACS workstation and HCI.

- **Human Engineering Design Approach Document – Operator (HEDAD-O) –** This document describes the layout and arrangement of the UA Pilot station as well as describes the accessibility and functionality for all information presented to the UA Pilot. Typically, information contained in this document is used by hardware and software engineers to implement the defined HCI. This information can also be used to support the development of training material and the pilot flight manual.

- **Human Engineering Design Approach Document – Maintainer (HEDAD-M) –** This document describes the accessibility of the equipment that is to be maintained. This should include descriptions of equipment located both on the aircraft and in the ACS. This document should also describe the procedures used to identify and isolate faults, and to remove and replace failed equipment. This information can also be used to support the development of training material for the required maintenance personnel

- **Human Engineering Test/Demonstration Plans -** Human Engineering testing and other forms of design validation are implemented by detailed test and program plans. These plans and procedures document the approach that the applicant will use to validate that the specified mission(s) can be accomplished safely and effectively. The methodology used and the results obtained from all tests and evaluations should be summarized in this report. Test plans describe the purpose of each test, the test facility to be used, the test methodology. MOCs, procedures, subject requirements (number and skill levels), the training to be provided to the test subjects, the objective and subjective data to be collected, and other essential information.

# 8. CERTIFICATION SCHEDULE

This section of the human factors ACS Human Factors Certification Plan should include the major milestones of the certification program related to human factors. This may include:

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

- **ACS Reviews, Early Prototype Reviews, and Simulator Reviews.** The ACS Human Factors Certification Plan can document planned design reviews. Even when 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 pilot interface tradeoffs and design proposals,
  - Allowing the Certification Team to provide the applicant with early feedback on any potential certification issues, and
  - Supporting cooperative teaming between the applicant and the Certification Team, in a manner consistent with the Certification Process Improvement initiative.

- **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 on the schedule.

The Certification Team can use this 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 DESIGNATED ENGINEERING REPRESENTATIVES (DERS)

This section should describe how the applicant will make use of DERs and other designees during the certification program. The specific roles and responsibilities for each DER should be specified in the plan. Brief resumes for each DER should be provided in an Appendix to the plan.

# APPENDIX A: SAMPLE PROCEDURES

This appendix provides procedural guidance for accomplishing the Human Factors tasks that are required to provide the FAA with a body of data to support ACS certification. Specific top level criteria and a recommended approach for providing the required data are provided for each subsection in Section 2 starting with Intended System Function.

## A.1 INTENDED SYSTEM FUNCTION

### A.1.1 Top Level Criteria

Verify that all critical ACS system functions have been defined and allocated to hardware, software, the UA pilot, or combination thereof. This assessment should include the performance of all required normal and identified abnormal/contingency operations.

### A.1.2 Approach

A human-system engineering process should be used to support the design and validation of ACS Human System Interfaces (HSIs). This process includes developing Design-To-Requirements (DTRs) to ensure that the specified ACS requirements and Human Engineering criteria are incorporated into design. DTRs should be developed for applicable sections of FAR Parts 23, 65 and 91, and DOT/FAA/CT-91/1, etc. These DTRs should be distributed throughout the program and to suppliers to facilitate the incorporation of applicable human engineering criteria into design.

ACS system functions should be developed and verified by accomplishing the following tasks:

- Review applicable system requirement documents, relevant ConOps and Functional Requirements Documents (FRDs) to identify potential system and pilot requirements
- Develop a Statement of Similarity, if applicable, to describe how the current system is similar (e.g., physical, logical, or operational) to a previously certified system
- Perform a technology assessment to identify state-of-the-art technology concepts for providing the functionality identified in the Function Analysis
- Perform Mission and Function analyses to define roles and responsibilities for the UA pilot and to identify preliminary pilot information and control requirements. Determine system speed/accuracy requirements for the identified functions. Analyses should cover normal and contingency/abnormal operations.
- For tasks that involve significant automation, identify the following information:
    - Operating modes

- Principles underlying mode transitions
- Mode annunciation schemes
- Automation engagement/disengagement principles
- Preliminary logic diagrams

- Describe underlying guidelines or principles that form the basis for pilot procedures. Key topics covered should include:
  - Expected use of memorized procedures with confirmation checklists vs. read-and-do procedures/checklists
  - Pilot interactions during procedure/checklist accomplishment
  - Automated support for procedures/checklists, if applicable.

## A.2 UA PILOT STATION LAYOUT

### A.2.1 Top Level Criteria

- Verify that all critical ACS displays and controls are accessible to enable a pilot to monitor and control the UA safely and effectively.
- Verify anthropometric accommodation for the full range of pilots (e.g., 5$^{th}$ percentile female to 95$^{th}$ percentile male). Ensure that the location and arrangement of ACS controls and displays conform to Part 23 requirements.
- Verify that the pilot station is arranged to give the pilot a sufficiently extensive, clear and undistorted natural or artificial view to enable them to safely perform any maneuvers within the operating limitations of the airplane, including taxi, takeoff, approach and landing.
- Verify that the ACS will provide sufficient information to enable to pilot to detect, identify and maneuver as necessary to avoid traffic, terrain, obstacles and other flight hazards.
- Verify that alerts (e.g., airspeed, altitude and direction, approach guidance, windshear guidance, TCAS resolution advisories, terrain avoidance warnings, and unusual attitude recovery cues, and other information required for safe flight) can be readily determined and used to safely operate the aircraft under all operating conditions.

### A.2.2 Approach

UA pilot station layout and arrangement should be verified by accomplishing the following tasks:

- Develop a configuration description of the ACS layout and arrangement

- Develop Design-To-Requirements for Part 23 and AC 23-773 to provide design criteria for ACS pilot reach and vision requirements.

- Develop engineering drawings for all aspects of the ACS that involve the location and arrangement of pilot controls, displays and indicators. Computer man-models can be used to provide an early indication of anthropometric suitability for the intended user population. For these evaluations, computer models representing critical body dimensions for small females and large males should be used (e.g., seated eye-height, functional reach, knee clearance, extended leg reach, etc.).

- A full-size mockup can be developed to provide a mechanism for evaluating ACS layout and arrangement. This facility enables the preliminary assessment of the ACS arrangement and anthropometric suitability. Pilot's representative of the entire anthropometric range should be used to evaluate ACS layout and arrangement. FAA representatives should be invited to either serve as test subjects, or to observe these evaluations. The results of these evaluations are used to update the final ACS design.

- Conduct Ground and Flight Test evaluations to verify that all FAR Part 23 requirements relating to ACS layout and arrangement are satisfied. Any ACS layout and arrangement problems that are identified should be reviewed to identify solutions for the ACS prior to the system being placed in service.

- Perform safety and reliability analyses to show that loss of information at a critical time will be extremely improbable

- Perform tests to validate that the all applicable UA Pilot sensory requirements are satisfied and that the pilot will be able to detect, accurately identify, and maneuver the UA, as necessary, to avoid traffic, terrain, obstacles, and other flight hazards. FAA and company pilots should serve as the participants for these evaluations.

## A.3 PILOT STATION CONTROLS AND DISPLAYS

### A.3.1 Top Level Criteria

Verify that the design and performance of ACS control and display systems adhere to FAA and Human Engineering design criteria to enable the pilot to safely and effectively control the flight of the aircraft and to monitor and control all aircraft subsystems that have an ACS interface. Pilot workload and internal and external Situation Awareness (SA) must be considered in the design, performance and integration of UA pilot controls and displays.

### A.3.2 Approach

ACS control and display design and performance should be verified by accomplishing the following tasks:

- Develop Design-To-Requirements (e.g., FAR Part 23 and MIL-STD-1472, DOT/FAA/CT-96/1, etc.) to provide criteria for the design and performance of ACS HSI equipment.
- Conduct trade studies to optimize the design and selection of the ACS control and display subsystems
- Develop an ACS description document to describe the intended function of all ACS interfaces. This document should describe the operational capabilities of each device, its modes, control features, when and how often the device is used, pilot requirements for using the device, etc. The document should also describe the proposed certification method for each interface device (e.g., similarity to an existing certified interface device, simulation, ground and flight testing, etc.).
- Perform visibility evaluations to ensure that all displays are easily readable under all anticipated ambient light conditions. This should include assessing the contrast/brightness capabilities for all displays, indicators and warning lights. Mockup and Ground/Flight test lighting evaluations can be conducted to ensure that ACS illumination will enable the pilot to accomplish assigned tasks safely and effectively, and that glare and reflections from the displays and ACS interfaces do not negatively impact pilot performance.
- Evaluate the functionality of all new and modified ACS interfaces to ensure their ease and effectiveness of use. All control panel and display designs should be assessed for ease of use and clarity of function. This should include the design of all formats and the display hierarchy used to access all formats. Capabilities used to interact with information presented on the MFDs (e.g., cursor control, use of bezel switches, keyboard operation, voice control, etc.) should also be assessed. Rapid Prototyping and Usability evaluations can be used to support these evaluations.
- Perform Flight Display evaluations to ensure that the pilots can effectively monitor/control the flight of the aircraft through all flight regimes, and that the flight information provides sufficient information to enable the pilots to identify and recover from unusual attitudes.
- Develop concept for an Integrated Caution and Warning (ICAW) system to alert the pilot to all abnormal and emergency conditions requiring awareness or action. The control and display aspects for pilot interaction with the ICAW system should be fully described, and evaluated.
- Perform System Safety assessments (i.e., Functional Hazard Assessment (FHA), Failure Modes and Effects Analysis (FEMA), Fault Tree Analyses, etc.) to assess the safety impacts for all aircraft systems, and to provide data to assess whether any

expected failure condition could require the pilot to compensate for failures beyond expected capabilities.

- Conduct applicable testing to verify that all FAR Part 23 requirements relating to ACS design and performance are satisfied. Any ACS problems that are identified should be reviewed to identify solutions for the ACS that will be placed in service.

## A.4 UA PILOT PROCEDURES

### A.4.1 Top Level Requirement

Verify that the UA pilot can safely and effectively accomplish all assigned procedures for all phases of flight. This will include the verification of normal and anticipated abnormal procedures.

### A.4.2 Approach

ACS procedures should be verified by accomplishing the following tasks:

- Develop a Human Engineering Program Plan to specify what analysis, design and test and evaluation activities should be accomplished to support the design of the ACS and to provide the required data for certification.
- Perform mission and function analyses to identify required UA system tasks as a function of phase of flight. Functions will be allocated between hardware, software and the pilot. A concept of operations, including pilot roles and responsibilities should be developed.
- Develop concepts for automation to reduce pilot workload and enhance internal and external situation awareness. The underlying principles for automation should be defined, along with defining the way in which the automation operates and communicates its operation to the pilot. The operating modes of the automation, the principles underlying mode transitions, the mode annunciation scheme, and automation engagement/disengagement techniques should be provided for all automation schemes.
- Define the underlying guideline or principles that form the basis for crew procedures. Key topics 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
- Perform detailed task analyses to identify pilot sensory, cognitive and psychomotor task demands. The task analysis should identify the stimuli used to initiate a task, the information and controls provided to accomplish the task, the decision and

psychomotor response to accomplish the assigned task. The feedback mechanism used to indicate successful task performance should also be indicated. The accuracy and speed requirements for each task should be identified. Task analyses should cover normal and contingency operations.

