(4) Arrangement - Powerplant Information

(a) Required engine indications necessary to set and monitor engine thrust or power should be continuously displayed in the flight crew's primary field of view, unless the applicant can demonstrate that this is not necessary (see the guidance in paragraph 36c(3) of this chapter and Appendix 2 of this AMC). The automatically selected display of powerplant information should not suppress other information that requires flight crew awareness.

(b) Powerplant information must be closely grouped (in accordance with § 25.1321) in an easily identifiable and logical arrangement which allows the flight crew to clearly and quickly identify the displayed information and associate it with the corresponding engine. Typically, it is considered to be acceptable to arrange parameters related to one powerplant in a vertical manner and, according to powerplant position, next to the parameters related to another powerplant in such a way that identical powerplant parameters are horizontally aligned. Generally, place parameter indications in order of importance with the most important one at the top. Typically, the top indication is the primary thrust setting parameter.

(5) Arrangement - Other Information (For Example, Glideslope and Multi-Function Displays)

(a) Glideslope or glidepath deviation scales should be located to the right side of the primary attitude indication. If glideslope deviation data is presented on both an electronic horizontal situation indicator and an electronic attitude direction indicator, the information should appear in the same relative location on each indicator.

(b) When the glideslope pointer is being driven by a RNAV (area navigation) system with VNAV (vertical navigation) or ILS (instrument landing system) look-alike functionality, the pointer should not be marked "GS" or "glideslope."

(c) Navigation, weather, and vertical situation display informationis often displayed on multi-function displays. This information may be displayed on one or more physical electronic displays, or on several areas of one larger display. When this information is not required to be displayed continuously, it can be displayed part-time, but the displayed information should be easily recoverable to the flight crew when needed. For guidance on part-time displays see paragraph 36c(3) of this chapter.

(d) Other information should not be located where the primary flight information or required powerplant information is normally presented. See paragraphs 36b(1) and 36b(3) of this chapter for primary flight information guidance. See paragraphs 21e(10) and 36b(4) of this AMC for powerplant information guidance.

c. Managing Display Information. The following paragraphs address managing and integrating the display of information throughout the flight deck. This includes the use of windows to present information and the use of menus to manage the display of information.

(1) Window. A window is a defined area which can be present on one or more physical displays. A window that contains a set of related information is commonly referred

to as a format. Multiple windows may be presented on one physical display surface and may have different sizes. Guidelines for sharing information on a display, using separate windows, are as follows:

— The window(s) should have fixed size(s) and location(s).

— Separation between information elements within and across windows should be sufficient to allow the flight crew to readily distinguish separate functions or functional groups (for example, powerplant indication) and avoid any distractions or unintended interaction.

— Display of selectable information, such as a window on a display area, should not interfere with or affect the use of primary flight information.

— For additional information regarding the display of data on a given location, data blending, and data over-writing (see Aeronautical Radio, Inc (ARINC) Standard 661-5, Cockpit Display System Interfaces to User Systems).

(2) Menu

(a) A menu is a displayed list of items from which the flight crew can choose. Menus include drop-down and scrolling menus, line select keys on a multi-function display, and flight management system menu trees. An option is one of the selectable items in a menu. Selection is the action a user makes in choosing a menu option, and may be done by pointing (with a cursor control device or other mechanism), entering an associated option code, or activating a function key.

(b) The hierarchical structure and organisation of the menus should be designed to allow the flight crew to sequentially step through the available menus or options in a logical way that supports their tasks. The options provided on any particular menu should be logically related to each other. Menus should be displayed in consistent locations, either a fixed location or a consistent relative location, so that the flight crew knows where to find them. At all times the system should indicate the current position within the menu and menu hierarchy.

(c) The number of sub-menus should be designed to assure timely access to the desired option without over-reliance on memorisation of the menu structure. The presentation of items on the menu should allow clear distinction between items that select other menus and items that are the final selection.

(d) The number of steps required to choose the desired option should be consistent with the frequency, importance, and urgency of the flight crew's task.

(e) Whena menu is displayed it should not obscure required information.

