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AEROSPACE RECOMMENDED PRACTICE

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FLIGHT DECK INSTRUMENTATION, DISPLAY CRITERIA AND ASSOCIATED CONTROLS FOR TRANSPORT AIRCRAFT

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CANCELLED

1. **PURPOSE AND SCOPE:** This document recommends display criteria for instrumentation on the flight deck of transport aircraft, taking account of human factors that affect engineering design.

1.1 Applicable Documents:

- AS 264 - Instrument and Flight Deck Lighting for Transport Aircraft
- ARP 268 - Location and Actuation of Flight Deck Controls for Transport Aircraft
- ARP 450 - Flight Deck Visual, Audible and Tactile Signals
- ARP 571 - Instrumentation and Flight Deck Controls for Electronic Navigation and Communication Aids
- AS 580 - Pilot Visibility from the Flight Deck Design Objectives for Transport Aircraft
- AIR 1093 - Numeral, Letter and Symbol Dimensions for Aircraft Instrument Displays
- AS 8034 - Airborne Multi-Purpose Electronic Displays

Proposed Applicable Documents:

- ARP 1570 - Flight Management System
- ARP 1782 - Color and Light Intensity Measurements for Direct View CRT
- ARP 1847 - Instrumentation and Flight Deck Controls for Anti-Collision Devices for Transport Aircraft

2. **GENERAL:** The instrumentation must clearly inform the crew of the current flight condition and the status of flight guidance, flight control, navigation and aircraft systems; and provide information required to control the aircraft and monitor its progress with respect to the desired flight path. The information must be presented with the accuracy, legibility and readability required for error-free control of the aircraft in all workload

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2. (Continued):

conditions. Adequate redundancy of displays and controls must be provided for all functions that are essential to the safety and successful completion of the flight.

3. INSTRUMENT PANEL LOCATION AND FUNCTION:3.1 Pilot's Primary Instrument Panels:

- 3.1.1 Each panel shall be located directly in front of the pilot and shall display the necessary vertical and horizontal situation and command information as well as auxiliary navigation data.
- 3.1.2 Frequently operated controls on the panel shall be within the normal arm's reach of the pilot, in accordance with ARP 268.
- 3.1.3 Areas of the panel that contain displays or controls used during any flight phase shall be visible to the pilot from all eye positions within a sphere whose radius is 32mm (1.25") from the design eye position (AS 580), assuming binocular vision.
- 3.1.4 Adequate clearance between the lower edge of the panels and the pilot's legs shall be provided in the most adverse combination of seat position, rudder pedal position and toebrake application.
- 3.1.5 The panel shall be oriented so as to minimize parallax, while at the same time preventing reflections and glare.
- 3.1.6 The top of the panel should be as close to the windshield lower cutoff as possible, so as to minimize vertical scan between head down displays and external vision.

3.2 Pilot's Center Instrument Panel:

- 3.2.1 The panel should include those system controls and displays that are vital to the safe operation of the aircraft. These may include power plant, configuration, flight control, systems monitoring/status and alerting system displays.
- 3.2.2 Either pilot shall be able to operate controls on the panel from his seated position normal for the relevant phase of flight.
- 3.2.3 Areas of the panel that contain displays or controls, used during any flight phase shall be visible to both pilots from all eye positions within a sphere whose radius is 32mm (1.25") from the design eye position.

3.3 Pilot's Flight Guidance, Communication, Navigation, and Display Selector Panels:

- 3.3.1 Where space is available on the glareshield it should be used for locating frequently used control panels whose operation by either pilot is routine. The installation should not compromise external vision or the vertical dimension of the flight or systems instrument panels, and should be used whenever possible since this is an area requiring minimum deviation of the eyes from instrument panels or external vision.
- 3.3.2 A less preferable location is on the pedestal forward, alongside or immediately aft of the thrust levers, provided that thrust lever movement does not interfere with access to or view of such controls and displays. This location requires more deviation of the eyes from the external field of vision, especially the area aft of the thrust levers. Panels may be located in the aft area provided they do not require frequent operation or observation. Controls on any of these panels shall be within normal arm's reach of either pilot, in accordance with ARP 268.
- 3.3.3 Flight guidance, communication, navigation and display selector panels for each pilot shall be visible to both pilots from all eye positions within a sphere whose radius is 32mm (1.25") from the design eye position. Panels used during take-off, initial climb, final approach or landing phases of flight should be located within a 60° cone whose axis is parallel to the aircraft longitudinal axis and whose apex is at the design eye position.
- 3.3.4 Panels containing alpha numeric keyboards should be located in the forward pedestal area in such a position that operation in turbulence is not significantly degraded.

3.4 Pilot's Overhead Panel:

- 3.4.1 The space overhead and between the two pilots may be utilized for locating infrequently used controls and displays. All items on this panel should be clearly visible and accessible to either pilot. The controls for landing lights and rain removal are examples of high priority items that should be located on the forward area of the overhead panel.

3.5 External Viewing:

- 3.5.1 It is desirable that means be provided to view the engines, wing and tail leading edges, and landing gear wheels and doors from the flight deck, when seated at the normal crew station.

