



AEROSPACE STANDARD

AS6296™

Issued

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Electronic Flight Instrument System (EFIS) Displays

RATIONALE

Historically, FAA Technical Standard Orders (TSOs) and associated industry Minimum Operational Performance Specifications (MOPS) were developed to address sensor and indicator requirements for single functions, such as airspeed, altitude, or fuel flow. In contrast, modern Electronic Flight Instrument System (EFIS) displays normally present indications for multiple functions, but do not normally include the sensor. Until now, a MOPS did not exist to address the operational/functional requirements for such an EFIS display.

Requirements for this type of EFIS typically consist of a few requirements for each function, drawn from many TSOs and associated MOPS. As a result, TSO applications for EFIS displays have multiple deviations to many TSOs and may include incomplete TSO authorizations. This document is intended to facilitate EFIS TSO authorizations by addressing only the EFIS display requirements for a broad set of aircraft functions.

This document provides criteria for EFIS displays that are intended for use in the flight deck by the flight crew in aircraft to include, but not limited to, Title 14 CFR Part 23, 25, 27, and 29.

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1. SCOPE

This SAE Aerospace Standard (AS) specifies minimum performance standards for Electronic Flight Information System (EFIS) displays that are head-down and intended for use in the flight deck by the flight crew in all 14 CFR Part 23, 25, 27, and 29 aircraft. This document is expected to be used by multiple regulatory agencies as the basic requirement for a technical standard order for EFIS displays.

The requirements and recommendations in this document are intended to apply to, but are not limited to, the following types of display functions:

- Primary Flight and Primary Navigation displays, including vertical situation and horizontal situation functions.
- Displays that provide flight crew alerts, which may include engine instrument, aircraft systems information/control.
- Control displays including communication, navigation and system control displays.
- Information displays, which may include navigation displays used for situation awareness only, supplemental data, and maintenance and documentation displays.
- Display Systems including a Display Unit (display) and a symbol generator.

The display functions herein were based on the display aspects of functions covered by previous TSOs that included an end-to-end system, including sensors.

This document does not address video display terminals or video monitors without the means to generate symbols. The symbol generating function may be contained within the display or may be external to the display unit and part of the display system.

This document is not intended to address the display of single function equipment (e.g., airspeed). Two functions are required as a minimum.

This document does not address the sensors or computational engines (e.g., TAWs computer, navigation computer, or TCAS processor) that transmit their data to the EFIS display.

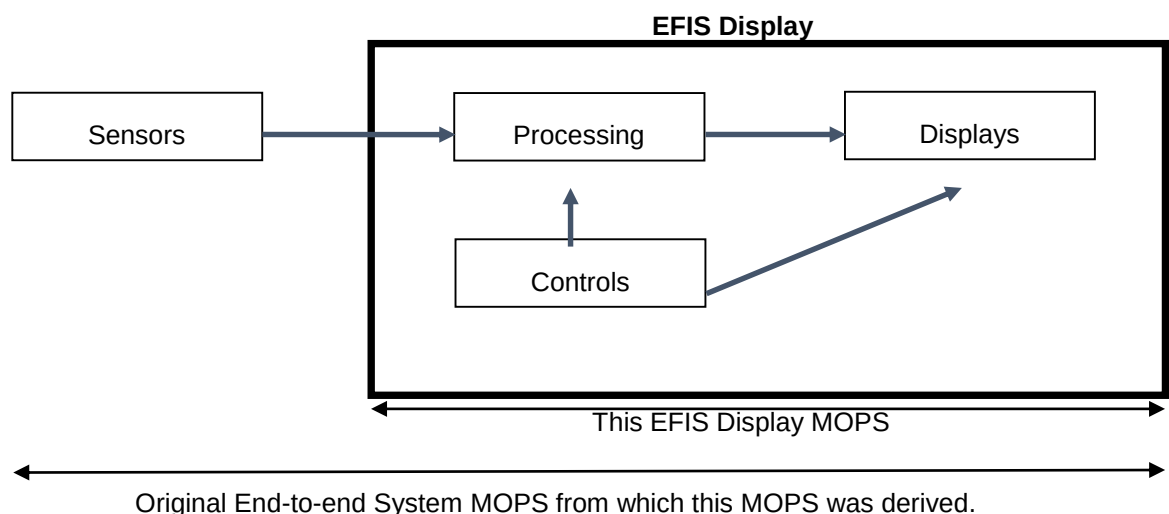


Figure 1 - Electronic Flight Instrument System (EFIS) functions covered by this MOPS

Functions that are not covered in this document include: Overspeed Warning; Air Traffic Control Radar Beacon System (ATCRBS)/Mode Select (Mode S); Automatic Dependent Surveillance - Broadcast (ADS-B); Traffic Information System - Broadcast (TIS-B); Electronic Map Display; Synthetic Vision; Enhanced Vision; Head-Up Displays (HUD); and Head Worn Displays (HWD).

This document does address the following types of control functions:

- Control functions related to the data presented on the EFIS display(s).
- Control means that are integrated into the displays.

NOTE: This document is expected to be used for a technical standard order for EFIS displays. This document does not address the hardware, physical, or optical (ocular) requirements of the EFIS displays. Those requirements are addressed in AS8034B. This document is subject to change to keep pace with experience and technical advances.

Many functions often included in an EFIS in existing systems were considered for this MOPS. In general, the functions that were not included here were excluded because it was too complicated to extract and separate the display requirements from the sensor requirements. In other cases, the display requirements in the original MOPS were too extensive to add to this document without essentially replicating the original MOPS. Applicants will need to apply separately for approval for those functions.

2. REFERENCES

The documents listed in 2.1 are those referenced within various parts of this document as guidance or direction. The documents listed in 2.2 are provided for informational purposes only and do not form a part of the requirements of this document.

2.1 Applicable Documents

The following publications form a part of this document only to the extent that they are explicitly invoked by the requirements within this Aerospace Standard (AS). The latest issue of all SAE International publications shall apply except in cases where referring documents call out specific versions. In the event of conflict between these documents and this standard, the contents of this standard shall govern.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AIR1093	Numerical, Letter and Symbol Dimensions for Aircraft Instrument Displays
ARP4102/7	Electronic Displays
ARP4761	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment
ARP5289	Electronic Aeronautical Symbols
ARP5621	Electronic Display of Aeronautical Information (Charts)
AS8034B	Minimum Performance Standard for Airborne Multipurpose Electronic Displays

2.1.2 Code of Federal Regulations (CFR)

Copies of 14 CFR parts 21 and 45 are available from the Superintendent of Documents, U.S. Government Printing Office (GPO), P.O. Box 979050, St. Louis, MO 63197, Tel: (202) 512-1800, fax (202) 512-2250. You can also order copies online at www.access.gpo.gov. Select "Access," then "Online Bookstore." Select "Aviation," then "Code of Federal Regulations."

Copies also available digitally at no cost from the GPO's Electronic Code of Federal Regulations website, at: http://www.ecfr.gov/cgi-bin/text-idx?&c=ecfr&tpl=/ecfrbrowse/Title14/14tab_02.tpl,

or from the FAA's Regulatory and Guidance Library (RGL), at http://rgl.faa.gov/Regulatory_and_Guidance_Library/rgFinalRule.nsf/MainFrame?OpenFrameset.

