

European Aviation Safety Agency

The Executive Director

DECISION NO. 2003/6/RM

OF THE EXECUTIVE DIRECTOR OF THE AGENCY

of 17 October 2003

on certification specifications, including airworthiness codes and acceptable means of compliance, for all weather operations (« CS-AWO »)

THE EXECUTIVE DIRECTOR OF THE EUROPEAN AVIATION SAFETY AGENCY

Having regard to Regulation (EC) No 1592/2002 of the European Parliament and of the Council of 15 July 2002 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency¹ (hereinafter referred to as the “Basic Regulation”), and in particular Articles 13 and 14 thereof,

Having regard to the Commission Regulation (EC) No 1702/2003 of 24 September 2003² laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations, in particular 21A.16A of Part 21 thereof;

Whereas :

- (1) The Agency shall issue certification specifications, including airworthiness codes and acceptable means of compliance, as well as guidance material to be used in the certification process.
- (2) The Agency has, pursuant to Article 43 of the Basic Regulation, consulted widely interested parties on the matters which are subject to this Decision and following that consultation provided a written response to the comments received,

¹ OJ L 240, 7.09.2002, p. 1.

² OJ L 243, 27.09.2003, p. 6.

HAS DECIDED AS FOLLOWS:

Article 1

The certification specifications, including airworthiness codes and acceptable means of compliance, for all weather operations are those laid down in the Annex to this Decision.

Article 2

This Decision shall enter into force on 17 October 2003. It shall be published in the *Official Publication of the Agency*.

Done at Brussels, 17 October 2003.

For the European Aviation Safety Agency,

Patrick GOUDOU

Executive Director

European Aviation Safety Agency

**Certification Specifications
for
All Weather Operations**

CS-AWO

CONTENTS

CS—AWO

ALL WEATHER OPERATIONS

BOOK 1 AIRWORTHINESS CODE

- SUBPART 1 AUTOMATIC LANDING SYSTEMS
- SUBPART 2 AIRWORTHINESS CERTIFICATION OF AEROPLANES FOR OPERATIONS WITH DECISION HEIGHTS BELOW 60 M (200 FT) DOWN TO 30 M (100 FT) – CATEGORY 2 OPERATIONS
- SUBPART 3 AIRWORTHINESS CERTIFICATION OF AEROPLANES FOR OPERATIONS WITH DECISION HEIGHTS BELOW 30 M (100 FT) OR NO DECISION HEIGHT – CATEGORY 3 OPERATIONS
- SUBPART 4 DIRECTIONAL GUIDANCE FOR TAKE-OFF IN LOW VISIBILITY

BOOK 2 ACCEPTABLE MEANS OF COMPLIANCE

- ACCEPTABLE MEANS OF COMPLIANCE TO SUBPART 1
- ACCEPTABLE MEANS OF COMPLIANCE TO SUBPART 2
- ACCEPTABLE MEANS OF COMPLIANCE TO SUBPART 3
- ACCEPTABLE MEANS OF COMPLIANCE TO SUBPART 4
- GENERAL ACCEPTABLE MEANS OF COMPLIANCE

CS-AWO

EASA Certification Specifications
for
All Weather Operations

CS-AWO
Book 1

Airworthiness code

SUBPART 1

AUTOMATIC LANDING SYSTEMS

GENERAL

CS-AWO 100 Applicability and Terminology

(a) Subpart 1 of this airworthiness code is applicable to aeroplanes, which are capable of automatic landing carried out in association with an Instrument Landing System (ILS), a Microwave Landing System (MLS) or both. In addition, the automatic landing system must meet the requirements of CS 25.1329. (See AMC AWO 100(a))

(b) The term 'automatic landing system' in this CS-AWO refers to the airborne equipment, which provides automatic control of the aeroplane during the approach and landing. It includes all of the sensors, computers, actuators and power supplies necessary to control the aeroplane to touchdown. It also includes provisions to control the aeroplane along the runway during the landing rollout. In addition, it includes the indications and control necessary for its management and supervision by the pilot.

CS-AWO 101 Safety level

The safety level in automatic landing may not be less than that achieved in manual landing. Hence, in showing compliance with the performance and failure requirements, the probabilities of performance or failure effects may not be factored by the proportion of landings made under automatic control.

CS-AWO 104 Control actions

In the absence of failure or extreme conditions, the control actions of the system and the resulting aeroplane flight path may not contain unusual features liable to cause a pilot to intervene and assume control.

CS-AWO 106 Approach speed

The approach speed to be used must be established taking into account the accuracy with which speed is controlled. It must be specified in the aeroplane Flight Manual.

CS-AWO 107 Manual override of automatic pilot

When established on the final approach path it must not be possible to change the flight path of

the aeroplane with the automatic pilot(s) engaged, except by initiating an automatic go-around.

CS-AWO 109 Out-of-trim forces at disengagement

It must be possible to disengage the automatic landing system at any time without the pilot being faced with out-of-trim forces that might lead to an unacceptable flight path disturbance.

CS-AWO 111 Manual override of automatic throttle

It must be possible to override the automatic throttle (when provided) without using excessive force.

EQUIPMENT

CS-AWO 123 Automatic throttle control

(a) An automatic landing system must include automatic control of throttles to touchdown unless it can be shown that:

- (1) Aeroplane speed can be controlled manually without an excessive workload in conditions for which the system is to be certificated;
- (2) With manual control of throttles the touchdown performance limits of CS-AWO 131 (c) are achieved; and
- (3) The touchdown performance is not critically affected by reasonable errors in speed control.

(b) An automatic throttle system must provide safe operation taking into account the factors listed in CS-AWO 131(a). The system should:

- (1) Adjust throttles to maintain aeroplane speed within acceptable limits (See AMC AWO 123(b)(1));
- (2) Provide throttle application at a rate consistent with the recommendations of the appropriate engine and airframe manufacturers.

PERFORMANCE**CS-AWO 131 Performance demonstration**

(a) The automatic landing system, under the conditions for which its use is to be approved, must be demonstrated to achieve the performance accuracy and the limits in CS-AWO 131(c) and taking into account at least the following variables:

- (1) Configurations of the aeroplane (e.g. flap settings);
- (2) Centre of gravity;
- (3) Landing weight;
- (4) Conditions of wind, turbulence and wind shear (see AMC AWO 131, paragraph 3);
- (5) ILS and/or MLS characteristics (see AMC AWO 131, paragraph 4); and
- (6) System tolerances.

If limitations are necessary in respect of any of these variables, then these must be established.

(b) Compliance with the accuracy limits of CS-AWO 131(c) must be demonstrated by a combination of:

- (1) An analysis (e.g. by simulation) considering reasonable combinations of variables listed in CS-AWO 131(a) (see AMC AWO 131); and
- (2) Validation of simulation by flight test demonstrations (using either statistical or deterministic methods).

(c) It must be shown that the touchdown performance will be such that exceedance of any of the limits prescribed in this paragraph will be improbable (see AMC AWO 131, paragraph 1.4 for acceptable values for the actual probability level) when the variables follow their expected distribution and also when one of the variables is at its most critical value while the others vary in their expected manner:

- (1) Longitudinal touchdown earlier than a point on the runway 60 m (200 ft) from the threshold;
- (2) Longitudinal touchdown beyond the end of the touchdown zone lighting, 823m (2700 ft) from threshold;
- (3) Lateral touchdown with the outboard landing gear more than 21 m (70 ft) from runway centreline. (This value assumes a 45 m (150 ft) runway. It may be appropriately increased if operation is limited in the aeroplane Flight Manual to wider runways, or to runways with load bearing shoulders);

- (4) Sink rate for structural limit load;
- (5) Bank angle resulting in hazard to the aeroplane; and
- (6) Lateral velocity or slip angle for structural limit load.

CS-AWO 132 Aerodrome conditions

Aerodrome conditions (e.g. elevation, ambient temperature, runway slope and ground profile under the approach path) must be investigated and appropriate limitations entered in the aeroplane flight manual where necessary. (See AMC AWO 131, paragraph 5).

CS-AWO 140 Approach and Automatic Landing with an Inoperative Engine

(See AMC-AWO 140.)

If approval is sought to include automatic landing where the approach is initiated, and the landing made, with an inoperative engine, the automatic landing system must be shown to perform a safe landing and, where applicable, safe rollout in this non-normal aircraft condition taking account of the following: –

- (a) The critical engine inoperative, with the propeller, where applicable, feathered;
- (b) All flap positions used for landing with an inoperative engine;
- (c) Loss of systems associated with the inoperative engine, e.g. electrical and hydraulic power;
- (d) Crosswinds in each direction greater than 18.5 Km/h (10 knots);
- (e) Weight of aircraft.

The go-around from any point on the approach to touchdown must not require exceptional piloting skill, alertness or strength and must ensure that the aeroplane remains within the obstacle limitation surface for a precision runway, Category II or III, specified in Annex 14 Chicago Convention.

CS-AWO 142 Landing distance

The landing distance required must be established and scheduled in the aeroplane Flight Manual if it exceeds the distance scheduled for manual landing.

CONTROLS, INDICATORS AND WARNINGS**CS-AWO 151 General**

(See AMC to AWO 151, AWO 252 and AWO 352)

The controls, indicators and warnings must be designed to minimise flight crew errors, which could create a hazard. Mode and system malfunction indications must be presented in a manner compatible with the procedures and assigned tasks of the flight crew. The indications must be grouped in a logical and consistent manner and be visible under all expected normal lighting conditions

CS-AWO 153 Audible Warning of Automatic Pilot Disengagement

(a) Where, following failure of the automatic pilot or loss of the automatic landing mode, it is necessary for the pilot to assume manual control immediately, an audible warning must be given. This audible warning must be distinct from any other audible cockpit warnings and must operate with no delay until silenced by operating the automatic pilot quick-release control on the control wheel (see CS 25.1329 (d)). It must be audible to all members of the flight crew specified in the aeroplane Flight Manual.

(b) The audible warning in paragraph (a) must operate for a period long enough to ensure that it is heard and recognised by the other crew members when the automatic pilot is disengaged by one of the pilots.

CS-AWO 154 Automatic throttle

(a) An indication of automatic throttle engagement must be provided.

(b) An appropriate alert or warning of automatic throttle failure must be provided.

(c) Automatic throttle disengagement switches must be mounted on or adjacent to the throttle levers where they can be operated without removing the hand from the throttles.

FAILURE CONDITIONS**CS-AWO 161 General**

(a) Any single failure or combination of failures affecting trim, flight path or attitude

must be shown to be acceptable in relation to its probability. (See CS 25.1309 and its AMC)

(b) Compliance with the requirements of paragraph (a) must be shown by analysis and, where necessary, by appropriate ground simulation or flight tests and may take account of pilot recognition and recovery action in making a landing or go-around as appropriate. (See AMC 25.1309 and AMC 25.1329.)

CS-AWO 172 ILS and/or MLS ground facility failure

The effects of failures of the ground facility must be investigated taking into account the Standards and Recommended Practices of Annex 10 Chicago Convention, including monitor thresholds, and transmitter changeover or shut down times.

AEROPLANE FLIGHT MANUAL**CS-AWO 181 General**

The aeroplane Flight Manual must contain the limitations, procedures and other information pertinent to the operation of the automatic landing system and must include the following appropriate to the use for which the particular system has been certificated:

(a) The approved limits established as a result of consideration of the factors listed in CS-AWO 131(a) and 132;

(b) The approved limits established as a result of consideration of any other factor that the certification has shown to be appropriate;

(c) The normal and abnormal procedures, including airspeeds;

(d) The minimum required equipment;

(e) Any additional aeroplane performance limitations (see CS-AWO 142); and

(f) The category of the ILS and/or MLS ground facilities, which have been used as the basis for certification (see AMC AWO 181(f)).

CS-AWO 182 Wind speed limitations

Wind speed limitations higher than those established in showing compliance with CS-AWO 131 may be specified for decision heights of 60 m (200 ft) or more, provided that:

(a) It can be shown that reliance may be placed on external visual reference for the detection of unsatisfactory performance; and

(b) The wind speed limits without reliance on external visual reference are not less than 46km/h (25 knots) head, 28km/h (15 knots) cross and 18.5km/h (10 knots) tail.

CS-AWO 183 Approach and Automatic Landing with an Inoperative Engine

If compliance with CS-AWO 140 is established, a statement must be included in the Non-normal Procedures, or equivalent section of the Flight Manual, that approach and automatic landing made with an engine inoperative have been satisfactorily demonstrated, together with the conditions under which that demonstration was made.

INTENTIONALLY LEFT BLANK

SUBPART 2

**AIRWORTHINESS CERTIFICATION OF AEROPLANES FOR OPERATIONS WITH
DECISION HEIGHTS BELOW 60 M (200 FT) AND DOWN TO 30 M (100 FT) – CATEGORY
2 OPERATIONS**

General**CS-AWO 200 Applicability and Terminology**

(a) Subpart 2 of this airworthiness code is applicable to aeroplanes for which certification is sought to allow the performance of approaches with decision heights below 60 m (200 ft) down to 30 m (100 ft) - Category 2 operations, using a precision approach system as defined in Annex 10 Chicago Convention, i.e. an Instrument Landing System (ILS), or a Microwave Landing System (MLS) which has outputs indicating the magnitude and sense of deviation from a preset azimuth and elevation angle giving equivalent operational characteristics to that of a conventional ILS. (See AMC AWO 200(a))

(b) Terminology

(1) The term 'approach system' used here refers only to the airborne system. It includes the equipment listed in CS-AWO 221 and all related sensors, instruments and power supplies.

(2) 'Decision height' is the wheel height above the runway elevation by which a go-around must be initiated unless adequate visual reference has been established and the aircraft position and approach path have been visually assessed as satisfactory to continue the approach and landing in safety. Where it is used in this Subpart 2 it means the minimum decision height at which compliance with the requirements of this Subpart 2 have been demonstrated.

(3) A go-around is the transition from an approach to a stabilised climb.

(4) 'Failure condition' and terms describing the probabilities and effects of failure conditions are defined in AMC 25.1309.

CS-AWO 201 Safety Level

The safety level for precision approaches with decision heights below 60 m (200 ft) down to 30 m (100 ft) must not be less than the average safety level achieved in precision approaches with decision heights of 60 m (200 ft) and above. Hence, in showing compliance with the performance and failure requirements, the

probabilities of performance or failure effects may not be factored by the proportion of approaches, which are made with the decision height below 60 m (200 ft).

CS-AWO 202 Go-around rate

(See AMC AWO 202)

The proportion of approaches terminating in a go-around below 150 m (500 ft) due to the approach system performance or reliability may not be greater than 5%.

CS-AWO 204 Control of flight path

The approach system must either:

(a) Provide information of sufficient quality to the flight crew to permit the manual control of the aeroplane along the flight path within the prescribed limits; or

(b) Automatically control the aeroplane along the flight path within the prescribed limits.

CS-AWO 206 Control of Speed

Automatic throttle control must be provided unless it is demonstrated in flight that speed can be controlled manually by the crew within acceptable limits and without excessive workload. When making an approach using an automatic throttle system the approach speed may be selected manually or automatically.

CS-AWO 207 Manual control

(a) In the absence of a failure, the approach down to the decision height must not require a change in the means of control (e.g. a change from the automatic flight control system to flight director).

(b) The use of a manual mode or the transition from an automatic mode to manual control must not require exceptional piloting skill, alertness or strength.

CS-AWO 208 Oscillations and deviations

The approach system must cause no sustained nuisance oscillations or undue attitude changes or control activity as a result of configuration or

power changes or any other disturbance to be expected in normal operation.

CS-AWO 215 Decision height recognition

Decision height recognition must be by means of height measured by a radio altimeter.

CS-AWO 216 Go around

The go-around may not require exceptional piloting skill, alertness or strength to maintain the desired flight path.

EQUIPMENT

CS-AWO 221 Installed Equipment (See AMC AWO 221)

The approach guidance system must include:

- (a) Two ILS and/or two MLS receivers with a display of the selected deviation information at each pilot's station;
- (b) An automatic approach coupler or a flight director system with display at each pilot's station (or an alternative giving equivalent performance and safety);
- (c) A radio altimeter with displays at each pilot's station of:
 - (1) radio altitude, and
 - (2) the selected decision height (e.g. an index on an analogue scale or a digital indication);
- (d) Clear visual indication at each pilot's station (e.g. an alert light) when the aeroplane reaches the pre-selected decision height appropriate to the approach;
- (e) Automatic or flight director go-around system or acceptable attitude indicators;
- (f) Audible warning of automatic pilot failure (for automatic approach);
- (g) An automatic throttle system where necessary (see CS-AWO 206)
- (h) An appropriate equipment failure warning system; and
- (i) An alert of excess deviation from the required approach path, at each pilot's station (e.g. amber flashing light).

CS-AWO 222 Minimum equipment

The minimum equipment, which must be serviceable at the beginning of an approach, for compliance with the general requirements of this Subpart 2 and those relating to performance and failure conditions, must be established. For example, where justified by a system safety assessment, one ILS or one MLS receiver may be unserviceable.

PERFORMANCE

CS-AWO 231 Flight path and speed control (See AMC AWO 231.)