- Perform workload analyses to verify that pilot sensory, cognitive, or psychomotor task demands are not excessive. Initially subjective techniques should be used to assess workload, and to identify required interface changes. As the design matures part-task and full mission simulations, as well as ground and flight test evaluations should be conducted to verify workload acceptability. Workload assessments should be based upon time stress and task difficulty. Time stress should be based upon the time required to accomplish assigned tasks in comparison to the time available for task completion. This analysis should be performed for each flight phase. Task difficulty estimates should be obtained to assesses the sensory (visual, auditory tactile), cognitive and psychomotor demands associated with each task.

- Develop concepts for pilot Crew Resource Management (CRM) to enable pilots to work effectively as a team to accomplish all assigned tasks under all operating conditions. This should include developing procedures for normal and anticipated abnormal procedure.

- Perform tests to verify that realistic demands have been placed upon the pilots and that they can safely and effectively control the flight of the aircraft and ACS interfaces under all operating conditions.

- Document analysis, design and test activities used to verify UA Pilot procedures. The FAA should have approval rights on all such documentation.

- Develop a tracking system to identify and track ACS hardware and software problems identified in the performance of the tasks listed in this section.

## A.5 UA PILOT CHARACTERISTICS

### A.5.1 Top Level Requirements

Identify pilot skill, knowledge, ability, experience, medical, and training requirements for the pilot to safely and effectively monitor and control the UA for all phases of flights for all planned missions. Requirements for normal and contingency operations should be addressed in developing the pilot rating criteria.

### A.5.2 Approach

Minimum pilot requirements can be derived by performing the following tasks:

- Specify pilot roles and responsibilities, including a description of the level of autonomy, and the levels and types of automation provided to support UA monitoring and control.

- Review the results of mission and function analyses to identify pilot responsibilities for all phases of flights for all planned missions. A composite, worst-case scenario can be developed to “stress” pilot requirements. Developing this type of scenario eliminates the requirements to perform multiple mission/function decompositions, and provides the opportunity to perform task and workload analyses using reasonable, pre-defined system errors and unplanned mission contingencies.

- Review the results of the task analyses to identify pilot decision making requirements. Knowledge of pilot decision making requirements is a pre-requisite for determining training requirements.

- Review applicable research results on UA pilot capabilities and training requirements.

- Review the qualifications of current UA pilots, and assess changes necessary to support operations in the NAS

## A.6 ACS HABITABILITY AND PILOT ACCOMMODATIONS

### A.6.1 Top Level Requirements

Verify that the ACS environment will not interfere with the safe operation of the aircraft and that the impact of potential environmental stressors (e.g., illumination, noise, ventilation and cooling/heating, etc.) is minimized. Verify that Pilot accommodations (e.g., Seats, Work Consoles, etc.) are designed to facilitate pilot performance and comfort.

### A.6.2 Approach

The acceptability of the ACS environment will be verified by accomplishing the following tasks:

- Develop Design-To-Requirements for Part 23, MIL-STD-1472, DOT/FAA/CT-96/1 to provide criteria for the design and performance of the ACS environmental systems.

- Perform lighting evaluations to ensure that the ACS environment is acceptable for all expected operating conditions. The purpose of these evaluations is to identify and resolve any vision problems that might be caused by glare and reflections within the ACS

- Perform analyses/evaluations to assess noise levels within the ACS. Both objective sound pressure and subjective rating data should be obtained to assess the ACS noise environment. Determine whether noise levels are within the acceptable levels as defined in the DTRs. If not, perform trade studies/support design activities to ensure that the resultant noise levels do not exceed established limits (e.g., both for peak and continuous noise). Also ensure that the ambient noise level does not mask audible ICAW tones or messages.

- Conduct tests to obtain data to validate that the ACS environment will not interfere with the safe operation of the aircraft under all expected operational use conditions. Physical measurement data (e.g., noise, ventilation, etc.), and subjective data should be obtained to validate that the ACS environment satisfies all crew environmental and habitability requirements.
- Provide documentation to the FAA on all activities related to the planning, analysis, design and testing of ACS Habitability and Pilot Accommodations activities.

## APPENDIX B: LISTING OF REGULATIONS IN 14 CFR PART 23 RELATED TO ACS HUMAN FACTORS.

**This table includes all of the Part 23 regulations that are related to ACS human factors. Regulations regarding aircraft performance are not covered in this table! We still need to complete the second column and the regulation text needs to be cross checked to make sure lines haven't be cut off, and to fill in the missing text For the next iteration of this report, this Table will be tailored to applicable UAS requirements.**

| Reg. # | Regulation Text | Comments for UAS Application |
|---|---|---|
| Sec. 23.0031 | (b)Instructions are included in the Airplane Flight Manual, approved manual material, or markings and placards, for the proper placement of the removable ballast under each loading condition for which removable ballast is necessary. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0033 | (c) Controllable pitch propellers without constant speed controls. Each propeller that can be controlled in flight, but that does not have constant speed controls, must have a means to limit the pitch range so that--<br>(d) Controllable pitch propellers with constant speed controls. Each controllable pitch propeller with constant speed controls must have- | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0045 | (f) Unless otherwise prescribed, in determining the takeoff and landing distances, changes in the airplane's configuration, speed, and power must be made in accordance with procedures established by the applicant for operation in<br>(3) Unless otherwise prescribed, in determining the critical engine-inoperative takeoff performance, takeoff flight path, the accelerate-stop distance, changes in the airplane's configuration, speed, and power must be made in<br>(4) Procedures for the execution of discontinued approaches and balked landings associated with the conditions prescribed in Secs.23.67(c)(4) and 23.77(c) must be established.<br>(5) The procedures established under paragraphs (h)(3) and (h)(4) of this section must-- | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0051 | (ii) The takeoff decision speed, V1, is the calibrated airspeed on the ground at which, as a result of engine failure or other reasons, the pilot is assumed to have made a decision to continue or discontinue the takeoff. The takeoff decision | To be provided by the applicant |
| Sec. 23.0055 | (b) Means other than wheel brakes may be used to determine the accelerate-stop distances if that means-- | To be provided by the applicant |
| Sec. 23.0143 | (c) If marginal conditions exist with regard to required pilot strength, the control forces necessary must be determined by quantitative tests. In no case may the control forces under the conditions specified in paragraphs (a) and (b) of this | Applicable to UAS's that provide pilot flight controls (Stick and Rudder). |
| Sec. 23.0145 | (b) Unless otherwise required, it must be possible to carry out the following maneuvers without requiring the application of single-handed control forces exceeding those specified in Sec.23.143(c). The trimming controls must not be adjusted<br>(d) It must be possible, with a pilot control force of not more than 10 pounds, to maintain a speed of not more than VREF during a power-off glide with landing gear and wing flaps extended, for any weight of the airplane, up to and including | Applicable to UAS's that provide pilot flight controls (Stick and Rudder). |
| Sec. 23.0155 | (a) The elevator control force needed to achieve the positive limit maneuvering load factor may not be less than-- | Applicable to UAS's that provide pilot flight controls (Stick and Rudder). |
| Sec. 23.0161 | (a) General. Each airplane must meet the trim requirements of this section after being trimmed and without further pressure upon, or movement of, the primary controls or their corresponding trim controls by the pilot or the automatic | Applicability to a specific UAS is to be determined by the manufacturer |

| Reg. # | Regulation Text | Comments for UAS Application |
|---|---|---|
| Sec. 23.0173 | (a) A pull must be required to obtain and maintain speeds below the specified trim speed and a push required to obtain and maintain speeds above the specified trim speed. This must be shown at any speed that can be obtained, except<br>(b) The airspeed must return to within the tolerances specified for applicable categories of airplanes when the control force is slowly released at any speed within the speed range specified in paragraph(a) of this section. The<br>(c) The stick force must vary with speed so that any substantial speed change results in a stick force clearly perceptible to the pilot. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0207 | (a) There must be a clear and distinctive stall warning, with the flaps and landing gear in any normal position, in straight and turning flight.<br>(b) The stall warning may be furnished either through the inherent aerodynamic qualities of the airplane or by a device that will give clearly distinguishable indications under expected conditions of flight. However, a visual stall warning<br>(d) When following procedures furnished in accordance with Sec. 23.1585, the stall warning must not occur during a takeoff with all engines operating, a takeoff continued with one engine inoperative, or during an approach to landing.<br>(e) During the stall tests required by Sec. 23.203(a)(2), the stall warning must begin sufficiently in advance of the stall for the stall to be averted by pilot action taken after the stall warning first occurs. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0221 | (ii) Reduce the airplane speed using pitch control at a rate of approximately 1 knot per second until the pitch control reaches the stop; then, with the pitch control pulled back and held against the stop, apply full rudder control in a manner<br>(4) There must be no characteristics during the spin (such as excessive rates of rotation or extreme oscillatory motion) that might prevent a successful recovery due to disorientation or incapacitation of the pilot. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0253 | (b) Allowing for pilot reaction time after occurrence of the effective inherent or artificial speed warning specified in Sec. 23.1303, it must be shown that the airplane can be recovered to a normal attitude and its speed reduced to | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0367 | (b) Pilot corrective action may be assumed to be initiated at the time maximum yawing velocity is reached, but not earlier than 2 seconds after the engine failure. The magnitude of the corrective action may be based on the limit pilot forces | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0395 | (1) The system limit loads need not exceed the higher of the loads that can be produced by the pilot and automatic devices operating the controls. However, autopilot forces need not be added to pilot forces. The system must be<br>(c) Pilot forces used for design are assumed to act at the appropriate control grips or pads as they would in flight, and to react at the attachments of the control system to the control surface horns. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0397 | (a) In the control surface flight loading condition, the air loads on movable surfaces and the corresponding deflections need not exceed those that would result in flight from the application of any pilot force within the ranges<br>(b) The limit pilot forces and torques are as follows: | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0455 | Ailerons. | |
| Sec. 23.0499 | (e) For airplanes with a steerable nose wheel that has a direct mechanical connection to the rudder pedals, the mechanism must be designed to withstand the steering torque for the maximum pilot forces specified in Sec. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0671 | (a) Each control must operate easily, smoothly, and positively enough to allow proper performance of its functions.<br>(b) Controls must be arranged and identified to provide for convenience in operation and to prevent the possibility of confusion and subsequent inadvertent operation. | Applicable to all UASs |

| Reg. # | Regulation Text | Comments for UAS Application |
|---|---|---|
| Sec. 23.0672 | (a) A warning, which is clearly distinguishable to the pilot under expected flight conditions without requiring the pilot's attention, must be provided for any failure in the stability augmentation system or in any other automatic or power-<br>(b) The design of the stability augmentation system or of any other automatic or power-operated system must permit initial counteraction of failures without requiring exceptional pilot skill or strength, by either the deactivation of the system | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0673 | Primary flight controls are those used by the pilot for the immediate control of pitch, roll, and yaw. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0677 | (a) Proper precautions must be taken to prevent inadvertent, improper, or abrupt trim tab operation. There must be means near the trim control to indicate to the pilot the direction of trim control movement relative to airplane motion. In<br>(d) It must be demonstrated that the airplane is safely controllable and that a pilot can perform all maneuvers and operations necessary to effect a safe landing following any probable powered trim system runaway that reasonably might | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0679 | (a) There must be a means to--<br>(b) The device must be installed to limit the operation of the airplane so that, when the device is engaged, the pilot receives unmistakable warning at the start of takeoff.<br>(c) The device must have a means to preclude the possibility of it becoming inadvertently engaged in flight. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0685 | (a) Each detail of each control system must be designed and installed to prevent jamming, chafing, and interference from cargo, passengers, loose objects, or the freezing of moisture.<br>(b) There must be means in the cockpit to prevent the entry of foreign objects into places where they would jam the system. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0691 | (c) In addition to the stall warning required by Sec. 23.207, a warning that is clearly distinguishable to the pilot under all expected flight conditions without requiring the pilot's attention, must be provided for faults that would prevent the<br>(d) Each system must be designed so that the artificial stall barrier can be quickly and positively disengaged by the pilots to prevent unwanted downward pitching of the airplane by a quick release (emergency) control that meets the<br>(e) A preflight check of the complete system must be established and the procedure for this check made available in the Airplane Flight Manual (AFM).Preflight checks that are critical to the safety of the airplane must be included in<br>(f) For those airplanes whose design includes an autopilot system:<br>(g) In showing compliance with Sec. 23.1309, the system must be evaluated to determine the effect that any announced or unannounced failure may have on the continued safe flight and landing of the airplane or the ability of the crew to cope | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0697 | (a) Each wing flap control must be designed so that, when the flap has been placed in any position upon which compliance with the performance requirements of this part is based, the flap will not move from that position unless the<br>(b) The rate of movement of the flaps in response to the operation of the pilot's control or automatic device must give satisfactory flight and performance characteristics under steady or changing conditions of airspeed, engine power,<br>(c) If compliance with Sec. 23.145(b)(3) necessitates wing flap retraction to positions that are not fully retracted, the wing flap control lever settings corresponding to those positions must be positively located such that a definite | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0699 | There must be a wing flap position indicator for-- | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0703 | Takeoff warning system. | |

