GAMA PUBLICATION NO. 12

RECOMMENDED PRACTICES AND GUIDELINES FOR AN INTEGRATED COCKPIT / FLIGHTDECK IN A 14 CFR PART 23 CERTIFICATED AIRPLANE

THE GAMA-CLASS INTEGRATED COCKPIT / FLIGHTDECK

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1.0 PURPOSE

This publication prescribes one means, but not the only means of designing an integrated flightdeck/cockpit for the applicable airplane (see applicability section below) certificated in accordance with 14 CFR Part 23. Designs that meet the necessary practices and guidelines (see definitions) for the display and control functions included herein for an integrated ("all glass") cockpit or flightdeck may be designated as a "GAMA-Class Flightdeck™" or a "GAMA-Class Cockpit™.

The practices and guidelines described in this publication begin to increase commonality between integrated flightdeck/cockpit designs in the applicable airplanes. The ultimate goal is that it allows a pilot proficient in flying under IFR using one manufacturer's integrated flightdeck/cockpit to make a safe transition into an integrated electronic flightdeck/cockpit designed by either the same or another manufacturer without "formal" training. However, it is the FAA's responsibility to determine if this goal has been achieved.

The primary goal of this publication is encourage standardization for essential or critical functions in new integrated cockpits/flightdecks and to help ensure a sufficient level of safety when small airplane pilots move frequently between differing cockpit/flightdecks, especially for pilots who rent their airplane on an hourly basis. FAA has not required type ratings for these small airplanes, making their advanced capabilities widely available. While training is not mandatory for every integrated flightdeck design or application, pilots must objectively evaluate their needs and capabilities in order to safely operate this new generation of airplanes.

Some pilots find they learn faster and develop a deeper understanding of the subject if they voluntarily attend a structured, more "formal" training program. Training programs for GA integrated cockpit/flightdeck systems are offered by manufacturers, universities, pilot associations, training facilities and flight schools around the country. Most instructor pilots will develop training programs specifically tailored to a pilot's needs or desires. Other pilots prefer to learn on their own. Both ways of learning can be effective. It is up to each pilot to select his or her preferred method for maintaining aeronautical knowledge and proficiency.

In any case, the primary goal of this publication (easing transition between integrated cockpit designs) will only be realized if pilots comply with Federal Aviation Regulations (FARs) requiring them to review the Pilots Operating Handbook, Airplane Flight Operations Manual, and supplements, before operating any airplane or equipment installed therein.

This document assumes that pilots will require some training when first transitioning from traditional flightdeck/cockpit displays, often referred to as "steam gauges" or "round dials", into cockpits or flightdecks using integrated electronic displays and controls.

In addition to helping pilots transition between integrated cockpit designs, compliance with this document should reduce the cost and time incurred by manufacturers as they certify integrated cockpits in 14 CFR Part 23 airplanes. These new technologies, while improving general aviation aircraft capabilities, require that the FAA accommodate many new processes and standards. As is usually the case with new technologies, old standards may not even be relevant, and relevant standards may not exist.

This publication was drafted by a team of industry and FAA experts. It describes the elements the FAA expects to see in an integrated cockpit/flight deck if it is to be certified. Because of this work, a manufacturer that presents a new design to the FAA for certification already knows many of the questions the FAA will ask, and what answers the FAA will probably expect. If a manufacturer's product design differs from this publication, they should be prepared to explain why their system maintains the level of safety envisioned in this document.

The result of following the practices and guidelines in this document will be a more efficient and timely certification process. One where the FAA and manufacturers can focus on certifying leading-edge technologies -

not on design aspects the FAA has already determined is acceptable because the FAA may have already approved it in another manufacturer's product.

Both the FAA and manufacturers are constantly searching for designs and technologies that will improve safety and efficiency. As they are discovered, they become the "norm", replacing the old. This GAMA publication is therefore a "living" document, always under review and revision.

2.0 APPLICABILITY

The design practices and guidelines described herein apply to airplanes certificated in accordance with 14 CFR Part 23, and certificated for single-pilot operations in Instrument Meteorological Conditions (IMC). This publication is applicable to both single and multi-engine airplanes with a maximum gross take-off weight of 12,500 lbs. or less. This publication does not apply to any rotary-wing aircraft.

If the airplane is equipped with an autopilot or flight director, and the manufacturer desires the "GAMA-Class Flightdeck™" or "GAMA-Class Cockpit™" designation, it must meet the applicable practices and guidelines presented in Appendix A. However, installation of an autopilot or flight director is not required for the "GAMA-Class Flightdeck™" or "GAMA-Class Cockpit™" designation.

These practices and guidelines do not replace other FAA requirements to carry paper-based Flight Manuals, Pilot Operating Handbook (POHs), Flight Operations Manual, checklist (if FAA approved), navigation charts, U.S. Terminal Publications or airport diagrams.

3.0 DEFINITIONS

Integrated Cockpit/Flightdeck. Generally, an integrated cockpit/flightdeck combines a number of flight guidance, airplane systems, and situational awareness control and display functions onto a minimum number of interdependent electronic displays. For the purposes of this publication, at a minimum, an integrated cockpit/flightdeck must include electronic display and control of all primary airplane airspeed, altitude and attitude instruments, and all essential navigation and communication functions. Integration may also include display and control of airborne surveillance, airplane systems and engine systems.

Primary Flight Display. A Primary Flight Display (PFD) is a single physical unit that displays all of the following: altitude, airspeed, airplane direction and flight attitude. In accordance with 14 CFR Part 23.1321, the PFD must be located directly in front of the pilot in a fixed layout. Other information may be displayed on the PFD, but this additional information cannot obstruct any items required on the PFD.

Multi-Function Display. A Multi-Function Display (MFD) is any other electronic physical display unit, other than the PFD, which can be used to display various types of information, including a variety of required or supplemental information. The items and the location where they are displayed on an MFD may be selected by the pilot.

GAMA-Class Cockpit/Flightdeck™. On an applicable airplane, a cockpit/flightdeck design that meets or exceeds all the necessary practices and guidelines contained in this publication may be designated by GAMA as a "GAMA-Class Cockpit™" or a "GAMA-Class Flightdeck™". Practices and guidelines that are necessary to achieve these designations are indicated by the use of the words "must", "shall" or "will" in this publication. Practices and guidelines preceded by the word "should", "can" or "may" are not necessary for the "GAMA-Class Cockpit™" or "GAMA-Class Flightdeck™" designation, but manufacturers are encouraged to comply.