Title 14, CFR Part 21, Certification Procedures for Products and Parts, and particularly, Subpart O, Technical Standard Order Approvals

Title 14, CFR Part 45, Identification and Registration Marking, and particularly, Subpart B, Marking of Products and Articles, section §45.15.

2.1.3 RTCA/EUROCAE Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

Order EUROCAE documents from EUROCAE, 102 rue Etienne Dolet, 92240 Malakoff France. Telephone 33 (0) 1 4092 7930, fax 33 (0) 1 4655 6265. You can also order from the EUROCAE Internet website at www.eurocae.net.

DO-143	Minimum Performance Standards - Airborne Radio Marker Receiving Equipment Operating on 75 MHz
DO-161A	Minimum Performance Standards - Airborne Ground Proximity Warning Equipment
DO-163	Minimum Performance Standards - Airborne High Frequency Radio Communications Transmitting and Receiving Equipment Operating Within the Radio-Frequency Range 1.5 - 30 MHz
DO-173	Minimum Operational Performance Standards for Airborne Weather and Ground Mapping Pulsed Radars
DO-174	Minimum Operational Performance Standards for Optional Equipment Which Displays Non-Radar-Derived Data on Weather and Ground Mapping Radar Indicators
DO-177	Minimum Operational Performance Standards for Microwave Landing System (MLS) Airborne Receiving Equipment
DO-179	Minimum Operational Performance Standards for Automatic Direction Finding (ADF) Equipment
DO-185B	Minimum Operational Performance Standards for Traffic Alert and Collision Avoidance Systems II (TCAS II)
DO-186B	Minimum Operational Performance Standards for Airborne Radio Communications Equipment Operating Within the Radio Frequency Range 117.975-137.000 MHz
DO-189	Minimum Operational Performance Standards for Airborne Distance Measuring Equipment (DME) Operating within the Radio Frequency Range of 960-1215 MHz
DO-191	Minimum Operational Performance Standards for Airborne Thunderstorm Detection Equipment
DO-192	Minimum Operational Performance Standards for Airborne ILS Glide Slope Receiving Equipment Operating Within the Radio Frequency Range of 328.6-335.4 Megahertz

DO-195	Minimum Operational Performance Standards for Airborne ILS Localizer Receiving Equipment Operating within the Radio Frequency Range of 108-112 Megahertz
DO-196	Minimum Operational Performance Standards for Airborne VOR Receiving Equipment Operating Within the Radio Frequency Range of 108- 117.95 Megahertz
DO-197A	Minimum Operational Performance Standards for an Active Traffic Alert and Collision Avoidance System I (Active TCAS I)
DO-220	Minimum Operational Performance Standards (mops) For Airborne Weather Radar with Forward-looking Windshear Detection Capability
DO-229D	Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment
DO-257A	Minimum Operational Performance Standards for the Depiction of Navigational Information on Electronic Maps
DO-267A	Minimum Aviation System Performance Standards (MASPS) for Flight Information Services-Broadcast (FIS-B) Data Link
DO-283A	Minimum Operational Performance Standards for Required Navigation Performance for Area Navigation
DO-309	Minimum Operational Performance Standards (MOPS) for Helicopter Terrain Awareness and Warning System (HTAWS) Airborne Equipment
DO-325	Minimum Operational Performance Standards (MOPS) for Automatic Flight Guidance and Control Systems and Equipment
DO-334	Minimum Operational Performance Standards (MOPS) for Strapdown Attitude and Heading Reference Systems (AHRS)
ED-30	Minimum Performance Standards for Airborne Low-Range Radio (Radar) Altimeter Equipment

2.2 Related Informational Publications

The following publications are provided for information purposes only and are not a required part of this SAE Aerospace Technical Report.

2.2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AS392	Altimeter, Pressure Actuated Sensitive Type
AS396	Bank and Pitch Instruments (Indicating Stabilized Type) (Gyroscopic Horizon, Attitude Gyro)
AS404	Electric Tachometer: Magnetic Drag (Indicator & Generator)
AS405	Fuel and Oil Quantity Instruments
AS407	Fuel Flowmeters
AS408	Pressure Instruments - Fuel, Oil and Hydraulic (Reciprocating Engine Powered Aircraft)

AS8001	Minimum Performance Standard for Bank & Pitch Instruments
AS8004	Minimum Performance Standard for Turn and Slip Instrument
AS8005	Minimum Performance Standard Temperature Instruments
AS8009B	Pressure Altimeter Systems
AS8013	Minimum Performance Standard for Direction Instrument, Magnetic (Gyroscopically Stabilized)
AS8016	Vertical Velocity Instrument (Rate-of-Climb)
AS8018	Minimum Performance Standard for Mach Meters
AS8019	Airspeed Instruments
AS8021	Minimum Performance Standard for Direction Instrument, Non-Magnetic (Gyroscopically Stabilized)
AS8042	Manifold Pressure Instruments

2.2.2 FAA Reference Documents

2.2.2.1 Advisory Circulars and Orders

AC 20-41A	Substitute Technical Standard Order (TSO) Aircraft Equipment
AC 21-43A	Production Under 14 CFR Part 21, Subparts F, G, K, and O
AC 20-175	Controls for Flight Deck Systems
AC 25-11B	Electronic Flight Displays (Note: In the EASA system, AMC 25-11 is technically similar).

2.2.2.2 FAA Orders

8120.22	Production Approval Procedures
8150.1C	Technical Standard Order Program

2.2.2.3 FAA Technical Standard Orders

A current list of Technical Standard Orders (TSOs) and advisory circulars can be found on the FAA Internet website Regulatory and Guidance Library (RGL) at <http://rgl.faa.gov>.

TSO-C2d	Airspeed Instruments
TSO-C3e	Turn and Slip Instrument
TSO-C4c	Bank and Pitch Instruments
TSO-C5f	Direction Instrument, Non-Magnetic
TSO-C6e	Direction Instrument, Magnetic (Gyroscopically Stabilized)
TSO-C8e	Vertical Velocity Instruments
TSO-C10b	Altimeter, Pressure Actuated, Sensitive Type

