

This sub-paragraph is included because new technology enables new kinds of flight crew interfaces that previous requirements don't address. Specific deficiencies of existing requirements in addressing human factors are described below:

- [CS 25.771\(a\)](#) addresses this topic for controls, but does not include criteria for information presentation.
- [CS 25.777\(a\)](#) addresses controls, but only their location.
- [CS 25.777\(b\)](#) and [CS 25.779](#) address direction of motion and actuation but do not encompass new types of controls such as cursor devices. These requirements also do not encompass types of control interfaces that can be incorporated into displays via menus, for example, thus affecting their accessibility.
- [CS 25.1523](#) and CS-25 Appendix D have a different context and purpose (determining minimum crew), so they do not address these requirements in a sufficiently general way.

[CS 25.1302\(c\)](#) requires that installed equipment be designed so its behaviour that is operationally relevant to flight crew' tasks is:

- Predictable and unambiguous.
- Designed to enable the flight crew to intervene in a manner appropriate to the task (and intended function).

Improved flight deck technologies involving integrated and complex information and control systems, have increased safety and performance. However, they have also introduced the need to ensure proper interaction between the flight crew and those systems. Service experience has found that some equipment behaviour (especially from automated systems) is excessively complex or dependent upon logical states or mode transitions that are not well understood or expected by the flight crew. Such design characteristics can confuse the flight crew and have been determined to contribute to incidents and accidents.

The phrase “operationally-relevant behaviour” is meant to convey the net effect of the equipment’s system logic, controls, and displayed information upon flight crew awareness or perception of the system’s operation to the extent that this is necessary for planning actions or operating the system. The intent is to distinguish such system behaviour from the functional logic within the system design, much of which the flight crew does not know or need to know and which should be transparent to them.

[CS 25.1302\(c\)\(1\)](#) requires that system behaviour be such that a qualified flight crew can know what the system is doing and why. It requires that operationally relevant system behaviour be “predictable and unambiguous”. This means that a crew can retain enough information about what their action or a changing situation will cause the system to do under foreseeable circumstances, that they can operate the system safely. System behaviour must be unambiguous because crew actions may have different effects on the aeroplane depending on its current state or operational circumstances.

[CS 25.1302\(c\)\(2\)](#) requires that the design be such that the flight crew will be able to take some action, or change or alter an input to the system in a manner appropriate to the task.

[CS 25.1302\(d\)](#) addresses the reality that even well-trained, proficient flight crews using well-designed systems will make errors. It requires that equipment be designed to enable the flight crew to manage such errors. For the purpose of this rule, errors “resulting from

flight crew interaction with the equipment” are those errors in some way attributable to, or related to, design of the controls, behaviour of the equipment, or the information presented. Examples of designs or information that could cause errors are indications and controls that are complex and inconsistent with each other or other systems on the flight deck. Another example is a procedure inconsistent with the design of the equipment. Such errors are considered to be within the scope of this requirement and AMC.

What is meant by design which enables the flight crew to “manage errors” is that:

- The flight crew must be able to detect and/or recover from errors resulting from their interaction with the equipment, or
- Effects of such flight crew errors on the aeroplane functions or capabilities must be evident to the flight crew and continued safe flight and landing must be possible, or
- Flight crew errors must be discouraged by switch guards, interlocks, confirmation actions, or other effective means, or
- Effects of errors must be precluded by system logic or redundant, robust, or fault tolerant system design.

The requirement to manage errors applies to those errors that can be reasonably expected in service from qualified and trained flight crews. The term “reasonably expected in service” means errors that have occurred in service with similar or comparable equipment. It also means error that can be projected to occur based on general experience and knowledge of human performance capabilities and limitations related to use of the type of controls, information, or system logic being assessed.

[CS 25.1302\(d\)](#) includes the following statement: “This sub-paragraph does not apply to skill-related errors associated with manual control of the aeroplane”. That statement means to exclude errors resulting from flight crew proficiency in control of flight path and attitude with the primary roll, pitch, yaw and thrust controls, and which are related to design of the flight control systems. These issues are considered to be adequately addressed by existing requirements, such as CS-25 Subpart B and [CS 25.671\(a\)](#). It is not intended that design be required to compensate for deficiencies in flight crew training or experience. This assumes at least the minimum flight crew requirements for the intended operation, as discussed at the beginning of Paragraph 5.1 above.

This requirement is intended to exclude management of errors resulting from decisions, acts, or omissions by the flight crew that are not in good faith. It is intended to avoid imposing requirements on the design to accommodate errors committed with malicious or purely contrary intent. [CS 25.1302](#) is not intended to require applicants to consider errors resulting from acts of violence or threats of violence.

