هيئة الطيران المدني
CIVIL AVIATION AUTHORITY

# FLIGHT INSPECTION MANUAL

# For

# Radio Navigation Aids

Manual No: 1.3.20.

Issue Date: 20 July 2026

Revision Number: 01

Controlled Copy

**Reference No: DGCAR/4/3/3/ 1148 /2026** **Date: 19 July 2026**
**Classification: General**

**Subject:** Approval – Approval of Flight Inspection Manual For Radio Navigation Aids

Pursuant to the Civil Aviation Law of the Sultanate of Oman, the applicable Civil Aviation Regulations, and ICAO Critical Element (5) – Technical Guidance, Tools and Provision of Safety Critical Information, the Directorate General for Civil Aviation Regulation (DGCAR) hereby approves the following document as Acceptable Means of Compliance and Guidance Material (AMC/GM):

- **Title:** Flight Inspection Manual for Radio Navigation Aids (FIM-RNA)
- **Revision:** Rev. 01
- **Effective Date:** 20 July 2026.

The Manual establishes standardized technical guidance, policies, procedures and best practices governing the planning, conduct and oversight of flight inspections of radio navigation aids. It shall be used by CNS inspectors, Flight Inspection personnel and other authorized personnel in support of the implementation and oversight of the applicable Civil Aviation Regulations.

This approval is issued under the authority of the Directorate General of Civil Aviation Regulations and shall take effect on the date indicated above. It supersedes any previous versions, where applicable, and shall remain valid unless amended, suspended, or withdrawn by the Authority.

**Rawya Nasser Hamed Al-Adawi**
**Director General of Civil Aviation Regulations**

هيئة الطيران المدني CIVIL AVIATION AUTHORITY سلطنة عمان CAA 2 SULTANATE OF OMAN GENERAL DIRECTORATE OF CIVIL AVIATION المديرية العامة لتنظيم الطيران المدني

# RECORD OF AMENDEMENT

| Rev. | Effective Date | Description |
|---|---|---|
| **00** | **09 April 2020** | **The first issuance of GM Number 1.3.20; Flight Inspection Manual for Radio Navigation Aids** |
| **01** | **20th July 2026** | **This amendment incorporated the followings:**<br>**(1) Changes to new CAA logo**<br>**(2) Additional Abbreviation**<br>**(3) Additional definition**<br>**(4) Additional Flight Inspection Procedure for VOR**<br>**(5) Additional Flight Inspection Procedure for DME**<br>**(6) Flight Inspection Requirement for Surveillance System**<br>**(7) Attachment A insertion** |

Intentionally Left Blank

# FOREWORD

This Document, Flight Inspection Manual for Radio Navigation Aids has been issued by Civil Aviation Authority (hereinafter referred as OMAN CAA) under the provisions of the Civil Aviation Regulation (CAR) 171, Aeronautical Telecommunication Service Provider.

This Document sets out the procedures and criteria of the flight inspection, extension of flight inspection period and approval of Radio Navigation and Visual Aids services;

Where visual aids or PBN-related procedures are referenced, these Manual addresses only the associated CNS/NAVAID performance evidence unless the applicable aerodrome or instrument flight procedure validation framework expressly requires otherwise

The following ICAO provisions form the technical basis of this Manual, as applicable :

a. Oman Civil Aviation Law (CAL) Royal Decree 62/2023.
b. CAR 171 (Aeronautical Telecommunication Service Provider)
c. ICAO Annex 10 (CAO Annex 10, Volume I, for radio navigation aids;
d. ICAO Annex 10. Volume IV, for surveillance radar and SSR/Mode S systems;
e. ICAO Doc 8071 (Manual on Testing of Radio Navigation Aids) Volume I and III
f. ICAO Doc 9924 (Aeronautical Surveillance Manual)
g. ICAO Doc 9871 (Technical Provisions for Mode S Services and Extended Squitter)

The editing practices used in this document are as follows:

a. ‘Shall’ is used to it describes a condition, evidence item or implementation expectation to be satisfied when demonstrating compliance with the applicable CARs; it does not, by itself, create an independent regulatory obligation.
b. ‘Should’ is used to indicate a recommendation
c. ‘May’ is used to indicate discretion by the AUTHORITY the industry or the applicant, as appropriate.
d. ‘Will’ indicates a mandatory requirement and is used to advise of action incumbent on the Authority

Intentionally Left Blank

# Table of Contents


RECORD OF AMENDEMENT 3

FOREWORD 5

TABLE OF CONTENTS 7

GLOSSARY OF TERMS OR ABBREVIATIONS 10

1. GENERAL 14

1.1. INTRODUCTION 14

1.2. DEFINITION 14

1.3. FACILITIY INSPECTION 26

1.4. INSPECTION PERIODIZATION 29

1.5. PRIORITY OF FLIGHT INSPECTION 30

1.6. GRACE PERIOD for PERIODIC FLIGHT INSPECTION 30

1.7. EXTENTION OF FLIGHT INSPECTION PERIOD 30

1.8. UNIT OF MEASUREMENT 33

2. FLIGHT INSPECTION CREW AUTHORITY AND OBLIGATIONS 35

2.1. THE AUTHORITY OF FLIGHT INSPECTION CREW 35

2.2. THE OBLIGATION OF FLIGHT INSPECTION CREW 35

3. GENERAL FLIGHT INSPECTION PROCEDURES 37

3.1. PRE-FLIGHT INSPECTION 37

3.2. PREPARTION BEFORE FLYING 37

3.3. FLIGHT INSPECTION 38

3.4. ANALYSIS AND EVALUATION 39

3.5. POST-FLIGHT INSPECTION 40

4. VERY HIGH FREQUENCY OMNIDIRECTIONAL RADIO RANGE (VOR) 46

4.1. GENERAL 46

4.2. FLIGHT Inspection performance parameter. 46

4.3. FLIGHT INSPECTION PROCEDURE 49

4.4. TEST EQUIPMENT 59

**5. DISTANCE MEASURING EQUIPMENT (DME) 61**

5.1. GENERAL 61

5.2. FLIGHT INSPECTION PERFORMANCE PARAMETERS 61

5.3. FLIGHT INSPECTION PROCEDURES 64

5.4. TEST EQUIPMENT 66

**6. INSTRUMENT LANDING SYSTEM 70**

6.1. GENERAL 70

6.2. SPECIAL MEASURE PREVENTING THE OPERATIONAL USE OF TEST SIGNAL. 71

6.3. ANALYSIS CONCERNING HARMFUL INTERFERENCE CAUSED BY OPPOSITE RUNWAY LOCALIZER TRANSMISSION 72

6.4. FLIGHT INSPECTION PERFORMANCE PARAMETERS 72

6.5. FLIGHT INSPECTION PROCEDURE 82

6.6. CHARTS AND REPORTS 94

6.7. ANALYSIS 95

6.8. POSITIONING. 96

6.9. SAMPLE ILS FLIGHT INSPECTION REPORT 98

**7. ENROUTE VHF MARKER BEACON (75 MHZ) 107**

**8. PRECISION APPROACH RADAR (PAR) 109**

**9. NON-DIRECTIONAL BEACON (NDB) 111**

**10. PERFORMANCE BASED NAVIGATION (PBN) 113**

10.1. VOR FOR PBN 113

10.2. DME for PBN 113

10.3. FLIGHT TESTING 114

**11. SURVEILLANCE RADAR SYSTEM 116**

11.1. GENERAL 116

11.2. FLIGHT TESTING METHODS 116

12. SECONDARY SURVEILLANCE RADAR 135

12.1. PREFLIGHT REQUIREMENTS 135

12.2. DETAILS OF FLIGHT INSPECTION PROCEDURE. 135

ATTACHMENT A: FLIGHT INSPECTION AIRCRAFT ANTENNA PERFORMANCE. 141

A.1 ANTENNA 141

A.2 ANTENNA MEASUREMENT TECHNIQUES 141

A.3 ANTENNA INSTALLATION CONSIDERATION 142

## Glossary of Terms or Abbreviations

The following terms, abbreviations, and acronyms may be used in any manual or document published by the Oman Civil Aviation Authority (CAA). Reproduction of this list, in whole or in part, is permitted without prior approval.

The abbreviations and definitions have been harmonized, where applicable, with the terminology used in ICAO Annex 10, ICAO Doc 8071, ICAO Doc 9924, and CAR 1.