The performance of the aeroplane and its systems must be demonstrated by flight tests supported where necessary by analysis and simulator tests. Flight-testing must include a sufficient number of approaches conducted in conditions, which are reasonably representative of actual operating conditions and must cover the range of parameters affecting the behaviour of the aeroplane (e.g. wind speed, ILS and/or MLS ground facility characteristics, aeroplane configurations, weight, centre of gravity etc.).

CS-AWO 233 Decision height

The decision height must not be less than 1.25 times the minimum permissible height for the use of the approach system. (See AMC 25.1329.)

CS-AWO 236 Excess-deviation alerts

- (a) Excess-deviation alerts must operate when the deviation from the ILS or MLS glide path or localizer centreline exceeds a value from which a safe landing can be made from offset positions equivalent to the excess-deviation alert, without exceptional piloting skill and with the visual references available in these conditions. (See AMC AWO 236(a).)
- (b) They must be set to operate with a delay of not more than 1 second from the time that the values determined in CS-AWO 236(a) are exceeded.
- (c) They must be active at least from 90 m (300 ft) to the decision height but the glide path alert should not be active below 30 m (100 ft).

CS-AWO 243 Go-around climb gradient

The aeroplane Flight Manual must contain either a WAT (Weight, Altitude, Temperature) limit corresponding to a gross climb gradient of

2.5%, with the critical engine failed and with the speed and configuration used for go-around, or the information necessary to construct a go-around gross flight path with an engine failure at the start of the go-around from the decision height.

CONTROLS, INDICATORS AND WARNINGS

CS-AWO 251 Mode selection and switching

(a) A positive and continuous indication must be provided of the modes actually in operation. In addition, where engagement of a mode is automatic (e.g. localizer and glide path acquisition) clear indication must be given when the mode has been armed by a member of the flight crew.

(b) Where reliance is placed on the pilot to detect non-engagement of go-around mode when it is selected, an appropriate indication or warning must be given.

(c) The system must be designed so that no selection or changes of switch settings (other than system disengagement) need be made manually below a height of 150 m (500 ft) in the absence of a failure.

CS-AWO 252 Presentation of information to the crew

(See AMC to AWO 151, AWO 252 and AWO 352)

(a) The display of information to the crew, including that required to monitor the flight path, must be compatible with the procedures specified in the aeroplane Flight Manual. All indications must be designed to prevent crew errors.

(b) Essential information and warnings necessary to the crew in the use of the approach system must be so located and designed as to permit both their accurate use in normal operation and the rapid recognition of malfunctions, in all expected lighting conditions.

CS-AWO 253 Audible warning of automatic pilot disengagement

(a) Where the approach flight path is controlled automatically, an audible warning must be given following disengagement of the automatic pilot or loss of the automatic approach mode. This warning must comply with the provisions of CS-AWO 153.

(b) For aeroplanes with automatic landing systems, the same warning must be used for automatic approach as is used for automatic landing.

FAILURE CONDITIONS

(See CS 25.1309 and its AMC)

CS-AWO 262 Automatic pilot

The automatic pilot must comply with CS 25.1329 and its AMC.

CS-AWO 263 Flight director system

(a) The flight director system, or alternative form of information display, must be so designed that the probability of display of incorrect guidance commands to the pilot is Remote when credit is taken for an excess-deviation alert.

(b) The deviation profile method of AMC 25.1329 must be used in assessing failures of flight director systems.

(c) Wherever practicable a fault must cause the immediate removal from view of the guidance information but, where a warning is given instead, it must be such that the pilot cannot fail to observe it whilst using the information.

CS-AWO 268 Radio altimeter

The radio altimeter installation must be such that the probability of the provision of false height information leading to a hazardous situation is Extremely Remote. The warning must be given by the removal or obscuration of displayed information, at least in the height band from 30 m (100 ft) downwards.

CS-AWO 269 Excess-deviation alerts

The excess-deviation alerts must be such that the probability of failure to operate when required is not frequent.

AEROPLANE FLIGHT MANUAL**CS-AWO 281 General**

The aeroplane Flight Manual must state:

(a) Limitations, including the minimum decision height to which the aeroplane is certificated;

(b) Normal and abnormal procedures;

(c) Changes to the performance information, if necessary (e.g. approach speed, landing distance, go-around climb); and

(d) Minimum required equipment, including flight instruments.

(e) The maximum head, tail and cross wind components in which the performance of the aeroplane has been demonstrated.

INTENTIONALLY LEFT BLANK

SUBPART 3

**AIRWORTHINESS CERTIFICATION OF AEROPLANES FOR OPERATIONS WITH
DECISION HEIGHTS BELOW 30 M (100 FT) OR NO DECISION HEIGHT –
CATEGORY 3 OPERATIONS**

GENERAL

CS-AWO 300 Applicability and Terminology

(a) Subpart 3 of this airworthiness code is applicable to aeroplanes for which certification is sought to allow the performance of approaches with decision heights below 30 m (100 ft) or with no decision height - Category 3 operations, using a precision approach system as defined in Annex 10 Chicago Convention, i.e. an Instrument Landing System (ILS), or a Microwave Landing System (MLS) which has outputs indicating the magnitude and sense of deviation from a preset azimuth and elevation angle giving equivalent operational characteristics to that of a conventional ILS.

The criteria are divided, where necessary, into those applicable to the following types of operation:

- (1) Decision heights below 30 m (100 ft) but not less than 15 m (50 ft);
- (2) Decision heights below 15 m (50 ft);
- (3) No decision height.

(See AMC AWO 300(a))

(b) Terminology

(1) The term 'landing system' used here refers only to the airborne system. It includes the equipment listed in JAR-AWO 321 and also all related sensors, instruments and power supplies.

(2) Automatic Landing System: The airborne equipment which provides automatic control of the aeroplane during the approach and landing.

(3) Fail-passive Automatic Landing System: An automatic landing system is fail-passive if, in the event of a failure, there is no significant out-of-trim condition or deviation of flight path or attitude but the landing is not completed automatically.

For a fail-passive automatic landing system the pilot assumes control of the aircraft after a failure.

The following are typical arrangements:

(i) A monitored automatic pilot in which automatic monitors will provide the necessary failure detection and protection.

(ii) Two automatic pilots with automatic comparison to provide the necessary failure detection and protection.

(4) Fail-operational Automatic Landing System: An automatic landing system is fail-operational if, in the event of a failure, the approach, flare and landing can be completed by the remaining part of the automatic system.

In the event of a failure, the automatic landing system will operate as a fail-passive system.

The following are typical arrangements:

(i) Two monitored automatic pilots, one remaining operative after a failure.

(ii) Three automatic pilots, two remaining operative (to permit comparison and provide necessary failure detection and protection) after a failure.

(5) Fail-operational Hybrid Landing System: A system which consists of a primary fail-passive automatic landing system and a secondary independent guidance system enabling the pilot to complete a landing manually after failure of the primary system.

A typical secondary independent guidance system consists of a monitored head-up display providing guidance which normally takes the form of command information, but it may alternatively be situation (or deviation) information.

(6) The alert height is a specified radio height, based on the characteristics of the aeroplane and its fail-operational landing system. In operational use, if a failure occurred above the alert height in one of the required redundant operational systems in the aeroplane (including, where appropriate, ground roll guidance and the reversionary mode in a hybrid system), the approach would be discontinued and a go-around executed unless reversion to a higher decision height is possible. If a failure in one

of the required redundant operational systems occurred below the alert height, it would be ignored and the approach continued.

(7) Decision height is the wheel height above the runway elevation by which a go-around must be initiated unless adequate visual reference has been established and the aircraft position and approach path have been assessed as satisfactory to continue the approach and landing in safety.

Where it is used in this document it means the minimum decision height determined in the airworthiness certification.

(8) A go-around is the transition from an approach to a stabilised climb

CS-AWO 301 Safety Level

The safety level for precision approaches with decision heights below 30 m (100 ft) or no decision height may not be less than the average safety level achieved in precision approaches with decision heights of 60 m (200 ft) and above. Hence, in showing compliance with the performance and failure requirements, the probabilities of performance or failure effects may not be factored by the proportion of approaches, which are made with the decision height below 30 m (100 ft).

CS-AWO 302 Go-around rate

The go-around rate below 150 m (500 ft) attributable to the landing system performance or reliability may not be greater than 5%. Additionally, for decision heights below 15 m (50 ft) and no decision height, the probability of go-around below the alert height attributable to the landing system performance and reliability must be such that compliance with CS-AWO 301 is achieved. (See CS-AWO 365(a).)

CS-AWO 303 Minimum flight crew

The workload associated with use of the minimum decision height must be considered in showing compliance with CS 25.1523, AMC 25.1523, and CS 25 Appendix D.

CS-AWO 304 Control of flight path and ground roll

The landing system must control the aeroplane within the prescribed limits along the flight path to touchdown (see CS-AWO 331(a)

and (b)) and along the runway (see CS-AWO 338) when appropriate, and specifically:

(a) The primary mode of controlling the aeroplane must be automatic until the main wheels touch the ground (except as in CS-AWO 321(b)(1)), and for operation with no decision height, control must be automatic until the nose wheels touch down;

(b) For decision heights below 15 m (50 ft), a fail-operational landing system (automatic or hybrid) must be provided which, when appropriate, includes provision for control of the aeroplane along the runway during the ground roll down to a safe speed for taxiing.

(c) If the landing rollout is to be accomplished automatically using rudder control, the rudder axis should be engaged during the approach phase to ensure that it is functioning correctly prior to touchdown.

CS-AWO 306 Control of Speed

Automatic throttle control must be provided unless:

(a) The decision height is 15 m (50 ft) or greater; and

(b) It is demonstrated in flight that speed can be controlled manually by the crew within acceptable limits and without excessive workload. (See CS-AWO 123 and AMC AWO 231.)

CS-AWO 307 Manual control

The transition from an automatic mode to manual mode or the use of a manual mode may not require exceptional piloting skill, alertness or strength.

CS-AWO 308 Oscillations and deviations

The landing system may cause no sustained nuisance oscillations or undue attitude changes or control activity as a result of configuration or power changes or any other disturbance to be expected in normal operation.

CS-AWO 312 Alert Height

(See AMC AWO 312)

For a fail-operational system with a decision height below 15 m (50 ft) or with no decision height, an alert height must be established in accordance with CS-AWO 365(a) and must be at least 30 m (100 ft).

CS-AWO 314 Decision Height

When the decision height is during the landing flare, it must be below the height at which the major attitude changes associated with this manoeuvre take place.

CS-AWO 315 Decision Height recognition

Decision height recognition must be by means of height measured by a radio altimeter.

CS-AWO 316 Go around

(See AMC AWO 316)

(a) The aircraft must be capable of safely executing a go-around from any point on the approach to touchdown in all configurations to be certificated. The manoeuvre may not require exceptional piloting skill, alertness or strength and must ensure that the aeroplane remains within the obstacle limitation surface for a Category II or III precision approach runway as specified in Annex 14 Chicago Convention.

(b) For decision heights below 15 m (50 ft) automatic go-around must be provided.

(c) When automatic go-around is provided, it must be available down to touchdown.

(d) When automatic go-around is engaged, subsequent ground contact should not cause its disengagement.

EQUIPMENT**CS-AWO 321 Installed Equipment**

(See AMC AWO 321)

The following items of equipment must be installed for certification to the decision heights specified unless it is shown that the intended level of safety is achieved with alternative equipment, or the deletion of some items:

(a) All decision heights below 30 m (100 ft) or no decision height:

(1) Two ILS and/or two MLS receivers. Each pilot's station must display: -

(i) deviation information from the selected ILS/MLS navigation source; and

(ii) deviation information from a source independent of the other pilot's display.

(2) One radio altimeter with display at each pilot's station;

(3) Clear visual indication at each pilot's station (e.g. an alert light) when the aeroplane reaches the pre-selected decision height appropriate to the approach;

(4) An appropriate equipment failure warning system; and

(5) An alert of excess deviation from the required approach path at each pilot's station (e.g. amber flashing light).

(6) In the case of aeroplanes having a minimum flight crew of two pilots, an automatic voice system, which calls when the aeroplane is approaching the decision height (or when approaching the ground during a no decision height approach) and when it reaches decision height.

The number of ILS and/or MLS receivers and radio altimeters may need to be increased in order to provide fail-operational capability where required.

(b) Decision Height 15m (50ft) or greater (See AMC AWO 321(b)):

Compliance with any one of the following subparagraphs (1), (2) or (3) is acceptable. The RVR minima authorised will be dependent on the equipment installed in compliance with a particular subparagraph, and in accordance with the operational rules.

(1) (i) Fail-passive automatic approach system without automatic landing, provided that:

(A) It is demonstrated that manual landings can be made without excessive workload in the visibility conditions; and

(B) The aeroplane has a low approach speed, is easily manoeuvrable and the height of the pilot's eyes above the wheels is small;

(ii) Automatic throttle control, unless it can be shown that speed control does not add excessively to the crew workload;

(iii) Automatic or flight director go-around or suitable attitude indicators.

or

(2) (i) Fail-passive automatic landing system;

(ii) Automatic throttle control, unless it can be shown that speed control does not add excessively to the crew workload.

(iii) Automatic or flight director go-around or suitable attitude indicators.

or

(3) (i) Fail-passive automatic landing system, provided that:

(A) It is demonstrated that a manual go-around can be made without excessive crew workload following loss of automatic landing capability; and

(B) The aeroplane has a low approach speed, is easily manoeuvrable and the height of the pilot's eyes above the wheels is small;

(ii) Automatic throttle control, unless it can be shown that speed control does not add excessively to the crew workload;

(iii) Fail-passive automatic go-around;

(iv) Automatic ground roll control or head up ground roll guidance, for control or guidance, along the runway during the ground roll down to a safe speed for taxiing.

(c) Decision height below 15 m (50 ft):

(1) Fail-operational automatic landing system or fail-operational hybrid landing system;

(2) Fail-passive automatic go-around;

(3) Automatic throttle control; and

(4) Automatic ground roll control or head-up ground roll guidance (see CS-AWO 304.)

(d) No decision height:

(1) Fail-operational automatic landing system;

(2) Fail-passive automatic go-around;

(3) Automatic throttle control;

(4) Fail-operational or fail-passive automatic ground roll control or head-up ground roll guidance (see CS-AWO 304); and

(5) Anti-skid braking system.

CS-AWO 322 Minimum Equipment

The minimum equipment, which must be serviceable at the beginning of an approach for compliance with the general criteria of this Subpart 3 and those relating to performance and failure conditions, must be established.

PERFORMANCE

CS-AWO 331 Performance demonstration (See AMC AWO 331)

(a) Flight path and speed control must comply with the provisions of CS-AWO 231 and 243. (See AMC AWO 231.)

(b) Touchdown performance of automatic landing systems must comply with the provisions of CS-AWO 131, 132, 142. For operation with no decision height, compliance with the lateral touchdown performance criteria must be demonstrated at main wheel and nose wheel touchdown.

(c) The automatic throttle system must comply with the provisions of CS-AWO 123.

(d) Compliance with CS-AWO 337 and 338(a) may be demonstrated primarily by flight test. Compliance with sub-paragraphs (a) and (b) of this paragraph and CS-AWO 338(b) must be demonstrated by analysis and simulator tests supported by flight tests. Flight testing and any associated analysis must include a sufficient number of approaches and landings conducted in conditions which are reasonably representative of actual operating conditions and must cover the range of parameters affecting the behaviour of the aeroplane (e.g. wind conditions, runway and ILS or MLS ground facility characteristics, aeroplane configurations, weight, centre of gravity).

CS-AWO 337 Head-up display

Where a head-up display is fitted as part of a hybrid system, its performance need not meet the same criteria as the primary system provided that:

(a) It meets the overall performance requirements, taking into account the probability that it will be used; and

(b) It is sufficiently compatible with the primary system so as to retain pilot confidence

CS-AWO 338 Automatic ground roll control (See AMC AWO 331)

(a) When automatic ground roll control or head-up ground roll guidance is being used, the probability must be less than 5% that the point on the aeroplane centreline between the main wheels will deviate more than 8.2 m (27 ft) from the runway centreline on any one landing.

(b) Additionally, when the operation is predicated on the provision of fail-operational ground roll control, the probability must be less

than 10^{-6} that the outboard landing gear will deviate to a point more than 21.3 m (70 ft) from the runway centreline while the speed is greater than 74km/h (40 knots).

CS-AWO 342 Landing distance

If there is any feature of the system or the associated procedures which would result in an increase to the landing distance required, the appropriate increment must be established and scheduled in the aeroplane Flight Manual.

CONTROLS, INDICATORS AND WARNINGS

CS-AWO 351 Mode selection and switching

(a) A positive and continuous indication must be provided of the modes actually in operation. In addition, where engagement of a mode is automatic (e.g. localizer and glide path acquisition), clear indication must be given when the mode has been armed by a member of the flight crew.

(b) Where reliance is placed on the pilot to detect non-engagement of go-around mode when it is selected, an appropriate indication or warning must be given.

(b) The system must be designed so that no manual selections or changes of switch settings need be made below a height of 150 m (500 ft) in normal operation, other than system disengagement or selection of automatic go-around as necessary.

CS-AWO 352 Indications and warnings

(See AMC No.1 to CS-AWO 361 and AMC to AWO 151, AWO 252 and AWO 352))

(a) The display of information to the crew, including that required to monitor the approach, flare and ground roll must be compatible with the procedures specified in the aeroplane Flight Manual and normal crew tasks. All indications must be designed to minimise crew errors.