This “good faith” exclusion is also intended to avoid imposing requirements on design to accommodate errors due to obvious disregard for safety by a flight-crew member. However, it is recognised that errors committed intentionally may still be in good faith but could be influenced by design characteristics under certain circumstances. An example would be a poorly designed procedure not compatible with the controls or information provided to the flight crew.

The intent of requiring errors to be manageable only “to the extent practicable” is to address both economic and operational practicability. It is meant to avoid imposing requirements without considering economic feasibility and commensurate safety benefits. It is also meant to address operational practicability, such as the need to avoid

introducing error management features into the design that would inappropriately impede flight crew actions or decisions in normal or non-normal conditions. For example, it is not intended to require so many guards or interlocks on the means to shut down an engine that the flight crew would be unable to do this reliably within the available time. Similarly, it is not intended to reduce the authority or means for the flight crew to intervene or carry out an action when it is their responsibility to do so using their best judgment in good faith.

This sub-paragraph was included because managing errors that result from flight crew interaction with equipment (that can be reasonably expected in service), is an important safety objective. Even though the scope of applicability of this material is limited to errors for which there is a contribution from or relationship to design, [CS 25.1302\(d\)](#) is expected to result in design changes that will contribute to safety. One example, among others, would be the use of an "undo" functions in certain designs.

## 5.2 Intended Function and Associated Flight Crew Tasks

[CS 25.1301\(a\)](#) requires that: “each item of installed equipment must - (a) Be of a kind and design appropriate to its intended function”. [CS 25.1302](#) establishes requirements to ensure the design supports flight-crew member’s ability to perform tasks associated with a system’s intended function. In order to show compliance with [CS 25.1302](#), the intended function of a system and the tasks expected of the flight crew must be known.

An applicant’s statement of intended function must be sufficiently specific and detailed that the Agency can evaluate whether the system is appropriate for the intended function(s) and the associated flight crew tasks. For example, a statement that a new display system is intended to “enhance situation awareness” must be further explained. A wide variety of different displays enhance situation awareness in different ways. Examples are; terrain awareness, vertical profile, and even the primary flight displays). The applicant may need more detailed descriptions for designs with greater levels of novelty, complexity or integration.

An applicant should describe intended function(s) and associated task(s) for:

- Each item of flight deck equipment,
- Flight crew indications and controls for that equipment,
- Individual features or functions of that equipment.

This type of information is of the level typically provided in a pilot handbook or an operations manual. It would describe indications, controls, and flight crew procedures.

As discussed in paragraph 4, novel features may require more detail, while previously approved systems and features typically require less. Paragraph 4.1 discusses functions that are sufficiently novel that additional scrutiny is required. Applicants may evaluate whether statements of intended function(s) and associated task(s) are sufficiently specific and detailed by using the following questions:

- Does each feature and function have a stated intent?
- Are flight crew tasks associated with the function described?
- What assessments, decisions, and actions are flight-crew members expected to make based on information provided by the system?
- What other information is assumed to be used in combination with the system?

- Will installation or use of the system interfere with the ability of the flight crew to operate other flight deck systems?
- Are there any assumptions made about the operational environment in which the equipment will be used?
- What assumptions are made about flight crew attributes or abilities beyond those required in regulations governing flight operations, training, or qualification?

### 5.3 Controls

#### 5.3.1 Introduction

For purposes of this AMC, we define controls as devices the flight crew manipulates in order to operate, configure, and manage the aeroplane and its flight control surfaces, systems, and other equipment. This may include equipment in the flight deck such as;

- Buttons
- Switches
- Knobs
- Keyboards
- Keypads
- Touch screens
- Cursor control devices
- Graphical user interfaces, such as pop-up windows and pull-down menus that provide control functions
- Voice activated controls

#### 5.3.2 Showing Compliance with [CS 25.1302\(b\)](#)

Applicants should propose means of compliance to show that controls in the proposed design comply with [CS 25.1302\(b\)](#). The proposed means should be sufficiently detailed to demonstrate that each function, method of control operation, and result of control actuation complies with the requirements, i.e.:

- Clear
- Unambiguous
- Appropriate in resolution and precision
- Accessible
- Usable
- Enables flight crew awareness (provides adequate feedback)

For each of these requirements, the proposed means of compliance should include consideration of the following control characteristics for each control individually and in relation to other controls:

- Physical location of the control
- Physical characteristics of the control (e.g., shape, dimensions, surface texture, range of motion, colour)

- Equipment or system(s) that the control directly affects
- How the control is labelled
- Available control settings
- Effect of each possible actuation or setting, as a function of initial control setting or other conditions
- Whether there are other controls that can produce the same effect (or affect the same target parameter) and conditions under which this will happen
- Location and nature of control actuation feedback

The following discussion provides additional guidance for design of controls that comply with [CS 25.1302](#). It also provides industry accepted best practices.

