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Advisory Circular

Subject: Controls for Flightdeck Systems

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This advisory circular (AC) provides guidance for the installation and airworthiness approval of flightdeck system controls, primarily from a human factors (HF) perspective. This AC addresses cursor control devices, software generated controls (soft controls), touch screens and speech recognition systems, as well as dedicated controls such as physical switches and knobs. It does not address primary flight controls, secondary flight controls, or controls that are located outside the flightdeck.

If you have suggestions for improving this AC, you may use the form at the end of this AC.

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CHAPTER 1. INTRODUCTION

1.1 Purpose.

1.1.1 This AC provides guidance for aircraft and avionics manufacturers and designers who are designing systems for aircraft flightdecks that are certified according to Title 14 of the Code of Federal Regulations (14 CFR) parts 23, 25, 27, and 29. This AC provides general guidance for the design, installation, integration, and approval of flightdeck controls. As indicated in the AC, "controls" includes both the hardware and software components of the input device as well as any other components that are related to its intended use. It also covers components of other systems that have an impact on the control system and information related to the control system.

1.1.2 This AC addresses the following topics:

- Controls for avionics systems in the flightdeck.
- Dedicated controls (e.g. physical switches, knobs).
- Multifunction controls.
- Menu-based controls.
- Cursor control devices (CCDs).
- Touch screens.
- Speech controls.

1.1.3 This AC does not address the following topics:

- Primary and secondary flight controls for fixed wing, including yoke, side-stick, rudder pedals, throttle levers and related powerplant controls, and flaps.
- Primary flight controls for rotorcraft, including cyclic, collective, directional control (tail rotor) pedals, and throttle.
- Controls located outside the flightdeck.
- Controls installed in the flightdeck that are not intended for use by the flightcrew (e.g., controls supporting airplane maintenance activities).
- Aircraft performance responses to manipulation of the "in scope" controls
- Control failure analysis or control behavior in the presence of other system failures.
- Detailed design guidance.
- Control guidance not related to usability or human performance.

1.2 Applicability.

1.2.1 The guidance provided in this AC is for airplane manufacturers, modifiers, foreign regulatory authorities, Federal Aviation Administration (FAA) type certification engineers, and FAA designees.

1.2.2 This is a guidance document. Its content is not legally binding in its own right and will not be relied upon by the Department as a separate basis for affirmative enforcement action or other administrative penalty. Conformity with the guidance document is voluntary only. Nonconformity will not affect rights and obligations under existing statutes and regulations.

1.2.3 The FAA will consider other methods of demonstrating compliance that an applicant may elect to present. Terms such as "should," "may," and "must" are used only in the sense of ensuring applicability of this method of compliance when the acceptable method of compliance in this document is used. If the FAA becomes aware of circumstances in which following this AC would not result in compliance with the applicable regulations, the FAA may require additional substantiation or design changes as the basis for finding compliance.

1.2.4 This material contained in this AC does not change or create any additional regulatory requirement, nor does it authorize changes in, or permit deviations from existing regulatory requirements.

1.3 Cancellation.

1.3.1 This AC cancels AC 20-175, *Controls for Flight Deck Systems*, dated December 8, 2011.

1.4 Related Material.

1.4.1 Title 14, Code of Federal Regulations (14 CFR).

Specific regulations relating to human factors can be found in appendix C for historic part 23 (amendment (amdt.) 63), current part 23 (amdt. 64 and higher), as well as parts 25, 27, and 29. The full text of these regulations is available at www.ecfr.gov.

1.4.2 FAA Advisory Circulars.

The following ACs are related to the guidance in this AC. The latest version of each AC referenced in this document is available on the FAA website at FAA Advisory Circulars and on the Dynamic Regulatory System.

- AC 00-74, *Avionics Human Factors Considerations for Design and Evaluation,* dated May 1, 2019.
- AC 21.17-4, *Type Certification—Powered-Lift*, dated July 18, 2025.
- AC 23-23, *Standardization Guide for Integrated Cockpits in Part 23 Airplanes,* dated September 30, 2004.
- AC 23.1311-1, *Installation of Electronic Display in Part 23 Airplanes,* dated November 17, 2011.
- AC 25-11B, *Electronic Flight Displays,* dated October 7, 2014.

- AC 25.671-1, Control Systems-General, dated August 30, 2024.
- AC 25.1302-1, *Installed Systems and Equipment for use by the Flightcrew*, dated May 3, 2013.
- AC 25.1309-1B, *System Design and Analysis,* dated August 30, 2024.
- AC 25.1322-1, *Flightcrew Alerting*, dated December 13, 2010.
- AC 27-1B, Change 9, *Certification of Normal Category Rotorcraft,* dated June 23, 2023.
- AC 29-2C, Change 9, *Certification of Transport Category Rotorcraft,* dated June 23, 2023.
- AC 120.123, *Flight Path Management*, dated November 21, 2022.

1.4.3 FAA Policy Statements.

The following Policy Statements are related to the guidance in this AC. The latest version of each policy statement referenced in this document is available on the Dynamic Regulatory System.

- FAA Policy Statement (PS)-ACE100-2001-004, *Guidance for Reviewing Certification Plans to Address Human Factors for Certification of Part 23 Small Airplanes*, dated August 29, 2002.
- FAA PS-AIR-21-2023-01, *Classification of Type Design Changes That Would Materially Alter Safety Critical Information as Major Design Changes*, dated November 20, 2023.
- FAA PS-ANM100-01-03A, *Factors to Consider when Reviewing an Applicant's Proposed Human Factors Methods of Compliance for Flight Deck Certification, in Part 25 Airplanes,* dated February 7, 2003.
- FAA PS-ANM111-1999-99-2, *Guidance for Reviewing Certification Plans to Address Human Factors for Certification of Transport Airplane Flight Decks,* issued September 29, 1999.

1.4.4 RTCA.

The following RTCA documents are related to the guidance in this AC. Unless otherwise specified, use the latest FAA-accepted revision for guidance. If the document is revised after publication of this AC, you should verify that the FAA accepts the subsequent revision or update as an acceptable form of guidance. These documents can be ordered online at https://www.rtca.org.

- RTCA/DO-275, *Minimum Operational Performance Standards for Integrated Night Vision Imaging System Equipment*.

- RTCA/DO-372, *Addressing Human Factors/Pilot Interface Issues for Avionics*.

1.4.5 SAE International.

The following SAE Aerospace Recommended Practice (ARP) documents are related to the guidance in this AC. Unless otherwise specified, use the latest FAA-accepted revision for guidance. If the document is revised after publication of this AC, you should verify that the FAA accepts the subsequent revision or update as an acceptable form of guidance. The documents are available online at: https://www.sae.org.

- SAE ARP4102, *Flight Deck Panels, Controls, and Displays*.
- SAE ARP4102/7, *Electronic Displays*.
- SAE ARP4105, *Abbreviations and Acronyms for Use on the Flight Deck.*
- SAE ARP60494, *Touch Interactive Display Systems: Human Factors Considerations, System Design and Performance Guidelines, for touch screens*.

1.4.6 Other Publications.

- Campbell, R. D., and M. Bagshaw. 2002. *Human Performance and Limitations in Aviation*. 3rd ed. Wiley-Blackwell.
- FAA Report, *Human Factors Considerations in the Design and Evaluation of Flight Deck Displays and Controls, Version 3.0 (*DOT/FAA/AM-24/23), dated September 2024.
- MIL-STD-1472H, *Department of Defense, Design Criteria Standard: Human Engineering*, dated September 15, 2020.

1.5 Background.

1.5.1 Revisions to this AC include:

- Adding new sections on non-functioning controls, emergency controls, and multi-modal controls.
- Adding a chapter on emerging aircraft.
- Relocating "*Multifunction Controls Labeling"* and "*Inadvertent Operation"* to "*General Controls Guidance"*.
- Expanding and retitling "*Multifunction Controls - Voice Recognition and Voice Activation"* to *"Speech Controls – Speech Recognition*," reflecting current technologies.
- Updating references, regulations, and guidance.