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| Sec. 23.0729 | (c) Emergency operation. For a landplane having retractable landing gear that cannot be extended manually, there must be means to extend the landing gear in the event of either--<br>(e) Position indicator. If a retractable landing gear is used, there must be a landing gear position indicator (as well as necessary switches to actuate the indicator) or other means to inform the pilot that each gear is secured in the extended (or<br>(f) Landing gear warning. For landplanes, the following aural or equally effective landing gear warning devices must be provided: | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0745 | (a) If nose/tail wheel steering is installed, it must be demonstrated that its use does not require exceptional pilot skill during takeoff and landing, in crosswinds, or in the event of an engine failure; or its use must be limited to low speed<br>(b) Movement of the pilot's steering control must not interfere with the retraction or extension of the landing gear. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0773 | Pilot compartment view.<br>(a) Each pilot compartment must be--<br>(b) Each pilot compartment must have a means to either remove or prevent the formation of fog or frost on an area of the internal portion of the windshield and side windows sufficiently large to provide the view specified in paragraph | For UASs, this relates to camera/sensor apertures that provide info into the ACS |
| Sec. 23.0775 | (e) The windshield and side windows forward of the pilot's back when the pilot is seated in the normal flight position must have aluminous transmittance value of not less than 70%<br>(f) Unless operation in known or forecast icing conditions is prohibited by operating limitations, a means must be provided to prevent or to clear accumulations of ice from the windshield so that the pilot has adequate view for taxi,<br>(2) The windshield panels in front of the pilots must be arranged so that, assuming the loss of vision through any one panel, one or more panels remain available for use by a pilot seated at a pilot station to permit continued safe flight | For UASs, this relates to camera/sensor apertures that provide info into the ACS, and to the location and ambient environment for ACS pilot displays |
| Sec. 23.0777 | (a) Each cockpit control must be located and (except where its function is obvious)identified to provide convenient operation and to prevent confusion and inadvertent operation.<br>(b) The controls must be located and arranged so that the pilot, when seated, has full and unrestricted movement of each control without interference from either his clothing or the cockpit structure.<br>(c) Powerplant controls must be located--<br>(d) The control location order from left to right must be power (thrust) lever, propeller (rpm control), and mixture control (condition lever and fuel cut-off for turbine-powered airplanes).Power (thrust) levers must be at least one inch<br>(e) Identical Powerplant controls for each engine must be located to prevent confusion as to the engines they control.<br>(f) Wing flap and auxiliary lift device controls must be located--<br>(g) The landing gear control must be located to the left of the throttle centerline or pedestal centerline.<br>(h) Each fuel feed selector control must comply with Sec. 23.995and be located and arranged so that the pilot can see and reach it without moving any seat or primary flight control when his seat is at any position in which it can be<br>(1) For a mechanical fuel selector:<br>(2) For electrical or electronic fuel selector:<br>(3) If the fuel valve selector handle or electrical or digital selection is also a fuel shut-off selector, the off position marking must be colored red. If a separate emergency shut-off means is provided, it also must be colored red. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0779 | Motion and effect of cockpit controls. | Applicable to ACS that are located on a moving platform. |
| Sec. 23.0781 | Cockpit control knob shape. | Applicability to a specific UAS is to be determined by the manufacturer |

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| Sec. 23.0785 | Seats, berths, litters, safety belts, and shoulder harnesses.<br>(i) The cabin area surrounding each seat, including the structure, interior walls, instrument panel, control wheel, pedals, and seats within striking distance of the occupant's head or torso(with the restraint system fastened) must be free<br>(n) Proof of compliance with the static strength requirements of this section for seats and berths approved as part of the type design and for seat and berth installations may be shown by-- | Applicable to ACS that are located on a moving platform. |
| Sec. 23.0805 | (c) For each emergency exit that is not less than six feet from the ground, an assisting means must be provided. The assisting means may be a rope or any other means demonstrated to be suitable for the purpose. If the assisting | Applicable to ACS that are located on a moving platform. |
| Sec. 23.0807 | (3) If the pilot compartment is separated from the cabin by a door that is likely to block the pilot's escape in a minor crash, there must be an exit in the pilot's compartment. The number of exits required by paragraph(a)(1) of this section<br>(b) Type and operation. Emergency exits must be movable windows, panels, canopies, or external doors, openable from both inside and outside the airplane, that provide a clear and unobstructed opening large enough to admit a 19-by- | Applicable to ACS that are located on a moving platform. |
| Sec. 23.0831 | (a) Each passenger and crew compartment must be suitably ventilated. Carbon monoxide concentration may not exceed one part in 20,000 parts of air.<br>(b) For pressurized airplanes, the ventilating air in the flight crew and passenger compartments must be free of harmful or hazardous concentrations of gases and vapors in normal operations and in the event of reasonably probable | Applicable to ACS that are located on a moving platform. Crew compartment is N/A. |
| Sec. 23.0841 | (4) An automatic or manual regulator for controlling the intake or exhaust airflow, or both, for maintaining the required internal pressures and airflow rates.<br>(5) Instruments to indicate to the pilot the pressure differential, the cabin pressure altitude, and the rate of change of cabin pressure altitude.<br>(6) Warning indication at the pilot station to indicate when the safe or preset pressure differential is exceeded and when a cabin pressure altitude of 10,000 feet is exceeded.<br>(7) A warning placard for the pilot if the structure is not designed for pressure differentials up to the maximum relief valve setting in combination with landing loads. | Applicable to ACS that are located on a moving air platform. |
| Sec. 23.0851 | (a) There must be at least one hand fire extinguisher for use in the pilot compartment that is located within easy access of the pilot while seated.<br>(c) For hand fire extinguishers, the following apply: | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0863 | (b) Compliance with paragraph (a) of this section must be shown by analysis or tests, and the following factors must be considered:<br>(c) If action by the flight crew is required to prevent or counteract a fluid fire (e.g. equipment shutdown or actuation of afire extinguisher), quick acting means must be provided to alert the crew.<br>(d) Each area where flammable fluids or vapors might escape by leakage of a fluid system must be identified and defined. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0903 | (2) The Powerplant systems associated with engine control devices, systems, and instrumentation must be designed to give reasonable assurance that those operating limitations that adversely affect turbine rotor structural integrity will not<br>(2) Require immediate action by any crewmember for continued safe operation of the remaining engines.<br>(d) Starting and stopping (piston engine).<br>(1) The design of the installation must be such that risk of fire or mechanical damage to the engine or the airplane, as a result of starting the engine in any conditions in which starting is to be permitted, is reduced to a minimum. | Applicability to a specific UAS is to be determined by the manufacturer |

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| Sec. 23.0955 | (2) If there is a placard providing operating instructions, a lesser flow rate may be used for transferring fuel from any auxiliary tank into a larger main tank. This lesser flow rate must be adequate to maintain engine maximum continuous<br>(iii) Compliance with this paragraph must require no pilot action after completion of the engine starting phase of operations.<br>(3) For single-engine airplanes, require no pilot action after completion of the engine starting phase of operations unless means are provided that unmistakenly alert the pilot to take any needed action at least five minutes prior to the needed | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0963 | (e) Each fuel quantity indicator must be adjusted, as specified in Sec.23.1337(b), to account for the unusable fuel supply determined under Sec. 23.959(a). | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0991 | (c) Warning means. If both the main pump and emergency pump operate continuously, there must be a means to indicate to the appropriate flight crewmembers a malfunction of either pump. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.0995 | (a) There must be a means to allow appropriate flight crew members to rapidly shut off, in flight, the fuel to each engine individually. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1001 | (f) The fuel jettisoning valve must be designed to allow flight crewmembers to close the valve during any part of the jettisoning operation.<br>(g) Unless it is shown that using any means (including flaps, slots, and slats) for changing the airflow across or around the wings does not adversely affect fuel jettisoning, there must be a placard, adjacent to the jettisoning control, to warn flight | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1141 | (a) Powerplant controls must be located and arranged under Sec. 23.777 and marked under Sec. 23.1555(a).<br>(b) Each flexible control must be shown to be suitable for the particular application.<br>(c) Each control must be able to maintain any necessary position without--<br>(d) Each control must be able to withstand operating loads without failure or excessive deflection.<br>(e) For turbine engine powered airplanes, no single failure or malfunction, or probable combination thereof, in any Powerplant control system may cause the failure of any Powerplant function necessary for safety.<br>(g) Powerplant valve controls located in the cockpit must have-- | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1142 | Auxiliary power unit controls. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1143 | (a) There must be a separate power or thrust control for each engine and a separate control for each supercharger that requires a control.<br>(b) Power, thrust, and supercharger controls must be arranged to allow--<br>(c) Each power, thrust, or supercharger control must give a positive and immediate responsive means of controlling its engine or supercharger.<br>(d) The power, thrust, or supercharger controls for each engine or supercharger must be independent of those for every other engine or supercharger.<br>(e) For each fluid injection (other than fuel) system and its controls not provided as part of the engine, the applicant must show that the flow of the injection fluid is adequately controlled.<br>(f) If a power, thrust, or a fuel control (other than a mixture control) incorporates a fuel shutoff feature, the control must have a means to prevent the inadvertent movement of the control into the shutoff position. This means must-- | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1145 | (a) Ignition switches must control and shut off each ignition circuit on each engine.<br>(b) There must be means to quickly shut off all ignition on multiengine airplanes by the groupings of switches or by a master ignition control.<br>(c) Each group of ignition switches, except ignition switches for turbine engines for which continuous ignition is not required, and each master ignition control must have a means to prevent its inadvertent operation. | Applicability to a specific UAS is to be determined by the manufacturer |