### 5.3.3 Clear and Unambiguous Presentation of Control Related Information

#### a. Distinguishable and Predictable Controls [[CS 25.1301\(a\)](#), [CS 25.1302](#)]

Each flight-crew member should be able to identify and select the current function of the control with speed and accuracy appropriate to the task. Function of a control should be readily apparent so that little or no familiarisation is required. The applicant should evaluate consequences of control activation to show they are predictable and obvious to each flight-crew member. This includes control of multiple displays with a single device and shared display areas that flight-crew members access with individual controls. Controls can be made distinguishable or predictable by differences in form, colour, location, and/or labelling. Colour coding is usually not sufficient as a sole distinguishing feature. This applies to physical controls as well as to controls that are part of an interactive graphical user interface.

#### b. Labelling [[CS 25.1301\(a\)](#), [CS 25.1543\(b\)](#), [CS 25.1555\(a\)](#)]

For general marking of controls see [CS 25.1555\(a\)](#). Labels should be readable from the crewmember's normally seated position in all lighting and environmental conditions. If a control performs more than one function, labelling should include all intended functions unless function of the control is obvious. Labels of graphical controls accessed by a cursor device such as a trackball should be included on the graphical display. When menus lead to additional choices (submenus), the menu label should provide a reasonable description of the next submenu.

The applicant can label with text or icons. Text and icons should be shown to be distinct and meaningful for the function that they label. The applicant should use standard and/or non-ambiguous abbreviations, nomenclature, or icons, consistent within a function and across the flight deck. ICAO 8400 provides standard abbreviations and is an acceptable basis for selection of labels.

The design should avoid hidden functions (such as clicking on empty space on a display to make something happen). However, such hidden functions may be acceptable if adequate alternate means are available for accessing the function. The design should still be evaluated for ease of use and crew understanding.

When using icons instead of text labelling, the applicant should show that the flight crew requires only brief exposure to the icon to determine the function of a control and how it operates. Based on design experience, the following guidelines for icons have been shown to lead to usable designs:

- The icon should be analogous to the object it represents
- The icon should be in general use in aviation and well known to flight crews
- The icon should be based on established standards, when they exist, and conventional meanings.

In all cases, the applicant should show use of icons to be at least equivalent to text labels in terms of speed and error rate. Alternatively, the applicant should show that the increased error rate or task times have no unacceptable effect on safety or flight crew workload and do not cause flight crew confusion.

c. **Interaction of Multiple Controls** [[CS 25.1302](#)]

If multiple controls for the flight crew are provided for a function, the applicant should show that there is sufficient information to make the flight crew aware of which control is currently functioning. As an example, crewmembers need to know which flight-crew member's input has priority when two cursor control devices can access the same display. Designers should use caution when dual controls can affect the same parameter simultaneously.

**5.3.4 Accessibility of controls** [[CS 25.771\(a\)](#), [CS 25.777\(b\)](#), [CS 25.1302](#)]

The applicant must show that each flight-crew member in the minimum flight crew, as defined by CS 25.1523, has access to and can operate all necessary controls. Accessibility is one factor in determining whether controls support the intended function of equipment used by the flight crew. Any control required for flight-crew member operation in the event of incapacitation of other flight-crew members (in both normal and non-normal conditions) must be shown to be viewable, reachable, and operable by flight-crew members with the stature specified in [CS 25.777\(c\)](#), from the seated position with shoulder restraints on. If shoulder restraints are lockable, this may be shown with shoulder restraints unlocked.

[CS 25.777\(c\)](#) requires that the location and arrangement of each flight deck control permit full and unrestricted movement of that control without interference from other controls, equipment, or structure in the flight deck.

Layering of information, as with menus or multiple displays, should not hinder flight crew in identifying the location of the desired control. In this context, location and accessibility are not only the physical location of the control function (on a display device) or any multifunction control (for example,, a cursor control device) used to access them. Location and accessibility also includes consideration of where the control functions may be located within various menu layers and how the flight-crew member navigates those layers to access the functions. Accessibility should be shown in conditions of system failures (including crew incapacitation) and minimum equipment list dispatch.

Control position and direction of motion should be oriented from the vantage point of the flight-crew member. Control/display compatibility should be maintained from that regard. For example, a control on an overhead panel requires movement of the flight-crew member's head backwards and orientation of the control movement should take this into consideration.

