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The Approval of Flight Calibration Organizations

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Part 1 Preliminary Material

FOREWORD

This document is produced and published by Air Traffic Services Standards Department of the Safety Regulation Group of the UK Civil Aviation Authority. It provides those requirements that must be met to achieve approval under the Air Navigation Order. This document is based upon those relevant and applicable ICAO standards and recommended practices. This document supersedes and replaces all earlier versions.

1 INTRODUCTION

Article 79 (2) of The Air Navigation Order requires that a navigation aid is ‘flight checked by the authority or a person approved by the authority, on such occasions as the Authority may require’.

The purpose of this document is to define the conditions for such an approval.

2 SCOPE

This document defines the procedures and requirements for the approval of flight calibration organisations and their equipment.

It is divided into three sections as follows:

Section 1 – Flight Calibration Organisation – Approval Procedure
This section defines the procedure to be followed when requesting approval of a flight calibration organisation.

Section 2 – Flight Calibration System - Navigation aids (general)

Section 3 - Annexes specific to each navigational aid

3 STATUS

Consultation.

4 REFERENCES

ICAO Annex 10 Volume 1 Part 1
ICAO Doc 8071
CAP 581 ILS 02 – Requirement for ILS flight inspection – Limits to be applied.

5 DEFINITIONS, SYMBOLS AND ABBREVIATIONS

A ‘general use’ glossary of definitions, symbols and abbreviations can be found at Appendix 1 to Part B of CAP 581. Specific definitions and abbreviations can be found in the annexes in section 3.

Part 2 Requirements

SECTION 1

6.0 FLIGHT CALIBRATION ORGANISATIONS - APPROVAL PROCEDURE

6.1 SAFETY OBJECTIVE. An approved applicant shall be capable of using flight inspection techniques to measure accurately the signals in space radiated by those navigational aids which they are approved to inspect.

6.2 Applicants shall submit the required information in coherent documentary form.

6.3 Applicants shall detail the overall operation in an Exposition document including references to associated documents. See section 2, Paragraph 7 for details.

Note: *Air Traffic Services (ATS) Standards will examine the submitted documentation and may call for further information on certain subjects. For example, the method used to calculate the measurement uncertainty for certain parameters may need to be examined in more detail.*

6.4 The applicant may propose an aircraft or system, which is new in concept, or not in common use for flight calibration. In such a case, ATS Standards will seek advice from other expert departments within the Safety Regulation Group and may also initiate a general consultation with the industry.

6.5 If the applicant proposes a new system or aircraft or the organisation does not have a demonstrable history of flight calibration, then practical demonstrations of capability will be necessary.

Note: *The tests will be in two parts. Applicants may be required to perform either or both tasks:*

(a) A demonstration of position fixing accuracy. This will be evaluated on an established test range. The precise details of this trial cannot be defined until details of the applicant's system are known.

(b) A demonstration of overall system performance. For this trial the applicant will make a simulated commissioning inspection of the selected navigational aid. The trial may require several similar flight profiles to be flown to demonstrate the repeatability of measured results.

6.6 ATS Standards shall evaluate or require evaluation of the results of these trials.

6.7 If special R/T facilities are required during the trials the applicant shall be in possession of the relevant approvals and licences for their use.

6.8 The applicant shall provide ATS Standards with a build state of the measuring equipment, a complete and formalised list of the current issues of all relevant documentation and an Exposition describing the entire operation. ATS Standards shall retain this documentation and update it to always reflect the current state of the applicant's flight calibration system operation and organisation. If the applicant proposes to make any changes to his flight inspection system, operation, or organisation, ATS Standards shall approve these changes before the applicant is permitted to make any further flight inspections.

6.9 Where approval for ILS inspection is granted under this procedure it may be limited to the flight calibration of specific categories of ILS.

6.10 ATS Standards reserves the right to inspect the flight calibration system or organisation at any time and to request regular flight inspection reports.

Note: *If the applicant is an organisation which has been making flight inspections for many years under a formal or implicit approval from another Aviation Authority, the submitted documentation may suffice for approval.*

6.11 For all applicants ATS Standards reserves the right to require that a practical demonstration of ability is given.

SECTION 2

Note: *The requirements in this section apply to the flight inspection of all types of navigational aid. Additional requirements for specific navigational aids are given in Section 3.*

7 ORGANISATION and QUALITY

7.1 SAFETY OBJECTIVE. Any organisation intending to perform flight inspection of navigation aids shall satisfy the Authority (SRG) that it is competent, having regard to any relevant previous conduct and experience, equipment, organisation, staffing maintenance and other arrangements, to produce accurate and adequate flight inspection results in relation to ATS safety aspects.