TSO-C34e	ILS Glide Slope Receiving Equipment Operating Within the Radio Frequency Range of 328.6-335.4
TSO-C35d	Airborne Radio Marker Receiving Equipment (a.k.a. Radio Marker Beacon)
TSO-C36e	Airborne ILS Localizer Receiving Equipment Operating within the Radio Frequency Range of 108-112 (a.k.a. ILS Localizer)
TSO-C40c	VOR Receiving Equipment Operating Within the Radio Frequency Range of 108-117.95 Megahertz (MHz)
TSO-C41d	Automatic Direction Finding (ADF) Equipment
TSO-C43c	Temperature Instruments
TSO-C44c	Fuel Flowmeters
TSO-C45b	Manifold Pressure Instruments
TSO-C46a	Maximum Allowable Airspeed Indicator Systems
TSO-C47a	Fuel, Oil, and Hydraulic Pressure Instruments
TSO-C49b	Electric Tachometer: Magnetic Drag (Indicator and Generator)
TSO-C55a	Fuel and Oil Quantity Instruments
TSO-C63d	Airborne Weather Radar Equipment (a.k.a. Predictive Windshear)
TSO-C66c	Distance Measuring Equipment (DME) Operating Within the Radio Frequency Range of 960-1215 Megahertz
TSO-C87a	Airborne Low-Range Radio Altimeter
TSO-C92c	Airborne Ground Proximity Warning Equipment (a.k.a. Ground Proximity Warning Systems or GPWS)
TSO-C95a	Mach Meters
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-C113a	Airborne Multipurpose Electronic Displays
TSO-C115c	Flight Management System (FMS) Using Multi-Sensor Inputs
TSO-C117a	Airborne Windshear Warning and Escape Guidance Systems for Transport Airplanes (a.k.a. Reactive Windshear)
TSO-C118a	Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS I
TSO-C119d	Traffic Alert and Collision Avoidance System (TCAS) Airborne Equipment, TCAS II with Hybrid Surveillance TCAS II

TSO-C146d	Stand-alone Airborne Navigation Equipment Using the Global Positioning System Augmented by the Satellite Based Augmentation System WAAS
TSO-C147a	Traffic Advisory System (TAS) Airborne Equipment
TSO-C151c	Terrain Awareness and Warning System (TAWS)
TSO-C157a	Aircraft Flight Information Services-Broadcast (FIS-B) Data Link Systems and Equipment FIS-B
TSO-C165a	Electronic Map Display Equipment for Graphical Depiction of Aircraft Position Moving Maps
TSO-C169a	VHF Radio Communications Transceiver Equipment Operating Within Radio Frequency Range 117.975 to 137.000 Megahertz
TSO-C170	High Frequency (HF) Radio Communications Transceiver Equipment Operating Within the Radio Frequency Range 1.5 to 30 Megahertz
TSO-C194	Helicopter Terrain Awareness and Warning System (HTAWS)
TSO-C198	Automatic Flight Guidance and Control System (AFGCS) Equipment
TSO-C201	Attitude and Heading Reference Systems (AHRS)

2.2.3 RTCA/EUROCAE Publications

The RTCA documents referenced here may be purchased from RTCA, Inc., 1150 18th Street NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

DO-256	Minimum Human Factors Standards for Air Traffic Services Provided Via Data Communications Utilizing the ATN, Builds I and IA
ED-38	Minimum Performance Specification for Airborne Weather, Ground Mapping and Assisted Approach Pulse Radars (Including Surface-Based Transponder Beacon System Characteristics)

2.3 Definitions

Definitions used in this document shall be as noted in the Glossary of Terms defined in Section 6.

The word “shall” is used to express an essential requirement where compliance is mandatory.

The word “should” is used to express a recommendation. Deviation from the specified recommendation shall require justification.

The use of the word warning(s) in this document could mean a warning, caution, or advisory level alert. A warning is a condition that requires immediate flightcrew awareness and immediate flightcrew response. A caution is a condition that requires immediate flightcrew awareness and subsequent flightcrew response. An advisory is a condition that requires flightcrew awareness and may require subsequent flightcrew response.

3. GENERAL STANDARDS

3.1 Material

Material shall be of a quality that experience and/or tests have demonstrated to be suitable and dependable for use in aircraft instruments.

3.1.1 Workmanship

Workmanship shall be consistent with high quality aircraft electromechanical and electronic instrument manufacturing practices.

3.2 Compatibility of Components

If an EFIS component is individually acceptable but requires calibration adjustments or matching to other components in the aircraft for proper operation, it shall be identified in a manner that will ensure performance to the requirements of this document.

3.3 Equipment Functions and Mechanical Operations

The EFIS shall operate electrically and mechanically.

3.4 Interchangeability

Display system components that are identified with the same manufactured part number shall be completely interchangeable.

3.5 Operation and Accessibility of Controls

Controls that are not normally adjustable in flight shall not be readily accessible to flight personnel when the instrument is installed in accordance with the instrument manufacturer's instructions.

Controls intended for use on the EFIS during flight shall be designed to minimize errors. No combinations or sequences of these controls shall result in a condition that will be detrimental to the continued performance of the equipment.

The display controls intended for flight operations shall not require the simultaneous use of more than one hand.

Minimizing pilot workload should be considered when designing EFIS controls. The layering of information should not hinder the pilot in identifying the location of the desired control.

Controls shall provide feedback when operated. Feedback can include one or more auditory cues, tactile cues, or visual cues.

When a control occurs in multiple places (for example, a "Return" control on multiple pages of a flight management function), the control label location on all pages should be consistent across all occurrences.

If a control is provided to perform multiple functions, the functionality shall be clearly distinguished. There should be a clear indication when any control is in an altered state and not the default (e.g., if a knob is pulled out and then functions differently when rotated).

3.6 Self-Test Capability

If the equipment contains integral arrangements to permit pre-flight and/or in-flight self-test checks on the operation of the equipment in combination with other aircraft sub-systems, such tests shall not adversely affect any associated subsystem.

In-flight, self-test activation features shall include a means to alert the pilot or appropriate flight crew member of this mode of operation.

3.7 Effect of Tests

Unless otherwise stated, the application of all prescribed in service testing shall not produce a subsequent condition that would be detrimental to the continued performance of the EFIS.

3.8 Malfunctions and Failure Indications

3.8.1 Malfunction Indication

Means shall be provided to indicate malfunctions, loss of functions, degradations, or failures to the appropriate crew member. A blank display or an “X” across the display are examples of an acceptable means of indicating failure.

3.8.2 Power Failure Indication

Means shall be provided to indicate when electrical power (voltage and/or current of all required phases) is not sufficient for proper operation of display and/or display system. A blank display is an example of an acceptable means of indicating failure.

3.8.3 Fail Safe Provision

No single failure or malfunction of the display system shall introduce unsafe conditions to interconnected equipment. Unsafe conditions of the display system results from failures, malfunctions, external events, errors, or combinations thereof.

A Failure Modes and Effects Analysis (FMEA) should be performed to identify, isolate, and mitigate individual failures of the display. This is needed for a System Safety Assessment (SSA) for an aircraft airworthiness determination.

ARP4761 Table 1 shows the failure condition severity as related to probability objectives and assurance levels for components and systems in aircraft.

3.9 Multiple Mode Indications

When a display and/or display system has more than one mode, each mode of operation shall be indicated on the display, including any armed modes, transitions, and reversions. Selector switch position is not an acceptable means of indication. One example of an acceptable exception is the depiction of the Horizontal Situation Indicator (HSI)-Full Compass versus Arc mode, which does not require a mode indication.

NOTE: For the purposes of this document, a mode is not a function. Examples of modes on a display include heading-up versus track up (i.e., flight path is on top) or north up (magnetic north is shown on top). A mode could also be an alternate display format, such as a normal or primary mode versus a reversionary mode.

3.10 Source Selection

Where multiple system configurations and more than one sensor input are available for source selection, the switching configuration by annunciation or by selector switch position should be readily visible, readable, and should not be misleading.

