Section / Paragraph	Rule Text	Where Acceptable Means of Compliance Found in this AMC
	envelope. If the aircraft experiences an excursion outside this range, the flight guidance system must not provide guidance or control to an unsafe speed.	
CS 25.1329(i)	The FGS functions, controls, indications, and alerts must be designed to minimize flight crew errors and confusion concerning the behaviour and operation of the FGS. Means must be provided to indicate the current mode of operation, including any armed modes, transitions, and reversions. Selector switch position is not an acceptable means of indication. The controls and indications must be grouped and presented in a logical and consistent manner. The indications must be visible to each pilot under all expected lighting conditions.	Section 9, Controls Indications and Alerts
CS 25.1329(j)	Following disengagement of the autopilot, a warning (visual and aural) must be provided to each pilot and be timely and distinct from all other cockpit warnings.	Section 8.1.2.1, Autopilot Disengagement Alerts Section 13, Safety Assessment
CS 25.1329(k)	Following disengagement of the autothrust function, a caution must be provided to each pilot.	Section 8.3.2, Autothrust Disengagement Section 13, Safety Assessment
CS 25.1329(l)	The autopilot must not create an unsafe condition when the flight crew applies an override force to the flight controls.	Section 8.4.1, Flight Crew Override of the FGS – Autopilot Section 13, Safety Assessment
CS 25.1329(m)	During autothrust operation, it must be possible for the flight crew to move the thrust levers without requiring excessive force. The autothrust response to flight crew override must not create an unsafe condition.	Section 8.4.2, Flight Crew Override of the FGS - Autothrust Section 13, Safety Assessment

8 Flight Guidance System Engagement, Disengagement and Override

The characteristics of the FGS during engagement, disengagement and override have caused some concern with systems on some aeroplanes. The following criteria should be addressed in the design of a FGS.

8.1 Autopilot Engagement/Disengagement and Indications

Autopilot engagement and disengagement should be accomplished in a manner consistent with other flight crew procedures and tasks, and should not require undue attention.

8.1.1 Autopilot Engagement

Each pilot should be able to select the autopilot function of the flight guidance system with a single switch action. The single switch action should engage pitch and roll axes. The autopilot system should provide positive indication to the flight crew that the system has been engaged. The selector switch position is not acceptable as a means of indication (reference CS 25.1329(i)).

NOTE: If an operational need is identified for split-axis engagement, then annunciation or indication should be provided for each axis.

For aeroplanes with more than one autopilot installed, each autopilot may be individually selected and should be so annunciated. It should not be possible for multiple autopilots to be engaged in different modes.

The engagement of the autopilot should be free of perceptible transients. Under dynamic conditions, including manoeuvring flight, minor transients are acceptable.

Without a flight director engaged, the initial lateral and vertical modes should be consistent with minimal disturbance from the flight path. For example, the lateral mode at engagement may roll the aeroplane to wings level and then hold the aeroplane heading/track or maintain the existing bank angle (if in a normal range). A heading/track pre-select at engagement function may be provided if precautions are taken to ensure that selection reflects the current intent of the flight crew. The modes at engagement should be annunciated and any associated selected target values should be displayed.

With a flight director engaged, the autopilot should engage into a mode consistent (i.e., the same as, or if that is not possible, then compatible with) the active flight director mode of operation. Consideration should be given to the mode into which the autopilot will engage when large commands are present on either or both flight directors. For example, consideration should be given whether to retain the active flight director mode or engage the autopilot into the basic mode, and the implications for current flight path references and targets. The potential for flight crew confusion and unintended changes in flight path or modes should be considered.

Regardless of the method used, the engagement status (and changes in status) of the autopilot(s) should be clearly indicated and should not require undue attention or recall.

For modes that use multiple autopilots, the additional autopilots may engage automatically at selection of the mode or after arming the mode. A means should be provided to determine that adequate autopilot capability exists to support the intended operation (e.g., "Land 2" and "Land 3" are used in some aircraft).