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| Sec. 23.1147 | If there are mixture controls, each engine must have a separate control, and each mixture control must have guards or must be shaped or arranged to prevent confusion by fuel with other controls.<br>(b) For reciprocating single-engine airplanes, each manual engine mixture control must be designed so that, if the control separates at the engine fuel metering device, the airplane is capable of continued safe flight and landing. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1149 | (a) If there are propeller speed or pitch controls, they must be grouped and arranged to allow--<br>(b) The controls must allow ready synchronization of all propellers on multiengine airplanes. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1153 | If there are propeller feathering controls installed, it must be possible to feather each propeller separately. Each control must have a means to prevent inadvertent operation. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1155 | Turbine engine reverse thrust and propeller pitch settings below the flight regime. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1157 | Carburetor air temperature controls. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1165 | (d) There must be means to warn appropriate crewmembers if malfunctioning of any part of the electrical system is causing the continuous discharge of any battery used for engine ignition. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1189 | (1) Each engine installation must have means to shut off or otherwise prevent hazardous quantities of fuel, oil, deicing fluid, and other flammable liquids from flowing into, within, or through any engine compartment, except in lines, fittings,<br>(6) There must be means to guard against inadvertent operations of each shutoff means, and to make it possible for the crew to reopen the shutoff means in flight after it has been closed.<br>(b) Turbine engine installations need not have an engine oil system shutoff if--<br>(c) Power operated valves must have means to indicate to the flight crew when the valve has reached the selected position and must be designed so that the valve will not move from the selected position under vibration conditions likely to exist | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1203 | (d) There must be means to allow the crew to check, in flight, the functioning of each fire detector electric circuit. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1303 | The following are the minimum required flight and navigational instruments:<br>(e) A speed warning device for--<br>(f) When an attitude display is installed, the instrument design must not provide any means, accessible to the flight crew, of adjusting the relative positions of the attitude reference symbol and the horizon line beyond that necessary for<br>(1) If airspeed limitations vary with altitude, the airspeed indicator must have a maximum allowable airspeed indicator showing the variation of VMO with altitude | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1305 | The following are required Powerplant instruments:<br>(b) For reciprocating engine-powered airplanes. In addition to the Powerplant instruments required by paragraph (a) of this section, the following Powerplant instruments are required:<br>(4) For each pump-fed engine, a means:<br>(c) For turbine engine-powered airplanes. In addition to the Powerplant instruments required by paragraph (a) of this section, the following Powerplant instruments are required:<br>(d) For turbojet/turbofan engine-powered airplanes. In addition to the Powerplant instruments required by paragraphs (a)and (c) of this section, the following Powerplant instruments are required:<br>(e) For turbo propeller-powered airplanes. In addition to the Powerplant instruments required by paragraphs (a) and (c) of this section, the following Powerplant instruments are required: | Applicability to a specific UAS is to be determined by the manufacturer |

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| Sec. 23.1309 | (3) Warning information must be provided to alert the crew to unsafe system operating conditions and to enable them to take appropriate corrective action. Systems, controls, and associated monitoring and warning means must be designed | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1311 | (a)Electronic display indicators, including those with features that make isolation and independence between Powerplant instrument systems impractical, must:<br>(b) The electronic display indicators, including their systems and installations, and considering other airplane systems, must be designed so that one display of information essential for continued safe flight and landing will remain<br>(c) As used in this section, "instrument" includes devices that are physically contained in one unit, and devices that are composed of two or more physically separate units or components connected together (such as a remote indicating | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1321 | (a) Each flight, navigation, and Powerplant instrument for use by any required pilot during takeoff, initial climb, final approach, and landing must be located so that any pilot seated at the controls can monitor the airplane's flight path<br>(b) For each multiengine airplane, identical Powerplant instruments must be located so as to prevent confusion as to which engine each instrument relates.<br>(c) Instrument panel vibration may not damage, or impair the accuracy of, any instrument.<br>(d) For each airplane, the flight instruments required by Sec. 23.1303, and, as applicable, by the operating rules of this chapter, must be grouped on the instrument panel and centered as nearly as practicable about the vertical plane of<br>(e) If a visual indicator is provided to indicate malfunction of an instrument, it must be effective under all probable cockpit lighting conditions. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1322 | Warning, caution, and advisory lights. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1323 | Airspeed indicating system. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1325 | Static pressure system. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1326 | If a flight instrument pitot heating system is installed to meet the requirements specified in Sec. 23.1323(d), an indication system must be provided to indicate to the flight crew when that pitot heating system is not operating. The indication | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1329 | (a) Each system must be designed so that the automatic pilot can--<br>(b) If the provisions of paragraph (a)(1) of this section are applied, the quick release (emergency) control must be located on the control wheel (both control wheels if the airplane can be operated from either pilot seat) on the side<br>(c) Unless there is automatic synchronization, each system must have a means to readily indicate to the pilot the alignment of the actuating device in relation to the control system it operates.<br>(d) Each manually operated control for the system operation must be readily accessible to the pilot. Each control must operate in the same plane and sense of motion as specified in Sec. 23.779 for cockpit controls. The direction of motion<br>(e) Each system must be designed and adjusted so that, within the range of adjustment available to the pilot, it cannot produce hazardous loads on the airplane or create hazardous deviations in the flight path, under any flight<br>(f) Each system must be designed so that a single malfunction will not produce a hard over signal in more than one control axis. If the automatic pilot integrates signals from auxiliary controls or furnishes signals for operation of other equipment,<br>(g) There must be protection against adverse interaction of integrated components, resulting from a malfunction.<br>(h) If the automatic pilot system can be coupled to airborne navigation equipment, means must be provided to indicate to the flight crew the | Applicability to a specific UAS is to be determined by the manufacturer |

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| | current mode of operation. Selector switch position is not acceptable as a means of indication. | |
| Sec. 23.1331 | For each instrument that uses a power source, the following apply:<br>(b) The installation and power supply systems must be designed so that--<br>(c) There must be at least two independent sources of power (not driven by the same engine on multiengine airplanes), and a manual or an automatic means to select each power source. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1335 | If a flight director system is installed, means must be provided to indicate to the flight crew its current mode of operation. Selector switch position is not acceptable as a means of indication. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1337 | (b) Fuel quantity indicator. There must be a means to indicate to the flight crew members the quantity of usable fuel in each tank during flight. An indicator calibrated in appropriate units and clearly marked to indicate those units<br>(d) Oil quantity indicator. There must be a means to indicate the quantity of oil in each tank-- | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1351 | (1) Each system, when installed, must be--<br>(4) There must be a means to give immediate warning to the flight crew of a failure of any generator/alternator.<br>(d) Instruments. A means must exist to indicate to appropriate flight crewmembers the electric power system quantities essential for safe operation. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1357 | (c) Each reset table circuit protective device ("trip free" device in which the tripping mechanism cannot be overridden by the operating control) must be designed so that--<br>(d) 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 so located and identified that it can be readily reset or replaced in flight.<br>(e) For fuses identified as replaceable in flight-- | Applies to ACSs that are located on moving platforms |
| Sec. 23.1361 | (a) There must be a master switch arrangement to allow ready disconnection of each electric power source from power distribution systems, except as provided in paragraph (b) of this section. The point of disconnection must be<br>(c) The master switch or its controls must be so installed that the switch is easily discernible and accessible to a crewmember. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1367 | Each switch must be-- | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1381 | Instrument lights. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1383 | Taxi and landing lights. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1416 | (c) Means to indicate to the flight crew that the pneumatic de-icer boot system is receiving adequate pressure and is functioning normally must be provided. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1419 | (d) A means must be identified or provided for determining the formation of ice on the critical parts of the airplane. Adequate lighting must be provided for the use of this means during night operation. Also, when | Applicability to a specific UAS is to be determined by the manufacturer |

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| | monitoring of the | |
| Sec. 23.1431 | (a) In showing compliance with Sec. 23.1309(b)(1) and (2) with respect to radio and electronic equipment and their installations, critical environmental conditions must be considered.<br>(c) For those airplanes required to have more than one flight crew member, or whose operation will require more than one flight crew member, the cockpit must be evaluated to determine if the flight crewmembers, when seated at their<br>(d) If installed communication equipment includes transmitter "off-on" switching, that switching means must be designed to return from the "transmit" to the "off" position when it is released and ensure that the transmitter will return<br>(e) If provisions for the use of communication headsets are provided, it must be demonstrated that the flight crew members will receive all aural warnings under the actual cockpit noise conditions when the airplane is being operated | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1435 | (2) A means to indicate the pressure in each hydraulic system which supplies two or more primary functions must be provided to the flight crew. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1441 | (a) If certification with supplemental oxygen equipment is requested, or the airplane is approved for operations at or above altitudes where oxygen is required to be used by the operating rules, oxygen equipment must meet the<br>(b) The oxygen system must be free from hazards in itself, in its method of operation, and its effect upon other components.<br>(c) There must be a means to allow the crew to readily determine, during the flight, the quantity of oxygen available in each source of supply.<br>(d) Each required flight crewmember must be provided with--<br>(e) There must be a means, readily available to the crew in flight, to turn on and to shut off the oxygen supply at the high pressure source. This shutoff requirement does not apply to chemical oxygen generators. | Applicable to airborne ACSs |
| Sec. 23.1443 | (b) If demand equipment is installed for use by flight crewmembers, the minimum mass flow of supplemental oxygen required for each flight crewmember may not be less than the flow required to maintain, during inspiration, a | Applicable to airborne ACSs |
| Sec. 23.1449 | Means for determining use of oxygen. | Applicable to airborne ACSs |
| Sec. 23.1457 | (3) There is an aural or visual means for preflight checking of the recorder for proper operation. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1459 | (4) There is an aural or visual means for preflight checking of the recorder for proper recording of data in the storage medium. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1501 | (b) The operating limitations and other information necessary for safe operation must be made available to the crewmembers as prescribed in Secs. 23.1541through 23.1589. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1523 | The minimum flight crew must be established so that it is sufficient for safe operation considering-- | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1541 | (a) The airplane must contain--<br>(b) Each marking and placard prescribed in paragraph (a) of this section--<br>(c) For airplanes which are to be certificated in more than one category-- | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1543 | Instrument markings: general. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1545 | (a) Each airspeed indicator must be marked as specified in paragraph (b) of this section, with the marks located at the corresponding indicated airspeeds.<br>(c) If VNE or VNO vary with altitude, there must be means to indicate to the pilot the appropriate limitations throughout the operating altitude range.<br>(d) Paragraphs (b)(1) through (b)(3) and paragraph (c) of this section do not apply to aircraft for which a maximum operating speed VMO/MMO is established under Sec. 23.1505(c). For those aircraft there must either be a maximum | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1547 | Magnetic direction indicator. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. | Powerplant and auxiliary power unit instruments. | Applicability to a specific UAS is to be determined |

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| 23.1549 | | by the manufacturer |
| Sec. 23.1551 | Each oil quantity indicator must be marked in sufficient increments to indicate readily and accurately the quantity of oil. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1553 | Fuel quantity indicator. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1555 | (a) Each cockpit control, other than primary flight controls and simple push button type starter switches, must be plainly marked as to its function and method of operation.<br>(b) Each secondary control must be suitably marked.<br>(c) For Powerplant fuel controls--<br>(d) Usable fuel capacity must be marked as follows:<br>(e) For accessory, auxiliary, and emergency controls-- | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1559 | Operating limitations placard.<br>(b) For airplanes certificated in more than one category, there must be a placard in clear view of the pilot stating that other limitations are contained in the Airplane Flight Manual.<br>(c) There must be a placard in clear view of the pilot that specifies the kind of operations to which the operation of the airplane is limited or from which it is prohibited under Sec. 23.1525. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1561 | Safety equipment. | Applicability to a specific UAS is to be determined by the manufacturer. Primarily for moving ACSs. |
| Sec. 23.1563 | Airspeed placards. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1567 | (a) For normal category airplanes, there must be a placard in front of and in clear view of the pilot stating: "No acrobatic maneuvers, including spins, approved."<br>(b) For utility category airplanes, there must be--<br>(c) For acrobatic category airplanes, there must be a placard in clear view of the pilot listing the approved acrobatic maneuvers and the recommended entry airspeed for each. If inverted flight maneuvers are not approved, the placard must<br>(d) For acrobatic category airplanes and utility category airplanes approved for spinning, there must be a placard in clear view of the pilot-- | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1581 | (a) Furnishing information. An Airplane Flight Manual must be furnished with each airplane, and it must contain the following: | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1583 | Operating limitations. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1587 | Performance information. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23.1589 | Loading information. | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23A.0013 | (a) Primary flight controls and systems. Each primary flight control and system must be designed as follows:<br>(b) Dual controls. If there are dual controls, the systems must be designed for pilots operating in opposition, using individual pilot loads equal to 75 percent of those obtained in accordance with paragraph (a) of this section, except that | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23H.0005 | (b) The APR must be designed to--<br>(c) For airplanes equipped with limiters that automatically prevent engine operating limits from being exceeded, other means may be used to increase the maximum level of power controlled by the power levers in the event of an APR | Applicability to a specific UAS is to be determined by the manufacturer |
| Sec. 23H.0006 | Powerplant instruments. | Applicability to a specific UAS is to be determined by the manufacturer |