1.5.2 Flightdeck controls can present unique opportunities and challenges to the design and certification process. In particular, showing compliance with regulatory requirements related to the latest flightdeck controls has been subject to various degrees of interpretation by applicants and the FAA. Whereas conventional controls are typically dedicated hardware components, such as single-function knobs, modern controls are often software-based, multifunctional, and integrated with displays and other systems. A key challenge is to interpret and comply with the regulations consistently and appropriately, across the design spectrum of flightdeck controls. Therefore, to assist applicants, this AC gathers control-related guidance from FAA policy statements, memorandums, and Aircraft Certification issue papers for general controls, touch screens, cursor control devices (CCDs), and automatic speech recognition (ASR) systems.

Note: For projects requiring an issue paper, applicants should contact the Aircraft Certification Service for the latest information on requirements. Online links can be found in appendix A in A.2.1.

1.6 Regulatory Requirements.

1.6.1 In this AC, the notation "2X" is used for brevity to indicate multiple regulations, as applicable, in parts 25, 27, 29, and historic part 23 (Amendment 63 and earlier).

1.6.2 On August 30, 2017, Amendment 64 of part 23 went into effect. To avoid confusion, the current part 23 regulations use a different numbering scheme. Subpart A begins at § 23.2000, subpart B at § 23.2100, and so on, with the regulation numbers increasing by incremental steps of 5, i.e., §§ 23.2005, 23.2010.

1.6.3 When the system includes flightdeck controls, include special consideration of the following regulations: §§23.2300, 23.2405, 23.2410, 23.2425, 23.2430, 23.2500, 23.2505, 23.2510, 23.2530, 23.2600, 23.2605, 23.2610, 23.2615, 23.2620, 2X.671, 2X.771, 2X.777, 2X.1301, 25.1302, 2X.1309, 2X.1321, 2X.1322, 2X.1381, 2X.1523, and 2X.1555. These regulations are related to human factors. They address separate but related topics, including the following human factors topics associated with controls:

- Minimum crew.
- Accessibility.
- Concentration and fatigue.
- Convenience and ease of operation.
- Identification and marking.
- Confusion and inadvertent operation.
- Unrestricted movement.
- Intended function.

1.6.4 This AC provides compliance guidance related to human factors concerning controls in the flightdeck. Appendix B provides a tool the applicant can use to organize their design and compliance effort. Appendix C provides quick reference tables mapping these topics to their associated regulations.

1.7 Recommended Practices.

1.7.1 In AC 00-74, *Avionics Human Factors Considerations for Design and Evaluation*, dated May 1, 2019, the FAA highlighted the following documents as reference material for designers of avionics systems. The documents are not intended as guidance material or policy for showing or finding compliance for airworthiness certification or operational approval. Rather, the objective of the documents is to increase human factors awareness by the individuals who are responsible for the design and certification of systems and equipment and related interfaces designed for use by the flightcrew.

1.7.2 RTCA DO-372, *Addressing Human Factors/Pilot Interface Issues for Avionics*, dated December 2017. This document identifies a recommended process for evaluating the human factors/pilot interface aspects of avionics and identifies some prevalent human factors issues that may aid the early identification and resolution of those issues during the design and evaluation process. The recommended process in this document is not intended as a means of compliance but rather provides steps for identifying and resolving human factors issues related to the pilot interface during both the engineering design and certification process.

1.7.3 FAA Report, *Human Factors Considerations in the Design and Evaluation of Flight Deck Displays and Controls, Version 3.0 (*DOT/FAA/AM-24/23), dated September 2024. This report, also known as the *Human Factors General Guidance* document, serves as a single comprehensive reference for all human factors-related regulations and guidance material for flightdeck displays and controls, to facilitate the identification and resolution of human factors issues with these systems. The information contained in the report is not intended as a means of compliance.

CHAPTER 2. GENERAL CONTROLS GUIDANCE

2.1.1 Design Philosophy.

2.1.1.1 If you are an applicant, document and follow a design philosophy for controls which supports the intended functions in accordance with § 2X.1301 and § 23.2500. The documented design philosophy may be included as part of a system description, certification plan, or other document that is submitted to the FAA during a certification project. The design philosophy should include a high-level description of controls features, such as labeling, feedback, automated behavior, and error recovery. Also, include a high-level description of human performance considerations, such as flightcrew workload, error potential, and expected training requirements.

2.1.1.2 Apply a particular design philosophy consistently throughout the flightdeck to the greatest extent practicable.

2.1.2 Environment and Use Conditions.

2.1.2.1 Consider a variety of environments, use conditions, and other factors that can impact flightcrew interaction with controls during aircraft operations that can be reasonably expected in service, including:

- Appropriate representation of pilot population.
- Bright and dark lighting conditions.
- Use of gloves.
- Turbulence and other vibrations.
- Interruptions and delays in tasks.
- Objects that may physically interfere with the motion of a control.
- Incapacitation of one pilot (multi-crew aircraft).
- Use of the non-dominant hand.
- Excessive ambient noise.
- Hot and cold temperatures.

2.1.2.2 Since not all possible environment and use conditions can be specifically addressed, develop a representative set including nominal and worst cases. These cases should cover the full environment in which the system is assumed to operate, given its intended function. This includes operating in normal, non-normal, and emergency conditions. The following paragraphs describe the environment and use conditions in more detail. For more information about common human factors issues in the flightdeck, see AC 00-74 / RTCA DO-372.

2.1.3 Appropriate Representation of Pilot Population.

2.1.3.1 Controls are designed with an assumption of a certain range of pilot attributes. These assumptions may include physical attributes, such as body size and proportion, and non-physical attributes, such as experience with a given type of control.

2.1.3.2 Design the controls to provide acceptable performance for a broad range of pilot physical attributes. The appropriate pilot representation is key in demonstrating compliance to the applicable regulations. For example, buttons too small for a given finger size can be prone to usability problems, such as finger positioning errors, finger slippage, inadequate feedback, insufficient label size, and inadvertent operation.

2.1.3.3 In some cases, certain attributes of the pilot population are addressed within control-related regulations. For example, § 2X.777 requires controls to be located and arranged in a manner that provides full and unrestricted movement of controls. Section 25.777 addresses a pilot population that ranges in height from 5’2” to 6’3”. Sections 27.777 and 29.777 address a pilot population that ranges in height from 5’2” to 6’0”. Part 23 does not address a particular pilot population. Although §§ 25.777, 27.777, and 29.777 regulations require compliance for a certain range of pilot heights, you may also use individuals from a fifth percentile female to ninety fifth percentile male body statures. Consider using individuals that have a range of arm and reach dimensions, as well as seating heights, that may affect the reach envelopes. To show compliance with this aspect of the regulation, show that all positions of the control fall within the reach envelopes of the intended pilot population.

2.1.3.4 Additionally, 14 CFR 2X.785 is related to § 2X.777, as it requires pilots, while seated and wearing their restraint system, to be able to perform functions necessary to flight operations. As with § 2X.777, consider using individuals with various arm lengths, reach areas, and sitting heights.

2.1.3.5 Since human dimensions can vary greatly, the environment and use conditions should account for such variations. Some acceptable means of accounting for human size variations include:

- Selecting individuals for testing based on reference to an anthropometric database. Anthropometric databases contain information collected from comparative studies of human body measurements and properties.
- Supplementing physical mock-ups with computer anthropometrically-based models.
- Comparing physical measurements of control positioning relative to physical measurements in anthropometric databases.

2.1.3.6 In addition to considerations for unrestricted movement of controls, anthropometric data is important for many other performance considerations, including inadvertent activation and physical workload.

2.1.3.7 Consider other pilot characteristics relevant to controls, beyond anthropometrics, including physical strength, visual acuity, and color perception. Pilot culture characteristics are also relevant in the selection of graphical elements, word choice, and certain control features (e.g., menu structure). Generally, it is appropriate to assume minimal prior pilot experience with a given control.

2.1.3.8 Environment and use conditions should cover a range of pilot characteristics relevant to controls to represent the intended pilot population. Show not only that the controls are acceptable over this range but also provide data describing the range of pilot characteristics, and how this range represents the intended pilot population.

2.1.4 Bright and Dark Lighting Conditions.

2.1.4.1 Controls should be operable under foreseeable lighting conditions. Labels and other information related to a control's functions and method of operation should be readable over a wide range of ambient illumination, including, but not limited to the following:

- Direct sunlight on the controls.
- Indirect sunlight through a front window illuminating white clothing and causing reflections.
- Sun above the forward horizon and above a cloud deck in the pilot's eyes.
- Night and/or dark environment.

