Aviation Rulemaking Advisory Committee (ARAC)
Transport Airplane and Engine (TAE) Issues Area

Meeting Minutes

Date:	August 3, 2006 (ad hoc)
Time:	11:00 a.m. EDT
Location:	Washington, DC

Call to Order/Administrative Reporting

Mr. Craig Bolt (Assistant Chair) called the meeting to order at 11:00 a.m. Mr. Mike Kaszycki (Assistant Executive Director) read the Federal Advisory Committee Act statement. Mr. Bolt began the introductions. All attendees were listening via teleconference.

Craig Bolt	Assistant Chair	Keith Barnett	Bombardier
Mike Kaszycki	Assistant Executive Director	Walter Desrosier	GAMA
Jill DeMarco	Boeing	Tom Peters	Embraer
Clark Badie	Honeywell	Dan Hayworth	FAA
Eric Lucas	Transport Canada	Ric Peri	AEA
Kirk Baker	FAA	Rolf Greiner	Airbus
Steve Boyd	FAA	John Linsenmeyer	FAA
Frank Bartonek	Cessna		

ASHWG Report

Mr. Badie began a discussion of the Avionics Systems Harmonization Working Group (ASHWG) report **[handout #1]** and the draft Advisory Circular (AC) 25.11 **[handout #2]**. Mr. Badie commented that the AC-25-11 report includes a response to the Commercial Aviation Safety Team (CAST) safety enhancement. He said the CAST schedule required the FAA to publish a final AC 25-11 by June 2007 and therefore the FAA had declined the working group's request for an additional extension beyond their latest TAE deadline. He said the group's two deliverables were the draft AC and a letter describing the group's position on several issues examined during deliberations on the AC.

Mr. Kaszycki commented that the FAA had minimal latitude to request an extension from CAST because the agency is committed to satisfy the CAST enhancement deadlines. He said the FAA concluded it was better to move forward with the existing draft AC 25-11 information from ASHWG that was available as of June 2006, and consider additional material for future AC revisions at a later date.

Mr. Bolt asked if there were any questions from the committee about the ASHWG report. Mr. Desrosier asked if the ASHWG's work on the appendixes planned as part of the original report had been abandoned. Mr. Badie said the working group's members had an interest in the content of those appendixes, and that he expects some of the members to continue that work.

Mr. Kaszycki added that the FAA is still deliberating how best to develop future compliance guidance associated with newer technology displays, and the FAA had assembled a steering committee to decide on which steps to take. He stated the FAA was planning to task some additional work to the ASHWG related to consolidation of compliance guidance for existing display systems that were not accounted for in the existing draft of AC 25-11.

Mr. Desrosier also asked if the FAA was going to continue to work with the European Aviation Safety Agency (EASA) on developing those issues, and Mr. Kaszycki said the FAA is working on it but has had some difficulty getting EASA support for this as well as other ARAC proposals.

Mr. Greiner asked who would dispose the public comments generated from the AC. Mr. Kaszycki said the FAA might ask the ASHWG to do it if the comments raise controversial issues, but that the FAA could dispose of the comments itself. Mr. Greiner said Airbus would support having the ASHWG dispose the comments, and Mr. Kaszycki said the short deadlines may prevent that.

Mr. Barnett said he was concerned about how the working group will handle issues raised by the Powerplant Indication Task Team (PITT). Mr. Kaszycki responded by saying that resolving the issues would likely take a lot of time, and that it was important for industry management representatives in the TAE to develop a company position on the propulsion display issues that were dispositioned by the ASHWG. Mr. Kaszycki added that the companies could resolve this by providing clarifying comments during the formal comment period, as defined in the upcoming Notice of Availability. Mr. Barnett asserted the issues would be better handled by the TAE committee before issuing the draft AC, and the solutions may be very simple. Mr. Badie and Mr. Boyd offered some examples of the complexity and controversial nature of some of the issues in the extensive ASHWG discussion of the definition of "misleading information" used in the AC.

Mr. Barnett asked Mr. Badie to verify the ASHWG's CAST recommendation is reflected in Appendix A of the AC. Mr. Barnett said he is concerned about how the AC would apply to avionics installations on existing airplanes (retrofit). Mr. Badie agreed that applicability has been a difficult issue, and Mr. Barnett said the AC is a good document but that he is concerned about how the AC will be applied.

Mr. Bolt called for a vote from the committee on a proposal to submit the report to ARAC as a recommendation. Ms. DeMarco said Boeing was in favor of the recommendation, but she said she wants to make sure two of the items submitted in the letter from ASHWG are included in the report. She said she felt there will be substantial Boeing comments on the draft AC, and that the committee should work to ensure harmonization with EASA.

Mr. Lucas, Mr. Desrosier, Mr. Greiner, and Mr. Peters voted in favor of the proposal. Mr. Barnett abstained from voting on the proposal. There were no votes against the proposal. Mr. Desrosier asked Mr. Bolt to emphasize in the recommendation transmittal letter to FAA the importance of harmonization with EASA.

Mr. Bolt said the proposal was approved as a recommendation, and he would encourage the FAA in his recommendation letter to harmonize the AC with EASA. Mr. Bolt thanked Mr. Badie and the ASHWG for their work. Mr. Desrosier asked for an action item for the FAA to report back to the committee on a plan for moving forward on guidance for new avionics technologies. Mr. Kaszycki said FAA already has that action item, and he would address it at the next TAE meeting. Mr. Bolt commented that the next regular TAE meeting would be in October 2006 in Seattle, WA.

Mr. Bolt asked for comments and a vote on the minutes from the March and June 2006 ad hoc TAE meetings. There were no comments, and the committee approved both minutes unanimously. Mr. Barnett asked if Mr. Yves Morier (EASA) had responded to Mr. Bolt's letter to EASA on its participation in ARAC, and Mr. Bolt said that he had not received a response from Mr. Morier.

Adjourn at 11:30 a.m.

Public Notification

The *Federal Register* published a notice **[handout #3]** of this meeting on July 14, 2006.

Approval

I certify the minutes are accurate.

Craig R. Bolt
Assistant Chair, ARAC

Date: June 23, 2006

Re: Transport Airplane and Engine Issues Group (TAEIG)
Avionics Systems Harmonization Working Group
Task 4 – Warning, Caution and Advisory Lights

Attn: Mr. Craig Bolt, Assistant Chair, TAEIG

Dear Mr. Bolt,

In accordance with the reference task, the Avionics Systems Harmonization Working Group (ASGWG) is pleased to submit the attached technical report which provides the group's recommendations for a harmonized revision to AC/AMC 25-11 (herein referred to as "the report"). This report is provided for approval by the TAEIG.

In addition to the report, the group would like to bring to your attention the following relevant points:

1) Part of the process included coordination with AIA PITT, to provide technical expertise and input to this draft report. Most of the AIA PITT input is included in this report. However, there are a few items received from AIA PITT which were not incorporated in this report. These are identified as follows:

- Section 6.5, Safety Design Guidelines: "*Loss of one or more required engine indications on more than one engine*" – current draft states this as "remote" however PITT requested that it be listed as "extremely remote"
- Section 6.5, Safety Design Guidelines: "*Display of misleading required engine indications on more than one engine*" – current draft states this as "extremely remote" however PITT requested that it be listed as "extremely improbable"

  ASHWG Response: With the improvement of display systems, introduction of fully autonomous engine controls, and other mitigating factors, both safety objectives have been accepted in recent certifications. The report's section on safety design lists these as "Examples of generally accepted safety objectives for engine related failure conditions," and in the case of engine indications the assumption is made (and clearly stated) that a fully autonomous engine control is provided.

  The ASHWG position is to provide only guidance (objectives) for certain failure conditions, and that they need to be substantiated (or changed) through the development of an airplane Functional Hazard Assessment. The basis for a higher minimum objective applied to display system indications (e.g. specific scenarios) need to be provided.

  A suggestion for resolution is to omit these specific safety objectives and point to AMC 901 (c) and a previously generated ARAC report for AC 901 (c) – note that the AC is an ARAC recommended draft since 1998 but it is not yet released. This wording was considered but not incorporated in our draft document.

- Appendix B, Powerplant Indications - AIA PITT requested the addition of the following: "*No single failure may cause misleading indications on more than one engine. [ref., §25.903(b)]*."

  ASHWG Response: ASHWG rejected this input since there are common mode failures in any display system (e.g. design errors) that can not meet this requirement – for any display indication not just engine indications. In addition no safety objective or failure classification is provided.

- Appendix B, Powerplant Indications - AIA PITT requested the addition of the following: "*No single failure should cause the loss of all thrust setting parameters on more than one engine [ref. §25.901(b)(2), §25.901(c), §25.1301, §25.1305 §25.1309].*"

ASHWG Response: ASHWG rejected this input since there are common mode failures in any display system (e.g. design errors) that can not meet this requirement – for any display indication not just engine indications. In addition no safety objective or failure classification is provided.

- Appendix B, Powerplant Indications - AIA PITT requested the addition of the following: *"For single failures leading to the partial loss of indications on an engine, sufficient indications should remain to allow continued safe operation of the engine [ref. §25.901(b)(2), §25.901(c), §25.903(d)(2)]"*

  ASHWG Response: ASHWG generally accepted this but included the idea of non-recoverable loss of indications. There may be procedures that the flight crew can perform to recover the loss of a display indication (e.g. display reversion). Proposed text that was incorporated in this report: *For single failures leading to the non-recoverable loss of any indications on an engine, sufficient indications should remain to allow continued safe operation of the engine [ref. §25.901(b)(2), §25.901(c), §25.903(d)(2)]*

- Appendix B, Powerplant Indications - AIA PITT requested the addition of the following "*Indications required for continued safe operation of the engines, including engine restart, should be displayed after the loss of normal electrical power.* "

  ASHWG Response: This was considered unnecessary since the failure condition in section 6.5 "*Loss of one or more required engine indications on a single engine*" would need to be met through a system safety assessment that considers many causes, including the loss of electrical power. Therefore this statement is redundant.

- One of the CAST objectives assigned to the ASHWG is related to powerplant indications was coordinate with AIA PITT and discussed below (with the complete list of CAST objectives).

2) After the formal task for AC/AMC 25-11 was released, the ASHWG was further tasked with incorporating the recommendations made by the Commercial Aviation Safety Team (CAST), as a result of the report named "Enhancement 34: Implement certain display/alerting features (see next slide) on all new airplane cert and future derivative model planes." This is driving the current delivery date of this report.

Since this is an AC/AMC, the group can not provide wording which requires the inclusion of these enhancements. Our wording reflects the guidance that the ASHWG feels is appropriate for an AC/AMC.

Each CAST enhancement item, along with the relevant text from the report (or other response from the ASHWG) is identified below:

- Graphical depiction of vertical situation – real time graphical depiction of their vertical situation

  ASHWG Response: Group position is to not explicitly state (require) VSD, but to include considerations for implementation within the current context of this AC. This report is not prescribing functionality unless required by regulation.

  Current text included in section 8 of the draft AC/AMC: *"Information such as navigation information, weather, and vertical situation display is often displayed on Multi-Function Displays (MFD) which may be displayed on one or more physical electronic displays or on areas of a larger display. When this information is not required to be displayed continuously, it can be displayed part-time."*

  Current text included in section 7 of the report: *Depictions include schematics, synoptics, and other graphic depictions such as attitude indications, moving maps, and vertical situation displays.*

  To avoid visual clutter, graphic elements should be included only if they add useful information content, reduce flight crew access or interpretation time, or decrease the probability of interpretation error.

To the extent it is practical and necessary, the graphic orientation and the flight crews' frame of reference should be correlated. For example, left indications should be on the left side of the graphic and higher altitudes should be shown above lower altitudes..

Graphics that include three-dimensional effects should ensure the symbol elements being used to achieve these effects would not be interpreted as information in and of themselves.

In addition TSO-C165, "Electronic Map Display Equipment for Graphical Depiction of Aircraft Position," specifically addresses vertical situation displays.

- Graphic speed trend information

ASHWG Response: Current text included in Appendix A of the report: *Airspeed scale graduations found to be acceptable have been in 5-knot increments with graduations labeled at 20-knot intervals.* ***In addition, a means to rapidly identify a change in airspeed (e.g. speed trend vector or acceleration cue) should be provided****; if trend or acceleration cues are used, or a numeric present value readout is incorporated, scale markings at 10-knot intervals have been found acceptable.*

Vertically oriented moving scale airspeed indication is acceptable with higher numbers at the top or bottom if no airspeed trend or acceleration cues are associated with the speed scale. Such cues should be oriented so that increasing energy or speed results in upward motion of the cue.

- Pitch Limit Indication

ASHWG Response: Current text included in Appendix A of the report: *There should be a means to determine the margin to stall and display it when necessary. For example, a pitch limit indication has been found to be acceptable*

- Bank angle limits to buffet

ASHWG Response: Current text included in Appendix A of the report: *There should be a means to identify an excessive bank angle condition prior to stall buffet.*

- Barber poles/amber bands (minimum and maximum speeds)

ASHWG Response: Current text included in Appendix A of the report: *Airspeed scale markings that remain relatively fixed (such as stall warning, VMO/MMO), or that are configuration dependent (such as flap limits), should be displayed to provide the flight crew a quick-glance sense of speed. The markings should be predominant enough to confer the quick-glance sense information, but not so predominant as to be distracting when operating normally near those speeds (e.g., stabilized approach operating between stall warning and flap limit speeds).*

- Detection and annunciation of conflicting attitude, airspeed and altitude information

ASHWG Response: Current text included in Section 6 of the report: *There should be a means to detect and provide immediate awareness of conflicting attitude, altitude, and airspeed information between the captain and the first officer.*

- Detection and removal of invalid attitude, airspeed and altitude info, and
- Detection and removal of misleading attitude, airspeed and altitude info (i.e. from an external fault)

ASHWG Response: In this particular case "misleading" is interpreted as being "incorrect." There are cases where there may not be the capability to determine which source is incorrect. Both CAST items are addressed as follows:

Current text included in Section 6 of the report: *There should be a means to detect lost or erroneous primary flight information, either as a result of a display system failure or a failure of the associated sensor. This means should be sufficient to ensure that the lost or erroneous information is not useable by the flight crew (e.g. removal of the information, "X" through the failed display).*

- Information to perform effective manual recovery from unusual attitudes using chevrons, sky pointers, and/or permanent ground-sky horizon on all attitude indications

  <u>ASHWG Response:</u> Current text included in Appendix A of the report: *An accurate, easy, quick-glance interpretation of attitude should be possible for all unusual attitude situations. Information to perform effective manual recovery from unusual attitudes using chevrons, sky pointers, and/or permanent ground-sky horizon on all attitude indications is recommended.*

- Salient annunciation of autoflight mode changes and engagement status

  <u>ASHWG Response</u>: This is already addressed in AC 25-1329B, Chapter 4, paragraph 44:
  a. Annunciation of Engagement of the FGS
  b. Description of FGS Modes
  c. FGS Mode Annunciations
  d. Mode Changes
  e. Failure to Engage or Arm
  f. FGS mode Display and Indications

- Effective sideslip information and alerting of excessive sideslip (ex split trapezoid)

  <u>ASHWG Response:</u> Current text included in Appendix A of the report: *Sideslip should be clearly indicated to the flight crew (e.g. split trapezoid on attitude indicator), and an indication of excessive sideslip should be provided.*

- Clear annunciation of engine limit exceedances and significant thrust loss

  <u>ASHWG Response</u>: The following text has been added to Appendix B of the report:.

  "Safety-related engine limit exceedances should be indicated in a clear and unambiguous manner. Flight crew alerting is addressed in 14CFR/CS §25.1322."

  "If an indication of significant thrust loss is provided it should be presented in a clear and unambiguous manner."

  Additional input from AIA PITT re: Indication of Engine Exceedance:
  AIA PITT feels that the display aspect of engine exceedance is covered by 25.1322 / AC25.1322, 25.1305, 25.1521, 25.1583.

  Additional input from AIA PITT re: Significant Thrust Loss:
  There is an entire section specifically devoted to the subject of Undetected Thrust Loss in the ARAC recommended Draft AC25.901(c) (circa 1998).

  EASA released the material in an NPA in 2004
  (http://www.easa.eu.int/doc/Rulemaking/NPA/NPA_13_2004.pdf)

  The FAA has worked on the AC but not yet released it. There is an FAA Policy which says we can use this proposed draft AC as the basis for an ESF with the current §25.901(c), although no one has yet done so.

In addition to the proposed text in the report, the ASHWG recommends that the FAA release AC25.901(c).

3) The current draft of the report includes pointers to the ARAC reports for 25.1302 and 25.1322. EASA has already released an NPA for 25.1302 and is planning to release a NPA for 25.1322. This group strongly requests that the final rules and associated ACs be prioritized such that they are published simultaneously with the publication of AC 25-11. Our original task was drafted assuming that 25.1302 and 25.1322 would be released prior to the release of AC/AMC 25-11. There is a potential for lack of harmonization between FAA and EASA, and inconsistent application of new vs. old regulations should the release of 25.1302 and 25.1322 be delayed.

4) Industry is concerned that without further harmonization between EASA and the FAA there will be an increase in the cost to develop and certify new capabilities such as HUD, EVS, and SVS. Industry burden of these costs and impacts to schedule are mitigated by the coordinated guidance provided by the multi-disciplinary and regulatory harmonization process.

A significant part of the industry rationale for creating a harmonized AC/AMC 25-11 was a result of the latest capabilities and technologies being introduced, without any airworthiness guidance (e.g. HUD, EVS, and SVS). This group was originally tasked with, and intended on drafting harmonized material for HUD, EVS, and SVS, but was forced to drop activity on these subjects based on the deadline to meet CAST objectives.

EASA is planning to continue drafting guidance for HUD, EVS, and SVS, and this group strongly requests that the TAEIG provide additional tasking to develop a harmonized update to AC/AMC 25-11 to include HUD, EVS, and SVS.

5) The ASHWG expects to disposition the public comments, in a typical ARAC forum with the content experts from the FAA, EASA, AIA PITT, and industry. This group believes that each of the member companies will be providing a significant amount of comments, based on the significant amount of original comments received while writing the draft report.

Please do not hesitate to contact me if you have any questions.