(3) Full-time vs. Part-time Display of Information.Some aeroplane parameters or status indications are required to be displayed by the specifications (for example, powerplant information required by CS 25.1305), yet they may only be necessary or required in certain phases of flight. If it is desired to inhibit some parameters from full-time display, a usability level and functionality equivalent to a full-time display should be demonstrated.

(a) When determining if information on a display can be part-time, consider the following criteria:

— Continuous display of the parameter is not required for safety of flight in all normal flight phases.

— The parameter is automatically displayed in flight phases where it is required, when its value indicates an abnormal condition, or when it would be relevant information during a failure condition.

— Display of the inhibited parameter can be manually selected by the flight crew without interfering with the display of other required information.

— If the parameter fails to be displayed when required, the failure effect and compounding effects must meet the specifications of all applicable specifications (for example, CS 25.1309).

— The automatic or requested display of the inhibited parameter should not create unacceptable clutter on the display. Also, simultaneous multiple "pop-ups" should not create unacceptable clutter on the display.

— If the presence of a new parameter is not sufficiently self-evident, suitable alerting or other annunciations should accompany the automatic presentation of the parameter.

(b) Pop-up Display of Information

1 Certain types of information, such as terrain and TCAS, are required by operating rules to be displayed, yet they are only necessary or required in certain phases of flight (similar to the part-time display of required aeroplane parameters, (see paragraph 36b(3) of this chapter)) or under specific conditions. One method commonly employed to display this information is called “automatic pop-up.” Automatic pop-ups may be in the form of an overlay, such as a TCAS overlay on the moving map, or in a separate window as a part of a display format. Pop-up window locations should not obscure required information.

2 Consider the following criteria for displaying automatic pop-up information:

— Information is automatically displayed when its value indicates a predetermined condition, or when the associated parameter reaches a predetermined value.

— Pop-up information should appropriately attract the flight crew’s attention while minimising task disruption.

— If the flight crew deselects the display of the automatic pop-up information, then another automatic pop-up should not occur until a new condition/event causes it.

— If an automatic pop-up condition is activated and the system is in the wrong configuration or mode to display the information, and the system configuration cannot be automatically changed,

then an annunciation should be displayed in the colour associated with the nature of the alert, prompting the flight crew to make the necessary changes for the display of the information. This guidance differs from the part-time display of information required by CS-25 because the required information should be displayed regardless of the configuration.

— If a pop-up(s) or simultaneous multiple pop-ups occur and obscure information, it should be shown that the obscured information is not relevant or necessary for the current flight crew task. Additionally, the pop-ups should not cause a misleading presentation.

— If more than one automatic pop-up occurs simultaneously on one display area, for example a terrain and TCAS pop-up, then the system should prioritise the pop-up events based on their criticality. Pop-up display orientation should be in track-up or heading-up.

— Any information to a given system that is not continuously displayed, but the safety assessment determines it is necessary to be presented to the flight crew, should automatically pop-up or otherwise indicate that its display is required.

d. Managing Display Configuration. The following paragraphs address managing the information presented by an electronic display system and its response to failure conditions and flight crew selections. The following paragraphs also provide guidance on the acceptability of display formats and their required physical location on the flight deck, both during normal flight and in failure modes. Manual and automatic system reconfiguration and source switching are also addressed.

(1) Normal Conditions. In normal conditions (that is, non-failure conditions) there may be a number of possible display configurations that may be selected manually or automatically. All possible display configurations available to the flight crew should be designed and evaluated for arrangement, visibility, and interference.

(2) System Failure Conditions (Reconfiguration). The following paragraphs provide guidance on manual and automatic display system reconfiguration in response to display system failures. Arrangement and visibility specifications also apply in failure conditions. Alternative display locations used in non-normal conditions should be evaluated by the Agency to determine if the alternative locations meet the criteria for acceptability.

(a) Moving display formats to different display locations on the flight deck or using redundant display paths to drive display information is acceptable to meet availability and integrity specifications.

(b) In an instrument panel configuration with a display unit for primary flight information positioned above a display unit for navigation information, it is acceptable to move the primary flight information to the lower display unit if the upper display unit fails.