(b) Essential information and warnings necessary to the crew in the use of the landing system must be so located and designed as to permit both their accurate use in normal operation and the rapid recognition of malfunctions in all expected lighting conditions.

(c) Any malfunction of the landing system or of the ILS or MLS ground facility which requires a missed approach must annunciate

positively and unambiguously to each pilot, so that pilot action may be initiated promptly without further interpretation. See AMC 25.1322, Alerting Systems.

(d) Notwithstanding sub-paragraphs (a), (b) and (c) of this paragraph, for fail-operational systems, failure warnings may be inhibited below alert height if:

(1) The failure does not preclude continuation of an automatic landing; and

(2) The failure requires no specific action of the flight crew; and

(3) Information on the occurrence of any failure warnings so inhibited is subsequently available to flight and maintenance crews.

(e) Where the capability of the aeroplane is dependent on equipment serviceability and modes selected, means must be provided whereby the pilot can readily determine the capability at alert height (e.g. fail-operational status, ground roll availability)

FAILURE CONDITIONS

CS-AWO 361 General

(See CS 25.1309 and its AMC, and AMCs Nos. 1 and 2 to CS-AWO 361)

(a) The automatic landing system must comply with the provisions of CS-AWO 161 and 172.

(b) The radio altimeter, and excess-deviation alerts must comply with the provisions of CS-AWO 268 and 269 respectively.

CS-AWO 364 Fail-passive automatic landing system

(a) For a fail-passive automatic landing system, failure conditions resulting in the loss of automatic landing control capability below decision height may not be Frequent. (See AMC No. 1 and No. 2 to AWO 364(a) and AMC No.2 to CS-AWO 361)

(b) For a fail-passive automatic landing system, any failure condition, which is not Extremely Remote, must be automatically detected and neutralised before it has a significant effect on the trim, flight path or attitude. (See AMCs No.1 and 2 to CS-AWO 361)

CS-AWO 365 Fail-operational landing system (Automatic or Hybrid)

(See AMC No.2 to CS-AWO 361)

(a) For a fail-operational landing system, the probability of total loss of the landing system below the alert height must be Extremely Remote. Demonstration of compliance must be by means of a suitable analysis programme supported, where necessary, by a simulation and flight test programme. (See AMC No. 1 to AWO 364(a).) Special precautions must be taken to ensure that redundant sub-systems are not vulnerable to simultaneous disengagement or failure warning. (See AMC AWO 161(b) paragraph 1.3(c).)

(b) A fail-operational landing system must operate as a fail-passive system following a first failure, which leads to loss of fail-operational capability. (See AMC No.1 to CS-AWO 361)

(c) A fail-operational automatic throttle system must be provided unless the effect of loss of automatic throttle control is minor. (See AMC No.1 to CS-AWO 361)

CS-AWO 366 Head-up display (or other form of guidance display)

(See AMCs No.1 and 2 to CS-AWO 361)

Where a head-up display or other form of guidance display is fitted for use in the event of automatic landing system failure, the combination of the two systems must comply with CS-AWO 161 and 172. In addition, the failure modes of the display may not be such as might lead a pilot to disengage a satisfactorily functioning autopilot and obey the malfunctioning display.

CS-AWO 371 Nose-wheel steering

(See AMCs No.1 and 2 to CS-AWO 361)

In showing that the nose-wheel steering system complies with CS 25.745(c), account must be taken of the effect of the visibility conditions on the ability of the pilot to detect steering faults and to take over control.

CS-AWO 372 Automatic go-around

Total failure (shutdown) of the ILS or MLS ground facility may not result in loss of automatic go-around capability.

AEROPLANE FLIGHT MANUAL**CS-AWO 381 General**

The aeroplane Flight Manual must state:

(a) Limitations, including the minimum crew, alert height, the decision heights for which the aeroplane is certificated, etc (See AMC AWO 381(a));

(b) Permitted configurations (e.g. flap setting, number of engines operating);

(c) Normal and abnormal procedures (see AMC No. 2 to CS-AWO 361);

(d) Changes to the performance information, if necessary (e.g. the approach speed, landing distance required, go-around climb); and

(e) Minimum required equipment including flight instrumentation (see CS-AWO 321 and 322).

(f) The height losses for go-around initiation heights below 30m (100ft), determined in accordance with AMC AWO 316 paragraph 2a.

CERTIFICATION DOCUMENTATION**CS-AWO 390 Documentation required**

Documentation providing the following information is required for certification:

(a) A specification of the aeroplane and the airborne equipment.

(b) Evidence that the equipment and its installation comply with the applicable standards;

(c) A failure analysis and an assessment of system safety (see AMC 25.1309);

(d) A performance analysis demonstrating compliance with the performance criteria of CS-AWO 331, 337 and 338 (see CS-AWO 131 (b));

(e) Flight test results including validation of any simulation;

(f) Limitations on the use of the system and crew procedures to be incorporated in the aeroplane Flight Manual;

(g) Evidence that the crew work-load complies with CS 25.1523; and

(h) Inspection and maintenance procedures shown to be necessary by the system safety assessment (see CS 25.1529)

SUBPART 4

DIRECTIONAL GUIDANCE FOR TAKE-OFF IN LOW VISIBILITY

CS-AWO 400 Applicability and Terminology

(a) Subpart 4 of this airworthiness code is applicable to aeroplanes for which certification is sought to allow the performance of take-off in lower visibilities than those which are sufficient to ensure that the pilot will at all times have sufficient visibility to complete or abandon the take-off safely. It is only concerned with directional guidance during the ground-borne portion of the take-off (i.e. from start to main wheel lift-off, or standstill in the event of abandoned take-off). (See AMC AWO 400(a))

(b) Take-off Guidance System: A take-off guidance system provides directional guidance information to the pilot during the take-off or abandoned take-off. It includes all the airborne sensors, computers, controllers and indicators necessary for the display of such guidance. Guidance normally takes the form of command information, but it may alternatively be situation (or deviation) information.

CS-AWO 401 Safety level

The Safety level in take-off in low visibility must not be less than the average safety level achieved in take-off in good visibility. Hence, in showing compliance with the performance and failure requirements, the probabilities of performance or failure effects may not be factored by the proportion of take-offs that are made in low visibility.

CS-AWO 417 Guidance information

The take-off guidance system must provide guidance information which will, in the event of loss of visibility during the take-off, enable the pilot to control the aeroplane to the runway centreline during the take-off or abandoned take-off using the normal steering controls. Its use must not require exceptional piloting skill or alertness.

CS-AWO 418 Guidance display

(a) The take-off guidance information must be provided in such a form that it is immediately usable by the pilot who is making the take-off. Its use must not require him to refer to his

instrument panel for this information, nor must it require the other pilot to take control of the aeroplane. Reversion to the system must be easy and natural.

(b) The information display must be usable in all appropriate conditions of ambient light, runway lighting and visibility.

(c) The system must be designed to minimise crew errors. (See AMC AWO 418(c)).
Equipment

CS-AWO 422 Minimum equipment

The minimum equipment, which must be serviceable at the start of the take-off for compliance with the general criteria of this Subpart 4 and those relating to performance and failure conditions, must be established.

PERFORMANCE**CS-AWO 431 Performance demonstration**

(See AMC AWO 431 and Figure 1)

(a) It must be demonstrated that the performance of the take-off guidance system is such that the aeroplane will not deviate significantly from the runway centreline during take-off while the system is being used within the limitations established for it. Compliance may be demonstrated by flight test, or by a combination of flight test and simulation. Flight-testing must cover those factors affecting the behaviour of the aeroplane, e.g. wind conditions, ILS and/or MLS ground facility characteristics, aeroplane configurations, weight, and centre of gravity.

(b) In the event that the aeroplane is displaced from the runway centreline at any point during the take-off or abandoned take-off, the system must provide such guidance as would enable the pilot to control the aeroplane smoothly back to the runway centreline without any sustained nuisance oscillation.

(c) In the event of an engine failure, if the pilot follows the guidance information and disregards external visual reference, the lateral deviation of the aeroplane must remain safely within the confines of the runway.

CS-AWO 445 Limitations and procedures

Limitations on the use of the system and appropriate procedures must be established, where these are necessary for compliance with the criteria of CS-AWO 431. Account should be taken of the method by which the system defines the runway centreline and associated errors or delays.

CONTROLS, INDICATORS AND WARNINGS**CS-AWO 455 WARNINGS**

(See AMC AWO 455)

(a) System warnings must be so designed and located as to ensure rapid recognition of failures.

(b) The information display and system warnings must not distract the pilot making the take-off or significantly degrade forward view.

FAILURE CONDITIONS

(See AMC 25.1309)

CS-AWO 461 Guidance system

(a) The take-off guidance system must be such that the display of incorrect guidance information to the pilot during the take-off run is assessed as Remote. In demonstrating compliance with this criterion account need only be taken of incorrect guidance of such magnitude that it would lead to the aeroplane deviating from the runway, if it is followed.

(b) Probability of loss of take-off guidance during the take-off must be assessed as Remote.

CS-AWO 462 Aeroplane failures

Any single failure of the aeroplane which disturbs the take-off path (e.g. engine failure) must not cause loss of guidance information or give incorrect guidance information.

AEROPLANE FLIGHT MANUAL**CS-AWO 481 General**

(See AMC AWO 481)

In relation to the approval of the aeroplane for take-off in reduced visibility, the aeroplane Flight Manual must state –

- (a) Limitations,
- (b) Normal and abnormal procedures including where appropriate the most critical conditions demonstrated,
- (c) Minimum required equipment.

INTENTIONALLY LEFT BLANK

**EASA Certification Specifications
for
All Weather Operations**

**CS-AWO
Book 2**

Acceptable Means of Compliance

ACCEPTABLE MEANS OF COMPLIANCE FOR SUBPART 1**AMC AWO 100(a)**
Applicability

MLS is assumed to have equivalent operational characteristics to that of a conventional ILS. The terms "localiser" and "glide path" have been retained for use with either ILS or MLS.

AMC AWO 123(b)(1)
Automatic throttle control

The approach speed may be selected manually or automatically.

AMC AWO 131
Performance Demonstration1 *General*

1.1 The analysis referred to in CS-AWO 131(b)(1) should:

a. Establish compliance with the performance limits specified in CS-AWO 131(c);

NOTE: When systems employing automatic control ground roll are provided, additional analysis may be required.

b. Determine any limitations on the use of the system for compliance with performance limits of CS-AWO 131(c) (see CS-AWO 182); and

c. Provide, if appropriate, information necessary for the calculation of the required landing distance (see CS-AWO 142).

1.2 Account should be taken of the variation of wind speed, turbulence, ILS and/or MLS beam characteristics, system performance variation and flight crew procedures. System performance variations due to equipment tolerances (e.g. datum shifts and gain changes) should be investigated taking into account setting-up procedures and monitoring practices. Acceptable models of wind, turbulence and wind shear are given in paragraph 3. ILS and MLS signal in space characteristics are given in paragraph 4.

1.3 In accordance with CS-AWO 132, the effects of aerodrome conditions (e.g. elevation, ambient temperature, runway slope and ground profile under the approach path) are to be investigated and, if necessary, appropriate limitations derived for inclusion in the aeroplane Flight Manual. Guidance is given in paragraph 5.

1.4 Acceptable values for the probabilities of exceedance of the limits of paragraph CS-AWO 131(c) are as follows. These values may be varied where the characteristics of a particular aeroplane justify such variation:

	Average	Limit
a. <i>Longitudinal touchdown</i> earlier than a point on the runway 60 m (200 ft) from the threshold.	10 ⁻⁶	10 ⁻⁵
b(i). <i>Longitudinal touchdown</i> beyond the end of the touchdown zone lighting, 823 m (2700 ft) from the threshold.	10 ⁻⁶	Not applicable
(ii). <i>Longitudinal touchdown</i> beyond the end of the touchdown zone lighting, 914 m (3000 ft) from the threshold.	Not applicable	10 ⁻⁵
c. <i>Lateral touchdown</i> with the outboard landing gear greater than 21 m (70 ft) from the runway centreline, assuming a 45 m (150 ft) runway.	10 ⁻⁶	10 ⁻⁵
d. <i>Sink rate</i> for structural limit load.	10 ⁻⁶	10 ⁻⁵
e. <i>Bank angle</i> such that wing tip touches ground before wheels.	10 ⁻⁸	10 ⁻⁷
f. <i>Lateral velocity or slip angle</i> for structural limit load.	10 ⁻⁶	10 ⁻⁵

NOTE: The 'Average' column is the probability of occurrence if all variables vary according to their probability distributions. The 'Limit' column is the probability of occurrence if one variable is held at its most adverse value, while the other variables vary according to their probability distributions.

1.5 Acceptance limits for automatic throttle speed holding are ± 9.3 km/h (± 5 knots) (two standard deviations) of programmed airspeed (disregarding rapid airspeed fluctuations associated with turbulence) under all intended flight conditions.

2 *Flight Demonstrations*

2.1 A programme of landings should be completed sufficient to demonstrate the validity of the simulation and support the conclusions of the analysis.

NOTE: Typically, programmes of 100 landings have been used.

2.2 Individual landings should be carried out to demonstrate that errors, which can reasonably be expected to occur, are not hazardous, for example:

- landing with approach speed 9.3 Km/h (5 knots) below the specified speed, and
- landing with approach speed 18.5 Km/h (10 knots) above the specified speed.

3 *Wind Model for Approach Simulation*. In carrying out the analysis described in paragraph 1, one of the following models of wind, turbulence and wind shear may be used:

3.1 *Wind Model Number 1*

3.1.1 *Mean Wind*. It may be assumed that the cumulative probability of reported mean wind speed at landing, and the crosswind component of that wind are as shown in Figure 1. Normally, the mean wind which is reported to the pilot, is measured at a height, which may be between 6 m (20 ft) and 10 m (33 ft) above the runway. The models of wind shear and turbulence given in paragraphs 3.2 and 3.3 assume this reference height is used.

3.1.2 *Wind Shear*

3.1.2.1 *Normal Wind Shear*. Wind shear should be included in each simulated approach and landing, unless its effect can be accounted for separately. The magnitude of the shear should be defined by the expression:

$$u = 0.43 U \log_{10}(z) + 0.57 U \dots\dots\dots (1)$$

where u is the mean wind speed at height z metres (z ≥ 1m) and U is the mean wind speed at 10 m (33 ft).

3.1.2.2 *Abnormal Wind Shear.* The effect of wind shears exceeding those of paragraph 3.1.2.1 should be investigated using known severe wind shear data.

3.1.3 *Turbulence*

3.1.3.1 *Horizontal Component of Turbulence.* It may be assumed that the longitudinal component (in the direction of mean wind) and lateral component of turbulence may each be represented by a Gaussian process having a spectrum of the form:

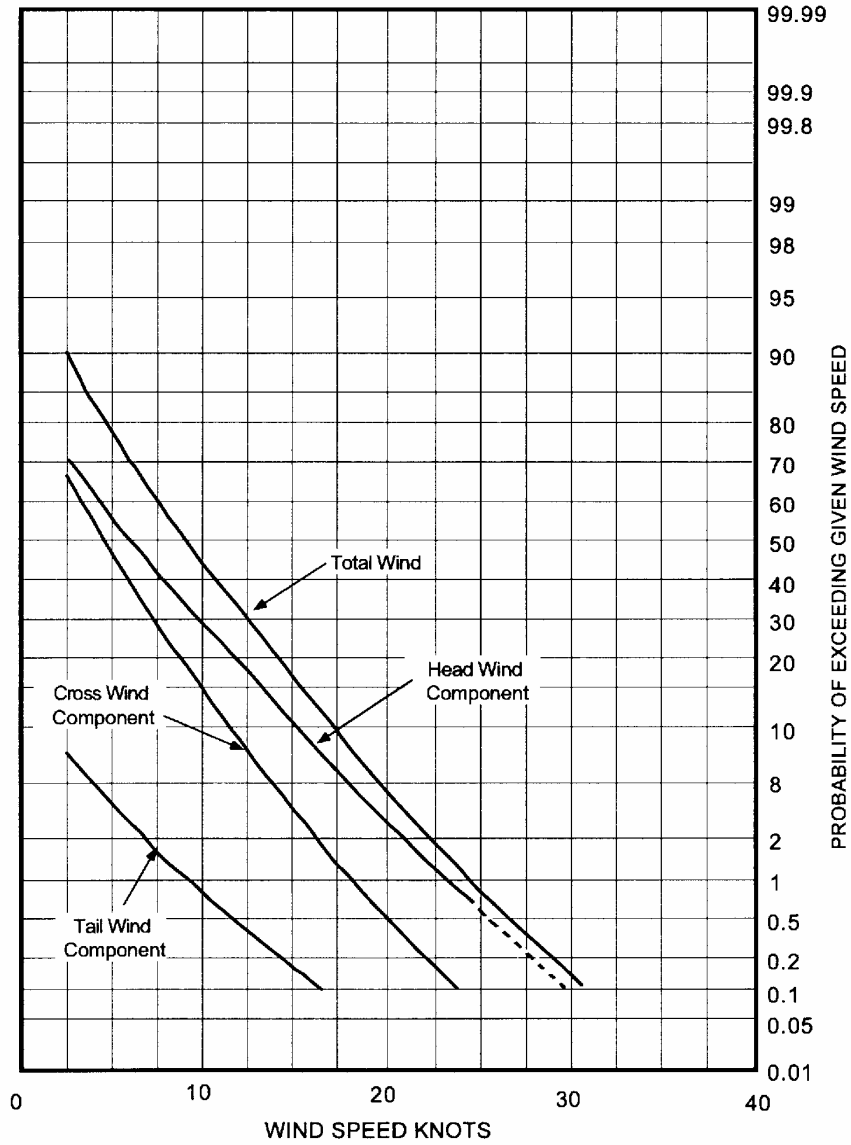
$$\Phi(\Omega) = \frac{2\sigma^2}{\pi} \frac{L}{1 + \Omega^2 L^2} \dots\dots\dots (2)$$

where

- Φ (Ω) = a spectral density [[metres/sec]² per [radian/metre]].
- σ = root mean square (rms) turbulence intensity = 0.15 U.
- L = scale length = 183 m (600 ft)
- Ω = frequency [radians/metre].