## APPENDIX C: EXAMPLE ACS COMPLIANCE MATRIX

**This Compliance Matrix will be completed in the next update to this document.**

### Methods of Verification (ANALYSIS, INSPECTION, DEMONSTRATION or TEST)

The following verification methods can be used in measuring equipment performance and compliance of individual requirements identified in this document. The four verification methods, listed in decreasing order of complexity, are defined as:

a. Test: This is a method of verification wherein performance is measured during or after systematic and controlled application of functional and/or environmental stimuli. Quantitative measurements are analyzed to determine degree of compliance. The process used laboratory equipment, procedures, items and services.

b. Demonstration: This is a method of verification where qualitative determination of properties is made for an end item, including the use of technical data and documentation. The items being verified are observed, but not quantitatively measured in a dynamic state.

c. Analysis. Analysis is a method of verification that consists of comparing hardware design with known scientific and technical principles, procedures and practices to estimate the capability of the proposed design to meet the mission and system requirements. This method may also include mathematical evaluation, simulation and review of design and representative data.

d. Inspection. This method of verification determines compliance without the use of special laboratory appliances, procedures or services and consists of a non-destructive static-state examination of the hardware, technical data and documentation.

**TABLE C-1 SAMPLE ACS COMPLIANCE MATRIX**

| Regulation | Regulation Text | Method(s) of Compliance | Deliverable Product |
|---|---|---|---|
| §23.679 | (a) There must be a means to-- (1) Give unmistakable warning to the pilot when the lock is engaged; or (2) Automatically disengage the device when the pilot operates the primary flight controls in a normal manner.<br><br>(b) The device must be installed to limit the operation of the airplane so that, when the device is engaged, the pilot receives unmistakable warning at the | □ Simulator evaluations<br>□ Simulator demonstration<br>□ ACS test with simulated UA<br>□ ACS test with actual UA | □ Demonstration report<br>□ Test report |

| Regulation | Regulation Text | Method(s) of Compliance | Deliverable Product |
|---|---|---|---|
| | start of takeoff. | | |
| §23.691 | (e) A preflight check of the complete system must be established and the procedure for this check made available in the Airplane Flight Manual (AFM). Preflight checks that are critical to the safety of the airplane must be included in the limitations section of the AFM. | □ Inspection | AFM |
| §23.699(a)-(b) | There must be a wing flap position indicator for-- (a) Flap installations with only the retracted and fully extended position, unless-- (1) A direct operating mechanism provides a sense of "feel" and position (such as when a mechanical linkage is employed); or (2) The flap position is readily determined without seriously detracting from other piloting duties under any flight condition, day or night; and (b) Flap installation with intermediate flap positions if-- (1) Any flap position other than retracted or fully extended is used to show compliance with the performance requirements of this part; and (2) The flap installation does not meet the requirements of paragraph (a)(1) of this section. | □ Inspection | Inspection Report |
| §23.729(e) | Position indicator. If a retractable landing gear is used, there must be a landing gear position indicator (as well as necessary switches to actuate the indicator) or other means to inform the pilot that each gear is secured in the extended (or retracted) position. If switches are used, they must be located and coupled to the landing gear mechanical system in a manner that prevents an erroneous indication of either "down and locked" if each gear is not in the fully extended position, or "up and locked" if each landing gear is not in the fully retracted position. | □ Inspection | Inspection Report |
| §23.729(f)-(f)(2) | Landing gear warning. For landplanes, the following aural or equally effective landing gear warning devices must be provided: (1) A device that functions continuously when one or more | □ Inspection | Inspection Report |

| Regulation | Regulation Text | Method(s) of Compliance | Deliverable Product |
|---|---|---|---|
| | throttles are closed beyond the power settings normally used for landing approach if the landing gear is not fully extended and locked. A throttle stop may not be used in place of an aural device. If there is a manual shutoff for the warning device prescribed in this paragraph, the warning system must be designed so that when the warning has been suspended after one or more throttles are closed, subsequent retardation of any throttle to, or beyond, the position for normal landing approach will activate the warning device. (2) A device that functions continuously when the wing flaps are extended beyond the maximum approach flap position, using a normal landing procedure, if the landing gear is not fully extended and locked. There may not be a manual shutoff for this warning device. The flap position sensing unit may be installed at any suitable location. The system for this device may use any part of the system (including the aural warning device) for the device required in paragraph (f)(1) of this section. | | |
| §23.777(h)(2)-(h)(2)(ii) | For electrical or electronic fuel selector: (i) Digital controls or electrical switches must be properly labeled. (ii) Means must be provided to indicate to the flight crew the tank or function selected. Selector switch position is not acceptable as a means of indication. The "off" or "closed" position must be indicated in red. | Inspection | Inspection Report |
| §23.859(e)(1)(ii) | Means to warn the crew when any heater whose heat output is essential for safe operation has been shut off by the automatic means prescribed in subparagraph (i) of this paragraph. | • Analysis Results<br>• Simulation Demonstration | Demonstration Report |
| §23.863(c) | If action by the flight crew is required to prevent or counteract a fluid fire (e.g. equipment shutdown or actuation of a fire extinguisher), [quick] acting means must be provided to alert the crew. | • Analysis Results<br>• Simulation Demonstration | Demonstration Report |

| Regulation | Regulation Text | Method(s) of Compliance | Deliverable Product |
|---|---|---|---|
| §23.903(d)(1)-(d)(1)(ii) | Starting and stopping (piston engine). (1) The design of the installation must be such that risk of fire or mechanical damage to the engine or airplane, as a result of starting the engine in any conditions in which starting is to be permitted, is reduced to a minimum. Any techniques and associated limitations for engine starting must be established and included in the Airplane Flight Manual, approved manual material, or applicable operating placards. Means must be provided for-- (i) Restarting any engine of a multiengine airplane in flight, and (ii) Stopping any engine in flight, after engine failure, if continued engine rotation would cause a hazard to the airplane. | • Analysis Results<br>• Simulation Demonstration | Demonstration Report |
| §23.955(c)(3) | For single-engine airplanes, require no pilot action after completion of the engine starting phase of operations unless means are provided that unmistakenly alert the pilot to take any needed action at least five minutes prior to the needed action; such pilot action must not cause any change in engine operation; and such pilot action must not distract pilot attention from essential flight duties during any phase of operations for which the airplane is approved. | • Analysis Results<br>• Simulation Demonstration | Demonstration Report |
| §23.955(f)(3) | For single-engine airplanes, require no pilot action after completion of the engine starting phase of operations unless means are provided that unmistakenly alert the pilot to take any needed action at least five minutes prior to the needed action; such pilot action must not cause any change in engine operation; and such pilot action must not distract pilot attention from essential flight duties during any phase of operations for which the airplane is approved. | • Analysis Results<br>• Simulation Demonstration | Demonstration Report |

| Regulation | Regulation Text | Method(s) of Compliance | Deliverable Product |
|---|---|---|---|
| §23.963(e) | (e) Each fuel quantity indicator must be adjusted, as specified in §23.1337(b), to account for the unusable fuel supply determined under [§23.959(a).] | □ Analysis<br>□ Demonstration | □ Analysis report<br>□ Demonstration report |
| §23.991(c) | Warning means. If both the [main] pump and emergency pump operate continuously, there must be a means to indicate to the appropriate flight crewmembers a malfunction of either pump. | □ Analysis<br>□ Demonstration | □ Analysis report<br>□ Demonstration report |
| §23.1001(g) | Unless it is shown that using any means (including flaps, slots, and slats) for changing the airflow across or around the wings does not adversely affect fuel jettisoning, there must be a placard, adjacent to the jettisoning control, to warn flight crewmembers against jettisoning fuel while the means that change the airflow are being used. | □ Demonstration | □ Demonstration report |
| §23.1019(a)(3) | The oil strainer or filter, unless it is installed at an oil tank outlet, must incorporate a means to ] indicate contamination before it reaches the capacity established in accordance with paragraph (a)(2) of this section. | □ Analysis<br>□ Demonstration | □ Analysis report<br>□ Demonstration report |
| §23.114(g)(2) | Powerplant valve controls located in the cockpit must have-- (1) For manual valves, positive stops or in the case of fuel valves suitable index provisions, in the open and closed position; and (2) For power-assisted valves, a means to indicate to the flight crew when the valve-- (i) Is in the fully open or fully closed position; or (ii) Is moving between the fully open and fully closed position. | □ Analysis<br>□ Demonstration | □ Analysis report<br>□ Demonstration report |
| §23.1142 | Means must be provided in the ACS for starting, stopping, monitoring, and emergency shutdown of each installed auxiliary power unit. | □ Analysis<br>□ Demonstration | □ Analysis report<br>□ Demonstration report |
| §23.1165 | (d) There must be means to warn appropriate crewmembers if malfunctioning of any part of the electrical system is causing the continuous discharge of any battery | □ Simulator evaluations<br>□ Simulator demonstration | □ Demonstration report<br>□ Test report |

| Regulation | Regulation Text | Method(s) of Compliance | Deliverable Product |
|---|---|---|---|
| | used for engine ignition. | □ ACS test with simulated UA<br>□ ACS test with actual UA | |
| §23.1309 | (b)(3) Warning information must be provided to alert the crew to unsafe system operating conditions and to enable them to take appropriate corrective action. Systems, controls, and associated monitoring and warning means must be designed to minimize crew errors that could create additional hazards. | □ Simulator evaluations<br>□ Simulator demonstration<br>□ ACS test with simulated UA<br>□ ACS test with actual UA | □ Demonstration report<br>□ Test report |



