CS 25.1329 Flight Guidance System

ED Decision 2007/020/R

(See AMC Nos. 1 and 2 to CS 25.1329)

(a) Quick disengagement controls for the autopilot and autothrust functions must be provided for each pilot. The autopilot quick disengagement controls must be located on both control wheels (or equivalent). The autothrust quick disengagement controls must be located on the thrust control levers. Quick disengagement controls must be readily accessible to each pilot while operating the control wheel (or equivalent) and thrust control levers.

(b) The effects of a failure of the system to disengage the autopilot or autothrust functions when manually commanded by the pilot must be assessed in accordance with the specifications of CS 25.1309.

(c) Engagement or switching of the flight guidance system, a mode, or a sensor must not produce a transient response affecting the control or flight path of the aeroplane any greater than a minor transient.

(d) Under normal conditions, the disengagement of any automatic control functions of a flight guidance system must not produce a transient response affecting the control or flight path of the aeroplane any greater than a minor transient.

(e) Under rare-normal or non-normal conditions, the disengagement of any automatic control functions of a flight guidance system must not produce a transient response affecting the control or flight path of the aeroplane any greater than a significant transient.

(f) The function and direction of motion of each command reference control (e.g., heading select, vertical speed) must be readily apparent or plainly indicated on, or adjacent to, each control if necessary to prevent inappropriate use or confusion.

(g) Under any condition of flight appropriate to its use, the flight guidance system must not:

— produce unacceptable loads on the aeroplane (in accordance with CS 25.302), or

— create hazardous deviations in the flight path.

This applies to both fault-free operation and in the event of a malfunction, and assumes that the pilot begins corrective action within a reasonable period of time.

(h) When the flight guidance system is in use, a means must be provided to avoid excursions beyond an acceptable margin from the speed range of the normal flight envelope. If the aircraft experiences an excursion outside this range, the flight guidance system must not provide guidance or control to an unsafe speed.

(i) The flight guidance system functions, controls, indications, and alerts must be designed to minimise flight crew errors and confusion concerning the behaviour and operation of the flight guidance system. 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.

(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.

(k) Following disengagement of the autothrust function, a caution must be provided to each pilot.

(l) The autopilot must not create an unsafe condition when the flight crew applies an override force to the flight controls.

(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.

[Amdt 25/4]

AMC No. 1 to CS 25.1329 Flight Guidance System

ED Decision 2020/024/R

1 PURPOSE

This AMC provides interpretative material and acceptable means of compliance with the specifications of CS 25.1329 for Flight Guidance Systems. These means are intended to provide guidance to supplement the engineering and operational judgment that must form the basis of any compliance demonstration.

2 RELATED CERTIFICATION SPECIFICATIONS

CSs

The following are related CS standards:

CS 25.115	Take-off flight path
CS 25.302	Interaction of systems and structures
CS 25.671	Control systems, General
CS 25.672	Stability augmentation and automatic and power-operated systems
CS 25.677	Trim systems
CS 25.777	Cockpit controls
CS 25.779	Motion and effect of cockpit controls
CS 25.781	Cockpit control knob shape
CS 25.901	Powerplant, General, Installation–
CS 25.903	Powerplant, General, Engines
CS 25.1301	Equipment, General, Function and installation–
CS 25.1309	Equipment, systems, and installations
CS 25.1322	Flight Crew Alerting System
CS 25.1419	Ice protection
CS 25.1420	Supercooled large drop icing condition
CS 25.1581	Aeroplane Flight Manual, General
CS-AWO	All Weather Operations

3 RELATED ADVISORY MATERIAL

EASA Acceptable Means of Compliance (AMC) and FAA Advisory Circulars (FAA AC).

The following guidance and advisory materials are related to this AMC:

AMC 20-115	Software Considerations for Airborne Systems and Equipment Certification
AMC 25.1309	System Design and Analysis
AMC 25.1322	Alerting Systems
AMC 25.1581	Aeroplane Flight Manual
AMC 25-11	Electronic Display Systems

FAA AC 20-129	Airworthiness Approval of Vertical Navigation (VNAV) Systems for use in the U.S. National Airspace System (NAS) and Alaska
FAA AC 25-7C	Flight Test Guide for Certification of Transport Category Airplanes
FAA AC 25-12	Airworthiness Criteria for the Approval of Airborne Windshear Warning Systems in Transport Category Airplanes
FAA AC 120-28D	Criteria for Approval of Category III Weather Minima for Takeoff, Landing, and Rollout
FAA AC 120-29A	Criteria for Approval of Category I and Category II Weather Minima for Approach
FAA AC 120-41	Criteria for Operational Approval of Airborne Wind Shear Alerting and Flight Guidance Systems

4 RELATED DOCUMENTS

JAA documents:

JAR-OPS 1	Commercial Air Transportation (Aeroplanes)

Industry documents.