Sincerely,

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Draft AC/AMC 25-11 – Electronic Flight Deck Displays

Draft	Date	Description of Changes
A	October 2004	First draft. Main sections drafted include: 7.3 Optical; 8.1 Criticality; 9.2.3 Symbology; 10 Information Management; 10.2 Windowing, 10.3 Basic T Format; 10.5.1. Menuing; 10.5.2 Linking; 10.7 Failure Modes; 11 Interactivity; 12 Test and evaluation; 14 Continued Airworthiness; TBD EVS; TBD Situational Awareness Display
B	January 2004	Includes all material reviewed at the January 2004 meeting. Updates for sections: 1 Purpose; 2 Scope; 3 Background; 9.2.2 Labeling; 9.2.3 Symbology; 9.2.5 Color; 9.3.1 Dynamic Coding; 9.3.2 Data Display Dynamics; 9.4.1 Data Mingling; 9.4.4 Overall Formats Consistency; 12 Test and Evaluation; 14 Continued Airworthiness; Section 1 -
C	April 2004	Includes material reviewed at the April 2004 London meeting
D	July 2004	Includes all material prepared prior and during the July 2004 Toulouse meeting, does not include comments discussed during the plenary session. Updates for sections : 2 scope, 5 Definition, 7 Display characteristics, 8 safety aspects, 9 Display functions,10 Information management, 12 Test and Evaluation, App C HUD, App E Synthetic Vision
E	October 2004	Includes all material drafted during the October 2004 Dallas meeting. Updates for sections: 2 – Scope, 5 – Definition, 6 – Related Regulations, 7 – Display Characteristics, 8 – Safety Aspects, 9 – Display Functions, 10 – Information Management, 11 – Interactivity, 12 – Certification Considerations, 13 (Deleted), 14 Renumbered to 13, Appendix Table of Hazard Classifications, subsequent draft appendices were moved to insert appendix A
F	Jan 2005	Filename “Draft AC-AMC 25-11 Jan 2005 post_Savannah_meeting_v1.doc” Includes updates from Savannah Meeting (Jan 2005)- specifically updates to Sections: 4 Glossary 5 Definitions 9 Display Functions 10 Information Management 11 Interactivity
G	Apr 2005	Filename Includes updates from Bordeaux meeting (April 2005) with specific comments from the AVHWG team members. All sections affected.
H	Jun 2005	Includes updates from the Paris meeting (June 2005), incorporating the disposition of all internal comments. Sections were re-ordered.
I	Oct 2005	Includes updates to section 7 from Stephane (7.3.4.1 & 7.3.4.2) from the PITT input, includes Ian’s input to Integrated Standby Appendix (was Appendix H and is now Appendix C), updates to section 4 made on Friday and Section 10 made on Friday. Includes changes made to Appendix A and Appendix B, as well as changes to sections 6 and 8 from the PITT input
J	Mar 2006	Includes changes made as a result of company comments. Ch 1, 2, 3, 5, 6, 8 and 11.
K	Apr 2006	Includes changes made from the AVHWG meeting, April 2006
L	June 2006	Includes changes made at late May pre-meeting and June 2006 team meeting – prepared for release

1 Purpose

This advisory circular/acceptable means of compliance (AC/AMC) provides guidance for the design, integration, installation, and approval of electronic flight deck displays and display systems installed in transport category airplanes. Like all AC/AMC material, this AC/AMC is not mandatory and does not constitute a regulation. It is issued to minimize the need for additional interpretation and to provide guidance for a means of compliance with Title 14 of the Code of Federal Regulations (14 CFR)/CS25 Certification Specifications for Large Airplanes applicable to the installation of electronic displays in Part 25 airplanes.

While these guidelines are not mandatory, they are derived from extensive regulatory and industry experience in determining compliance with the relevant regulations. A means of compliance shall be established using this AC or an acceptable alternative method proposed by the applicant.

2 Scope

This AC applies to the design, integration, installation, and certification of electronic flight deck displays, components, and systems for Transport Category airplanes. As a minimum this includes:

- general airworthiness considerations
- display system and component characteristics
- safety and criticality aspects
- functional characteristics
- display information characteristics
- guidance to manage display information
- flight crew interface and interactivity,
- airworthiness approval (means of compliance) considerations.

In scope	**Out of scope**
Electronic Pilot displays (front panel) – including single function and multi-function displays	In flight entertainment (IFE) displays
	Flight attendant displays
	Maintenance terminals, even if they are in the flight deck, but not intended for use by the pilots
Cabin surveillance if being used on the front panel or side panel displays	Displays in the crew rest area
Display functions intended for use by the pilot, or display aspects of other functions intended for use by the pilot	Display functions not intended for use by the pilot
Display functions not intended for use by the pilot if they may interfere with the pilot's flying duties	Handheld or laptop items (not installed equipment)
Display aspects of class III Electronic Flight Bag (EFB) (installed equipment)	Class I and Class II EFB
	Electromechanical instruments
Visual electronic displays	Auditory "displays" (e.g. aural alerts), tactile "displays" (e.g. stick shaker)
Controls associated with items in this column – includes hard controls (physical buttons and knobs) and soft controls (virtual buttons and knobs, generally controlled through a cursor device)	Flight controls, throttles, other (hard) controls not directly associated with the electronic displays
Electronic standby displays	

Table 2-1: In-scope and out-of-scope guidelines for the applicability of AC/AMC 25-11

Editorial note – change so that these are not tables, replace with bullet lists

This AC is intended to supersede the original AC 25-11, dated 16 July 1987, and AMJ 25-11.

In addition to this AC, a new AC/AMC 25-1302 has been proposed to provide acceptable means of compliance for many rules associated with certification of the design of flight crew interfaces such as displays, indications, and controls. A new AC/AMC 25-1322 has also been proposed to provide means of compliance for flight deck alerting systems.

The combination of the guidance listed in this document along with the proposed AC/AMJ 25-1302 and AC/AMC 25-1322 is intended to embody a variety of design characteristics and human-centered design techniques that have wide acceptance, are relevant to the regulatory requirements, and can be reasonably applied to transport airplane certification programs.

The links below include information about the recommendations for the proposed AC/AMC 25.1302 and AC/AMC 25.1322, respectively.

http://www.faa.gov/regulations_policies/rulemaking/committees/arac/media/tae/TAE_HFH_T1.pdf
http://www.faa.gov/regulations_policies/rulemaking/committees/arac/media/tae/TAE_ASH_T4.pdf

For the purposes of this AC/AMC a “Display System” includes not only the display hardware and software components. Hardware and software components of other systems that affect displays, display functions, or display controls have to take into account the display aspects of this AC/AMC. For example, this AC/AMC would be applicable to a barometric set display, even though the barometric set function may be part of another system.

For the purposes of this AC/AMC, “foreseeable conditions” is the full environment that the display or the display system is assumed to operate within, given its intended function. This includes operating in normal, non-normal, and emergency conditions.

Other advisory material is used to establish guidance for specific functionality and characteristics provided by electronic displays. For example, AC 25-23 describes a means for airworthiness approval of Terrain Awareness and Warning System (TAWS), and includes guidance on the display of TAWS. This AC/AMC is not intended to replace or conflict with these existing ACs/AMCs but rather provides a top-level view of flight deck displays. Conflicts between this AC/AMC and other advisory material will be resolved on a case-by-case basis in agreement with the authorities.

The acronyms and abbreviations used throughout this document are defined in section 12. Definitions of technical terms used in this AC can be found in section 13. A list of applicable regulations, and related guidance and industry material is included in section 14.

3 Background

The FAA and EASA have established a number of regulatory requirements intended to improve aviation safety by requiring that the flight deck design have certain capabilities and characteristics. Certification of flight deck displays and display systems has typically been addressed by invoking many rules that are specific to certain systems, or to rules with general applicability such as 25.1301(a), 25.771(a), and 25.1523.

Electronic displays can present unique opportunities and challenges to the design and certification process. In many cases, showing compliance with regulatory requirements related to the latest flight deck display system capabilities has been subject to a great deal of interpretation.

The initial release of Advisory Circular 25-11 (16 July 1987) established guidance for the approval of cathode ray tube (CRT) based electronic display systems used for guidance, control, or decision-making by the flight crews of transport category airplanes. At the time the first electronic displays were developed, they were direct replacements for the conventional electromechanical components. This guidance has been updated in accordance with the latest-generation display technologies as well as other improvements in flight deck designs.

4 General

This section provides guidance that applies to the overall electronic display. The remainder of this section, together with sections 5 through 9, provides compliance objectives and design guidance. Section 10 provides general guidance on how to show compliance (such as, analysis or evaluation). The material in Sections 4 through 9, together with the process for identifying and applying appropriate means of compliance (Section 10) constitutes an overall method of compliance for certifying an electronic display.

The applicant should establish, document and follow a design philosophy for the display system that supports the intended function, including a high level description of:

1. General philosophy of information presentation – e.g., is a "quiet, dark" flight deck philosophy used or is some other approach used?

2. Color philosophy on the electronic displays – the meaning and intended interpretation of different colors – e.g., magenta represents a constraint.

3. Information management philosophy– e.g., when should the pilot take an action to retrieve information or is it brought up automatically? When and where? What is the intended interpretation of location of information?

4. Interactivity philosophy- e.g., when and why confirmation of actions is requested. When is feedback provided?

Human performance considerations include flight crew workload, training time to become sufficiently familiar with interfacing with the display, the potential for flight crew error, system ease of use, and pilot concentration required to use the display. For example, high workload or excessive training time may indicate a display design that is difficult to use, requires excessive concentration, or may be prone to flight crew errors.

The certification plan for an electronic display system should include a description of the intended function. To demonstrate compliance with §25.1301(a), an applicant must show that the design is appropriate for its intended function. The applicant's description of intended function must be sufficiently specific and detailed for the Authority to be able to evaluate that the system is appropriate to its intended function. General and/or ambiguous intended function descriptions are not acceptable (e.g., a function described only as "situation awareness"). More detailed descriptions may be warranted for designs that are new, novel, highly integrated, or complex. A system description is one way to document the intended function(s).

Display systems and display components that are not intended for use by the flight crew (such as maintenance displays) should not interfere with the flying duties of the flight crew.

5 Display Hardware Characteristics

This section provides general guidance and a means of compliance for electronic display hardware with respect to its basic optical and installation characteristics. A more detailed set of guidelines for electronic display hardware can be found in SAE ARP 4256A and SAE AS8034A for head down displays and SAE AS 8055 for head up displays

5.1 Hardware Optical characteristics

The visual display characteristics of a flight deck display are directly linked to their optical characteristics. A set of nine basic parameters, which are independent of the technology, provides a means of compliance to flight deck performance requirements. In addition, the visual display characteristics should provide performance that is in accordance with section 7 of this AC/AMC.

Display defects (e.g. element defects, stroke tails) should not impair readability of the display or create erroneous interpretation.

(1) Image Size
The display image size should be large enough to display information in a form that is useable (e.g. readable, identifiable) to the flight crew and in accordance with its intended function(s).

(2) Resolution and line width
The resolution and minimum line width should be sufficient to support all the operational images without misinterpretation of the displayed information.

(3) Luminance
Information should be readable over a wide range of ambient illumination under all foreseeable operating conditions including but not limited to:

- Direct sunlight on the display
- Sunlight through a front window illuminating white shirts (reflections)
- Sun above the forward horizon and above a cloud deck in the flight crew member's eyes
- Night and/or dark environment.

For low ambient conditions, the display should be dimmable to levels allowing for the flight crew's dark ambient adaptation, such that outside vision is maintained while maintaining an acceptable presentation.

Display luminance variation within the entire flight deck should be minimized so that displayed symbols, lines, or characters of equal luminance remain uniform under any luminance setting and under all foreseeable operating conditions.

(4) Contrast Ratio
The Contrast Ratio of the display should be sufficient to ensure that display information is discernable under the whole ambient illumination range under all foreseeable operating conditions.

The contrast between all symbols, characters, lines, and their associated backgrounds should be sufficient to preclude confusion or ambiguity as to information content of any necessary information.

(5) Chromaticity
The display chromaticity range should be sufficient to allow graphic symbols to be discriminated from their background (external scene, image background) and other symbols in all ambient conditions. Raster or Video fields (e.g. non-vector graphics) such as weather radar should allow the image to be discriminated from overlaid symbols, and should allow the desired graphic symbols to be displayed.

The display should provide chromaticity stability over the foreseeable range of operating temperatures, viewing envelope, and dimming range such that the symbology is not misleading.

(6) Gray Scale

The number of shades of gray and the difference between shades of gray that the display can provide should depend on the image content and its use, and should accommodate for all viewing conditions.

The display should provide sufficient gray scale stability over the foreseeable range of operating temperatures, viewing envelope, and dimming range.

(7) Flight Deck Viewing Envelope

The size of the viewing envelope should provide the flight crew with visibility of the flight deck displays over their normal range of head motion, and to support cross-flight deck viewing if necessary (for example, when it is required that the captain be able to view and use the first officer's primary flight information).

(8) Display Response

The display response should be sufficient to provide discernability and readability of the displayed information without presenting misleading information. The response time should be sufficient to ensure dynamic stability of colors, line widths, gray scale and relative positioning of symbols by minimizing artifacts such as smearing of moving images and loss of luminance.

(9) Display Refresh Rate

The display refresh rate (e.g. update rate of an LCD) should be sufficient to prevent smearing and flicker effects that result in misleading information.

5.2 Display Hardware Installation

Flight deck display equipment and installation designs should be compatible with the overall flight deck design characteristics (such as flight deck size and shape, flight crew member position, position of windows, external luminance, etc.) as well as the airplane environment (such as temperature, altitude, electromagnetic interference, vibration).

RTCA document DO-160E and EUROCAE document ED-14E (or later applicable versions) provide information to be used for an acceptable means of qualifying display equipment for use in the airplane environment.

The display unit must be located in the flight deck such that airspeed, altitude, attitude, and heading information are not visually obstructed (25.1321(a)).

The installation of the display equipment should not adversely impair its readability and the external scene visibility of the flight crew under all foreseeable flight deck lighting conditions (25.1321(a), 25.773 (a)(1))

The installation of the display equipment must not cause glare or reflection that could interfere with the normal duties of the flight crew. (25.773 (a)(2))

If the display system design is dependent on cross-flight deck viewing for its operation, the installation should take into account the viewing angle limitations of the display units, the size of the displayed information, and the distance of the display from each flight crew member.

When a display is used to align or overlay symbols with real-world external data (i.e. conformal), the display should be installed such that positioning accuracy of these symbols is maintained during all phases of flight (e.g. HUD symbols). SAE ARP 5288 describes in additional detail the symbol positioning accuracy for conformal symbology on a HUD.

The display system components should not cause physical harm to the flight crew under foreseeable operating conditions.

The display system should not be adversely susceptible to electromagnetic interference from other airplane systems (25.1431).

When installed the display should not visually obstruct other controls and instruments that prevent those controls and instruments from performing their intended function (25.1301).

The display components should be installed in such a way that they retain mechanical integrity (secured in position) for all foreseeable flight conditions.

Liquid spill on or breakage of a display system component should not result in a hazard.

5.3 Power Bus Transient

RTCA document DO-160E and EUROCAE document ED-14E (or later applicable versions) provides information to be used for an acceptable means of qualifying display equipment such that they perform their intended function when subjected to anomalous input power. SAE ARP 4256A provides some additional information for power transient recovery (specifically for the display unit).

Flight deck displays and display systems should be insensitive to power transients caused by normal load switching operation of the airplane, in accordance with their intended function.

Non-normal bus transients other than those caused by engine failure (e.g. generator failure) should not initiate a power up initialization or cold start process.

The display response to a short term power interrupt (<200ms) should be such that the intended function of the display is not adversely affected.

Following in-flight long term power interrupts (>200ms), the display system should quickly return to operation in accordance with its intended function, and should continue to permit the safe control of the airplane in attitude, altitude, airspeed, and direction.

The large electrical loads required to restart some engine types should not affect more than one pilot’s display.

6 Safety Aspects

CFR 14/CS 25.1309 (Equipment, Systems, and Installation) defines the basic safety requirements for airworthiness approval of airplane systems and AC/AMC 25.1309 provides an acceptable means of demonstrating compliance with this rule. This section provides additional guidance and interpretative material for the application of CFR 14/CS 25.1309 and also CFR 14/CS 25.1333(b) to the approval of Display Systems.

ARP4761, "Guidelines and Methods for conducting the safety assessment process on civil airborne systems and equipment" provides a recommended practice that may be used to perform a system safety assessment.

The Failure Condition should identify the impacted functionality, the effect on the airplane and/or its occupants, specify any considerations related to phase of flight and should identify any flight deck indication, flight crew action, or other mitigation means that are relevant.

6.1 Identification of Failure Conditions

One of the initial steps in establishing compliance with CFR 14/CS 25.1309 is to identify the Failure Conditions that are associated with a display or the Display System. This section provides material that may be useful in supporting this initial activity.

The type of the Display System Failure Conditions will depend, to a large extent, upon the architecture, design philosophy and implementation of the system. Types of Failure Conditions should include:

- Loss of function (system or display)
- Failures of software controls and mechanical display controls – loss of function or malfunction such that they perform in an inappropriate manner, including erroneous display control.
- Malfunction (system or display) that could lead to:
  - Partial loss of data
  - Erroneous display of data that could be:
    - Detected by the system (e.g. flagged, comparator alert), or easily detectable by the crew
    - Difficult to detect by the crew or not detectable and assumed to be correct (e.g. "Misleading display of …")

When a flight deck design includes primary and standby displays, consideration should be given to failure conditions involving failures of standby displays in combination with failures of primary displays. The crew may use standby instruments in 2 complementary roles:

- Redundant display to cope with failure of main instruments
- Independent third source of information to resolve inconsistencies between primary instruments

When the display of erroneous information is caused by failure of other systems, which interface with the display system, the effects of these failures may not be limited to the display system. Associated Failure Conditions may be dealt with at the aircraft level and/or within the other systems Safety Analyses as appropriate in order to assess the cumulative effect.

6.2 Effects of Failure Conditions

The effects of failures of a Display System are highly dependent on the flight crew proficiency, flight deck procedures, phase of flight, the type of operations being conducted, instrumental or visual meteorological conditions, and other system protections.

The Failure Condition definition is complete when the effects resulting from "failure" are identified. A complete definition of the Failure Condition and its effect will then support the subsequent Failure Condition classification.

Based on experience of previous airplane certification programs, section 6.5 sets safety objectives for some Failure Conditions. These safety objectives do not preclude the assessment of the actual effects of these failures, which may be more or less severe depending on the design. Therefore the classifications for these Failure Conditions will also need to be agreed with the certification authority during the 14CFR/CS-25.1309 safety assessment process.