The primary benefits of complying with the guidance in this Publication are negated if the pilot is required to hold a type rating. However, adherence to this guidance when designing integrated cockpits/flightdecks for any applicable airplane certificated in accordance with 14 CFR Part 23 (or equivalent in other countries), will improve the ability of pilots to make an easier transition between type-rated and non-type rated small airplanes. Accordingly, any 14

CFR Part 23 airplane that complies with the applicability requirements and design guidance provided in this publication can be designated as having a "GAMA-Class Cockpit™" or "GAMA-Class Flightdeck™ .

A"GAMA-Class Cockpit™" or "GAMA-Class Flightdeck™ designation is awarded for an airplane make, model and serial number by the General Aviation Manufacturers Association after receiving application from the airplane manufacturer (or modifier, if applicable). The application must include the following:

1. Attestation that the airplane (or make/model series) has been issued a certificate of airworthiness by a National Aviation Authority (NAA), and;
2. Airplane make/model designation, serial number, registration number, and;
3. Attestation that the airplane(s) incorporates an Integrated cockpit/flightdeck, as defined herein, and;
3. Attestation that all necessary guidance provided in this publication has been met or exceeded.

Once granted, manufacturers are encouraged to include the "GAMA-Class Cockpit™" or "GAMA-Class Flightdeck™ designation in any section of the Flight Operations Manual not requiring approval by the NAA, or in the Pilots Operating Handbook. These designations may also be incorporated in marketing materials.

Manufacturers and operators may also choose to provide a visual indication, either on the exterior or interior of the airplane, that the airplane incorporates a "GAMA-Class Cockpit™" or "GAMA-Class Flightdeck™. However, such visual designations must comply with all applicable NAA regulations and guidance.

4.0 BACKGROUND

The recent advent of affordable electronic displays, with dimensions and other characteristics suitable for installation in small airplanes, offers general aviation avionics and airplane manufacturers more flexibility of presentation and placement of flightdeck/cockpit instruments and system controls than ever before possible. These new technologies can provide dramatic improvements in the capabilities of 14 CFR Part 23 certificated airplanes flown by a single pilot in IMC.

Absent appropriate design guidance, these technologies could lead to a level of cockpit/flightdeck system diversity that would necessitate flightdeck/cockpit extensive training on a specific flightdeck/cockpit design. This could occur in airplanes that are otherwise quite similar, and did not require mandatory transition training.

This electronic display technology did not exist when FAA regulations, standards and guidelines applicable to flightdeck/cockpit designs were first written for 14 CFR Part 23 certificated airplanes. In some cases, existing guidance allows a level of flexibility in design implementation that different design teams could produce flightdeck/cockpit layouts that are significantly different, yet meet all existing standards for Part 23 flightdeck/cockpit designs. Pilots could find transitioning between a multiplicity of design implementations, at best, an irritation, and at worst a safety hazard. This is especially true for pilots who typically fly numerous Part 23 airplane makes or models, such as pilots who rent airplane on a per-hour basis. . In other cases, existing guidance, often available from many different sources, is conflicting. Additionally, existing guidance may not be mandatory, thereby allowing many alternative design choices, all of which could meet FAA certification standards.

As integrated flightdeck/cockpits were first developed for larger airplanes certificated in accordance with 14 CFR Part 25, guidance for such airplane is readily available. In many cases, however, this guidance is simply not applicable or reasonable for single-pilot flown airplanes certificated under 14 CFR Part 23. Applying part 25, two-crew flightdeck standards to these airplanes could dramatically increase cost and complexity and increase workload for a single pilot The result could drive pilots away from installing new technologies, nullifying any possible safety benefit.

In order to address new part 23 integrated cockpit/flightdeck equipment and installations, the General Aviation Manufacturers Association assembled a group of flightdeck/cockpit-design experts from the government, avionics

and airplane manufacturers, and others, to develop this publication. As part 23 is based on minimal training, one of the goals of this publication was to ensure safe operations are maintained without mandating additional pilot training under 14 CFR Part 61.31(H). Another goal was to facilitate FAA certification of integrated flightdecks/cockpits in small airplanes by providing adequate interpretation and reference to existing guidance and appropriate new guidance.

This publication provides guidance for critical airplane control, communication, navigation, and surveillance functions. This publication does not require manufacturers to display every function in the same position on all products. The objective is to provide uncluttered, easily interpreted control and display features providing the basic information needed to maintain airplane control, navigate and communicate with Air Traffic Control. This allows manufacturers to offer optional features and encourages innovation.

5.0 AVIATE – CONTROL OF THE AIRPLANE

5.1 Display of Instruments Used to Aviate

5.1.1 Display of Airspeed

5.1.1.1 Airspeed Indication Format

Airspeed must be indicated by a fixed pointer and moving tape. The tape shall have the following features:

5.1.1.1.1 White shall be used for the Airspeed scale and the background shall provide good contrast. [Reference ARP 4102.]

5.1.1.1.2 Tapes shall retain the same color bands (arcs) required by FAR Part 23. [Reference AC 23.1311- (*)]

5.1.1.1.3 A digital display of airspeed shall be presented in a box with no other information presented behind the digital value. The use of a transparent or opaque tape is acceptable, but the tape must be readily distinguishable from the background.

5.1.1.1.4 The range visible on the airspeed tape must be appropriate to airplane performance; but should be no less than +/- 15 percent of V_{NE} or V_{MO}, as appropriate.

5.1.1.1.5 Large airspeed values must be displayed at the top of the tape display.

5.1.1.1.6 During takeoff, the red arc indication of low speed should not be displayed.

5.1.1.1.7 If Angle of Attack (AOA) is not displayed, speeds for arcs on the airspeed should be determined from the Pilots operating handbook (POH) or Aircraft Flight Operations Manual (FOM).

5.1.1.2 Airspeed Reference Bugs

Reference bugs are not required unless the airplane has scheduled performance (weight, altitude, or temperature limitations). If displayed, reference bugs shall be clear and unambiguous.

5.1.1.3 Airspeed Trend Indicator

5.1.1.4.1 A six second trend indicator for airspeed must be displayed.

5.1.1.4.2 The symbol used for the trend indicator should be in accordance with ARP 4102-7 or MIL SPEC 1787.

5.1.1.4.3 The airspeed trend vector shall be displayed adjacent to the airspeed indicator.

5.1.1.4.4 The trend indicator shall not obscure any numbers or letters on the airspeed tape.

5.1.2 Display of Altitude

5.1.2.1 Altitude Indication Format

Altitude shall be indicated by a fixed pointer and moving tape. The altitude scale shall be white and the background shall provide good contrast. [Reference ARP 4102]

5.1.2.2 Digital Indication of Altitude

A digital display of altitude shall be presented in a box with no other information presented behind the digital value. The use of a transparent or opaque tape is acceptable, but the tape must be readily distinguishable from the background.