NOTE: The design should consider the possibility that the pilot may attempt to engage the autopilot outside of the normal flight envelope. It is not required that the autopilot should compensate for unusual attitudes or other situations outside the normal flight envelope, unless that is part of the autopilot's intended function.

8.1.2 Autopilot Disengagement

In consequence of specifications in CS 25.1329(d), under normal conditions, automatic or manual disengagement of the autopilot must be free of significant transients or out-of-trim forces that are not consistent with the manoeuvres being conducted by the aeroplane at the time of disengagement. If multiple autopilots are engaged, any disengagement of an individual autopilot must be free of significant transients and should not adversely affect the operation of the remaining engaged autopilot(s) CS 25.1329(d)).

Under non-normal or rare-normal conditions (see CS 25.1329(e)), disengagement of the autopilot may result in a significant transient. The flight crew should be able to respond to a significant transient without:

— exceptional piloting skill, alertness, or strength,

— forces greater than those given in CS 25.143(d), and

— accelerations or attitudes in the aeroplane that might result in a hazard to secured or non-secured occupants.

The flight crew should be made aware (via a suitable alerting or other indication) of conditions or situations (e.g., continued out-of-trim) that could result in a significant transient at disengagement. (See Section 9.3.3 on Awareness of Potential Significant Transient Condition ("Bark before Bite")).

8.1.2.1 Autopilot Disengagement Alerts (see CS 25.1329(j))

Since it is necessary for a pilot to immediately assume manual control following disengagement of the autopilot (whether manual or automatic), a visual and aural warning must be given (CS 25.1329(j)).

Visual warning: a timely visual warning, distinct from all other cockpit warnings, must be provided and must be located in the primary field of view for both pilots. See CS 25.1329(j).

Aural warning: a timely aural warning must be provided and must be distinct from all other cockpit warnings. See CS 25.1329(j). Even when the autopilot is disengaged by a pilot, it should sound for long enough to ensure that it is heard and recognised by the pilot and other flight crew members (at least a single cycle), but not for so long that it adversely affects communication between crew members or that it is a distraction. The aural warning should continue until silenced by one of the following means:

— Activation of an autopilot quick disengagement control;

— Re-engagement of the autopilot; or

— Another acceptable means.

Multiple-autopilot system: Disengagement of an autopilot within a multiple-autopilot system (e.g., downgraded capability), requiring immediate flight crew awareness and possible timely action, should cause a Caution level alert to be issued to the flight crew.

Disengagement of an autopilot within a multiple-autopilot system, requiring only flight crew awareness, should cause a suitable advisory to be issued to the flight crew.

Disengagement of an autopilot within a multiple-autopilot system (e.g., downgraded capability), requiring immediate flight crew awareness and possible timely action, should cause a Caution level alert to be issued to the flight crew.

Disengagement of an autopilot within a multiple-autopilot system, requiring only flight crew awareness, should cause a suitable advisory to be issued to the flight crew.

8.1.2.2 Quick Disengagement Control (see CS 25.1329(a))

The purpose of the "Quick Disengagement Control" is to ensure the capability for each pilot to manually disengage the autopilot quickly with a minimum of pilot hand/limb movement. The "Quick Disengagement Control" must be located on each control wheel or equivalent CS 25.1329(a)

and should be within easy reach of one or more fingers/thumb of the pilot's hand when the hand is in a position for normal use on the control wheel or equivalent. The "Quick Disengagement Control" should meet the following criteria:

(a) Be accessible and operable from a normal hands-on position without requiring a shift in hand position or grip on the control wheel or equivalent;

(b) Be operable with one hand on the control wheel or equivalent and the other hand on the thrust levers;

NOTE: When establishing location of the quick disengagement control, consideration should be given to:

— its accessibility with large displacements of, or forces on, the control wheel (or equivalent), and

— the possible need to operate the quick disengagement control with the other hand.