3.1.3.2 *Vertical Component of Turbulence.* It may be assumed that the vertical component of turbulence has a spectrum of the form defined by equation (2) in paragraph 3.1.3.1. The following values have been in use:

- σ = 2.8 km/h (1.5 knots) with L = 9.2 m (30 ft)
- or alternatively
- σ = 0.09 U with L = 4.6m (15 ft) when z < 9.2 m (30 ft)
- and L = 0.5 z when 9.2 < z < 305 m (30 < z < 1 000 ft.)



NOTE: This data is based on world-wide in-service operations of UK airlines (Sample size about 2000)

FIGURE 1 Cumulative probability of reported Mean Wind and Headwind, Tailwind and Crosswind Components when landing

3.2 Wind Model Number 2

3.2.1 *Mean Wind.* The mean wind is the steady state wind measured at landing. This mean wind is composed of a **downwind** component (headwind and tailwind) and a **crosswind** component. The cumulative probability distributions for these components are provided in Figure 2 (downwind) and Figure 3 (crosswind). Alternatively, the mean wind can be defined with magnitude and direction. The cumulative probability for the mean wind magnitude is provided in Figure 4, and the histogram of the mean wind direction is provided in Figure 5. The mean wind is measured at a reference altitude of 20 feet AGL. The models of the wind shear and turbulence given in sections 3.2.2 and 3.2.3 assume this reference altitude of 20 feet AGL is used.

3.2.2 *Wind Shear.* When stable and steady horizontal wind blows over the ground surface, terrain irregularities and obstacles such as trees and buildings alter the steady wind near the surface and a boundary layer will cause a form of windshear. The magnitude of this shear is defined by the following expression:

$$V_{wref} = 0.204 * V_{20} * \ln((h + 0.15)/0.15)$$

where V_{wref} is the mean wind speed measured at h feet and V_{20} is the mean wind speed (feet/sec) at 20 feet AGL.

NOTE: This expression does not represent the violent windshears created by unstable airmass conditions.

3.2.3 Turbulence

3.2.3.1 *Turbulence Spectra.* The turbulence spectra are of the Von Karman form.

The vertical component of turbulence (perpendicular to the earth's surface) has a spectrum of the form defined by the following equation:

$$\Phi_w(\Omega) = \frac{\sigma_w^2 L_w}{2\pi} \frac{1 + \frac{8}{3} (1.339 L_w \Omega)^2}{\left(1 + (1.339 L_w \Omega)^2\right)^{11/6}}$$

The horizontal component of turbulence (in the direction of the mean horizontal wind) has a spectrum of the form defined by the following equation:

$$\Phi_u(\Omega) = \frac{\sigma_u^2 L_u}{\pi} \frac{1}{\left(1 + (1.339 L_u \Omega)^2\right)^{5/6}}$$

The lateral component of turbulence (perpendicular to the mean horizontal wind) has a spectrum of the form defined by the following equation:

$$\Phi_v(\Omega) = \frac{\sigma_v^2 L_v}{2\pi} \frac{1 + \frac{8}{3} (1.339 L_v \Omega)^2}{\left(1 + (1.339 L_v \Omega)^2\right)^{11/6}}$$

where

- Φ = spectral density [feet/sec]²
- σ = root mean square (rms) turbulence intensity [feet/sec]
- L = scale length
- Ω = spatial frequency [radians/foot] = ω/V_T
- ω = temporal frequency [radians/sec]
- V_T = aircraft speed [feet/sec]

3.2.3.2 *Turbulence Intensities and Scale Lengths.* At or above an altitude h_1 , turbulence is considered to be isotropic i.e. the statistical properties of the turbulence components are independent. This means that one can consider the turbulence components to have equal intensities.

Below h_1 , turbulence varies with altitude. In this case, intensity and scale length are expressed as functions of V_{20} (feet/sec ... see above) and altitude.

Turbulence Intensities

$$\sigma_W = 0.1061 V_{20}$$

For $h < h_1$,

$$\sigma_U = \sigma_V = \frac{\sigma_W}{\left(0.177 + \frac{0.823h}{h_1}\right)^{0.4}}$$

For $h \geq h_1$,

$$\sigma_U = \sigma_V = \sigma_W$$

where $h_1 = 1\ 000$ ft.

Scale Lengths

For $h < h_1$,

$$L_W = h$$

$$L_U = L_V = L_W \left(\frac{\sigma_U}{\sigma_W}\right)^3 = \frac{h}{\left(0.177 + \frac{0.823h}{h_1}\right)^{1.2}}$$

For $h \geq h_1$

$$L_W = L_U = L_V = h_1$$

where $h_1 = 1\ 000$ ft.

3.2.3.3 *Fixed turbulence intensities for pilot-in-the-loop simulations.* The following fixed levels of turbulence intensity [feet/sec] have been found to be representative when used to program low altitude simulations with the pilot in the loop.

Turbulence Intensity	Light	Medium	Heavy
$\sigma_v = \sigma_V$	2.5	5.0	8.3
σ_W	1.25	2.5	4.17

Turbulence scale lengths vary with altitude according to the equations of para 3.2.3.2.

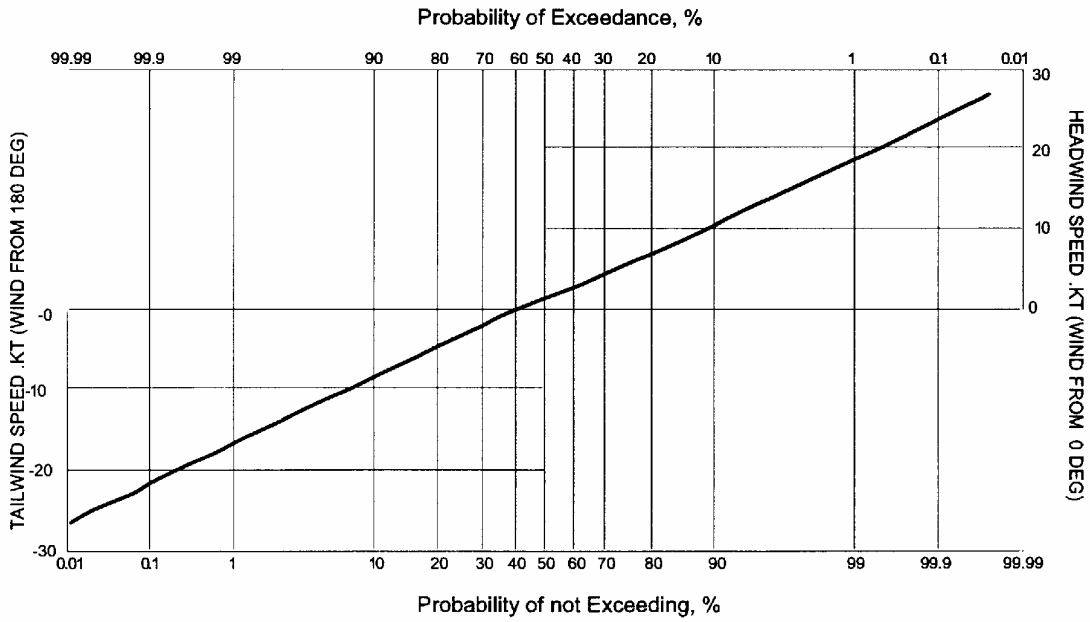


FIGURE 2 Headwind – Tailwind Description

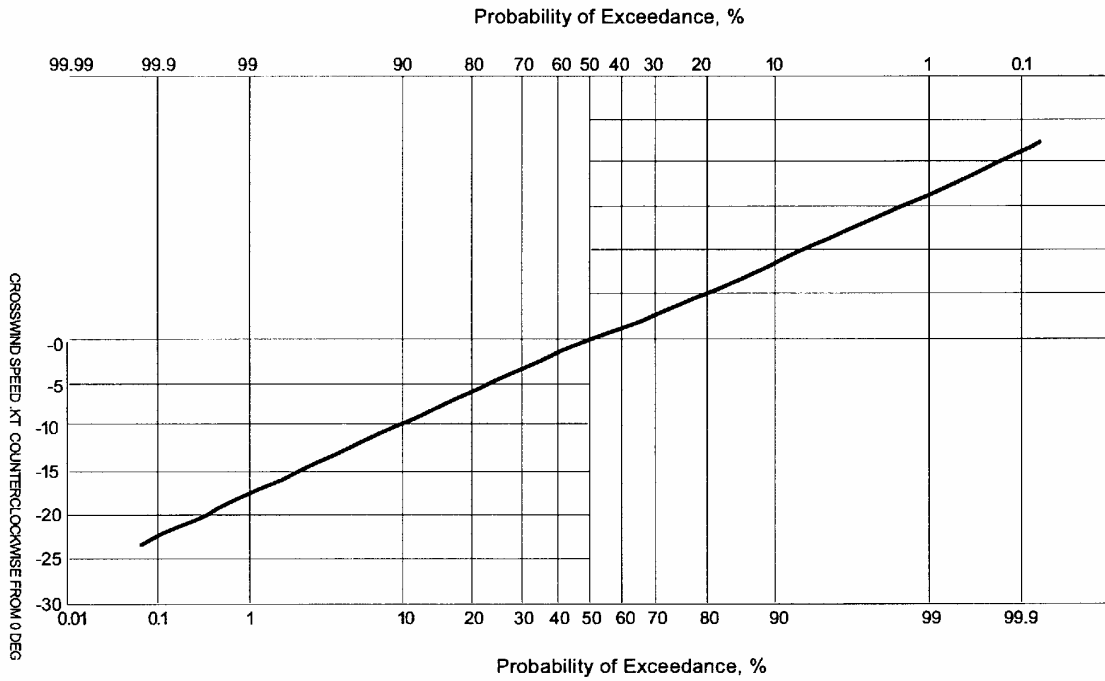


FIGURE 3 Crosswind Description

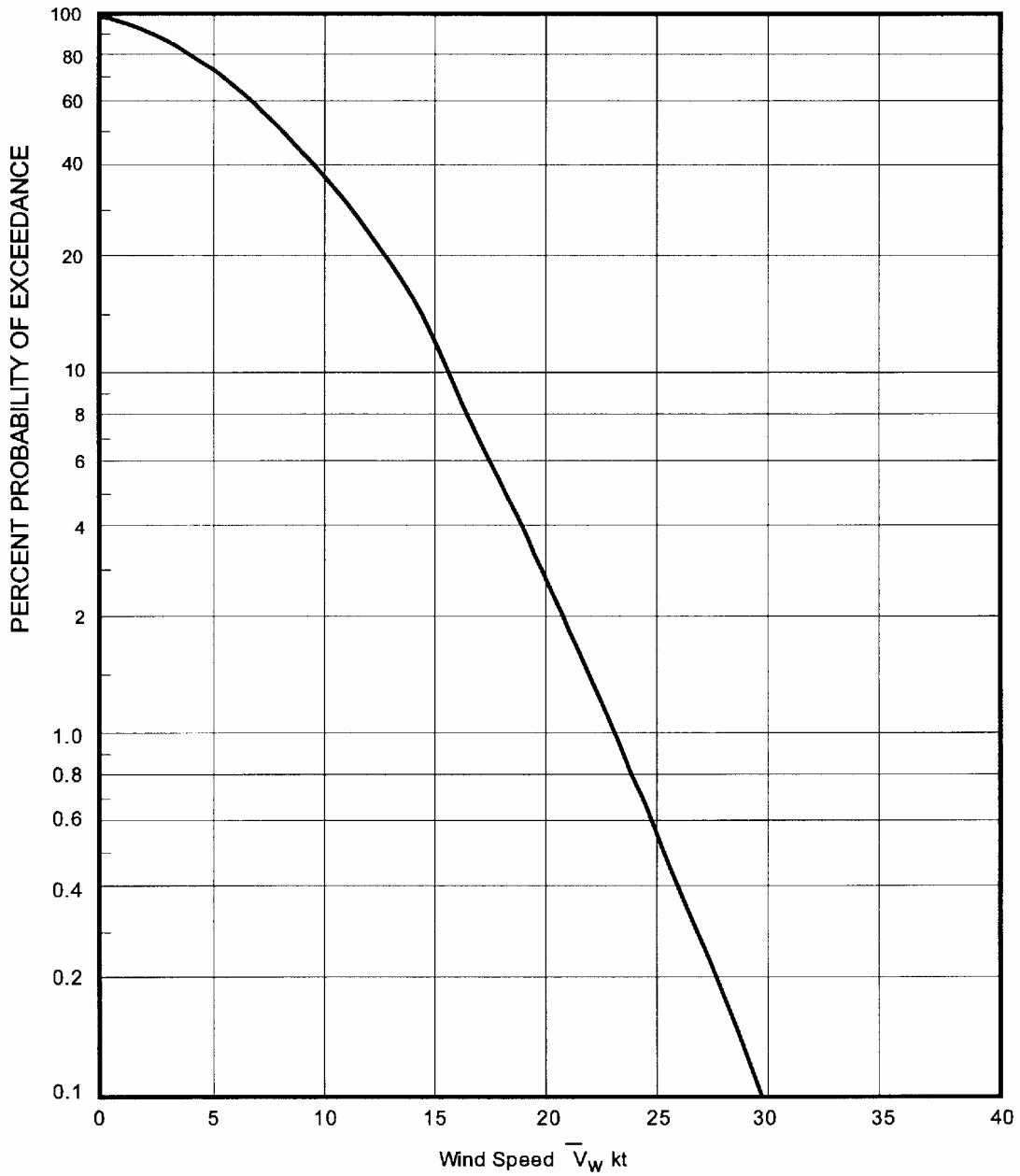


FIGURE 4 Annual percent probability of Mean Wind Speed equalling or exceeding given values

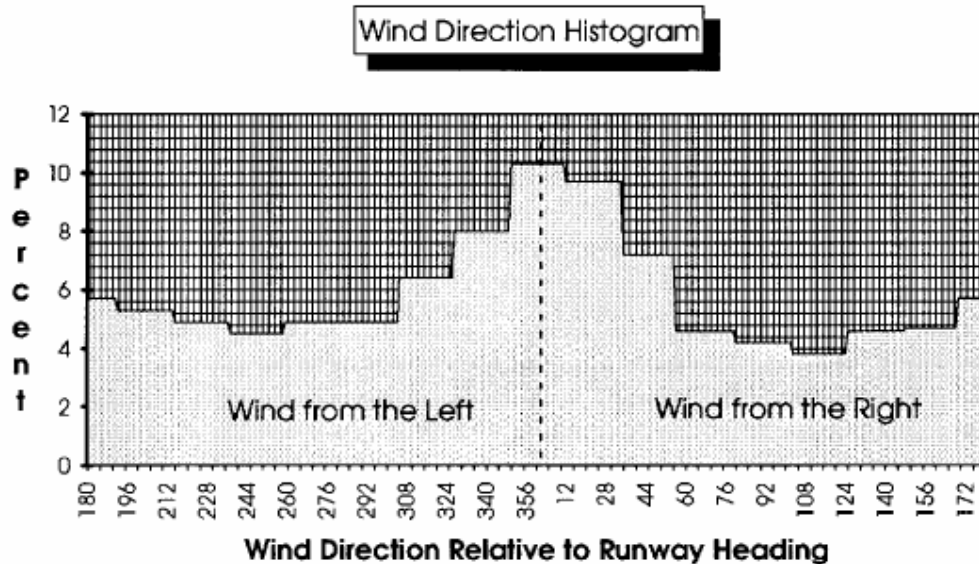


FIGURE 5 Wind direction relative to Runway Heading

4 Models of ILS and MLS Signals in Space for use in Approach Simulations

4.1 ILS Model

4.1.1 General

4.1.1.1 Automatic landing system evaluation including computer analysis of system performance should be based on the use of ILS ground facilities, which meet the performance characteristics, listed herein.

4.1.1.2 The values given are derived from the performance characteristics for Category II ILS, contained in ICAO Annex 10, Volume 1, Third Edition dated July 1972 at Amendment No. 58 except where indicated.

4.1.1.3 Analysis of results of in-flight demonstrations may include subtraction of measured ILS beam distortions, and treatment of the contribution of the ILS beam on a probability basis using the information that follows. (See CS-AWO 131(b)(2).)