5.1.2.3 Altitude Source for Approach Minimums

If the airplane is equipped with multiple altitude sensors, a clearly distinguishable means must be provided for setting and displaying altitude minimums on barometric altitude instruments, radio altitude instruments, and any other altitudes. If the airplane is equipped with multiple altitude sensors, the default setting and primary altitude reference will be barometric. When displayed, the altitude source indication must always be displayed in the same location on the manufacturers product, labeled with the correct abbreviation(s).

5.1.2.4 Altitude-Reference "Bugs"

5.1.2.4.1 Display of Approach Minima. If displayed, instrument approach minimums (e.g. DA or MDA) shall be labeled as "Minimums" or "MIN".

5.1.2.4.2 Annunciation When at Minima. When reaching instrument approach minima (e.g. DA or MDA), a visual and/or aural annunciation shall be provided.

5.1.2.4.3 Altitude "bug". Display and control for altitude "bugs" shall be provided, even in airplanes with no autopilot.

5.1.2.4.4 Altitude Alerting. Altitude alerting functions shall be provided and the altitude "bug" shall be synchronized with appropriate altitude alerting functions.

5.1.2.4.5 Synchronized Altitude "Bugs". There shall be a single pre-select altitude value in the flightdeck/cockpit. There can be multiple altitude pre-select controls; however, they must all be slaved together. Display of altitude pre-select should be consistent and integrated across the flight deck.

5.1.2.4.6 Altitude Values. Large altitude values must be displayed at the top of the tape display.

5.1.2.5 Altitude Trend Indicator

Unless a VSI is located adjacent and to the right of the altimeter, a six-second altitude-trend indicator must be displayed.

5.1.2.6 Altitude Scale

5.1.2.6.1 The altitude scale shall provide label indications at the 500 and 1,000 foot increment, and may include labels in increments of 100 feet. [Reference ARP 4102-7 and 23.1311]

5.1.2.6.2 A digital (rolling drum) indication of altitude, marked 20 foot increments must be displayed. [Reference TSO C10B]

5.1.3 Display of Attitude

5.1.3.1 Airplane Symbol Displayed on the PFD

5.1.3.1.1 The airplane symbol shall be a solid, conventional shape. [Reference ARP 4102-7 items 4 and 88]

5.1.3.1.2 If the airplane is equipped with a flight director, the airplane reference symbol shall be a wedge with horizontal lines. [Reference ARP 4102-7, item 2, page 10]

5.1.3.2 Pitch Ladder and Horizon Line

5.1.3.2.1 The horizon reference line on the PFD should be not less than 3.25 inches wide in straight and level flight.

5.1.3.2.2 When the true horizon is no longer displayed, a horizon line representation must be displayed to provide distinctive demarcation between sky and ground (or the background).

5.1.3.2.3 The pitch ladder should be caged to the center of the display.

5.1.3.2.4 For use in initiating unusual attitude recovery toward the correct horizon and altitude within one second of when it is recognized (reference MILSTD 1787C, Appendix E, Figure 91), some indication of both sky and ground shall always be visible. At pitch attitudes when the true horizon line would not normally be displayed, some sky or ground should be indicated on the PFD pitch display (minimum 3/8 in. and maximum of 11.5 percent of the display), and the horizon line should indicate off-scale.

5.1.3.2.5 With the airplane symbol on the horizon line, the range of visible pitch attitude shall be at least + 25 to -15 degrees, but not to exceed a total pitch range of 50 degrees.

5.1.3.3 Bank Angle Indication

5.1.3.3.1 Bank angle presentations should use a roll pointer; however, roll pointers and sky-pointers shall not be mixed in the same flightdeck/cockpit.

5.1.3.3.2 Roll scale indices shall be placed at 10, 20, 30, 60, and 90 degrees. An index may also be placed at 45 degrees.

5.1.4 Display of Heading

5.1.4.1 Range of Heading Display

The primary heading indicator shall be an arc or a circle. A minimum of 120 degrees (± 60 degrees) in front of the airplane shall be visible at all times.

5.1.4.2 Heading Tapes

Tapes shall not be used to display primary heading.

5.1.4.3 Location of Heading Display

The primary heading indication should be located below the indication of attitude.

5.1.4.4 Heading "Bug"

A heading "bug" is required, and if a flight director or autopilot is installed, it shall be integrated with the heading bug.

5.1.5 Display of Vertical Speed Indication. A Vertical Speed Indicator shall be located near the altitude indicator, with a minimum full-scale of ± 2,000 feet per minute, commensurate with the performance of the airplane. [Reference ARP 4102-7]

5.1.6 Display of Rate of Turn. If provided, a rate of turn indicator shall be located adjacent to the heading indicator.

5.2 Control of Aviate Instruments

5.2.1 Settings. Control for the following functions must be installed and each shall have a dedicated control, always visible to the pilot in the same location on a supplier's product. Each control must be clearly labeled with the correct abbreviation, and should be in proximity to the display.

- Setting the barometric pressure.
- Selecting the desired altitude.
- Selecting the desired heading.
- Selecting the desired course.

6.0 NAVIGATION

6.1 Display of Navigation Information

6.1.1 General

6.1.1.1 Power Up

At power-up, Primary Flight Displays, Navigation Displays and Multi-Function Displays will be oriented to either heading-up or track-up. Preference should be given to the orientation being used at power-down.

6.1.1.2 Own-Ship Symbol

On a moving map display, the own-ship symbol must be prominent and constantly oriented so as to indicate the relative direction of flight.

6.1.1.3 Orientation

The orientation for the primary navigation display shall be limited to heading-up or track-up. The orientation of any secondary navigation display is optional (e.g. Track-up, North-up, Heading-Up). Unless magnetic heading-up is being used for a display, the selected orientation for any navigation display shall be continuously indicated.

6.1.2 Primary Navigation Display

6.1.2.1 Minimum Display Capabilities

At a minimum, the primary navigation display shall include:

6.1.2.1.1 A Horizontal Situation Indicator (HSI) . The HIS shall be capable of displaying vertical deviation and a digital distance indication to/from the selected fix. The HSI may provide arc and/or 360° moving-map modes. (Reference RTCA DO-257)

6.1.2.1.2 'TO' and 'FROM' Indication. The TO indication will be situated between the airplane symbol and the head of the course indicator. The FROM indication will be situated between the airplane symbol and the tail of the course indicator. The TO/FROM indication should be visible in both a 360° mode and an arc display.