**TABLE C-2: SAMPLE COMPLIANCE METHOD CHECKLIST**

| FAA Requirement Part 23 | Compliance Method | | | | Comments |
|---|---|---|---|---|---|
| | Inspect | Analysis | Demo | Test | |
| **Performance** | | | | | |
| **Controllability and Maneuverability** | | | | | |
| § 25.143 General. | | | | | |
| (a) The airplane MUST be safely controllable and maneuverable during-- | | | | | |
| (1) Takeoff; | X | | X | | |
| (2) Climb; | X | | X | | |
| (3) Level flight; | X | | X | | |
| (4) Descent; and | X | | X | | |
| (5) Landing. | X | | X | | |
| § 25.207 Stall Warning | | | X | | |
| **Control Systems** | | | | | |

| FAA Requirement Part 23 | Compliance Method | | | | Comments |
|---|---|---|---|---|---|
| §25.675 Stops. | X | | X | | |
| §25.677 Trim systems. | X | | X | | |
| §25.679 Control system gust locks. | X | | X | | |
| §25.697 Lift and drag devices, controls. | X | | X | | |
| §25.699 Lift and drag device indicator. | X | | X | | |
| §25.703 Takeoff warning system. | X | | X | | |
| | | | | | |
| **Personnel and Cargo Accommodations** | | | | | |
| §25.771 Pilot compartment. | | | X | X | |
| §25.773 Pilot compartment view. | X | | X | | |
| §25.775 Windshields and windows. | X | | X | | Applicable to camera/ sensor windows |
| §25.777 Cockpit controls. | | | X | | |
| §25.779 Motion and effect of cockpit controls. | | | X | | |
| §25.781 Cockpit control knob shape. | | | X | X | |
| §25.785 Seats, berths, safety belts, and harnesses. | | | X | X | Only applicable if ACS is located on moving vehicle |
| §25.791 Personnel information signs and placards. | X | | | X | |
| **Emergency Provisions** | | | | | Only applicable if ACS is located on moving vehicle |
| §25.801 Ditching. | X | | X | | |
| §25.803 Emergency evacuation. | X | | X | | |
| §25.807 Emergency exits. | X | | X | | |
| §25.809 Emergency exit arrangement. | X | | | X | |
| §25.810 Emergency egress assist means and escape routes. | | | X | | |
| §25.811 Emergency exit marking. | | | | X | |
| §25.812 Emergency lighting. | | | X | | |

| FAA Requirement Part 23 | Compliance Method | | | | Comments |
|---|---|---|---|---|---|
| § 25.813 Emergency exit access. | | | X | | |
| § 25.815 Width of aisle. | X | | | X | |
| § 25.817 Maximum number of seats abreast. | X | | | X | |
| **Ventilation and Heating** | | | | | |
| § 25.831 Ventilation. | X | | X | | |
| **Pressurization** | | | | | Only applicable if ACS is located on moving, airborne vehicle |
| 25.841 Pressurized cabins. | X | | X | | |
| 25.843 Tests for pressurized cabins. | | | X | | |
| **Fire Protection** | | | | | |
| §25.851 Fire extinguishers. | X | | X | | |
| §25.853 Compartment interiors. | X | | | X | |
| §25.854 Cabin fire protection. | X | | | X | |
| §25.855 Cargo or baggage compartments. | X | | | X | |
| §25.858 Cargo or baggage compartment smoke or fire detection systems. | X | | X | | |
| §25.869 Fire protection: systems. | X | | X | X | |
| **Subpart E - Powerplant** | | | | | |
| **General** | | | | | |
| **Fuel System** | | | | | |
| § 25.955 Fuel flow. | X | | X | | |
| **Powerplant Controls and Accessories** | | | | | |
| § 25.1141 Powerplant controls general. | X | | X | | |
| § 25.1142 Auxiliary power unit controls. | X | | X | | |
| § 25.1143 Engine controls. | X | | X | | |
| | | | | | |
| **SC 25.1141(f) Powerplant controls: General** | | | | | |
| **Add new paragraph (f) to FAR 25.1141 to read as follows:** | | | | | |
| § 25.1145 Ignition switches. | X | | X | | |
| § 25.1161 Fuel jettisoning | X | | X | | |

| FAA Requirement Part 23 | Compliance Method | | | | Comments |
|---|---|---|---|---|---|
| system controls. | | | | | |
| § 25.1163 Powerplant accessories. | X | | X | | |
| § 25.1165 Engine ignition systems. | X | | X | | |
| **Powerplant Fire Protection** | | | | | |
| § 25.1189 Shutoff means. | X | | X | | |
| § 25.1195 Fire extinguishing systems. | X | | X | | |
| § 25.1197 Fire extinguishing agents. | X | | X | | |
| § 25.1199 Extinguishing agent containers. | X | | X | | |
| § 25.1203 Fire detector system. | X | | X | | |
| § 25.1207 Compliance. | X | | X | | |
| **Subpart F- Equipment** | | | | | |
| **General** | | | | | |
| §25.1301 Function and installation. | X | | X | | |
| §25.1303 Flight and navigation instruments. | X | | X | | |
| **SC 25.1303 (c )(3)** | X | | X | | |
| §25.1305 Powerplant instruments. | X | | X | | |
| **SC 25.1305 Powerplant Instruments** | | | | | |
| §25.1307 Miscellaneous equipment. | X | | X | | |
| §25.1316 System lightning protection. | X | | | | |
| **Instruments: Installation** | | | | | |
| §25.1321 Arrangement and visibility. | X | | X | | |
| §25.1322 Warning, caution, and advisory lights. | X | | X | | |
| §25.1323 Airspeed indicating system. | X | | X | | |
| §25.1325 Static pressure systems. | X | | | | |
| §25.1326 Pitot heat indication systems. | X | | | | |

| FAA Requirement Part 23 | Compliance Method | | | | Comments |
|---|---|---|---|---|---|
| §25.1327 Magnetic direction indicator. | X | | X | | |
| §25.1329 Automatic pilot system. | X | | X | | |
| §25.1331 Instruments using a power supply. | X | | X | | |
| §25.1333 Instrument systems. | X | | X | | |
| §25.1335 Flight director systems. | X | | X | | |
| §25.1337 Powerplant instruments. | X | | X | | |
| **Electrical Systems and Equipment** | | | | | |
| **SC 25.1351(d)** | X | | X | | |
| §25.1357 Circuit protective devices. | X | | X | | |
| **Lights** | | | | | |
| §25.1381 Instrument lights. | X | | X | | |
| §25.1383 Landing lights. | X | | X | | |
| §25.1401 Anticollision light system. | X | | X | | |
| §25.1403 Wing icing detection lights | X | | X | | |
| **Safety Equipment** | | | | | |
| §25.1411 General. | X | | | | |
| §25.1415 Ditching equipment. | X | | | X | |
| §25.1419 Ice protection. | X | | X | | |
| §25.1421 Megaphones. | X | | | X | |
| §25.1423 Public address system. | X | | X | | |
| **Miscellaneous Equipment** | | | | | |
| §25.1439 Protective breathing equipment (PBE). | X | | X | | Only applicable if ACS is located on moving, airborne vehicle |
| § 25.1441Oxygen equipment and supply. | X | | X | | |
| §25.1459 Flight recorders. | X | | X | | |
| §25.1523 Minimum flight crew. | X | | X | | |
| §25.1525 Kinds of operation. | X | | | | |
| **Markings and Placards** | | | | | |

| FAA Requirement Part 23 | Compliance Method | | | | Comments |
|---|---|---|---|---|---|
| §25.1541 General. | X | | | | |
| §25.1543 Instrument markings: general. | X | | | X | |
| §25.1545 Airspeed limitation information. | X | | | X | |
| §25.1547 Magnetic direction indicator. | X | | X | | |
| §25.1549 Powerplant and auxiliary power unit instruments. | X | | X | | |
| §25.1551 Oil quantity indication. | X | | X | | |
| §25.1553 Fuel quantity indicator. | X | | X | | |
| §25.1555 Control markings. | X | | | X | |
| §25.1557 Miscellaneous markings and placards. | X | | | X | |
| §25.1561 Safety equipment. | X | | X | | |
| § 25.1563 Airspeed placard. | X | | | X | |
| **Airplane Flight Manual** | | | | | |
| §25.1581 General. | X | | | X | |
| §25.1583 Operating limitations. | X | | | X | |
| **SC 25.1583 Operating Limitations** | | | | | |
| §25.1585 Operating procedures. | X | | | X | |
| §25.1587 Performance information. | X | | | X | |



## APPENDIX D: ACS CERTIFICATION ISSUES AND VALIDATION CONCEPTS

Table will be updated in the next document release.

| REQUIREMENT | CONCEPT | VALIDATION |
|---|---|---|
| **A. General Requirements** | | |
| Field of View/ELOS | Varies as a function of Flight Phase. Requirements will be satisfied by a combination of windows, sensors, and | Cockpit Drawings, simulation and flight test evaluations |

| REQUIREMENT | CONCEPT | VALIDATION |
|---|---|---|
| | External Vision System | |
| Flight Crew Workload | Acceptable workload levels will be provided (TA/TR not to exceed 80%, and average task difficulty low to moderate) | Analytical, simulation and flight test evaluations |
| Situation Awareness | Acceptable SA for both internal and external environments | Simulation and flight test evaluations |
| Illusions in Flight | Minimize | Simulation and flight test evaluations |
| System Availability & Reliability | System Availability = 95% +<br>Reliability = TBD | Analysis, Flight Test and Operational Data |
| Warning Information | Integrated Caution and Warning System provided to alert pilots to abnormal, caution and warning conditions | Design demonstrations, simulation and flight test data |
| Crew Operating Procedures | For both normal and contingency operations | Design demonstrations, simulation and flight test data |
| General Safety | ACS habitability and comfort provisions | Design-To-Requirements (DTR) Checklist and ACS Demonstrations |
| Medically Safe Environment | ACS habitability and comfort provisions | Design-To-Requirements (DTR) Checklist and ACS Demonstrations |
| Transient Physiological Effects (Vertigo, Disorientation, etc.) | Design of displays and pilot procedures to minimize onset of vertigo, disorientation | Design demonstrations, simulation and flight test data |
| Data Availability | Availability of information to enable the PIC to perform all tasks quickly and accurately | Design demonstrations, simulation and flight test data |
| Mode Annunciation | Mode awareness provided on Primary Flight Display format directly in front of both pilots | Design demonstrations, simulation and flight test data |
| Failure Alerting | Integrated Caution and | Design demonstrations, |

| REQUIREMENT | CONCEPT | VALIDATION |
|---|---|---|
| | Warning System provided to alert pilots to abnormal, caution and warning conditions | simulation and flight test data |
| Automation | TBD automation will be provided to reduce workload, and enhance safety | Design demonstrations, simulation and flight test data |
| Anthropometry | Cockpit will be designed to support 5th percentile females to 95th percentile males | Computer drawings, mockup, and flight test demonstrations |
| ATC Compatibility | Relative 'seamlessness" of the UAS into the NAS | Measurement of communication latency, ATC workload, and subjective comments on UAS integration |
| Sunlight Readability | All displays will be sunlight readable | Lighting evaluations, simulations, and flight test demonstrations |
| Crew Coordination | Ability of the crew to work together to accomplish assigned tasks (CRM) | Pilot workload and subjective assessment during simulations and flight test evaluations |
| Avoidance of ground obstacles such as terrain, towers and buildings on visual approaches | Ground situation awareness, and ability of ACS displays to convey this type of info to the PIC | Simulation and flight test evaluations |
| Runway recognition, centerline alignment, and touchdown zone recognition | Ability of displays to provide SA to the PIC to support landing operations | Simulation and flight test evaluations |
| Recognition of visual aids (lighting and markings) to assist the pilot in identifying correct runway, runway alignment, and touchdown zone alignment in low visibility conditions. | Ability of displays to provide SA to the PIC to support landing operations | Simulation and flight test evaluations |
| Pathway clearance | Ability of displays to provide SA to the PIC to support | Simulation and flight test evaluations |