When assessing the effects that result from a display failure, the following effects should be considered, accounting for phases of flight when relevant:

- Effects on the flight crew's ability to control the airplane in terms of attitude, speed, accelerations, flight path, potentially resulting in:
    - controlled flight into terrain (CFIT)
    - loss of control
    - inadequate performance capability for phase of flight, including
        - loss of obstacle clearance capability
        - exceeding takeoff or landing field length
    - exceeding the flight envelope
    - exceeding the structural integrity of the airplane
    - exciting structural modes.
- Effects on the flight crew's ability to control the engines, such as
    - those effects resulting in shutting down a non-failed engine in response to failure of a different engine
    - undetected, significant thrust loss
- Effects on the flight crew's management of the aircraft systems
- Effects on the flight crew's performance, workload and ability to cope with adverse operating conditions
- Effects on situation awareness (e.g. related to navigation, system status)

When the display system is used as a control device for other airplane systems, assessment of the failure of the display system as a control device has to consider the cumulative effect on all the controlled systems.

6.3 Failure Condition – Mitigation

When determining the mitigation means and the resulting severity of a Failure Condition, the following may be considered:

- Fault isolation and reconfiguration
- Redundancy (e.g. heading information may be provided by an independent integrated standby and/or a magnetic direction indicator)
- Availability of, level of, and type of alerting provided to the flight crew
- The flight phase and the aircraft configuration
- The duration of the condition
- The aircraft motion cues that may be used by the flight crew for recognition
- Expected flight crew corrective action on detection of the failure, and/or operational procedures
- Ability of the flight crew to control the airplane after a loss of primary attitude display on one side in some flight phases
- For multiple failures (e.g. primary and standby) the non-simultaneity of the failures
- Protections from other systems (flight envelope protection, augmentation systems)

Mitigation means should be described in the Safety Analysis/Assessment document or by reference to another document (e.g., a System Description document).

Note: Means to assure continued performance of any system design mitigation means should be identified.

The safety assessment should include the rationale and coverage of the Display System protection and monitoring philosophies employed. The safety assessment should include an appropriate evaluation of each of the identified Display System Failure Conditions and an analysis of the exposure to common mode/cause or cascade failures in accordance with AMC/ACJ 25.1309. Additionally, the safety assessment should include justification and description of any functional partitioning schemes employed to reduce the effect/likelihood of failures of integrated components or functions.

6.4 Validation of the Classification of Failure Conditions and their effects

There may be situations where the severity of the effect of a failure condition identified in the safety analysis needs to be confirmed. Laboratory, simulator or flight test, as appropriate, may accomplish the confirmation.

The method of validating the classification of Failure Conditions will depend on the effect of the condition, assumptions made and any associated risk. The severity of some Failure Conditions may be easily determined while other conditions may be somewhat difficult to determine, in particular when there is uncertainty on the likelihood of the crew to detect failures not detected by the systems. If flight crew action is expected to cope with the effect of a Failure Condition, the information available to the flight crew should be useable for detection of the failure condition and to initiate corrective action.

6.5 Safety - design guidelines

In order to provide acceptable criteria when establishing the display system safety analysis required by CFR 14/CS 25.1309 (and indirectly by other paragraphs such as 25.901, 25.903, and 25.1333), this section provides examples of generally accepted display system failure conditions together with their associated safety objectives for some typical display parameters. These examples of failure conditions should therefore not be considered an exhaustive list. Some display system designs may result in additional or different operational effects, failure conditions or different safety objectives, as determined by the system safety analysis. For example, the applicant should also identify Failure Conditions

addressing the loss of the Display Units (e.g. PFD, ND) and the cumulative effect of multiple information loss.
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More general Display System design guidelines to contribute to the acceptable Safety level are also provided in this section.

This list is based on the experience of past certification programs but the list of failure conditions to be considered in the display system safety analysis and the associated safety objective will depend on

- The full set of functions of display system
- Display system architecture and design philosophy (e.g. failure detection, redundancy management, failure annunciation, etc..)

Safety objectives identified in the following sub-sections were determined in past certification programs on the basis of conventional display systems. Future display system design may result in different failure conditions classification and associated safety objectives.

The following failure conditions are based on the hypothesis of a generic cockpit design that includes two primary displays and one standby display.

(1) Attitude (pitch and roll)

Examples of generally accepted safety objectives for attitude related failure conditions:

Failure Condition	**Safety objective**
Loss of all attitude display, including standby display	Extremely Improbable
Loss of all primary attitude display	Remote
Display of misleading attitude information on both primary displays	Extremely Improbable
Display of misleading attitude information on one primary display	Extremely Remote
Display of misleading attitude information on the standby display	Remote (1)
Display of misleading attitude information on one primary display combined with a standby failure (loss of attitude or incorrect attitude)	Extremely Improbable (2)

(1) In the absence of mitigation supported by the System Safety Assessment for the total flight deck display system
(2) Consistent with the Safety Objective of the “Loss of all attitude display, including standby display” since the crew may not be able to sort out the correct display.
Consideration will be given to the ability of the crew to control the airplane after a loss of attitude primary display on one side in some flight phases (e.g. during takeoff).

(2) Airspeed

Examples of generally accepted safety objectives for airspeed related failure conditions:

Failure Condition	**Safety objective**
Loss of all airspeed display, including standby display	Extremely Improbable
Loss of all primary airspeed display	Remote
Display of misleading airspeed information on both primary displays, coupled with loss of stall warning or loss of over-speed warning	Extremely Improbable

Display of misleading airspeed information on the standby display	Remote (1)
Display of misleading airspeed information on one primary display combined with a standby failure(loss of airspeed or incorrect airspeed)	Extremely Improbable (2)

(1) In the absence of mitigation supported by the System Safety Assessment for the total flight deck display system
(2) Consistent with the Safety Objective of the "Loss of all airspeed display, including standby display" since the crew may not be able to sort out the correct display.

(3) Barometric Altitude

Examples of generally accepted safety objectives for altitude related failure conditions:

Failure Condition	**Safety objective**
Loss of all barometric altitude display, including standby display	Extremely Improbable
Loss of all barometric altitude primary display	Remote
Display of misleading barometric altitude information on both primary displays.	Extremely Improbable
Display of misleading barometric altitude information on the standby display	Remote (1)
Display of misleading barometric altitude information on one primary display combined with a standby failure (loss of altitude or incorrect altitude)	Extremely Improbable (2)

(1) In the absence of mitigation supported by the System Safety Assessment for the total flight deck display system
(2) Consistent with the Safety Objective of the "Loss of all barometric altitude display, including standby display" since the crew may not be able to sort out the correct display.
Consideration should be given that barometric setting function design is commensurate with the safety objectives identified for barometric altitude.

(4) Heading

Examples of generally accepted safety objectives for heading related failure conditions:

Failure Condition	**Safety objective**
Loss of stabilized heading in the cockpit	Remote (1)
Loss of all heading information in the cockpit	Extremely Improbable
Display of misleading heading information on both pilots' primary displays	Remote (1)
Display of misleading heading information on one primary display combined with a standby failure (loss of heading or incorrect heading)	Remote (1)(2)

(1) This assumes the availability of independent non-stabilized heading required by 25.1303 (a)(3)
(2) Consistent with the Safety Objective of the "Loss of all stabilized heading in the cockpit"

Standby heading may be provided by an independent integrated standby or the Magnetic direction indicator.

The safety objectives listed above can be alleviated if it can be demonstrated that track information is available and correct.

(5) Navigation and Communication (excluding heading, airspeed, and clock data)

Examples of generally accepted safety objectives for navigation and communication related failure conditions:

Failure Condition	**Safety objective**
Loss of display of all navigation information	Remote
Loss of display of all navigation information coupled with total loss of communication functions	Extremely Improbable
Display of misleading navigation information simultaneously to both pilots	Remote – Extremely Remote (1)
Loss of all communication functions	Remote

(1) The navigation information may have a safety objective which is higher than remote, based upon specific operational requirements.

(6) Other parameters (typically provided on Electronic Display Systems)

Examples of generally accepted safety objectives for other related failure conditions:

Failure Condition	**Safety objective**
Display of misleading Flight Path Vector information on one side	Remote (1)
Loss of all Vertical Speed display	Remote
Display of misleading Vertical Speed information to both pilots	Remote
Loss of all slip/skid indication display	Remote
Display of misleading Slip/Skid indication to both pilots	Remote
Display of misleading weather radar information	Remote (2)
Total loss of crew alerting display	Remote (3)
Display of misleading crew alerting information	Remote (3)
Display of misleading flight crew procedures Loss of the standby displays	Remote Remote (4)

(1) The safety objective may be more stringent depending on the use and on the flight phase
(2) Applicable to the display part of the system only
(3) See also AMC 25.1322
(4) 10E-4/flight hour is the minimum reliability level for the crew to have confidence in the standby display and to be able to rely on it when needed.

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(7) Engine
Examples of generally accepted safety objectives for engine related failure conditions:
:
The term “required engine indications” refers specifically to the engine thrust/power setting parameter (e.g. Engine Pressure Ratio, fan speed, torque) and any other engine indications that may be required by the flight crew to maintain the engine within safe operating limits (e.g. rotor speeds, Exhaust Gas Temperature).

This table assumes the display failure occurs while operating in an autonomous engine control mode. Autonomous engine control modes, such as those provided by Full Authority Digital Engine Controls (FADECs), protect continued safe operation of the engine at any thrust lever setting. Hence, the flight deck indications and associated flight crew actions are not the primary means of protecting safe engine operation.

Failure Condition	Safety objective
Loss of one or more required engine indications on a single engine	Remote
Display of misleading display of one or more required engine indications on a single engine.	Remote
Loss of one or more required engine indications on more than one engine.	Remote
Display of misleading display of any required engine indications on more than one engine	Extremely Remote

(8) Use of Display Systems as controls

Failure Condition
Total loss of capability to use display system as a control
Undetected erroneous input from the display system as a control

Safety objectives are not provided for these failure conditions because they are dependant on the functions/systems being controlled and on alternative means of control.

Use of display systems as controls is described in Section 9.

(9) General Safety Design guidelines

Experience from previous certification has shown that a single failure which would induce misleading display of primary flight information may have negative safety effects. It is therefore recommended that the Display System design and architecture implements monitoring of the primary flight information in order to reduce the probability of displaying misleading information

Experience from previous certification has shown that combined failure of the primary display and the standby system (ref AMC 25.1333) can result in Failure Conditions with catastrophic effects.
When an Integrated Standby Display (ISD) is used to provide a backup means of primary flight information, the safety analysis should substantiate that the resulting potential for common cause failures has been addressed adequately in the design, including the design of software and complex hardware. In particular the safety analysis should show that the independence between the primary instruments and the integrated standby instruments is not violated because the ISD may interface with a large number of airplane resources, including power supplies, pitot/static ports and other sensors.

There should be a means to detect lost or erroneous primary flight information, either as a result of a display system failure or a failure of the associated sensor. This means should be sufficient to ensure that the lost or erroneous information is not useable by the flight crew (e.g. removal of the information, “X” through the failed display).

There should be a means to detect and provide immediate awareness of conflicting attitude, altitude, and airspeed information between the captain and the first officer.

(10) Development Assurance guidelines for window management

For those systems that integrate windowing architecture into the display system a means should be provided to control the information shown on the displays, such that the integrity of the display system as a whole will not be adversely impacted by anomalies in the functions being integrated.
This means of controlling the display of information, called window manager hereafter, should be developed to the development assurance level (DAL) at least as high as the highest integrity function of any window. For example, a window manager should be level A if the information displayed in any window is level A. ARP4754, “Certification Considerations For Highly-Integrated or Complex Aircraft Systems” or its latest edition, provides a recommended practice that may be used to perform development assurance.

7 Display Information Elements and Features

This section provides guidance for the display of information elements including text, labels, symbols, graphics and other depictions (such as schematics) in isolation and in combination. It covers the design and formatting of these information elements within a given display area. Section 8 covers the integration of information across several display areas across the flight deck, including guidance on flight deck information location, display arrangement, windowing, redundancy management, and failure management.

7.1 General

General objectives for each display information element, in accordance with its intended function:

- It should be easily and clearly discernable, and have enough visual contrast for the pilot to see and interpret it.
- All probable lighting conditions should be considered for all display configurations including failure modes such as lighting and power system failures. This includes the full range of flight deck lighting options, day and night operations (per 25.773(a)) and 25.1321(e), and display system lighting options.
- Information elements (text, symbol, etc.) should be large enough to see and interpret in all foreseeable operating conditions.
- Overall, the display should allow the pilot to identify and discriminate the information without eyestrain.
- The pilots should have a clear and undistorted view of the displayed information (25.773(a)(1)). (move to section 5.2 “Display hardware installation” and fold in appropriate parts of the text below)

Factors to consider when designing and evaluating the viewability of the displayed information include:

- *Position* of *displayed information*: Distance from the Design Eye Position (DEP) is generally used. If cross-flight deck viewing of the information is needed, distance from the offside DEP, accounting for normal head movement, should be used. For displays not mounted on the front panel, the distance determination should include any expected movement off the DEP by the flight crewmember.
- Vibrations: Viewability should be maintained in adverse conditions, such as vibration (as defined in AC 25-24).

7.2 Consistency

Display information should be presented consistent with the flight deck design philosophy in terms of location, control, behavior, size, shape, color, labeling, and alerting. Consistency implies a common standard of use and equivalent look and feel, in accordance with the overall flight deck design philosophy. In addition to symbology, the color, shape, dynamics and other symbol characteristics representing the same function on more than one display on the same flight deck should be consistent. Acronyms should be used consistently, and messages/annunciations should contain text in a consistent way. Inconsistencies should be evaluated to ensure that they are not susceptible to confusion, errors, and do not adversely impact the intended function of the system(s) involved.

Consistent positioning may be accomplished by always putting the information in the same location or by keeping the position consistent relative to some other information on the display.

The following information should be in a consistent position:

- Autopilot and flight director modes of operation
- Failure flags. (Where appropriate, flags should appear in the area where the data is normally placed)

The following information should be placed in the same relative position whenever shown: [Need to re-write for consistency, clarity, and to ensure that the "relative to what" is specified]

- Real time sensor data (e.g. localizer deviation, radio altitude, traffic), airplane position, and menus
- Airplane system information (relative to actual airplane position <u>and</u> to other graphics for that system) such as propulsion indications
- Map features (relative to current position)
- Failure flags (relative to the indications they replace)
- Segment of flight information (relative to similar information for other segments)
- Bugs, limits and associated data (relative to the information they support) such as tape markings
- Data messages (relative to other related messages) such as crew alerts or data links
- Image reference point, unless the flight crew takes action to alter the reference point

  When a control or indication occurs in multiple places (e.g. a "Return" control on multiple pages of a Flight Management function), the control or indication should be located consistently for all occurrences

7.3 Display Information Elements

(1) Text
This section contains general guidance on all text used in the flight deck, including labels and messages.

Text should be shown to be distinct and meaningful for the information presented. Messages should convey the meaning intended. Abbreviations and acronyms should be clear and consistent with established standards. For example, ICAO 8400/5 provides internationally recognized standard abbreviations and airport identifiers.

Regardless of the font type, font size, color, and background, text should be readable in all of the conditions specified above. General guidelines for text are as follows:

- Standard grammatical use of lower and upper case fonts for lengthy documentation and lengthy messages
- All upper case letters for text labels are acceptable.
- The use of contractions, such as "can't" instead of "can not," is not recommended
- Lines of text should be broken only at spaces or other natural delimiters
- The use of excessive abbreviations and acronyms should be minimized
- Generally, ARP 4102-7 provides guidelines on font sizes that have found to be acceptable. For displays close to the DEP, larger fonts may be desirable to accommodate flight crewmembers who have difficulty focusing up close (far-sighted).

The choice of font also affects readability. The following guidelines apply:

- The font chosen should be compatible with the display technology to facilitate readability. For example, serif fonts may become distorted on some low pixel resolution displays. However, on displays where serif fonts have been found acceptable, they have been found to be useful for depicting full sentences or larger text strings.
- Sans serif fonts (e.g., Futura or Helvetica) are recommended for displays viewed under extreme lighting conditions.

(2) Labeling
This section contains guidance on labeling items such as knobs, buttons, symbols, and menus. Labels may be text or icons. The guidance in this section applies to labels that are on the display, or which label the display, or the display controls. Regulation 14 C.F.R. § 25.1555(a) requires that each flight deck control, other than controls whose function is obvious, must be plainly marked as to its function and

method of operation. For a control function to be considered obvious, a crewmember with little or no familiarity with the aircraft should be able to rapidly, accurately and consistently identify all of the control functions.

Text and icons should be shown to be distinct and meaningful for the function(s) they label. Standard or non-ambiguous symbols, abbreviations, and nomenclature should be used.

If a control performs more than one function, labeling should include all intended functions unless the function of the control is obvious. Labels of graphical controls accessed via a cursor control device should be included on the graphical display.

When using icons instead of text labeling, only brief exposure to the icon should be needed in order for the flight crew to determine the function and method of operation of a control. The use of icons should not cause significant flight crewmember confusion.

The following are guidelines and recommendations for labels.

- Data fields should be uniquely identified either with the unit of measurement or a descriptive label. However, some basic “T” instruments have been found to be acceptable without units of measurement.
- Labels should be consistent with related labels located elsewhere in the flight deck.
- When a control or indication occurs in multiple places (e.g. a “Return” control on multiple pages of a Flight Management function), the label should be consistent across all occurrences

Labels should be placed such that:

- The spatial relationships between labels and the objects they reference should be unambiguous.
- Labels for display controls should be on or adjacent to the controls they identify.
- Control labels should not be obstructed by the associated controls
- Labels should be oriented to facilitate readability. (e.g. continuously maintain an upright orientation or align with associated symbol such as runway or airway).
- On multi-function displays a label should be used to indicate the active function(s), unless it’s function is obvious. When the function is no longer active or being displayed the label should be removed unless another means of showing availability of that function is used (e.g. graying out an inactive menu button).

(3) Symbols

This section provides guidance related to flight deck symbols.

Symbol appearance and dynamics should be designed to enhance flight crew comprehension, retention, and minimize crew workload and errors in accordance with the intended function.

- Symbols should be positioned with sufficient accuracy to avoid interpretation error or significantly increased interpretation time.
- Each symbol used should be identifiable and distinguishable from other related symbols.
- The shape, dynamics, and other symbol characteristics representing the same function on more than one display on the same flight deck should be consistent.
- Within the flight deck, using the same symbol for different purposes increases the likelihood of interpretation errors and increases training times and therefore should be avoided.

It is recommended that standardized symbols be used. The symbols in the following documents have been found to be acceptable: SAE ARP 4102/7 Appendix A-C (for primary flight, navigation, and powerplant displays), SAE ARP 5289 (for depiction of navigation symbology) and SAE-ARP 5288 (for HUD symbology).