6.1.2.1.3 Display Status. The approach, terminal, enroute, Course Deviation Indicator (CDI) scale or RNP status shall be displayed in the same location on a supplier's product, labeled with the correct abbreviation.

6.1.2.1.4 Course Deviation Indictor. When operating in RNAV mode, the CDI scaling shall be displayed in nautical miles. The display of CDI scaling shall be adjacent to the CDI.

6.1.2.1.5 Display of Navigation Sources. If not displayed on the PFD, the navigation source commanding the lateral deviation bar or bearing indicators shall be labeled in a prominent and unambiguous manner on the primary navigation display. This information will be provided to the pilot in the same location on a supplier's product, using the correct abbreviations. (Reference CFR 14 Part 23.1329, 23.1335, 23.1311).

6.1.2.1.5.1 Navigation-Source Labels. If installed, the following labels should be used to indicate navigation sources:

VOR1, VOR2
ADF1, ADF2
LOC1, LOC2
GPS1, GPS2
FMS1, FMS2
LRN1, LRN2
NAV1, NAV2

6.1.3 Display of Navigation Frequency At initial start up, when there is no stand-alone (dedicated) tuning display, the selected frequency of all installed, pilot-tunable navigation sources will be displayed on the PFD or MFD. The selection of navigation frequencies should be displayed to the pilot in the same location on a manufacturer's product in a prominent manner.

6.1.4 Display of Range When applicable, map range should be displayed. The range scale of the primary navigation display should be displayed to the pilot in the same location on that manufacturer's product.

6.1.5 Display of Overlays (Weather, Traffic, Terrain, etc)

6.1.5.1 Consistency of Orientation

All overlay data shall be the same map orientation and range scale as the display upon which it is placed. (Reference RTCA DO-257A, section 2.2.1.3) Orientation of the presentation on any display should not change when an overlay is added, unless required by TSO guidance.

A "thumbnail" display is considered a separate display. If there are multiple displays, such as the above mentioned "thumbnail", the orientation (e.g. heading up, track-up) must be the same for each display. Critical information such as traffic or terrain should always be displayed as "track/heading up" on thumbnail displays.

6.1.5.2 Symbols

Symbols used to depict the location of airports or navigation aids on an overlay must be in the ICAO symbol set. [Reference RTCA DO-257(*)]

6.2 Control of Navigation Equipment

6.2.1 Tuning Navigation Equipment. If there is no dedicated Navigation control, then the same single action (always visible in the same location on a manufacturer's product, labeled with the correct abbreviation) shall access any Navigation tuning function.

6.2.1.1 Control of Blended Navigation Sources

Controls for blended navigation sources, such as GPS/WAAS, LORAN, FMS, and INS, should comply with RTCA DO-229C.

6.2.2 Direct-TO Function This function shall be labeled in accordance with RTCA/DO-229C, paragraph 2.2.1.1.6.

6.2.3 Flight Plan Editing and Activation. This function shall be labeled "FPL". [Reference RTCA/DO-229C 2.2.1.1.6]

6.2.3.1 Airport References

All ICAO-referenced airports will be identified by the appropriate four character ICAO code. When data entry is not done via a keyboard and the pilot is selecting an airport identifier, the unit will automatically insert the ICAO region identifier (first letter). The pilot may select the default region as a preference.

6.2.3.2 Discontinuities

Any "break" in a flight plan (routing between waypoints or "leg" not defined) should be labeled a "discontinuity". A "gap" in a flight plan is a point where automatic sequencing is suspended awaiting pilot input.

6.2.3.3 Inserting Data

Any insert function will insert items preceding the point selected.

6.2.3.4 Executing Procedures

Executing a Procedure when it is not already entered in a Flight Plan. [Reference RTCA DO-229C (2.2.1.1.6]

6.2.3.4.1 Go direct to any fix: The pilot shall be able to go direct to any fix by selecting "Direct-To"(a single pilot action to select, always visible and displayed in the same location on the manufacturer's product), shall provide immediate access to any waypoint in the database.

6.2.3.4.2 Procedures Function: The pilot will always be able to access the "Procedure" function (e.g. holding, departure, arrival or approach) with a maximum of two pilot actions. This function will be labeled "PROC", and shall always be in the same location on the same manufacturer's product. Additional pilot actions may be required to activate or load the procedure. Implementation of the following functions shall be accessible through the function labeled "PROC":

- Departure Procedures (labeled "DP")
- Standard Terminal Arrival Routes (labeled "STARS")
- Holding procedures (labeled "HOLD").
- Implementation of any instrument approach

6.2.3.4.3 Enroute (airways, jetways, routes etc.)

Reserved.

6.2.3.4.4 Required Time of Arrival

Reserved.

6.2.3.5 Selecting Navigation Frequencies

If there is no dedicated navigation tuner/controller, then a single action (always visible in the same location on supplier's product, labeled with the correct abbreviation) shall access navigation tuning functions. (See Paragraph 6.1.2.1.5.1 for abbreviations.)

6.2.3.6 Selecting Primary Navigation Source

A readily apparent means shall be available for the pilot to initiate selection of the primary navigation source. It shall be displayed in the same location on a supplier's product.

6.2.3.7 Frequency Control (Deselecting VOR, DME)

If the navigation system uses DME/DME area navigation, the system shall provide the capability to inhibit an individual DME or VOR facility from an automatic selection process. If implemented, the "DME Hold" function must be clearly identified.

7.0 Other Controls and Functions

7.1 De-clutter During Unusual Attitudes. Without any pilot actions, only altitude, attitude, direction, airspeed indication, airspeed trend shall be displayed on the PFD during attitudes exceeding 70 degrees of bank or ±30 degrees of pitch. (This requirement is not applicable to airplanes certificated in the aerobatic category.) The Primary Navigation Display is not required to de-clutter during unusual attitudes.

7.2 UNDO Function

7.2.1 Applicability An UNDO function shall be provided while controlling any navigation or communication function. Because of the concern that selecting UNDO could inadvertently change an autopilot or flight mode, an UNDO function will not be provided during control of Aviate functions.

7.2.2 UNDO Function Placement When available, the UNDO function should be located in proximity to the function to which it applies, visible in the same location on a manufacturer's product. (However, it need only be visible on pages where an UNDO function is provided.)

7.2.3 UNDO Functionality

7.2.3.1 UNDO Functionality During Flight Plan Waypoint Data Entry

Selecting UNDO shall provide the following actions during Flight Plan Waypoint Data Entry:

Scenario	UNDO action
During data entry	Moves the cursor to the previous character position in the waypoint identifier; minimum of 1 backup step shall be provided.
Data entry has been accepted and the navigation state is not currently predicated upon that waypoint	Stay in the editing mode and in no case changes the current navigation status. Restores the cursor to last character of data entry of the waypoint identifier.