If information from more than one navigation source can be presented, the selected navigation source should be continuously indicated. If multiple navigation sources can be presented simultaneously, the display should indicate unambiguously what information is provided by each source.

3.11 Display

The information being displayed should conform to the applicable requirements in Section 4 of this document.

3.11.1 Multi-Page Display Capability

Similar data and control markings should be consistent across pages (e.g., lat/long should be displayed in the same format on all pages where it appears). Lines of text shall be broken only at spaces or other natural delimiters.

3.11.2 Discernibility

Task essential information allows the flightcrew to accomplishment all tasks required to safely perform the equipment's intended function. Appropriate means shall be incorporated to prevent obscuration or confusion of task essential information. Task essential information shall be identified and defined.

Alerts and symbols shall be distinctive and readily discernible from one another. Fields that are editable, selectable, or require operator entry should be clearly denoted.

3.11.3 Critical Information

Means shall be provided to prevent the removal of information deemed critical to safe aircraft operation.

3.11.4 Information Limit Indication

A means shall be provided to identify when critical displayed information exceeds display format functional limits.

3.11.5 Scale Indications

The display scaling, graduations, and numeration shall be appropriate for the level of reading accuracy and dynamic range required (e.g., familiar units of measure are not as significant as the values and may be a smaller font, but shall be discernible). The display should indicate if display items are not drawn to scale (e.g., TAWS displays). The minimum dimensions of characters, numerals, and symbols used on the EFIS display should meet the requirements of AIR1093.

3.11.6 Ambiguity

Appropriate means shall be used to prevent ambiguous indications within the operating range of the display system.

3.11.7 Symbology

Displays should use characteristics and symbols that follow commonly accepted aviation practices. The potential for misinterpreting symbols should be minimized. Guidelines for electronic display symbology are provided in ARP4102-7.

Symbols used for one purpose on published charts should not be used for another purpose on the EFIS display. Reference ARP5621.

3.12 Display Latency

The maximum amount of latency induced by the display system shall be appropriate to the priority of the function displayed, and shall not cause flight crew misinterpretation or lead to an unsafe condition. The display update rate should be sufficient to preclude objectionable motion artifacts that could be misleading or distracting.

Examples of maximum latency for specific functions are as follows:

- a. Aircraft position data update, 1 second;
- b. Initial response to operator control input, 300 ms;
- c. Airspeed, altitude, attitude data update, 100 ms;
- d. Cursor or softkey response, 80 ms.

3.13 Orientation

Displayed labels should be oriented to facilitate readability. For example, the labels should continuously maintain an upright orientation or align with an associated symbol (e.g., a runway, an airway, or a cardinal position on a compass). Images should be oriented in such a way that their presentation is easily interpreted.

3.14 Identification

The information in a. through d. shall be legible and permanently marked on the equipment or nameplate attached thereto. If the information in e. and f. are provided, permanently mark it on the equipment or nameplate or in the installation manual.

- a. Manufacturer's part number.
- b. Manufacturer's serial number or date of manufacture or both.
- c. Manufacturer's name, trademark, symbol, or other approved identification.
- d. "See Installation Manual (IM) for Declared EFIS Functions", or equivalent, on the primary (most prominent) component of the EFIS.
- e. Name of equipment.
- f. "AS6296" or equivalent approval identification such as TSO marking.

3.14.1 Declaration of EFIS Functions

For each EFIS function listed in 4.1.1 through 4.6.2 of this document, the equipment manufacturer shall select the particular functions (and classes, as applicable) that are included in the EFIS. The EFIS functions and applicable classes thus determined shall be tabulated on the "Declaration of Electronic Flight Instrument System (EFIS) Functions" form, in accordance with the guidelines in Appendix A. The completed Declaration of EFIS Functions Form shall be included in the installation manual and maintenance instructions.

4. MINIMUM PERFORMANCE STANDARDS UNDER STANDARD CONDITIONS

The subsections below group individual EFIS functions into broad categories:

Flight Instrument Functions, Navigation and Communication Functions, Engine and Fuel Management Functions, Weather Surveillance and Avoidance Functions, Terrain Surveillance and Avoidance Functions, and Traffic Surveillance and Avoidance Functions. *This grouping is for convenience only, and does not imply that all functions within a group are required for any given EFIS.*

Where appropriate, each function below addresses the accuracy (allowable error) requirements for that function. In some cases, only a system-level error budget is provided. In other cases, the allowable EFIS contribution to the total error is provided.

In this document, the term "Displayed Error" is used when the accuracy value or error tolerance is intended to represent only the error contributed by the EFIS (see Section 6).

It is recognized that many EFIS implementations receive digital data that directly represents the value to be displayed, with little or no EFIS processing required. In this document, the term "Display-Ready Data" (see Section 6) is used to describe this case. In other implementations, the EFIS may need to determine the displayed value based upon received analog sensor data, or upon multiple inputs that shall be processed together to determine the displayed value.

4.1 Flight Instrument Functions

4.1.1 Airspeed

4.1.1.1 Indicating Means

The airspeed shall be indicated by means of a pointer, dial, tape, drum, digital numeric readout, other type of moving element, or any combination thereof. Unless otherwise specified, relative motion of the index with respect to the scale (either the index or the scale may be the moving element) shall be clockwise, up, or to the right for increasing airspeed.

4.1.1.2 Graduations

The graduations shall be arranged to provide the maximum readability consistent with the accuracy of the EFIS display. Graduations shall be as follows

- a. The first graduation shall be at the lowest usable airspeed of the EFIS display, as specified by the manufacturer.
- b. From the 10 knot, 10 mph, or 20 km/h graduation nearest to the first graduation and continuing to 250 knots, 250 mph, or 400 km/h, graduations shall be separated by no greater than 20 knots, 20 mph, or 40 km/h. If minor graduations are used, they shall be half the value of the major graduations. If digital numeric readout is not used, then scale marking increments of 5 knots, 5 mph, or 10 km/h shall be used.
- c. Over 250 knots, 250 mph, or 400 km/h, graduations shall be at least every 50 knots, 50 mph, or 100 km/h.

4.1.1.3 Numerals

The display shall include sufficient numerals positioned to permit quick and positive identification of each graduation. Numerals shall distinctly indicate the graduations to which each applies.

When digital numeric readouts are used in conjunction with scales, they should be located close enough to the scale to ensure proper association, yet not detract from the interpretation of the graphic or the readout.

4.1.1.4 Identification

The word AIRSPEED or IAS shall be marked on the dial. This marking may be omitted if the airspeed indication is a part of a "basic T" configuration. If the units of measure are other than knots or mach, the units of measure shall be labeled.

4.1.1.5 Limits

The indicating means shall be limited in such a way that the moving element will not move more than (a) 10 degrees for circular display or (b) 0.25 inch (6 mm) for linear displays beyond the greatest or least graduation in both increasing and decreasing directions.

For circular displays, positive means shall be taken so that no ambiguity will exist when the indicator is at the maximum or minimum position, including the maximum over-travel of 10 degrees. If a digital display is used, a positive indication shall be provided on the display when the airspeed exceeds the calibrated range.

4.1.1.6 Accuracy

If the airspeed data for the display is Display-Ready Data, then the displayed error shall not exceed ± 1 knot or equivalent.