The following are related Industry Standards that may be useful in the design process:

SAE ARP5366	Autopilot, Flight Director and Autothrust Systems
SAE ARP4754A/ EUROCAE ED-79A	Guidelines for development of civil aircraft and systems
SAE ARP4100	Flight Deck and Handling Qualities Standards for Transport Aircraft
SAE ARP4761	Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment
RTCA DO-160G/ EUROCAE ED-14G	Environmental Conditions and Test Procedures for Airborne Equipment
RTCA DO-254/ EUROCAE ED-80	Design Assurance Guidance for Airborne Electronic Hardware
DOT/FAA/CT-96/1	Human Factors Design Guide for Acquisition of Commercial-Off-the-Shelf Subsystems, Non-Developmental Items, and Developmental Systems.

5 DEFINITIONS AND ACRONYMS

The following definitions apply to the specifications of CS 25.1329 and the guidance material provided in this AMC. They should not be assumed to apply to the same or similar terms used in other regulations or AMC material. Terms for which standard dictionary definitions apply are not defined in this AMC.

5.1 Definitions

Abnormal Condition	See Non-normal
Advisory	EASA: Crew awareness is required and subsequent crew action may be required. (AMC 25.1322)
Alert	A generic term used to describe a flight deck indication meant to attract the attention of the flight crew to a non-normal operational or aeroplane system condition without implying the degree or level of urgency for recognition and corrective action by the crew. Warnings, Cautions and Advisories are considered to be Alerts.

	EASA definition: A signal to the crew intended to draw their attention to the existence of an abnormality, system fault or aircraft condition and to identify it. (AMC 25.1322)
Analysis	The terms “analysis” and “assessment” are used throughout. Each has a broad definition and the two terms are to some extent interchangeable. However, the term analysis generally implies a more specific, more detailed evaluation, while the term assessment may be a more general or broader evaluation but may include one or more types of analysis (AMC 25.1309).
Arm	A condition where the intent to transition to a new mode or state has been established but the criteria necessary to make that transition has not been satisfied.
Assessment	See the definition of analysis above (AMC 25.1309).
Autopilot	The autopilot function provides automatic control of the aeroplane, typically in pitch, roll, and yaw. The term includes the sensors, computers, power supplies, servo-motors/actuators and associated wiring, necessary for its function. It includes any indications and controllers necessary for the pilot to manage and supervise the system. Any part of the autopilot that remains connected to the primary flight controls when the autopilot is not in use is regarded as a part of the primary flight controls.
Autothrust	The autothrust function provides automatic control of the thrust of the aeroplane. The term includes the sensors, computers, power supplies, servo-motors/actuators and associated wiring, necessary for its function. It includes any indications and controllers necessary for the pilot to manage and supervise the system. Any part of the autothrust that remains connected to the engine controls when the autothrust is not in use is regarded as a part of the engine control system.
Caution	A flight deck indication that alerts the flight crew to a non-normal operational or aeroplane system condition that requires immediate crew awareness. Subsequent pilot corrective compensatory action will be required.
Cognitive Task Analysis	An analysis that focuses on the mental processes, skills, strategies, and use of information required for task performance.
Complex	A system is Complex when its operation, failure modes, or failure effects are difficult to comprehend without the aid of analytical methods (AMC 25.1309).
Conformal	Positioned and scaled with respect to the outside view
Control Wheel Steering (CWS)	A Flight Guidance System (FGS) function which, when engaged, enables the pilot/first officer to manually fly the aeroplane by positioning the flight control surfaces using the autopilot servos. The positions of the flight deck controls (e.g., control column, control wheel) are determined by the FGS, which converts them into autopilot servo commands. The autopilot servos, in turn, drive the appropriate flight control surfaces.
Conventional	A system is considered to be Conventional if its functionality, the technological means used to implement its functionality, and its intended usage are all the same as, or closely similar to, that of previously approved systems that are commonly-used (AMC 25.1309).
Engage	A steady state that exists when a flight crew request for mode or system functionality has been satisfied.
Error	An omission or incorrect action by a crewmember or maintenance personnel, or a mistake in requirements, design, or implementation (AMC 25.1309).
Failure	An occurrence that affects the operation of a component, part, or element such that it can no longer function as intended (this includes both loss of function and malfunction).