The Safety Regulation Department of the Oman CAA reserves the right to incorporate this list of abbreviations and definitions into any Oman CAA manual or document prior to publication to ensure consistency and standardization of terminology.

| | |
|---|---|
| ADF | Automatic direction finder |
| AFC | Automatic frequency control |
| AFIS | Automatic Flight Inspection System |
| AGC | Automatic gain control |
| AIP | Aeronautical Information Publication |
| AM | Amplitude modulation |
| ANSP | Air navigation service provider |
| ATC | Air traffic control |
| ATIS | Automatic terminal information service |
| CATV | Cable television |
| CVOR | Conventional VOR |
| CMN | Control motion noise |
| CW | Continuous wave |
| DDM | Difference in depth of modulation |
| DGNSS | Differential global navigation satellite system |
| DME | Distance measuring equipment |
| DVOR | Doppler VOR |
| EIRP | Equivalent isotropic radiated power |
| EMI/EMC | Electromagnetic interference/compatibility |
| FM | Frequency modulation |
| FMS | Flight management system |
| GNSS | Global navigation satellite system |
| GP | Glide path |
| IF | Intermediate frequency |
| IFR | Instrument flight rules |
| ILS | Instrument landing system |
| IM/MM/OM | Inner/middle/outer marker |
| INS | Inertial navigation system |
| ISM | Industrial scientific medical |
| ITE | Information technology equipment |

| | |
|---|---|
| ITU | International Telecommunication Union |
| LDA | Localizer Type Directional Aid |
| LF/MF/HF | Low/medium/high frequency |
| LOC | Localizer |
| MDS | Minimum discernible signal |
| MHA | Minimum holding altitude |
| MSL | Mean sea level |
| MTBF | Mean time between failures |
| MTBO | Mean time between outages |
| NDB | Non-Directional beacon |
| NOTAM | Notice to Airmen |
| PAR | Precision approach radar |
| PBN | Performance-based navigation |
| PFE | Path following error |
| PFN | Path following noise |
| PLC | Power line carrier |
| PM | Phase modulation |
| POP | Proof of performance |
| pp/s | Pulse pairs per second |
| PRF | Pulse repetition frequency |
| RDH | Reference datum height |
| RF | Radio frequency |
| RMS | Root mean square |
| RNAV | Area navigation |
| SARPs | Standards and recommended practices |
| SDF | **Simplified Directional Facility** |
| SDM | Sum of depths of modulation |
| TLS | Transponder Landing System |
| VFR | Visual flight rules |
| VOR | VHF omnidirectional radio range |
| VSWR | Voltage standing wave ratio |
| ACP | Azimuth count pulses |
| ADS | Automatic dependent surveillance |
| ASP | Asynchronous surveillance processor |
| ATC | Air traffic control |
| ATCC | Air traffic control centre |
| ATS | Air traffic service |
| BITE | Built-in test equipment |
| CAP | Close approach probability |
| CFAR | Constant false alarm rate |
| CMB | Combined (PSR and SSR) |
| CMV | Coverage measurement volume |
| CW | Continuous wave |

| | |
|---|---|
| DAP | Downlink aircraft parameters |
| DATAS | Data test and analysis system |
| DPE | Digital plot extractor |
| DSS | Dependent surveillance sensor |
| FDPS | Flight data processing system |
| FFM | Far field monitor |
| FRUIT | False replies unsynchronized in time |
| GICB | Ground initiated Comm-B |
| GTC | Gain time control |
| HRP | Horizontal radiation pattern |
| IC | Interrogator code |
| IF | Intermediate frequency |
| II | Interrogator identifier |
| I/O | Input/output |
| I/R | Interrogator/responder |
| IRAS | Interactive radar analysis system |
| IRF | Interrogation repetition frequency |
| ISLS | Interrogator side-lobe suppression |
| I2SLS | Improved interrogation side-lobe suppression |
| LAN | Local area network |
| LCS | Life cycle stage |
| LRU | Line replaceable unit |
| LVA | Large vertical aperture antenna |
| MA | Message, Comm-A |
| MAPt | Missed approach point |
| MB | Message, Comm-B |
| MDS | Minimum detectable signal |
| MOCA | Minimum obstacle clearance altitude |
| MSP | Mode S specific protocol |
| MSSR | Monopulse secondary surveillance radar |
| MTD | Moving target detection |
| MTI | Moving target indicator |
| MTL | Minimum triggering level |
| OBA | Off-boresight angle |
| ODS | Operational display system |
| PAR | Precision approach radar |
| Parrot | Position adjustable range reference orientation transponder |
| PD | Probability of detection |
| PE | Permanent echo |
| PFA | Probability of false alarm |
| PPI | Plan position indicator |
| PRF | Pulse repetition frequency |
| PSR | Primary surveillance radar (also “PR”) |

| | |
|---|---|
| RCS | Radar cross section |
| RDPS | Radar data processing system |
| RDQC | Radar data quality characteristic |
| RF | Radio frequency |
| RFM | Remote field monitor |
| RMCS | Remote monitoring and control system |
| RSLS | Receiver side lobe suppression |
| RTQC | Real-time quality control |
| SCF | Surveillance coordination function |
| SCN | Surveillance coordination network |
| SDD | Synthetic data display |
| SDPS | Surveillance data processing system |
| SLM | Standard length message |
| SLS | Side-lobe suppression |
| SRE | Surveillance radar element |
| SSR | Secondary surveillance radar |
| STC | Sensitivity time control |
| STCA | Short-term conflict alert |
| TLS | Target level of safety |
| UTC | Coordinated universal time |
| VDU | Visual display unit |
| VRP | Vertical radiation pattern |
| VSWR | Voltage standing wave ratio |
| ZVF | Zero velocity filter |

# 1. GENERAL

## 1.1. INTRODUCTION

Each Radio Navigation and Visual Aids operated for Air Navigation Services shall be calibrated/tested/inspected in a manner periodically to ensure that Radio Navigation systems meet the regulatory requirements of CAR 171 and the SARPs in ANNEX 10.

Radio Navigation Aids and Visual Aids, includes:

1. Ground Based Radio Navigation System
   a. VHF Omnidirectional Range (VOR)
   b. Distance Measurement Equipment (DME)
   c. Non-Directional Beacon (NDB)
   d. Instrument Landing System (ILS)
   e. VHF Marker Beacon (OM/MM/IM)
2. Surveillance Radar System
3. Visual Aids
   a. Precision Approach Path Indicator (PAPI)
   b. Visual approach Slope Indicator (VASI)

## 1.2. DEFINITION

The following term and meaning are applied in this document:

*Flight Inspection Service Provider*. Any organization that obtain certificates from Authority (Oman CAA) to conduct flight inspection for Radio Navigation Aids.

*Flight Inspector*. A Competent personal that authorized by Oman CAA to examine the signal of Radio Navigation Aids in space to ensure that it meet the standards in Annex 10, and state the operational status of equipment being tested.

*Active reflector.* A device used in primary radar systems for geographical alignment and system performance checking. It generates a signal from a stationary installation with an artificial Doppler shift to ensure that a stationary target will be presented on an ATC screen after moving target detection (MTD) or moving target indicator (MTI) processing.

*Aircraft address.* A unique combination of twenty-four bits available for assignment to an aircraft for the purpose of air ground communications, navigation, and surveillance.

*Note. — The aircraft address is also referred to as the Mode S address or the aircraft Mode S address.*

*All-call.* An intermode or Mode S interrogation that elicits replies from more than one transponder.

*All-call (Mode A/C-only).* An intermode interrogation that elicits replies from Mode A/C transponders only. Mode S transponders do not accept this interrogation.

*All-call (Mode A/C/S).* An intermode interrogation that elicits Mode A/C replies from Mode A/C transponders and all-call replies from Mode S transponders that are currently not in the lockout state.

*All-call (Mode S-only).* A Mode S interrogation that elicits all-call replies from Mode S transponders that are currently not in the lockout state.

*All-call period.* The time interval during which a Mode S interrogator issues all-calls (SSR only, Mode S only and intermode) to detect Mode A/C transponders and, for acquisition, Mode S transponders that have not been previously locked out.

*All-call (stochastic).* A Mode S-only all-call that elicits all-call replies from only a random subset of the Mode S transponders that are currently not in the lockout state.

*Altitude.* The vertical distance of a level, point or an object measured above mean sea level.

*Analogue.* In radar terms, a signal which has not been converted into digital values. Analogue signals are to be found at antenna and receiver level in radar systems.

*Analogue-to-digital converter.* A device for the conversion of analogue signals into digital values. Usually operates by sampling the analogue signal at regular time intervals and converting the measured value of the analogue sample to a binary encoded number.