If the airspeed data for the display is not Display-Ready Data, the manufacturer shall determine the maximum error contributed by the EFIS. The error contributed by the EFIS shall not exceed the error in Table 1. The displayed error shall be documented in the installation manual.

NOTE: The scale error in Table 1 is defined for a system, including the sensor(s). This gives the EFIS manufacturer flexibility to define the displayed error introduced by the EFIS itself, without the sensors.

In all cases, the EFIS shall be tested to confirm that it meets the appropriate displayed error. The EFIS shall be tested with inputs to the EFIS increased and decreased over the full range of operation.

Table 1 - Airspeed scale error system tolerance

Airspeed (knots or mph)	Room Ambient Tolerance (knots)	Room Ambient Tolerance (mph)	Airspeed (km/hour)	Room Ambient Tolerance (km/hour)
20	5	5	40	8
30	5	5	60	8
40	5	5	80	8
50	5	5	100	8
60	5	5	120	6
70	4	4	140	6
80	4	4	160	5
90	4	4	180	5
100	3	3	200	5
120	3	3	250	5
140	3	3	300	5
160	3	3	350	10
180	5	3	400	10
200	5	6	450	10
220	5	6	500	10
250	5	6	600	10
300	5	6	700	15
350	5	6	800	15
400	8	6	900	15
450	8	9	1000	15
500	8	9	1100	20
550	8	9	1200	20
600	10	9	1300	20
650	10	9		
700	10	12		

NOTE: System tolerances include the contributions of the sensor and the EFIS.

4.1.1.7 Smoothing

The indication of airspeed shall be smooth and free from irregular motion (e.g., jitter, jerkiness, or ratcheting effects) as the differential pressure or its electrical equivalent is increased and decreased smoothly.

4.1.2 Vertical Velocity (Rate of Climb)

4.1.2.1 Indicating Means

The vertical velocity shall be indicated by means of a pointer, dial tape, drum, or other type of moving element, or by a digital display with appropriate direction indication. Relative motion of the index with respect to the scale, or of the direction indicator (either the index or the scale may be the moving element) shall be clockwise, up, or to the right for ascending vertical velocity.

4.1.2.2 Limits

When the indication is pegged at its maximum rate indication, the direction of that indication, whether ascending or descending, shall be clear and unambiguous. If a digital numeric readout is used, a positive indication shall be provided on the display when the vertical velocity of the aircraft exceeds the readout capability.

4.1.2.3 Accuracy

The manufacturer shall determine the maximum error contributed by the EFIS. The displayed error shall not exceed the error in Table 2. The displayed error shall be documented in the installation manual.

NOTE: The scale error in Table 2 is defined for a display system, including the sensor(s). This gives the EFIS manufacturer flexibility to define the displayed error introduced by the EFIS.

In all cases, the EFIS shall be tested to confirm that it meets the appropriate displayed error. The EFIS shall be tested with inputs to the EFIS increased and decreased over the full range of operation.

Table 2 - Vertical speed scale error tolerance

Standard Altitude Test Interval (Feet)	Standard Altitude Test Interval (Meters)	Test Rate Ascent and Descent (ft/min)	Test Rate Ascent and Descent (m/min)	Tolerance (ft/min)	Tolerance (m/min)
2000 to 2500	600 to 750	500	150	100	30
2000 to 3000	600 to 900	1000	305	200	61
2000 to 4000	600 to 1200	2000	610	300	91
2000 to 5000	600 to 1500	3000	915	300	91
2000 to 6000	600 to 1800	4000	1220	400	122
2000 to 7000	600 to 2400	5000	1525	500	152
15000 to 17000	4500 to 5200	2000	610	300	91
15000 to 19000	4500 to 5800	4000	1220	400	122
28000 to 30000	8550 to 9150	2000	610	300	91
28000 to 32000	8550 to 9800	4000	1220	400	122

4.1.2.4 Smoothing

The indication of vertical velocity shall be smooth and free from irregular motion (e.g., jitter, jerkiness, or ratcheting effects) as the static pressure or its electrical equivalent is increased and decreased smoothly over the full range of operation.

4.1.3 Altimeter

4.1.3.1 Indicating Means

Altitude shall be indicated in feet or meters as required, by means of one or more pointers, dials, tapes, drums, digital readouts, or any combination thereof. Relative motion of the index with respect to the scale (either the index or the scale may be the moving element) shall be clockwise, up, or to the right for increasing altitude. In the case of counters, drums, or tapes, the higher number shall be above the lower.

4.1.3.2 Identification

The word ALTITUDE or ALT shall be marked on the dial. The altitude range shall be shown on the dial. This marking may be omitted if the altitude indication is a part of a "basic T" configuration. If the unit of measure is other than feet, the unit of measure shall be labeled.

4.1.3.3 Altitude Range

The minimum calibrated altitude (at a 29.92 in Hg/1013.2 mb barometric setting) shall be -1000 feet (-300 m). The maximum shall be as specified by the manufacturer and documented in the equipment manual(s).

4.1.3.4 Barometric Setting System

The display of barometric setting shall permit the altimeter to be set to any ambient barometric pressure throughout a minimum range of 27.50 to 31.50 in Hg (931.3 to 1066.7 mb). A feature shall be provided that will prevent incorrect indication if attempts are made to operate the barometric setting adjustment beyond the design range specified for the instrument. If a knob is used for control, the barometric setting number shall increase with a clockwise motion of the knob.

4.1.3.5 Multiple Mode Indications (Altimeter)

An EFIS that is intended for operation in more than one altimeter mode shall meet the requirements of this document in each mode. The "normal" mode shall be as specified by the manufacturer. Means shall be provided to indicate when in other than the "normal" mode. If the EFIS is provided with an automatic static source correction function, positive indication shall be given when it is not in use.

4.1.3.6 Static Source Error Correction

When the EFIS implements an altitude correction mechanism that is unique to a particular aircraft, the aircraft type and model number for which the EFIS has been created and performs its intended function shall be documented in the manual(s).

4.1.3.7 Cold Temperature Corrections

When an altimeter indication employs automatic cold temperature corrections, it shall use corrections given in Table 3. The EFIS display shall provide a clear indication to the pilot when the cold temperature corrections are being automatically applied. If the altimeter indication normally provides automatic cold temperature correction and cannot compute the correction, positive indication shall be given that corrections are not being performed.

Table 3 - Cold temperature correction - altitude correction chart¹

		Height Above Airport* in Feet													
Reported Temp °C		200	300	400	500	600	700	800	900	1000	1500	2000	3000	4000	5000
	+10	10	10	10	10	20	20	20	20	20	30	40	60	80	90
	0°	20	20	30	30	40	40	50	50	60	90	120	170	230	280
	-10°	20	30	40	50	60	70	80	90	100	150	200	290	390	490
	-20°	30	50	60	70	90	100	120	130	140	210	280	420	570	710
	-30°	40	60	80	100	120	140	150	170	190	280	380	570	760	950
	-40°	50	80	100	120	150	170	190	220	240	360	480	720	970	1210
	-50°	60	90	120	150	180	210	240	270	300	450	590	890	1190	1500

* This is normally the destination airport's elevation.