2.1.4.2 Consider the above conditions when evaluating controls and show that the controls are acceptable. Compensating factors, such as tactile characteristics, can also be included as part of the environment and use conditions. Special consideration is needed for controls whose function is affected by illuminated information, such as lighted switches and soft keys on displays.

2.1.5 Use of Gloves.

Pilots might wear gloves for protection or during operations in cold weather. Design assumptions regarding skin contact, tactile feedback, and finger characteristics alone might not adequately cover situations in which pilots wear gloves. Therefore, include gloved pilot operations in environment and use conditions. In cases where controls cannot be operated with gloves, clearly describe any limitations or methods for determining limitations, in the aircraft flight manual or flight manual supplement, as appropriate.

2.1.6 Turbulence and Other Vibrations.

2.1.6.1 Ensure controls are operable during vibrations. Vibrations affect not only the ability of pilots to intentionally activate a control but also affect inadvertent activation and awareness of activation. Vibrations can be caused by turbulence, taxi conditions, propulsion systems, or other means.

2.1.6.2 Title 14 CFR 25.771(e), 27.771(c), and 29.771(c) require vibration and noise characteristics of the cockpit equipment to not interfere with the safe operation of the aircraft. Compliance with these regulations should be demonstrated over a range of vibration environments for the intended aircraft and operations. Theoretical analysis alone is unlikely to be sufficient for such a demonstration. Therefore, also show through other means, such as test or demonstration, that control is acceptable over a range of vibration environments for the intended aircraft and operations. For functions with multiple means of control access, ensure that at least one of the controls is operable during vibrations.

2.1.7 Interruptions and Delays in Tasks.

Some control operations involve multiple steps such that interruptions and delays might affect successful completion. For example, pilots might forget to complete a task they started (e.g., air traffic control calls), or they might not understand how the system behavior accommodates unfinished tasks (e.g., data entry timeouts). In environment and use conditions, include interruptions and delays during pilot-system interaction tasks to understand if the controls' behavior results in any safety-critical consequences.

2.1.8 Objects that can Physically Interfere with the Motion of a Control.

Ensure control motion is not obstructed by other objects in the flightdeck. Section 2X.777 addresses unrestricted movement of each control without interference. Interference can potentially arise not only from other components of the flightdeck and the flightcrew's clothing, but also from objects brought on board.

2.1.9 Incapacitation of One Pilot (Multi-Crew Aircraft).

For aircraft designed for multi-crew operations, the incapacitation of one pilot must be considered in the determination of minimum flightcrew, per § 2X.1523. Any control required for flight crewmember operation in the event of incapacitation of other flight crewmember(s), in both normal and non-normal conditions, must be viewable, reachable, and operable by pilots, from the seated position (§§ 25.777(c), 27.777(b), 29.777(b), 23.2600(a), and historic 23.777(b)). For rotorcraft (parts 27 and 29) multi-crew effects are addressed differently than part 25.

2.1.10 Use of Non-Dominant Hand.

Controls should be used by both left-handed and right-handed pilots. Give special consideration to controls requiring speed or precision in force or motion (e.g., cursor control devices) and controls designed to be operated with one specific hand (e.g., controls that can only be reached with the right hand).

2.1.11 Excessive Ambient Noise.

Excessive ambient noise interferes with the ability of pilots to hear aural feedback and other sounds important to control functions. Therefore, when aural feedback is a control feature, it may be necessary to incorporate other sensory feedback as well (e.g., visual, tactile).

2.2 Controls Layout and Organization.

2.2.1 Use the following guidance to the extent practicable (considering system tradeoffs) when developing a layout and organization scheme that will support pilot performance of system functions:

- Group and arrange controls logically, such as by function or by sequence of use.
- For functions frequently used by the flightcrew, controls should be readily accessible.
- Position controls to allow a clear view of their related elements (e.g., displays, indication, labels) when in operation. In general, placing controls below the display or to one side of these elements will minimize visual obstruction during control operation.
- Arrange controls to be easily associated with their related elements (e.g., displays, indications, labels). Ensure the association is readily apparent, understandable, and logical (e.g., line select function keys that align with adjacent text on a display). Give special consideration to large spatial separations between a control and its indication or display.
- Position controls that are common to multiple tasks (e.g., numerical entry controls, “enter” or “execute” keys) to be easily accessible to the pilot and easily associated with their function(s). Position controls to prevent substitution errors, which can arise from inconsistent control placements.
- Ensure hand-operated controls are operable with a single hand. The remaining hand will then be free to operate the primary flight controls.
- Ensure maintenance functions or other functions not intended for pilot use are not readily accessible by pilots during operations.

2.3 Movement of Controls.

2.3.1 Control devices typically transform their movement or force to achieve a control's function. Ensure the interaction between a control and its related elements (e.g., aircraft systems, displays, indications, labels) are readily apparent, understandable, logical, and consistent with applicable cultural conventions and with similar controls in the same flightdeck. Table 2-1 provides examples of conventional relationships between the movement of control and its function.

Table 2-1. Examples of Conventional Relationships Between Control Functions and Movements

Function	Direction of Movement
Increase	Up, Right, Clockwise, Forward, Push-in, Depress
Decrease	Down, Left, Counter-Clockwise, Rearward, Pull-out, Release
On Off	Up, Right, Depress, Clockwise, Forward Down, Left, Release, Counter-Clockwise, Rearward
Raise Lower	Up, Rearward, Pull-out Down, Forward, Push-in
Right Left	Right, Clockwise Left, Counter-Clockwise

2.3.2 Interpretation of the terms used in table 2-1 may depend upon the specific function, or upon the installation location of the control. For example, the interpretation of "increase" is dependent upon the parameter that the control modifies (e.g., magnification and range scale are inversely related, so as one increases, the other decreases). On the other hand, a device with a linear movement might be oriented vertically, horizontally or in between, such that "pull-out" can result in an "up" or "down" component, depending on installation location in the flightdeck.

2.3.3 The conventions in table 2-1 are examples only. Installation location, cultural convention, flightdeck consistency, and adhering to a consistent flightdeck design philosophy are other important considerations.

2.4 Sensitivity and Gain of Controls.

Since many controls transform their movement or force to achieve a function, the gain or sensitivity is a key design parameter. It strongly affects the tradeoff between task speed and error. High gain values tend to favor pilot comfort and rapid inputs, but can also contribute to errors (e.g., overshoot, inadvertent activation). Low gain values tend to favor tasks that require precision but can also be too slow for the task. Gain and sensitivity of the control typically need to be traded off to support the intended function. Give special consideration to variable-gain controls. Accurately replicate the response lag and control gain characteristics that will be present in the actual airplane and show that gain and sensitivity of the control are acceptable for the intended function.

2.5 Feedback from Controls.

2.5.1 Design the control to provide feedback to the pilot when operating. Feedback from controls provides pilots with awareness of the effects of their inputs, including the following effects:

- Physical state of the control device (e.g., position, force);
- State of data construction (e.g., text string);
- State of activation or data entry (e.g., “enter”);
- State of system processing;
- State of system acceptance (e.g., error detection); and
- State of system response (e.g., cursor position, display zoom, autopilot disconnect).

2.5.2 Feedback can be visual, aural, or tactile. If feedback or awareness is required for safe operation, it should be provided to inform the flightcrew of the following conditions:

- State of activation or data entry;
- State of system processing (for extended processing times); and
- State of system response, if different from the commanded state.

2.5.3 Provide clear, unambiguous, and positive feedback to indicate the successful or unsuccessful actuation of a control action. Feedback within the control device (such as the tactile snap of a switch) without any other system effect should not be the sole means of detecting the actuation of a control.

2.5.4 The type, response time, duration, and appropriateness of feedback will depend upon the pilots’ task and the specific information required for successful operation.

2.5.5 The final display response to control input should be fast enough to prevent unreasonable concentration being required when the flightcrew sets values or display parameters (§ 2X.771(a)). The specific acceptable response times depend on the intended function.

2.5.6 Once the control device is activated, if processing time is extended it might be appropriate to display progress to provide the pilot with a sense of time remaining for completion.

2.5.7 If control device position is the primary means of indicating the status of a function (e.g., switch in the Up position indicates that the function is On), the control position should be obvious from any pilot seat.

2.5.8 When a control is used to move an actuator through its range of travel, the equipment should provide operationally significant feedback of the actuator's position within its range.

2.5.9 Show feedback is adequate in performance of the tasks associated with the intended function of the equipment.

2.6 Identifiable and Predictable Controls.

2.6.1 Pilots should be able to identify and select the current function of the control with speed and accuracy appropriate to the task.