3.6 Third Crew Member's Panel:

- 3.6.1 The panel shall not be oriented so that it would require the third crew member to sit facing more than 90° away from directly forward.
- 3.6.2 The third crew member's seat shall have sufficient travel, adjustment and swivelling capability to permit easy observation of the appropriate displays.

- 3.6.3 It is desirable that the more important controls and displays should be grouped at eye level or below.
- 3.6.4 The captain, from the seat position established for the design eye position, should be able to observe the third crew member's station.
- 3.6.5 Controls required immediately for safe operation with an incapacitated/absent third crew member should be visible to and within reach of the first officer in his seated position. This applies to those controls that are required to be operated rapidly as a result of the more probable system failures or abnormal flight conditions.
- 3.6.6 If the third crew member's panel is located aft of the pilots' seats, the arrangement should be in accordance with ARP 268.
- 3.6.7 If all the system's controls and displays are located in the pilot's overhead panel and the aircraft is normally operated by three crew members, the third crew member shall be located so that the distance from his normally seated position to all important system controls in the overhead and aft pedestal panels does not exceed the maximum given in ARP 268 except that the body position may move relative to the seat reference point for flight phases other than take-off and landing.

4. INSTRUMENTATION AND DISPLAY ARRANGEMENT:

4.1 Pilot's Primary Instrument Panels:

- 4.1.1 In each panel pitch and roll attitude as well as flightpath situation and command information shall be displayed in the central upper area. The Basic T arrangement shall be implemented by locating basic flight data in the position described in Paras. 4.1.2 - 4.1.5.
- 4.1.2 The vertical center line of the primary attitude instrument shall not be displaced more than 25mm (1") from the vertical plane passing through the design eye position and parallel to the longitudinal axis of the aircraft. The instrument shall be located as high in the panel as possible.
- 4.1.3 Airspeed and related parameters such as Mach number shall be displayed on the left side of the vertical center line.
- 4.1.4 Altitude and related parameters such as glideslope, radio height and vertical speed shall be displayed on the right side of the vertical center line.
- 4.1.5 Essential navigation information shall be displayed in the lower central area, except as permitted by Para. 5.3.2.9.
- 4.1.6 Standby instruments shall be located in a position that enables both pilots to control and monitor the flightpath with minimum eye movement between standby instruments. (See Para. 5.3.4).

4.2 Pilot's Center Instrument Panel:

- 4.2.1 The necessary power plant, configuration, system and alerting displays and controls shall be laid out in an easily identifiable and logical arrangement.
- 4.2.2 Power plant indicators or displays shall be aligned by function and power plant position and arranged in the order (a)(b)(c) below, either from top to bottom or from left to right. Space limitations may require that secondary instruments be located on the third crew member's panel.
 - (a) Primary power or thrust parameter indicator e.g. EPR/N1/BHP/manifold pressure/reverser position.
 - (b) Primary limitation and function indicators e.g. TGT/N2/Cyl head temp/fuel flow.
 - (c) Secondary limitation and function indicators e.g. Oil press/oil temp/vibration.
- 4.2.3 Systems and alerting system controls, indicators and displays should be visible to all crew members and accessible to each pilot.
- 4.2.4 Systems displays should present system information in a format that corresponds with the relative positions of the system components and their instrument panel arrangement. (See Paras. 4.5.3 and 5.6)
- 4.2.5 Alerting System visual displays should be in accordance with ARP 450 (See Para. 5.5).
- 4.2.6 Where system parameters and alerting functions are combined in a single display format, dedicated areas should be provided for each function.

4.3 Pilot's Flight Guidance, Communication, Navigation, and Display Selector Panels:

- 4.3.1 The necessary controls, displays and annunciators shall be located so as to avoid mis-selection or ambiguity. Visual and tactile distinction between controls shall be provided, (e.g. heading, course, airspeed, altitude) and correlation between identification of control and associated symbol shall be incorporated.
- 4.3.2 Controls other than those associated with flight guidance, communication, navigation and display selection shall not be located in the glareshield. Dimming control for the glareshield should be located in the glareshield area.
- 4.3.3 Controls located in the glareshield shall not constitute a head hazard in the event of rapid deceleration.

4.4 Pilot's Overhead Panel:

- 4.4.1 Controls, displays and annunciators shall be aligned from top to bottom or from left to right in the same relative order as the power plants, or the function with which they are associated.
- 4.4.2 When the panel incorporates system displays, controls and annunciators, the layout shall comply with the recommendations given in Paras. 4.5.2 and 4.5.3.

4.5 Third Crew Member's Panel:

- 4.5.1 Power plant and systems controls, displays and annunciators shall be aligned from top to bottom or left to right in the same relative order as the power plants, or the function with which they are associated. (Alignment shall not be a function of physical geometry such as wing sweepback or aft engine location).
- 4.5.2 Each system shall have its associated controls, displays and annunciators grouped in one area allocated for this purpose.
- 4.5.3 The use of schematic light plates and flow line switching in association with system controls, displays and annunciators is very desirable. Schematic arrangement and flow lines should, as far as is practicable, correspond with the relative positions of the system components. Flow direction should be consistent throughout the flight deck.
- 4.5.4 Adequate table space for the third crew member shall be provided (28 x 50cm, 11 x 20 ins. minimum), consistent with the duties of the crew member and the requirements of recording equipment provided. A clear plastic overlay shall be incorporated.