### 5.3.5 Use of controls

- a. Environmental issues affecting controls [[CS 25.1301\(a\)](#) and [CS 25.1302](#)]

Turbulence or vibration and extremes in lighting levels should not prevent the crew from performing all their tasks at an acceptable level of performance and workload. If use of gloves is anticipated for cold weather operations, the design should account for the effect of their use on the size and precision of controls. Sensitivity of controls should afford precision sufficient to perform tasks even in adverse environments as defined for the aeroplane's operational envelope. Analysis of environmental issues as a means of compliance (see 6.3.3) is necessary, but not sufficient for new control types or technologies or for novel use of controls that are themselves not new or novel.

The applicant should show that controls required to regain aeroplane or system control and controls required to continue operating the aeroplane in a safe manner are usable in conditions such as dense smoke in the flight deck or severe vibrations. An example of the latter condition would be after a fan blade loss.

- b. Control-display compatibility [[CS 25.777\(b\)](#)]

To ensure that a control is unambiguous, the relationship and interaction between a control and its associated display or indications should be readily apparent, understandable, and logical. A control input is often required in response to information on a display or to change a parameter setting on a display. The applicant should specifically assess any rotary knob that has no obvious "increase" or "decrease" function with regard to flight crew expectations and its consistency with other controls on the flight deck. The Society of Automotive Engineers' (SAE) publication ARP 4102, section 5.3, is an acceptable means of compliance for controls used in flight deck equipment.

When a control is used to move an actuator through its range of travel, the equipment should provide, within the time required for the relevant task, operationally significant feedback of the actuator's position within its range. Examples of information that could appear relative to an actuator's range of travel include trim system positions, target speed, and the state of various systems valves.

Controls associated with a display should be located so that they do not interfere with the performance of the crew task. Controls whose function is specific to a particular display surface should be mounted near to the display or function being controlled. Locating controls immediately below a display is generally preferable as mounting controls immediately above a display has, in many cases, caused the flight-crew member's hand to obscure viewing of the display when operating controls. However, controls on the bezel of multifunction displays have been found to be acceptable.

Spatial separation between a control and its display may be necessary. This is the case with a system's control located with others for that same system, or when it is one of several controls on a panel dedicated to controls for that multifunction display. When there is large spatial separation between a control and its associated display, the applicant should show that use of the control for the associated task(s), is acceptable in terms of types of errors, error rate(s) and access time(s).

In general, control design and placement should avoid the possibility that the visibility of information could be blocked. If range of control movement temporarily blocks the flight crew's view of information, the applicant should show that this information is either not necessary at that time or available in another accessible location.

Annunciations/labels on electronic displays should be identical to labels on related switches and buttons located elsewhere on the flight deck. If display labels are not identical to related controls, the applicant should show that flight-crew members can quickly, easily, and accurately identify associated controls.

#### 5.3.6 Adequacy of Feedback [[CS 25.771\(a\)](#), [CS 25.1301\(a\)](#), [CS 25.1302](#)]

Feedback for control inputs is necessary to give the flight crew awareness of the effects of their actions. Each control should provide feedback to the crewmember for menu selections, data entries, control actions, or other inputs. There should be clear and unambiguous indication when crew input is not accepted or followed by the system. This feedback can be visual, auditory, or tactile. Feedback, in whatever form, should be provided to inform the crew that:

- A control has been activated (commanded state/value)
- The function is in process (given an extended processing time)
- The action associated with the control has been initiated (actual state/value if different from the commanded state).

The type, duration and appropriateness of feedback, will depend upon the crew's task and the specific information required for successful operation. As an example, switch position alone is insufficient feedback if awareness of actual system response or the state of the system as a result of an action is required.

Controls that may be used while the user is looking outside or at unrelated displays should provide tactile feedback. Keypads should provide tactile feedback for any key depression. In cases when this is omitted, it should be replaced with appropriate visual or other feedback that the system has received the inputs and is responding as expected.

Equipment should provide appropriate visual feedback, not only for knob, switch, and pushbutton position, but also for graphical control methods such as pull-down menus and pop-up windows. The user interacting with a graphical control should receive positive indication that a hierarchical menu item has been selected, a graphical button has been activated, or other input has been accepted.

The applicant should show that feedback in all forms is obvious and unambiguous to the flight crew in performance of the tasks associated with the intended function of the equipment.