NOTE: Values are to be added to published altitudes.

¹ This table is taken from the FAA's Aeronautical Information Manual, section 7-2-3. "Altimeter Errors", table "TBL 7-2-3", which is titled "ICAO Cold Temperature Error Table".

4.1.3.8 Graduations

Markings shall be provided at intervals not exceeding 20 feet of altitude with major markings at 100 foot intervals. ARP4102-7 Appendix A, items 39 and 40 provide an acceptable alternative means. For indicating an ascent in altitude when using a dial, the sensitive pointer shall move in a clockwise direction completing one revolution (360 degrees) for each 1000 feet of altitude change. A means shall be provided for showing the multiples of 1000 feet.

4.1.3.9 Accuracy

When provided with Display-Ready Data, the EFIS shall not contribute more than 20 feet error to the displayed altitude.

If the altitude data for the display is not Display-Ready Data, the manufacturer shall determine the maximum error contributed by the EFIS. The error contributed by the EFIS shall not exceed the error in Table 4, except as outlined in the paragraphs below. The displayed error shall be documented in the installation manual. Examples of non-Display-Ready Data include barometric correction, static source error correction, and cold temperature correction.

NOTE: The scale error in Table 4 is defined for a system, including the sensor(s). This gives the EFIS manufacturer flexibility to define the displayed error introduced by the EFIS itself, without the sensors. .

4.1.3.9.1 Scale and Hysteresis Error

The instrument shall meet the tolerance specified in Table 4, which includes the following conditions:

1. Decreasing and increasing pressure for the test pressure ranges specified in Table 4, or
2. These pressures plus the static defect correction pressures (if specified) for the applicable aircraft as supplied by the airframe manufacturer.

4.1.3.9.2 Static Source Correction

Where a static source correction means is in operation, the scale error tolerance shall be that shown in Table 4, increased by an amount of 10% of the static source error plus 10 feet (3 m).

In all cases, the EFIS shall be tested to confirm that it does not exceed the appropriate displayed error. The EFIS shall be tested with inputs to the EFIS increased and decreased over the full range of operation.

**Table 4 - Scale and hysteresis errors for increasing and decreasing altitude
(at ambient room temperature)**

Test Pressure Altitude		Tolerance	
Feet	Meters		
-1000	-300	±20	±9
0	0	±20	±9
2000	300	±20	±9
2000	600	±30	±9
3000	900	±30	±9
4000	1200	±35	±9
5000	1500	±35	±9
10000	3000	±80	±15
20000	6000	±130	±20
30000	9000	±180	±35
40000	12000	±230	±45
50000	15000	±280	±55

NOTE: System tolerances include the contributions of the sensor and the EFIS.

4.1.3.10 Barometric Setting Scale

If the EFIS performs barometric correction, the pressure-to-altitude coordination shall meet the requirements of Table 5 - Barometric setting mechanism.

Table 5 - Barometric setting mechanism

Barometric Pressure Scale		Correct Difference		Baro-Setting Tolerance	
in Hg	mb	Feet	Meters	Feet	Meters
22.0	745	-8266	-2520	±40	±12
23.27	788	-6794	-2071	±35	±11
23.92	810	-6065	-1830	±35	±11
24.98	846	-4907	-1496	±30	±9.0
25.98	880	-3850	-1173	±30	±9.0
26.99	914	-2825	-861	±25	±7.5
27.55	933	-2265	-691	±25	±7.5
28.20	955	-1630	-497	±25	±7.5
28.58	968	-1264	-385	±25	±7.5
28.94	980	-920	-280	±25	±7.5
29.91	1013	-10	-3	±25	±7.5
30.15	1021	211	64	±25	±7.5
30.77	1042	776	237	±25	±7.5
30.98	1049	965	294	±25	±7.5

4.1.3.11 Minimum Operating Rate

The altimeter indication shall be capable of a minimum operating rate of 20000 ft/min (6100 m/min).

4.1.3.12 Monitoring Functions

The EFIS display shall provide a means to indicate the loss of a “valid” signal provided by a remote sensor or computer.

4.1.4 Attitude (Bank and Pitch)

4.1.4.1 Indicating Method

The EFIS shall present pitch and roll angles such that over the range of indication the earth horizon appears as viewed by the pilot when looking forward out of the aircraft.

The design shall provide suitable contrast between sky and ground segments such that pitch up/down are immediately recognizable. Some indication of both sky and ground shall always be visible at extreme attitude.

4.1.4.2 Graduations

The display shall provide a roll attitude index that indicates through 360 degrees with markings at least for 0 degrees and 30 degrees right and left roll angles.

The pitch display shall provide minor graduations every 5 degrees and major graduation lines every 10 degrees between -30 degrees and +50 degrees. This entire range need not be visible at one time. The major graduations shall be marked with their numerical value.

4.1.4.3 Pitch Attitude Reference

A 0 degree pitch reference shall be provided and may be adjustable to accommodate a range of pitch attitude trim.

4.1.4.4 Accuracy

When provided with Display-Ready Data, the EFIS shall not contribute more than a 0.5 degree error to the displayed pitch and roll.

If the pitch and roll data for the display is not Display-Ready Data, the manufacturer shall determine the maximum error contributed by the EFIS. The error contributed by the EFIS shall not exceed a total scale error of 2.5 degrees. The displayed error shall be documented in the installation manual.

NOTE: The total scale error of 2.5 degrees is defined for a display system, including the sensor(s). This gives the EFIS manufacturer flexibility to define the display tolerance error introduced by the EFIS. However, the displayed error introduced by the EFIS should still be a small portion of the total system error budget, which has sensors not included here. The EFIS scale error tolerance shall be documented in the installation manual.

In all cases, the EFIS shall be tested to confirm that it meets the appropriate displayed error. The EFIS shall be tested with inputs to the EFIS increased and decreased over the full range of operation.

4.1.5 Direction Indicator

4.1.5.1 Indicating Method

Direction shall be indicated using either of the two following methods:

1. A rotating dial or dial segment with a fixed datum or lubber line; dial rotation shall be counterclockwise for right turns.
2. A horizontal scale display with fixed datum or lubber line; scale graduations shall move to the left for right turns.

4.1.5.2 Operating Mode

Direction of flight indications may be shown using aircraft heading or ground track. If more than one operating mode is provided, the direction reference shall be clearly indicated to the pilot. In addition, the direction of flight reference may be displayed in various units, such as magnetic north, true north, or grid north reference. The direction reference shall be indicated if more than one method is available.

4.1.5.3 Graduations

The indicator shall provide minor graduation lines at 5 degrees or smaller intervals, with major graduation lines every 10 degrees. Direction numerals shall be provided at 30 degrees, 60 degrees, 120 degrees, 150 degrees, 210 degrees, 240 degrees, 300 degrees, and 330 degrees. The markings at 0 degrees (360 degrees), 90 degrees, 180 degrees, and 270 degrees shall be either numerals or the letters "N", "E", "S", and "W" respectively. It is acceptable to use the hundreds and tens place numerals and drop the ones place (e.g., 33 for 330 degrees).