*Antenna (electronically scanned, E-Scan).* An SSR antenna consisting of a number of planar arrays or a circular array of radiating elements. The antenna beams are electronically steered to the desired azimuth angle by applying phase shifting techniques, without rotating the antenna mechanically.

*Antenna elevation (tilt).* An angle between the direction of maximum gain of the antenna and the tangent to the surface of the earth. A distinction is sometimes made between electronic (radio signal) and mechanical tilt, especially for SSR LVA antennas. In this case the mechanical tilt may be zero while the antenna is radiating at a different electronic tilt (typically +3°).

*Antenna (hog-trough).* An SSR antenna comprising a horizontal linear array of radiating elements installed in an extended corner reflector assembly (resembling in shape a hog-trough). The linear array is usually of sufficient length to give an azimuth beam width of between 2° and 3° and the hog-trough reflector achieves typically between ± 40° and 45° vertical beam width. For special purposes shorter arrays can be used. These have increased azimuth beam width.

*Antenna (large vertical aperture, LVA).* An SSR antenna comprising two-dimensional array radiating elements. A typical LVA consists of a number of columns (each consisting of a vertical linear array designed to produce beam shaping in the vertical plane) arranged in a horizontal linear array to produce between 2° and 3° azimuth beam width. Typically, LVA antennas are a pre-requisite for monopulse SSR systems.

*Antenna (linear array).* An antenna consisting of a "battery" or array of radiating elements in a straight line. The desired radiation characteristic of the antenna is obtained by the varied distribution of radio frequency energy in amplitude or phase so as to produce the shaped "beam" or wave front.

*Antenna (omni-directional).* An antenna with an approximately circular radiation pattern in the horizontal plane. In earlier SSR systems it was used to form the control pattern for ISLS by transmitting the P2 pulse and also for transmission of the P1 pulse for I2SLS. Modern antennas for ground SSR form a control pattern that is omni-directional except for a null or "notch" in the direction of the antenna mainbeam (coinciding with the peak of the main beam sum pattern).

*Antenna (reflector).* An antenna producing the beam by a method analogous to optics. In most cases the “reflector” surface of the antenna is illuminated by a radio frequency source (e.g. a radio-frequency “horn” assembly). The dimensions of the reflector antenna both in the horizontal and vertical plane, together with the characteristics of the illuminating source, determine the shape and magnitude of the radar beam produced.

*Antenna (sum and difference).* A hog-trough or LVA antenna which is electrically split into two halves. The two half antenna outputs are added in phase at one output port (sum, S) and added in antiphase at a second output port (difference, D) to produce output signals which are sensitive to the azimuth angle of arrival of received signals, enabling an off-boresight angle for the signal source to be obtained.

*Asynchronous surveillance processor (ASP).* A type of video-plot processor.

*Azimuth count (or change) pulses (ACPs).* Output pulses of the incremental azimuth measuring device fitted to the radar antenna turning platform (turning gear). The encoding device may give its output in serial or parallel form but typically provides 4 096 pulses (12-bit encoding), 16 384 pulses (14-bit encoding) or 65 536 pulses (16 bit encoding) in serial form per 360° in azimuth.

*Azimuth extension (plot length, delta theta).* An azimuth increment, often expressed as a number of ACPs, from detection of the leading edge of a radar plot to detection of the trailing edge of that plot, in a digital plot extractor system.

*Back lobe.* A lobe of radiated energy to the rear of an antenna (180° in azimuth with respect to the main lobe).

*Beam sharpening.* A technique applied to the monopulse antenna to decrease the plot run length of SSR replies. The reduced run length is required to improve the resolution capabilities of the extraction system.

*Beam width.* An angle subtended (either in azimuth or elevation) at the half-power points (3 dB below maximum) of the main beam of an antenna.

*Blip.* A presentation on an analogue radar display of the received signal from a target.

*Blip-to-scan ratio.* An approximation of detection probability (PD) (i.e. for a given observation time, the number of blips actually detected for a selected aircraft divided by the number of radar scans).

*Boresight.* A main lobe electrical (radio) axis of an antenna.

*Bracket decodes.* A decoding of the F1 – F2 framing pulses (nominal interval 20.3 μs) without regard to the content of the data pulses between these framing pulses.

*Built-in-test equipment (BITE).* Internal self-check facilities in electronic equipment which allow the correct operation to be monitored on a continuous basis. Many checks may be GO-NOGO tests, with a failure causing a visual (or possibly audio) alarm to be given. The BITE is usually part of the remote control and monitoring system of a radar. Modern BITE can isolate faults down to a line-replaceable unit (e.g. a printed circuit board) in a majority (e.g. 80 per cent) of all fault conditions.

*Chaining.* A process of linking together radar target reports (plots and tracks) and other information relating to one particular object.

*Chip.* A 0.25 µs carrier interval following possible data phase reversals in the P6 pulse of Mode S interrogations (see "data phase reversal").

*Clutter.* A generic PSR term for unwanted, interfering reflections of radio energy from various sources. Types of clutter include ground clutter, sea clutter, precipitation clutter and "angels".

*Code.* A combination of data bits contained in signals transmitted by an SSR transponder in reply to an SSR interrogator.

*Code train.* A sequence of bracket (framing) and information pulses in an SSR Mode A or Mode C reply.

*Combination criteria.* Criteria in respect to azimuth and range coincidence with which a primary radar plot and an SSR plot must meet to be considered to have come from the same aircraft and therefore able to be combined.

*Combined plot.* A radar plot for which both PSR and SSR plots have been detected and found sufficiently adjacent to be combined to one plot message.

*Cone of silence.* A gap in coverage above a radar due to the limitations of the antenna performance at high elevation angles.

*Constant false alarm rate (CFAR).* A thresholding technique used to reduce false alarms (noise, clutter, etc.) to a quasicontractual level. Also known as constant false alarm regulation.

*Control antenna.* An SSR antenna having a polar diagram which is designed to "cover" the side lobes of the main interrogating antenna. It is used to radiate a control pulse which, if it exceeds in amplitude the associated interrogation signal at the input to the transponder, will cause the transponder to inhibit responses to the interrogation pulses. Modern SSR antennas have the control elements built into the main array. The control antenna is also known as the SLS (side-lobe suppression) antenna.

*Control pattern.* A polar diagram of the control antenna. Modern integrated SSR antennas have a "modified cardioid" beam shape.

*Control pulse.* A pulse (P2 for Modes A and C, P5 for Mode S) transmitted by the ground equipment (SSR interrogator) in order to ensure side-lobe suppression.

*Correlated tracks.* Tracks which have been correlated with a flight plan (sometimes this term applies only to tracks for which the Mode A code has been correlated with a call-sign in the code/call-sign list, i.e. flight plan association).

*Correlation criteria.* A number of pulse repetition intervals over which range correlation of replies must be achieved in a sliding or moving window extractor before the presence (or tentative presence, subject to further tests) of a plot can be declared.

*Cosecant squared antenna pattern.* An antenna pattern for which the gain is proportional to the square of the cosecant of the elevation angle. This results in an approximately constant signal, as a function of range, from an aircraft at constant flight level.

*Data phase reversal.* A 180° phase shift which precedes a chip in a Mode S interrogation (see "chip") and is used to encode a binary ONE. The absence of the phase reversal encodes a binary ZERO.

*Dead time.* A period of time during which an SSR transponder is inhibited from receiving signals after a valid interrogation is received and a reply transmitted. The term is also used to describe the time after the normal range for returns and before the next transmission from an interrogator or from a primary radar system.

*Dedicated flight check aircraft.* An aircraft used occasionally in operational evaluations of radar systems. This aircraft will fly routes, etc., not normally covered by regular traffic and allow a complete operational evaluation through the specified coverage of the radar under test.

*Defruiter.* Equipment used to eliminate unsynchronized replies (fruit) in an SSR ground system.

*Defruiting.* A process by which aircraft replies accepted by the interrogator-responsory are tested by means of storage and a comparator for synchronism with the interrogation-repetition frequency. Only replies which are in synchronism (correlate on a repeated basis in range) will be output from the defruiter. Other replies are rejected as "fruit" or false.

*Degarbling.* A process of separating (and possibly validating) garbled SSR replies. (See "Garbling".)

*Delta theta.* A number of azimuth count pulses (ACPs) as measured from the plot leading edge to the plot trailing edge in a sliding window plot extractor. Also known as azimuth extension or plot run length.