4.1.2 *Glide Path*

4.1.2.1 *Glide Path Angles.* It should be assumed that the operationally preferred glide path angle is 3°. The automatic landing system should be shown to meet all applicable requirements with promulgated glide path angles from 2.5° to 3°. Where certification is requested for the use of a larger beam angle, performance on such a beam should be assessed.

4.1.2.2 *Height of ILS Reference Datum (height of glide path at threshold).* For establishing compliance with the longitudinal touchdown performance limits it may be assumed that the height of the ILS Reference Datum is 15 m (50 ft).

4.1.2.3 *Glide Path Alignment Accuracy.* It should be assumed that the standard deviation of beam angle about the nominal angle (Θ) is 0.025 Θ .

4.1.2.4 *Displacement Sensitivity.* It should be assumed that the angular displacement from the nominal glide path for 0.0875 DDM has the value of 0.12 Θ .

4.1.2.5 *Glide Path Structure.* For the purposes of simulation, the noise spectrum of ILS glide path may be represented by a white noise passed through a low pass first order filter of time constant 0.5 sec. For the whole of the approach path the output of the filter should be set to a two-sigma level of 0.023 DDM.

(Background: An interpretation of Annex 10, paragraph 3.1.5.4.2.)

NOTE: This model is primarily intended to simulate the characteristics of beams at low altitude, and therefore results derived from its use should not be relied on for heights above 150 m (500 ft).

4.1.3 *Localizer*

4.1.3.1 *Course Alignment Accuracy.* It should be assumed that at the threshold the standard deviation of the course line about the centreline is 1.5 m (5 ft).

NOTE: This value is in between those given in Annex 10, paragraph 3.1.3 for Category II and Category III ILS which are assumed to be three sigma values, 2.5 m (8.3 ft) and 1.0 m (3.3 ft) respectively.

4.1.3.2 *Displacement Sensitivity.* It should be assumed that the nominal displacement sensitivity at the threshold has the value of 0.00145 DDM/m.

4.1.3.3 *Course Structure.* For the purposes of simulation, the noise spectrum of ILS localizers may be represented by a white noise passed through a low pass first order filter of time constant 0.5 sec. For the whole of the approach path the output of the filter should be set to a two-sigma level of 0.005 DDM. (See Note to paragraph 4.2.5.)

(Background: An interpretation of Annex 10, paragraph 3.1.3.4.2.)

4.2 *MLS Ground Facility Model.*

The MLS models defined by the ICAO All Weather Operations Panel (AWOP), reference AWOP/14-WP/659, dated 4/2/93 should be used for approach simulations. Alternatively, if certification of MLS is only sought for ILS look-alike operations, the applicant may use the ILS model defined in section 4.1. This is based on the assertion that the MLS quality is equal to or better than that of ILS and requires no further substantiation.

5 *Aerodrome Conditions*

5.1 *Elevation and Temperature.* The effects of aerodrome elevation and ambient temperature should be examined where operation is envisaged at aerodromes about 750 m (2 500 ft) or in temperatures greater than ISA + 15°C.

5.2 *Ground Profile*

5.2.1 Where use is made of radio altimeter signals in the automatic landing system, any effects of ground profile before the runway or along the runway on the performance of the system should be examined.

5.2.2 The family of profiles to be investigated should take due account of the way in which the system uses the radio altimeter signals at different heights on the approach. Terrain and runway up slopes, down slopes and other terrain irregularities should be investigated.

NOTE: The information on characteristics of aerodromes is contained in ICAO Annex 14. Examination of a number of airports used for automatic landing has shown that the following features may be encountered:

- a. Sloping runway – slopes of 0.8%;
- b. Hilltop runway – 2.5% slope up to a point 60 m prior to the threshold; or
- c. Sea-wall – 6 m (20 ft) step up to threshold elevation at a point 60 m prior to the threshold.

AMC AWO 140**Performance Demonstration**

1 Identification of a critical engine should consider the effects on performance, handling, loss of systems, and autoland status. More than one engine may be critical for different reasons.

2 If the aeroplane configuration and operation are the same as that used in the performance demonstration of AWO 131 for the all engine operating case, compliance with AWO 140 may be demonstrated by, typically, 10 to 15 landings, or by statistical analysis supported by flight test if the aeroplane configuration or operation is changed significantly from the all engine operating case.

3 If the aeroplane configuration and operation are not the same as for the all engine operating case, the effect on landing distance will need to be considered.

4 To aid planning for automatic landing with an inoperative engine, appropriate procedures, performance, and obstacle clearance information will need to be established enabling a safe go-around at any point in the approach.

5 For the purposes of this requirement, demonstration of automatic landing and go-around performance in the event of a second engine failure need not be considered.

AMC to AWO 151,AWO 152 and AWO 352**Controls, Indicators and Warnings**

Where certification of installations involving more than one type of precision approach system (e.g. MLS and ILS) is requested, the following considerations should be taken into account: -

- (i) Where practicable, the flight deck procedure for the ILS and MLS precision approach should be the same.
- (ii) The loss of deviation data should be indicated on the deviation display. The failure indication on the deviation display for each axis of the ILS and MLS may be common.
- (iii) The ILS or MLS precision approach system selected as the navigation source for the approach and automatic landing should be indicated positively in the primary field of view at each pilot station.
- (iv) The ILS frequency or MLS channel data for the selected approach should be displayed to each pilot.
- (v) Means should be provided to enable the flight crew to confirm that the intended type of approach system has been correctly selected.
- (vi) A common set of mode indications for the armed and active conditions is recommended.
- (vii) The capability of each element of a multi-mode landing system should be available to the flight crew to support dispatch of the aeroplane.
- (viii) A failure of each element of a multi-mode landing system should be indicated to the flight crew as either an advisory or a caution, during en-route operation.
- (ix) A failure of the selected element of a multi-mode landing system during an approach should be accompanied by a warning or caution, as appropriate. These alerts may be inhibited at the Alert Height, if appropriate to the operation.
- (x) If an indication of a failure in each non-selected element of a multi-mode landing system during an approach and landing is provided, it should be available to the flight crew as an advisory and should not produce a caution or warning. These advisories may be inhibited at the Alert Height, if appropriate to the operation.
- (xi) Failure indications should not mislead the flight crew through a possible incorrect association with the navigation source. For example, it would be unacceptable for "ILS FAIL" to be displayed when the selected navigation source is MLS and the failure affects the MLS receiver.

**AMC AWO 161(b)
Failure Conditions**1 *Analysis of Failure Conditions and their Effects*

1.1 *Analysis.* An analysis should be carried out to define the failure conditions and their effects and to show that the probability of each failure condition is such that the requirements of CS-AWO 161 (a) are achieved.

1.2 *Failure conditions and their effects*

1.2.1 The effect of a failure condition on the aeroplane and occupants should be established, taking into account the stage of flight. There should be a flight demonstration (see paragraph 2) taking account of the warning cues and the information available to the pilot making the corrective action.

1.2.2 Where the effect of a failure condition is neither readily apparent nor deducible by analysis, either the most adverse consequence should be assumed, or such testing should be carried out as may be required to establish the effect.

1.2.3 All failures and combinations of failures leading to the same or a similar effect on the functioning of the system should be regarded as the same failure conditions.

1.3 *Probability of failure conditions.* The probability of a failure condition should be based on engineering judgement of evidence relevant to the components used, and account should be taken of previous experience on similar systems. The analysis should take account of the following:

a. A single failure of a system or component may only be accepted when the system or component is assessed to have the necessary order of reliability based on:

i. Service experience which can be shown to be applicable, normally supported by analysis and/or testing of the particular design; or

ii. A detailed engineering evaluation of the design supported by testing.

b. A single failure may only be assessed to be an Extremely Improbable failure when it applies to a particular mode of failure and it can be shown from the aspects of design, construction and installation, that such a failure need not be considered as a practical possibility.

c. In systems, which rely for their airworthiness on redundancy techniques, particular attention should be given in the analysis to common mode failures (i.e. multiple failures arising from a single cause). The following are typical examples of common mode failures:

i. A local fire causing multiple failures;

ii. Electro-magnetic interference or electrical transients causing multiple malfunctions;

iii. Mechanical vibration causing multiple failures or malfunctions;

iv. Leakage of water or other liquids (e.g. from a galley or from cargo) causing multiple electrical failures;

v. The failure of a cooling system or the leakage of hot air causing multiple failures in other systems;

vi. Lightning strike; and

vii. Software errors in digital systems.

1.4 *Numerical probabilities*

1.4.1 Where numerical analyses are used in assessing compliance with CS-AWO 161 (a) the probability values given in AMC 25.1309 should be used in providing a common point of reference. The analysis should take into account the period in the landing for which the particular failure condition is critical.

1.4.2 Combinations of failures may be accepted on the basis of assessed numerical values only where these values can be substantiated and a suitable analysis technique has been employed.

1.4.3 Statistical methods should be used to complement engineering judgement and should not be regarded as a substitute.

1.5 *Dormant failures (latent)*. When the failure of a device can remain undetected in normal operation, the frequency with which the device is checked will directly influence the probability that such a failure is present on any particular occasion. This should be taken into account when assessing the probabilities of any failure conditions which include the dormant failures of monitoring devices or unchecked redundant items.

1.6 *Cascade failures*. When failure of a component or equipment can be expected to result in other failures, account should be taken in the analysis of these further failures. In assessing which failures may follow, consideration should be given to any change in the equipment operating conditions for other components or equipment consequential on the first failure.

1.7 *Damage from external sources*. In considering damage from external sources, account should be taken of the location of the equipment in the aeroplane and other features of the installation.

2 *Flight Demonstrations*

2.1 Simulation tests, and the assessed probability of the failure condition should be taken into account in determining which failure conditions should be demonstrated in flight.

2.2 Where system tolerances significantly affect the consequences of failure, the system should be adjusted for flight-testing to the most adverse tolerances, which can be maintained in service.

2.3 The effects of failures of the ILS and/or MLS ground facilities should, if necessary, be demonstrated in flight.

3 *Consideration of the Effects of Engine Failure*

3.1 Where the landing system provides automatic control of the rudder pedals, a demonstration should be made to show that, for automatic approaches initiated with all engines operating:

- a. automatic go-around, and
- b. automatic landing,

can be performed safely after the failure of any single engine at any point during the approach down to touchdown without the pilot needing to intervene and assume control.

3.2 The automatic pilot should remain engaged following the failure of any single engine, taking account of the loss of systems associated with the failed engine (e.g. electrical and hydraulic systems).

AMC AWO 181(f) Aeroplane Flight Manual

The Aeroplane Flight Manual may contain a statement to the effect that the categories of ILS and/or MLS ground facilities, which have been used as a basis for certification, should not be taken as a limitation. In that case the Aeroplane Flight Manual should also contain a statement that some Category I ILS and/or MLS ground facilities may not be suitable for automatic landing

ACCEPTABLE MEANS OF COMPLIANCE FOR SUBPART 2**AMC AWO 200(a)
Applicability**

An aeroplane with a basic airworthiness approval for IFR operations is eligible to perform ILS or MLS precision approaches down to a decision height of 60 m (200 ft), assuming that the necessary ILS/MLS receiver(s) and instruments and their installation have been approved. The purpose of Subpart 2 is to specify the supplementary airworthiness requirements for the performance of ILS or MLS approaches with decision heights below 60 m (200 ft) down to 30 m (100 ft). This material may not be appropriate to other precision approach aids.

The term "localiser" and "glide path" have been retained for use with either ILS or MLS.

Cross reference is made in this Subpart to AMC AWO 151 which provides guidance on controls, indicators and warnings associated with installations incorporating more than one type of approach system (e.g. ILS and MLS).

**AMC AWO 202
Go-around Rate**

On the assumption that system failures will not significantly reduce the success rate, compliance with this requirement may be demonstrated by means of the Continuous Method of AMC AWO 231 using the following interpretation: –

- 1 On no more than 5% of approaches will a localiser excess deviation alert occur between 90 m (300 ft) and 30 m (100 ft).
- 2 On no more than 5% of approaches will a glide path excess deviation alert occur between 90 m (300 ft) and 30 m (100 ft).

**AMC AWO 221
Installed Equipment**

1. ILS and MLS Airborne Equipment Standards
Acceptable standards for airborne receiver equipment include: -

a. Localiser receivers complying with the minimum performance standards of EUROCAE ED-46B or later revision, or an equivalent standard, and glide path receivers complying with the minimum performance standards of EUROCAE ED-47A or RTCA DO-192 or later revision.

Note - The aforementioned localiser specifications are in accordance with the FM Broadcast Interference Immunity requirements of ICAO Annex 10, Vol. 1, Chapter 3, and Paragraph 3.1.4.

b. MLS receivers complying with the minimum performance standards of EUROCAE ED-36A or later revision, or an equivalent standard, and DME/P or DME/N transceivers complying with the minimum performance standards of EUROCAE ED-54 or RTCA DO-189.

c. Combined ILS/MLS receivers complying with the minimum performance standards of EUROCAE ED-74 or equivalent standard.

d. Combined ILS/MLS/GPS receivers complying with the minimum performance standards of EUROCAE ED-88 or equivalent standard.

2. Radio Altimeter Equipment Standard

The airborne equipment used to provide height above terrain may be a radio altimeter complying with the minimum performance standards of EUROCAE ED-30 or RTCA DO-155.

AMC AWO 231 Flight Demonstration

1 *Flight Path Control.* Compliance with AWO 231 may be shown by a flight test programme covering a representative range of weight, CG position, aeroplane configurations and wind speed. At least three ILS ground facilities and/or at least 2 MLS ground facilities should be used with an approximately equal number of approaches to each. The aeroplane and its equipment should be representative of the production standard in relevant areas.

Since it is not economically possible to make a large number of approaches to show compliance with AWO 231 it is necessary to impose a confidence level on the results of the programme. A confidence level of 90% has been selected to allow a reasonable number of approaches. Two methods of demonstrating compliance are given; the 'Continuous Method' and the 'Pass or Fail Method'. The mathematical derivation of these two methods is given in Appendix 1 to AMC AWO 231.

1.1 *Continuous Method (Analysis of Maximum Value).* If this method is used a minimum of 30 approaches should be made to provide an adequate sample. If more than one type of precision approach system is installed, approximately equal numbers of approaches should be carried out for each type of approach system being certificated. The maximum glide path and localiser deviations occurring between 90m (300 ft) and 30m (100 ft) should be recorded using test instrumentation and the results analysed in one of the following two ways.

1.1.1 Numerical Analysis

a. Calculate
$$\lambda = \sqrt{\frac{1}{2n} \sum_{i=1}^n (x_i)^2}$$

where: x_i is the maximum glide path (or localiser) deviation recorded between 90 m (300 ft) and 30 m (100 ft)

on the approach, and

n is the number of approaches.

b. Calculate
$$\alpha = \frac{x_0}{\lambda} \sqrt{1 - \left(\frac{1.28}{\sqrt{n}} \right)^2}$$

where x_0 is the excess deviation alert setting

c. Calculate the probability of success, $P(\alpha)$, where:

$$P(\alpha) = 100 \left(1 - e^{-\frac{\alpha^2}{2}} \right)$$

If $P(\alpha)$ is 95% or more, the aeroplane meets the criteria with the required levels of confidence.

1.1.2 *Graphical Analysis.* This is essentially the same as the numerical analysis but it allows inspection of the results as the programme progresses so as to give an early indication of the likelihood of success.

a. Calculate
$$\sum_{i=1}^n (x_i)^2$$
 as the programme progresses

and plot the result against the number of approaches completed on Figure 1.

Note: Figure 1 is based on excessive glideslope and localiser deviation thresholds of 75 μA and 25 μA , respectively, as specified in AMC AWO 236. If lower thresholds are used, Figure 1 should be amended using the method specified in Appendix 1 to AMC AWO 231, paragraph 3, 'Graphical Analysis'.

b. When the plotted line enters the 'pass' region the programme may be stopped.

1.2 *Pass or Fail Method.* This method is suitable for use when it is not practicable to install recording equipment. A total of at least 46 successful approaches are necessary to pass this method. If more than one type of precision approach system is installed, approximately equal numbers of approaches should be carried out for each type of approach system being certificated. Each approach is made using Category 2 procedures and a record is kept of any unsatisfactory approaches due to ILS or MLS tracking performance or airborne system malfunctions. The success of the programme is judged against the criterion shown in Figure 2.

2 *Speed Control.* Where an auto throttle is used, airspeed should be recorded and shown to remain within ± 9.3 Km/h (± 5 kt) of the intended value, disregarding rapid fluctuations due to turbulence.