(c) In an instrument panel configuration with a display unit for primary flight information positioned next to a display unit for navigation information, it is

acceptable to move the primary flight information to the display unit directly adjacent to it if the preferred display unit fails. It is also acceptable to switch the navigation information to a centrally located auxiliary display (multi-function display).

(d) If several possibilities exist for relocating the failed display, a recommended flight crew procedure should be considered and documented in the aeroplane flight manual.

(e) It is acceptable to have manual or automatic switching capability (automatic switching is preferred) in case of system failure; however, CS 25.1333(b) requires that the equipment, systems, and installations must be designed so that sufficient information is available to assure control of the aeroplane's airspeed, altitude, heading, and attitude by one of the pilots without additional flight crew action, after any single failure or combination of failures that is not assessed to be extremely improbable.

(f) The following means to reconfigure the displayed information are acceptable:

— Display unit reconfiguration. Moving a display format to a different location (for example, moving the primary flight information to the adjacent display unit) or the use of a compacted format may be acceptable.

— Source/graphic generator reconfiguration. The reconfiguration of graphic generator sources either manually or automatically to accommodate a failure may be acceptable. In the case where both the captain and first officer's displays are driven by a single graphic generator source, there should be clear, cautionary alerting to the flight crew that the displayed information is from a single graphic generator source.

— In certain flight phases, manual reconfiguration may not satisfy the need for the pilot controlling the aeroplane to recover primary flight information without delay. Automatic reconfiguration might be necessary to ensure the timely availability of information that requires immediate flight crew member action.

— When automatic reconfiguration occurs (for example, display transfer), it should not adversely affect the performance of the flight crew and should not result in any trajectory deviation.

— When the display reconfiguration results in the switching of sources or display paths that is not annunciated and is not obvious to the flight crew, care should be taken that the flight crew is aware of the actual status of the systems when necessary, depending on flight deck philosophy.

e. Methods of Reconfiguration

(1) Compacted Format

(a) The term "compacted format," as used in this AMC, refers to a reversionary display mode where selected display components of a multi-display configuration are combined in a single display format to provide higher priority information following a display failure. The “compacted format” may be automatically selected in case of a primary display failure, or it may be manually (automatic selection preferred) selected by the flight crew. Except for training purposes, the “compacted format” should not be selectable unless there is a display failure. The concepts and specifications of CS 25.1321, as discussed in paragraph 36(b)(3) of this chapter, still apply.

(b) The compacted display format should maintain the same display attributes (colour, symbol location, etc.) and include the same required information, as the primary formats it is replacing. The compacted format should ensure the proper operation of all the display functions it presents, including annunciation of navigation and guidance modes, if present. However, due to size constraints and to avoid clutter, it may be necessary to reduce the amount of display functions on the compacted format. For example, in some cases, the use of numeric readouts in place of graphical scales has been found to be acceptable. Failure flags and mode annunciations should, wherever possible, be displayed in a location common with the normal format.

(2) Sensor Selection and Annunciation

(a) Automatic switching of sensor data to the display system should be considered, especially with highly integrated display systems to address those cases where multiple failure conditions may occur at the same time and require immediate flight crew action. Manual switching may be acceptable.

(b) Independent attitude, direction, and air data sources are required for the captain and first officer’s displays of primary flight information (see CS 25.1333). If sources can be switched such that the captain and first officer are provided with single sensor information, each of them should receive a clear annunciation indicating the vulnerability to misleading information.

(c) If sensor information sources cannot be switched, then no annunciation is required.

(d) There should be a means of determining the source of the displayed navigation information and the active navigation mode. For approach operations the source of the displayed navigation information and the active navigation mode should be available on the primary flight display or immediately adjacent to the primary flight display.

(e) The selected source should be annunciated if multiple or different types of navigation sources (flight management system, instrument landing system, GNSS (global navigation satellite system) landing system, etc.) can be selected (manually or automatically).

(f) An alert should be given when the information presented to the flight crew is no longer meeting the required integrity level, in particular when there is a single sensor or loss of independence.