(4) Display Indications

This section contains guidance on numeric readouts, gauges, scales, tapes and graphical depictions such as schematics. Graphics related to interactivity are discussed in section 9.

The following are general guidelines and apply to all graphics and display indications:

- They should be readily understood and compatible with other graphics and indications in the flight deck. Additionally they should be identifiable and readily distinguishable.
- Guidance for viewability, text and legends in the sections above apply to graphic elements and display indications as well.

(5) Numeric Readouts

Numeric readouts include displays that emulate rotating drum readouts where the numbers scroll, as well as displays where the digit locations stay fixed.

Data accuracy of the numeric readout should be sufficient for the intended function and to avoid inappropriate crew response. The number of significant digits should be appropriate to the data accuracy. Leading zeroes should not be displayed unless convention dictates otherwise. As the digits change or scroll, there should not be any confusing motion effects such that the apparent motion does not match the actual trend.

When a numeric readout is not associated with any scale, tape, or pointer, it may be difficult for pilots to determine the margin relative to targets or limits, or compare between numeric parameters. A scale, dial or tape may be needed to accomplish the intended crew task.

Numeric readouts of heading should indicate 360, as opposed to 000, for North.

(6) Scales, Dials, and Tapes

Scales, dials and tapes with fixed or moving pointers have been shown to effectively improve crew interpretation of numeric data,

The displayed range should be sufficient to perform the intended function. If the entire operational range is not shown at any given time, the transition to the other portions of the range should not be distracting or confusing.

Scale resolution should be sufficient to perform the intended task. They may be used without an associated numeric readout if alone they provide sufficient accuracy for the intended function. When numeric readouts are used in conjunction with scales, tapes or dials, they should be located close enough to ensure proper association yet not detract from the interpretation of the graphic or the readout.

Delimiters such as tick marks should allow rapid interpretation without adding unnecessary clutter. Markings and labels should be positioned such that their meaning is clear yet they do not hinder interpretation. Pointers and indexes should be unambiguous and readily identifiable. They should not obscure the scales or delimiters such that they can no longer be interpreted. They should be positioned with sufficient accuracy at all times. Accuracy includes effects due to data resolution, latency, graphical positioning, etc.

(7) Other Graphical Depictions
Depictions include schematics, synoptics, and other graphic depictions such as attitude indications, moving maps, and vertical situation displays.

To avoid visual clutter, graphic elements should be included only if they add useful information content, reduce flight crew access or interpretation time, or decrease the probability of interpretation error.

To the extent it is practical and necessary, the graphic orientation and the flight crews' frame of reference should be correlated. For example, left indications should be on the left side of the graphic and higher altitudes should be shown above lower altitudes..

Graphics that include three-dimensional effects should ensure the symbol elements being used to achieve these effects would not be interpreted as information in and of themselves.

(8) Use of Color
This sub-section provides guidance on the use of color.

When color is used for coding, at least one other distinctive coding parameter should be used (e.g., size, shape, location, etc.).

Color standardization is highly desirable, to ensure correct information transfer, and is required for the use of red and amber/yellow per 25.1322.Colors used for one purpose in one information set should not be used for another purpose within another information set. To avoid confusion or interpretation error, there should be no change in how the color is perceived over the range of operating conditions.
If the color coding does not represent the outside world (e.g. weather radar depictions), it should not conflict with pilots' inherent understanding of the meaning of the colors used.

The use of no more than six colors for coding is considered good practice. Each coded color should have sufficient chrominance separation such that it is identifiable and distinguishable in all foreseeable operating conditions and when used with other colors. Colors should be identifiable and distinguishable across the range of information element size, shape, and movement. The colors available for coding from an electronic display system should be carefully selected to maximize their chrominance separation.

The following table depicts previously accepted colors related to their functional meaning recommended for electronic display systems with color displays.

Feature	Color
Warnings*	Red
Flight envelope and system limits, exceedances*	Red or Yellow/Amber as appropriate (see above)
Cautions, non-normal sources*	Yellow/amber
Scales, dials, tapes, and associated information elements	White
Earth	Tan/brown
Sky	Blue/Cyan
Engaged Modes/normal conditions	Green
ILS deviation pointer	Magenta

* Reference to AC 25-1322.

When background color is used (e.g. Grey),it should not impair the use of the overlaid information elements. Labels, display-based controls, menus, symbols, and graphics should all remain identifiable and distinguishable. The use of background color should conform to the overall flight deck philosophies for color usage and information management. If texturing is used for a background, it should not result in loss of readability of the symbols overlaid on it, nor should it increase visual clutter or pilot information access time. Transparency is a means of seeing a background information element through a foreground one – the use of transparency should be minimized because it may increase pilot interpretation time or errors.

Requiring the flight crew to discriminate between shades of the same color for distinct meaning is not recommended. The use of pure blue should not be used for important information because it has low luminance on many display technologies (e.g. CRT, LCD).

Any foreseeable change in symbol size should ensure correct color interpretation.

7.4 Dynamic Information

This section covers the motion of graphic information elements on a display, such as the indices on a tape display.

Graphic objects that translate or rotate should do so smoothly without distracting or objectionable jitter, jerkiness, or ratcheting effects. Data update rates for information elements used in direct airplane or powerplant manual control tasks (such as attitude, engine parameters, etc.) equal to or greater than 15 hertz have been found to be acceptable. Any lag introduced by the display system should be consistent with the airplane control task associated with that parameter. In particular, display system lag (including the sensor) for attitude which does not exceed a first order equivalent time constant of 100 milliseconds for airplanes with conventional control system response has been found to be acceptable.

Movement of display information elements should not blur or shimmer or produce unintended dynamic effects such that the image becomes distracting or difficult to interpret. Filtering or coasting of data intended to smooth the motion of display elements should not introduce significant positioning errors or create system lag that makes it difficult to perform the intended task.

When a symbol reaches the limit of its allowed range of motion, the symbol should either slide from view or change visual characteristics to clearly indicate that it has reached a fixed limit condition.

Dynamic information should not appreciably change shape or color as it moves. .
Objects that change sizes (e.g. as the map range is changed) should not cause confusion as to their meaning and remain consistent throughout their size range. At all sizes the objects should meet the guidance of this section as applicable (discernable, legible, identifiable, accuracy of placement, not distracting, etc.)

7.5 Sharing Information on a Display

There are three methods of sharing information on a given display. First, the information may be overlayed or combined, such as when TCAS information is overlayed on a map display. Second, the information can be time shared so that the pilot toggles between functions, one at a time. Third, the information may displayed in separate physical areas or windows that are concurrently displayed.

(1) Overlays and Combined Information Elements
The following guidelines apply:

- When information elements interact or share the same location on a display, the loss of information availability, information access times, and potential for confusion should be minimized.
- When information obscures other information – it should be shown that the obscured information is either not needed, or can be recovered. Needed information should not be covered. This may be accomplished by protecting certain areas of the display.
- If information, such as traffic or weather, is integrated with other information (such as the navigation information) on a display, the projection, the placement accuracy, the directional orientation and the display data ranges should all be consistent. When information elements temporarily obscure other information (e.g. pop-up menus or windows), the resultant loss of information should not cause a hazard in accordance with the obscured information's intended

function. Care should be taken to ensure the information being out-prioritized will not be needed more quickly than it can be recovered, if it can be recovered at all.

(2) Time Sharing
Guidance relating to time sharing information:

- Any information that should or must be continuously monitored by the flight crew (e.g., attitude) should be displayed at all times.
- Whether information may be time shared or not will depend on how easily it can be retrieved Information for a given performance monitoring task may be time shared if the method of switching back and forth does not jeopardize the performance monitoring task.
- System information, planning, and other information not necessary for the pilot tasks can generally be time shared.
- Care should be taken to ensure the information being out-prioritized will not be needed more quickly than it can be recovered, if it can be recovered at all.

(3) Separating Information
When different information elements are adjacent to each other on a display, there should be sufficient visual separation such that the pilots can easily distinguish between them. Visual separation can be achieved with spacing, delimiters or shading in accordance with the overall flight deck information management philosophy. Required information presented in reversionary or compacted display modes following a display failure should still be uncluttered and not drastically increase information access time.

(4) Clutter and De-Clutter
A cluttered display is one which presents an excessive number and/or variety of symbols, colours, or other information. This causes increased flight crew processing time for display interpretation, and may detract from the interpretation of information necessary for the primary tasks.

Declutter of unnecessary data may be considered to enhance the pilot's performance in certain conditions (e.g. de-selection of automatic pilot engaged mode annunciation and flight director in extreme attitudes).

7.6 Annunciations and Indications

Annunciations and indications include annunciator switches, messages, prompts, flags, status or mode indications which are either on the flight deck display itself, or control a flight deck display.

Additional guidance for crew alerting is provided in AC/AMC 25-1322.

Annunciations and indications should be operationally relevant and limited to minimize the adverse effects on flight crew workload.

Annunciations and indications should be clear, unambiguous, and consistent with the flight deck design philosophy. When annunciation is provided for the status or mode of a system, it is recommended that the annunciation indicates the actual state of the system and not just switch position or selection. Annunciations should only be indicated while the condition exists.

(5) Location of Annunciations and Indications
Annunciations and indications should also be consistently located in a specific area of the electronic display. Annunciations that may require immediate flight crew awareness should be located in the flight crew's forward/primary field of view.

(6) Managing of Messages and Prompts
The following guidance applies to all messages and prompts:

- There should be an indication if there are additional messages that are in a message queue that are not being displayed.

- Within levels of urgency, messages should be displayed in logical order.
- If the length of the information for the message, prompt, or response options is not displayed on the a single page, there should be an indication that additional information exists.

The following contains general guidance on selecting the type of attention getting cue:

- A text change by itself is typically inadequate to annunciate automatic or uncommanded mode changes.

Blinking information elements such as readouts or pointers has been shown to be an effective annunciation. However, the use of blinking should be limited as it can be distracting and excessive use reduces the attention getting effectiveness. Blinking rates between .8 and 4 Hz should b used, depending on the display technology and the compromise between urgency and discomfort. If blinking of an information element can occur for more than approximately 10 seconds, a means to cancel the blinking should be provided.

7.7 Use of Imaging

This section covers the use of images, which depict a specific portion of the airplane environment. Images may be static or continuously evolving. Imaging includes weather radar returns, terrain depictions, forecast weather maps, video, enhanced vision displays and synthetic vision displays. Images may be generated from databases or by sensors.

Images should be of sufficient size and include sufficient detail to meet the intended function. The pilots should be able to readily distinguish the features depicted. Images should be oriented in such a way that their presentation is easily interpreted. All images, but especially dynamic images, should be located or controllable such that they do not distract the pilots from required tasks. The control, coloring, labeling, projection and dynamics of images throughout the flight deck should be consistent. The source and utility of the image and the level of operational approval for use of the image should be available to the pilots. This can be accomplished using the airplane flight manual, image location, adequate labeling, distinct texturing or other means.

Image distortion should not compromise image interpretation. Images meant to provide information about depth (i.e. 3D) should provide adequate depth information to meet the intended function.

Dynamic images should meet the guidance in sub-section 7.3 above. The overall system lag time of a dynamic image relative to real time should not cause crew misinterpretation or lead to a potentially hazardous condition. Image failure, freezing or coasting should not be misleading and should be considered during the safety analysis.

When overlaying coded information elements over images, the information elements should be readily identifiable and distinguishable. The information elements should not obscure necessary information contained in the image. They should be placed with sufficient accuracy to avoid being misleading. They should retain and maintain their shape, size and color for all foreseeable conditions of the underlying image and range of motion.

When fusing or overlaying multiple images, the resultant combined image should meet its intended function despite any differences in image quality, projection, data update rates, sensitivity to sunlight, data latency or sensor alignment algorithms. When conforming an image to the outside world, such as on a HUD, the image should not obscure or significantly hinder the flight crew's ability to detect real world objects. An independent brightness control of the image may satisfy this guideline. Image elements that correlate or highlight real world objects should be sufficiently coincident to avoid interpretation error or significantly increase interpretation time.

8 Organization of Information Elements

8.1 General

This section provides guidance concerning integration of information into the flight deck related to managing the location of information, display arrangement (such as Basic T), windowing, display reconfiguration, and sensor selection across the flight deck displays. Section 7 covers the information elements including: text, labels, symbols, graphics and other depictions (such as video) in isolation and combination.

This section will cover the various flight deck configurations from dedicated electronic displays for ADI and HSI to larger display sizes which use windowing techniques to display various functionalities, such as PFI and ND or more, on one display area. This section also provides guidance for managing display configuration.

8.2 Types and Arrangement of Display Information

This section provides guidance for the arrangement and location of categories of information. The categories of information include:

1. Primary Flight Information (PFI) including attitude, airspeed, altitude and heading.
2. Powerplant Information (PI) which covers functions relating to propulsion.
3. Other Information

The position of a message or symbol within a display converys meaning to the pilot. Without the consistent or repeatable location of a symbol in a specific area of the electronic display, interpretation error and response times may increase. The following information should be placed in a consistent location under normal (i.e. no display failure) conditions:

- Crew alerts – each crew alert should be displayed in a specific location or a central crew alert area
- Autopilot and flight director modes of operation
- Lateral and vertical path deviation indicators
- Radio altitude indications

The following information should be displayed in a consistent relative location:

- Failure flags should be presented in the location of the information they reference or replace
- Data labels for navigation, traffic, airplane system and other information should be placed in a consistent position relative to the information they are labeling
- Airplane system information, relative to related displayed information
- Supporting data for other information such as bugs and limit markings should be consistently positioned relative to the information they support.

(1) Basic T Information

Regulation 25.1321(b) includes requirements for the “Basic T” arrangement of certain information required by 25.1303(b): attitude, airspeed, altitude, and direction.. This sub-section provides guidance for the presentation of this information. It applies whether the information is displayed on one display surface or spread across multiple display surfaces.

The Basic T information should be displayed continuously, directly in front of each flight crew member under normal (i.e. no display system failure) conditions.

The Basic T arrangement applies to the primary display of attitude, airspeed, altitude and direction of flight. Depending on the flight deck design, there may be more than one indication of the Basic T information elements, such as heading, in front of a pilot (e.g. back-up displays, HUD, or moving map displays). In this case, primary attitude is the attitude reference located most directly in front of the pilot and operationally designated as the primary attitude reference. The primary airspeed, altitude and direction indications are the respective display indications closest to the primary attitude indication.

The primary attitude indication should be centered as nearly as practicable about the plane of the flight crew's forward vision. This should be measured from the Design Eye Position. If located on the main instrument panel, the primary attitude indication must be in the top center position (25.1321b). . The attitude indication should be placed such that the display is unobstructed under all flight conditions. Refer to ARP 4102/7 for additional information.
The primary airspeed, altitude and direction of flight indications should be located adjacent to the primary attitude indication. Display information placed within, overlaid, or between these indications such as lateral and vertical deviation, has been found to be acceptable when it is relevant to completing the basic flying task and is shown to not disrupt the normal crosscheck or decrease manual flying performance.

The instrument that most effectively indicates airspeed must be adjacent to and directly to the left of the primary attitude indication (25.1321b). The center of the airspeed indication should be aligned with the center of the attitude indication. For round dial airspeed indications, deviations vertically have been found acceptable up to one inch below or above the direct horizontal position. For tape type airspeed indications, the center of the indication is defined as the center of the current airspeed status reference. Deviations have been found acceptable up to 15 degrees below and 10 degrees above the direct horizontal position as referenced to the attitude indication.

Parameters related to the primary airspeed indication, such as reference speeds or a mach indication, should be displayed to the left of the primary attitude indication.

The instrument that most effectively indicates altitude must be located adjacent to and directly to the right of the primary attitude indication (25.1321b). The center of the altitude indication should be aligned with the center of the attitude indication. For round dial altitude indications, deviations vertically have been found acceptable up to one inch below or above the direct horizontal position. For tape type altitude indications, the center of the indication is defined as the center of the current altitude status reference. Deviations have been found acceptable up to 15 degrees below and 10 degrees above the direct horizontal position.

Parameters related to the primary altitude indication, such as the barometric setting or the primary vertical speed indication, should be displayed to the right of the primary attitude indication.

The instrument that most effectively indicates direction of flight must be located adjacent to and directly below the primary attitude indication (25.1321b). The center of the direction of flight indication should be aligned with the center of the attitude indication. The center of the direction of flight indication is defined as the center of the current direction of flight status reference.

Parameters related to the primary direction of flight indication, such as the reference (i.e. magnetic or true) or the localizer deviation should be displayed below the primary attitude indication.

Any deviation from 25.1321b, as by equivalent safety findings, can not be granted without human factors substantiation which may include well-founded research, or relevant service experience from military, foreign, or other sources.

(2) Powerplant Information

This section provides guidance for location and arrangement of required powerplant information.

Parameters 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 Appendix B). The automatic or manually selected display of powerplant information should not suppress other information that requires flight crew awareness.

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 at the top.

(3) Other Information

Glideslope deviation scales should be located to the right side of the primary attitude indication. If glideslope deviation data is presented on both an EHSI and an EADI, they should be on the same side.

Information such as navigation information, weather, and vertical situation display is often displayed on Multi-Function Displays (MFD) which may be displayed on one or more physical electronic displays or on areas of a larger display. When this information is not required to be displayed continuously, it can be displayed part-time.

Other Information should not be located where the PFI or required PI is normally presented.

8.3 Managing Display Information

This section addresses managing and integrating the display of information across the flight deck. This includes the use of windowing on a display area to present information and the use of menuing 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:

- It is recommended that the window(s) have fixed size(s) and location(s).
- The window size and location should be defined for normal and non-normal conditions.
- Separation between information elements should be sufficient to allow the flight crew to readily distinguish separate functions or functional groups (e.g. powerplant indication) and avoid any distractions or unintended interaction.
- Display of flight crew selectable information such as a window on a display area should not interfere with or affect the use of primary flight information.
- See also ARINC 661 for display of data on a given location, data blending, and data over-writing.

(2) Menu
A menu is a displayed list of items from which the flight crewmember can choose. Examples of menus used in electronic display systems include drop-down menus, and scrolling menus. 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), by entry of an associated option code, or by activation of a function key.

Menu structure is the organization of options into individual menus and their hierarchical relationship. The menu structure should be designed to allow flight crewmembers to sequentially step through the available menus or options in a logical way that supports their tasks. For the grouping of options into individual menus, the options provided on any particular menu should be logically related to each other. Menus should be displayed in consistent locations so that the flight crew knows where to find them. The system should at all times indicate the current position within the menu.

The number of sub-menus should be designed to assure appropriate access to the desired option without over-reliance on memorization 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.

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.