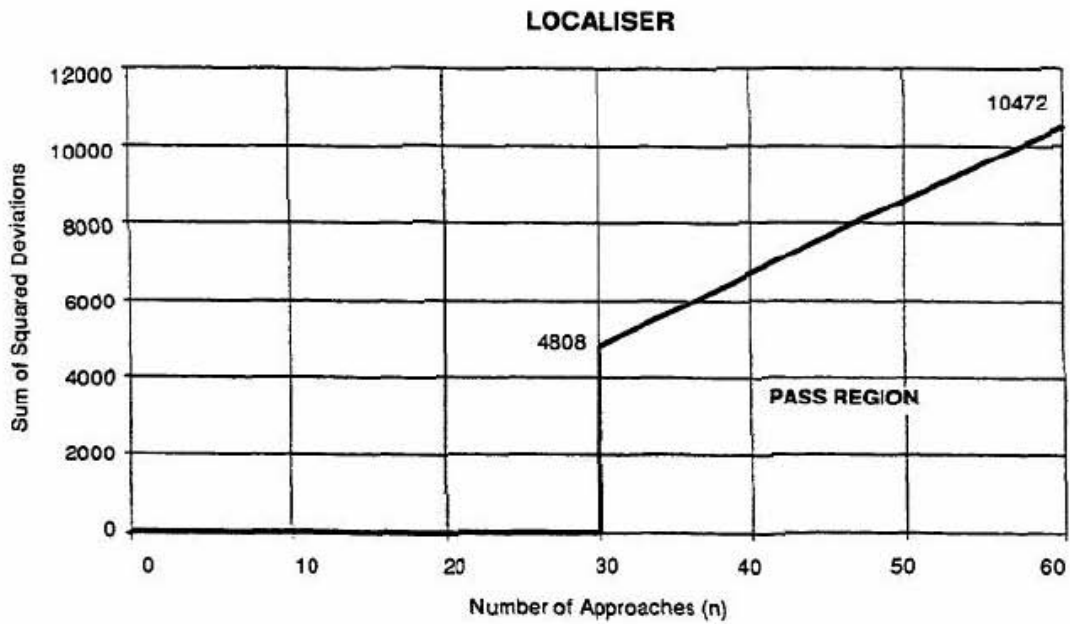
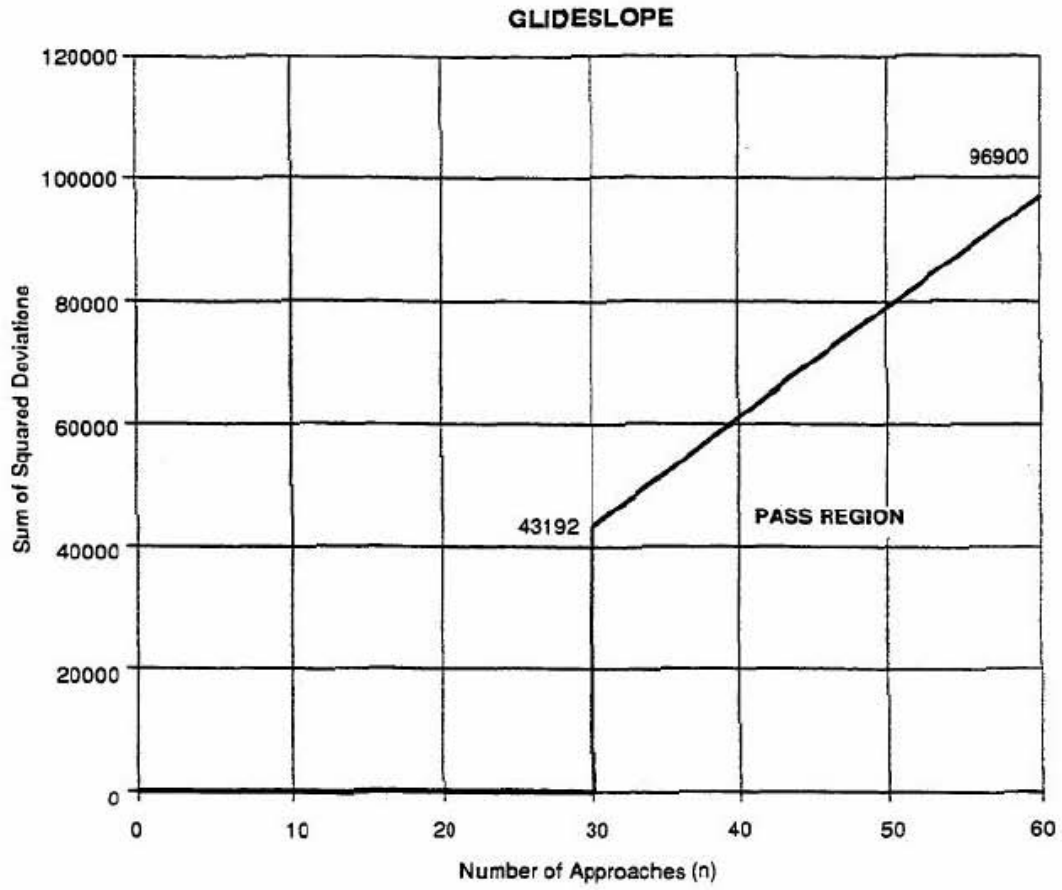
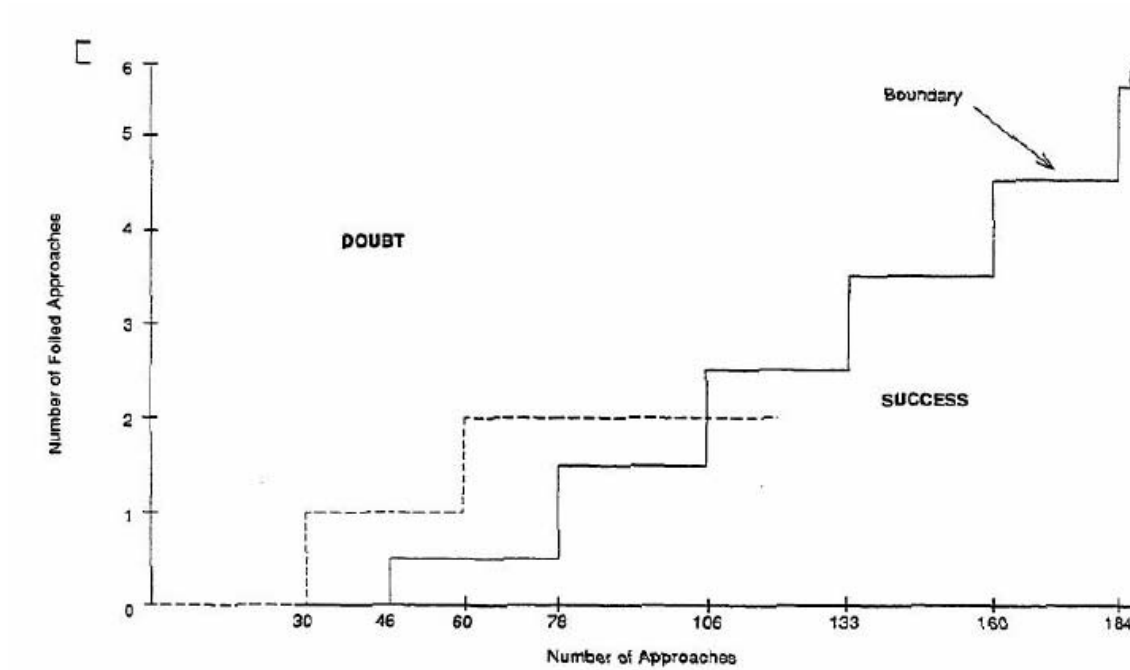


FIGURE 1 Graphical Analysis



The dashed line illustrates achieved progress with failures on approaches 30 and 60.

FIGURE 2 Pass or Fail Method

**AMC AWO 236(a)
Excess-deviation Alerts**

The excess deviation alerts should be set to operate when the ILS or MLS deviation exceeds not more than the following: –

- 75 μ A for the glide path
- 25 μ A for the localiser.

APPENDIX 1 TO AMC AWO 231**Category 2 ILS and MLS Tracking Performance**1 *Introduction*

AMC AWO 231 gives acceptable methods of demonstrating acceptable ILS and/or MLS tracking performance. This appendix gives the mathematical derivation of these methods.

2 *Numerical Analysis*

The maximum glide path or localiser deviation recorded during an ILS or MLS approach will vary from one approach to another and may be treated as a statistical variable. If it is assumed that the glideslope and localiser deviations recorded during an ILS or MLS approach have a normal distribution with mean zero, then it can be shown that the maximum deviations (ignoring the sign of the maximum value) during a certain approach interval follow a Rayleigh distribution of the form:

$$P(x) = \frac{x}{\lambda_0^2} e^{-\frac{1}{2} \left(\frac{x}{\lambda_0} \right)^2}$$

where x is the maximum glideslope or localiser deviation and λ_0 is the scale parameter of the Rayleigh Distribution function.

It follows that the probability of recording a maximum deviation less than some specified value x_0 is:

$$P(x_0) = \int_0^{x_0} P(x) dx = 1 - e^{-\frac{1}{2} \left(\frac{x_0}{\lambda_0} \right)^2}$$

It can be shown that: –

$$\lambda_0^2 = \frac{1}{2} \int_0^x x^2 P(x) dx$$

and, to a good approximation: –

$$\lambda^2 = \frac{1}{2n} \sum_{i=1}^n (x_i)^2$$

where n is the number of approaches and x_i the maximum deviation recorded on each approach.

If large numbers of approaches were made, λ_0 could be calculated and used to find the probability that the maximum ILS and/or MLS deviation will not exceed the excess deviation alert setting. For example, if: –

$$\lambda_0^2 = \frac{1}{2n} \sum_{i=1}^n (x_i)^2 = 625$$

and the excess deviation alert setting is 75 μ A, then:

$$\frac{x_0}{\lambda_0} = 3.0$$

and

$$P(x_0) = 98.9\%$$

However, it is not economically practicable to make large numbers of approaches and the effects of small sample sizes should be considered. The usual method of doing so is to impose a confidence level (in this case 90%) on the results of the measured sample.

If values of λ^2 are calculated from a number of samples, sampling theory shows that they will be normally distributed with a mean value λ_0^2 and a standard deviation of $\frac{\lambda_0^2}{\sqrt{n}}$ where n is the number of approaches in each sample.

Parameter $\mu = \frac{(\lambda^2 - \lambda_0^2) \sqrt{n}}{\lambda_0^2}$ is normally distributed with a mean value 0 and a standard deviation 1.

The probability (or confidence level) that a value of μ is greater (or smaller) than a certain value is given by the probability distribution function of the normal distribution N (0,1):

$$P(\mu > \mu_1) = P(\mu < -\mu_1) = \tau = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\mu_1} e^{-\frac{\mu^2}{2}} d\mu$$

Figure A1-1 shows numerical solutions of this integral, in percentages of the integral from $-\infty$ to ∞ , representing one-sided exceedance probabilities (or confidence levels) τ for a range of μ_1 values.

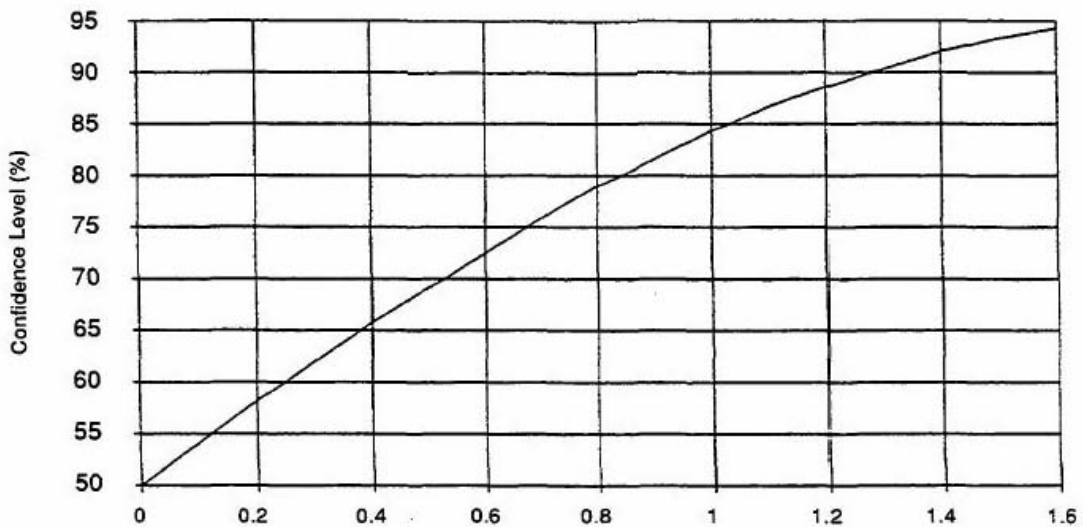


FIGURE A1-1 Confidence Level

From this Figure it can be seen that for $\tau = 90\%$, $\mu_1 = 1.28$.

Thus, there is a given level of confidence τ that: –

$$\mu = \frac{(\lambda^2 - \lambda_0^2) \sqrt{n}}{\lambda_0^2} > -\mu_1$$

from which $\lambda_0^2 < \frac{\lambda^2}{1 - \frac{\mu_1}{\sqrt{n}}}$

The value of λ^2 for the sample is, as shown earlier: –

$$\lambda^2 = \frac{1}{2n} \sum_{i=1}^n (x_i)^2$$

Hence, the maximum value of λ_0 can be calculated, followed by the minimum value of

$$\alpha = x_0 \sqrt{\frac{1 - \frac{\mu^2}{\lambda^2}}{\lambda^2}}$$

where, as before, x_0 is the excess deviation alert setting.

The minimum probability of not exceeding the excess deviation alert setting is found by using the probability equation:

$$P(\alpha) = 100 \left(1 - e^{-\frac{\alpha^2}{2}} \right)$$

3 Graphical Analysis

As before, the distribution of the maximum deviation on an approach is assumed to be such that the probability that it is less than a value x_0 is given by: –

$$P(x_0) = 1 - e^{-\frac{1}{2} \left(\frac{x_0}{\lambda_0} \right)^2}$$

From this equation, given that the required probability is 95%, the value of can be calculated as: –

$$\frac{x_0}{\lambda_0} = 2.4477$$

The limiting deviations (x_0) are the excess deviation alert settings; 75 μA for the glide path and 25 μA for the localiser. Hence: –

$$\lambda_0 = 30.64 \text{ for the glide path}$$

$$\lambda_0 = 10.21 \text{ for the localiser}$$

As given earlier:

$$\lambda = \sqrt{\frac{1}{2n} \sum_{i=1}^n (x_i)^2}$$

so that:

$$\sum_{i=1}^n (x_i)^2 = 2n\lambda^2$$

$$\begin{aligned} &= 1\,878\,n \text{ for the glide path} \\ &= 209\,n \text{ for the localiser} \end{aligned}$$

Thus, a 95% success rate can be represented graphically as in Figure A1-2 showing $\sum x_i^2$ plotted against i :

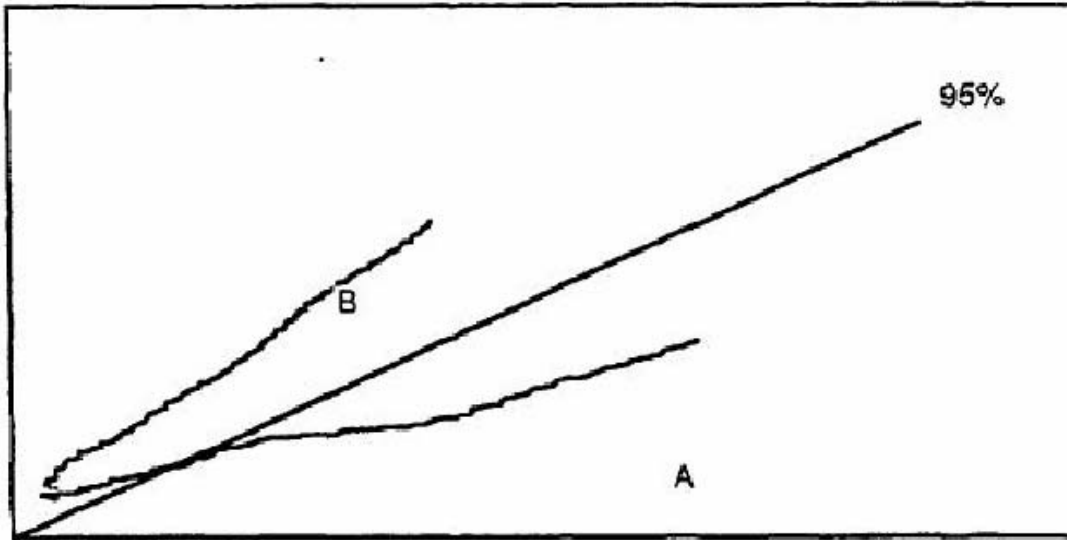


FIGURE A1-2 Examples of results of flight trials

If, now, a flight trials programme is carried out and the accuracy of the results needs to be checked against the 95% success criterion, this can be achieved by plotting the value of $\sum x_i^2$, the sum of the squares of the maximum recorded deviations, against n , the number of runs as the trial progresses. If the results are better than required, the graph will cross the 95% line as shown by line A above. If they are worse the results will appear as line B.

So far, the effect of sample size has not been considered. Its effect is to lower the 95% success line.

For the sample:

$$\lambda = \sqrt{\frac{1}{2n} \sum_{i=1}^n (x_i)^2}$$

As shown earlier:

$$\lambda_0^2 < \frac{\lambda^2}{1 - \frac{\mu_1}{\sqrt{n}}}$$

which, in the limiting case becomes:

$$\lambda^2 = \lambda_0^2 \left(1 - \frac{\mu_1}{\sqrt{n}}\right)$$

Hence:

$$\lambda_0^2 \left(1 - \frac{\mu_1}{\sqrt{n}}\right) = \frac{1}{2n} \sum_{i=1}^n (x_i)^2$$

or

$$\sum_{i=1}^n (x_i)^2 = 2n\lambda_0^2 \left(1 - \frac{\mu_1}{\sqrt{n}}\right)$$

$$\lambda_0 = 30.64 \quad \text{for the glide path}$$

$$\lambda_0 = 10.21 \quad \text{for the localiser}$$

$$\mu_1 = 1.28 \quad \text{for 90% confidence level}$$

$$\begin{aligned} \sum_{i=1}^n (x_i)^2 &= 1\,878\,n - 2\,403\,\sqrt{n} \quad \text{for the glide path} \\ &= 209\,n - 267\,\sqrt{n} \quad \text{for the localiser} \end{aligned}$$

These expressions have been used to produce Figure 1 of AMC AWO 231.