	NOTE: Errors may cause failures, but are not considered to be failures (AMC 25.1309).
Failure Condition	A condition having an effect on the aeroplane and/or its occupants, either direct or consequential, which is caused or contributed to by one or more failures or errors, considering flight phase and relevant adverse operational or environmental conditions, or external events (AMC 25.1309)
Fail Operational System	A system capable of completing an operation, following the failure of any single element or component of that system, without pilot action.
Fail Passive System	A system which, in the event of a failure, results in: (a) no significant deviation in the aircraft flight path or attitude and (b) no out-of-trim condition at disengagement that is not easily controlled by the pilot.
Flight Director	A visual cue or set of cues that are used during manual control of the aeroplane as command information to direct the pilot how to manoeuvre the aeroplane, usually in pitch, roll and/or yaw, to track a desired flight path. The flight director, displayed on the pilot's primary head down attitude indicator (ADI) or head up display (HUD), is a component of the flight guidance system and is integrated with airborne attitude, air data and navigation systems.
Flight Guidance System	A system consisting of one or more of the following elements: (a) autopilot, (b) flight director, (c) automatic thrust control, and any interactions with stability augmentation and trim systems.
Flight Management System	An aircraft area navigation system and associated displays and I/O device(s) having complex multi-waypoint lateral (LNAV) and vertical (VNAV) navigation capability (or equivalent), data entry capability, data base memory to store route and instrument flight procedure information, and display readout of navigation parameters. The Flight Management System provides guidance commands to the FGS for the purpose of automatic navigation and speed control when the FGS is engaged in an appropriate mode or modes (e.g., VNAV, LVAV, RNAV).
Head-Up Display (HUD)	A transparent optical display system located level with and between the pilot and the forward windscreen. The HUD displays a combination of control, performance, navigation, and command information superimposed on the external field of view. It includes the display element, sensors, computers and power supplies, indications and controls. It is integrated with airborne attitude, air data and navigation systems, and as a display of command information is considered a component of the light guidance system.
Inadvertent	A condition or action that was not planned or intended.
Latent Failure	A failure is latent until it is made known to the flight crew or maintenance personnel. A significant latent failure is one, which would in combination with one or more specific failures, or events result in a Hazardous or Catastrophic Failure Condition (AMC 25.1309).
Limit Flight Envelope	This envelope is the most outside flight envelope, generally associated with aeroplane design limits
Mode	A mode is system configuration that corresponds to a single (or set of) FGS behaviour(s).
Non-normal Condition	A condition or configuration of the aeroplane that would not normally be experienced during routine flight operations - usually due to failures or non-routine operating conditions (e.g., excessive out-of-trim due to fuel imbalance or under certain ferry conditions).

Normal Condition	Any fault free condition typically experienced in normal flight operations. Operations typically well within the aircraft flight envelope, and with routine atmospheric and environmental conditions.
Normal Flight Envelope	The range of altitude and operating speeds that are defined by the aeroplane manufacturer as consistent with conducting flight operations for which the aeroplane is designed. This envelope is generally associated with practical, routine operation and/or prescribed conditions, whether all-engine or engine inoperative.
Override	An action taken by the flight crew intended to prevent, oppose or alter an operation being conducted by a flight guidance function, without first disengaging that function.
Rare Normal Condition	A fault-free condition that is experienced infrequently by the aeroplane due to significant environmental conditions (e.g., significant wind, turbulence, or icing, etc.)
Redundancy	The presence of more than one independent means for accomplishing a given function or flight operation (AC/AMC 25.1309).
Select	The flight crew action of requesting functionality or an end state condition.
Significant transient	See “transient.”
Stability Augmentation System	Automatic systems, which provide or enhance stability for specific aerodynamic characteristics of an aeroplane (e.g., Yaw Damper, Longitudinal Stability Augmentation System, Mach Trim).
System	A combination of components, parts, and elements that are inter-connected to perform one or more specific functions (AMC 25.1309).
Transient	A disturbance in the control or flight path of the aeroplane that is not consistent with response to flight crew inputs or current environmental conditions. Minor transient: A transient that would not significantly reduce safety margins, and which involves flight crew actions that are well within their capabilities involving a slight increase in flight crew workload or some physical discomfort to passengers or cabin crew. Significant transient: A transient that would lead to a significant reduction in safety margins, a significant increase in flight crew workload, discomfort to the flight crew, or physical distress to passengers or cabin crew, possibly including non-fatal injuries. NOTE: The flight crew should be able to respond to any significant transient without: exceptional piloting skill, alertness, or strength, forces greater than those given in CS 25.143(cd), and accelerations or attitudes in the aeroplane that might result in further hazard to secured or non-secured occupants.
Warning	A flight deck indication that alerts the flight crew to a non-normal operational or aeroplane system requiring immediate recognition. Immediate corrective or compensatory action by the flight crew is required.