Menus should minimize obscuration of the presentation of required information while a menu is displayed.

(3) Full-time vs. Part-time Displays
Some airplane parameters or status indications are required to be displayed (e.g. 25.1305), yet they may only be necessary or required in certain phases of flight. If it is desired to inhibit some parameters from a full-time display, an equivalent level of safety to full-time display should be demonstrated. Criteria to be considered include the following:

- 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.
- The inhibited parameter is automatically displayed when its value indicates an abnormal condition.
- Display of the inhibited parameter can be manually selected by the 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 requirements of 25.1309.
- The automatic, or requested, display of the inhibited parameter should not create unacceptable clutter on the display; simultaneous multiple "pop-ups" should be considered.
- If the presence of the new parameter is not sufficiently self-evident, suitable alerting must accompany the automatic presentation.

(4) Pop-up/Linking
Certain types of display information such as Terrain and TCAS are required by the operating regulations to be displayed, yet they are only necessary or required in certain phases of flight 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 TCAS overlaying the moving map, or in a separate window as a part of a display format. Pop-up window locations should not obscure required information. Criteria for displaying "automatic pop-up" information include the following:

- 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 attention.
- 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 asserted and the system is in the wrong configuration or mode to display the information, and the system configuration can not be automatically changed, then an annunciation should be displayed in the color associated with the nature of the alert, prompting the flight crew to make the necessary changes for the display of the information.
- If a pop-up(s) occurs and obscures information, it should be shown that the obscured information is not relevant or necessary for the flight crew task. Additionally it should not cause a misleading presentation. Simultaneous multiple “pop-ups” should be considered.
- 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 prioritize the pop-up events based on their criticality.
- Any information to a given system that is not continuously displayed, but that the safety assessment of the system determines is necessary to be presented to the flight crew, should automatically pop-up or otherwise give an indication that its display is required.

8.4 Managing Display Configuration

This section addresses the management of the information presented by an electronic display system and its response to failure conditions and flight crew selections. It will 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) Managing Display Configuration in Normal Conditions
In normal conditions (i.e. 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) Display System Reconfiguration
This section provides guidance on manual and automatic display system reconfiguration in response to display system failure. The arrangement and visibility requirements also apply in failure conditions and alternative display locations used in non-normal conditions will have to be evaluated by the Authority.

Moving display formats to different display locations on the flight deck or using redundant display paths to drive display information has been found to be acceptable to meet availability and integrity requirements.

In an instrument panel configuration with a display unit for Primary Flight Information (PFI) positioned above a display unit for navigation information, it has been found acceptable to move the PFI to the lower display unit when the upper display unit has failed.

In an instrument panel configuration with a display unit for Primary Flight Information (PFI) positioned next to a display unit for navigation information, it has been found acceptable to move the PFI to the display unit directly adjacent to it in case the preferred display unit has failed. It has been found acceptable to switch the navigation information to a centrally located auxiliary display (multifunction display).

If several possibilities exist for relocating the failed display, there should be a recommended procedure in the airplane flight manual.

It has been found acceptable to have manual or automatic switching capability in case of system failure (source, symbol generator, display unit) to ensure that required information remains available to the flight crew. In case several displays have failed, complete suppression of primary flight information may be considered for brief periods of time on a case-by-case basis, provided that the standby indication is operational and the primary flight information is readily recoverable.

The following means to reconfigure the displayed information have been found acceptable:

- Display unit reconfiguration. Moving a display format to a different location (e.g. move the PFI to adjacent display unit) or the use of a compacted format has been found acceptable.

- Source/graphic generator reconfiguration. The reconfiguration of graphic generator sources either manually or automatically to accommodate a failure has been found acceptable. In the case where both Captain and First Officer 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 flying pilot to recover PFI without delay. Automatic reconfiguration might be necessary to cope with failure conditions that require immediate flight crew member action.

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

An alert should be given when the information presented to the crew is no longer meeting the required safety level, in particular single source or loss of independence.

8.5 Methods of Reconfiguration

(1) Compacted Format
The term "compacted format," as used in this AC, 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. The “compacted format” may be automatically selected in case of a primary display failure or it may be manually selected by the flight crew. The concepts and requirements of § 25.1321, as discussed in Section 8.2.1, still apply.

The compacted display format should maintain the same display attributes (color, symbol location, etc..) as the primary formats it replaces. The compacted format should ensure the proper operation of all the display functions it presents, including annunciation of navigation and guidance modes if present. 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 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
Manual or automatic switching of sensor data to the display system is acceptable in the event of sensor failure.

Independent attitude, direction, and air data sources are required for the Captain and First Officer displays of Primary Flight Information (Ref 14 CFR/CS25 § 25.1333). If sources can be switched such that the Captain and First Officer are provided with single sensor information, there should be a clear annunciation indicating this vulnerability to misleading information to both flight crew members.

If sensor information sources can not be switched, then no annunciation is required.

There should be a means of determining the source of the displayed navigation information and the active navigation mode.

If multiple or different type of navigation sources (FMS, ILS, GLS, etc.) can be selected (manually or automatically), then the selected source should be annunciated.

For highly integrated display systems, automatic sensor switching is recommended to address those cases where multiple failure conditions may occur at the same time and require immediate flight crew member action.

For automatic switching of sensors that is not annunciated and is not obvious to the crew, care should be taken that the crew is aware of the actual status of the systems when necessary. An alert should be given when the information presented to the crew is no longer meeting the required integrity level, in particular when there is a single sensor or loss of independence.

9 Display Control Devices

Advances in technology have enabled displays to do more than just provide traditional information presentation. The means of interaction with the display system can be as varied as the modalities of human perception. Each of these modalities has characteristics unique to its operation that need to be considered in design of the functions it 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 compatible, if not consistent, user interface scheme for auxiliary displays throughout the flight deck.

(1) Multifunction controls should be labeled 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 multifunction knob.
- Determine quickly and accurately the function of the knob without extensive training or experience.

9.1 Mechanical Controls

The installation guidelines below apply to control input devices that are dedicated to the operation of a specific function (e.g. control knobs, wheels), as well as new control features (e.g. Cursor Control Device, or CCD).

Mechanical controls (e.g knobs, wheels) used to set numeric data on a display should have adequate friction or tactile detents to allow the flight crew to set values (e.g. setting an out-of-view heading bug to a displayed number) without extensive training or experience.. Controls for this purpose should have an appropriate amount of feel to minimize the potential for inadvertent changes.

The display response gain to control input should be optimized for gross motion as well as fine positioning tasks without overshoots. The sense of motion of controls should comply with the requirements of §25.779, where applicable.

9.2 Software Controls

Display systems can range from no crew interaction to crew interaction that can affect airplane systems. Three display types are identified below.

i) <u>Display only</u>: The most common function of displays is to provide information only. This includes display technologies (e.g. CRT, LCD).There is no crew interaction involved other than perception of the display information.

ii) <u>Interactive display</u>: Displays that utilize a graphical user interface (GUI) permit information within different display areas to be directly manipulated by the crew (e.g. changing range, scrolling CAS messages or electronic checklists, configuring windows, layering information). This level of display interaction affects only the presentation of display information and has a minimal effect on flight deck operations. There is no effect on control of airplane systems.

iii) <u>Airplane system control through displays</u>: Displays that provide a GUI to control airplane systems operations (e.g., utility controls on displays traditionally found in overhead panel functions, FMS operations, graphical flight planning) are also considered "interactive". The amount of airplane control that a system provides should be compatible with, and equivalent testing required, for the level of criticality of the GUI and control device for that system. These are discussed in detail in section 9.1 below.

The design of display systems as “controls” is dependent on the functions they control, and the applicant should consider the following guidelines:

(1) 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 (i.e. vulnerability to common mode failures), and to the combined effects of the loss of control of multiple systems and functions.

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

(3) To show compliance with §§ 25.777(a) and 25.1523, the applicant should show that the flight crew can conveniently access required and backup control functions in all expected flight scenarios, without unacceptable disruption of airplane control, crew task performance, and Crew Resource Management (CRM).

(4) 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 airplane.

(5) To minimize flight crew workload and error, the initial response to a control input should take no longer than250 msec to acknowledge the input. 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.

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

9.3 Cursor Control Device

When the input device controls cursor activity on a display, it is called a cursor control device (CCD). 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 provide control of several functions and are the means for directly manipulating display elements. In addition to the above guidelines the following are design considerations unique to CCDs.

(1) The CCD design and installation should enable the flight crew to clearly and precisely control the CCD, and to maintain display configuration control, without exceptional skill during foreseeable flight conditions, both normal and adverse (e.g. turbulence, vibrations). Certain selection techniques, such as double or triple clicks, should be avoided..

(2) The safety assessment of the CCD may need to address reversion to alternate means of control following loss of the CCD. This includes an assessment on the impact of the failure on 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 (e.g. turbulence, engine imbalance. 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 (e.g. wrist rest).
(e) Ease of recovery from incorrect use.

9.4 Cursor Display

(1) The cursor display should be restricted from areas of primary flight information or where occlusion of display information by a cursor could result in misinterpretation by the crew. If a cursor is allowed to enter a critical display information field, it should be demonstrated to not cause interference for all phases of flight and failure conditions that it will be presented in.

(2) Manipulation of the cursor on the display allows crew access to display elements. Because it is a directly controllable element on the display it has unique characteristics that need consideration:

(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 crew member will be using the cursor, the applicant should establish an acceptable method for handling “dueling cursors” that is compatible with the overall flight deck philosophy (e.g., “last person on display wins”).
(d) If a cursor is allowed to fade from a display, some means should be employed for the crew to quickly locate it on the display system. Common examples of this are “blooming” or “growing” the cursor to attract the crew’s attention.
(e) A means should be provided to distinguish between cursors if more than one is used on a display system.

10 Compliance Considerations (Test and Compliance)

This section provides considerations and guidance for demonstrating compliance to the regulations for the approval of electronic flight deck displays. Since some much of display system compliance is dependent on subjective evaluations by pilots and human factors specialist, this section will focus on providing specific guidance that facilitates these types of evaluations.

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

In selecting the MOC, other factors might include the subjectivity of the acceptance criteria, and the evaluation facilities of the applicant (e.g., high-fidelity flight simulators). Furthermore, the manner in which these facilities are used (e.g., data collection) are influenced by the considerations listed below.

10.1 Means of Compliance (MOC) Descriptions

The following MOC descriptions are focused on electronic displays:

A. System Descriptions. System descriptions may include a system architecture, description of the layout and general arrangement of the flight deck, description of the intended function, crew interfaces, system interfaces, functionality, operational modes, mode transitions, and characteristics (e.g. dynamics of the display system), and applicable requirements addressed by this description. Layout drawings and/or engineering drawings may show the geometric arrangement of hardware or display graphics. Drawings typically are used when demonstration of compliance can easily be reduced to simple geometry, arrangement, or the presence of a given feature, on a technical drawing. The following questions may be used to evaluate whether the description of intended function is sufficiently specific and detailed:

- Does each system, feature and function have a stated intended function?
- What assessments, decisions, or actions are the flight crewmembers intended to make based on the display system?
- What other information is assumed to be used in combination with the display system?
- What is the assumed operational environment in which the equipment will be used (e.g., the pilots tasks and operations within the flight deck, phase of flight and flight procedures)

B. Statement of similarity. This is a substantiation to demonstrate compliance by a comparison to a previously approved display (system or function). The comparison details the physical, logical, and functional and operational similarities of the two systems. This method of compliance should be used with care because the flight deck should be evaluated as a whole, rather than merely as a set of individual functions or systems. For example, display functions that have been previously approved on different programs may be incompatible when applied to another flight deck. Also, changing one feature in a flight deck may necessitate corresponding changes in other features, in order to maintain consistency and prevent confusion.

C. Calculation & Engineering Analysis. These include assumptions of relevant parameters and contexts, such as the operational environment, pilot population, and pilot training. For analyses that are not based on advisory material or accepted industry standards, validation of calculations and engineering analysis using direct participant interaction with the display should be considered. Examples of analysis include computer modeling to show performance (e.g. optical performance) and human performance timing (e.g., latency, potential workload).

D. Evaluation. This is an assessment of the design, conducted by the applicant, who then provides a report of the results to the Authority. Evaluations have two defining characteristics that distinguish themselves from tests: (1) the representation of the display design does not necessarily conform to the final documentation, and (2) the Authority does not need to be present. Evaluations may contribute to a finding of compliance, but they generally do not constitute a finding of compliance by themselves.

Evaluations may begin early in the program. They may involve static assessments of the basic design and layout of the display, part-task evaluations and/or, full task evaluations in an operationally representative environment (environment may be simulated). A wide variety of development tools may be used for evaluations, from mockups to full installation representations of the actual product or flight deck.

In cases where human subjects (typically pilots) are used to gather data (subjective or objective), the applicant should fully document the process used to select subjects, the type of data collected, and the method(s) used to collect the data. This should be provided to the Authority in advance to get agreement on the extent to which the evaluations are valid and relevant for certification credit. Additionally, credit will depend on the extent to which the equipment and facilities actually represent the flight deck configuration and realism of the flight crew tasks.

E. Test. This MOC is conducted in a manner very similar to evaluations (see above), but is performed on conformed systems (or conformed items relevant to the test), in accordance with an approved test plan, with either the aircraft certification authority or their designated representative present. A test can be conducted on a test bench, in a simulator, and/or on the actual aircraft, and is often more formal, structured and rigorous than an evaluation.

Bench or simulator tests that are conducted to show compliance should be performed in an environment that adequately represents the airplane environment, for the purpose of those tests. Flight tests can be the validation and verification of other data, such as display unusual attitude behavior from analysis, evaluations, and simulation. It is often best to use flight tests as a final confirmation of data collected using other means of compliance. “Workload assessments in the presence of failures and validation of failure effect classification need to be addressed in a simulator and/or the actual airplane during certification.”

11 Considerations for Continued Airworthiness and Maintenance

This section provides guidance for the preparation of instructions for continued airworthiness of the display system and its components, to show compliance with 25.1309 and 25.1529 (including Appendix H) which requires that Instructions for Continued Airworthiness should be prepared. The guidance given is not a definitive list, and other maintenance tasks may be developed as a result of the safety assessment, design reviews, manufacturer’s recommendations, and Maintenance Steering Group (MSG)-3 analyses that are conducted.

11.1 General Considerations

Information on the preparation of the instructions for continued airworthiness can be found in Appendix H to Part 25.

(i) If the display system uses pin programming by software means, maintenance information should be provided to enable replacement display equipment to be programmed with the approved airplane configuration.

(ii) Maintenance procedures may also need to be considered for:

(a)Reversionary switches if they are not used in normal operation. The concern is that they are potential latent failures, and consequently the switching or back up display/sensor may not be available when required. These failures may be addressed by a System Safety Assessment, and in the preparation of the airplane's maintenance program (e.g. MSG-3).

(b) Display cooling fans and filters integral with cooling ducting.

11.2 Design for Maintainability

The system should be designed to minimize maintenance error:

(i)The display mounting, connectors, and labeling, should allow quick, easy, safe, and correct access, for identification, removal and replacement. Means should be provided (e.g. physically coded connectors) to prevent inappropriate connections of system elements

(ii) If the system has the capability of providing information on system faults (e.g. diagnostics) to maintenance personnel, it should be displayed in text instead of coded information.

(iii) If the flight crew needs to provide information to the maintenance personnel (example: Overheat warning), problems associated with the display system should be communicated to the flight crew as appropriate, relative to the task and criticality of the information displayed.

(iv) Suitable maintenance instructions should be provided with installation design changes. For example, this may include wiring diagram information addressing pin programming, following the incorporation of a Supplemental Type Certificate (STC) that introduces a new or modified interface to the display system.

11.3 Maintenance of Display Characteristics

Maintenance procedures may be used to ensure that the display characteristics remain within the levels presented and accepted at certification.

Experience has shown that display quality may degrade with time and become difficult to use. Examples are: lower brightness/contrast; distortion or discoloration of the screen (blooming effects); and parts of the screens that may not display information properly.

Test methods and criteria may be established to determine if the display system remains within acceptable minimum levels. Display system manufacturers may alternatively provide "end of life" specifications for the displays which could be adopted by the aircraft manufacturer.

12 Glossary of Acronyms/Abbreviations

AC – Advisory Circular
ADI- Attitude Director Indicator
AFM-Airplane Flight Manual
AMC-Acceptable Means of Compliance
AMJ - Advisory Material Joint
ARP-Aerospace Recommended Practices
AS-Aerospace Standard
CAS- Crew Alerting System
CCD- Curser Control Device
CDI- Course Deviation Indicator
CFIT - controlled flight into terrain
CFR – Code of Federal Regulations
CIE- Commissions Internationale de L'Eclairage
COM-Communication
CRT – Cathode Ray Tube
CS-Certification Specification (EASA Only)
DAL - Development Assurance Level
DEP- Design Eye Position
DME-Distance Measuring Equipment
DOD-Department of Defense
DU- Display Unit
EADI-Electronic Attitude Direction Indicator
EASA- European Aviation Safety Agency
EDS - Electronic Display System
EFB – Electronic Flight Bag
EGT- Exhaust Gas Temperature
EHSI-Electronic Horizontal Situation Indicator
EICAS –Engine Indicating and Crew Alerting System
ETSO-European Technical Standard Order
EURCAE – European Organization for Civil Aviation Equipment
EVS-Enhanced Vision System
FAA – Federal Aviation Administration
FADEC - Full Authority Digital Engine Controls
FHA- Functional Hazard Assessment
FMS-Flight Management System
FOV-Field of View
GLS – GNSS (Global Navigation Satellite System) Landing System
GPS – Global Positioning System
GUI-Graphical User Interface
HDD- Head down Display
HUD –Head up Display
ICAO-International Civil Aviation Organization
IFE - In Flight Entertainment
ILS-Instrument Landing System
INS- Inertial Navigation System
I/O- Input/Output
ISD-Integrated Standby Display
JAA- Joint Airworthiness Authority
LCD –Liquid Crystal Display
LED-Light Emitting Diode
MASPS- Minimum Aviation System Performance Standard

MFD- Mutli-Function Display
MIL STD- Military Standard
MMO- Maximum Operating Mach Number
MOC - Means Of Compliance
MOPS- Minimum Operational Performance Standard
MSG - Maintenance Steering Group
ND-Navigation Display
PFD-Primary Flight Display
PFI-Primary Flight Information
PI-Powerplant Information
SA-Situation Awareness
SAE- Society of Automotive Engineers
STC - Supplemental Type Certificate
SVS-Synthetic Vision System
TAWS-Terrain Awareness and Warning System
TCAS-Traffic Alert and Collision Avoidance System
TSO-Technical Standard Order
UA - User Application
VHF-Very High Frequency
VMO- Maximum Operation Speed
VOR- Very High Frequency Omnirange

13 Definitions

Basic T – The arrangement of primary flight information as required by 25.1321(b); including attitude, airspeed, altitude, and direction information.