2.6.2 Make the function and method of operation of control readily apparent (i.e., predictable and obvious), so that little or no familiarization is needed. Show that the intended pilot population can rapidly, accurately, and consistently identify and execute all control functions, assuming qualified and trained pilots.

2.6.3 Controls can be made distinguishable or predictable by differences in attributes such as form, color, location, and labeling. For example, buttons, which are pushed, should be readily discernable from knobs, which are rotated. Control shapes easily determined with tactile senses can improve ease of operation, particularly during periods when pilot tasks require significant visual attention.

2.6.4 If color is used for coding task-essential information, use at least one other distinctive coding parameter (e.g., size, shape, label). Whenever possible, color coding should be consistent across all controls and displays. Consider the effect of flightdeck lighting on the appearance of the label, and the use of colors throughout the flightdeck (i.e., color philosophy).

2.7 Labeling of Controls.

2.7.1 <u>General.</u>

2.7.1.1 Each item of installed equipment related to the flightcrew interface must be labelled, if applicable, as to its identification, function, or operating limitations, or any combination of these factors (§ 23.2605(a)).

2.7.1.2 Control labels must be visible, legible, and understandable for the population of pilots using the controls, per § 2X.1555(a).

2.7.1.3 Unless the control function and method of operation are obvious or indicated through other means (e.g., form, location), the control labeling scheme should clearly and unambiguously convey:

2.7.1.3.1 The current function performed by each control, and

2.7.1.3.2 The method for actuating the control when performing the current function.

2.7.1.4 Indicate a control's function in a manner that is readily discernable from the current state. For example, a button labeled "Track Up" should not represent the current display orientation of "Heading Up," but should instead change the display orientation to "Track Up" when selected.

2.7.1.5 Size control labels so that they are easily legible from the pilot's normally seated position. SAE International, (SAE) Aerospace Standard (ARP) 4102/7, *Electronic Displays*, dated July 2007 provides guidelines on font sizes that are generally acceptable.

2.7.1.6 Ensure labels resist scratching, hazing, erasure, disfigurement, and other legibility degradation that might result from normal use.

2.7.1.7 Use terms, icons, or abbreviations recommended in applicable FAA policy, or wording acceptable to the FAA.

2.7.1.8 Use only one abbreviation and/or one icon for labeling a function. This is to prevent confusion when a label appears in multiple locations.

2.7.1.9 Labels can be full text (e.g., "Standby"), abbreviated text (e.g., "STBY"), acronyms (e.g., "AGL" for "Above Ground Level"), as well as icons.

2.7.2 Icons.

For controls using icons in lieu of text labeling, substantiate that pilots with the minimum expected training program can adequately perform their duties at an acceptable level of workload, as required by normal, non-normal, and emergency situations. While a limited number of control functions might have icons associated with them that pilots would likely know, many control functions have no universally accepted icons.

2.7.3 If appropriate, consider incorporating icons in controls to complement rather than replace text labels (e.g., continuous text display, temporary "mouseover" display).

2.7.4 Controls for the same function.

2.7.4.1 If multiple controls exist for the same function, clearly label all such controls. Exceptions can include alternate controls that provide flexibility to accommodate a wide range of pilots. For example, experienced users might choose less-intuitive methods to gain a performance advantage such as speed. Double-clicking or push-and-hold are examples generally not recommended as a sole method of operation but may be acceptable as a secondary method for advanced users. Show that multiple controls for the same function are acceptable, and do not result in confusion or inadvertent operation.

2.7.4.2 If multiple controls exist (multi-crew aircraft) for the same function, show there is sufficient information or other means available to make each crewmember aware of which control is currently functioning.

2.7.5 Non-functioning controls.

2.7.5.1 Avionics manufacturers are designing systems with the intent of creating one system that can be used in many models of aircraft with many different configurations. However, when installed these non-customizable avionics may have control functions that are not integrated into the system but are still labeled with the intended function.

2.7.5.2 If permanently installed controls in the flightdeck are purposely non-functioning controls, the label Inoperative (INOP) is non-compliant to 14 CFR 2X.1301, 2X.1555(a), and 23.2610(b). The use of INOP label is not suitable for showing compliance to parts 23, 25, 27, and 29 due to implications under § 91.213.

2.7.5.3 Acceptable means of compliance for non-functional controls are: 1) amend the type design to remove the non-functional control, thereby removing the non-compliance, 2) remove the label and replace the non-functional control with a blank plate or cap over the control, and 3) for knobs, add a stop to the knob, so pilots can only select the functional areas or markings, and remove the corresponding label.

2.7.6 Multifunction Control Labeling.

Labels for multifunction controls introduce different challenges for both conventional (mechanical) and software generated controls. For example, a flightdeck cursor control device may include wheels, push buttons, or multifunction rotary knobs to control various functions. Unless the function of these controls is obvious to the pilot, § 2X.1555 requires the controls to be labeled.

- As with all controls, pilots should be able to quickly and accurately identify the function and understand the method of operation of a control.
- Ensure pop-up text that describes a control's function does not result in unacceptable distractions, interference, or clutter.
- If a control activates several different functions based on sequential commands or selections, clearly label each of the functions.

2.8 Control Lighting.

2.8.1 For controls with visual markings intended for use in low-light conditions, the markings must be lighted in some way allowing them to be easily read, for compliance with § 2X.1555(a) and § 2X.1381(a). This lighting might be from an external source or from an internal source (e.g., backlighting or luminous controls). Controls should be visible over a wide range of ambient light conditions.

2.8.2 Ensure lighting of controls is consistent with flightcrew alerting such as warning, caution, and advisory lights (§ 2X.1322).

2.8.3 For low-light conditions, make lighted controls dimmable to brightness levels commensurate with other flightdeck instrument lighting. This allows for the flightcrew's adaptation to the dark, so controls are legible, and maintains outside vision.

2.8.4 Ensure lighting of controls from an internal source is not dimmable to brightness levels so low that the controls appear inactive.

2.8.5 Ensure lighting of controls from an internal source does not produce light leaks, bright spots, or reflections from the windshield that can interfere with pilot's vision or performance.

2.8.6 You may use automatic adjustment of lighted controls. Consider preference differences in multi-crew operations.

2.8.7 Ensure lighted controls intended for operation in a night vision imaging system (NVIS) lighting-modified cockpit meets 2.8.1 through 2.8.6 and are compatible with night vision goggles (NVG). See the following for additional guidance:

- AC 27.1B, *Certification of Normal Category Rotorcraft*, dated September 30, 1999, refers to miscellaneous guidance (MG) 16.
- AC 29.2C, *Certification of Transport Category Rotorcraft*, dated September 30, 1999 MG 16.
- RTCA, Inc. (RTCA) document (DO) RTCA/DO-275, *Minimum Operating Performance Standards for Integrated Night Imaging System Equipment*, dated October 12, 2001.

2.8.8 NVIS lighting must allow color transmission to meet aircraft certification regulations (e.g., §§ 2X.1381, 2X.1555). For controls that do not need color discrimination, NVIS A lighting can be used. For controls where color discrimination is needed, then NVIS lighting must (§ 2X.1555) allow the pilot to easily discern the required colors (typically accomplished using NVIS white). Make perceived color for reds, yellows (or ambers), and greens the same across the cockpit.

2.9 Emergency Controls.

2.9.1 Emergency controls should be distinguishable from non-emergency controls in the flightdeck.

2.9.2 For compliance with §§ 27.1555(d)(2), 29.1555(d)(2), and historic 23.1555(e)(2), each emergency control must be red and must be marked as to method of operation.

2.9.3 For part 25, an emergency control (including fuel jettisoning and fluid shutoff control) that incorporates alerting features may be considered a part of the aircraft-alerting scheme; therefore, it should meet the applicable guidance within AC 25.1322-1 *Flightcrew Alerting*. For added clarification, if showing compliance with § 25.1555(d)(1), the emergency control must be colored red or illuminate red when a condition that necessitates its use is identified by the appropriate airplane system. The emergency control shall be readily identifiable under all lighting conditions and under no conditions be misinterpreted for the illumination of any other control.