Data entry has been accepted and the navigation state is predicated upon that entered data.	Restores the page or context in which the last entry was provided with the cursor in a state in which data entry or modification may immediately begin upon the last entered data. This does not undo the current navigation state. For example, if a new "direct to" waypoint has been entered, accepted, and navigation to the new waypoint has begun, UNDO would not remove or backup to the previous navigation setup.

7.2.3.2 UNDO Functionality During Direct-To Waypoint Data Entry

Selecting UNDO shall provide the following actions during Direct-To Waypoint Data Entry:

Scenario	UNDO action
During data entry	Moves the cursor to the previous character position in the waypoint identifier.
Data entry has been accepted (Navigation state is predicated upon the waypoint identifier entered)	Restores the page or context in which the Direct-To waypoint identifier was entered with the cursor in a state in which data entry may immediately begin. This will not undo the current navigation state.

7.2.3.3 UNDO Functionality While Loading Procedures

Selecting UNDO shall provide the following actions while loading an approach, departure procedure or STAR:

Scenario	UNDO action
After the procedure type is selected	Restores the cursor to the procedure selection field
After procedure transition is selected	Restores the cursor to the procedure transition selection field
After procedure runway is selected	Restores the cursor to the procedure runway selection field
After procedure is loaded into flight plan	Restores the page or context in which the last entry was provided. The cursor goes to a state in which data entry or modification may immediately begin upon the last entered data. This does not undo the current navigation state.

8.0 COMMUNICATION AND AUDIO SYSTEM(S)

8.1 Communication Display

8.1.1 Selected Communication Frequency (VHF, SATCOM, Datalink, etc.)

8.1.1.1 Location of Communication Displays

If there is no stand-alone (dedicated) tuning display, the selected frequency of all installed pilot-tunable communication sources will be displayed at power-up on the PFD or MFD. Display of communication frequencies should be grouped and located near the center of the instrument panel. When using "soft keys" or "touch-screens" to select communication frequencies, the selected communication frequencies should be displayed in a prominent manner in the same location on a manufacturer's product.

8.1.1.2 Labels for Communication Displays

Communication displays should be labeled using the abbreviations in SAE ARP-4105.

8.1.1.3 Time-Out of Dual-Use (NAV/COM) Tuning Displays

If a single control is used for navigation and communication tuning, the tuning control shall time-out to communication-tuning after a maximum of 20 seconds of inactivity.

8.1.2 Volume and Squelch. If there is no stand-alone (dedicated) tuning display, a function shall be available to display volume selections. Volume shall always be displayed in the same location on a manufacturer's product.

8.1.3 Display of Audio Functions (Including Intercom) The status (selected or not selected) of all installed audio sources must be displayed with no more than a single pilot action. This display will always be in the same location on a manufacturer's product.

8.1.4 Volume and Squelch A function shall be provided to display squelch and volume selections. Volume and Squelch selections shall always be displayed in the same location on a manufacturer's product.

8.1.5 Primary Communication Radio and Frequency A means must be provided to indicate to the pilot the radio and frequency that will be activated the next time the pilot keys the microphone. This indication must be prominently displayed to the pilot, always in the same location on a manufacturer's product.

8.2 Communication Control

8.2.1 Location of Communication Controls If there is no dedicated control for the communication-tuning function, controls for selecting communication functions, when displayed, will be adjacent to the display of the frequency, always in the same location on a manufacturer's product and labeled using the abbreviations in SAE ARP-4105.

8.2.2 Selecting VHF Communication Frequencies If there is no dedicated control for the communication-tuning function, frequency selection for the radio in-use shall require no more than a single pilot action. (The second pilot action begins changing the frequency.) Frequency selection for the second VHF communication radio should require no more than two pilot actions.

8.2.3 Selecting Other Communication Frequencies (FM, SATCOM, Datalink, etc.) If there is no dedicated control for the communication-tuning function, then the same initial action used for selecting VHF radio tuning shall access all other communication-tuning functions.

8.2.4 Selecting Volume and Squelch function shall be available to control squelch and volume. This function shall always be visible in the same location on a manufacturer's product.

8.2.5 Control of Audio Functions If there is no dedicated audio control panel, then display of the audio control functions shall be accessed with no more than a single pilot action. These functions will be displayed in the same location on a manufacturer's product. As a minimum, audio control functions shall include:

- Selecting the audio channels monitored at each pilot's position (It shall not be possible to de-select required audio warnings.)

- Selecting audio channels to transmit by each pilot's position
- Selecting audio channel volume
- Selecting the speaker, headphone, and/or microphone (including oxygen mask) configuration, as applicable
- Intercom selections, including isolating the pilot from passenger communications on the intercom, if applicable

8.2.6 Selecting the Primary Communication Radio A function must be provided to the pilot to select the radio that will be activated the next time the pilot keys the microphone. The pilot shall be able to select the radio, or a pre-selected frequency, to be used for a transmission with a maximum of one pilot action. Until changed by the pilot, the primary communication radio and communication frequency shall default to the last radio and frequency used. When displayed, this control must always be located in the same position on a manufacturer's product.

9.0 SURVEILLANCE AND SITUATIONAL AWARENESS

9.1 Display

9.1.1 Transponder

9.1.1.1 Display of Selected Transponder Code

A maximum of one pilot action shall be required to display the selected transponder code. The selected code shall always be displayed in the same location on the manufacturer's product. If there is more than one transponder installed, the code displayed will only be that of the active transponder.

9.1.1.2 Indication of Active Transponder

If there is more than one transponder installed, the active transponder will be clearly identified after the pilot changes the transponder code.

9.1.1.3 Indication of Transponder Reply

Each time the transponder replies to an interrogation, an indication shall be immediately visible to the pilot.

9.1.1.4 IDENT

When the pilot selects transponder IDENT, an indication to the pilot shall be immediately visible. This indication shall always be displayed in the same location on the manufacturer's product

9.1.2 Display of ADS-B (Reserved)

9.1.3 Display of TIS-B (Reserved)

9.1.4 Synthetic Vision Displays (Reserved)

9.1.5 Enhanced Vision Displays (Reserved)

9.2 Control

9.2.1 Transponder Controls

9.2.1.1 Selecting Transponder Codes

If there is no dedicated transponder control, no more than one pilot action shall be required to access transponder control functions. When displayed, this control shall always be located in the same location on the manufacturer's product, labeled with the correct abbreviation. If there is more than one transponder installed, the transponder being tuned will be clearly identified when the pilot selects the transponder codes.