(c) Be easily located by the pilot without having to first locate the control visually;

(d) Be designed so that any action to operate the "Quick Disengagement Control" should not cause an unintended input to the control wheel or equivalent; and

(e) Be designed to minimize inadvertent operation and interference with other nearby control wheel (or equivalent) switches/devices (e.g., radio control, trim).

8.1.2.3 Alternative Means of Autopilot Disengagement

When a CS 25.1309 assessment shows a need for an alternative means of disengagement, the following should be addressed:

— Independence,

— The alternate means should be readily accessible to each pilot,

— Latent failure/reliability of the alternate means.

The following means of providing an alternative disengagement have been found to be acceptable:

— Selection of the engagement control to the "off" position.

— Disengage bar on mode selector panel.

— Trim switch on yoke.

NOTE: Use of circuit breakers as a means of disengagement is not considered to be acceptable.

8.1.2.5 Flight Crew Pitch Trim Input

If the autopilot is engaged and the pilot applies manual pitch trim input, either the autopilot should disengage with no more than a minor transient, or pitch trim changes should be inhibited (see CS 25.1329(l)).

8.2 Flight Director Engagement/Disengagement and Indications

Engagement and disengagement should be accomplished consistent with other flight crew procedures and tasks and should not require undue attention.

8.2.1 Flight Director Engagement

A means should be provided for each pilot to select (i.e., turn on) and deselect the flight director for display on their primary flight display (e.g., attitude display). The selection status of the flight director and the source of flight director guidance should be clear and unambiguous. Failure of a selected flight director should be clearly annunciated.

A flight director is considered “engaged” if it is selected and displaying guidance cues.

NOTE: The distinction is made between “engaged” and “selected” because the flight director might be selected, but not displaying guidance cue(s) (e.g., the cue(s) are biased out of view).

If there are multiple flight directors, and if required for crew awareness, indications should be provided to denote which flight director is engaged (e.g., FD1, FD2, HUD source). For aeroplanes with multiple flight directors installed, both flight directors should always be in the same armed and active FGS modes. The selection status of each flight director should be clear and unambiguous for each pilot. In addition, indications should be provided to denote loss of flight director independence (i.e., first officer selection of captain’s flight director).

A flight director should engage into the current modes and targets of an already engaged autopilot or flight director, if any. With no autopilot engaged, the basic modes at engagement of the flight director functions should be established consistent with typical flight operations.

NOTE: The engagement of the pitch axis in Vertical Speed or Flight Path Angle, and engagement of the lateral axis in Heading Hold, Heading Select or Bank Angle Hold have been found to be acceptable.

Since the HUD can display flight guidance, the HUD guidance mode should be indicated to both pilots and should be compatible with the active head-down flight director mode.

Engagement during manoeuvring flight should be considered.

NOTE: The design should consider the safety consequences if it is possible for the flight director to engage outside of the normal flight envelope. It is not required that the flight director should compensate for unusual attitudes or other situations outside the normal flight envelope, unless that is part of the flight director’s intended function.

8.2.1.1 Guidance Cue(s)

The flight director command guidance cue(s) will typically be displayed when the flight director is selected and valid command guidance is available or if it is automatically providing guidance as per paragraph 8.2.1.2 below. The flight director guidance cue(s) should be removed when guidance is determined to be invalid. The display of guidance cue(s) (e.g., flight director bars) is sufficient indication that the flight director is engaged.

8.2.1.2 Reactive Windshear Flight Director Engagement

For aeroplanes equipped with a flight director windshear guidance system, flight director engagement should be provided, consistent with the criteria contained in FAA AC's 25-12 and 120-41.

8.2.2 Flight Director Disengagement

There may be a means for each pilot to readily deselect his or her on-side flight director function. Flight crew awareness of disengagement and de-selection is important. Removal of guidance cue(s) alone is not sufficient indication of de-selection, because the guidance cue(s) may be removed from view for a number of reasons, including invalid guidance, autopilot engagement, etc. Therefore, the flight director function should provide clear and unambiguous indication (e.g., switch position or status) to the flight crew that the function has been deselected.