4.1.5.4 Accuracy

When provided with Display-Ready Data, the EFIS shall not contribute more than a 0.5 degree error to the displayed magnetic heading or ground track.

If the heading or ground track data for the display is not Display-Ready Data, the manufacturer shall determine the maximum error contributed by the EFIS. The error contributed by the EFIS shall not exceed a total scale error of 2 degrees. The displayed error shall be documented in the installation manual. Note: The total scale error of 2 degrees is defined for a display system, including the sensor(s). This gives the EFIS manufacturer flexibility to define the display tolerance error introduced by the EFIS. However, the displayed error introduced by the EFIS should still be a small portion of the total system error budget, which has sensors not included here. The display scale error tolerance shall be documented in the installation manual.

In all cases, the EFIS shall be tested to confirm that it meets the appropriate displayed error. The EFIS shall be tested with inputs to the EFIS increased and decreased over the full range of operation.

4.1.6 Maximum Allowable Airspeed

4.1.6.1 Maximum Allowable Airspeed Indication

The maximum allowable airspeed indication shall show maximum allowable airspeed values.

Maximum allowable airspeed shall be displayed in such a manner that the numerical values on the scale increase in a clockwise, left to right, or bottom to top direction.

4.1.6.2 Accuracy

When provided with Display-Ready Data, the EFIS shall not contribute more than one knot error to the displayed maximum allowable airspeed.

When provided with Display-Ready Data, the EFIS shall not contribute more than 0.001 mach error to the displayed maximum allowable mach.

If the maximum allowable airspeed or maximum allowable mach data for the display is not Display-Ready Data, the manufacturer shall determine the maximum error contributed by the EFIS. The displayed error shall be documented in the installation manual.

The EFIS shall be tested to confirm that it meets the appropriate displayed error. The EFIS shall be tested with inputs to the EFIS increased and decreased over the full range of operation.

4.1.7 Mach

This function provides mach number indication.

4.1.7.1 Indicating Method

Indicators comprising a dial shall be provided with mach number graduations at intervals not to exceed 0.01 with major graduations every 0.05 and with numerical markings at intervals not greater than 0.1. When a digital numerical readout is employed, the resolution shall be better than or equal to 0.01 mach.

4.1.7.2 Accuracy

When mach is received as Display-Ready Data, the EFIS shall not contribute more than 0.002 mach error to the displayed mach number.

If the mach data for the display is not Display-Ready Data, the manufacturer shall determine the maximum error contributed by the EFIS. The displayed error shall be documented in the installation manual.

The EFIS shall be tested to confirm that it meets the appropriate displayed error. The EFIS shall be tested with inputs to the EFIS increased and decreased over the full range of operation.

4.1.8 Turn and Slip

4.1.8.1 Turn Rate²

The turn rate shall be indicated by a pointer deflecting in the direction of the turn, or by other means equally suitable. If the aircraft is not turning, the pointer shall align with the center tick mark or be removed from view.

When displaying rate of turn by means of a pointer on a fixed scale, indices for standard rate (180 degrees/minute) shall be provided. Indices for half standard rate (90 degrees/minute) may be provided.

The range of the rate of turn indicator shall be a minimum of ± 240 degrees/minute.

4.1.8.2 Standard Turn Bank Angle

When it is displayed, the standard rate bank angle shall be indicated on the roll scale in both directions.

4.1.8.3 Slip/Skid

When it is displayed slip/skid shall be indicated by a figure or object moving with respect to a reference, or by other means equally suitable. A slip is indicated by the ball (or figure or object) on the inside (wing down side) of a turn. A skid is indicated by the ball (or figure or object) on the outside (wing up side) of the turn.

If an inclinometer is used, when the indicator is centered, the scale on either side of the indicator shall include the greater of one and half indicator widths or 7 degrees. Typically, 0.1 g laterally is one ball width.

It is recognized that different scaling may be required for different applications. The manufacturer shall specify the scaling.

4.1.8.4 Accuracy

The EFIS shall not significantly contribute to the error of Turn Rate or Slip/Skid. The manufacturer shall define the 95% displayed error in the installation manual. The manufacturer shall provide instructions on determining total installed system error.

In all cases, the EFIS shall be tested to confirm that it meets the appropriate displayed error. The EFIS shall be tested with inputs to the EFIS increased and decreased over the full range of operation.

4.1.9 Airborne Low-Range Radio Altimeter

4.1.9.1 Accuracy

When provided with Display-Ready Data, the EFIS shall not contribute more than 1 foot error to the displayed radio altitude.

If the radio altitude data for the display is not Display-Ready Data, the manufacturer shall determine the maximum error contributed by the EFIS. The error contributed by the EFIS shall not exceed the error in Table 6. The displayed error shall be documented in the installation manual.

The total scale error in Table 6 is defined for a display system, including the sensor(s). This gives the EFIS manufacturer flexibility to define the display tolerance error introduced by the EFIS. However, the displayed error introduced by the EFIS should still be a small portion of the total system error budget, which has sensors not included here.

In all cases, the EFIS shall be tested to confirm that it meets the appropriate displayed error. The EFIS shall be tested with inputs to the EFIS increased and decreased over the full range of operation.

² This is taken from RTCA DO-334, section 2.5.5.1-3, and is used by permission. The complete document may be purchased from RTCA, Inc., 1150 18th Street NW, Suite 910, Washington DC, 20036, (202) 833-9339, www.rtca.org

Table 6 - Radio altitude scale error tolerance

Height Range	Total System Accuracy
3 to 100 feet (1 to 30 m)	±5 feet (1.5 m)
100 to 500 feet (30 to 150 m)	±5% of true height
500 feet (150 m) to maximum display scale	±7% of true height

4.1.9.2 Alerts for Airborne Low-Range Radio Altimeter

4.1.9.2.1 Failure Indication

An indication shall be provided when there is a failure of the radio altimeter to accomplish its intended function because of the following conditions:

1. Loss of power, and
2. Loss of signal or altitude sensing capability when within the manufacturer's stated operating altitude range.

4.1.9.2.2 Decision Height

For use in landing systems, it is strongly recommended that an indication be provided when the decision height is reached.

4.1.10 Automatic Flight Guidance and Control System

This function provides flight guidance indications and autoflight mode indications.

The EFIS shall display any annunciations provided to it by flight guidance systems.

Scaling and presentation of flight director command bars should ensure that valid steering commands are displayed and that invalid or off-scale steering commands are not displayed. Note: under tests under environmental conditions, the display is not required to operate normally during *abnormal* voltage inputs, but shall not provide misleading information during or after the tests.

4.2 Navigation and Communication Functions

4.2.1 Very High Frequency Omnidirectional Range (VOR)

4.2.1.1 Bearing Accuracy

If the bearing data for the display is Display-Ready Data, the EFIS shall not contribute more than ± 0.5 degrees error to the displayed Bearing.

If the bearing data for the display is not Display-Ready Data, the manufacturer shall determine the maximum displayed error contributed by the EFIS. The error contributed by the EFIS shall not exceed 2.7 degrees with probability of 95%. This bearing accuracy requirement applies to any VOR bearing information that is provided for use in aircraft navigation. The displayed error shall be documented in the installation manual.