7.2 Exposition

An Exposition shall be provided to detail the overall organisation and its intended operation. The following aspects shall be included (or referenced to other documents) in the Exposition, or provided in a coherent documentary system.

7.2.1 IDENTIFICATION

(a) Organisation name, document title, reference number.
(b) Base location
(c) Amendment status, issue number, date, amendment record.
(d) Approval by appropriate manager
(e) Distribution list
(f) Exposition administrator
(g) Contents list

7.2.2 *ORGANISATION*

Introduction, Purpose of document, General information on the organisation. Interfaces with other organisations and departments. General statements on organisational policy with respect to ATS safety related aspects.

7.2.3 *UNDERTAKING*

Scope of tasks. Types of navigational aids to be inspected. (For ILS the applicant must state the categories of ILS which he wishes to calibrate.)

7.2.4 Organisational Chart

7.2.5 Personnel responsibilities, terms of reference and authority to act.

7.2.6 Procedures for notifying SRG of major organisational changes.

7.2.7 Procedures for notifying SRG regularly of the latest state of the flight inspection programme.

7.2.8 Procedures for notifying SRG of proposed equipment changes and modifications or change of aircraft type.

7.2.9 Details of the aircraft which the applicant wishes to use for flight inspection.

7.2.10 Functional description, technical specification and manufacturer’s type number for all major items of the flight inspection system. This shall include details of the equipment used for calibrating the system.

7.2.11 Location, characteristic and type of all measurement aerials on the aircraft.

7.2.12 Technical description of any parts of the system which the applicant has designed or built.

7.2.13 The design authority for all equipment shall be stated.

7.2.14 Procedures for calibration of equipment.

7.2.15 Details of all uses of software and firmware in the measurement system. Also details of software and firmware support.

7.2.16 Details of a log or record system for faults and maintenance of the measuring system.

7.2.17 Spares holding and control.

7.2.18 Documentation Control. List of documents held and produced.

7.2.19 Personnel training, competency and recency checking arrangements.

7.2.20 Details of any internal and external auditing system e.g. auditing of the organisation by any other organisation not associated with the production of inspection results.

7.2.21 Details of the quality management system.

7.2.22 Details of the history of the organisation.

7.2.23 Details of any formal or implicit approvals which the applicant has received from other Aviation Authorities.

7.2.24 A list of any navigation aids which the applicant regularly inspects under such a formal or implicit approval. This will include:

(a) Type of navigation aid
(b) Location of navigation aid
(c) Category of navigation aid (if applicable)

7.2.25 Flight calibration operating instructions for the inspector and flight crew.

7.2.26 A typical or test flight inspection report.

7.2.27 A typical or test sample structure measurement for those navigational aids where structure measurements form part of a normal flight inspection.

7.2.28 A statement showing to 95% confidence, the measurement uncertainty which the applicant claims to achieve for each of the measurable parameters.

7.2.29 Details of statistical methods or interpolative techniques which may be applied.

7.2.30 Details of AOC (Air Operator's Certificate) related approvals held in respect of any aircraft operation, including flight inspection.

7.2.31 Procedures for the control of sub-contractors.

7.2.32 A statement of compliance with the requirements of ATS Standards.

8 AIRCRAFT

8.1 **SAFETY OBJECTIVE. The aircraft used shall be appropriate for the purpose of flight inspection and shall be operated in a way which ensures accurate measurement of all parameters.**

8.2 The aircraft shall be a multi-engine type capable of safe flight with one engine inoperative, fully equipped and instrumented for night and instrument flight.

8.3 The aircraft shall be operated by two flying crew members.

8.4 A cross-wind limit shall be set which will allow measurement accuracies to be within the limits required. This limit shall be shown in the operating instructions.

8.5 The aircraft shall have a stable electrical system with sufficient capacity to operate the additional electronic and recording equipment.

8.6 Measures shall be taken to reduce propeller modulation to an acceptably low level.

Recommendation: *As the aircraft may be required to fly abnormal procedures during an inspection, it is normal practice to add markings and/or lights which will increase the visibility of the aircraft against all normal backgrounds.*

9 EQUIPMENT

9.1 **SAFETY OBJECTIVE. The purpose of the navigation aid flight inspection is to verify that all parameters of the navigation aid meet the requirements specified in Annex 10 to the Convention on Civil Aviation and any other specific requirements of the CAA. The equipment fitted in the aircraft must be capable of measuring all these parameters.**

9.2 The navigation aid measuring equipment shall not interfere with the operation or accuracy of the aircraft’s normal navigation and general avionics equipment.