9.2.1.2 Selecting IDENT

A single pilot action shall be required to select transponder IDENT.

9.2.2 Control of ADS-B Functions (Reserved)

9.2.3 Control of TIS-B Functions (Reserved)

9.2.4 Control Synthetic Vision Functions (Reserved)

9.2.5 Control of Enhanced Vision Functions (Reserved)

10.0 AIRPLANE SYSTEMS

10.1 Display of Engine Indications

10.1.1 Display of Engine Parameters

During engine start, required engine parameters (as applicable for the engine type) must always be visible to the pilot. After engine start, and if there is no dedicated display, a maximum of one pilot action shall be required to display required engine parameters.

10.1.2 Engine Parameter Labels

When displayed, engine parameters shall always be in the same location on the same manufacturer's product. Each parameter should be appropriately labeled along with the parameter's value and unit of measure. (Reference AC 23.1311 and AC 23.17) Engine parameters should be labeled according to the table below:

Parameters	Acceptable Labels	Guidance Source
Engine RPM (Reciprocating engines)	"RPM"	TSO-C49b AS 404b ARP 4105b
Propeller RPM Turboprop RPM	"RPM" or "N_P"	TSO-C49b AS 404b ARP 4105b
Percent Power	"% PWR" or "PCT PWR"	ARP 4105b
Manifold Pressure	"MP"	TSO-C45a AS 8042
Exhaust Gas Temperature	"EGT"	TSO-C43c AS 8005 ARP 4105b
Cylinder Head Temperature	"CHT"	TSO-C43c AS 8005 ARP 4105b
Carburetor Temperature	"CARB TEMP"	AS 8005 ARP 4105b
Fuel Flow (Each Engine)	"FF"	TSO-C44b AS 407b ARP 4105b
Fuel Quantity	"FUEL QTY"	TSO-C55 AS 405b ARP 4105b
Outside Air Temperature	"OAT"	ARP 4105b
Oil Pressure	"OIL PRESS"	TSO-C47 AS 408b
Oil Temperature	"OIL TEMP"	TSO-C43c AS 8005
Fire Warning	"FIRE"	None found
Liquid Coolant Level (Reciprocating Engines)	"COOLANT QTY"	None found
Fuel Pressure	"FUEL PRESS"	TSO-C47 AS 408b ARP 4105b
Coolant Temperature	"COOLANT TEMP"	AS 8005

Parameters	Acceptable Labels	Guidance Source
Fuel Low Level Indicator	"LOW FUEL"	None found
Oil Low Pressure Warning	"LOW OIL PRESS"	TSO-C47 AS 408b ARP 4105b
Torque	"TORQ"	None
Means for Indicating Fuel Strainer Contamination	"FUEL BYPASS"	None
Warning Means for the Oil Strainer Filter	"OIL BYPASS"	None
Propeller Blade Angle—Beta	"BETA"	None
Chip Detector	"ENG CHIP"	None
Inlet Turbine Temperature	"ITT"	TSO-C43c AS 8005 ARP 4105b
Gas Generator Speed	"N_2"	None
Fan Speed	"N_1"	None

10.2 Display of Airplane and Systems Configuration

10.2.1 Displaying the State of Airplane Configuration Controls

Airplane configuration should be depicted using an airplane diagram on a synoptic page. Displays of airplane configuration will remain visible until deselected by the pilot. If an airplane diagram is used to depict the state of configuration controls, the method of display will be in accordance with the following table:

Item	Control	State	Display on Airplane Diagram
Retractable Gear	Gear Select Lever	Up	Nothing; do not show any landing gear on the airplane diagram
Retractable Gear	Gear Select Lever	In transit	A distinct 'in transit' indication is required

Item	Control	State	Display on Airplane Diagram
Retractable Gear	Gear Select Lever	Down	A solid green symbol for each retractable gear or landing device.
Flap	Flap Select Lever	All Positions	A graphical representation of flap position, accompanied by an alphanumeric indication of actual flap position. (Consistent with nomenclature for the airplane.)
Fuel Tank Selection	Fuel Selector Control	All Positions	This indication should be clearly labeled "FUEL SELECT" and should provide a graphical depiction of the fuel source accompanied by text indicating the selected fuel source (e.g. LEFT, BOTH, RIGHT, etc.)
Throttle or Power Control	Throttle or Power Lever	All Positions	Throttle or Power lever position relates directly to engine power as depicted by the appropriate engine parameter display.
Mixture Control	Mixture Lever	All Positions	The Engine EGT or FF indicator is the associated display for mixture settings.
Prop Control	Prop Lever	All Positions	The engine RPM indicator is the associated display for prop position.
Trim Control	Trim Switches	Pitch	If complying with Part 23.677 through use of the display, a full time display of trim position shall be displayed, shall be clearly labeled, and shall move in the same sense as the trim control. The airplane nose down trim position shall be labeled "DOWN" or "NOSE DOWN" and the airplane nose up trim position shall be labeled "UP" or "NOSE UP." A takeoff trim position or band must be displayed.
Trim Control	Trim Switches	Roll	If applicable and complying with Part 23.677 through use of the display a full time display of trim position shall be displayed, shall be clearly labeled, and shall move in the same sense as the trim control (e.g. right for right wing down). The right wing down trim position shall be labeled "R" and left wing down trim position shall be labeled "L".
Trim Control	Trim Switches	Yaw	If applicable, and complying with Part 23.677 through use of the display, trim position shall be displayed full-time, it shall be clearly labeled, and shall move in the same sense as the trim control (e.g. right for nose right). The airplane nose right trim position shall be labeled "R" and airplane nose left trim position shall be labeled "L".

10.2.2 Displaying Airplane Systems

10.2.2.1 Clustering

Airplane system displays should be clustered with related systems, with no intermixing of other information. When displayed, the following items should be clustered:

- Aerodynamics – trim, flaps (high lift devices), gear, spoilers, etc.
- Electrical – battery, busses, alternator, primary power status, backup power status, etc.
- Powerplant – RPM, fuel flow, fuel pressure, etc.

10.2.2.2 Checklist

If a checklist is mandated or deemed necessary by the manufacturer or FAA, all information needed to complete the checklist must be visible on any electronic checklist display, including all warnings and cautions.

10.2.2.3 Lighting/Display Performance and Brightness

At power-on, all displays shall default to an illumination so as to be readable.

10.2.2.4 ADC/Air Data source

When an alternate source of Air Data is driving a PFD, the source shall be indicated and always visible to the pilot. This indication shall always be located in the same location on a manufacturer's product.