| REQUIREMENT | CONCEPT | VALIDATION |
|---|---|---|
| | landing operations | |
| Detection and avoidance of any obstacles on the runway | Ability of displays to provide SA to the PIC to support taxiway, and landing operations | Simulation and flight test evaluations |
| **B. Task Dependent Requirements** | | |
| Flight Path Guidance—Tracking and Pointing Accuracy | Flight Path Guidance provided on PFD format and backup flight guidance provided on a SFD | Design, Simulation and flight test evaluations |
| Altitude Awareness | Flight Path Guidance provided on PFD format and backup flight guidance provided on a SFD | Design, Simulation and flight test evaluations |
| Maintain Track Heading and Altitude Profiles | Flight Path Guidance provided on PFD format and backup flight guidance provided on a SFD | Design, Simulation and flight test evaluations |
| See to Avoid –Detection of Airborne Vehicles | Requirements will be satisfied by assessing the ability of the pilot/system to detect potential airborne targets | Simulation and flight test evaluations |
| See to Avoid –Detection of Ground Vehicles | Requirements will be satisfied by assessing the ability of the pilot/system to detect potential ground targets | Simulation and flight test evaluations |
| See to Avoid—Detection of Other Hazards | Requirements will be satisfied by assessing the ability of the Pilot/ACS to detect other potentials hazards | Simulation and flight test evaluations |
| See to Avoid –Detection of Weather and Atmospheric Hazards | Requirements will be satisfied by assessing the ability of the Pilot/ACS to detect the location of potentially hazard weather cells | Simulation and flight test evaluations |

| REQUIREMENT | CONCEPT | VALIDATION |
|---|---|---|
| Determination of Path Conflicts | Requirements will be satisfied by assessing the ability of the Pilot/ACS to plan and execute an effective avoidance maneuver | Simulation and flight test evaluations |
| Estimating Time-to-Go | TTG and DTG will be provided on the PFD format | Design, Simulation and flight test evaluations |
| Estimating Distance | TTG and DTG will be provided on the PFD format | Design, Simulation and flight test evaluations |
| **C. Flight Phase Requirements** | | |
| **1. Taxi** | | |
| Determining Ground Path to the Gate to the Departure Runway, or to the Ground Flight Termination Point | Requirements will be satisfied by assessing the adequacy of ACS displays and pilot procedures for accomplishing taxi operations | Simulation and flight test evaluations |
| Executing the Ground Path Maneuvering the Airplane | Requirements will be satisfied by assessing the adequacy of ACS displays and pilot procedures for accomplishing taxi operations | |
| Identifying Signals from Ground Personnel Directing Aircraft | Requirements will be satisfied by assessing the adequacy of communications between ground and flight personnel, if applicable | Simulation and flight test evaluations |
| Recognition of Unsafe Deviations | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for recognizing and avoiding unsafe deviations | Simulation and flight test evaluations |
| Recognition of Hold Lines | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for recognizing hold lines | Simulation and flight test evaluations |

| REQUIREMENT | CONCEPT | VALIDATION |
|---|---|---|
| Identification of Marker Colors | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for identifying Marker Colors | Simulation and flight test evaluations |
| Recognition of Aircraft Position by reading airport signs and markings. | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for recognizing aircraft position and airport signs and markings | Simulation and flight test evaluations |
| Judgment of Speed | Speed information provided on PFD format and SFD | Design, Simulation and flight test evaluations |
| Detection and identification of other Specific Aircraft | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for identifying specific aircraft | Simulation and flight test evaluations |
| **2. Takeoff** | | |
| Pre-takeoff Runway Identification | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for identifying the pre-takeoff Runway | Simulation and flight test evaluations |
| Following of Positioning Markings | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for following Position Markers | Simulation and flight test evaluations |
| Tracking within Runway Boundaries | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for Tracking with Runway Boundaries | Simulation and flight test evaluations |
| Judgment of Speed and acceleration | Speed and Vertical Velocity will be displayed on the PFD | Design, Simulation and flight test evaluations |
| Determine Runway Remaining | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for determining Runway | Design, Simulation and flight test evaluations |

| REQUIREMENT | CONCEPT | VALIDATION |
|---|---|---|
| | Remaining | |
| Detect Atmospheric Disturbances | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for detecting Atmospheric Disturbances | Simulation and flight test evaluations |
| Detect Traffic in Approach Path | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for detecting Traffic in the Approach Path | Simulation and flight test evaluations |
| Detect Departure Route is Clear | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for detecting Departure Route Clearance | Simulation and flight test evaluations |
| **3. After Liftoff** | | |
| Terrain Avoidance | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for detecting potential Terrain Hazards | Simulation and flight test evaluations |
| Navigation Hazard Avoidance | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for detecting potential Navigation Hazards | Simulation and flight test evaluations |
| Noise Abatement Cues and Procedures | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for following Noise Abatement Cues and procedures | Simulation and flight test evaluations |
| **4. High Level Flight** | | |
| Traffic avoidance | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures | Simulation and flight test evaluations |

| REQUIREMENT | CONCEPT | VALIDATION |
|---|---|---|
| | for avoiding traffic | |
| **5. Approach** | | |
| Identification of Airport | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for Airport Identification | Simulation and flight test evaluations |
| Identification of Runway | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for Runway Identification | Simulation and flight test evaluations |
| Verification and alignments with Runway | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for Aligning with assigned Runway | Simulation and flight test evaluations |
| Determination of Touchdown Point | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for determining the Touchdown Point | Simulation and flight test evaluations |
| Maintaining Alignment with Runway | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for maintaining Runway Alignment | Simulation and flight test evaluations |
| Detect and Identify Runway Incursions | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for detecting/identifying Runway Incursions | Simulation and flight test evaluations |
| **6. VMC Approach** | | |
| Follow Preceding Aircraft to Landing | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for following a preceding Aircraft to Landing | Simulation and flight test evaluations |

| REQUIREMENT | CONCEPT | VALIDATION |
|---|---|---|
| Parallel Runway Operations | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for accomplishing Parallel Runway Operations | Simulation and flight test evaluations |
| Avoid Clouds on Approach | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for avoiding Clouds on Approach | Simulation and flight test evaluations |
| Avoid Terrain | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for Avoiding Terrain | Simulation and flight test evaluations |
| Avoid Microbursts and Severe Weather | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for avoiding Microbursts and Severe Weather | Simulation and flight test evaluations |
| Avoid Wake Turbulence | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for avoiding Wake Turbulence | Simulation and flight test evaluations |
| Avoid Runway Conflicts | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for avoiding Runway Conflicts | Simulation and flight test evaluations |
| **7. Landing** | | |
| Control Altitude and Sink Rate | Information provided on PFD & Center stick provided for control | Simulation and flight test evaluations |
| Control Longitudinal Position | Information provided on PFD & Center stick provided for control | Simulation and flight test evaluations |
| Control Lateral Position and Alignment with Runway | Information provided on PFD & Center stick provided for | Simulation and flight test evaluations |

| REQUIREMENT | CONCEPT | VALIDATION |
|---|---|---|
| Centerline | control | |
| **8. Rollout** | | |
| Track within Runway Boundaries | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for maintaining the aircraft position within Runway Boundaries | Simulation and flight test evaluations |
| Determine Runway Remaining | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures for determining Runway Remaining | Simulation and flight test evaluations |
| Judge Speed and Deceleration | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures to judge UA Speed and Deceleration | Simulation and flight test evaluations |
| Detect and Identify Runway Exits | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures to detect/identify Runway Exits | Simulation and flight test evaluations |
| Track Transition to Taxiway | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures to Track Transition to Taxiway | Simulation and flight test evaluations |
| Monitor Vehicle Movements | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures to monitor UA Movements | Simulation and flight test evaluations |
| Determine runway is clear of obstacles | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures to avoid Runway Obstacles | Simulation and flight test evaluations |
| **9. Go-Around** | | |

| REQUIREMENT | CONCEPT | VALIDATION |
|---|---|---|
| Attitude Awareness and Control | Provided on Flight Displays | Simulation and flight test evaluations |
| Awareness of Aircraft Heading with Runway Centerline | Flight Displays, and windows | Simulation and flight test evaluations |
| Avoidance of Severe Weather and Atmospheric Hazards | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures to Avoid Severe Weather and Atmospheric Hazards | Simulation and flight test evaluations |
| Terrain Avoidance | Requirements will be satisfied by assessing the adequacy ACS displays and pilot procedures to Avoid Terrain | Simulation and flight test evaluations |

## APPENDIX E: ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| AC | Advisory Circular |
| ACS | Aircraft Control Station |
| AEG | Aircraft Evaluation Group |
| AFM | Aircraft Flight Manual |
| ATC | Air Traffic Control & Amended Type Certificate |
| CAD | Computer-aided Design |
| COTS | Commercial Off-The-Shelf |
| CFR | Code of Federal Regulations |
| CRM | Crew Resource Management |
| CWT | Cognitive Walk-through |
| DER | Designated Engineering Representative |
| DTR | Design-To-Requirement(s) |
| FAA | Federal Aviation Administration |
| FAR | Federal Aviation Regulation |
| FEMA | Failure Modes and Effects Analysis |
| FHA | Failure Hazard Analysis |
| FL | Flight Level |
| FRD | Functional Requirements Document |
| HALE | High Altitude Long Endurance |
| HEDAD-O | Human Engineering Design Approach Document-Operator |
| HEDAD-M | Human Engineering Design Approach Document-Maintainer |
| HESAR | Human Engineering Systems Analysis Report |
| HCI | Human Computer Interface |
| HSI | Human System Integration |
| ICAW | Integrated Caution and Warning |
| IPT | Integrated Product Team |
| LOA | Level of Autonomy |
| MMEL | Master Minimum Equipment List |
| MFD | Multifunction Display |
| MOC | Method of Compliance |
| NAS | National Airspace |
| QRH | Quick Reference Handbook |
| SEIT | Systems Engineering and Integration Team |
| SA | Situation Awareness |
| STC | Supplier Type Certificate |
| TC | Type Certificate |
| TSO | Technical Standard Order |
| UA(S) | Unmanned Aircraft System |

# APPENDIX F: GLOSSARY OF TERMS

**Advisory Alert**: Non-normal operational or aircraft system condition that requires flight crew awareness and may require subsequent corrective or compensatory flight crew action.

**Airspace:** In the most general sense, airspace refers to the atmosphere in which aircraft operate, extending upwards from the surface of the earth. However, the term airspace also commonly denotes the spatial boundaries used to define areas restricted to civilian flight and to subdivide the airspace into areas controllable by individual air traffic controllers. These airspace boundaries add a constraint to aircraft operations by limiting acceptable aircraft flight paths.

**Alert:** A visual, auditory or tactile stimulus presented to attract the flight crew's attention and convey some information concerning an event/situation.

**Aural Alert:** Discrete tone/sound used for attention-getting.

**Availability:** Is the probability that a function is operational and able to perform were it called on.

**Caution:** Non-normal operational or aircraft system conditions that require immediate flight crew awareness and subsequent corrective or compensatory flight crew action.

**Conflict:** Any situation involving two or more aircraft/ground vehicle, or an aircraft and an airspace, or an aircraft and ground terrain or obstacle, in which the applicable separation minima may be violated.

**Conflict Avoidance:** A strategic maneuver taken to preclude a conflict.

**Conflict Detection:** The process of projecting an aircraft's trajectory both spatially and temporally to determine whether it is probable that the applicable separation minimum will not be maintained between the aircraft and another aircraft or vehicle. The level of uncertainty in the projection is reduced with increased knowledge about the situation, including aircraft capabilities, flight plan, short-term intent information, etc.

**Conflict Management:** Process of detecting and resolving conflicts.

**Conflict Probe:** An airborne or ground-based system that performs the process of conflict detection.

**Conflict Resolution:** The process of identifying and or performing a tactical maneuver or a set of maneuvers that are intended to resolve a conflict or potential conflict between the ownship and either 1) another aircraft or vehicle, 2) a given airspace, or 3) terrain.