9.2.1 The flight inspection measurements shall be adequately protected against the prevailing EMC environment internal or external to the aircraft. Abnormal interference effects shall be clearly identified on the inspection results.

9.3 The inspection system shall have the facility for listening to the identity modulation of the navigation aid being inspected.

9.4 Position Fixing and Tracking Equipment

The flight inspection system shall include equipment which can determine and record the aircraft’s position in space relative to a fixed reference point. The uncertainty of measurement must be commensurate with the parameter being inspected.

9.5 Recording Equipment

9.5.1 The flight inspection system shall include equipment which can record the measured parameters of the navigation aid being inspected.

9.5.2 All recordings shall be marked so that they can be correlated with the aircraft's position at the time of the measurement,

Recommendation: *Where possible the flight inspection should comply with the guidance and recommendations given in ICAO Doc 8071 Vol II.*

Recommendation: *As far as is reasonably possible the flight inspection equipment, including associated aerials should be totally independent from the aircraft’s operational avionics fit.*

9.6 **Aerials**

9.6.1 The aerials shall be positioned in such a manner that they are not obscured from the signal during any normal inspection flight profiles.

Note: *To achieve this may require the use of more than one measuring aerial for one particular function. If duplicated navigation aid measuring receivers are used they may use a common aerial.*

9.6.2 The aerials to be used for tracked structure measurements shall be positioned with due regard to the tracking reference on the aircraft. If the aerials and the reference are not in close proximity, this error must be addressed in the measurement uncertainty calculations and in setting the operational crosswind limit. Alternatively, the errors may be corrected using information from the aircraft's attitude sensors.

9.7 **Spectrum Analyser**

Note: *It is useful if a spectrum analyser is available for investigating equipment malfunctions and sources of interference. The analyser should have a method of image storage.*

10.0 MEASUREMENT UNCERTAINTY

10.1 **SAFETY OBJECTIVE. The measurement uncertainty for any parameter must be small compared with the operational limits for that parameter.**

10.2 The measurement uncertainty to 95% probability must be calculated for each of the parameters to be measured. The method of calculation and any assumptions made must be clearly shown.

10.3 Many measurements are a combination of receiver output and aircraft position. In these cases the figure required is the sum of all the errors involved in the measurement, including aircraft position.

10.4 Where several measurements are combined to produce a single result, these errors should be added by the RSS method (the square-root of the sum of the squares), to give the overall expected measurement uncertainty.

Note: For certain ILS system parameters, the maximum permitted measurement uncertainty depends on the category of the ILS being inspected.

10.5 For measurements which can only be derived from recordings, the accuracy and resolution of the recording equipment shall be included in calculating the expected measurement uncertainty.

10.6 When modifications are made which will affect the uncertainty of measurement of any parameter, new calculations shall be submitted.

10.7 Temperature Stability

10.7.1 The uncertainties stated in section 3 shall be maintained under the specified environmental conditions for a flight inspection procedure. The operator shall define the environmental conditions (temperature range, humidity range, etc.)

10.7.2 Details of measurement uncertainty with respect to temperature shall be available for all the measuring equipment. This may be in the form of test results made by the operator, or manufacturer's specifications. If manufacturer's specifications are quoted, the proposer shall be prepared to produce manufacturer's test results as evidence.

10.7.3 If the measuring equipment requires any warm-up or cooling time, this shall be clearly indicated in the operating instructions.

Note: *If necessary, any temperature dependent apparatus may be fitted in a temperature controlled enclosure. An indicator/alarm shall be fitted to inform the navigation aid inspector of any error in temperature.*

10.8 Position Marking of Flight Inspection Data

The accuracy of marking shall be commensurate with the accuracy required in the final figure. Specific requirements are given in section 3.

11 CALIBRATION PROCEDURES and STANDARDS

11.1 **SAFETY OBJECTIVE. All measuring equipment used for flight inspection shall be calibrated to defined standards.**

11.2 Clearly defined calibration procedures shall be applied to all equipment involved in the measurement of parameters in Paragraph 9. All equipment and standards used in the calibration process shall have traceability to national or international standards.

11.3 When any equipment used is claimed to be self calibrating, the internal processes involved shall be clearly defined. This involves showing how the equipment's internal standard is applied to each of the parameters which it can measure or generate. The internal standard shall have traceability to national or international standards.

11.4 Details of calibration intervals required shall be contained in the calibration records. The proposer shall be prepared to produce evidence in support of the quoted calibration intervals.