Brightness: The perceived or subjective luminance. As such, it should not be confused with **luminance**.

Chrominance – The quality of a display image which includes both luminance and chromaticity and is a perceptual construct subjectively assessed by the human observer.

Chromaticity: Color characteristic of a symbol or an image defined by its u', v' coordinates (CIE pub number 15.2, Colorimetry, second edition 1986).

Coding characteristics: Coding characteristics are readily identifiable attributes commonly associated with a symbol by means of which such symbols are differentiated; i.e., size, shape, color, motion, location, etc.

Color coding – A means to use color to differentiate display information.

Command information: Displayed information directing a control action.

Compact mode – In display use, this most frequently refers to a single, condensed display presented in numeric format that is used during reversionary or failure conditions.

Conformal: Refers to displayed information which overlays the real world element that it is meant to portray irrespective of the viewing position.

Contrast Ratio:
For HUD – ratio of the luminance over the background scene (AS 8055)
For HDD – ratio of the total foreground luminance to the total background luminance

Criticality: Indication of the hazard level associated with a function, hardware, software, etc., considering abnormal behavior (of this function, hardware, software) alone, in combination, or in combination with external events.

Design eye position: The position at each pilot's station from which a seated pilot achieves the optimum combination of outside visibility and instrument scan. The design eye position is a single point selected by the applicant that meets the requirements of Secs. 25.773(d) and 25.777(c) for each pilot station. It is normally a point fixed in relation to the aircraft structure (neutral seat reference point) at which the midpoint of the pilot's eyes should be located when seated at the normal position. The DEP is the principal dimensional reference point for the location of flight deck panels, controls, displays, and external vision.

Display refresh rate: The rate at which a display completely refreshes its image

Display response time: time needed to change the information from one level of luminance to a different level of luminance. Display response time related to the **intrinsic response** (time linked to the electro-optic effect used for the display and the way to address it).

Display Surface/Screen: The area of the display unit that provides an image.

Display System: The entire set of avionic devices implemented to display information to the flight crew. Also known as an Electronic Display System (EDS)

Display Unit: A line replaceable unit that is located in the flight deck, in direct view of the flight crew, that is used to provide display information. Examples include a color head down display, and a head up display projector and combiner.

Enhanced Vision System (EVS): An electronic means to provide a display of the forward external scene topography (natural or manmade features of a place or region especially in a way to show their relative positions and elevation) through the use of imaging sensors, such as a forward looking infrared, millimeter wave radiometry, millimeter wave radar, low light level image intensifying. Note: An Enhanced Flight Vision System (EFVS) is an EVS that is intended to be used for instrument approaches under provisions of 14 CFR §91.175 (l) and (m), and must display the imagery with instrument flight information on a head up display.

Eye Reference Position: A single spatial position located at or near the center of the HUD Eye Box. The HUD ERP is the primary geometrical reference point for the HUD.

Failure: An occurrence which affects the operation of a component, part, or element, such that it can no longer function as intended (this includes both loss of function and malfunction). Note: errors may cause failures but are not considered to be failures.

Failure Condition: A condition having an effect on the airplane and/or its occupants, either direct or consequential, which is caused or contributed to by one or more failures or errors, considering flight phase and relevant adverse operational or environmental conditions, or external events.

Field of View: The angular extent of the display that can be seen by either pilot with the pilot seated at the pilot's station.

Flicker – An undesirable display effect that occurs when a display does not generate quickly enough and can cause discomfort for the viewer (such as headaches and irritation).

Flight Deck Philosophy – A high level description of the design principles that guide the designer and ensure a consistent and coherent interface is presented to the flight crew.

Functional Hazard Assessment: A systematic, comprehensive examination of airplane and system function to identify potential Minor, Major, Hazardous, and Catastrophic failure conditions that may arise as a result of a malfunction or a failure to function.

Format (Fig 13-2): An image rendered on the whole display unit surface. A format is constructed from one or more windows (Ref ARINC661)

Gray Scale: number of incremental luminance levels between full dark and full bright

Hazard: Any condition that compromises the overall safety of the airplane or that significantly reduces the ability of the flight crew to cope with adverse operating conditions.

HUD Design eye box: The three-dimensional area surrounding the design eye position, which defines the area, from which the HUD symbology performance parameters are defined.

Icon – A single graphical symbol that represents a function or event.

Image Size: useful viewing area (field) of the display surface.

- Direct view display: it refers to the useful (or active) area of the display (ex: units cm x cm)
- Head Up Display: the Total Field Of View (units usually in degrees x degrees)

(Total field of view defines the maximum angular extent of the display that can be seen by either eye allowing head motion within the eyebox. (AS8055))

Indication: Any visual information - e.g. graphical gauges, graphical representations, numeric data displays (i.e. numeric), messages, lights, symbols, synoptics, etc.

Information update rate: The rate at which new data is displayed or updated**.**

Interaction – the ability to directly affect a display by utilizing a graphical user interface (GUI) that consists of a control device (e.g, trackball), cursor, and "soft" display control that is the cursor target.

Latency: The time taken by the display system to react to a triggered event coming from I/O device, the symbol generator, the graphic processor, or the information source).

Layer (Fig 13-3): A layer is the highest level entity of the Display System that is known by a User Application (UA).

Luminance: Visible light that is emitted from the display. Commonly-used units: foot-lamberts, cd/m^2

Menu: A displayed list of items from which the flight crewmember can choose

Mirror image – the arrangement of a pair of displays or control panels where the images or controls are laid out such that they are flipped representations of each other.

Misleading Information: Misleading information is incorrect information that is not detected by the flight crew because it appears as correct and credible information under the given circumstances.

When incorrect information is automatically detected by a monitor resulting in an indication to the flight crew or when the information is obviously incorrect, it is no longer considered misleading.

The consequence of misleading information will depend on the nature of the information, and the given circumstances.

Mode: A mode is the functional state of a display and/or control system(s). A mode can be manually or automatically selected.

Occlusion: Visual blocking of one symbol by another. Sometimes called sparing or occulting.

Partitioning – A technique for providing isolation between functionality independent software components to contain and/or isolate faults and potentially reduce the effort of the software verification process.

Pixel: LCD picture element which usually consists of three (red, green, blue) sub-pixels (also called dots on a CRT).

Primary Displays – The display used to present primary flight information.

Primary Field of View (FOV) – Primary Field-of-View is based upon the optimum vertical and horizontal visual fields from the design eye reference point that can be accommodated with eye rotation only. The description below provides an example of how this may apply to head-down displays.

Primary flight information – The information whose presentation is required by 25.1303(b) and 25.1333(b), and arranged by 25.1321(b).

Primary flight instrument - A primary flight instrument is any display or instrument that serves as the flight crew's primary reference of a specific parameter of primary flight information. For example, a centrally located attitude director indicator (ADI) is a primary flight instrument because it is the flight crew's primary reference for pitch, bank, and command steering information.

Primary flight reference (PFR): A primary flight reference is any display, or suite of displays or instruments, that provides the flight crew with primary flight information.

Resolution: Size of the minimum element that can be displayed, expressed by the total number of pixels or dots.

Pixel Defect: A pixel that appears to be in a permanently on or off-state.

Required Powerplant Parameters – The information whose presentation is required by 25.1305.

Reversionary – This event occurs refers to the crew initiated (manual) or automatic relocation of displays following a display failure.

Shading - Shading is a variation on chromatic coordinates along an axis. Shading is used as:
- a coding method for separating information, change in state, give emphasis, and depth information
- a blending method between graphic elements (map displays, SVS)
- to enhance similarity between a synthetic image and the real world image

Software control – display elements used to manipulate, select, or de-select information (e.g. menus and soft keys)

Standby Display – A backup display that is used in case of a primary display malfunction.

Status information: Information about the current condition of an airplane system and its surroundings.

Symbol: A symbol is a geometric form or alphanumeric information used to represent the state of a parameter on a display. The symbol maybe further defined by its location and motion on a display.

Synthetic Vision System: A system which creates computer generated imagery or symbology representing how an outside forward vision scene would otherwise appear, or elements of that scene would appear, if a pilot could optically see through the visibility restriction or darkness.

Texturing - Texturing is a graphic, pictorial effect placed on a display surface to give the surface a specific "look" (metallic, grassy, cloudy, etc.). Texturing is used as:
- a coding method for separating information, change in state, give emphasis, and depth information
- a blending method between graphic elements (map displays, SVS)
- to enhance similarity between a synthetic image and the real world image

Transparency – Transparency is a way of allowing seeing "through" a front element what's "behind". By doing this, it can alter the color perception of both the "front" and "back" element.

User Application: A user application is an avionics system, interfaced with the display system, which uses the display system as a resource to display and collect information related to its own function (Ref. A661).

User Application Layer Definition or Definition file: The layer definition or definition file is a software file, running on the display system but defined by the user application which describes the constitution of images (widgets hierarchical structure) as needed by the User Application (Ref. ARINC661).

Viewing Envelope (Fig 13-1): total volume of space where the minimum optical performance of the display is met (e.g. luminance, contrast, chromaticity.). For a direct view display it is the solid angle with respect to the normal of the display image and for a HUD a three- dimensional volume (Eyebox).

Widget (Fig 13-3): A single graphical object. A widget is a generic object whose parameters can be set dynamically by a User Application.

Window (Fig 13-2, 13-3): A rectangular physical area of the display surface. A window consists of one or more layers (Ref. ARINC661).

Windowing – The technique to create windows. Segmenting a single display area into two or more independent display areas or inserting a new display area onto an existing display.

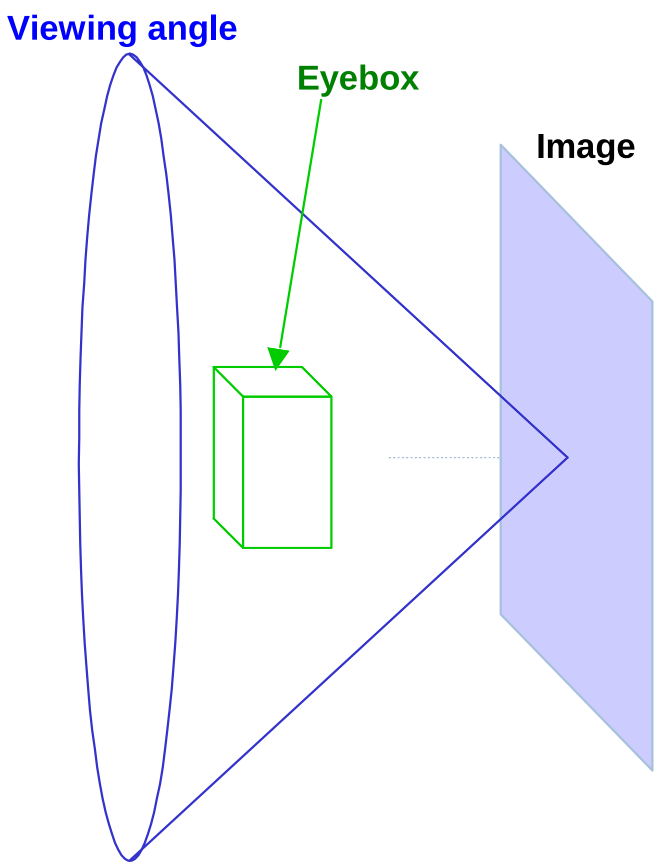

Figure 13-1 – Viewing Envelope

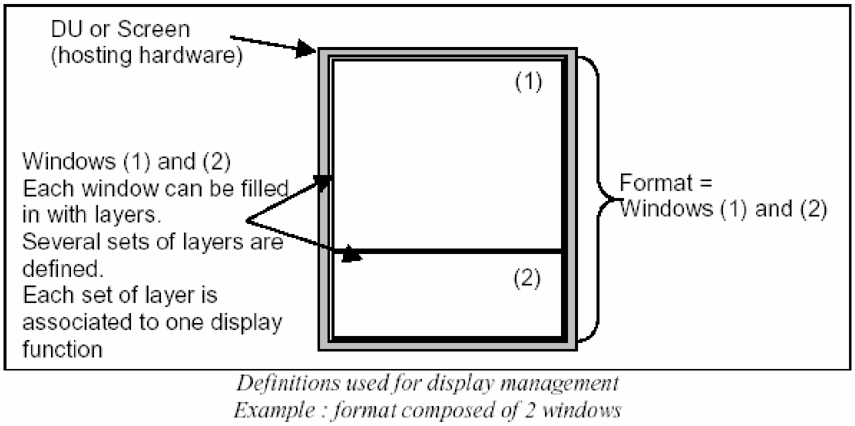

Figure 13-2 – Display Format

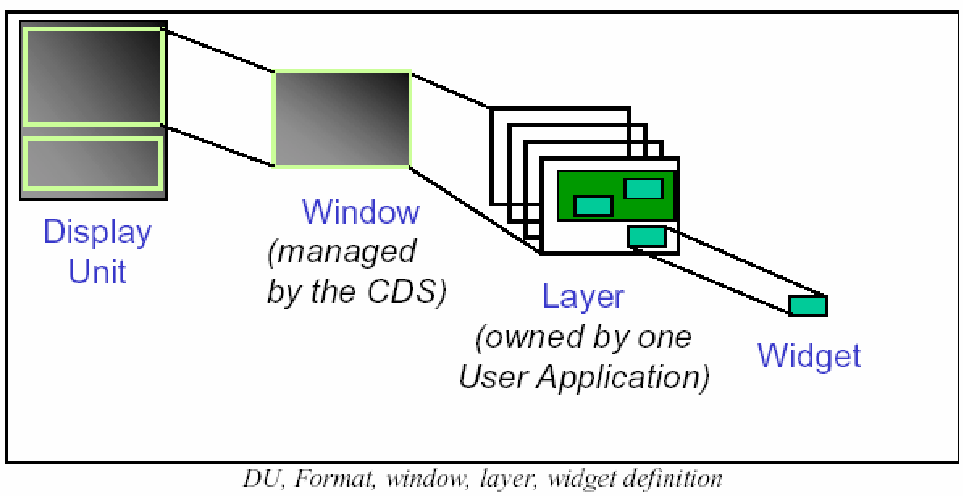

Figure 13-3 – Display Window, Layer, Wigdet relationship

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14 Related Regulations and Documents

14.1 General

The regulations and standards listed below are applicable to particular systems or functions which may have implications on the display system characteristics even though they do not explicitly state display requirements. It is not an exhaustive list, and the references should be reviewed to ensure currency of issue status, and to check for any others that may be applicable.

14.2 Regulatory Sections

The following is a complete list of regulations/certifications that should be considered when certifying a display system:

§ 25.143 Controllability and Maneuverability: General
§ 25.207 Stall warning
§ 25.672 Stability augmentation and power operated systems
§ 25.677 Trim systems
§ 25.679 Control system gust locks
§ 25.699 Lift and drag device indicator
§ 25.703 Takeoff warning system
§ 25.729 Retracting mechanism
§ 25.771 Pilot compartment
§ 25.773 Pilot compartment view
§ 25.777 Cockpit controls
§ 25.783 Doors
§ 25.812 Emergency lighting
§ 25.841 Pressurized cabins
§ 25.854 Lavatory fire protection
§ 25.857 Cargo compartment classification
§ 25.858 Cargo or baggage compartment smoke or fire detection systems
§ 25.859 Combustion heater fire protection
§ 25.863 Flammable fluid fire protection
§ 25.901 Powerplant installation
§ 25.903 Engines
§ 25.904 Automatic takeoff thrust control system (ATTCS)
§ 25.1001 Fuel Jettison Systems
§ 25.1019 Oil strainer or filter
§ 25.1141 Powerplant controls: General
§ 25.1165 Engine ignition systems
§ 25.1199 Extinguishing agent containers
§ 25.1203 Fire detector system
§ 25.1301 Function and installation
§ 25.1303 Flight and navigation instruments
§ 25.1305 Powerplant instruments
§ 25.1309 Equipment, systems, and installations
§ 25.1316 System lightning protection
§ 25.1321 Arrangement and visibility
§ 25.1322 Warning, caution, and advisory lights
§ 25.1323 Airspeed indicating system

§ 25.1326 Pitot heat indication systems
§ 25.1327 Magnetic direction indicator
§ 25.1329 Automatic pilot system
§ 25.1331 Instruments using a power supply
§ 25.1333 Instrument systems
§ 25.1335 Flight director systems
§ 25.1337 Powerplant instruments
§ 25.1351 Electrical Systems and Equipment: General
§ 25.1353 Electrical equipment and installations
§ 25.1355 Distribution system
§ 25.1357 Circuit protective devices
§ 25.1381 Instrument lights
§ 25.1383 Landing lights
§ 25.1419 Ice protection
§ 25.1431 Electronic equipment
§ 25.1435 Hydraulic systems
§ 25.1441 Oxygen equipment and supply
§ 25.1457 Cockpit voice recorders
§ 25.1459 Flight recorders
§ 25.1501 Operating Limitations and Information: General
§ 25.1523 Minimum flight crew
§ 25.1529 Instructions for Continued Airworthiness
§ 25.1541 Markings and Placards: General
§ 25.1543 Instrument markings: General
§ 25.1545 Airspeed limitation information
§ 25.1547 Magnetic direction indicator
§ 25.1549 Powerplant and auxiliary power unit instruments
§ 25.1551 Oil quantity indication
§ 25.1553 Fuel quantity indicator
§ 25.1555 Control markings
§ 25.1563 Airspeed placard
§ 25.1581 Airplane Flight Manual :General
§ 25.1583 Operating limitations
§ 25.1585 Operating procedures
§ 33.71 Lubrication System
§ 91.33 Instrument and equipment requirements
§ 91.205 Powered civil aircraft with standard category U.S. airworthiness certificates: Instrument and equipment requirements
§ 91.219 Altitude alerting system or device; turbojet powered civil airplanes
§ 91.221 Traffic Alert and Collision Avoidance System Equipment and use
§ 91.223 Terrain Awareness and Warning System
CFR 91 Appendix A, Section 2 Required Instruments and Equipment
§ 121.221 Fire Precautions
§ 121.305 Flight and navigational equipment
§ 121.307 Engine Instruments
§ 121.308 Lavatory Fire Protection
§ 121.313 Miscellaneous Equipment
§ 121.323 Instruments and Equipment for Operations at Night
§ 121.325 Instruments and Equipment for Operations under IFR or Over-the-Top
§ 121.344 Digital Flight Data Recorders for Transport Category Aeroplanes (note : DFDRs may be required to record Electronic display status)
§ 121.354 Terrain awareness and warning system
§ 121.356 Traffic Alert and Collision Avoidance System
§ 121.357 Airborne Weather Radar Equipment Requirements
§ 121.358 Low-Altitude Windshear Systems Requirements

§ 121.360 Ground proximity warning – glideslope deviation alerting system
§ 135.149 Equipment requirements: General
§ 135.153 Ground Proximity Warning System
§ 135.154 Terrain Awareness and Warning System
§ 135.159 Equipment requirements: Carrying passengers under Visual Flight Rules (VFR) at night or under VFR over-the-top conditions
§ 135.163 Equipment requirements: Aircraft carrying passengers under Instrument Flight Rules (IFR)
§ 135.180 Traffic Alert and Collision Alerting System
CFR 135 Appendix A, Additional Airworthiness Standards for Ten or More Passenger Airplanes

14.3 Advisory Circulars and Related Documents

(1) FAA Documents

Note: The ACs, Orders and policy memorandum can be accessed on the FAA website: www.faa.gov. Copies of current editions of the following publications may be obtained free of charge from the U.S. Department of Transportation, Subsequent Distribution Office, M-30, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785.