*Difference pattern.* A receive (1 090 MHz) characteristic of a monopulse SSR antenna, obtained by connecting in antiphase the signals (replies) received by two partial antennas. The difference pattern has a minimum in the main radiation direction of the antenna and an amplitude and phase characteristic which varies as a function of angle of arrival of the received signal. Used in conjunction with the sum output of the antenna, it enables the off-boresight angle to be found.

*Digitized video.* A binary encoded signal, the value of which is equivalent to the value of the originating analogue signal.

*Display (analogue).* A display in which the raw video (PSR or SSR) is normally presented on the radar screen in the form of a blip. The update of the display is synchronized with the radar antenna turning rate. The preceding processing is normally analogue (i.e. no digital messages).

*Display (synthetic).* A display in which information (radar, map, labels, etc.) is based on digital messages. The displayed radar data are not normally in "real time" due to digital processing delays.

*Doppler speed.* A radial velocity of a target (aircraft) or of a clutter source (false alarm) measured from its doppler frequency shift in a received radar reflection.

*Double curvature.* A PSR reflector design in which the upper and lower sections of the antenna have a different curvature. This technique is used to optimize the vertical radiation patterns for high beam (short range) and low beam (long range) performance.

*En-route radar.* A surveillance radar for the traffic passing through the area of control. Typically, the range of such a radar is between 240 km (150 NM) and 370 km (200 NM) and the information renewal rate for a mechanically rotating antenna is 8 to 12 seconds.

*ERP.* Effective radiated power (ERP) is the transmitted power enhanced by the gain of the antenna less the losses in cables, rotary joints, etc.

*False plot.* A radar plot report (PSR, SSR or combined plot) which does not correspond to the actual position of a real aircraft (target), within certain limits.

*Far field monitor (FFM).* See remote field monitor.

*Framing pulses.* Pulses which “frame” the information pulses (code) of SSR Mode A and C replies (described as F1 and F2 respectively). Also known as “bracket pulses”.

*Fringe (inner and outer).* A minimum and maximum range respectively for a successful plot detection.

*Fruit.* A term applied to unwanted SSR replies received by an interrogator which have been triggered by other SSR interrogators. Fruit is the acronym of false replies unsynchronized in time, or false replies unsynchronized to interrogator transmission.

*Gain (of antenna).* A measure for the antenna of the relative transmitted power density radiated in a particular direction as compared with the power density that would have been radiated from an isotropic antenna with the same power input (usually expressed in dB) and at the same distance from the radiator.

*Gain time control (GTC).* A circuit which controls the gain of a radar receiver, allowing it to rise from an initial preset value to maximum at a predetermined rate to compensate for the decrease in received signal strength as range increases. Also known as sensitivity time control (STC).

*Garbling.* A term applied to the overlapping in range and/or azimuth of two or more SSR replies so that the pulse positions of one reply fall close to or overlap the pulse positions of another reply, thereby making the decoding of reply data prone to error.

*Hit.* A reception and recognition by the aircraft (trans-ponder) of the SSR interrogation pulses P1 and P3, re-sulting in the return of a detectable reply code to the ground receiver.

*I and Q channels.* In-phase and quadrature channels of a primary radar receiver used for the extraction of phase and amplitude of the received signal. In older systems these channels were processed separately to avoid “blind phases”.

*Improved interrogation side-lobe suppression (I2SLS).* A technique whereby interrogation pulse P1 is transmitted via both the main beam and the control beam of the SSR antenna, so that a transponder in a side-lobe direction more reliably receives a P1-P2 pulse pair.

*Improvement factor.* Target to clutter ratio at the output of an MTI processor divided by the target to clutter ratio at the input of the processor, averaged uniformly over all target radial velocities of interest.

*Integrated antenna.* A PSR antenna in which the reflector of a PSR radar is used in conjunction with SSR radiating elements in order to obtain the required SSR horizontal and vertical radiation patterns.

*Interlace.* A repeating series of SSR interrogation modes. The interlace pattern may be determined either on a p.r.p. (pulse-repetition period) to p.r.p. basis or on an antenna rotation to antenna rotation basis. It may also be made on a combined p.r.p./antenna basis.

*Interleave.* A condition where two or more pulse trains become superimposed in time so that their pulse time spacing can be distinguished and the correct codes established.

*Intermode interrogations.* Interrogations that consist of 3 pulses (P1, P3 and P4) and are capable of eliciting replies:

a) from both Mode A/C and Mode S transponders or

b) from Mode A/C transponders but not from Mode S transponders

*Interrogation.* See "Mode".

*Interrogator.* A ground-based (normally) transmitter element of an SSR system.

*Interrogator identifier (II).* One of the codes (1 to 15) used to identify a Mode S ground station using the multisite protocols.

*Interrogator repetition frequency (IRF).* An average number of interrogations per second transmitted by the radar. See also "Pulse repetition frequency".

*Interrogator-responsor.* A ground-based combined transmitter-receiver element of an SSR system.

*Interrogator side-lobe suppression (ISLS).* A method of preventing transponder replies to interrogations trans-mitted through the ground antenna side lobes.

*Line replaceable unit (LRU).* A unit, part of a system, which can be exchanged as an entity for a spare of the same type and which may consist of a single printed circuit board, power supply or equipment module. The exchange of unit will take place at equipment (system) level.

*Lobing (antenna pattern).* A process whereby, due to interference of two waves, one direct and one reflected, differences in phases cause larger or smaller amplitudes than expected for free space, causing differences in signal amplitudes.

*Lockout state.* A state in which a Mode S transponder has been instructed not to accept certain all-call interrogations. Lockout is deliberately induced by command from the Mode S ground station.

*LogFTC.* A signal processing technique comprising a logarithmic amplification stage followed by a differentiation (short time constant) stage used for the suppression of unwanted PSR signals.

*Mode.* SSR interrogation mode as specified in Annex 10, Volume IV, Chapter 2.

*Mode S*. An enhanced mode of SSR that permits selective interrogation and reply capability.

*Mode S ground station.* Ground equipment that interrogates Mode A/C and Mode S transponders using intermode and Mode S interrogations.

*Mode S period.* Refer to roll-call period.

*Mode S transaction.* The initiation, control and exchange of data between a Mode S interrogator and transponder over the air/ground link.

*Monitor display.* A device for the presentation of radar data, usually working in the plan-position indicator (PPI) mode of operation. This device is generally found as part of the maintenance equipment of a PSR and/or SSR station. Generally, radar data at various stages of processing may be observed on the monitor display.

*Monopulse.* A technique wherein the amplitudes and/or phases of the signals received in overlapping antenna lobes are compared to estimate the angle of arrival of the signal. The technique determines the angle of arrival of a single pulse, or reply, within an antenna beam width. The angle of arrival is determined by means of a processor using the replies received through the sum and difference patterns of the antenna. The monopulse technique is generally termed “monopulse direction finding”.

*Monopulse plot extractor.* A plot extractor using monopulse direction-finding techniques. See also plot extractor.

*Moving target detector (MTD).* A technique for achieving fixed and moving clutter rejection by a cascade of digital MTI and pulse Doppler filters.

*Moving target indicator (MTI).* Signal processing used in primary radar systems to reject signals from fixed or slow-moving unwanted targets (buildings, trees, rain, etc.) and retain for detection or display of signals from moving targets (aircraft).

*Moving window detector.* A radar signal processing device which stores radar returns over a given number of pulse repetition periods (the number depending upon the so-called moving window size) and uses these for the automatic detection of radar targets. Also known as sliding window detector.

*Multi-radar trajectory reconstitution (MURATREC).* A technique for the accurate a-posteriori determination of an object trajectory using simultaneous measured observations from a number of radars.

*Noise factor.* A figure defined for a receiver as the ratio of the noise at the output of the practical receiver and the noise output of an ideal receiver at standard temperature T0 (290° K). The noise factor is, in practice, defined as the signal to- noise ratio at the input divided by the signal-to-noise ratio at the output of a receiver.

*North marker (NoM).* A single pulse, typically produced by a digital encoder (shift encoder) attached to the radar antenna drive system, which indicates when the antenna passes through the direction to the North.

*North message.* Special messages generated by the extractor to indicate passage of the antenna rotation through an azimuth angle of zero degrees (true North).

*Object.* A combination of radar targets and related information which are correlated in time and space.

*Off-boresight angle (OBA).* In monopulse SSR, the angle within the beam width of the antenna (calculated by the OBA processor) by which a target is off (away from) the boresight.

*Orbit.* In the context of flight testing, a flight of circular pattern at a constant altitude and distance from the antenna of the ground equipment under test.