**Criticality:** Indication of the hazard safety level associated with a function.

**Dedicated Display:** A display that has only a single intended function in the ACS

**Display:** Visual, auditory and tactile elements of a system that present information to the operator.

**Error:** (1) An occurrence arising as a result of an incorrect action or decision by personnel operating or maintaining a system. (2) A mistake in specification, design, or implementation.

**Event:** An occurrence that has its origin distinct from normal aircraft operations, such as atmospheric conditions (e.g. wind gusts, icing, lightning strikes), runway conditions, and non-normal operational or system conditions.

**Failure:** A loss of function or a malfunction of a system or part thereof.

**False Alert:** An alert that occurs in a situation for which the system design should not have presented an alert.

**Fault:** An undesired anomaly in a function or system.

**Guidelines:** Recommendations for complying with regulations and design requirements and objectives.

**Late Alert:** An alert that does not provide the flight crew with sufficient time to respond successfully.

**Latency:** The total system time from the time of sensing information until the information is presented to the flight crew.

**Latency Compensation:** Correction of system latency introduced position errors using time synchronized position and velocity information.

**Luminance:** An objective measure of the effective intensity of light emitted from (or reflected by) a surface. Perceived luminance can also be affected by contrast from adjacent or surrounding colors.

**Master Visual Alert:** Discrete annunciator used for attention-getting and providing indication of situation urgency.

**Missed Alert:** From a system operation perspective (i.e., not a human operator perspective), the absence of an alert in a situation for which the system was designed to provide an alert.

**Mode:** The current selected state of a system that determines which of many possible functions the system will perform at that specific time.

**Multi-function Display:** A display capable of presenting multiple information or control functions.

**Navigation**: Planning task (short or long term) that involves positional awareness relative to other airport features for the purpose of moving the aircraft from current position to a destination.

**Nuisance Alert:** An alert that, while occurring as intended in the system design, was not appropriate in the specific situation for which it occurred

**Obstacle:** All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that are located on an area intended for the surface movement of aircraft or that extend above a defined surface intended to protect aircraft in flight. [ICAO Annex 14]

**Obstruction:** Any object that penetrates an obstruction identification surface. Note that this is considered to be a subset of the "Obstacle" definition. [FAA Doc. 405]

**Ownship:** The aircraft in which the system is installed and about which the situation mental model is being built.

**Pictorial Information:** The presentation of information in a way that creates a graphical and symbolic representation of the entity it is representing.

**Primary Field of View:** 1) head-down – a region that is within 15 degrees of a line running from the pilot's eye-reference point to the center of the PFD/EADI/ADI; 2) head-up – a region that is within 15 degrees of a line that runs out the window from the pilot's eye-reference point parallel to the aircraft centerline and 10 degrees down from horizontal.

**Primary Flight Display (PFD):** An electronic display that provides the basic "T" information (i.e., attitude, airspeed, altitude, and heading) and other information pertinent to navigation and primary control of flight.

**Reliability:** The frequency (probability) that a function will perform as required under specified conditions, without failure, for a specified period of time.

**Requirement:** An identifiable element of a specification that can be validated and against which an implementation must be verified.

**Risk:** The frequency (probability) of occurrence and the associated level of hazard.

**Shared Display:** A shared display is multi-function and integrates multiple inputs onto a single display (see MFD). Alternate definition is a display used by more than one crew person.

**Situation(al) Awareness:** A multidimensional construct that encompasses "the perception of elements in the environment, the comprehension of their meaning, and the projection of their status into the near future" [Endsley, 1990]. For example, for pilots, the multidimensional awareness elements of the environment include, but are not limited to, crew awareness, cabin awareness, aircraft systems awareness, time awareness, spatial awareness, weather/environmental awareness, traffic awareness, and awareness of ATC constraints. Any specific task that the pilot performs will require the application of one or more (usually not all) of these awareness elements.

**Sub-System Latency:** The various sub-elements that contribute to total system latency. These may include data communication, data processing, control-display latency, graphics rendering, and so on.

**Time-Critical Warning:** Non-normal operational or aircraft system conditions that require unconditionally immediate corrective or compensatory flight crew action usually involving the flight path of the airplane.

**Validation:** The determination that the requirements for a function or system are sufficiently correct and complete.

**Verification:** The evaluation of an implementation to determine that all applicable requirements are met.

**Visual Alert**: Discrete alphanumeric display or light used to get the attention of the flight crew and transfer some information about situation urgency.

**Voice Alert:** Auditory property of voice messages that gets the attention of the flight crew and transfers some information about situation urgency.

**Voice Message:** The information content of a voice alert.

**Warning:** Non-normal operational or aircraft system condition that requires immediate corrective or compensatory flight crew action conditional upon achieving and maintaining overall airplane safety.

## APPENDIX G: RELATED DOCUMENTS

The following documents are applicable reference documents. They can be considered part of this document to the extent they are directly referenced by specific sections of this document.

### GOVERNMENT DOCUMENTS

1. Federal Aviation Administration "FAR 23 Airworthiness Standards: XXXX Category Airplanes" (Amendment 107)

2. Federal Aviation Administration Advisory Circular 20-113, "Pilot Precautions and Procedures to be taken in Preventing Aircraft Reciprocating Engine Induction System and Fuel System Icing Problems", 10/22/81

3. Federal Aviation Administration Advisory Circular 20-129, "Airworthiness Approval of Vertical Navigation (VNAV) Systems for use in the U.S. National Airspace System (NAS) and Alaska", 9/12/88

4. Federal Aviation Administration Advisory Circular 20-130A, "Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors", 06/14/95

5. Federal Aviation Administration Advisory Circular 20-131A, "Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II) and Mode S Transponders", 03/29/93

6. Federal Aviation Administration Advisory Circular 20-133, "Cockpit Noise and Speech Interference Between Crewmembers", 03/22/89

7. Federal Aviation Administration Advisory Circular 20-138, "Airworthiness Approval of Global Positioning System (GPS) Navigation Equipment for use` as a VFR and IFR Supplemental Navigation System", 05/25/94

8. Federal Aviation Administration Advisory Circular 25-11, "Transport Category Airplane Electronic Display Systems", 07/16/87

9. Federal Aviation Administration Advisory Circular 25-12, " Airworthiness Criteria for the Approval of Airborne Windshear Warning Systems in Transport Category Airplanes", 11/02/87

10. Federal Aviation Administration Advisory Circular 25-23, "Airworthiness Criteria for the Installation Approval of a Terrain Awareness and Warning System (TAWS) for Transport Airplanes", 05/22/2000

11. Federal Aviation Administration Advisory Circular 25-1329A-1, "Automatic Pilot Systems Approval", 6/21/88.

12. Federal Aviation Administration Advisory Circular 90-45A, "Approval of Area Navigation System for use in the U.S. National Airspace System", 2/21/75.

13. TSO-C113, "Airborne Multipurpose Electronic Displays", 10/27/86

14. Flight Deck Controls for Transport Aircraft"

15. AS 425B, "Nomenclature and Abbreviations, Flight Deck Area", Date TBD

16. ARP 4101/2, "Flight Deck Visual, Audible, and Tactile Signals", Date ???

17. ARP 1068B, "Flight Deck Instrumentation Display Criteria and Associated Controls for Transport Aircraft", Date ???

18. ARP 1161, "Crew Station Lighting- Commercial Aircraft", 5/72

19. AS 8034, "Minimum Performance for Standards fir Airborne Multipurpose Electronic Displays", 12/82

20. FAA-RD-81-38II "Aircraft Alerting System Standardization Study: Volume II Aircraft Alerting System Design Guidelines", (Berson, et. al., 1981)

21. MIL-STD-1472,"Human Engineering Requirements for Military Systems, Equipment and Facilities", 06/15/98

22. AS425C "Nomenclature and Abbreviations for Use on the Flight Deck"

23. ARP571 "Flight Deck Controls and Displays for Communication and Navigation Equipment for Transport Aircraft"

24. ARP1068 "Flight Deck Instrumentation, Display Criteria and Associated Controls for Transport Aircraft"

25. ARP4032A "Human Engineering Considerations in the Application of Color to Electronic Aircraft Displays 4/88

26. ARP4033 "Pilot-System Integration", 8/95

27. ARP4067 "Design Objectives for CRT Displays for Part 23 Aircraft", 11/89

28. ARP4101 "Core Document, Flight Deck Layout and Facilities", 7/88
29. ARP4101/2 "Pilot Visibility from the ACSACSACSACS", 2/89
30. ARP4101/4 "Flight Deck Environment", 7/88
31. ARP4102/3 "Flight Deck Tire Pressure Monitoring System", 7/88
32. ARP4102/4 "Flight Deck Alerting Systems", 7/88
33. ARP4102/5 "Primary Flight Controls by Electrical Signaling Section", 7/88
34. ARP4102/5* "Engine Controls by Electrical or Fiber Optic Signaling", 11/89
35. ARP4102/6 "Communications and Navigation Equipment", 7/88
36. ARP4102/7 "Electronic Displays", 6/93
37. ARP4102/7 "Appendix A – Electronic Display Symbology for EADI/PFD", 12/91
38. ARP4102/7 "Appendix B – Electronic Display Symbology for EHSI/ND", 6/93
39. ARP4102/7 "Appendix C – Electronic Display Symbology for Engine Displays", 9/93
40. ARP4102/8A "Flight Deck Head-Up Displays", 11/98
41. ARP4102/9A "Flight Management Systems (FMS)", 12/01
42. ARP4102/10 "Collision Avoidance System", 6/93
43. ARP4102/11B "Airborne Windshear System", 6/93
44. ARP4102/13A "Data Link 6/93
45. ARP4102/15A "Electronic Data Management System (EDMS)", 7/00
46. ARP4105B "Abbreviations and Acronyms for Use on the Flight Deck", 7/92
47. ARP4107 "Aerospace Glossary for Human Factors Engineers", 8/88
48. ARP4153 "Human Interface Criteria for Collision Avoidance Systems in Transport Aircraft", 11/88
49. ARP4256A "Design Objectives for Liquid Crystal Displays for Part 25 (Transport) Aircraft", 12/01
50. ARP4260 "Photometric and Colorimetric Measurement Procedures for Airborne Direct View Flat Panel Displays (when approved)", 11/98
51. ARP 5364 "Human Factors Considerations in the Design of Multifunction Display Systems for Civil Aircraft", (draft)

52. AS8034 "Minimum Performance Standards for Airborne Multipurpose Electronic Displays", 12/82

53. DOT/FAA/PS-89/1 "Flight Status Monitor Design Guidelines", (Anderson, et. al. 1989)

54. RTCA/DO-242A "Minimum Aviation System Performance Standards for Automatic Dependent Surveillance Broadcast (ADS-B)", 2002.

55. RTCA/DO-247 "The Role of the Global Navigation Satellite System (GNSS) in Supporting Airport Surface Operations", (1999).

56. RTCA DO-257, "Minimum Operational Performance Standards for the Depiction of Navigation Information on Electronic Maps",

57. RTCA/DO-27 "User Requirements for Aerodrome Mapping Information", (2001)

58. ANM-01-03 "Factors to Consider when Reviewing an Applicant's Proposed Human Factors Methods of Compliance for Flight Deck Certification"

59. DOT/FAA/CT-96/1 Human Factors Design Guide for Acquisition of Commercial-Off-The-Shelf Subsystems, Non-Developmental Items, and Developmental Systems

| FAA Advisory Circulars | Title |
|---|---|
| TBD | TBD |

Military Specifications

| Military Specifications | Title |
|---|---|
| TBD | TBD |

**NON-GOVERNMENT DOCUMENTS**

TBD

| Source | Title |
|---|---|
| TBD | TBD |