## 5.4 Presentation of Information

### 5.4.1 Introduction

Applicants should propose means of compliance to show that information displayed in the proposed design complies with [CS 25.1302\(b\)](#). The proposed means should be sufficiently detailed to show that the function, method of control operation and result, complies with the requirements, i.e.:

- Clear
- Unambiguous
- Appropriate in resolution and precision
- Accessible
- Usable
- Enables Flight Crew awareness (provides adequate feedback)

Presentation of information to the flight crew can be visual (for instance, on an LCD), auditory (a “talking” checklist) or tactile (for example, control feel). Information presentation on the integrated flight deck, regardless of the medium used, should meet all of the requirements bulleted above. For visual displays, this AMC addresses mainly display format issues and not display hardware characteristics. The following provides design considerations for requirements found in [CS 25.1301\(a\)](#), [CS 25.1301\(b\)](#), [CS 25.1302](#), and [CS 25.1543\(b\)](#). In the event of a conflict between this document and AMC 25-11 regarding guidance on specific electronic visual display functions, AMC 25-11 takes precedence.

### 5.4.2 Clear and Unambiguous Presentation of Information

#### a. Qualitative and quantitative display formats [[CS 25.1301\(a\)](#) and [CS 25.1302](#)]

Applicants should show that display formats include the type of information the flight crew needs for the task, specifically with regard to the speed and precision of reading required. For example, the information could be in the form of a text message, numerical value, or a graphical representation of state or rate information). State information identifies the specific value of a parameter at a particular time. Rate information indicates the rate of change of that parameter.

If the flight crew’s sole means of detecting non-normal values is by monitoring values presented on the display, the equipment should offer qualitative display formats. Qualitative display formats better convey rate and trend information. If this is not practical, the applicant should show that the flight crew can perform the tasks for which the information is used. Quantitative presentation of information is better for tasks requiring precise values.

Digital readouts or present value indices incorporated into qualitative displays should not make the scale markings or graduations unusable as they pass the present value index.

#### b. Consistency [[CS 25.1302](#)]

If similar information is presented in multiple locations or modes (visual and auditory, for example), consistent presentation of information is desirable. Consistency in information presentation within the system tends to minimise flight crew error. If information cannot be presented consistently within the flight deck,

the applicant should show that differences do not increase error rates or task times leading to significant safety or flight crew workload and do not cause flight crew confusion.

c. Characters, fonts, lines and scale markings [[CS 25.1301\(a\)](#) and [CS 25.1543\(b\)](#)]

The applicable crew members, seated at their stations and using normal head movement, should be able to see and read display format features such as fonts, symbols, icons and markings. In some cases, cross flight deck readability may be required. Examples of situations where this might be needed are cases of display failure or when cross checking flight instruments. Readability must be maintained in sunlight viewing conditions (per CS 25.773(a)) and under other adverse conditions such as vibration. Figures and letters should subtend not less than the visual angles defined in SAE ARP 4102-7 at the design eye position of the flight-crew member who normally uses the information.

d. Colour [[CS 25.1302](#)]

Avoid using many different colours to convey meaning on displays. However, judicious use of colour can be very effective in minimising display interpretation workload and response time. Colour can be used to group logical electronic display functions or data types. A common colour philosophy across the flight deck is desirable, although deviations may be approved with acceptable justification. Applicants should show that the chosen colour set is not susceptible to confusion or misinterpretation due to differences in colour usage between displays. Improper colour coding increases response times for display item recognition and selection, and increases likelihood of errors in situations where the speed of performing a task is more important than accuracy. Extensive use of the colours red and amber for other than alerting functions or potentially unsafe conditions is discouraged. Such use diminishes the attention-getting characteristics of true warnings and cautions.

Use of colour as the sole means of presenting information is also discouraged. It may be acceptable however, to indicate the criticality of the information in relation to the task. Colour, when used for task essential information, should be in addition to other coding characteristics, such as texture or differences in luminance. [AMC 25-11](#) contains recommended colour sets for specific display features.

Applicants should show that layering information on a display does not add to confusion and clutter as a result of the colour standards and symbols used. Designs requiring flight-crew members to manually de-clutter such displays should also be avoided.

e. Symbology, Text, and Auditory Messages [[CS 25.1302](#)]

Designs can base many elements of electronic display formats on established standards and conventional meanings. For example, ICAO 8400 provides abbreviations and is one standard that could be applied to flight deck text. SAE ARP 4102-7, Appendix A-C and SAE ARP 5289 are acceptable standards for avionic display symbols.

The position of a message or symbol within a display also conveys meaning to the flight-crew member. Without the consistent or repeatable location of a symbol in a specific area of the electronic display, interpretation errors and response times may increase. Applicants should give careful attention to symbol priority (priority