- The reliability and integrity of providing the alert must meet the safety objectives of the applicable system safety standards, such as §§ 25.901(c) and 25.1309(b). The associated system function or airplane function for which the alert is provided must also meet the safety objectives.
- The system safety assessment should account for the full system installation, including the sensing or failure detection system, the emergency control, the emergency control illumination, and function of the system. Refer to the latest version of AC 25.1309-1B, *System Design and Analysis*, dated August 30, 2024, for further guidance on system safety assessments.

- To comply with § 25.1555(d)(1), an emergency control should have safeguards that allow it to be used when needed but otherwise prevent unintentional actuation. See 2.10 for methods to mitigate inadvertent operation for controls.

2.10 Preventing Inadvertent Operation of Controls.

2.10.1 Inadvertent operation of controls can occur for various reasons, such as when a pilot accidentally bumps a control, or actuates one control when intending to actuate a different control. This section discusses methods to mitigate inadvertent operation for both physical and software-based controls.

2.10.2 Questions.

2.10.2.1 Provide mitigation for inadvertent operation as appropriate. Consider these questions when designing and installing the control:

- Are there any safety-critical consequences if the pilot is not aware of the inadvertent operation?
- What will the pilot need to do to correct an inadvertent operation?
- Is the control designed to support "eyes free" use (i.e., when the pilot is not looking at the control)?
- Are there aspects of the design that will decrease the likelihood of inadvertent operation?
- Are there aspects of the design that will increase the likelihood of the pilot detecting an inadvertent operation?

2.10.3 Methods.

2.10.3.1 The following paragraphs provide multiple methods that reduce the likelihood of inadvertent operation of controls.

2.10.3.2 Location and Orientation. Section 2X.777 requires controls to be located to prevent inadvertent operation. Locate, space, and orient controls so the operator is not likely to strike or move them accidentally in the normal sequence of control movements. For example, switches located close to a frequently used lever could be oriented so the axis of rotation for the switches is perpendicular to the axis of rotation for the lever.

2.10.3.3 Physical Protection. Physical obstructions can be built into the design of a control to prevent accidental actuation of the control. Examples include recessed controls, shielded controls, flip-covers, and guards. Make physical protections so they do not interfere with the visibility or operation of the protected device or adjacent controls. Physical protections should be appropriately durable to ensure continued airworthiness.

2.10.3.4 Slippage Resistance. The physical design and materials used for controls can reduce the likelihood of finger and hand slippage (especially in the presence of vibration). For example, buttons can be designed with concave, textured, or tacky upper surfaces to prevent finger slippage.

2.10.3.5 Hand Stabilization. Provide hand rests, armrests, or other physical structures as a stabilization point for the pilot's hands and fingers when they are operating a control. This can be particularly useful for controls used in the presence of turbulence and other vibration, helping the pilot make inputs that are more precise.

2.10.3.6 Logical Protection. Software-based controls and software-related controls may be disabled at times when actuation of the control would be considered inappropriate, based on logic within the software. Make disabled (inactive) controls clearly discernable from active controls.

2.10.3.7 Complex Movements. The method of operation for a control can be designed so that complex movement is required to actuate it. For example, a rotary knob can be designed so that it can only be turned when it is also being pulled out. Double-click or push-and-hold methods are not recommended methods of protection.

2.10.3.8 Tactile Cues. The surfaces of different controls can have different shapes and textures, supporting the pilot in distinguishing different controls when operating in a dark or otherwise "eyes free" environment. For example, most keyboards have a small ridge on the "J" and "F" keys, cuing the user to the proper placement of their index fingers. Similarly, §§ 25.781 and historic 23.781 require specific shapes for certain cockpit controls.

2.10.3.9 Locked/Interlocked Controls. Locking mechanisms, interlocks, or the prior operation of a related control can prevent inadvertent operation. For example, a separate on/off control can activate/deactivate a critical control or physically lock it in place.

2.10.3.10 Sequential Movements. Controls can be designed with locks, detents, or other mechanisms to prevent the control from passing directly through a sequence of movements. This method is useful when strict sequential actuation is necessary.

2.10.3.11 Motion Resistance. Controls can be designed with resistance (e.g., friction, spring, inertia) so deliberate effort is required for actuation. When this method is employed, the level of resistance should not exceed the minimum physical strength capabilities for the intended pilot population.

2.10.4 Any method of protecting control from inadvertent operation should not preclude operation within the required pilot task time or interfere with the normal operation of the system. If a control is inadvertently operated, multisensory information can assist pilots in detecting the error. Feedback can include one or more auditory cues, tactile cues, or visual cues. Generally, the greater the consequence of an unintended operation, the greater the prevention method needed, and the more salient the cues that should be provided for detection.

2.10.5 Multifunction control considerations.

2.10.6 Multifunction controls may need different types of mitigations to prevent inadvertent operation. For example, the use of a touch screen as a means of control may not provide motion resistance, tactile feedback, or physical protection against inadvertent operation. The following paragraphs provide additional methods that may be applicable to multifunction controls.

2.10.6.1 Controls should clearly indicate which areas of the electronic display are active for control functionality. Active areas should be sized and organized to permit accurate selection. Moving a finger or cursor to the intended active area should not inadvertently operate other active areas.

2.10.6.2 A confirmation step may be provided before activating a function, where appropriate, such as for safety critical functions. For example, when an approach has been activated in a flight management system (FMS), and the pilot changes the selected approach, the system might ask, "Are you sure you want to discontinue the current approach?" Consider the tradeoff between the need for confirmation steps and the increase in pilot workload.

2.10.6.3 For controls functions that are accessible from multiple display pages or menus, place controls in a consistent display location, when appropriate. Inconsistent placement can disrupt pilot usage habits and lead to errors.

2.10.6.4 Provide a means to reverse an incorrect activation or input, when appropriate. An example means is an "undo" or similar simple reversionary functionality in the system.

2.11 Controls for Data Entry.

2.11.1 Numerous flightdeck tasks require some form of data entry, such as entering the airport code or radio frequency. Some controls lead pilots to enter data through compact devices (e.g., knobs that scroll through the alphabet), which might result in increased workload and head-down time. Controls for data entry must support the pilot when entering required data to support the intended function, per §§ 2X.1301 and 23.2500. Show the controls are acceptable for data entry speed, accuracy, error rates, and workload.

2.11.2 If data entry involves multiple steps, make sure each step is clearly discernable. For example, pilots should be aware that the first step is to construct a string of multiple characters, and the second step is to enter the string into the system.

2.11.3 During data construction, ensure automatically constructed data is clearly discernable from manually constructed data. Regardless of how the data was constructed, the system should allow pilots to readily determine the data entered the system.

2.11.4 Data entry controls should allow pilots to easily recover from typical input errors, such as a simple keyboard error or an incorrect auto fill.

2.11.5 Previously approved controls for data entry have used physical configurations and design features based on the following:

- Letter keys arranged in a QWERTY format (preferred) or alphabetically.
- Numeric keypads arranged in a 3x3 matrix with zero (0) at the bottom.
- Concentric knob assemblies containing no more than two knobs per assembly.
- Cursors automatically placed in the first data entry field.
- Data entry fields are large enough to show all of the entered data without scrolling.
- Partitioning of long data items into shorter sections for both data entry and feedback.

2.12 Continued Airworthiness.

2.12.1 Sections 25.1529, 27.1529, 29.1529, and appendix A to part 23 require instructions for continued airworthiness of equipment. Include any limitations or considerations for the conditions in which controls are operated, replaced, or serviced. For example:

- How should controls be serviced to ensure continued compliance with § 2X.671, requiring easy, smooth, positive operation?
- Will controls need cleaning from skin oils and perspiration, for labels to be legible?
- What type of interference may impede safe operation?
- Is the control susceptible to failure if exposed to liquids (e.g., spilled coffee or soda)?
- What maintenance or inspection should be conducted over a given time interval?

2.12.2 Design controls to minimize degradation (e.g., scratching, hazing) from operational use.

2.12.3 Define a reasonable maintenance and inspection interval for each control, along with verification tests that are conducted at each interval in the instructions for continued operational safety (COS).

CHAPTER 3. CONTROL SYSTEMS AND DEVICES

3.1 General.

3.1.1 This chapter provides additional guidance for control systems and devices. Topics include multifunction controls, cursor control devices (CCDs), touch screens, menus and navigation, and speech recognition. The guidance discussed in chapter 2 also applies to the control systems and devices in chapter 3.