*Over-interrogation.* Interference in the operation of a secondary radar system due to the fact that the number of interrogations exceeds the capacity of the transponder (a preset value). The action of the transponder is an automatic reduction in transponder receiver sensitivity.

*Overlapping targets.* A condition where radar replies overlap each other in range and/or azimuth. (See also “Garbling”.)

*Parrot.* See remote field monitor in this glossary.

*Plan position indicator (PPI).* A monitor display with radar and other related information in plan position (as if projected on a horizontal plane).

*Plot combiner.* A signal processing device for the combination of PSR and SSR data ascertained as having originated from the same target. Targets failing to meet pre-defined combination criteria will be output as “PSR only” or “SSR only” plots in place of “combined plots”.

*Plot extractor.* Signal processing equipment which converts radar video into an output data message suitable for transmission through a data transmission media, or possibly to further data processing equipment. (See “Plot filter”.)

*Plot filter.* Signal processing equipment which filters out radar plot data positively identified as stationary by a rotation scan-to-scan correlation process.

*Plot resolution.* A separation in range and azimuth between two plots, for which the quality of the information of one plot is not affected by the presence of the other plot.

*Plot run length.* The number of azimuth count pulses between the first and last detection of a plot presence in a sliding window plot extractor.

*Polar diagrams.* Horizontal or vertical radiation patterns for a radar antenna whereby the relative gain is plotted as a function of the relative azimuth (horizontal polar diagram) or as a function of the relative elevation angle (vertical polar diagram). Separate uplink and downlink frequency polar diagrams, in each plane, are plotted for each of the main beam, control and difference (mono-pulse only) SSR antenna patterns, referenced to the main beam axis.

*Polarization.* Direction of the electrical field vector of radiated radar energy with respect to a plane tangential to the earth (horizontal, vertical, left-hand circular, righthand circular, elliptical, etc.).

*Primary surveillance radar (PR or PSR).* A radar which detects the presence of a target based on reflected radar energy from that target.

*Probability of detection (PD).* Probability that a correct radar plot message is derived when a target is present.

*Pulse compression.* A transmitter frequency modulation technique (change in frequency within the pulse), coupled with a frequency sensitive receiver signal processing technique, which enables a radar to obtain the resolution and accuracy of a short pulse and the detection capability of a long pulse.

*Pulse length.* The time between the 50 per cent amplitude points on the leading and trailing edges of the pulse envelope. Also known as a pulse width.

*Pulse position modulation (PPM).* Modulation technique used for Mode S replies where a pulse transmitted in the first half of the bit position interval represents a binary ONE, whereas a pulse transmitted in the second half represents a binary ZERO.

*Pulse repetition frequency (PRF).* An average number of pulses/interrogations per second transmitted by the radar (see “Stagger”). Also known as pulse recurrence frequency.

*Pulse repetition interval (p.r.i.).* An average interval between two successive pulses/interrogations transmitted by a radar.

*Pulse train.* A sequence of framing and information pulses in the coded SSR reply.

*Quantized video (QV).* Generic term for a video signal generated by regularly sampling an analogue video signal and assigning it a binary value of one or zero depending on whether the analogue value exceeds or does not exceed a threshold. It is also known as hard bit quantized video. Specific terms that occur in some manufacturers’ documentation include:

a. for primary radar, the threshold may be referred to as a dynamic noise threshold or fast time constant threshold;
b. for secondary radar, quantized video may refer to a pulse generated within a plot extractor on detection of F1, F2 pulses, synchronized to the plot extractor timing; and
c. for monopulse SSR, quantized video may refer to an analogue video converted to digital words synchronized to the monopulse plot extractor master clock timing.

*Quantum.* Range unit used for quantization of the range information. Also known as range bin or range cell.

*Radar reinforcement.* In combined PSR/SSR plot extractors, the term is applied to the successful association of a primary plot with an SSR plot. Also known as plot combination. If successful association is achieved, the plot extractor generates an SSR message in which an additional bit, radar reinforcement, is set; the remaining primary radar plot information may be merged or it may be discarded.

*Raw video.* Unprocessed, analogue PSR or SSR video information.

*Real-time quality control (RTQC).* A form of built-in test equipment and/or software in which system performance parameters are monitored in real time (on-line).

*Receiver side-lobe suppression (RSLS).* A method, using two (or more) receivers to suppress aircraft replies which have been received via side lobes of the main beam of the antenna.

*Remote field monitor*. A system which monitors the uplink and/or downlink performance of an SSR or Mode S system from a site located at the specified distance from the radar (far field). The monitor is interrogated by the radar, and its replies can be evaluated on the radar site. In addition, the replies may contain data about certain interrogation parameters as seen by the monitor. Alternative terminology to “remote field monitor” in common usage includes “far field monitor”, “Parrot” and “site monitor”.

*Remote monitoring and control system (RMCS).* A system which allows manual or automatic reconfiguration of a radar system. The RMCS will also give an overall indication of the system status (equipment operational, equipment in standby, faults, etc.). The RMCS equipment may have a terminal either at the station level or at the ATC center level and often at both levels.

*Reply.* A pulse train received at an SSR ground station as a result of successful SSR interrogation.

*Reply code, reply pulse train.* See “Code train”.

*Reply preamble.* A sequence of four pulses, each with a duration of 0.5 microsecond, indicating the beginning of a Mode S reply.

*Residual errors.* Errors in position which exist between the corrected positions of an object (measured position minus systematic error) and the corresponding trajectory.

*Resolution.* Ability of a system to distinguish between two or more targets in close proximity to each other both in range and bearing (azimuth).

*Responsor.* A ground-based receiver part of the SSR. The complete equipment is generally known as the interrogator/responsor.

*Ring-around.* Continuous reception of replies to interrogations by the side lobes of the ground antenna. This normally occurs only at short ranges, usually due to the non-existence of a side-lobe suppression mechanism or the improper functioning of this mechanism, at either the interrogator or the transponder side.

*Roll-call.* On the uplink, the roll-call is a regular scheduled selective Mode S interrogation that is addressed to a specific Mode S transponder and intended to elicit a reply to support the surveillance function.

*Roll-call period (also known as Mode S period).* The time interval during which a Mode S interrogator schedules the time windows allocated for Mode S transactions.

*Round (trip) reliability.* An SSR term used to state the probability of receiving a detectable reply at the interrogator, resulting from an SSR interrogation.

*Run length.* See “Delta theta”.

*Screening.* When the shape of the terrain or certain objects prevent the detection of targets in certain parts of the airspace, one speaks about screening of the parts of the airspace concerned.

*Sea clutter.* Unwanted primary radar reflections from sea. Varies with sea state.

*Secondary surveillance radar (SSR) system.* A radar system which transmits coded interrogations to aircraft transponders in various modes and receives coded replies.

*Secondary surveillance radar (SSR) transponder.* A unit which transmits a response signal on receiving an SSR interrogation. The term is a derivative of the words transmitter and responder.

*Sensitivity time control (STC).* See “Gain time control”.

*Side lobes (antenna).* Lobes of the radiation pattern of an antenna, which are not part of the main or principal beam. Radar systems can have sufficient sensitivity via side lobes for successful detection of aircraft (par-ticularly for SSR, but also for PSR). Special precautions are necessary to protect against these false plots.

*Side-lobe suppression (SLS).* A mechanism in an SSR transponder activated by the transmission (radiation) of a control pulse (P2 or P5) of amplitude greater than the antenna side-lobe signals-in-space, which will enable the transponder to prevent itself from replying to the side-lobe interrogation signals.

*Split plots.* Generation of two plots by a radar extraction system for the same target for one passage of the antenna main beam through the target.

*Spurious plots.* An unwanted radar plot not corresponding directly with an aircraft position (generally applied to SSR).

*Stagger.* Deliberate, controlled variation of pulse repetition intervals of a PSR to overcome blind speeds and decorrelate second-time-around replies. Deliberate, controlled variation of the pulse repetition frequency of the SSR to prevent aircraft plots due to second-time-around replies.

*Sum pattern.* Normal radiation pattern for the main directional beam of an antenna. Contrasts with the “difference-pattern”, where a part of the radiating elements of the antenna is switched in anti-phase to produce signals proportional to the amount by which the source is off the boresight of the sum pattern.

*Surveillance Coordination Network (SCN).* The network used to connect Mode S radars that are operating as part of a cluster in order to share the same interrogator code (IC).