8.3 Autothrust Engagement/Disengagement and Indications

The autothrust function should be designed with engagement and disengagement characteristics that provide the flight crew positive indication that the system has been engaged or disengaged. Engagement and disengagement should be accomplished in a manner consistent with other flight crew procedures and tasks and should not require undue attention.

8.3.1 Autothrust Engagement

The autothrust engagement controls should be accessible to each pilot. The autothrust function must provide the flight crew positive indication that the system has been engaged.

The autothrust function should be designed to prevent inadvertent engagement and inadvertent application of thrust, for both on-ground and in-air operations (e.g., provide separate arm and engage functions).

The autothrust normally should be designed to preclude inadvertent engagement. However, intended modes such as a "wake up" mode to protect for unsafe speeds may be acceptable (see Section 10.4.1 on Low Speed Protection). If such automatic engagement occurs, it should be clear to the flight crew that automatic engagement has occurred, the automatic engagement should not cause any unsafe condition (e.g., unsafe pitch attitudes or unsafe pitching moments), to show compliance with CS 25.1329(c), and the reason for automatic engagement should be clear and obvious to the flight crew.

NOTE: The design should consider the possibility that the pilot may attempt to engage the autothrust function outside of the normal flight envelope or at excessive (or too low) engine thrust. It is not expected that the autothrust feature should compensate for situations outside the normal flight envelope or normal engine operation range, unless that is part of the intended function of the autothrust system.

8.3.2 Autothrust Disengagement

Autothrust disengagement should not cause any unsafe condition (e.g., pitch attitude, pitching moment, or significant thrust transient), to show compliance with CS 25.1329(d), and the disengagement should not preclude, inhibit, or interfere with timely thrust changes for go-around, landing, or other manoeuvres requiring manual thrust changes.

The autothrust normally should be designed to preclude inadvertent disengagement during activation of autothrust modes of operation.

Following disengagement of the autothrust function, positive indication of disengagement should include at least a visual flight crew alert and deletion of autothrust 'engaged' status annunciations (to show compliance with CS 25.1329(k)). For automatic disengagement, visual indications should persist until cancelled by flight crew action. For manual disengagement, if an aural is provided, visual indications should persist for some minimum period. If an aural is not provided, the visual indications should persist until cancelled by flight crew action. For aural indication, if provided, an aural alert of sufficient duration and volume should be provided to assure that the flight crew has been alerted that disengagement has occurred. An extended cycle of an aural alert is not acceptable following disengagement if such an alert can significantly interfere with flight crew coordination or radio communication. Disengagement of the autothrust function is considered a Caution alert.

8.3.2.1 Autothrust Quick Disengagement Control

Autothrust quick disengagement controls must be provided for each pilot on the respective thrust control lever as stated in CS 25.1329(a). A single-action, quick disengagement switch should be incorporated on the thrust control so that switch activation can be executed when the pilot's other hand is on the flight controls. The disengagement control should be positioned such that inadvertent disengagement of the autothrust function is unlikely. Positioning the control on the outboard side has been shown to be acceptable for multiengine aircraft. Thrust lever knob-end-mounted disengagement controls available on both sides to facilitate use by either pilot have been shown to be preferable to those positioned to be accessible by the pilot's palm.

8.4 Flight Crew Override of the FGS

The following sections discuss criteria related to the situation where the flight crew overrides the FGS.

8.4.1 Autopilot

1) The autopilot should disengage when the flight crew applies a significant override force to the controls. The applicant should interpret "significant" as a force that is consistent with an intention to overpower the autopilot by either or both pilots. The autopilot should not disengage for minor application of force to the controls (e.g., a pilot gently bumping the control column while entering or exiting a pilot seat during cruise).