37. – 40. [RESERVED]

**CHAPTER 7 ELECTRONIC DISPLAY SYSTEM CONTROL DEVICES**

41. General. Each electronic display system control device has characteristics unique to its operation that need to be considered when designing the functions the display system controls, and the redundancy provided during failure modes. Despite the amount of redundancy that may be available to achieve a given task, the flight deck should still present a consistent user interface scheme for the primary displays and a compatible, if not consistent, user interface scheme for auxiliary displays throughout the flight deck.

a. Multi-function Control Labels. Multi-function controls should be labelled such that the pilot is able to:

— Rapidly, accurately, and consistently identify and select all functions of the control device.

— Quickly and reliably identify what item on the display is “active” as a result of cursor positioning, as well as what function will be performed if the item is selected using the selector buttons and/or changed using the multi-function control.

— Determine quickly and accurately the function of the control without extensive training or experience.

b. Multi-function Controls. The installation guidelines below apply to control input devices that are dedicated to operating a specific function (for example, control knobs and wheels), as well as new control features (for example, a cursor control device (CCD)).

(1) “Hard” Controls

(a) Mechanical controlsused to set numeric data on a display should have adequate friction or tactile detents to allow a flight crew without extensive training or experience to set values (for example, setting an out-of-view heading bug to a displayed number) to a required level of accuracy within a time appropriate to the task.

(b) The input for display response gain to control should be optimised for gross motion as well as fine positioning tasks without overshoots. In accordance with CS 25.777(b), the direction of movement of the cockpit controls must meet the specifications of CS 25.779. Wherever practicable, the sense of motion involved in the operation of other controls must correspond to the sense of the effect of the operation on the aeroplane or on the part operated. Controls of a variable nature using a rotary motion must move clockwise from the off position, through an increasing range, to the full on position.

(2) “Soft” Controls

(a) There are two interactive types of soft control displays, one type affects aeroplane systems and the other type does not. Displays that utilize a graphical user interface (GUI) permit information within different display areas to be directly manipulated by the flight crew (for example, changing

range, scrolling crew alert messages or electronic checklists, configuring windows, or layering information.) This level of display interaction affects only the presentation of display information and has a minimal effect on flight deck operations. The other level of display interaction provides a GUI to control aeroplane system operations (for example, utility controls on displays traditionally found in overhead panel functions, FMS operations, and graphical flight planning).

(b) The design of display systems that will be used as soft controls is dependent on the functions they control. Consider the following guidelines when designing these display systems:

1 The GUI and control device should be compatible with the aeroplane system they will control. The hardware and software design assurance levels and tests for the GUI and control device should be commensurate with the level of criticality of the aeroplane system they will control.

2 Redundant methods of controlling the system may lessen the criticality required of the display control. Particular attention should be paid to the interdependence of display controls (that is, vulnerability to common mode failures), and to the combined effects of the loss of control of multiple systems and functions.

3 The applicant should demonstrate that the failure of any display control does not unacceptably disrupt operation of the aeroplane (that is the allocation of flight crew member tasks) in normal, non-normal, and emergency conditions.

4 To show compliance with CS 25.777(a) and CS 25.1523, the applicant should show that the flight crew can conveniently access required and backup control functions in all expected flight scenarios, without impairing aeroplane control, flight crew task performance, and flight crew resource management.

5 Control system latency and gains can be important in the acceptability of a display control. Usability testing should therefore accurately replicate the latency and control gains that will be present in the actual aeroplane.

6 The final display response to control input should be fast enough to prevent undue concentration being required when the flight crew sets values or display parameters CS 25.771(a)). The initial indication of a response to a soft control input should take no longer than 250 milliseconds. If the initial response to a control input is not the same as the final expected response, a means of indicating the status of the pilot input should be made available to the flight crew.

7 To show compliance with CS 25.771(e) the applicant should show by test and/or demonstration in representative motion environment(s) (for example, turbulence) that the display control is acceptable for controlling all functions that the flight crew may access during these conditions.

c. Cursor Control Devices

When the input device controls cursor activity on a display, it is called a cursor control device (CCD). The CCDs are used to position display cursors on selectable areas of the displays. These selectable areas are “soft controls” intended to perform the same functions as mechanical switches or other controls on conventional control panels. Typically, CCDs control several functions and are the means for directly selecting display elements. When designing CCDs, in addition to the guidance provided in paragraphs 41a, 41b, and 41d of this chapter, consider the guidance in the following paragraphs, which address design considerations unique to CCDs.