12 SOFTWARE

12.1 **SAFETY OBJECTIVE. All software used to produce flight inspection results shall be of such a standard that accuracy and integrity of all measurements using software shall be assured.**

Note: *The purpose of this section is to outline specific areas of concern relating to the software components of flight calibration systems. It is included here to assist developers of such systems and as such is not intended to be a comprehensive treatment. More general requirements and guidance notes on software and software development is given in the relevant section of the Air Traffic Services Engineering Requirements Manual (CAP 581).*

12.1.1 If software is used to implement system functions that can affect the safety of the aviation environment the following actions must be accomplished:

a) Through analysis of the potential hazards introduced to the environment by the system functions, target safety integrity levels must be specified for each software function.

b) Known hazardous software states must be either removed or mitigated by the total system design.

c) Documented evidence must be produced to demonstrate accomplishment of the target safety integrity levels.

12.2 Software Safety

The following sections detail specific requirements relating to the safety of software contained in flight calibration systems.

12.2.1 SOFTWARE DESIGN AUTHORITY

A Software Design Authority shall be appointed. The software design authority shall be responsible for the safety of all aspects of the design, development and production of software contained in the flight calibration system.

12.2.2 SOFTWARE SAFETY CLASSIFICATION

12.2.2.1 The Design Authority shall ensure that the software safety requirements are properly defined, consistent and complete. For approval purposes certain components of flight calibration systems are considered ‘safety related’. These safety-related components shall include at least those that are necessary for the correct calculation of:

– measured Navigation Aid critical parameters

– positional, tracking and essential timing information

relating to those measurements. For safe operation, the continuing approval of an Navigation Aid is contingent upon these critical parameters lying within the specified range of values (hence those components of the flight calibration system responsible for the measurement and calculation of these values in space shall be considered safety related).

Note 1: *The safety requirements should include those necessary for system calibration and self test.*

Note 3: *Not all software need be considered safety related but, justification will be required if such a case is to be made out.*

Note 3: *Display and presentation software may also need special consideration if such software is used to produce flight inspection records in support of a satisfactory flight inspection and continued Navigation Aid operation.*

12.2.3 SAFETY RELATED SOFTWARE

12.2.3.1 Safety related software within Flight Calibration Systems shall be subject to appropriate formal analysis in the specification, design, development, coding and testing stages to assure t – integrity of input and output data

(ie data required for the calculation of critical parameters)

- correctness of algorithms processing such data
- other safety performance requirements

Note: *This formal analysis is an essential part of the argument for the safety of the flight calibration system and will provide specific evidence in support of approval by the SRG.*

12.2.3.2 Proper account shall be taken of other aspects of the system that relate to the integrity, correctness and safety performance requirements such as the physical characteristics of the hardware and its environment and how these are modelled in the software.

12.2.4 ANALYSIS OF SAFETY RELATED SOFTWARE

Formal analysis of safety related software in flight calibration systems shall include:

(a) a rigourous specification of the method of measurement of the critical parameters, positional, tracking and timing information, including and justifying any assumptions made
(b) formal argument in support of the correctness of design with respect to the specification
(c) formal argument in support of the correctness of the implemented code with respect to the design
(d) specification and analysis of test coverage to demonstrate the:
(e) correctness of algorithms
(f) internal consistency of modules
(g) adequacy of subsystem interfaces

12.2.5 SAFETY REVIEWS

The design authority shall carry out formal safety reviews of the specification, design and code at appropriate intervals. These reviews shall be recorded.

12.3 General Software Engineering Considerations

12.3.1 SOFTWARE ENGINEERING PRACTICE

The design authority shall prepare a code of software engineering practice for all procedures, methods, techniques and tools used in the development of software.

12.3.2 SOFTWARE LIFECYCLE

12.3.2.1 A clearly defined and documented software development process shall exist and include the following phases:

(a) System and software requirements
(b) System and software design
(c) Code implementation and unit testing
(d) System integration and testing
(e) Software maintenance

12.3.2.2 Each phase shall have clearly established standards and procedures.

12.3.2.3 During system development, each phase has specific input and output requirements and corresponding deliverables which shall be fully documented and placed under configuration management.

12.3.3 SOFTWARE TOOLS

All software tools employed in the production of flight calibration systems shall be identified, including the system release and version, options selected and mode of use. Care shall be taken in the selection of such tools to assure their safety and integrity. Typically such tools might include:

(a) development tools and environments
(b) compilers and linkers
(c) test and debugging tools
(e) other verification and validation tools
(f) configuration management tools
(g) documentation tools

12.3.4 SOFTWARE CONFIGURATION MANAGEMENT

12.3.4.1 The design authority shall identify personnel responsible for configuration management and the control and release to configuration management of all configurable items.

12.3.4.2 All configurable items shall be held under configuration management control for all phases of the system lifecycle. All configurable items shall be traceable to the software requirements.