NOTE: This total error is for a display system, including the sensor(s). This gives the EFIS manufacturer flexibility to define the display tolerance error introduced by the EFIS. However, the displayed error introduced by the EFIS should still be a small portion of the total system error budget, which has sensors not included here.

In all cases, the EFIS shall be tested to confirm that it meets the appropriate displayed error. The EFIS shall be tested with inputs to the EFIS increased and decreased over the full range of operation.

4.2.1.2 Frequency Display

If tuning of the VOR sensor is a function of this EFIS, the frequency of paired channel or the identification of the navigation facility or facilities in active use shall be displayed or capable of recall at all times during flight.

4.2.1.3 VOR Course Deviation Indication (CDI)

If a course deviation indication is provided, the following requirements shall be met with valid input signals.

4.2.1.3.1 VOR Course Deviation Sensitivity³

The EFIS shall provide a display for presentation of VOR course deviation magnitude and direction (left/right). This display output shall have sufficient dynamic range to display course deviation of at least ± 10 degrees with a resolution of one degree or better.

4.2.1.3.2 VOR Course Deviation Accuracy

If the VOR Course Deviation data for the display is Display-Ready Data, the EFIS shall not contribute more than a ± 0.5 degree error to the displayed VOR course deviation.

If the VOR Course Deviation data for the display is not Display-Ready Data, the manufacturer shall determine the maximum error contributed by the EFIS. The displayed error shall be documented in the installation manual.

In all cases, the EFIS shall be tested to confirm that it meets the appropriate displayed error. The EFIS shall be tested with inputs to the EFIS increased and decreased over the full range of operation.

4.2.1.3.3 Ambiguity Indication (TO-FROM)

When valid, and at all bearings up to ± 75 degrees from the selected radial, the inbound/outbound (i.e., "TO" or "FROM") shall be clearly indicated.

4.2.1.4 Warnings

The VOR Bearing and, if provided, the Course Deviation Indication, shall be removed or placed in a warning condition when the VOR Bearing is not valid.

4.2.2 Distance Measuring Equipment (DME)

This function provides DME range and associated indications.

4.2.2.1 Display Parameters⁴

The EFIS should display unambiguous information to the flight crew. As a minimum, displays should provide distance information, warning indications and channel selection. As an alternative, the source of channel selection may be displayed.

4.2.2.1.1 DME Source or Channel Indication

When DME sources or channels are paired with multiple navigation sources, the EFIS shall display the DME source or channel associated with the currently selected navigation source.

³ This is taken from RTCA DO-196, paragraph 2.2.3.a. and is used by permission. The complete document may be purchased from RTCA, Inc., 1150 18th Street NW, Suite 910, Washington DC, 20036, (202) 833-9339, www.rtca.org

⁴ This is taken from RTCA DO-189, paragraph 1.4.6, and is used by permission.

4.2.2.1.2 DME Range

The EFIS display shall indicate the currently selected DME range (distance).

The EFIS shall indicate when the DME distance reported is not associated with the currently selected navigation source (DME HOLD).

4.2.2.2 DME Alerts

4.2.2.2.1 DME Warning Indication⁵

The EFIS display shall provide a warning, such as a flag, when the DME equipment indicates that DME distance is not valid.

4.2.2.3 Accuracy

The EFIS shall not significantly contribute to the DME range error. The manufacturer shall define the 95% error in the installation manual. The manufacturer shall provide instructions on determining total installed system error.

The EFIS shall be tested to confirm that it meets the appropriate displayed error. The EFIS shall be tested with inputs to the EFIS increased and decreased over the full range of operation.

4.2.3 Localizer

4.2.3.1 Localizer Display Parameters

The Localizer display parameters include the Localizer Deviation Indicator, and may include the localizer displayed frequency.

4.2.3.2 Localizer Frequency

If tuning of the localizer receiver is a function of this EFIS, the frequency of paired channel or the identification of the navigation facility or facilities in active use shall be displayed or capable of recall at all times during flight.

4.2.3.3 Localizer Deviation Indicator

The following requirements shall be met with valid input signals:

The localizer deviation indicator shall present localizer deviation magnitude and direction.

The displayed localizer deviation indicator shall have a sufficient dynamic range to display at least 0.155 depth of deviation modulation (ddm) left or right of center with a resolution of 0.016 ddm or better.

NOTE: The localizer function shall detect a back course approach condition. When a back course approach is detected, the localizer polarity shall be reversed.

⁵ This is taken from RTCA DO-189, paragraphs 1.4.5 and 2.2.18 respectively, and are used by permission. The complete DO-189 document may be purchased from RTCA, Inc., 1150 18th Street NW, Suite 910, Washington DC, 20036 (202) 833-9339, www.rtca.org

4.2.3.4 Accuracy

When provided with Display-Ready Data, the EFIS shall not contribute more than 0.008 ddm error to the displayed localizer deviation.

If the localizer deviation data for the display is not Display-Ready Data, the manufacturer shall determine the maximum error contributed by the EFIS. The displayed error shall be documented in the installation manual.

Over the deflection range from zero to 0.093 ddm, in no case shall the error be greater than 10% of the deviation produced by a 0.175 ddm input.

NOTE: The error listed here - for an EFIS without Display-Ready Data - is for an end-to-end system, including sensors. This gives the EFIS display manufacturer flexibility to define the displayed error introduced by the display.

In all cases, the EFIS shall be tested to confirm that it meets the appropriate displayed error. The EFIS shall be tested with inputs to the EFIS increased and decreased over the full range of operation.

4.2.3.5 Localizer Alerts

The Localizer indication shall be removed or placed in a warning condition when the Localizer is not valid.

4.2.4 Glideslope

The Glideslope function presents an indication of ILS Glideslope deviation, and may present an indication of the ILS paired channel frequency.

4.2.4.1 Display Parameters for the Glideslope Function

4.2.4.1.1 Frequency Display

If tuning of the glideslope receiver is a function of this EFIS, the frequency of paired channel or the identification of the navigation facility or facilities in active use shall be displayed or capable of recall at all times during flight.

4.2.4.1.2 Glideslope Deviation Indication

If a Glideslope Deviation indication is provided, the following requirements shall be met with valid input signals.

4.2.4.1.2.1 Deviation Sensitivity⁶

The equipment shall provide a display for presentation of glideslope deviation magnitude and direction of deviation. This output shall have sufficient dynamic range to display 0.175 ddm above or below center with a resolution of 0.016 ddm or better.

4.2.4.1.2.2 Deflection Response⁷

When the ddm of a standard glide slope test signal is abruptly changed from zero to any value less than ± 0.175 ddm, the pointer shall reach 67% of its ultimate deflection within 2 seconds and pointer overshoot shall not exceed 5%.

4.2.4.1.2.3 Glideslope Warnings

The Glideslope Deviation indication shall be removed or placed in a warning condition when the Glideslope is not valid.

NOTE: Glideslope deviation is not valid in back course.

⁶ This is based on RTCA DO-192, paragraph 2.2.4.a, and is used by permission.

⁷ This is taken from RTCA DO-192, paragraph 2.2.4.c, and is used by permission.