4 *Pass or Fail Method*

Suppose the rate of failed approaches measured over a large number of approaches is r .

In a number of approaches T the expected number of failures is $n = rT$.

In any given period of time, the number of failures occurring may be greater or less than n , and the small sample may not be typical.

If the failures are randomly distributed with respect to time the probability p of observing F failures when the expected number is n is given by the various terms of the Poisson distribution, viz:

F	0	1	2	3	F
P	e^{-n}	$e^{-n}n$	$\frac{e^{-n}n^2}{2!}$	$\frac{e^{-n}n^3}{3!}$	$\frac{e^{-n}n^F}{F!}$

This is a convenient form when the long-term average n is known and the probability of an occurrence of abnormally high or low numbers of failures over short periods is to be found. The problem here is the reverse of this. The observed number F is known and the value of n , which is consistent with it, is required.

In this case n can have any value above zero and less than infinity. By considering all values of n from zero to some selected maximum N , the Poisson distribution can be used to find the probability of occurrence of each value of n . Summing all these probabilities gives the cumulative probability P that, for an observed value of F , the expected value is not in excess of N . Thus:

$$P = \int_0^N \frac{n^F}{F!} e^{-n} dn$$

As F is a known whole number then, for various values of F , the value of P may be determined as follows:

$$F = 0, P = \int_0^N e^{-n} dn = 1 - e^{-N}$$

$$F = 1, P = \int_0^N ne^{-n} dn = 1 - (N + 1)e^{-N}$$

$$F = 2, P = \int_0^N \frac{n^2 e^{-n}}{2!} dn = 1 - \left(N^2 + 2N + 2 \right) \frac{e^{-N}}{2}$$

and generally for any value of F,

$$P = 1 - \left(\frac{N^F}{F!} + \frac{N^{F-1}}{(F-1)!} + \frac{N^{F-2}}{(F-2)!} + \dots + N + 1 \right) e^{-N}$$

By evaluating the integral for various values of N the variation of P with N is obtained. Then, for a given confidence level P, the value of N corresponding to the observed value F is obtained. Thus if the observed rate is F/T, then, for a selected confidence level, it is possible to determine the maximum value for the failure rate N/T.

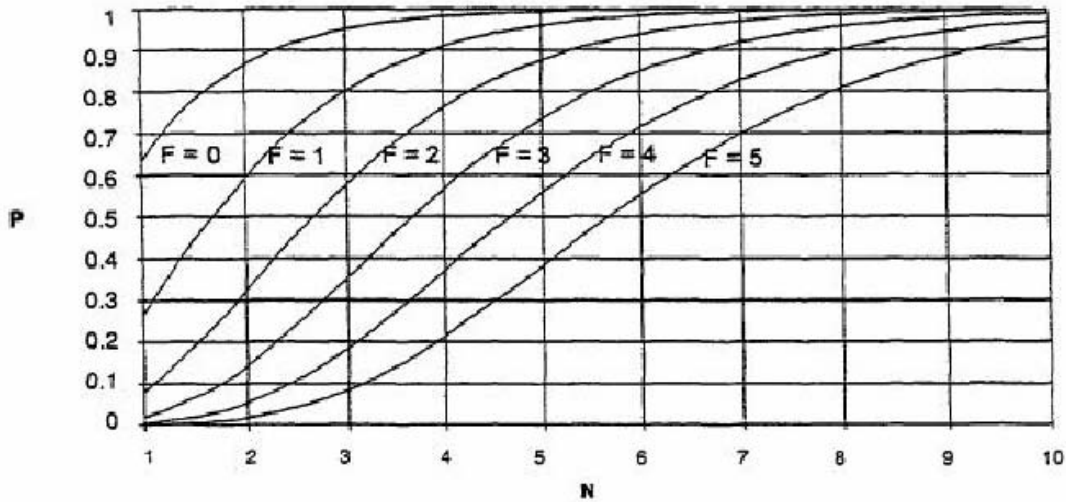


FIGURE A1-3 P, N and F Relationships

From Figure A1-3 it can be seen that for a failure rate r of 5% and a 90% confidence level, the required number of approaches T is: –

F	N	T
0	2.30	46
1	3.9	78
2	5.3	106
3	6.65	133
4	8	160
5	9.2	184

For example, it is necessary to make 46 approaches without a failure, 78 if one failure occurs and so on as shown in Figure 2 of AMC AWO 231.

ACCEPTABLE MEANS OF COMPLIANCE FOR SUBPART 3**AMC AWO 300(a)
Applicability**

An aeroplane with a basic airworthiness approval for IFR operations is eligible to perform ILS or MLS precision approaches down to a decision height of 60 m (200 ft), assuming that the necessary ILS and/or MLS receiver(s) and instruments and their installation have been approved. The supplementary airworthiness criteria for aeroplanes to perform precision approaches down to a decision height below 60 m (200 ft) and down to 30 m (100 ft) are contained in Subpart 2.

The purpose of Subpart 3 is to specify the supplementary airworthiness criteria for aeroplanes to perform precision approaches with decision heights below 30 m (100 ft) or with no decision height.

This material may not be appropriate to precision approach aids other than ILS and MLS.

It should be noted that when other guidance information is used to supplement the ILS or MLS (e.g. inertial navigation systems) some reduction may be acceptable in the standard of ILS or MLS ground facility indicated below.

The term "localiser" and "glide path" have been retained for use with either ILS or MLS.

Cross reference is made in this Subpart to AMC AWO 151 which provides guidance on controls, indicators and warnings associated with installations incorporating more than one type of approach system (e.g. ILS and MLS).

Background information regarding the characteristics of the types of operation as distinguished in subparagraphs (a)(1) (a)(2) and (a)(3) is presented in more detail in the paragraphs that follow.

1. Decision Height below 30 m (100 ft) but not less than 15 m (50 ft)

The Runway Visual Range (RVR) required by a pilot to make the decision to land from a decision height below 30 m (100 ft) is less than he would need at 30 m (100 ft). Furthermore, the time from the decision height to the start of the flare manoeuvre will be less.

Consequently, in order to achieve the desired success rate and to preserve the safety level, it has been considered necessary that the aeroplane be fitted with an automatic landing system. Use of such a system also ensures that the aeroplane is within the obstacle-free zone specified in ICAO Annex 14 during approach and any go-around so that there is no need to take obstacle clearance into account in determining the decision height. This is chosen to give an acceptably low probability of touching the ground during go-around. The RVR limit is set by the responsible national authority in accordance with applicable operating regulations and provides visibility at and below the decision height so that, if either the automatic landing system the ILS or the MLS ground facility fails when the aeroplane is below the decision height, the pilot can carry out a manual landing with an acceptable safety level.

The ground guidance system is either

i) a Category III or a Category II ILS complying with the Category III standards of ICAO Annex 10, Chapter 3-1 in respect of all significant performance parameters, at least down to ILS point D, 900m (3,000ft) from the runway threshold.

or

ii) a Category III MLS complying with the requirements of ICAO Annex 10, Chapter 3.11.

2. Decision Height below 15 m (50 ft)

Aeroplanes which have a fail-operational landing system, can be certificated for operation with a decision height below 15 m (50 ft).

In this type of operation, the RVR needs not only to be sufficient for the pilot to make the decision at the decision height, but also to be sufficient to enable the pilot to control the aeroplane during the ground roll. The main purpose of the decision height is so that he can assess the adequacy of the visibility before touchdown and prepare to take over visual manual control. It is desirable that the decision height be late in the flare after the major pitch changes have taken place, and that an automatic go-around system be fitted. There exists an unknown probability that, although the visibility is reported to be adequate, denser patches of fog may lie on the runway, and it is thought prudent to add a margin to the bare minimum required to control the ground roll. The RVR limit is set by the responsible national authority in accordance with applicable operating regulations.

The ground guidance system (ILS and MLS) are as described in paragraph B, and, additionally, comply with a continuity of service objective (failure survival capability) of $1-(2 \times 10^{-6})$. It is assumed that the pilot is promptly notified by ATC of a failure or degradation of the required ground equipment (e.g. loss of stand-by ILS or MLS transmitter).

3. No Decision Height

An aeroplane with a fail-operational landing system with automatic ground roll control (or ground roll guidance) may be certificated for operation without a decision height (operations when the pilot is not required to make a decision described in the definition of Decision Height). Any required RVR limit is set by the responsible national authority in accordance with applicable operating regulations.

In these visibility conditions, the pilot is likely to brake hard during the ground roll and therefore an anti-skid braking system is considered to be essential. Distance and ground speed indications and automatic braking would obviously be useful, but are not considered to be essential and are not required.

The ground guidance system (Category III ILS or Category III MLS) complies with the Standards of ICAO Annex 10 and, additionally, complies with an integrity objective of $1-(0.5 \times 10^{-9})$ and a continuity of service objective of $1-(2 \times 10^{-6})$.

AMC AWO 312 **Alert Height** **See CS-AWO 312**

It may be operationally useful for the alert height to be somewhat higher than 30 m (100 ft) since this would permit reversion to a higher decision height in the event of system failure. A maximum value should be established during certification and it should not normally be above 90 m (300 ft).

AMC AWO 316 **Go-Around**

1 *Safety Considerations*

1.1 Effects of Contact with the Runway: For aircraft in which a go-around from a very low altitude may result in inadvertent runway contact, the safety of the procedure should be established giving consideration to at least the following:

- a. The guidance information and control provided by the go-around mode should be retained and be shown to have safe and acceptable characteristics throughout the manoeuvre,
- b. Other systems (e.g. automatic throttle, brakes, spoilers, reverse thrust and alerting systems) should not operate in a way that would adversely affect the safety of the go-around manoeuvre.

1.2 Inadvertent Go-around Selection. Inadvertent selection of go-around mode after touchdown should have no adverse effect on the ability of the aircraft to safely roll out and stop.

2 Performance

Height losses from a range of altitudes during the approach and flare should be determined when under automatic control and when using the landing guidance system as appropriate.

- a. Height losses may be determined by flight testing (with typically 10 flight demonstrated go-around) supported by simulation.
- b. The simulation should evaluate the effects of variation in parameters, such as weight, centre of gravity, configuration and wind, and show correlation with the flight test results.
- c. Normal procedures for a go-around with all engines operating should be followed.

**AMC AWO 321
Installed Equipment)**

1. The list of items of equipment required to be installed for certification to the decision heights specified, is based on experience with conventional medium and large jet transports and it is recognised that changes may be appropriate in significantly different applications.
2. ILS and MLS Airborne Equipment Standards

Acceptable standards for airborne receiver equipment include: -

- a. Localiser receivers with centring accuracy for automatic landing complying with the minimum performance standards of EUROCAE ED-46B or later revision, or an equivalent standard, and glide path receivers complying with the minimum performance standards of EUROCAE ED-47A or RTCA DO-192 or later revision.

Note - The aforementioned localiser specifications are in accordance with the FM Broadcast Interference Immunity requirements of ICAO Annex 10, Vol. 1, Chapter 3, Paragraph 3.1.4.

- b. MLS receivers complying with the minimum performance standards of EUROCAE ED-36A or later revision, or an equivalent standard, and DME/P transceivers complying with the minimum performance standards of EUROCAE ED-54 or RTCA DO-189.
- c. Combined ILS/MLS receivers complying with the minimum performance standards of EUROCAE ED-74 or equivalent standard.
- d. Combined ILS/MLS/GPS receivers complying with the minimum performance standards of EUROCAE ED-88 or equivalent standard.

3. Radio Altimeter Equipment Standards.

The airborne equipment used to provide height above terrain may be a radio altimeter complying with the minimum performance standards of EUROCAE ED-30 or RTCA DO-155.

**AMC to CS AWO 321(b)
Suitability of aircraft for fail-passive operations with a decision height of 50ft or greater**

Operations in accordance with CS-AWO 321(b)(1) and (3) may not be suitable for all aircraft types. When assessing the suitability of an aircraft type in respect of size and approach speed, the following should be taken into account:

- i) landing gear track
- ii) wingspan
- iii) pilot's eye to wheel height
- iv) distance from the cockpit to the main wheels
- v) approach speed at maximum landing weight

AMC AWO 331**Performance Demonstrations**

1 *Approach.* The supporting flight tests to show compliance with CS-AWO 331(a) in respect of approach performance may be to a programme of flight demonstrations carried out in accordance with AMC AWO 231.

2 *Touchdown.* For compliance with CS-AWO 331(b) in respect of touchdown performance, a programme of flight demonstrations will be required to support the simulation and analysis. (See AMC AWO 131.)

3 *Ground Roll*

3.1 A programme of landings should be carried out to ensure that there is a confidence level of 90% that the criterion of CS-AWO 338(a) is complied with. This programme and the analysis of results should be in accordance with the procedures established for approach performance. (See AMC AWO 231 paragraph 2.)

3.2 When operation is based on fail-operational ground roll, a programme of flight demonstration landings is necessary to support the simulation and analysis programme which is required to demonstrate compliance with CS-AWO 338(b). (See AMC AWO 131.)

AMC No. 1 to CS-AWO 361**Flight Demonstrations of Failure Conditions**

1 *Failures*

1.1 *Indications and Warnings.* Failure indications and warnings should be demonstrated. (See AMC 25.1309.)

1.2 *Effects.* For compliance with CS 25.1309, the effects of failure conditions will need to be demonstrated including not only failures of the landing system but also failures in other aeroplane equipment which could affect the landing (e.g. engines, reverse thrust, nose-wheel steering) and failures in the ILS and/or MLS ground facility. Although this demonstration may be done primarily by using a ground simulation, some cases should also be demonstrated in flight to confirm the conclusions of the simulation. (See AMC 25.1309.)

2 *Crew Errors.* Individual landings additional to those of AMC AWO 131 paragraph 2.1 should be carried out to demonstrate that errors, which can reasonably be expected to occur, are not hazardous (e.g. asymmetric braking or reverse thrust, incorrect approach speed). (See AMC AWO 131 paragraph 2.2.)

AMC No. 2 to CS-AWO 361**Flight Crew and Maintenance Checks**

When exposure times relevant to failure probability calculations are dependent on flight crew and maintenance checks (i.e. pre-flight, first flight of the day, pre-land, etc.) and/or inspection intervals for dormant (latent) failures, these tasks, time intervals and the recommended component monitoring programme should be specified in the Flight Manual or Maintenance Manual as appropriate.

AMC No. 1 to CS-AWO 364(a)**Loss of System Function**

For compliance with CS-AWO 364(a) and 365(a) it may be necessary to measure monitored variables in flight to determine the probability that any will reach a warning threshold. (See AMC AWO 231.)

AMC No.2 to CS-AWO 364(a)**Safety of the Manual Landing and Go-around manoeuvres following loss of automatic control capability**1 *Manual Go-around*1.1 *Safety Considerations*

1.1.1 Following loss of the automatic pilot below decision height, the aircraft should be capable of safely executing a manual go-around from any point on the approach down to touchdown, in all configurations to be certificated. The manoeuvre may not require exceptional piloting skill, alertness or strength and should ensure that the aeroplane remains within the obstacle limitation surface specified in ICAO Annex 14, for a precision runway Category II or III.

1.1.2 For aircraft in which a go-around from a very low altitude may result in inadvertent runway contact, the safety of the procedure should be established giving consideration to at least the following:

- a. Where the guidance information provided by the go-around mode is retained, it should be shown to have safe and acceptable characteristics throughout the manoeuvre.
- b. Other systems (e.g. automatic throttle, brakes, spoilers and reverse thrust) should not operate in a way that would adversely affect the safety of the go-around manoeuvre.

1.1.3 Non-normal procedures applicable following loss of a fail-passive automatic landing system (see subparagraph 2)), may require reversion to manual control using primary display information such as attitude and airspeed, to perform a manual go-around. Where applicable, consideration should be given to failure conditions that could result in loss of both the automatic landing system and relevant primary display information.

1.2 *Performance*

The safety of the go-around manoeuvre may be determined by flight-testing (typically 10 go-arounds) supported where necessary by simulator testing.

If loss of the automatic pilot can result in loss of the flight director guidance, this should be considered during the performance demonstration.

2 *Manual Landing*

Following loss of the automatic control capability below decision height, a safe landing should be demonstrated in accordance with established procedures.

i) The demonstration should take into account at least the following variables:

- a) centre of gravity
- b) landing weight
- c) wind conditions

ii) If the demonstration is to be performed with a simulator, the simulator should:

- a) be equipped with a visual system that provides an acceptable representation of the actual visibility conditions for which operational approval is sought, and
- b) be suitably validated by flight test demonstrations for the landing manoeuvre.

iii) The number of manual landings to be performed should be related to the probability of loss of the automatic landing system below decision height.