12.3.5 SOFTWARE CHANGE CONTROL

12.3.5.1 Procedures for the control of software changes shall exist. Each proposed change shall be assessed and details of the nature of the change and its likely effect on the system documented. All relevant documentation shall be updated to reflect the change when approved and the change history maintained.

12.3.5.2 Changes to supplied or supporting software or software tools (eg compilers) shall be monitored and controlled.

12.3.5.3 Changes that affect the formal approval of the system shall first be notified to SRG for its approval before being introduced into service.

12.3.6 SOFTWARE QUALITY ASSURANCE

12.3.6.1 The design authority shall appoint personnel responsible for software quality assurance. Such personnel shall be responsible for the identification and evaluation of quality problems and authorised to ensure the necessary corrective actions are taken.

12.3.6.2 Software quality assurance shall ensure that delivered software items conform to requirements. This shall be achieved by the construction of a software quality plan covering all phases and aspects of software development. Conformance shall be assured by:

(a) software reviews
(b) quality audits
(c) software configuration audits
(d) problem reporting and corrective actions

12.3.6.3 Reviews and audits shall be scheduled within the software quality assurance plan.

12.3.7 PERSONNEL

The design authority shall ensure that the qualifications, experience, responsibility and authority of all personnel engaged in the production of software are appropriate to their tasks.

12.3.8 DOCUMENTATION

All documentation supporting system software shall be adequate, correct, current and under configuration management control throughout the system lifecycle.

12.3.8.1 Software Configuration Document

A top level document shall exist identifying all applicable software documentation and for each document, details of its current status, purpose and contents.

12.3.9 SUBCONTRACTORS SOFTWARE

The design authority shall ensure that software supplied by subcontractors and other suppliers conforms to the relevant safety requirements where appropriate. Similar assurance shall be required for embedded software.

13 OPERATING INSTRUCTIONS

13.1 **SAFETY OBJECTIVE. The operating instructions shall ensure that all measurements are made to defined and documented procedures.**

13.2 This documentation will include concise details of:

(a) The flight profile to be used for each individual measurement.
(b) Pre-flight calibration of measuring equipment.
(c) Siting of any necessary ground tracking or position fixing equipment.
(d) Scheduled maintenance and calibration of the measuring equipment.
(e) Operation of the measuring equipment.
(f) Production of the flight inspection report.
(g) Certification.
(h) The method of calculating any results which are not directly output by the measuring equipment.

14 PERSONNEL TRAINING AND QUALIFICATION REQUIREMENTS

14.1 **SAFETY OBJECTIVE. All personnel concerned with the flight inspection shall be adequately trained and qualified for their job functions.**

14.2 The proposer must show that all personnel concerned with the flight inspection are adequately qualified for their job functions.

14.3 The proposer must be prepared to submit CVs for all personnel directly concerned with the flight inspection, from which each person's experience and suitability can be determined.

14.4 The organisation must have a procedure for ensuring the competence of its personnel. This procedure must have provision for regular assessment of competence.

14.5 Particularly for the inspection of precision approach aids, the flight crew’s familiarity with each location to be inspected is considered to be of importance. The proposer’s procedures and instructions must include details of training and familiarisation which will apply to the flight crew.

15 FLIGHT INSPECTION REPORT

15.1 SAFETY OBJECTIVE. The flight inspection report shall clearly and accurately document the measured performance of a navigational aid.

15.2 All flight inspection results shall be documented to a report format agreed with ATS Standards. The minimum information to be provided on the report shall be:

(a) Station name and facility designation.
(b) Category of operation.
(c) Date of inspection.
(d) Serial number of report.
(e) Type of inspection.
(f) Aircraft registration.
(g) Manufacturer and type of system being inspected.
(h) Wind conditions.
(i) Names and functions of all personnel involved in the inspection.
(j) Results of all measurements made.
(k) Method of making each measurement (where alternatives are available). These may be referenced to the operating instructions.
(l) Details of associated attachments (recordings, etc.).
(m) Details of extra flights made necessary by system adjustments.
(n) An assessment by the aircraft captain of the navigational aid's performance.
(o) Comments by the navigation aid inspector/equipment operator.
(p) Details of any immediately notifiable deficiencies.
(q) Statement of conformance/non-conformance.
(r) Navigation aid inspector’s signature.
(s) Pilot’s signature.
(t) Signature of the individual who is legally responsible (if different from(r) or (s)).

16 RECORDS and GRAPHS

16.1 **SAFETY OBJECTIVE. Records and graphs shall be produced in a manner which ensures that system parameters may accurately be deduced from them.**

16.2 If recordings or graphs are used to derive figures for the inspection report, the scales shall be commensurate with the permitted measurement uncertainty limits.