3.2 Multifunction Controls.

3.2.1 When using electronic displays as a means of control, multifunction controls can be reconfigured by the system software (soft controls) creating flexible interfaces that are not possible with dedicated knobs, switches, and physical hardware. However, this space-saving advantage may lead to increased task time and workload if pilots have to navigate through multiple electronic pages or menu layers to access functions. What once required a simple button push at an easily memorized location might now require a sequence of multiple steps needing visual attention.

3.2.2 If a multifunction control replaces the function of a conventional control, make a comparison between the two to determine if replacement results in changes in performance and safety, relative to well-understood devices.

3.2.3 Show that multifunction controls do not result in unacceptable levels of workload, error rates, speed, and accuracy.

3.3 Cursor Control Devices (CCDs).

3.3.1 A CCD is a multifunction control that provides a means for pilots to indirectly access controls on electronic displays. Pilots use the CCD to position the display cursor on selectable areas or “soft controls” of the displays. Typical CCDs include mouse systems, trackballs, touch pads, and joysticks.

3.3.2 A key benefit of CCDs is their convenience; they are typically located on or close to the pilots' natural hand position and are often accompanied by a hand stabilizer or arm rest. This allows for convenient pilot inputs, particularly since hand and arm motion is minimized due to high device gain. However, CCDs can also lead to control errors, particularly when subject to vibration environments. Additionally, CCD inputs are more likely to go unnoticed by other crew members because pilot inputs are typically accomplished with small finger motions on the CCD. Consider effects on flightcrew coordination in the environment and use conditions of CCDs.

3.3.3 Ensure the cursor symbol is readily located on the displays and readily discernable from other information. This is particularly important if a cursor symbol is allowed to fade from a display. Some methods to enhance quick location of the cursor are “blooming” or “growing” it to attract the flightcrew’s attention.

3.3.4 If more than one cursor is used on a display system, provide a means to distinguish between the cursors.

3.3.5 Do not allow the cursor symbol to creep or move without pilot input. Exceptions can include automatic cursor positioning, if it can be shown it does not result in pilot confusion or unacceptable task completion time.

3.3.6 Restrict the cursor symbol from areas of flight critical information, so it does not interfere with legibility. If a cursor symbol enters a critical display information field, show that the cursor presence is acceptable.

3.3.7 In multi-crew aircraft, most applications will allow more than one flightcrew member to use one cursor. Establish an acceptable method for handling simultaneous “dueling cursors” that is compatible with the overall flightdeck philosophy. Establish acceptable methods for other possible scenarios, including the use of two cursors by two pilots.

3.4 Touch Screens.

3.4.1 In aviation, touch screens utilize different technologies, such as resistive, capacitive, and infrared types. The specific technology affects performance and failures and is therefore important to consider. For example, not all technologies support multi-touch. Thus, applicants should include the operating limitations for the touch system in their certification plans.

3.4.2 Touch screens can be susceptible to control errors in part because the electronic displays (on which pilot inputs occur) are typically smooth and flat. Their surface offers little tactile feedback for determining finger position and motion, which can result in a greater need for visual attention. Therefore, integrate an associated support for stabilizing the pilot's hand.

3.4.3 Ensure touch screens do not result in unacceptable levels of workload, error rates, and task execution times.

3.4.4 Ensure touch screens resist scratching, hazing, or other damage that can occur through normal use. Demonstrate the system will continue to provide acceptable performance after long-term use and exposure to skin oils, perspiration, environmental elements (e.g., sun), impacts (e.g., clipboard), chemical cleaners used in the flightdeck, and any liquids brought onboard by flightcrew members (e.g., tea or coffee). See example testing in SAE ARP60494, Section 6, Operational Considerations for Hardware.

3.4.5 If a touch screen’s calibration can drift or degrade, provide touch screen calibration procedures and other maintenance-related items to ensure proper calibration and operation. Include these procedures in the instructions for continued airworthiness, per § 2X.1529 and appendix A of current part 23.

3.4.6 Refer to SAE ARP60494 Touch Interactive Display Systems: Human Factors Considerations, System Design and Performance Guidelines, Section 3, System Design and Implementation Recommendations and Section 4, Human Machine Interface Considerations, dated October 2001 for more information.

3.4.7 Single and Multi-Touch

3.4.7.1 Single touch systems respond to touch screen inputs from a single digit. Multi-touch systems allow gestures, input from more than one digit, and use software that recognizes multiple, simultaneous touch points as opposed to a single touch. The location of the pilot's finger touch, as sensed by the touch screen, should be predictable and obvious.

3.4.7.2 If a single touch system experiences two or more touch inputs, the system's behavior must be predictable and unambiguous. See § 25.1302 and European Union Aviation Safety Agency (EASA) CS 25.1302, 27.1302 and 29.1302.

3.4.7.3 When possible, limit the gesture set to gestures requiring one or two digits. Research has shown that pilots prefer gestures using one or two digits, because the gestures were easier to remember and perform.

3.4.7.4 When choosing gestures, consider the effects of hand dexterity, turbulence, and vibrations on the pilot's ability to successfully perform the gestures.

3.4.7.5 Avoid gestures requiring wrist rotation or more than 2 digits, as these gestures have greater potential to obscure touch targets and flightdeck display information.

3.4.7.6 Limit the set of gestures that can interact with the touch screen. For example, a typical set of gestures might include gestures requiring one finger (tap, double tap, long press, drag/pan, select and drag), as well as the two finger gestures (swipe, pinch, and spread).

3.4.7.7 See SAE ARP60494, Section 5, *Touch Interaction Functions*, for a discussion of common gestures used with touch screens.

3.5 Menus and Navigation.

3.5.1 In menus, the layering of information should not hinder the pilot in identifying the location of the desired control. Location and accessibility are not only related to the physical location of the control function. They also include consideration of where the control functions are located within various menu layers, and how the pilot navigates through those layers to access functions.

3.5.2 For menu-based controls, ensure that the number and complexity of steps required to access and utilize a control is appropriate to the intended use of the control (e.g., frequently used controls and emergency controls should be available at top-level menus). The number of sub-menus should be designed to ensure timely access to the desired option without over-reliance on memorization of the menu structure.

3.5.3 Flightdeck controls must be located and identified to provide convenient operation and to prevent confusion, per § 2X.777(a). Layer control information in menus or hidden pages so it does not hinder the flightcrew in identifying the location of the desired control.

3.5.4 Fit top-level control menu pages (e.g., primary or "home" page) entirely on the display (i.e., do not require scrolling).

3.5.5 Make top-level control menus readily accessible. This is typically accomplished by continuously displaying the menu or menu access control in a fixed location (e.g., "home" page).

3.5.6 Provide feedback from page navigation that is an unambiguous indication of the current location.

3.6 Speech Controls – Speech Recognition.

3.6.1 Speech recognition systems, also known as Automatic Speech Recognition (ASR) or voice activated systems, provide a means for the pilot to control aircraft systems or equipment using oral commands. These systems use speech commands to duplicate actions that would normally require manual controls.

3.6.2 In aviation, speech recognition systems may be particularly useful for reducing head down time, for selecting tasks, and for manipulating data when the pilot's hands and eyes are busy (e.g., single pilot rotorcraft operations). However, past projects in rotorcraft have only allowed these systems to control non-required functions or functions that have a low safety impact. Additionally, the incorporation of speech recognition systems may increase the level of concentration needed to perform various tasks, particularly if commands are rejected or incorrectly recognized.

3.6.3 Section 2X.771(a) states that each pilot compartment and its equipment must allow each pilot to perform their duties without unreasonable concentration or fatigue. Similarly, § 23.2600(a) states that the pilot must be able to perform his or her duties without excessive concentration, skill, alertness, or fatigue. The potential for these systems to affect pilot concentration and fatigue makes it necessary to thoroughly evaluate their use in the performance of tasks in the flightdeck.

3.6.4 Speech recognition systems are not always accurate. Pilot characteristics, such as gender, voice frequency range, and regional accents, will affect the accuracy of the system. Moreover, operator stress, fatigue, and physical exertion can also affect speech recognition system accuracy.

3.6.5 Metrics

3.6.5.1 Two of the most common performance metrics for speech recognition systems are recognition accuracy and command success, also known as command accuracy.

- Recognition accuracy is defined as the number of words successfully recognized by the system. Normally, when manufacturers of speech recognition systems refer to the "accuracy" of their products, they are referring to recognition accuracy.
- Command success is defined as the number of speech commands correctly recognized, and successfully acted upon by the system. When testing control usability, the command success rating is the more useful metric. For example, a speech recognition system may have a 93% accuracy rating, but only a 65% command success rating. The two metrics are not equivalent.