*Surveillance processing.* A general term covering any processing applied to the target reports after the extraction functions and prior to the data transmission functions. Such processes include filtering, clutter reduction, data rate control and dynamic angel control.

*Sync phase reversal.* The first phase reversal in the Mode S P6 interrogation pulse. It is used to synchronize the circuitry in the transponder that decodes the P6 pulse by detecting data phase reversals, i.e. as a timing reference for subsequent transponder operations related to the interrogation.

*Terminal approach radar (TAR).* A surveillance radar for the approach area. Typically, the range of such a radar is limited to 110 km (60 NM) and the information renewal rate for mechanically rotating antennas is 4 to 5 seconds.

*Tilt.* See “Antenna elevation”.

*Track.* A succession of radar reported positions for one aircraft sometimes correlated and smoothed by a special tracking algorithm.

*Trailing edge (plot).* The azimuth, for which the extractor/plot processor logic detects the “end of plot”.

*Validation (code).* Process of correlation of the code information used in SSR Mode A/C systems. Generally, 2 identical codes in 2 successive replies suffice to validate the code. In Mode S, code validation occurs inherently when the reply is decoded (and, if appropriate, error corrected).

*Note.— Modern radar systems may provide “smoothed” code information when the so-called validation indication serves to indicate non-extrapolated code information.*

*Video display unit.* Also known as a monitor screen and is generally used for the display of alphanumeric data, but may also have some graphic capabilities (more modern systems).

*Zenithal gap.* See “Cone of silence”.

## 1.3. FACILITIY INSPECTION

The facilities calibration/testing or inspection of Radio Navigation and Visual Aids is defined in the following categories:

a. Ground Inspection
b. Flight Inspection

### 1.3.1. Ground Inspection

Ground Inspection shall be carried out by trained CNS personnel using appropriate test equipment at the facility site or at a point on the ground remote from the site. Ground Inspection is used as quick evaluation of the facility performance. Ground Inspection is carried out more frequently and can be used as indicator to determine when a special flight inspection might be required.

Ground Testing shall cover:

a. *Site proving*; Tests carried out at proposed sites for the ground element of radio navigation aids to prove suitability. Portable ground installations are used for this purpose.
b. *Initial proof of performance*: A complete inspection of the Facility after installation and prior to commissioning to determine whether the equipment meets the Standards and specifications.
c. *Periodic*: Regular or routine inspections carried out on a facility to determine whether the equipment continues to meet the Standards and specifications.
**d.** *Special*: Tests after a failure of the facility or other circumstances that indicate special testing is required or prior to Flight Inspection periodization. Special tests will often result in appropriate maintenance work to restore the facility and in a special flight inspection, if required.

### 1.3.2. Flight inspection

Flight Inspection are those carried out in the air by a trained flight inspection crew using a suitably equipped platform. Flight tests are required to examine the signals-in-space as received at the aircraft after being influenced by external factors such as site conditions, ground conductivity, terrain irregularities, metallic structures, propagation effects, etc. Flight Inspection will continue to be important in the proof of facility performance because it represents in-flight evaluation and provides a sampling of the radiated signals in the operating environment

Flight Inspection shall be carried out by Flight Inspection Service Provider approved by Oman CAA in accordance with Appendix A of **CAR 171, "CERTIFICATION REQUIREMENTS OF FLIGHT INSPECTION SERVICE PROVIDER**"

Flight inspection shall cover:

a. *Site proving*:
A Flight Inspection conducted at the proposed site at the option of the responsible Authority to determine the effects of the environment on the performance of the planned radio navigation aid.

b. *Commissioning*:
   i) An extensive flight inspection following ground proof-of-performance inspection to establish the validity of the signals-in-space. The results of this inspection should be correlated with the results of the ground inspection. Together they form the basis for certification of the facility.
   ii) Commissioning Inspection for facilities installed on an unfinished runway.
   In case of commissioning being carried out prior to the completion of ground construction activities, including painting and lighting, Special Inspection Conditions will be implemented only if flight inspector states that the rest of runway work shall not affect the navigational aids performance and another special inspection will not be needed prior the facility being put into operation.
   iii) Type of Commissioning:
      ❖ Initial: Prior to initial commissioning of an Equipment;
      ❖ Recommissioning. After relocation of an antenna or installation of a different type of antenna or of transmitting equipment;
      ❖ Categorization: At the time when categorization of an ILS is required.

*c. Periodic:*
   Flight inspections to confirm the validity of the signals-in-space on a regular basis or after major scheduled facility maintenance.

d. *Special*:
   i) Flight inspections required as a result of suspected malfunctions, aircraft accident, etc. Typically, it is necessary to test only those parameters which have or might have an effect on facility performance. However, it may be economically advantageous in many cases to complete the requirements for a periodic inspection.
   ii) Equipment replacement of the same type and configuration as well as placed on locations where the same physical condition, including the location of the antenna, is necessary to conduct a special inspection. Items required for antenna change shall be done to a minimum flight test performance required for the facility. Additional requirements of the inspection are determined jointly by the flight inspector and ground technician.
   iii) Equipment modification, reconfiguration and relocation on a facility that will affect the radiant pattern is subject to a special flight inspection. Changes in type of antenna is classified as reconfiguration. All commissioning inspections shall be carried out in accordance with the reconfiguration of facilities, unless not required by flight inspector and facility maintenance technician.
   iv) Replacement of spare parts or modules affecting the value of parameters need to be determined through flight inspection is subject to a special flight inspection

e. Flight inspections following ground maintenance activities. Certain ground maintenance activities, as well as changes in the ground environment near radiating antenna systems, require a confirming flight inspection. This is because ground measurements cannot duplicate the operational use of the signals in some respects. Although engineering judgement should be used in individual cases to prevent unnecessary costly airborne testing, the following changes typically require a confirming inspection:
   i) a change in the operating frequency;

ii) significant changes in the multipath environment within the antenna pattern limits;
iii) replacement of antenna arrays or antenna elements; and
iv) replacement of radio frequency components, such as bridges, phasers, amplifiers, and cabling, when ground measurements prior to and after the changes are not available, or the results do not support restoration without a flight inspection.

### 1.3.3. Post-Accident/Serious Incident Inspection.

This inspection is carried out at the request of the accident coordinator /investigator to verify that the performance of the system is still eligible to use and can support instrument flight procedures.

a. Follow-up
This inspection is a high priority and shall be implemented as soon as possible

b. The flight inspector shall obtain the following information:
i) Configuration of equipment at the time of the accident, i.e. receiver, transmitter or radar channel under operating conditions.
ii) The use of instrument flight procedures.
iii) Any additional information that helps in the inspection analysis.

c. Inspection Procedure.
i) Coordinate with the facility maintenance technician to configure system according to paragraph b (i).
ii) Complete periodic inspection checklist. Checking is done only on equipment and instrument flight procedures used by the accident/incident aircraft. VOR or orbit track adjustment TACAN (if any) is not necessary. It is strictly prohibited to perform facility adjustment after an accident. Adjustment of equipment shall be performed on separate special conditions inspection.
iii) If the system or procedure does not have periodic inspection requirements, evaluation shall be done on the area where the accident occurred.
iv) Complete any additional materials requested by maintenance technician's facilities, air traffic control personnel (ATC) or accident coordinator / investigator.
v) In cases where the cause of the accident may be related to natural or man-made obstacles on the earth's surface (mountains, buildings etc.), the evaluation shall be done by Aeronautical Study.

d. Confidentiality of accident/incident information.
Any findings on flight inspection or other information related to results of accident/incident investigation shall be restricted and shared only with the approval of the accident Investigator. Flight inspection results shall be submitted to OMAN CAA as soon as possible.

## 1.4. INSPECTION PERIODIZATION

**1.4.1.** Ground Inspection.

a. Periodic ground inspection, shall be conducted with the following periodization:

| SR | Type OF FACILITY | FACILITY FUNCTION | PERIOD |
|---|---|---|---|
| 1. | ILS | LANDING | 2 weeks |
| 2. | VOR | HOMING | 2 weeks |
| | | ENROUTE | 4 weeks |
| 3. | DME | HOMING | 2 weeks |
| | | ENROUTE | 4 weeks |
| | | CO-LOCATED GP-ILS | 2 weeks |
| 4. | NDB | LOCATOR | 2 weeks |
| 5. | NDB | HOMING/CHECK POINT | 4 weeks |
| 6. | RADAR | APPROACH | 2 weeks |
| | | ENROUTE | 4 weeks |
| | COMMUNICATION (VHF) | TOWER, APP, ACC | 4 weeks |
| 7. | PAPI WITH ILS | APPROACH | 2 weeks |
| 8. | PAPI WITHOUT ILS | APPROACH | 4 weeks |
| 9. | VASI | APPROACH | 4 weeks |

Table 1. Periodic Ground Test

b. Special test shall be conducted in accordance with Flight Inspection periodization.

c. Ground inspection shall be conducted using Ground Inspection Form as per attachment A of this document.