Note: *If the recordings or graphs are only used to show that results are within designated tolerances, they may be presented on a reduced scale.*

16.3 The data from which these recordings and graphs are made shall be stored with sufficient accuracy that expanded scale plots can be provided on demand.

16.4 For flights where parameters are evaluated by comparison of the received signal and the output of a tracking device, only the final result need be presented for a normal inspection. Position data and raw signal data shall be recorded or stored and provided on demand.

Note: *This will be necessary in cases where further analysis of the results is required. For example, to assess marginal performance or to assist in identifying causes of multi-path reflections.*

16.5 Identification

The minimum identification on each record and graph shall be:

(a) Serial number
(b) Date
(c) Description of type of flight
(d) Name of airport
(e) Designation of facility being inspected

16.6 Retention of data

The applicant shall provide, for the approval of ATS Standards, details of the arrangements to be made for archiving prime data from flight inspection results.

17 AOC ASPECTS

17.1 Applicants seeking an approval to become a flight calibration organisation may need to hold an Air Operator's Certificate (AOC). This requirement will be determined by the nature of the applicant's business. In the first instance, advice can be obtained from the Flight Operations Department, Aviation House, Gatwick (Telephone (44) (0) 1293 – 573399)

17.2 Applicants already holding an AOC will be subject to the supervision of the Authority when engaged in calibration work and are advised to contact the Assigned Inspector as soon as is practical to discuss the matter.

18 LEGAL REQUIREMENTS

Any general legal requirements will be advised in consultation with the CAA Legal Department. Applicants must comply with all such requirements.

SECTION 3

ANNEXES SPECIFIC TO INDIVIDUAL NAVIGATION AIDS

Note. *The annexes in this section contain requirements specific to the flight inspection of individual navigation aids. They must be read in conjunction with Section 2 of Part 2.*

Note. *To facilitate cross referencing, the chapters in the annexes have the same numbers as the relevant chapters in section 2.*

ANNEX 1 INSTRUMENT LANDING SYSTEM

CONTENTS

5 DEFINITIONS, SYMBOLS AND ABBREVIATIONS
(Where not included in the general section)
8 AIRCRAFT
9 EQUIPMENT
10 MEASUREMENT UNCERTAINTY
16 RECORDS AND GRAPHS

5 DEFINITIONS, SYMBOLS AND ABBREVIATIONS

None applicable

8 AIRCRAFT

8.1 Manual flight control using only the mandatory navigation instruments is not considered sufficiently accurate for calibration of the following types of ILS:

– Category III systems.
– Category II systems.
– Category I systems, which the operator wishes to use for autoland in good visibility.

8.2 For calibration of the above systems the aircraft shall be fitted with equipment which will provide repeatable following of the required path. Systems considered suitable to this purpose include telemetry of the ground based tracking system’s output to a separate instrument in the aircraft, or an autopilot. If an autopilot is used SRG shall be satisfied that it is capable of safe operation down to 50 feet above the threshold elevation.

9 EQUIPMENT

9.2 Measurement and Recording Equipment

9.2.1 A normal ILS/DME inspection system shall be capable of measuring and recording the following parameters:-

(a) Localiser Field strength
(b) Localiser Modulation Sum (SDM)
(c) Localiser Difference in Depth of Modulation (DDM)
(d) Glidepath Field strength
(e) Glidepath Modulation Sum (SDM)
(f) Glidepath Difference in Depth of Modulation (DDM)
(g) Marker Beacon Field strength
(h) Marker Beacon Fly-through Time
(i) DME Field strength
(j) DME Distance
(k) Radio Altimeter height

9.2.2 The recording equipment shall be capable of recording any of the ILS parameters listed in para. 9.2.1. The equipment shall measure and record beam structure by comparison of tracking data and the ILS signal, from a distance of at least 4 NM from the runway threshold.

9.2.3 It shall be possible to annotate the recordings with comments and any other necessary information at the time of making the recording.
For beam bend measurements, the total time constant of the measuring and recording equipment shall be 92.6/V seconds where V is the aircraft velocity in kilometres per hour.

9.2.4 If digital sampling/storage is used, the sampling rate shall be compatible with this time constant but never less than 4 samples per second for all parameters which are continuously measured.

9.2.5 The equipment shall be capable of recording a minimum of 4 parameters simultaneously.

Note: *Post inspection processing may be necessary to achieve the required accuracy for certain parameters*

10 MEASUREMENT UNCERTAINTY

10.1 Maximum permitted measurement uncertainty at 95% confidence level

Note: Throughout the following tables, the figure of 2dB for field strength is the permitted uncertainty for repeatability of measurement. It is not a requirement for absolute field strength measurement.