10.2.2.5 AHRS

When an alternate source of attitude or heading data is driving a PFD, the source shall be indicated and always visible to the pilot. This indication shall always be located in the same location on a manufacturer's product.

10.2.2.6 Identifying Software or Hardware Versions

The system should be able to display any software and/or hardware versions, and any other configuration data that is required by the flight manual supplement. This information should be displayed at start-up and/or be available to the pilot through a pilot selection option.

10.3 Control of Airplane Configuration

10.3.1 Dedicated Airplane Controls

Where installed, the following systems must have a dedicated control, always visible and in the same location on a manufacturer's product:

- Gear Selection
- Flap Selection
- Fuel Tank Selection
- Throttle Control
- Mixture Control
- Prop Control
- Electrical System Activation
- Trim Control
- Thrust reversers
- Spoilers/speed brakes

10.3.2 Lighting Controls

A selectable brightness control for each display shall always be available. This control shall always be lin the same location on a manufacturer's product. (Reference ARP 4256; AS 8034; AS 7788)

11.0 MALFUNCTION, WARNING, AND CAUTION INDICATIONS

11.1 Crew Alerting System (CAS) A visual enunciation of warnings and cautions should be displayed within the pilot's primary field of view, always located in the same position on a manufacturer's product. Separate and discrete enunciators for warnings and cautions should be integrated into a single display. If the CAS does not present required warnings or cautions in the pilot's primary field of view, a master warning/caution annunciation (aural and visual, if applicable) shall be provided. Visual indication of master warning/caution shall be located within the pilot's primary field of view.

11.2 Fuel Quantity Alert If a low-fuel warning system is installed, the system should provide a low-fuel enunciation based on approximately 45 minutes of usable fuel remaining at maximum cruise power, or at another time selected by the pilot. Visual and aural warnings should be annunciated as "Fuel Low".

11.3 Additional Voice Warnings Discrete voice warnings should provided for conditions the manufacturer deems to be a possible precursor to an accident or incident. If installed, these voice warnings should use the terminology provided in the following table:

System	Condition	Warning
Retractable Landing Gear	Gear Up, or in Transit, at Approx. 300 ft Above Field Elevation and Descending (Reference AC 23.729)	"Check Gear" or "Too Low, Gear"
Fuel Low Level Indicator	Less Than 45 Minutes of Usable Fuel Remaining	"Low Fuel"
Altitude Deviation	Deviations Greater Than 200 Feet From the Target Altitude, After Initial Capture	"Altitude"
Altitude Pre-select	1,000 Feet Above or Below Target Altitude	"Altitude"
Fire Detection	Fire	"Fire, Fire"
Autopilot	Autopilot Disconnected	"Autopilot"
Minimums	Pilot Selectable MDA or DH Altitude	"Minimums"
Stall Warning	Stall Vane or Other Sensor	"Stall"

12.0 STANDBY INSTRUMENTS FOR FLIGHT CONTROL

12.1 Standby Instruments Standby instruments may be required depending on the hazard analysis requirements in FAR 23.1309.

12.1.1 Location

If required, standby instruments should be located near the PFD.

12.1.2 Arrangement

If installed, the horizontal arrangement of standby instruments should be (left to right) airspeed, attitude, and altitude. Vertically (from top to bottom), standby instruments should be arranged as attitude, airspeed, and altitude.

12.1.3 Dimensions

Individual indicators should be a minimum of 2 inches in diameter, or if combined, a minimum 3 inch display.

13.0 REVERSIONARY MODE

13.1 Definition Reversionary flight displays (also called "composite" or "compacted" modes) are additional displays that provide a secondary means of displaying primary flight parameters. Depending on the hazard analysis requirements in 14 CFR Part 23.1309, reversionary flight displays or display modes may be required to display that information on the PFD (or elsewhere on the panel).

13.1.1 Display of Reversionary Modes

In the event an MFD fails, and required information was displayed on that MFD, a means of displaying the required information must be provided. This required information may be displayed on the PFD or elsewhere on the panel. If on the PFD, the format of the displayed information should be as close as possible to the MFD format. During display of a reversionary mode, the "basic T" arrangement should be retained in relation to other instruments.

13.1.2 Control of Reversionary Modes

If a reversionary mode is required, a maximum of one pilot action, always visible in the same location on the same manufacturer's product, shall be required to activate it.

14.0 USE OF COLORS

14.1 Color Coding Color-coding is the use of color to provide additional information or the context for a display symbol. No more than six colors, not including white, black, and grey, should be used for symbol color-coding on any PFD or non-map portions of a MFD. Use of additional colors for other purposes should not detract from the discrimination of colors used for coding.

14.2 Color Sets Display of the items in the following table must conform to the corresponding colors. The Acceptable Alternatives described below are the only options allowed. (A "Defined Display-Color Philosophy" is a rationale for using different colors for certain types of items or functions. It is developed by the manufacturer prior to application for certification and is consistently applied throughout a product's design.)

Displayed Item	Color
Warnings	Red
Flight Envelope and System Limits	Red
Cautions, Abnormal Sources	Amber or Yellow
Earth	Tan or Brown
Scales and Associated Figures (Normal State)	White
Coupled Flight Guidance Modes	Green
Sky	Cyan or Blue
ILS Deviation Pointer	Magenta
Flight Director Cue	Magenta
Fixed Reference Symbols (i.e. Lubber Lines, etc.)	White
Current Data, Values (i.e. IAS, ALT, VS)	White
Armed Flight Guidance Modes	White
Settable Data, Values (i.e. HDG, Course digital value)	Green
Pilot Selected References (i.e. bugs)	Magenta
CDI Deviation Bar/Scale	Green
Current Leg of Active Route/Flight Plan	Magenta
Future Leg of Active Route/Flight Plan	White

Displayed Item	Color
Acceptable Variations	
Scales and Associated Figures (With Associated Caution)	Amber or Yellow
Scales and Associated Figures (With Associated Warning)	Red
CDI Deviation Bar	White
CDI Deviation Bar	Consistent With a Defined Display-Color Philosophy
ILS Deviation Pointer	White
ILS Deviation Pointer	Consistent With a Defined Display-Color Philosophy
Flight Director	Magenta (coupled) Green (engaged)
Flight Director	Consistent With a Defined Display-Color Philosophy
Pilot Selected References (i.e. “Bugs”)	Consistent With a Defined Display-Color Philosophy
Settable Data, Values (i.e. HDG, Course Digital Value)	White
Settable Data, Values (i.e. HDG, Course Digital Value)	Consistent With a Defined Display-Color Philosophy
Current Leg of Active Route/Flight Plan	Consistent With a Defined Display-Color Philosophy
Future Leg of Active Route/Flight Plan	Consistent With a Defined Display-Color Philosophy

APPENDIX A – Autopilot

A.1 General The "GAMA-Class Cockpit™" The "GAMA-Class Flightdeck™" airplane should have an autopilot and flight director installed. If installed, the autopilot and flight director must conform to the guidance in this Appendix.