3.6.5.2 A low command success rating would limit the use in aircraft to less critical functions. Also, due to workload and task demands of operating an aircraft, pilots do not have time to repeat inputs or actions. Systems that do not function well in an aircraft environment may create additional hazards as pilots attempt to perform inputs while ignoring other aircraft tasks.

3.6.6 Manual control of the speech recognition functions should be available and should take precedence over speech commands. Speech should not be the sole means of control.

3.6.7 Speech recognition systems should consistently and accurately recognize and properly input speech commands from pilots under expected flight and ambient aircraft noise conditions.

3.6.8 Feedback to the pilot should be clear and unambiguous. The pilot should quickly and accurately recognize when the system is active, and if the system has correctly recognized and acted upon the pilot's instructions.

3.6.9 Pilots should be able to quickly identify and correct errors.

3.6.10 If a push-to-command button is used for speech command inputs, the button should be distinguishable. Depending on the location, pilots may confuse the push-to-talk button for radio communications, with the push-to-command button.

3.6.11 Command vocabulary

3.6.11.1 When creating a command vocabulary, select words that are natural, familiar, and relevant to the pilots' tasks.

3.6.11.2 Avoid memory items. The system's commands should be designed so the pilot is able to readily recall the desired command.

3.6.11.3 Avoid similar sounding words like LIST and LISTEN that may be misinterpreted by the system.

3.7 Multimodal Controls

3.7.1 In this AC, a multimodal control is a flightdeck control that provides the pilot with the ability to interact with avionics using multiple modes of inputs, such as a CCD, speech command, or touch screen. An example of multimodal controls is a pilot using a mouse to select and display a map, and then using a speech command to select the desired map range. A possible benefit of multimodal controls is redundancy. If the first mode fails (e.g., speech command), the pilot still has alternate mode options, such as using a physical switch, trackball, or a touch screen interface.

3.7.2 For certain tasks in the flightdeck, some modalities have better performance than others. For example, a speech command may excel when pilots are searching for a function from a buried menu, while touch may excel when pilots interact with maps.

3.7.3 Pilots should be able to easily switch between different control modalities.

3.7.4 For dual-crew aircraft, the design of feedback for multimodal input is critical. Ensure that the flightdeck crew (i.e., pilot flying, pilot monitoring, and tactical flight officer/rotorcraft) can observe the outcome of multimodal control inputs.

CHAPTER 4. EMERGING AIRCRAFT

4.1 General.

4.1.1 Emerging aircraft, such as powered-lift or electric vertical takeoff and landing (eVTOL) aircraft often possess unique designs, flight, and handling characteristics. These design elements result in new flight decks and new handling characteristics that may differ from traditional airplanes and helicopters. The certification basis for most of these aircraft falls under 21.17b special class. However, on July 18, 2025, the FAA published new guidance for powered-lift aircraft in AC 21.17-4 *Type Certification—Powered-lift*. The AC establishes a more efficient path in designating the type certification basis for certain powered-lift projects. Additionally, although these aircraft are new, the human factors considerations in this AC are also applicable to the flightdeck controls. Some of these considerations and recommended practices include:

4.1.1.1 Design philosophy: Document and follow a design philosophy. For controls, include a high-level description of controls features, such as labeling, feedback, automated behavior, and error recovery. Also, include descriptions of human performance considerations, such as flightcrew workload, error potential, and expected training requirements. A design philosophy will improve consistency and usability.

4.1.1.2 Pilot characteristics: Design the controls to provide acceptable performance for a broad range of pilots (e.g., body size, reach, etc.). Additionally, consider pilot physical limitations for control motion and placement. Controls designed to operate in optimal ranges of motion for wrists, shoulders, and necks, help to reduce fatigue and muscle disorders.

<u>Movement of controls</u>: The interaction between a control and its related elements (e.g., aircraft systems, displays, indications, and labels) should be readily apparent, understandable, logical, and consistent with applicable cultural conventions and with similar controls in the same flightdeck. Each pilot will bring their knowledge, skills, and expectations to a new aircraft, and some of their expectations may conflict with the proposed control operations. The guidance for powered-lift in AC 21.17-4, appendix A, sections PL.2300(a)(1) and PL.2600 includes motion criteria and states that control system designs must operate easily and smoothly, and the pilots must be able to perform their duties without excessive concentration, skill, alertness, or fatigue. **NOTE:** Applicants can find additional guidance in Appendix C, table C-2 that lists HF-related regulations for airplanes certificated using part 23 (amdt. 64 or higher), and for rotorcraft certificated using part 27, in AC 27-1B, *Certification of Normal Category Rotorcraft, Miscellaneous Guidance (MG) 20 Human Factors.*

APPENDIX A. RELATED DOCUMENTS AND ACRONYMS

A.1 REFERENCES.

A.1.1 If there is guidance in other ACs for specific aircraft categories (parts 23, 25, 27 and 29), equipment, and systems, that specific guidance has precedence if a conflict exists with the guidance provided in this AC.

A.1.2 The guidance in this AC does not address the topics listed in paragraph 1.1.3.

A.2 ACRONYMS

- AC Advisory circular
- AGL Above ground level
- ARP Aerospace Recommended Practice
- ASR Automatic speech recognition
- CCD Cursor control device
- CFR Code of Federal Regulations
- COS Continued operational safety
- DO Document
- DOT Department of Transportation
- EASA European Union Aviation Safety Agency
- eVTOL Electric vertical takeoff and landing
- FAA Federal Aviation Administration
- FMS Flight management system
- HF Human Factors
- MG Miscellaneous guidance
- NVG Night vision goggles
- NVIS Night vision imaging system
- RTCA RTCA Inc.
- RTCA/DO RTCA Inc. Document
- SAE SAE International
- STBY Standby

A.2.1 FAA Links.

- Human Factors in Aviation Safety (AVS)
- Part 23 Accepted Means of Compliance
- Aircraft Certification Product Issues Lists | Federal Aviation Administration

APPENDIX B. CONTROL FUNCTION MATRIX

B.1 INTRODUCTION.

This appendix provides a brief description and an example of a "control-function matrix". It is not required for compliance, but can be helpful as a method for organizing and sharing data with the FAA.

A control-function matrix primarily maps control devices (e.g., knob) to control functions (e.g., change radio frequency). The matrix also provides for an organization of controls-related attributes, such as those addressed in this AC. It is a tool sometimes used by applicants to organize their design and compliance effort.

B.2 TABLE B-1.

Table B-1 provides an example template of a control-function matrix. The columns in table B-1 are described as follows:

B.3.1 <u>Control:</u> List each control separately in the table. Include traditional dedicated controls (e.g., knobs) and multifunction controls (e.g., software menus, touch-screen buttons) in the list.

B.3.2 <u>Function Description Section:</u> Group information that describes a function performed by a control in the matrix. In the table B-1 example, the function, criticality, frequency of use, and operational conditions are addressed.

1. Function: Identify and describe the function provided by the control. Each function provided by a control is listed next to the name of the control. If a control provides multiple functions, list each function on a separate row, since the supplemental information may be quite different for each function.
2. Criticality for Safety: This column provides relevant information about the criticality of a function from a system safety analysis. Criticality information can be helpful when considering implications associated with the possible inadvertent operation of a control (e.g., critical controls may need additional degrees of protection against inadvertent operation).
3. Expected Frequency of Use: This column describes the function's frequency of activation, deactivation or manipulation. Frequency information can be helpful when considering the level of familiarity the pilot can be expected to have with a control relative to its accessibility and complexity of operation (e.g., frequently used controls that are at the edge of a pilot's reach envelope may not be compliant with 14 CFR 2X.777).
4. Operational and Use Conditions: This column describes any operational use conditions impacting the use of the control for that

particular function. Operational and use conditions include those described in this AC, as well as flight phase. The information therefore establishes context in which the controls will be operated (e.g., functions regularly performed during final approach and landing might need to employ a very simple method of operation to be compliant with 14 CFR 2X.771) and the acceptability of other features of the control's design.

B.3.3 Design Description Section: Group information describing the physical design of the control and its associated elements into the matrix. The table B-1 example groups information about methods of operation, labels, protection against inadvertent actuation, feedback from control actuation, and location of the control when installed.