10.1.1 *LOCALISER*

	Cat I	*Cat II*	*Cat III*
Alignment (average) (related to threshold)	2.0m	1.0m	0.7m

Recommendation: *The uncertainty should not exceed the figures below*

	1.0m	0.7m	0.3m
Displacement sensitivity (of the actual figure)	4.0%	4.0%	2.5%

Recommendation: *The uncertainty should not exceed the figures below*

	1.7%	1.7%	1.0%
Field strength (relative)	2dB	2dB	2dB
Off course clearance	3%	3%	3%
Course/clearance ratio	1dB	1dB	1dB
Course structure	1µA	1µA	1µA
Modulation sum0.4%	0.4%	0.4%	
	(absolute mod depth)		
Polarisation	1.5µA	1.0µA	1.0µA
Modulation balance (CSB)	1.0µA	1.0µA	1.0µA

10.1.2 *GLIDEPATH*

	Cat I	Cat II	Cat III
Angle	0.5%	0.3%	0.3%
	(of the glidepath angle)		
Displacement sensitivity	2.5%	2.0%	1.5%
	(of the actual figure)		
Field strength (relative)	2dB	2dB	2dB
Clearance	3%	3%	3%
	(of the actual figure)		
Course structure	3µA	2µA	2µA
Modulation sum0.5%	0.5%	0.5%	
Modulation balance (CSB)	1.0µA	1.0µA	1.0µA

10.1.3 *MARKER BEACON*

Field strength (relative)	2dB
Fly through time	1 second (at 96 knots)

10.1.4 *ASSOCIATED DME*

Field strength (relative)	2dB
Distance	60 metres at threshold and point A

Recommendation. *The uncertainty of DME distance measurement should not exceed 35 metres at threshold and point A.*

10.2 Uncertainty of Position Marking of Flight Inspection Data

10.2.1 *APPROACH TOWARD A FACILITY*

±0.1 NMile for markings at each nautical mile
±0.1 NMile for marking at ILS point A
±0.05 NMile for marking at ILS point B
±0.05° for marking glidepath slice at 1.8 x (glidpath angle)
±20 metres for marking the threshold crossing
±20 metres for marking any other points along the runway

10.2.2 *ORBITAL FLIGHTS*

±1.5 Degree

Note: *A marking accuracy of ±1.5° applies to clearance and coverage inspection, it is not sufficient for measuring displacement sensitivity.*

16 RECORDS AND GRAPHS

Where chart recordings are used for parameter evaluation, they shall have sufficient resolution for this purpose. The minimum requirements are given below.

16.1 **Structure Stability Recordings** (deviation current)

16.1.1 *LOCALISER*

Minimum sensitivity of 1 mm per µA

16.1.2 *GLIDEPATH*

Minimum sensitivity of 0.5 mm per µA

16.2 **Structure Measurements** (corrected recordings)

16.2.1 *LOCALISER*

Minimum sensitivity of 1mm per µA

16.2.2 *GLIDEPATH*

Minimum sensitivity of 0.5mm per µA for the initial part of the recording. For category II & III systems, it must be possible to show the signal characteristic down to threshold crossing. This may require reduced sensitivity depending on available chart width.

16.3 **Other Measurements**

Many other recordings will need sensitivity changes during the recording to obtain optimum resolution at all times. The chart produced must be capable of displaying at least 450 µA of deflection current without saturation. Sufficient different sensitivities of display must be available to allow signal characteristics to be measured accurately.

16.4 **Position Annotation**

Records and graphs must be annotated to show the position of the aircraft at the time of making the measurement. The minimum requirements are given below. Required accuracies of annotation are given in Chapter 10.

16.4.1 *APPROACHES TOWARDS A FACILITY*

Every nautical mile (referenced to 0 NM at the threshold), ILS points A, B & C, Threshold.

16.5.2 *GLIDEPATH LEVEL FLIGHT (on localiser centreline).*

Every nautical mile (referenced to 0 NM at the threshold), and 1.8 x (glidepath angle).

16.5.3 *ORBITAL FLIGHTS*

Every 5 degrees.

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5 DEFINITIONS, SYMBOLS AND ABBREVIATIONS

CMN	Control motion noise
MCE	Mean Course Error - The mean alignment error between 1 nautical mile and the approach reference datum.
MGE	Mean Glidepath Error - The mean alignment error between 4 nautical miles and the approach reference datum.
PFE	Path following errror
PFN	Path following noise
OCI	Out of coverage indication

8 AIRCRAFT

8.1 Manual flight control using only the mandatory navigation instruments is not considered sufficiently accurate for MLS calibration.