NOTE:111 N (25 lbf) at the control column or wheel has been determined to be a significant override force level for other than approach operations on some aircraft types. To reduce nuisance disengagement, higher forces have been found acceptable for certain approach, landing, and go-around operations on some aircraft types. The force to disengage an autopilot is not necessarily the force required at the column to oppose autopilot control (e.g., cause elevator movement). The corresponding forces for a side stick or centre stick controller may be different.

Under normal conditions, a significant transient should not result from autopilot disengagement when the flight crew applies an override force to the controls (to show compliance with CS 25.1329(d).

Sustained or incremental application of force below the disengagement threshold should not result in a hazardous condition (e.g., the automatic trim running that results in unacceptable aeroplane motion if the autopilot were to automatically disengage, or when manually disengaged).

2) If the autopilot is not designed to disengage in response to any override force, then the response shall be shown to be safe (CS 25.1329(l)).

a) The sustained application of an override force should not result in a potential hazard when the flight crew manually disengages the autopilot or abruptly releases the force on the controls. During sustained application of an override force, the automatic trim should not run to oppose the flight crew commands in any manner that would result in unacceptable aeroplane motion. Mitigation may be accomplished through the provision of an appropriate alert and flight crew procedure.

NOTE: The term 'sustained application of override force' is intended to describe a force that is applied to the controls, which may be small, slow, and sustained for some period of time. This may be due to an inadvertent crew action or may be an intentional crew action meant to 'assist' the autopilot in a particular manoeuvre. (See Chapter 14, Compliance Demonstration Using Flight Test and Simulation, paragraph 14.1.5, Flight Crew Override of the Flight Guidance System, of this AMC for more information.)

b) Transients resulting from an override force: Under normal conditions, a significant transient should not result from manual autopilot disengagement after the flight crew has applied an override force to the controls (CS 25.1239(d)).

NOTE 1: the term 'override force' is intended to describe a pilot action that is intended to prevent, oppose or alter an operation being conducted by a flight guidance function, without first disengaging that function. One possible reason for this action could be an avoidance manoeuvre (such as responding to an ACAS/TCAS Resolution Advisory) that requires immediate action by the flight crew and would typically involve a rapid and forceful input from the flight crew.

NOTE 2: For control wheel steering considerations, refer to Section 11.6.

8.4.2 Autothrust

It should be possible for the pilot to readily override the autothrust function and set thrust by moving the thrust levers (or equivalent) with one hand. CS 25.1329(m) requires that the autothrust response to a flight crew override must not create an unsafe condition.

Autothrust functions may be designed to safely remain engaged during pilot override. Alternatively, autothrust functions may disengage as a result of pilot

override, provided that the design prevents unintentional autothrust disengagement and adequately alerts the flight crew to ensure pilot awareness.

8.5 FGS Engagement Mode Compatibility

The philosophy used for the mode at engagement of the autopilot, flight director, and autothrust functions should be provided in flight crew training material.

It should not be possible to select incompatible FGS command or guidance functions at the same time (e.g., commanding speed through elevator and autothrust at the same time).

9 Controls, Indications and Alerts

The human-machine interface with the FGS is a key to ensuring safe, effective and consistent FGS operation. The manner in which FGS information is depicted to flight crews is essential to the flight crew awareness, and therefore, the safe operation of the FGS.

The controls, indications, and alerts must be so designed as to minimize flight crew errors and confusion (CS 25.1329(i)). Indications and alerts should be presented in a manner compatible with the procedures and assigned tasks of the flight crew and provide the necessary information to perform those tasks. The indications must be grouped and presented in a logical and consistent manner and be visible from each pilot's station under all expected lighting conditions (CS 25.1329(i)). The choice of colours, fonts, font size, location, orientation, movement, graphical layout and other characteristics such as steady or flashing should all contribute to the effectiveness of the system. Controls, indications, and alerts should be implemented in a consistent manner.

It is recommended that the applicant evaluate the adequacy and effectiveness of the information provided by the FGS interface (i.e., controls, indications, alerts, and displays) to ensure flight crew awareness of FGS behaviour and operation. See Section 14, Compliance Demonstration using Flight Test and Simulation, for more discussion of appropriate analyses (which may include, for example, cognitive task analysis as a basis for evaluation).