AMC AWO 381(a)
Aeroplane Flight Manual

Actual RVR minima to be used are subject to operational regulation and may vary from one Member State to another taking account of local circumstances. For this reason, RVR minima should not be included in the Aeroplane Flight Manual as Limitations. To aid operational assessment and the establishment of landing minima, the RVR values encountered during airworthiness certification may be given.

ACCEPTABLE MEANS OF COMPLIANCE FOR SUBPART 4**AMC AWO 400(a)
Applicability**

An aeroplane with a basic airworthiness approval is eligible for take-off in reported visibilities which are sufficient to ensure that the pilot will at all times have sufficient visibility to complete or abandon the take-off safely. The purpose of this Subpart is to specify the supplementary airworthiness criteria for aeroplanes equipped to take-off in lower visibilities. It is only concerned with directional guidance during the ground-borne portion of the take-off (i.e. from start to main wheel lift-off, or standstill in the event of abandoned take-off).

The RVR limits for take-off of transport aircraft are set by the responsible national authority in accordance with applicable operating regulations. The purpose of the guidance system, which is the subject of these requirements, is to permit a reduction of these limits but not to allow a take-off in visibility below the minimum necessary for a normal take-off using visual reference.

The requirements are based on the assumption that, if the take-off guidance system is based on ILS or MLS information, operational precautions are taken to ensure that the localizer signal is suitable (e.g. in each case the ILS, the localizer is Category III, or the airborne system has been shown to perform satisfactorily on that installation).

System Concept

The criteria for a take-off guidance system given in the paragraphs that follow are intended to provide for a reduction in take-off minima to a level where the pilot can normally line up on the runway centreline and carry out the take-off by visual reference, but where the visibility is sufficiently low that -

- a. Any further reductions in the visibility which may be encountered during the take-off run would make directional control by visual reference alone difficult; or
- b. Significant deviations from the runway centreline may be difficult to correct by visual reference alone.

Visual reference remains the primary means of guidance, with the system providing reversionary guidance. The pilot would therefore not commence the take-off run unless he had the prescribed visual reference and the values of RVR reported were adequate.

Experience indicates that pilots are able to hold the centreline in very low visibilities (e.g. one or two lights visible at one time), and that this ability improves as the speed increases. However, in such low visibilities the pilot may over-control in attempting to return to the centreline if the aeroplane deviates for any reason, and the reducing speed of an abandoned take-off may be the most critical phase in this respect.

**AMC AWO 418(c)
Guidance Display**

The system should be so designed that it is obvious if the pilot has not taken all the actions necessary for its correct operation.

**AMC AWO 431
Performance
See also Figure 1.**

The demonstration of system performance should comprise at least the following:

10 all-engine take-offs

3 take-offs with simulated failure of the critical engine at $V_{1MIN} + 10$ kt

2 rejected take-offs with simulated failure of the critical engine at V_1

Half of the all-engines take-offs and two of each of the engine failure conditions should be carried out in crosswinds equal to or greater than the level being sought for certification with optional aeroplane and runway configurations. The remainder should be carried out in optional winds in the most adverse aeroplane configuration at two different runways, which represent the reasonable extremes of those likely to be used in service.

In the engine failure take-offs, V_R should not be less than 28km/h (15 kt) above the engine failure speed and should be delayed until the path of the aeroplane has stabilised and the aeroplane is converging with the centreline.

The take-off may be begun using external visual reference but, from a speed no greater than 50% of V_1 , the guidance commands should be followed as accurately as possible without using the external view. To ensure that this is done it is recommended that the windscreen is blanked.

For ILS and/or MLS based systems compliance may be shown using an ILS and/or MLS, which complies with the requirements for Category III Operations in relation to centring error and beam bends along the runway. Allowance may be made for long-term perturbations of the ILS or MLS localizer.

AMC AWO 455

Warnings

1. The system should be so designed that wherever practicable a failure will cause the immediate removal of incorrect guidance information from view.
2. If failure indications are provided during take-off, these should not be such as to distract the pilot when he is controlling the aeroplane by visual reference (e.g. a persistent flashing light).

AMC AWO 481

Flight Manual: General

1. The Flight Manual should contain a statement that a system complying with the provisions of this Subpart 4 is approved for reversionary use only. Visual reference should be the primary means of guidance and the pilot should not commence the take-off run unless the visual reference and reported RVR are within prescribed limits.
2. Actual RVR minima to be used are subject to operational regulation and may vary from one Member State to another taking account of local circumstances. For this reason, RVR minima should not be included in the Aeroplane Flight Manual as Limitations. To aid operational assessment and the establishment of take-off minima, the RVR values encountered during airworthiness certification may be given.

DEVIATION ENVELOPES
(CENTRE OF MAINWHEELS)

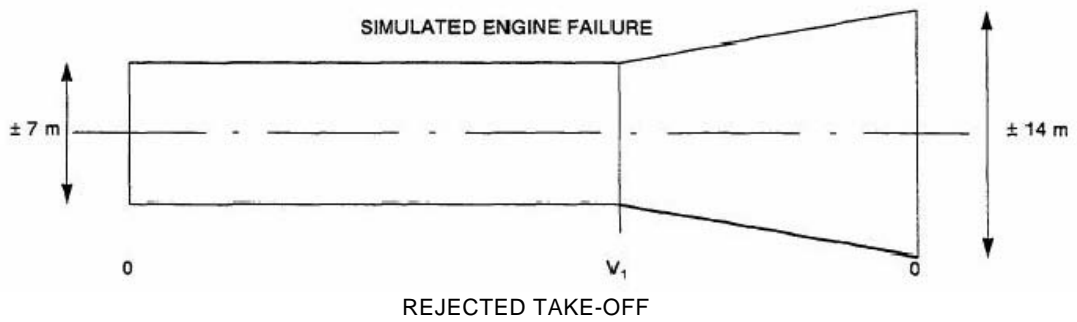
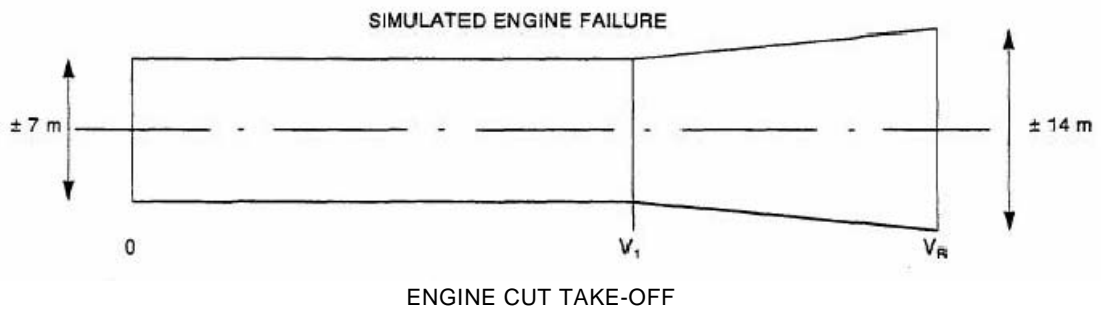
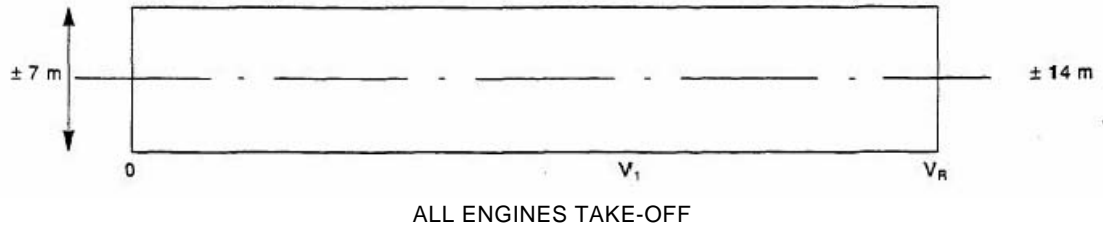


FIGURE 1

INTENTIONALLY LEFT BLANK

GENERAL ACCEPTABLE MEANS OF COMPLIANCE

AMC AWO-1

All Weather Operations Re-certification following the installation of New or Modified Navigation Receivers providing ILS/MLS capability

1 Purpose

The purpose of this AMC is to provide Acceptable Means of Compliance for retrofit certifications, addressing the certification of MLS receivers in so called "ILS Look alike" applications, and the certification of ILS installations with either new or modified receivers, e.g. those designed to provide improved FM immunity.

2 Scope

CS AWO already provides Acceptable Means of Compliance for the certification of new ILS or MLS installations. Where, for an already certificated installation, it is established that the proposed new or modified navigation receiver configuration can be considered to have "ILS look alike" characteristics, the contents of this AMC may be used as an alternative for that part of the certification affected by the revised installation.

Possible receiver configurations for retrofit applications include:-

- a) An ILS receiver from a new supplier.
- b) A modified ILS receiver from the same supplier (e.g. for purposes of providing improved FM Immunity).
- c) A re-packaged receiver from the same supplier (e.g. the ILS partition in an MMR, or the transition from ARINC 700 to 900 series equipment).
- d) A stand-alone MLS receiver ("ILS look alike").
- e) An MLS partition in an MMR ("ILS look alike").

This AMC provides acceptable means of compliance for All Weather Operations approval. Other generic certification processes (such as software, equipment, and radio approvals etc.) remain equally applicable to new and retrofit applications. These general certification considerations are summarised for reference in paragraph 6 below.

3 Background

The member States of ICAO agreed to extend the ILS protection date to 2010, to support regional implementation of MLS and to pursue a transition to a GNSS based approach, landing and departure system (GLS) at the COM/OPS 1995 meeting. This decision establishes the need for the incorporation of potentially three approach and landing systems in current and future aircraft. The level of equipage will be an economic decision of the operators. Multi-mode Receiver (MMR) characteristics have been developed by ARINC to provide ILS, MLS and GLS (provisions) functions, as one means of implementing this capability.

Based on the work of the FAA/JAA AWO Harmonisation Working Group, the JAA has introduced changes to JAR-AWO, to define the airworthiness requirements for MLS certification. However the industry also has a requirement to be able to introduce installations such as Multi-Mode Receivers (MMRs) containing one or more types of landing system, to aircraft with an existing all weather operations airworthiness approval. The JAA has concluded that while the requirement material for new certifications is equally applicable to retrofit applications, the means of compliance required for certification can be simplified, provided the necessary justification is provided.

The work required for certification will be dependent on the justification provided, usually in a certification plan. Within this AMC the justification is termed an "impact assessment".

4 *Definition*

"ILS look alike" - the ability of a non-ILS based navigation receiver function to provide operational characteristics and interface functionality to the rest of the aircraft equivalent to that provided by an ILS based receiver function. Specifically in the case of an MLS or GNSS based receiver function, the output should be in DDM/micro amps, with a sensitivity equivalent to an ILS receiver taking account of the effects of runway length.

5 *Related Requirements and Documents*

This AMC provides alternative means of compliance for retrofit certifications to the following CS AWO and CS 25 AMC material.

AMC AWO 131 Para. 2.1	Flight Demonstration - Programme of landings for certification
AMC AWO 161(b)	Failure Conditions
AMC AWO 231 Para. 1.1	Flight Demonstration - Continuous method (Analysis of maximum value)
AMC AWO 331	Performance Demonstration
AMC No.1 to AWO 361	Flight Demonstrations of Failure Conditions
AMC AWO 431	Performance (Interpretative Material)
AMC 25.1329 Para. 5.3.4.	Flight Demonstration of Autopilot Failure Conditions coupled to an ILS Glide path.

6 *General Certification Considerations*

6.1 *Certification Process*

An "impact assessment" is required to determine the tasks required to achieve approval of new receiver functionality in a retrofit application. Based on the "impact assessment" the certification plan should consider:-

- a) Differences between the current basis of certification and that requested (if applicable).
- b) The functionality being added.
- c) The credit that can be taken for the existing approval.

6.2 *Equipment Approval*

Suitable procedures for equipment approval should be employed. CS-TSO compliance should be demonstrated where appropriate, including software qualification and receiver environmental qualification to the appropriate levels.

6.3 *Aircraft Installation Approval (CS 25)*

The following should be considered for approval of the installation:-

- a) Impact on aeroplane system safety assessments.
- b) Radio approval (e.g. antenna positions, range, polar diagrams, coverage, compatibility between receiver and antenna).
- c) EMI/EMC testing.
- d) Functional integration aspects of the receiver with respect to other systems, controls, warnings, and displays.
- e) Electrical loading
- f) Flight data recorder requirements
- g) Impact on the aircraft Flight Manual.
- h) Certification means of compliance for the receiver installation e.g. ground and/or flight testing.

7 CS AWO Re-certification of the ILS Function following the Introduction of a New or Modified ILS Navigation Receiver Installation

The magnitude of the certification program will be based upon an “impact assessment” of the differences between the configuration offered for certification and the pre-existing ILS receiver system installed in a given aircraft type. The “impact assessment” should establish the basis and rationale for the work to be accomplished to obtain certification.

7.1 Impact Assessment

The impact assessment should assess the following aspects of the new or modified ILS receiver, or receiver function, for equivalence with the existing ILS receiver configuration:-

- a) Hardware design.
- b) Software design.
- c) Signal processing and functional performance.
- d) Failure analysis.
- e) Receiver function, installation and integration (e.g. with controls, indicators and warnings)

The impact assessment should also identify any additional considerations. This may include:-

- a) Any functionality, or provisions for future functionality, which have no impact on the functionality for which certification is sought.
- b) Any shared resources, which will support future functionality.

Based upon the assumption that the ILS receiver, or receiver function, can be shown to be equivalent to the current ILS configuration, it may be proposed that the new installation be treated as a new ILS receiver for approval on a given aeroplane type.

7.2 Failure Analysis

The failure characteristics of the new or modified installation should be reviewed in the context of the safety assessments of systems using ILS data, to ensure that the failure characteristics are equivalent to, or are compatible with and do not invalidate, the current safety assessments.

7.3 Flight Testing

For an installation which can be treated as a new ILS receiver, a flight test program of typically a minimum of eight approaches terminating in an automatic landing and rollout (if applicable) using the flight control/guidance system, including a minimum of two ILS facilities should be carried out. The approaches should include captures from the both sides of the beam.

The approach and landing performance (flight path deviation, touchdown data etc.) as appropriate, should be shown to be equivalent to that achieved in the original ILS certification. Recorded flight test data may be required to support the equivalency demonstration.

A demonstration of take off guidance performance should be included where applicable.

7.4 Documentation

The following documentation should be provided for certification:

- a) An Impact Assessment including effects on System Safety Assessments.
- b) A Flight test report.
- c) Revisions to the Flight Manual where appropriate.

8 CS AWO Re-certification following the Introduction of an MLS Navigation Receiver Installation

8.1 *Impact Assessment*

The MLS receiver or receiver function, can be certificated with an "impact assessment" similar to that required for the re-certification of a new or modified ILS receiver, provided that the unit has been shown to have satisfactory "ILS Look alike" characteristics. The "impact assessment" should assess the following aspects of the MLS receiver or receiver function, for equivalence with the existing ILS receiver configuration:-

- a) Hardware design.
- b) Software design.
- c) Signal processing and functional performance.
- d) Failure analysis.
- e) Receiver function, installation and integration (e.g. with controls, indicators and warnings).

The impact assessment should also identify any additional considerations. This may include:-

- a) Any functionality, or provisions for future functionality, which have no impact on the functionality for which certification is sought.
- b) Any shared resources, which will support future functionality.

Based upon the assumption that the MLS receiver or receiver function, can be shown to have "ILS look alike" characteristics, it may be proposed that the new installation be treated as a new ILS receiver for approval on a given aeroplane type.

8.2 *Failure Analysis*

The failure characteristics of the new or modified installation should be reviewed in the context of the safety assessments of systems using ILS data to ensure that either the failure characteristics are equivalent to an ILS receiver or are compatible with and do not invalidate, the current safety assessments.

8.3 *Statistical Performance Assessment*

The statistical performance assessment of a currently certificated automatic landing system or Head Up Display system should not have to be re-assessed for the addition of MLS functionality to the aircraft provided the MLS receiver, or the MLS partition of an MMR, is shown to have satisfactory "ILS Look alike" characteristics. This assumes that the flight control/guidance system control algorithms are unchanged.

8.4 *Antenna Location*

The implication of differences in position of the MLS and ILS aircraft antennas should be assessed e.g. impact on:-

- a) wheel to threshold crossing height.
- b) lateral and vertical performance.

8.5 *Flight testing*

For an installation which can be treated as a new ILS receiver, a flight test program of typically a minimum of 10-15 approaches terminating in a landing and rollout (if applicable) using the flight control/guidance system, including a minimum of two MLS facilities should be carried out. The approaches should include captures from the both sides of the beam, and representative wind conditions where antenna positions may impact performance.

The approach and landing performance (flight path deviation, touchdown data etc.) as appropriate, should be shown to be equivalent to that achieved in the original ILS certification. Recorded flight test data may be required to support the equivalency demonstration.

A demonstration of take off guidance performance should be included where applicable.

8.6 *Documentation*

The following documentation should be provided for certification:-

1. An Impact Assessment including effects on System Safety Assessments.
2. A Flight Test Report.
3. Revisions to the Flight Manual where appropriate.