8.2 For MLS calibration the aircraft shall be fitted with equipment which will provide repeatable following of the required path. Systems considered suitable to this purpose include telemetry of the ground based tracking system's output to a separate instrument in the aircraft, or an autopilot. If an autopilot is used SRG shall be satisfied that it is capable of safe operation down to 50 feet above the threshold elevation.

9 EQUIPMENT

9.1 Receiver

9.1.1 The receiver used for MLS flight inspection shall:

a Have a log video output.
b Have an oscilloscope trigger for all angle functions.
c Have independent Azimuth and Elevation flag outputs.
d Be capable of operating with the transmitter basic data word *2 set to "on test".
e Be capable of being calibrated to 0.005°for Azimuth and Elevation.
f Have a frame flag output

9.1.2 The equipment shall be capable of measuring and recording the relative signal levels of each component (scanning beam, clearance, multipath, OCI, preamble) within a function.

Note: *This measurement may be made by examining the receiver output or by the use of separate measuring equipment such as a spectrum analyser.*

9.1.3 An oscilloscope shall be provided. This shall be capable of being triggered from the receiver and examining the receiver's log video output.

9.1.4 The equipment shall record frame flag information from the receiver.

9.2 Measurement and Recording Equipment

9.2.1 An MLS inspection system shall be capable of measuring and recording the following parameters:-

Azimuth	PFE
Azimuth	PFN
Azimuth	CMN
Azimuth	Field strength
Elevation	PFE
Elevation	PFN
Elevation	CMN
Elevation	Field strength

9.2.2 The equipment shall be capable of measuring and recording PFE by comparison of tracking data and the MLS signal, from a distance of at least 4 nautical miles from the runway threshold.

9.2.3 The MLS inspection system shall be capable of decoding and displaying the contents of all basic and auxiliary data words.

9.2.4 It shall be possible to annotate the recordings with comments and any other necessary information at the time of making the recording.

Note *PFN and CMN may be derived and recorded using appropriate filters, but need not make reference to the position tracking device.*

9.2.5 The minimum data sampling rate shall be 5 Hz.

9.2.6 The filters used for measurement of PFE, PFN & CMN shall be designed using guidance given in Doc 8071 Vol III, chapter 7. The filter design shall be compatible with the digital data sampling rate.

9.2.7 The equipment shall be capable of recording a minimum of 4 parameters simultaneously.

Note: *Post inspection processing may be necessary to achieve the required accuracy for certain parameters*

10 MEASUREMENT UNCERTAINTY

10.1 Maximum permitted measurement uncertainty at 95% confidence level

Azimuth

PFE	0.5 metres at reference datum
PFN	0.5 metres
CMN	0.5 metres
At all other places where these parameters are measured, the uncertainty shall not exceed	0.01°
Relative signal levels	1.0 dB

Elevation

PFE	0.2 metres at reference datum
PFN	0.1 metres
CMN	0.1 metres
At all other places where these parameters are measured, the uncertainty shall not exceed	0.01°
Relative signal levels	1.0 dB

Note. *Relative signal levels above refer to measurement of the difference in signal level between the individual components of an MLS signal for a specific facility.*

The measurement uncertainty for a specific parameter at successive inspections shall be less than 2 dB.

10.1.1 *ASSOCIATED DME*

Field strength (relative)	2dB
Distance	60 metres at threshold and point A

Recommendation. *The uncertainty of DME distance measurement should not exceed 35 metres at threshold and point A.*

10.2 **Uncertainty of Position Marking of Flight Inspection Data**

10.2.1 *APPROACH TOWARD A FACILITY*

±0.1 NMile for markings at each nautical mile
±20 metres for marking the threshold crossing
±20 metres for marking any other points along the runway

15.2.2 *ORBITAL FLIGHTS*

±1.5 Degree

Note: *A marking accuracy of ±1.5° applies to clearance and coverage inspection, it is not sufficient for measuring displacement sensitivity.*

16 RECORDS AND GRAPHS

Where chart recordings are used for parameter evaluation, they shall have sufficient resolution for this purpose. The minimum requirements are given below.

For PFE, PFN and CMN: 0.05° per cm.

16.1 Position Annotation

Records and graphs must be annotated to show the position of the aircraft at the time of making the measurement. The minimum requirements are given below. Required accuracies are given in Paragraph 4.

16.1.1 *APPROACHES TOWARDS A FACILITY*

Every nautical mile (referenced to 0 NM at the threshold), ILS points A, B & C, Threshold.

16.1.2 *ORBITAL FLIGHTS*

Every 5 degrees.