5. INSTRUMENTATION AND DISPLAY CONSTRAINTS AND OBJECTIVES:

5.1 General:

- 5.1.1 Flight deck instrumentation shall be engineered as a complete information system with suitable redundancy and monitoring capability. Emphasis should be placed on flight simulator studies of instruments and displays in a representative working environment to ensure the attainment of high operational efficiency and the elimination of design and human factor errors.
- 5.1.2 Details of individual displays such as character type and size, scaling, increments, orientation of pointers and lubber lines shall be consistent throughout the flight deck. Where crew operated test facilities are included, a consistent test indication or clearly identified test mark shall be provided.

- 5.1.3 Light-reflecting displays shall be provided with white integral lighting conforming to ARP 264. The lighting of all displays in each panel shall be balanced and even. Separate, easily selectable dimming controls shall be provided for edge-lit, integral and light-emitting equipment. Provision should also be made for adjustable glareshield flood lighting.
- 5.1.4 The flight deck shall be engineered to minimize glare and reflections.
- 5.1.5 Displays shall be legible under all lighting conditions experienced in the flight deck, including direct sunlight, and throughout the flight envelope. Color degradation under high and low levels of lighting shall not preclude the pilot from interpreting display information. (See AS 8034).
- 5.1.6 Colors should be compatible with the alerting functions described in ARP 450. Blue and brown should be used for sky and ground shading, respectively, in attitude displays. Where colors such as green, cyan, orange/yellow or magenta are used they should have a similar significance in all displays on the flight deck. Color should not be used as the only distinguishing identification of critical data.
- 5.1.7 Electronic display colors shall harmonize with the colors used in other light-reflecting displays. A distinct difference shall always be discernible between colors; means should be employed to ensure that apparent color changes do not occur when electronic display elements overlap or the level of intensity (brightness) is changed, or background color (sky/ground) is altered.
- 5.1.8 Electronic displays must remain legible, stable and unambiguous when operating in a degraded or monochromatic mode.
- 5.1.9 Electronic displays must not cause eye strain or other undesirable physiological effects.
- 5.1.10 Bezel or surface curvature cut-off should not exist within the viewing angles specified for electronic displays in ARINC 725.
- 5.1.11 Lightning strike and high voltage discharges must not cause a significant interruption of display operation or change in display content.
- 5.1.12 Normal power transfers or other power fluctuation must not cause a significant interruption of display operation or change in display content. Pilot selected values shall not change as a result of power interruption.
- 5.1.13 Display elements should enter and leave the display area smoothly. The last digit of numerical read outs should change without causing distraction (e.g. rolling digit). Digital data of no current value should not be displayed.

- 5.1.14 Controls for operating displays and managing the information content, mode selection etc. shall be in a convenient location for each pilot. Either pilot should be able to operate the controls for both pilot's displays. (See Para. 3.3.)
- 5.1.15 All displays on the pilot's instrument panels should be free from distortion, and legible to both pilots. Those displays on the pilot's panels that a third crew member is required to monitor shall be visible and legible to him from the central seat position and harness condition specified for the phase of flight.

5.2 Fault Alerts:

- 5.2.1 Individual alerts shall be provided for each instrument that is essential for continuation of flight under any operational condition.
- 5.2.2 Alerts shall include mechanical and electrical malfunctions as well as power failures which result in any malfunction of the display.
- 5.2.3 Failure modes should result in an alert (see ARP 450) and for electronic displays the removal of the information affected by the failure. A distinction must be evident between loss of signal and equipment failure.
- 5.2.4 When a failure flag is used it should, if practicable, obscure the function indication for which the alert is pertinent.
- 5.2.5 Attitude, navigation and air data systems should incorporate an alert for significant discrepancies between similar systems, and between sensed and displayed values. Where possible (e.g. triple systems) a fault should be identified and indicated in an instrument of the faulty system.
- 5.2.6 Systems which utilize built-in test equipment (BITE) should provide the flight crew with appropriate annunciation during the test cycle.

5.3 Flight Displays:

5.3.1 General:

- 5.3.1.1 Primary flight instruments include Attitude Director Indicators (ADI), Horizontal Situation Indicators (HSI), Electronic ADI (EADI), Electronic HSI (EHSI), Primary Flight Displays (PFD) and Navigation Displays (ND).
- 5.3.1.2 The hysteresis, inertia and other lag effects of attitude, speed, altitude, vertical speed and flight guidance displays must be such that the pilot's ability to control the aircraft flight path manually is not degraded.
- 5.3.1.3 The lag between pilot selection and subsequent display of flight/mode data shall not exceed 0.1 seconds, or 0.25 seconds lag between format selection and display.