AC20-88A	Guidelines on the Marking of Aircraft Powerplant Instruments (Displays)
AC 20-115B	Radio Technical Commission for Aeronautic, Inc. Document RTCA/DO-178B
AC20-129	Airworthiness Approval of Vertical Navigation (VNAV) Systems for use in the National Airspace System (NAS) and Alaska
AC20-130A	Airworthiness approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors
AC20-131A	Airworthiness approval of Traffic Alert and Collision Avoidance Systems (TCAS II) and mode S transponders
AC 20-136	Protection of Aircraft Electrical/Electronic Systems against the Indirect Effects of Lightning
AC20-138A	Airworthiness approval of Global Navigation Satellite Systems (GNSS) Equipment
AC20-140	Guideline for Design Approval of Aircraft Data Communications Systems
AC 20-145	Guidance For Integrated Modular Avionics (IMA) that Implement TSO-C153 Authorized Hardware Elements
AC20-151	Airworthiness Approval of Traffic Alert and Collision Avoidance Systems (TCAS II) Version 7.0 and Associated Mode S Transponders
AC20-152	RTCA, Inc., Document RTCA/DO-254, Design Assurance Guidance for Airborne Electronic Hardware
AC20-155	SAE Documents to Support Aircraft Lightning Protection Certification

AC 25-4	Inertial Navigation System (INS)
AC 25-7A	Flight Test Guide for Certification of Transport Category Airplanes
AC 25-12	Airworthiness Criteria for the Approval of Airborne Windshear Warning Systems in Transport Category
AC25-15	Approval of Flight Management Systems in Transport Category Airplanes
AC 25-23	Airworthiness Criteria for the Installation Approval of aTerrain Awareness and Warning System (TAWS) for Part 25 Airplanes
AC 25-24	Sustained Engine Imbalance
AC 25-703-1	Takeoff Configuration warning Systems
AC 25.1309-1A	System Design and Analysis
AC25.1329-1A	Automatic Pilot Systems Approval
AC 90-45A	Approval of Area Navigation Systems for use in the US National Airspace System
AC120-28D	Criteria for Approval of Category III Weather Minima for Takeoff, Landing, and Rollout
AC120-29A	Criteria for Approval of Category I and Category II Weather Minima for Approach.
AC120-41	Criteria for Operational Approval of Airborne Wind Shear Alerting and Flight Guidance
AC120-55B	Air Carrier Operational Approval and Use of TCAS II
AC120-64	Operational Use and Modification of Electronic Checklists
AC 120-76A	Guidelines for the Certification, Airworthiness, and Operational Approval of Electronic Flight Bag Computing Devices
Order 8110.49	Software Approval Guidelines, dated June 3, 2003
PS-ACE100-2001-004	Guidance for Reviewing Certification Plans to Address Human Factors for Certification of Part 25 Small Airplanes
DOT/FAA/CT-03/05	Human Factors Design Standards for Acquisition of Commercial Off-The-Shelf Subsystems, Non-Developmental Items, and Developmental Systems. This document can be accessed on the FAA website: www.hf.faa.gov.
DOT/FAA/OAM-TM-03-01	Multi-Function Displays A Guide for Human Factors Evaluations
ICAO 8400/5	Procedures for Air Navigation Services, ICAO Abbreviations and Codes. Fifth Edition-1999.

(2) JAA/EASA Documents

Note: Copies of the EASA documents can be obtained from the EASA website www.EASA.eu.int/agency measures. JAA documents have to be purchased separately.

AMC 20-4	Airworthiness Approval and Operational Criteria for the use of Navigation Systems in European Airspace Designated for Basic RNAV Operations.
AMC 20-5	Airworthiness Approval and Operational Criteria for the use of the Navstar Global Positioning System (GPS).
JAA TGL 8, Revision 2	Certification Considerations for the Airborne Collision Avoidance System : ACAS II.
JAA TGL 10, Rev. 1	Airworthiness and operational approval for precision RNAV operations in designated European airspace
JAA TGL 12	Certification Considerations for the Terrain Awareness and Warning System :TAWS.
CS AWO	All Weather Operations

(3) Technical Standard Orders (TSO)

Note : You may obtain a copy of the current edition of the following publications from the Federal Aviation Administration; Aircraft Certification Service; Aircraft Engineering Division; Technical and Administrative Support Staff Branch, AIR-103; 800 Independence Avenue, SW; Washington, DC 20591 or at the FAA website: www.faa.gov. The following is a partial list of the FAA Technical Standard Orders (TSOs) that may relate to electronic displays. For a complete list of TSOs, see AC 20-110, "Index of Aviation Technical Standards Orders." It should be noted applicants might apply for a TSO that does not adequately address all of the functionality in the system. Alternatively, applicants may apply for multiple TSOs, since no single TSO applies to all functions.

PARTIAL INDEX OF TSOs THAT MAY BE APPLICABLE

TSO-C2d	Airspeed Instruments
TSO-C3d	Turn and Slip Instrument
TSO-C4c	Bank and Pitch Instruments
TSO-C5e	Direction Instrument, Non-magnetic (Gyroscopically Stabilized)
TSO-C6d	Direction Instrument, Magnetic (Gyroscopically Stabilized)
TSO-C7d	Direction Instrument, Magnetic Non-Stabilized Type (Magnetic Compass)
TSO-C8d	Vertical Velocity Instruments (Rate-of-Climb)
TSO-C9c	Automatic Pilots
TSO-C10b	Altimeter, Pressure Actuated, Sensitive Type

TSO-C31d	High Frequency (HF) Radio Communications Transmitting Equipment Operating within the Radio Frequency Range of 1.5-30 Megahertz
TSO-C34e	ILS Glide Slope Receiving Equipment Operating within the Radio Frequency Range of 328.6-335.4 Megahertz (MHz)
TSO-C35d	Airborne Radio Marker Receiving Equipment
TSO-C36e	Airborne ILS Localizer Receiving Equipment Operating within the Radio Frequency Range of 108-112 Megahertz (MHz)
TSO-C37d	VHF Radio Communications Transmitting Equipment Operating within the Radio Frequency Range 117.975 to 137.000 Megahertz
TSO-C38d	VHF Radio Communications Receiving Equipment Operating within the Radio Frequency Range 117.975 to 137.000 Megahertz
TSO-C40c	VOR Receiving Equipment Operating within the Radio Frequency Range of 108-117.95 Megahertz (MHz)
TSO-C41d	Airborne Automatic Direction Finding (ADF) Equipment
TSO-C43c	Temperature Instruments
TSO-C44b	Fuel Flowmeters
TSO-C46a	Maximum Allowable Airspeed Indicator Systems
TSO-C47	Pressure Instruments – Fuel, Oil, and Hydraulic
TSO-C49b	Electric Tachometer: Magnetic Drag (Indicator and Generator).
TSO-C52b	Flight Director Equipment
TSO-C54	Stall Warning Instruments
TSO-C55	Fuel and Oil Quantity Instruments (Reciprocating Engine Aircraft)
TSO-C63c	Airborne Weather and Ground Mapping Pulsed Radars
TSO-C66c	Distance Measuring Equipment (DME) Operating within the Radio Frequency Range of 960-1215 Megahertz
TSO-C67	Airborne Radar Altimeter Equipment (For Air Carrier Aircraft)
TSO-C87	Airborne Low-Range Radio Altimeter
TSO-C92c	Airborne Ground Proximity Warning Equipment

TSO-C93	Airborne Interim Standard Microwave Landing System Converter Equipment
TSO-C94a	Omega Receiving Equipment Operating within the Radio Frequency Range of 10.2 to 13.6 Kilohertz
TSO-C95	Mach Meters
TSO-C101	Over Speed Warning Instruments
TSO-C104	Microwave Landing System (MLS) Airborne Receiving Equipment
TSO-C105	Optional Display Equipment for Weather and Ground Mapping Radar Indicators
TSO-C106	Air Data Computer
TSO-C110a	Airborne Passive Thunderstorm Detection Equipment
TSO-C113	Airborne Multipurpose Electronic Displays
TSO-C115b	Airborne Area Navigation Equipment Using Multi-Sensor Inputs
TSO-C117a	Airborne Windshear Warning and Escape Guidance Systems for Transport Airplanes
TSO-C118	Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS I
TSO-C119b	Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS II
TSO-C120	Airborne Area Navigation Equipment Using Omega/Very Low Frequency (VLF) Inputs
TSO-C129a	Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS)
TSO-C145a	Airborne Navigation Sensors using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
TSO-C146a	Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented By the Wide Area Augmentation System (WAAS)
TSO-C147	Traffic Advisory System (TAS) Airborne Equipment
TSO-C151b	Terrain Awareness and Warning System
TSO-C153	Integrated Modular Avionics Hardware Elements

TSO-C165	Electronic Map Display Equipment for Graphical Depiction of Aircraft Position

14.4 Industry Documents

Copies of current editions of the following publications may be obtained as follows and may be suitable resource material for additional information, guidance, and standards for electronic flight deck display systems.

(1) ICAO Documents

International Civil Aviation Organization 8400/5. Procedures for Air Navigation Services ICAO Abbreviations and Codes. Fifth Edition- 1999.6.3.4.1

(2) RTCA Documents

Note: The RTCA documents are available from RTCA, Inc., Suite 805, 1828 L Street NW, Washington, DC 20036-4001 or at their website at www.rtca.org. The list of RTCA documents does not include those MOPS documents referenced in the aforementioned TSOs.

DO-160( )	Environmental Conditions and Test Procedures for Airborne Equipment
DO-178( )	Software Considerations in Airborne Systems and Equipment Certification
DO-236( )	Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation
DO-239	Minimum Operational Performance Standards for Traffic Information Service (TIS) Data Link Communications
DO-243	Guidance for Initial Implementation of Cockpit Display of Traffic Information
DO-253A	Minimum Operational Performance Standards for GPS Local Area Augmentation System Airborne Equipment
DO-254	Design Assurance Guidance for Airborne Electronic Hardware
DO-255	Requirements Specification for Avionics Computer Resource (ACR)
DO-257A	Minimum Operational Performance Standards for the Depiction of Navigation Information on Electronic Maps
DO-259	Applications Descriptions for Initial Cockpit Display of Traffic Information (CDTI) Applications
DO-268	Concept of Operations, Night Vision Imaging System for Civil Operators
DO-275	Minimum Operational Performance Standards for Integrated Night Vision Imaging System Equipment

DO-282A	Minimum Operational Performance Standards (MOPS) for Universal Access Tranceiver (UAT) Automatic Dependent Surveillance - Broadcast
DO-283A	Minimum Operational Performance Standards for Required Navigation Performance for Area Navigation
D0-286	Minimum Aviation System Performance Standards (MASPS) for Traffic Information Service – Broadcast (TIS-B).
DO-289	Minimum Aviation System Performance Standards (MASPS) for Aircraft Surveillance Applications.
D0-296	Safety Requirements for Aeronautical Operational Control (AOC) Datalink Messages.

(3) EUROCAE documents

Note: The EUROCAE documents are available from EUROCAE, 102 rue Etienne Dolet 92240, Malakoff, France or at their website at *www.eurocae.org.* The list of EUROCAE documents does not include those MOPS documents referenced in the aforementioned ETSO's.

ED-12( )	Software Considerations in Airborne Systems and Equipment Certification
ED-14( )	Environmental Conditions and Test Procedures for Airborne Equipment
ED-55	MOPS for Flight Data Recorder Systems
ED-75( )	MASPS Required Navigation Performance for Area Navigation
ED-79	Certification Considerations for Highly Integrated or Complex Aircraft Systems
ED-80	Design Assurance Guidance for Airborne Electronic Hardware
ED-81	Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning
ED-84	Aircraft Lightning Environment and Related Test Waveform Standard
ED-90A	Radio Frequency Susceptibility Test procedures
ED-91	Aircraft Lightning Zoning Standard
ED-96	Requirements Specification for an Avionics Computer Resource (See Kirk)
ED-98	User Requirements for Terrain and Obstacle Data
ED-107	Guide for Certification of Aircraft in a High Intensity Radiated Field (HIRF) Environment
ED-112	MOPS for Crash Protected Airborne Recorder Systems

(4) Society of Automotive Engineers

Note: The Society of Automotive Engineers (SAE International) documents are available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or from their website at www.sae.org.

AS 425C Nomenclature and Abbreviations, Flight Deck Area

ARP426A Compass System Installations

AS 439A Stall Warning Instrument (Turbine Powered Subsonic Aircraft)

ARP 571C Flight Deck Controls and Displays for Communication and Navigation Equipment for Transport Aircraft

AIR818D Aircraft Instrument and Instrument System Standards: Wording, Terminology, Phraseology, and Environmental and Design Standards For

ARP 926B Fault/Failure Analysis Procedure

AIR 1093A Numeral, Letter and Symbol Dimensions for Aircraft Instrument Displays

ARP 1161A Crew Station Lighting—Commercial Aircraft

ARP 1782A Photometric and Colorimetric Measurement Procedures for Airborne Direct View CRT Displays

ARP 1834A Fault/Failure Analysis for Digital Systems and Equipment

ARP 1874 Design Objectives for CRT Displays for Part 25 (Transport) Aircraft

ARP 4032A Human Engineering Considerations in the Application of Color to Electronic Aircraft Displays

ARP 4033 Pilot System Integration

ARP 4101 Flight Deck Layout and Facilities

ARP 4102 Flight Deck Panels, Controls, and Displays

ARP 4102/7 Electronic Displays

ARP4102/8 Flight Deck Head-Up Displays

ARP4102/15 Electronic Data Management System (EDMS)

ARP 4103 Flight Deck Lighting for Commercial Transport Aircraft

ARP 4105B Abbreviations and Acronyms for Use on the Flight Deck

ARP 4256A Design Objectives for Liquid Crystal Displays for Part 25 (Transport) Aircraft

ARP 4260 Photometric and Colorimetric Measurement Procedures for Airborne Flat Panel Displays

ARP 4754 Certification Considerations for Highly Integrated or Complex Aircraft Systems

ARP 4761 Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment

ARP 5287 Optical Measurement Procedures for Airborne Head-Up Display (HUD)

ARP 5288 Transport Category Airplane Head Up Display (HUD) Systems

ARP 5289 Electronic Aeronautical Symbols

ARP 5364 Human Factor Considerations in the Design of Multifunction Display Systems for Civil Aircraft

ARP 5365 Human Interface Criteria for Cockpit Display of Traffic Information

ARP5413 Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning

ARP5414 Aircraft Lightning Zoning

ARP5415A Users Manual for Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lighting

AS 8034 Minimum Performance Standard for Airborne Multipurpose Electronic Displays

AS 8055 Minimum Performance Standard for Airborne Head Up Display (HUD)

ARD 50017 Aeronautical Charting (NOTE: Unable to locate in SAE database)

ARD 50062 Human Factors Issues Associated With Terrain Separation Assurance Display Technology (NOTE: Unable to locate in SAE database)

NOTE: In the event of conflicting information, this AC takes precedence as guidance for certification of transport category airplane installations.

(5) ARINC Documents

ARINC 661 – Cockpit Display System Interfaces to User Systems

(6) Other Documents

Commissions Internationale de L'Eclairage (CIE) pub number 15.2, Colorimetry, second edition 1986).

Appendix A: Primary Flight Information (PFI)

This section provides additional guidance on the display of primary flight information elements, which is the information whose presentation is required by 25.1303(b), 1333(b) and arranged by 1321(b).

A.1 Attitude

Pitch attitude display scaling should be such that during normal maneuvers (such as takeoff at high thrust-to-weight ratios) the horizon remains visible in the display with at least 5 degrees pitch margin available.

An accurate, easy, quick-glance interpretation of attitude should be possible for all unusual attitude situations. Information to perform effective manual recovery from unusual attitudes using chevrons, sky pointers, and/or permanent ground-sky horizon on all attitude indications is recommended.

Both fixed airplane reference and fixed earth reference bank pointers ("sky" pointers) have been found to be acceptable as a reference point for primary attitude information. A mix of these types in the same flight deck is not recommended.

There should be a means to determine the margin to stall and display it when necessary. For example, a pitch limit indication has been found to be acceptable.

There should be a means to identify an excessive bank angle condition prior to stall buffet.

Sideslip should be clearly indicated to the flight crew (e.g. split trapezoid on attitude indicator), and an indication of excessive sideslip should be provided.

A.1.2 Continued function of primary flight information (including standby) in conditions of unusual attitudes or in rapid maneuvers

Primary flight information must continue to be displayed in conditions of unusual attitudes or in rapid maneuvers (25.1303). The pilot must also be able to rely on primary or standby instrument information for recovery in all attitudes and at the highest pitch, roll and yaw rates that may be encountered (25.1333).

In showing compliance with the requirements of 14 CFR §§ 25.1301(d) and 25.1309(a), (b), (c) and (d), the analysis and test program must consider the following conditions that might occur due to pilot action, system failures or external events:

- abnormal attitude (including the airplane becoming inverted);
- excursion of any other flight parameter outside protected flight boundaries; or
- flight conditions that may result in higher than normal pitch, roll or yaw rates.

For each of the conditions identified above, primary flight displays and standby indicators must continue to provide useable attitude, altitude, airspeed and heading information and any other information that the pilot may require to execute recovery from the unusual attitude and/or arrest the higher than normal pitch, roll or yaw rates.