**1.4.2.** Flight Inspection**.**

The validity period or periodization of flight inspection is as follows:

| SR | NAME OF FACILITY | FACILITY FUNCTION | FLIGHT INSPECTION PERIOD |
|---|---|---|---|
| 1 | ILS | LANDING | 6 Months |
| 2 | VOR | HOMING/ENROUTE | 12 Months |
| | DVOR | HOMING/ENROUTE | 3 Years |
| 3 | DME | CO-LOCATED VOR | 12 Months |
| | | CO-LOCATED DVOR | 3 Years |
| | | CO-LOCATED ILS | 6 Months |
| 4 | NDB | LOCATOR | 6 Months |
| 5 | | | |
| 6 | NDB | HOMING/CHECK POINT | 12 Months |
| 7 | RADAR | APPROACH | If Required |
| | | ENROUTE | If Required |

| SR | NAME OF FACILITY | FACILITY FUNCTION | FLIGHT INSPECTION PERIOD |
|---|---|---|---|
| 8 | COMMUNICATION (VHF) | TOWER, APP, ACC | If Required |
| 9 | PAPI WITH ILS | APPROACH | 6 Months |
| 10 | PAPI WITHOUT ILS | APPROACH | 12 Months |
| 11 | VASI | APPROACH | 12 Months |

Table 2. Periodic Flight Inspection

## 1.5. PRIORITY OF FLIGHT INSPECTION

Table 3 lists the priority of flight inspection to determine which mission will be conducted first when two or more requirements are competing for limited flight inspection resources (flight crew/aircraft/ground engineer or technician).

| Priority | Type of Service |
|---|---|
| 1A | Accident/Serious Incident Investigation and any facility which has exceeded its inspection interval |
| 1B | Restoration of a commissioned facility after an unscheduled outage and restoration of CAT II/ III ILS approach |
| 1C | Flight inspection of reported malfunctions or corrupted of the signal -in-space |
| 2A | Commissioning inspection of new facility or new instrument flight procedure |
| 2B | Periodic Inspection |
| 3A | Site Evaluation |
| 3B | Other Investigation |

Table 3. Flight Inspection Priority List

## 1.6. GRACE PERIOD for PERIODIC FLIGHT INSPECTION

Air Navigation Service Provider shall ensure that flight inspection of a commissioned Ground NAVAID shall be completed within the grace period of 14 days calendar from the due date of Flight inspection.

During the grace period of up to 14 calendar days, the ANSP shall demonstrate that the facility continues to operate within the specified performance tolerances, system monitoring remains normal, no unresolved safety concerns exist, and any required operational limitations or NOTAM actions have been implemented, where applicable.

## 1.7. EXTENTION OF FLIGHT INSPECTION PERIOD

In case flight inspection can’t be conducted within the grace period due to unforeseen circumstances e.g. technical and/or operational issue, then ANSP shall submit a proposal to Authority requesting approval for the extension of the Flight Inspection period.

Periodic flight inspections for NAVAID equipment may be extended by the authority up to the following provisions:

a. For instrument of ILS (Instrument Landing System) a period of extension up to 3 months;

b. For VOR equipment (Very High Omnidirectional Range) as homing facility function a period of extension up to 3 months;

c. For DME equipment (Distance Measuring Equipment) as homing facility function a period of extension up to 3 months;

d. For VOR equipment (Very High Omnidirectional Range) as en-route facility function a period of extension up to 6 months;

e. For DME equipment (Distance Measuring Equipment) as en-route facility function a period of extension up to 6 months;

f. For NDB equipment (Non-Directional Beacon) as locator a period of extension up to 3 months;

g. For NDB equipment (Non-Directional Beacon) as homing/check point period of extension up to 6 months;

h. For PAPI equipment (Precision Approach Path Indicator) a period of extension up to 3 months;

i. For VASI equipment (Visual Approach Slope Indicator) a period of extension up to 6 months.

Any request to extend a flight inspection interval shall include the reason for delay, facility criticality, reliability history, recent ground inspection results, monitor status, failure history, operational impact, risk assessment, proposed mitigation, NOTAM/AIP action if applicable, and the requested extension duration.

During the extension of Flight Inspection Period, ANSP shall:

a. Conduct periodic Ground Inspection as mentioned in paragraph 1.3 (a) using Ground Inspection Form as shown in Attachment A of this Manual.

b. submit the Ground Inspection result of related facility to the Authority as reference to review and evaluate the performance of facility during the proposed extension period;

c. Continue in Conducting the maintenance activities according to the maintenance plan for the facility, as well, the record the test result and monitor readings of critical parameters to indicate that the equipment consistently meets performance requirements.

d. Issue a NOTAM stating that the status of facility as:

“[Facility Name] Operating but ground checked only, awaiting flight Inspection”

When issuing the NOTAM, the ANSP shall indicate the validity period of the NOTAM according to the approval issued by the Authority.

As it cannot be guaranteed that an “Operational Status” is always received after flight inspection, it is suggested that the ANSP publish the time frame as an estimated period and include the letters EST after the expiry date and time of the NOTAM. In such cases the ANSP is required to coordinate with the NOTAM Office (NOF) prior to the expiry time advising if the NOTAM requires extension, cancellation or replacement with new criteria (i.e. if the facility returns to operation or is turned off etc.).

If the ANSP does not include the EST letters in the NOTAM, the NOTAM will automatically cancel at the expiry date and time, and the status of the facility will not be correctly notified to users.

Note: It is the responsibility of the ANSP to ensure the status of the NAV-AID is correctly published and to ensure the correctness of all NOTAM.

### 1.7.1. FLIGHT INSPECTION AT NIGHT

Flight inspection may be conducted at night only in certain areas which have high densities of air traffic during daylight hours. The following additional factors shall be considered for night-time flight inspection:

a. Effect of the environment on the radiated signal. The signals radiated by some types of radio navigation aids are affected by propagation which differs between day and night.

b. Effect of environment on the navigation aid. The ground facility maintenance technician/ engineer should inform the flight inspector of any equipment variations, such as field monitor performance which may change at night. The effects of the local environment, such as changes in the position of reflecting obstacles, shall be considered.

c. Position reference. Flight inspection at night may use an independent reference system including ground tracking equipment.

d. Evaluation of results. The flight inspector should indicate if there are differences from expected measurements and indicate if these differences are caused by night conditions, problems with the equipment or making the measurements at different positions.

e. Flight inspection reports. The flight inspection report should indicate whether the inspection was made at night.

f. Types of flight. The inspection flights shall be made in accordance with the guidance given in this manual, with the exception of measurements that specifically need low-level flights. It is recommended that at specific intervals an inspection is made under the same conditions as prevailed at the time of commissioning.

g. Safety of flight. Flights should be conducted 300 m (1000 ft.) above the level normally used for daytime flight inspection in areas with terrain or obstacles. It will be necessary to change some horizontal distances in order to retain the same vertical angle from the navigation aid, where this is important to the measurements. Low-level below path (safety approach) glide path inspection flights should not be made during the night or when the level of natural light is low. Flights should normally be carried out in accordance with VFR.

## 1.8. UNIT OF MEASUREMENT

Units of measurement used in flight inspection, reporting and publication actions shall be consistent with the applicable national requirements and ICAO Annex 5 conventions, unless otherwise approved by the Authority, are as follows:

| Term | Reference |
|---|---|
| Distance<br><br><br>Airspeed and Groundspeed | Nautical Mile<br>1 NM = 1.850 m<br>1 NM = 1.151 M<br>Knots |
| Bearing, Heading, Azimuth Radial, Direction Information and Instruction<br>Altitudes | Magnetic North<br><br>Absolute |

**INTENTIONALLY LEFT BLANK**

# 2. FLIGHT INSPECTION CREW AUTHORITY AND OBLIGATIONS

## 2.1. THE AUTHORITY OF FLIGHT INSPECTION CREW

The Flight inspection crew has the authority to:

a. Carry out flight inspections of Radio Navigation Aids (NAVAIDS) to determine that the navigation service meets tolerance set out in this manual, and the facility may support flight procedures.

b. Report any hazard conditions during flight inspection.

c. Take action in accordance with the procedure.

d. Review, verify, and customize topography, patterns and data barriers (roads, railways, antennas, towers, power lines, rivers, urban areas, etc.) contained on the flight map to evaluate the accuracy and usability of navigation aids.

e. The flight inspection crew shall identify and report the technical performance and recommended facility status. Operational restrictions, NOTAM action and regulatory acceptance shall be processed in accordance with approved ANSP and Authority procedures.