A.2 Definitions

A.2.1 Flight Director The function in an automatic flight control system that computes and provides guidance commands to either the command bars for manual flight control, or to the autopilot for automatic flight control. The flight director commands provide the required guidance cues, allowing the pilot or the autopilot to select a heading that will be tracked airplane by the airplane. Examples of Flight Director modes are Navigation, Vertical Speed, Altitude, Heading, etc. The Flight Director must act through an Autopilot for automatic control of the airplane flight path to be provided.

A.2.2 Autopilot The function in an automatic flight control system that computes and provides appropriate commands to servo mechanisms. These mechanisms manipulate the airplane control surfaces such that the airplane attitude is automatically controlled. Without Flight Director input, an autopilot will only be capable of controlling the airplane to maintain pitch and/or roll attitudes.

A.2.3 Yaw Damper The function of an automatic flight control system that computes and provides appropriate commands to a servo mechanism. These mechanisms manipulate the airplane rudder surface so as to continually maintain the airplane in coordinated flight and to dampen any natural yaw oscillation tendencies of the airplane.

A.2.4 Engaged The autopilot servo is connected to the airplane flight controls and manipulates the airplane surfaces.

A.2.5 Mode The operating state of the Flight Director or Autopilot. The mode determines how the airplane flight path is controlled.

A.2.6 Active Mode The flight director mode that is currently providing guidance.

A.2.7 Armed Mode The flight director mode that has been automatically or manually selected. It will become the active mode upon satisfaction of the capture conditions for that mode.

A.3 System Requirements

A.3.1 Guidance The Autopilot and Flight Director must comply with 14 CFR Part 23.1309 (or equivalent if certificated by other Countries) , RTCA DO-178(B) and RTCA DO-254. The Autopilot and Flight Director shall comply with the requirements of 14 CFR Part 23.1329 and 23.1335, and AC 23-17(*), (or equivalent if certificated by other countries).

A.3.2 Display of Autopilot Functions

A.3.2.1 Autopilot Engaged

When any portion or axis of the autopilot system is engaged to the airplane flight controls, an annunciation that the autopilot is engaged must always be displayed in the pilot's primary field of view.

A.3.2.2 Grouping of Mode Displays

When presented on the PFD, annunciation of autopilot modes shall be grouped by vertical and lateral modes such that the engaged state, lateral mode and vertical mode are always displayed in the same position on a manufacturers product.

A.3.2.3 Minimum Autopilot Mode

The autopilot must include a "Wings-Level Hold" mode.

A.3.2.4. Additional Autopilot Modes

The Flight Director/Autopilot should include the following modes:

- Roll attitude hold
- Heading hold
- Pitch hold
- Altitude hold

A.3.2.5 Discretionary Modes - Other

Flight Director/Autopilot modes include (but are not limited to):

- Airspeed Hold
- Vertical Speed Hold
- Altitude Capture
- Vertical Navigation
- Lateral Navigation
- Approach
- Flight Path Angle Hold

A.3.2.6 Display of Navigation Source In-Use by the Autopilot/Flight Director.

If the Flight Director or Autopilot can control the airplane's lateral or vertical flight path by tracking inputs from a navigation radio, computer, or other system, then the navigation source being used by the Flight Director/Autopilot for airplane control must be the same navigation source displayed to the pilot on the Primary Navigation Display, and on any vertical and lateral course deviation indicators displayed on either the ADI or the Primary Navigation Display. Any indication of navigation source must always be displayed to the pilot in the same location on the same manufacturer's product.

A.3.2.7 Display of Flight Director Command Bars and Autopilot Annunciations.

Any time the autopilot is engaged or the flight director is selected, it must be annunciated to the pilot.

A.3.3 Autopilot Control Functions

A.3.3.1 Engaging the Autopilot

The pilot will access the autopilot-engage function using a dedicated control, always located in the same position on a manufacturer's product. This control may also be used to disengage the autopilot. The pilot must not be able to engage the autopilot using a control placed on the control wheel (or stick) or throttles. The autopilot control must have safeguards that prevent inadvertent engagement.

A.3.3.2 Temporarily Disengaging the Autopilot

If a function is provided to temporarily release the autopilot servos during flight, it should be clearly labeled and always located in the same position on a manufacturer's product. If activation of this function also enables Control Wheel Steering, it shall be labeled "Control Wheel Steering" (or "CWS"). Whenever this function or switch is activated, the autopilot servos shall remain disengaged only as long as the function or switch is depressed. Activation shall not change autopilot modes. (When the "CWS", or temporary autopilot disconnect function or switch is released, the autopilot servos will re-engage in the same modes that were selected immediately prior to when "CWS" was activated.)

A.3.3.2.1 Reference-Value Synchronization While Temporarily Disengaged. Except for navigation or heading-hold modes, if the current mode has a fly-to reference, that reference will continuously synchronize to the present value whenever the CWS switch/function is activated. When the CWS function/switch is released, the autopilot will then maintain the reference value for the mode present at the time the function/switch was released.

A.3.3.3. Disengaging the Autopilot

A3.3.3.1 Pilot Actions to Disengage the Autopilot A maximum of a single pilot action shall be needed to disengage the autopilot. This shall be a dedicated function, located on the control wheel or "stick". The following pilot actions shall also disengage the autopilot:

- Removing autopilot electrical power, either by selecting "OFF" with the autopilot master-power function or switch, or by pulling the autopilot circuit breaker)
- Engaging trim functions on any axis for which the autopilot provides auto-trim.
- Activating the "Go-around" switch or function

A.3.3.3.2. Automatic Autopilot Disengagement

A.3.3.3.2.1. Exception to Automatic Disengagement. The autopilot shall not automatically disengage if the result will create a hazardously dynamic airplane response.

A.3.3.3.2.2 Disengaging Below 1.2 V_S **.** The autopilot shall automatically disengage any time it has commanded the airplane to fly below 1.2 V_S.

A.3.3.3.2.3 Disengaging When Limits Will Be Exceeded. The autopilot shall automatically disengage any time it has commanded the airplane in such a manner that it will the exceed auto-flight rates, acceleration or attitude limits pre-programmed for that airplane installation.