5.2 Acronyms

AC	Advisory Circular (FAA)
ACAS	Airborne Collision Avoidance System
AMC	Acceptable Means of Compliance
AFM	Aeroplane Flight Manual
AGL	Above Ground Level

AIM	Airman's Information Manual
ARP	Accepted and Recommended Practice
ATC	Air Traffic Control
AWO	All Weather Operations
CG	Centre of Gravity
CDI	Course Deviation Indicator
CWS	Control Wheel Steering
DA	Decision Altitude
DA(H)	Decision Altitude (Height)
DME	Distance Measuring Equipment
EFIS	Electronic Flight Instrument System
EVS	Enhanced Vision System
FAA	Federal Aviation Administration
FCOM	Flight Crew Operations Manual
F/D	Flight Director
FGS	Flight Guidance System
FLCH	Flight Level Change
FMA	Flight Mode Annunciator
FMS	Flight Management System
GA	Go-around
GLS	GNSS Landing System
GNSS	Global Navigation Satellite System
GPWS	Ground Proximity Warning System
HDD	Head Down Display
HUD	Head-Up Display
IAS	Indicated Air Speed
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
IMA	Integrated Modular Avionics
IMC	Instrument Meteorological Conditions
JAA	Joint Aviation Authorities
LNAV	Lateral Navigation
LOC	Localizer
MDA(H)	Minimum Descent Altitude (Height)
MLS	Microwave Landing System
MSL	Mean Sea Level
MSP	Mode Select Panel
MUH	Minimum Use Height
NAV	Navigation
ND	Navigation Display
NDB	Non Directional Beacon
NPA	Notice of Proposed Amendment
NPRM	Notice of Proposed Rulemaking
PF	Pilot Flying
PFD	Primary Flight Display
PNF	Pilot Not Flying

RNAV	Area Navigation
RNP	Required Navigation Performance
RTO	Rejected Takeoff
RVSM	Reduced Vertical Separation Margin
SAE	Society of Automotive Engineering
SVS	Synthetic Vision System
TCAS	Traffic Collision Alert System
TCS	Touch Control Steering
TO	Takeoff
TOGA	Takeoff or Go-around
VMC	Visual Meteorological Conditions
VNAV	Vertical Navigation
VOR	VHF Omni Range
WAT	Weight Altitude Temperature

6 BACKGROUND

This advisory material replaces material previously provided in AMC 25.1329 for Automatic Pilots. The automatic control and guidance systems in current aircraft have evolved to a level that dictates a revision to current advisory material.

There have been dramatic changes in technology and system design, which have resulted in much higher levels of integration, automation, and complexity. These changes have also redefined the allocation of functions and interfaces between systems. Relatively simple, dedicated systems have been replaced with digital multi-function systems with more modes, and automatic changes in modes of operation. The introduction of fly-by-wire flight control systems has created new interface considerations for the FGS elements. These new systems are capable of providing better performance, increased safety and decreased workload. But if designed without consideration for the criteria in this AMC, these systems could also be confusing and not immediately intuitive for the flight crew. Significant operational experience has been gained on new generation systems and guidance material is provided herein based on that experience.

This advisory material is provided for Flight Guidance Systems, which include any autopilot functions, flight director functions, automatic thrust control functions and any interactions with stability augmentation and trim functions.

7 GENERAL

The FGS is primarily intended to assist the flight crew in the basic control and tactical guidance of the aeroplane. The system may also provide workload relief to the pilots and may provide a means to fly a flight path more accurately to support specific operational requirements (e.g. RVSM, RNP, etc.).

The applicant should establish, document and follow a design philosophy that supports the intended operational use regarding the FGS behaviour; modes of operation; pilot interface with controls, indications, and alerts; and mode functionality.

Description of the FGS behaviour and operation should be addressed from flight crew and maintenance perspectives in appropriate documentation and training material.

Subsequent sections of this advisory material provide interpretative material and acceptable means of compliance with CS 25.1329 and the applicability of other CS-25 rules to FGS (e.g., CS

25.1301, CS 25.1309). The demonstrated means of compliance may include a combination of analysis, laboratory testing, flight-testing, and simulator testing. The applicant should coordinate with the authorities early in the certification programme, via a certification plan, to reach agreement on the methods to be used to demonstrate compliance.