A.2 Airspeed and Altitude

Airspeed and altitude displays should be able to convey to the flight crew a quick-glance sense of the present speed or altitude. Conventional round-dial moving pointer displays inherently give some of this sense that may be difficult to duplicate on moving scales. Scale length is one attribute related to this quick-glance capability. The minimum visible airspeed scale length found acceptable for moving scales has been 80 knots; since this minimum is dependent on other scale attributes and airplane operational speed range, variations from this should be verified for acceptability.

Altimeters present special design problems in that: (1) the ratio of total usable range to required resolution is a factor of 10 greater than for airspeed or altitude, and (2) the consequences of losing sense of context of altitude can be detrimental. The combination of altimeter scale length and markings, therefore, should be adequate to allow sufficient resolution for precise manual altitude tracking in level flight, as well as enough scale length and markings to reinforce the flight crew's sense of altitude and to allow sufficient look-ahead room to adequately predict and accomplish level-off. Addition of radio altimeter information on the scale so that it is visually related to ground position may be helpful in giving low altitude awareness.

Airspeed scale markings that remain relatively fixed (such as stall warning, VMO/MMO), or that are configuration dependent (such as flap limits), should be displayed to provide the flight crew a quick-glance sense of speed. The markings should be predominant enough to confer the quick-glance sense information, but not so predominant as to be distracting when operating normally near those speeds (e.g., stabilized approach operating between stall warning and flap limit speeds).

Low speed awareness cues should provide adequate visual cues to the pilot that the airspeed is below the reference operating speed for the airplane configuration (i.e., weight, flap setting, landing gear position, etc.); similarly, high speed awareness cues should provide adequate visual cues to the pilot that the airspeed is approaching an established upper limit that may result in a hazardous operating condition.

- The cues should be readily distinguishable from other markings such as V-speeds and speed targets (bugs). The cues should indicate not only the boundary value of speed limit, but must clearly distinguish between the normal speed range and the unsafe speed range beyond those limiting values CFR §§ 25.1545. Cross-hatching may be acceptable to provide delineation between zones of different meaning.

- The display requirements for airspeed awareness cues are in addition to other alerts associated with exceeding high and low speed limits, such as the stick shaker and aural overspeed warning.

Airspeed reference marks (bugs) on conventional airspeed indicators perform a useful function, and the implementation of them on electronic airspeed displays is encouraged. Computed airspeed/angle-of-attack reference marks (bugs) such as Vstall, Vstall warning, V1, VR, V2, flap limit speeds, etc., displayed on the airspeed scale will be evaluated for accuracy. Provision should be incorporated for a reference mark that will reflect the current target airspeed of the flight guidance system. This has been required in the past for some systems that have complex speed selection algorithms, in order to give the flight crew adequate information required by § 25.1309(c) for system monitoring.

Numeric only indications of airspeed and altitude have been accepted during specific phases of flight (e.g. HUD during approach) in combination with other cues (e.g. acceleration) in order to reduce display clutter. If a numeric only indication of airspeed/altitude is provided, there should still remain a system level awareness of airspeed/altitude, airspeed/altitude trends, deviations from selected airspeed/altitude targets, low and high airspeed limits, and selected airspeed/altitude setting changes.

Scale units marking for air data displays incorporated into PFDs are not required ("knots," "airspeed" for airspeed, "feet," "altitude" for altimeters) as long as the content of the readout remains unambiguous. For altimeters with the capability to display in both English and Metric units, the scale and primary present value readout should remain scaled in English units with no units marking required; the Metric display should consist of a separate present value readout that does include units marking.

Airspeed scale graduations found to be acceptable have been in 5-knot increments with graduations labeled at 20-knot intervals. In addition, a means to rapidly identify a change in airspeed (e.g. speed trend vector or acceleration cue) should be provided; if trend or acceleration cues are used, or a numeric present value readout is incorporated, scale markings at 10-knot intervals have been found acceptable.

Minimum altimeter graduations should be in 100-foot increments with a present value readout, or 50-foot increments with a present value index only. Due to operational requirements, it is expected that airplanes without either 20-foot scale graduations, or a readout of present value, will not be eligible for Category II low visibility operation with barometrically determined decision heights.

Vertically oriented moving scale airspeed indication is acceptable with higher numbers at the top or bottom if no airspeed trend or acceleration cues are associated with the speed scale. Such cues should be oriented so that increasing energy or speed results in upward motion of the cue. To be consistent with this convention, airspeed scales with these cues should have the high speed numbers at the top. Speed, altitude, or vertical rate trend indicators should have appropriate hysteresis and damping to be useful and non-distracting. Evaluation should include turbulence expected in service.

A.3 Vertical Speed

The display range of Vertical Speed (or rate of climb) indications should be consistent with the climb/descent performance capabilities of the aircraft. If the RA is integrated with the primary vertical speed indication, the range of vertical speed indication should be sufficient to display the red and green bands for all TCAS resolution advisory (RA) information.

A.4 Flight Path Vector / Symbol

The display of Flight Path Vector (FPV or velocity vector) or Flight Path Angle (FPA) cues on the primary flight display is not required, but may be included in many designs.

Definition of terms regarding the display of flight path:

- Earth Referenced System – Inertial-based system which provides an inertially-derived display of flight path through space. In a descent, an earth-referenced system will indicate point of impact (i.e. runway touchdown point) if displayed.
- Air Mass System – An air mass based system which provides a heading/airspeed/vertical velocity derived flight path presentation. It depicts the flight path through an air mass, will not account for air mass disturbances such as wind drift and windshear, and therefore cannot be relied on to show the point of impact on the earth's surface.
- Flight Path Angle (FPA) (also known as a Flight Path Symbol or "caged" Flight Path Vector in various designs) - A dynamic symbol displayed on an attitude display that depicts the vertical angle relative to the artificial horizon, in the pitch axis, that the airplane is moving. A flight path angle is the vector resultant of the forward velocity and the vertical velocity. For most designs, the FPA is earth referenced, though some use air mass vectors. Motion of the FPA on the attitude display is in the vertical (pitch) axis only with no lateral motion.
- Flight Path Vector (FPV) (also known as Velocity Vector) - A dynamic symbol displayed on an attitude display that depicts the vector resultant of real-time flight path angle (vertical axis) and lateral angle relative to airplane heading created by wind drift and slip/skid. For most designs, the FPV is earth referenced, though some use air mass vectors which cannot account for wind effects.
- HUD (Heads Up Display) - A display system that projects primary flight information (e.g., attitude, air data, guidance, etc.) on a transparent screen (combiner) in the pilot's forward field of view, between the pilot and the windshield. This allows the pilot to simultaneously use the flight information while looking along the forward path out the windshield, without scanning the head down displays. The flight information symbols should be presented as a virtual image focused at optical infinity. Attitude and flight path symbology needs to be conformal (i.e., aligned and scaled) with the outside view.

- HDD (Heads Down Display) - Aircraft primary flight display located on the aircraft main instrument panel directly in front of the pilot in the pilot's primary field of view. The HDD is located below the windscreen and requires the flight crew to look below the glareshield in order to use the HDD to fly the aircraft.
- FPV/FPA-referenced Flight Director (FD) - HUD or HDD flight director cue in which the pilot "flies" the FPV/FPA cue to the FD command in order to comply with flight guidance commands. This is different from attitude FD guidance where the pilot "flies" the aircraft (i.e., pitch, boresight) symbol to follow pitch and roll commands.

The FPV symbol is essential to certain Head-Up Display (HUD) applications. FPV display on the HUD should be conformal with the outside view when within the HUD field of view. During flight situations with large bank, pitch and/or wind drift angles, the movement of the FPV may be limited by the available display field-of-view. In some designs, the pilot can manually cage the FPV which restricts its motion to the vertical axis, thereby making it an FPA.

The FPV or FPA indication may also be displayed on the HDD. In some HDD applications, the FPV or FPA is the primary control and tracking cue for controlling the airplane during most phases of flight. Even though an FPV or FPA indication may be used as a primary flight control parameter, the attitude pitch and roll symbols (i.e., waterline or boresight) which are still required primary indications by 14 CFR §25.1303 must still be prominently displayed. In dynamic situations, constant availability of attitude or flight path control parameters is required.

Considerations for presentation of FPV/FPA; If the FPV/FPA is used as the primary means to control the airplane in pitch and roll, the FPV/FPA system design must allow pilots to control and maneuver the airplane with a level of safety that is at least equal to traditional designs based on attitude (CFR §§ 25.1333(b)).

Aircraft designs may exist where the HUD is a FPV presentation and the HDD is a FPA presentation. For these situations, some correlation between the HUD FPV display and the PFD FPA display should exist. Vertical axis presentation of FPV/FPA should be consistent. The pilot should be able to interpret and respond to them similarly.

It should be easy and intuitive to perform cognitive switching between FPV/FPA and attitude when necessary. Primary Flight Display of FPV/FPA symbology must not interfere with the display of attitude and there must always bebe attitude symbology at the top center of the pilot's primary field of view, as required by 14CFR 25.1321.

Airplane designs which display flight path symbology on the HUD and the HDD should use consistent symbol shapes (i.e., the HUD FPV symbol looks like the HDD FPV).

In cases where an FPV is displayed head up and an FPA head down, the symbols for each should not have the same shape. When different types of flight path indications may be displayed, head up and/or head down, the symbols should be easily distinguished to avoid any misinterpretation by the flight crew members.

The normal FPV, the field-of-view limited FPV and the caged FPV (i.e.,FPA) should each have a distinct appearance, so that the pilot is aware of the restricted motion, or non-conformality.

Implementation of Air Mass based FPV/FPA presentations should account for inherent limitations of air mass flight path computations.

Considerations for Flight Director Guidance Based on FPV/FPA;

FPV/FPA based flight directors should provide some lateral movement to the lateral flight director guidance cue during bank commands.

To show compliance with §25.1303(b)(5), §25.1301(a), and §25.143(b), the FPV/FPA FD design must:

1. Have no characteristics that may lead to oscillatory control inputs.
2. Provide sufficiently effective and salient cues to support all expected maneuvers in longitudinal, lateral, and directional axes.
3. Have no inconsistencies between cues provided on the HUD and HDD displays that may lead to pilot confusion or have adverse affects on pilot performance.

Performance and system safety requirements for flight guidance systems (e.g., FGS, Category II/III, takeoff) are found in Advisory Circulars 25.1329B, 120-29A and 120-28D, and CS-AWO.

Appendix B: Powerplant Indications

To comply with a provision of §25.1305 a display should provide all the instrument functionality of a full time dedicated analog type instrument as intended when the rule was adopted (ref. AC20-88A). The design flexibility and conditional adaptability of modern displays were not envisioned when §25.1305 "Powerplant instruments" and §25.1549 "Powerplant and auxiliary power unit instruments" were initially adopted. In addition, the capabilities of modern control systems to automate and complement flight crew functions were not envisioned. In some cases these system capabilities obviate the need for a dedicated full-time analog type instrument.

When making a finding, all uses of the affected displays should be taken into consideration, including:

(1) Flight deck indications to support the approved operating procedures [re: §25.1585],

(2) Indications as required by the powerplant system safety assessments [re: §25.1309]

(3) Indications required in support of the instructions for continued airworthiness [re: §25.1529]

Example:
Compliance with §25.1305(c)(3) for the engine N2 rotor was originally achieved by means of a dedicated full time analog instrument. This provided the continuous monitoring capability required to:

- support engine starting (e.g. typically used to identify fuel on point);
- support power setting (e.g. sometimes used as primary or back up parameter);
- "give reasonable assurance that those engine operating limitations that adversely affect turbine rotor structural integrity will not be exceeded in service" as required by §25.903(d)(2);
- provide the indication of normal, precautionary and limit operating values required by §25.1549; as well as
- support detection of unacceptable deterioration in the margin to operating limits and other abnormal engine operating conditions as required to comply with §§25.901, 25.1309, etc.

As technology evolved Full Authority Digital Engine Controls (FADECs) were introduced. FADECs were designed with the ability to monitor and control engine N2 rotor speed as required to comply with §25.903(d)(2). Additionally, engine condition monitoring programs were introduced and used to detect unacceptable engine deterioration. Flight deck technology evolved such that indications could be displayed automatically to cover abnormal engine operating conditions. The combination of these developments obviated the need for a full time analog N2 rotor speed indication.

B.2 Additional Design Guidelines

Safety-related engine limit exceedances should be indicated in a clear and unambiguous manner. Flight crew alerting is addressed in 14CFR/CS §25.1322.

If an indication of significant thrust loss is provided it should be presented in a clear and unambiguous manner.

The following design guidelines are to be considered in addition to the failure conditions listed in Section 6.5.7:

1) For single failures leading to the non-recoverable loss of any indications on an engine, sufficient indications should remain to allow continued safe operation of the engine [ref. §25.901(b)(2), §25.901(c), §25.903(d)(2)]
2) For engine indications that are required during engine re-start, they should be readily available after an engine out event. (ref. §25.901(b)(2), §25.901(c) §25.903(d)(2), §25.903(e), §25.1301, §25.1305 §25.1309).

that provision would otherwise prevent the U.S. Executive Directors of the EBRD from voting in favor of these projects.

This Determination shall be reported to the Congress and published in the **Federal Register**.

Dated: July 10, 2006.

Daniel Fried,

Assistant Secretary of State for European and Eurasian Affairs, Department of State.

[FR Doc. E6–11114 Filed 7–13–06; 8:45 am]

BILLING CODE 4710–22–P

DEPARTMENT OF TRANSPORTATION

Federal Aviation Administration

Aviation Rulemaking Advisory Committee Meeting on Transport Airplane and Engine Issues

AGENCY: Federal Aviation Administration (FAA), DOT.

ACTION: Notice of public meeting.

SUMMARY: This notice announces a public meeting of the FAA's Aviation Rulemaking Advisory Committee (ARAC) to discuss transport airplane and engine (TAE) issues.

DATES: The meeting is scheduled for Thursday, August 3, 2006, starting at 11 am eastern daylight time. Arrange for oral presentations by July 28, 2006.

ADDRESSES: Federal Aviation Administration, 800 Independence Ave., SW., Room 810, Washington, DC 20591.

FOR FURTHER INFORMATION CONTACT: John Linsenmeyer, Office of Rulemaking, ARM–207, FAA, 800 Independence Avenue, SW., Washington, DC 20591, Telephone (202) 267–5174, FAX (202) 267–5075, or e-mail at *john.linsenmeyer@faa.gov*.

SUPPLEMENTARY INFORMATION: Pursuant to section 10(a)(2) of the Federal Advisory Committee Act (Pub. L. 92–463; 5 U.S.C. app. III), notice is given of an ad hoc ARAC meeting to be held August 3, 2006 at the Federal Aviation Administration, 800 Independence Ave., Room 810, Washington, DC. The meeting/teleconference is being held to consider the report on new advisory material from the Avionics Systems Harmonization Working Group (ASHWG). The report from the ASHWG is a critical part of FAA's effort to develop new guidance for integration of new electronic flight deck display systems for transport category airplanes.

The agenda will include:

- Opening Remarks.
- ASHWG Report.
- FAA update on future activities regarding Advisory Circular 25–11.

Attendance is open to the public, but will be limited to the availability of meeting room space. Please confirm your attendance with the person listed in the **FOR FURTHER INFORMATION CONTACT** section no later than July 28, 2006. Please provide the following information: Full legal name, country of citizenship, and name of your industry association, or applicable affiliation. If you are attending as a public citizen, please indicate so.

For persons participating domestically by telephone, the call-in number is (202) 366–3920; the Passcode is ''8348'' To insure that sufficient telephone lines are available, please notify the person listed in the **FOR FURTHER INFORMATION CONTACT** section of your intent to participate by telephone by July 28, 2006. Anyone calling from outside the Washington, DC metropolitan area will be responsible for paying long-distance charges.

The public must make arrangements by July 28, 2006, to present oral statements at the meeting. Written statements may be presented to the committee at any time by providing 25 copies to the Assistant Executive Director for Transport Airplane and Engine Issues or by providing copies at the meeting. Copies of the document to be presented to ARAC for decision by the FAA may be made available by contacting the person listed in the **FOR FURTHER INFORMATION CONTACT** section.

If you need assistance or require a reasonable accommodation for the meeting or meeting documents, please contact the person listed in the **FOR FURTHER INFORMATION CONTACT** section. Sign and oral interpretation, as well as a listening device, can be made available if requested 10 calendar days before the meeting.

Issued in Washington, DC on July 10, 2006.

Tony F. Fazio,

Director, Office of Rulemaking.

[FR Doc. E6–11111 Filed 7–13–06; 8:45 am]

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DEPARTMENT OF TRANSPORTATION

Federal Motor Carrier Safety Administration

[Docket No. FMCSA–2006–25074]

Notice of Request for Comments on Extension of a Currently Approved Information Collection: OMB Control Number 2126–0031 (Annual and Quarterly Report of Class I Motor Carriers of Passengers) (Formerly OMB 2129–0003)

AGENCY: Federal Motor Carrier Safety Administration (FMCSA), DOT.

ACTION: Notice; request for comments.

SUMMARY: In accordance with the Paperwork Reduction Act of 1995, the Federal Motor Carrier Safety Administration announces its intent to submit a currently approved Information Collection Request (ICR), Annual and Quarterly Report of Class I Motor Carriers of Passengers, to the Office of Management and Budget (OMB) for review and approval. The ICR describes the relevant information collection activities and their expected costs and burdens. The Agency published a **Federal Register** notice providing a 60-day comment period on this ICR in April 2006 (71 FR 18136, Apr. 10, 2006). The Agency received two comments in support of continuation of this information collection.

DATES: Comments must be submitted on or before August 14, 2006. A comment to OMB is most effective if OMB receives it within 30 days of this publication.

ADDRESSES: Send comments to the Office of Information and Regulatory Affairs, Office of Management and Budget, 725 Seventeenth Street, NW., Washington, DC 20503, Attention: DOT/FMCSA Desk Officer.

FOR FURTHER INFORMATION CONTACT: Ms. Toni Proctor, Federal Motor Carrier Safety Administration, Office of Research and Analysis, Washington, DC 20590; phone (202) 366–2998; Fax (202) 366–3518; e-mail *Toni.Proctor@dot.gov.* Office hours are from 8 a.m. to 4 p.m., e.t., Monday through Friday, except Federal holidays.

SUPPLEMENTARY INFORMATION:

Title: Annual and Quarterly Report of Class I Motor Carriers of Passengers (formerly OMB Control Number 2129–0003). On September 29, 2004, the Secretary of Transportation (Secretary) transferred this information collection (IC) from the Bureau of Transportation Statistics (BTS), now a part of the Research and Innovative Technology