9.1 FGS Controls

The FGS controls should be designed and located to provide convenient operation to each crewmember and they must be designed to minimize crew errors, confusion and inadvertent operation (CS 25.1329(i)). To achieve this, CS 25,1329(f) requires that command reference controls to select target values (e.g., heading select, vertical speed) should operate as specified in CS 25.777(b) and 25.779(a) for cockpit controls. The function and direction of motion of each control must be readily apparent or plainly indicated on, or adjacent to, each control if needed to prevent inappropriate use or confusion (CS 25,1329(f)). CS 25.781 also provides requirements for the shapes of the knobs. The design of the FGS should address the following specific considerations:

— Differentiation of knob shape and position. (Errors have included confusing speed and heading knobs on the mode selector panel.)

— Design to support correct selection of target values. (Use of a single control (e.g., concentric controls) for selecting multiple command reference targets has resulted in erroneous target value selection.)

— Commonality of control design across different aircraft to prevent negative transfer of learning with respect to operation of the controls. (Activation of the wrong thrust function has occurred due to variation of TOGA and autothrust

disengagement function between aeroplane types- negative transfer of learning with respect to operation of the controls.)

— Positioning of individual FGS controls, FMAs, and related primary flight display information so that, as far as reasonably practical, items of related function have similarly related positions. (Misinterpretation and confusion have occurred due to the inconsistent arrangement of FGS controls with the annunciations on the FMA.)

— Design to discourage or avoid inadvertent operation; e.g., engagement or disengagement (to show compliance with CS 25.777(a)).

9.2 Flight Guidance Mode Selection, Annunciation, and Indication

Engagement of the Flight Guidance System functions must be suitably annunciated to each pilot (to show compliance with CS 25.1329(i)), as described in Section 8, Flight Guidance System Engagement, Disengagement, and Override. The FGS mode annunciations must effectively and unambiguously indicate the active and armed modes of operation (CS 25.1329(i)). The mode annunciation should convey explicitly, as simply as possible, what the FGS is doing (for active modes), what it will be doing (for armed modes), and target information (such as selected speed, heading, and altitude) for satisfactory flight crew awareness.

Mode annunciation must indicate the state of the system and not just switch position or selection (CS 25.1329(i)). Mode annunciation should be presented in a manner compatible with flight crew procedures / tasks and consistent with the mode annunciation design for the specific aircraft type (i.e., compatible with other flight deck systems mode annunciations).

Operationally relevant mode changes and, in particular, mode reversions and sustained speed protection, should be clearly and positively annunciated to ensure flight crew awareness. Altitude capture is an example of an operationally relevant mode that should be annunciated because pilot actions may have different effects on the aeroplane. Annunciation of sustained speed protection should be clear and distinct to ensure flight crew awareness. It should be made clear to the pilot if a mode has failed to arm or engage (especially due to invalid sensor data). FGS sub-modes (e.g., sub-modes as the FGS transitions from localizer capture to localizer track) that are not operationally relevant need not be annunciated.

In-service experience has shown that mode annunciation alone may be insufficient (unclear or not compelling enough) to communicate mode changes to the flight crew, especially in high workload situations. Therefore, the safety consequences of the flight crew not recognizing mode changes should be considered. If necessary, an appropriate alert should be used.

Mode annunciations should be located in the forward field of view (e.g., on the primary flight display). Mode selector switch position or status is not acceptable as the sole means of mode annunciation (CS 25.1329(i)). Modes and mode changes should be depicted in a manner that achieves flight crew attention and awareness. Aural notification of mode changes should be limited to special considerations. Colours, font type, font size, location, highlighting, and symbol flashing have historical precedent as good discriminators, when implemented appropriately. The fonts and font size should be chosen so that annunciation of FGS mode and status information is readable and understandable, without eye strain, when viewed by the pilot seated at the design eye position.