7.1 Flight Guidance System Functions

The following functions, when considered separately and together, are considered elements of a Flight Guidance System:

— Flight guidance and control (e.g., autopilot, flight director displayed head-down or head-up);

— Autothrottle/autothrust systems;

— Interactions with stability augmentation and trim systems; and

— Alerting, status, mode annunciation, and situation information associated with flight guidance and control functions.

The FGS includes those functions necessary to provide guidance and control in conjunction with an approach and landing system, such as:

— the Instrument Landing System (ILS),

— the Microwave Landing System (MLS) or

— the Global Navigation Satellite System (GNSS) Landing System (GLS).

The FGS also includes those functions necessary to provide guidance and control in conjunction with a Flight Management System (FMS). The FGS does not include the flight planning and the generation of flight path and speed profiles tied to waypoints and other flight planning aspects of the Flight Management System (FMS). However, it does include the interface between the FMS and FGS necessary for the execution of flight path and speed commands.

7.2 FGS Components

For the purpose of this AMC the term “FGS” includes all the equipment necessary to accomplish the FGS function, including the sensors, computers, power supplies, servo-motors/actuators, and associated wiring. It includes any indications and controllers necessary for the pilot to manage and supervise the system.

Any part of the FGS that remains mechanically connected to the primary flight controls or propulsion controls when the Flight Guidance System is not in use is regarded as a part of the primary flight controls and propulsion system, and the provisions for such systems are applicable.

7.3 Compliance with CS 25.1329

Table 7.3-A lists the relevant paragraphs of CS 25.1329 and provides an indication where acceptable means of compliance with each paragraph may be found within this AMC.

TABLE 7.3-A.

Where Means of Compliance Can Be Found in this AMC

Section / Paragraph	Rule Text	Where Acceptable Means of Compliance Found in this AMC
CS 25.1329(a)	Quick disengagement controls for the autopilot and autothrust functions must be provided for each pilot. The autopilot quick disengagement controls must be located on both control wheels (or equivalent). The autothrust quick disengagement controls must be located on the thrust control levers. Quick disengagement controls must be readily accessible to each pilot while operating the control wheel (or equivalent) and thrust control levers.	Section 8.1, Autopilot Engagement/Disengagement and Indications Section 8.3, Autothrust Engagement/Disengagement and Indications
CS 25.1329(b)	The effects of a failure of the system to disengage the autopilot or autothrust functions when manually commanded by the pilot must be assessed in accordance with the specifications of CS 25.1309.	Section 8.1, Autopilot Engagement/Disengagement and Indications Section 8.3, Autothrust Engagement/Disengagement and Indications Section 13.6, Safety Assessment – Failure to Disengage the FGS
CS 25.1329(c)	Engagement or switching of the flight guidance system, a mode, or a sensor must not produce a transient response affecting the control or flight path of the aeroplane any greater than a minor transient.	Section 8, FGS Engagement, Disengagement, and Override Section 13, Safety Assessment
CS 25.1329(d)	Under normal conditions, the disengagement of any automatic control functions of a flight guidance system must not produce a transient response affecting the control or flight path of the aeroplane any greater than a minor transient.	Section 8, FGS Engagement, Disengagement, and Override Section 13, Safety Assessment
CS 25.1329(e)	Under rare-normal or non-normal conditions the disengagement of any automatic control functions of a flight guidance system must not produce a transient response affecting the control or flight path of the aeroplane any greater than a significant transient.	Section 8, FGS Engagement, Disengagement, and Override Section 9.3.3, Awareness of Potential Significant Transient Condition (“Bark before Bite”)
CS 25.1329 (f)	The function and direction of motion of each command reference control (e.g., heading select, vertical speed) must be readily apparent or plainly indicated on, or adjacent to, each control if necessary to prevent inappropriate use or confusion.	Section 9, Controls, Indications and Alerts
CS 25.1329(g)	Under any condition of flight appropriate to its use, the Flight Guidance System must not: — produce unacceptable loads on the aeroplane (in accordance with CS 25.302), or — create hazardous deviations in the flight path. This applies to both fault-free operation and in the event of a malfunction, and assumes that the pilot begins corrective action within a reasonable period of time.	Section 10, Performance of Function Section 13, Safety Assessment Section 14, Compliance Demonstration using Flight Test and Simulation
CS 25.1329(h)	When the flight guidance system is in use, a means must be provided to avoid excursions beyond an acceptable margin from the speed range of the normal flight	Section 10.4, Speed Protection