1. Method of Operation: Describe the method of operation for a function. A control providing multiple functions could have the same method of operation for different functions, or it could have different methods of operation for different functions. If a method of operation is difficult to describe in this matrix, it might also be difficult to perform for the pilot.
2. Label: State the label associated with a function and method of operation. This information is useful to ensure all functions are labeled and there is no inappropriate use of the same label for different functions, or different labels for identical functions. If no label is provided, make an assessment to ensure the control is "obvious."
3. Protection from Inadvertent Operation: This column captures descriptions of any design features that will prevent or reduce the likelihood of inadvertent operation of a function. This information might support compliance with § 2X.777, requiring protection against inadvertent operation of controls.
4. Feedback: This column captures information regarding feedback to the pilot during or following operation of a control.
5. Location/Association: This column captures a description of the location of the control when installed. This information can be useful for understanding, for example, functional groupings and control-displays association.

B.3.4 Other Information Section: There may be several additional categories of information relevant to a function, the design of a control, factors influencing the design decision process for the control, or the process of showing compliance. Table B-1 uses a listing of related controls for each function, and a picture of the control.

Table B-1. Example for Control-Function Matrix

Control	Design Requirement	Function Description				Design Description					Other Information	
		Function	Criticality for Safety	Expected Frequency of Use	Operational and Use Conditions	Method of Operation	Label	Protection from Inadvertent Operation	Feedback	Location/ Association	Related Controls	Picture(s) of Control
[Name of Control, or Reference # in Diagram]		[Name and Brief Description of Function #1]	[e.g., Catastrophic Function, OR Major Function, OR Minor Function]	[e.g., Multiple times per flight , OR Once per flight , OR Occasional use, OR Rarely used]	[e.g., Control will be used during high workload phase of flight, in cold weather, in high vibration conditions]	[Description of pilot actions required to perform Function #1]	[Text of Label; or "None"]	[Description of design features that prevent inadvertent operation, or "None"]	[Description of visual, aural, tactile, or other cues provided to indicate successful or unsuccessful operation of the control]	[Position of control relative to the pilot upon installation] (e.g., using a flightdeck Zone reference)	[List of Names or Reference #'s for other Controls associated with Function #1]	
		[Name and Brief Description of Function #2]	[e.g., Catastrophic Function, OR Major Function, OR Minor Function]	[e.g., Multiple times per flight , OR Once per flight , OR Occasional use, OR Rarely used]	[e.g., Control will be used during high workload phase of flight, in cold weather, in high vibration conditions]	[Description of pilot actions required to perform Function #2]	[Text of Label; or "None"]	[Description of design features that prevent inadvertent operation, or "None"]	[Description of visual, aural, tactile, or other cues provided to indicate successful or unsuccessful operation of the control]	[Position of control relative to the pilot upon installation] (e.g., using a flightdeck Zone reference)	[List of Names or Reference #'s for other Controls associated with Function #2]	

APPENDIX C. REGULATIONS

Table C-1 provides a quick reference to some 14 CFR regulations addressing controls. While many other regulations also apply to flightdeck controls, as determined by the applicant's regulatory basis, the regulations in table C-1 are strongly related to human factors and have been subject to interpretation during aircraft certification projects. Some parts may have multiple regulations to address a certain aspect. Table C-2 lists part 23 (amdt. 64 or higher) regulations related to HF. These are listed separately because there is no longer a one-to-one correspondence with parts 25, 27, and 29. Finally, table C-3 lists additional regulations cited in the AC.

Table C-1. Quick Reference to Human Factors Related Regulations for Controls

Key Aspects of Regulation from a Human Factors Perspective Note: In some cases, wording may be paraphrased for clarity. Consult regulations for exact wording.	**14 CFR Parts 25, 27, 29, & Historic Part 23 (Amdt. 63 or lower)**
Each control must operate with ease, smoothness, and positiveness appropriate to its function.	25.671(a), 27.671(a), 29.671(a), 23.671(a)
Controls must be located to provide for convenient operation.	25.777(a), 27.777(a), 29.777(a), 23.671(b), 23.777(a)
Controls must be located to prevent the possibility of confusion and subsequent inadvertent operation {*29.771(b) only*: from either pilot position}.	25.777(a), 27.777(a), 29.771(b), 29.777(a), 23.671(b), 23.777(a)
The pilot compartment must allow the pilot to perform his/her duties without unreasonable concentration or fatigue.	25.771(a), 27.771(a), 29.771(a), 23.771(a)
The aircraft must be controllable with equal safety from either pilot seat.	25.771(c), 27.771(b), 29.771(b)
Vibration and noise characteristics of cockpit equipment may not interfere with safe operation of the aircraft.	25.771(e), 27.771(c), 29.771(c)
Controls must be identified (except where the function is obvious).	23.777(a)
Controls must be located and arranged, with respect to the pilot seat, to provide full and unrestricted movement of each control without interference.	25.777(c), 27.777(b),29.777(b), 23.777(b)
A control must be of a kind and design appropriate to its intended function.	25.1301(a), 27.1301(a), 29.1301(a), 23.1301(a)
Controls must function properly when installed.	27.1301(d), 29.1301(d)

Key Aspects of Regulation from a Human Factors Perspective Note: In some cases, wording may be paraphrased for clarity. Consult regulations for exact wording.	**14 CFR Parts 25, 27, 29, & Historic Part 23 (Amdt. 63 or lower)**
Flightdeck controls must be accessible and usable by the flightcrew. Information must be provided to the flightcrew in a clear and unambiguous manner. Installed systems and equipment must behave in a predictable and unambiguous manner. The installed equipment must incorporate a means to allow the flightcrew to manage errors.	25.1302*
Equipment, systems, and installations must be designed to perform their intended functions.	25.1309(a)(b)(c), 27.1309(a)(b)(c), 29.1309(a)(b)(c)(d)(4), 23.1309(a)(b)
Each flight, navigation, and powerplant instrument for use by the pilot must be easily visible to the pilot {part 27 stops here} from their station, with minimum practicable deviation from their normal position and line of vision when looking forward along the flight path. Group controls around the vertical plane of the pilot's forward vision.	25.1321(a)(b), 27.1321(a)(b), 29.1321(a)(b)
Visual alert indications must conform to the following color convention: red for warning alert indications, amber or yellow for caution alert indications, and any color except red or green for advisory alert indications.	25.1322(e)(1), (f)
Warning, caution, and advisory lights must be red for warning, amber for caution, and green for safe operation.	27.1322(a)(b)(c), 29.1322, (a)(b)(c) 23.1322(a) thru (e)
Instrument lights must make each instrument and control easily readable and discernable.	23.1381(a)
Instrument lights must make each instrument, switch, and other devices easily readable.	25.1381(a)(1), 27.1381(a), 29.1381(a)
Instrument lights must be installed so that no objectionable reflections are visible to the pilot.	25.1381(a)(2)(ii), 27.1381(b)(2), 29.1381(b)(2)
The minimum flightcrew must be able to access and easily operate controls required for safe operation.	25.1523, 27.1523, 29.1523, 23.1523
A cockpit control must be plainly marked as to its function and method of operation.	25.1555(a), 27.1555(a), 29.1555(a), 23.1555(a)

*Applicants should be aware that EASA has certification specifications (CSs) and acceptable means of compliance (AMCs) for rotorcraft: CS 27.1302 /AMC 27.1302 and CS 29.1302/ AMC 29.1302.

Table C-2. Part 23 HF-Related Regulations for Controls

14 CFR Part 23, Amendment 64 or higher	
Topic	**Section**
Flight control systems	23.2300
Automatic power or thrust control systems	23.2405 (c)(d)
Powerplant installation hazard assessment	23.2410 (c)
Powerplant operational characteristics	23.2425 (b)
Fuel systems	23.2430 (a)(4)
Airplane level systems requirements	23.2500
Function and installation	23.2505
Equipment, systems, and installations	23.2510
External and cockpit lighting	23.2530 (a)
Flightcrew interface	23.2600
Installation and operation	23.2605
Instrument markings, control markings, and placards	23.2610
Flight, navigation, and powerplant instruments	23.2615
Airplane flight manual	23.2620

Table C-3. Additional Cited Regulations

General Topic	Section
Cockpit control knob shape	25.781
Instructions for continued airworthiness	25.1529. 27.1529, 29.1529

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