(1) The CCD design and installation should enable the flight crew to operate the CCD without exceptional skill during foreseeable flight conditions, both normal and adverse (for example, turbulence and vibrations). Certain selection techniques, such as double or triple clicks, should be avoided.

(2) The safety assessment should address reversion to alternate means of control following loss of the CCD. This includes an assessment on the impact of the failure on flight crew workload.

(3) The functionality of the CCD should be demonstrated with respect to the flight crew interface considerations outlined below:

(a) The ability of the flight crew to share tasks, following CCD failure, with appropriate workload and efficiency.

(b) The ability of the flight crew to use the CCD with accuracy and speed of selection required of the related tasks, under foreseeable operating conditions (for example, turbulence, engine imbalance, and vibration).

(c) Satisfactory flight crew task performance and CCD functionality, whether the CCD is operated with a dominant or non-dominant hand.

(d) Hand stability support position (for example, wrist rest).

(e) Ease of recovery from incorrect use.

d. Cursor Displays

(1) The cursor symbol should be restricted from areas of primary flight information or where occlusion of display information by a cursor could result in misinterpretation by the flight crew. If a cursor symbol is allowed to enter a critical display information field, it should be demonstrated that the cursor symbol’s presence will not cause interference during any phase of flight or failure condition.

(2) Because the cursor is a directly controllable element on the display it has unique characteristics. Consider the following when designing a cursor display:

(a) Presentation of the cursor should be clear, unambiguous, and easily detectable in all foreseeable operating conditions.

(b) The failure mode of an uncontrollable and distracting display of the cursor should be evaluated.

(c) Because in most applications more than one flight crew member will be using one cursor, the applicant should establish an acceptable method for handling “duelling cursors” that is compatible with the overall flight deck philosophy (for example, “last person on display wins”). Acceptable methods

should also be established for handling other possible scenarios, including the use of two cursors by two pilots.

(d) If more than one cursor is used on a display system, a means should be provided to distinguish between the cursors.

(e) If a cursor is allowed to fade from a display, some means should be employed for the flight crew to quickly locate it on the display system. Common examples of this are “blooming” or “growing” the cursor to attract the flight crew’s attention.

42. – 45. [RESERVED]

**CHAPTER 8 SHOWING COMPLIANCE FOR APPROVAL OF ELECTRONIC DISPLAY SYSTEMS**

46. Compliance Considerations (Test and Compliance)

a. General. This chapter provides guidance for demonstrating compliance to the specifications for the approval of electronic flight deck displays. Since so much of display system compliance is dependent on subjective evaluations, this chapter focuses on providing specific guidance that facilitates these types of evaluations.

b. Means of Compliance

(1) The acceptable means of compliance for a display system depends on many factors and is determined on a case-by-case basis. For example, when the proposed display system technology is mature and well understood, means such as analogical reasoning documented as a Statement of Similarity may be sufficient. However, more rigorous and structured methods, such as analysis and flight test, are appropriate if the proposed display system design is deemed novel, complex, or highly integrated.

(2) The acceptable means of compliance depends on other factors as well. These include the subjectivity of the acceptance criteria and the evaluation facilities of the applicant (for example, high-fidelity flight simulators) and the manner in which these facilities are used (for example, data collection).

(3) When subjective criteria are used to satisfy a means of compliance, the subjective data should be collected from multiple people (including pilots, engineers, and human factor specialists.)

(4) The following guidance describes means of compliance for electronic displays:

(a) System Descriptions

1 System descriptions may include system architecture, description of the layout and general arrangement of the flight deck, description of the intended function, flight crew interfaces, system interfaces, functionality, operational modes, mode transitions, and characteristics (for example dynamics of the display system), and applicable specifications addressed by this description. Layout drawings and/or engineering drawings may show the geometric arrangement of hardware or display graphics. Drawings typically are used in cases where showing compliance to the specifications can easily be reduced to simple geometry, arrangement, or the presence of a given feature on the drawing.