## 2.2. THE OBLIGATION OF FLIGHT INSPECTION CREW

The Flight Inspector’s responsibility is limited to:

a. Prior to inspection, the flight crew, ATC unit and ground maintenance personnel shall agree the inspection plan, communications, test configurations, airspace/altitude requirements, test-signal safeguards, termination criteria and post-inspection reporting arrangements;

b. Conducting flight inspections in accordance with the procedures established by this manual;

c. Determining the adequacy of the system to meet its required functions;

d. Analyzing and evaluating the flight inspection data to enable a status classification to be assigned;

e. Certifying the signal-in-space of a NAVAID in accordance with the tolerances prescribed in this manual;

f. Reporting the flight inspection results and status of the system to the ANSP;

g. Providing the technical details for NOTAMs based on the flight inspection data;

h. Verifying the accuracy of NOTAMs and published information related to facility status;

i. Inspecting the flyability of instrument procedures prior to their publication;

j. Optimizing facility performance during flight inspections requiring adjustments by coordinating with the ground engineer or technician;

k. Flight inspection personnel shall maintain their qualification, Authorization, currency and competency for the facility type and inspection scope.

**INTENTIONALLY LEFT BLANK**

# 3. GENERAL FLIGHT INSPECTION PROCEDURES

The order of activities of the flight inspection implementation in general as follows:

1. Pre-Flight Inspection.
2. Preparation before Flying
3. Flight inspection.
4. Analysis and Evaluation.
5. Flight inspection review and Reporting
6. Post Flight Inspection

## 3.1. PRE-FLIGHT INSPECTION

### 3.1.1. Status of Facility

Flight inspection shall not be conducted unless the facility is installed, ground-checked, and operating within the declared configuration, except where the approved inspection scope is specifically a site evaluation, investigation or special inspection

### 3.1.2. Notification

a. The flight inspection service provider shall notify the Air Navigation Service Provider about the Flight Inspection plan and Estimate Time Arrival (ETA) of aircraft.
b. The flight Inspection Service Provider shall coordinate with ANSP for any other notifications that are required for the purpose of flight inspection i.e. field evaluation, commissioning, periodical with monitors or inspections that require the support of the ground technician or maintenance personnel.
c. Regular inspection of ILS without a monitor does not require initial coordination with the maintenance personnel. This inspection shall be carried out on transmitters that are in operation. If there is nonconformity with tolerance, the flight inspector shall inform the maintenance personnel and conduct flight inspection for back up or standby equipment. Where a nonconformity affects or may affect operational use, coverage, IFP minima, ILS category, facility availability or user safety information, the ANSP shall initiate NOTAM or other approved publication action without delay.

## 3.2. PREPARTION BEFORE FLYING

Understanding between maintenance personnel and Flight Inspection crew is crucial to support the smoothness of flight inspection. Coordination shall be established between Flight inspection crew and maintenance personnel at times before, during, and after flight inspection.

The flight inspection crew shall give directions to the maintenance personnel about important steps taken before implementation of flight inspection or commissioning and for special circumstances.

Efficiency and smoothness of Flight Inspection require good preparation before flying and actions from maintenance personnel. These preparations include:

a. Provide the applicable CNS facility data, including the facility configuration, coordinates, assigned frequencies/channels, monitor parameter settings, previous inspection or flight inspection results, applicable operational limitations or NOTAMs.

b. Prepare two-way radio communications equipment and resources at facility locations.

c. Ensure that the facility is in normal operation and all parameters are in tolerance according to technical specification requirement.

d. Ensure the presence of qualified technician to perform corrections and adjustments.

e. Prepare the means of transportation to transfer the calibration equipment and personnel.

f. Prepare accurate facility data for new facilities or relocated.

The following actions shall be conducted by Flight Inspection crew prior to flight inspection:

a. Ensure that all flight inspection equipment has been calibrated and can be operated.

b. Gives direction to the maintenance personnel and/or ground technician.

c. Gives direction to the crew of the calibration aircraft.

d. Set up maps, charts, tools, data sheets, etc.

e. Review the status, limitations, and characteristics of the facility. Ensure that the publication and recording of results from flight inspections which applicable previously, and all the restrictions applied were accurate.

f. Providing direction to Air Traffic Control (ATC) personnel about the areas and altitude used for flying maneuvers during flight inspections and possible changes.

## 3.3. FLIGHT INSPECTION

Flight inspection shall be carried out according to the procedures in this manual.

The following shall be considered during the flight inspection implementation:

**a.** Expert. During the flight inspection, qualified personnel shall be assigned to avoid errors of equipment performance.

**b.** Standby Equipment. This is required to identify which system or transmitter is operating so that the performance of each such equipment can be tested. If one unit of dual equipped facility is found not according to tolerance, then the out of tolerance unit shall be identified and shall not be used in the service. The unit can be identified as transmitter number 1 or 2. Channel A or B, serial number, etc.

**c.** Standby Power. During the commissioning /flight inspection. flight inspector shall check the facility with the standby power (if it is installed with standby power), to ensure that performance of the facility does not decrease with the standby power system and ensure that all parameters are in tolerance. If the

standby power is installed after flight commissioning / flight inspection, then flight inspector shall check the facilities with standby power on next flight periodic inspection.
The examination of standby power is not required for facilities equipped with batteries which are constantly supplied by other resources.

Standby power replacement doesn't requires re-inspection.

**d.** Philosophy in the field. If in the implementation of flight inspection, it is found that parameters that do not meet the standards and tolerance, the flight inspector should provide assistance to the ground engineer to attempt to resolve the issue.

**e.** Restrictions. When the facility parameters do not meet the tolerance or existing standards, flight inspector shall carry out an inspection to determine the area that can be used by the facility. This data is used as a basis for restriction, NOTAM, or to re-create a procedure.

**f. Limitations of spectrum management. Facilities set in the limitation of spectrum management is classified as "Restricted" and shall be identified in the facility data sheet. This restriction still applies although there is no disruption to facility performance. It is not allowed to remove the limitation of spectrum management that based on the results of the flight inspection.**

**g.** Incomplete Inspection. In case, the commissioning inspection of the facility shall be terminated before completing all the flight inspection procedure due to aircraft damage, weather, etc., flight inspection crew shall discuss the condition of the facility under inspection.

i. If the facility maintenance manual allows setting parameters without flight inspection, and there are insufficient references on previous flight inspection, the equipment can be used in the service. This inspection is classified as incomplete inspection until the procedure of flight inspection completed.

ii. If there is an item on the flight inspection checklist that cannot be set according to the tolerance limit, the inspection shall be stopped. The status of facilities is changed to "unusable", and Inspections are classified as incomplete inspection until the rest of the flight inspection procedure are completed.

h. Any deviation from the approved flight inspection plan, test configuration or required procedure shall be recorded, justified, coordinated with the relevant operational unit and assessed for impact on the validity of the inspection result.

## 3.4. ANALYSIS AND EVALUATION

Flight inspection data shall be analyzed and evaluated during the implementation of flight inspection in accordance with the value of tolerance which are set forth in this manual. Recording which is done during the flight inspection shall be entered permanent into a facility performance record data.

Flight inspection recording data is created and provided to maintenance technicians for technical analysis purpose. Aeronautical telecommunication service provider shall maintain the flight inspection recording data.

Setting Omni-directional facility (VOR, TACAN, DF, NDB, etc.) shall be calculated through the addition of algebra. The azimuth reference (AFIS, Theodolite, map) should always be positive (+), and the azimuth reference of ground facilities shall always be negative (-). So, if the VOR radial receiver is 090.5 and the AFIS / theodolite position 090.0, then error at facility -0.50. Setup errors can also be understood i. e clockwise (positive) and counterclockwise (negative).

## 3.5. POST-FLIGHT INSPECTION

After completing the flight inspection, flight inspection crew shall perform the following actions:

a. Advise the maintenance technician/engineer about the result of flight inspection. Flight inspection of all facilities shall be reported to authorized personnel.
b. Setting Facility status. Flight inspection shall set status facilities (see. 3.5.1.1). Flight inspection also shall notify all notes about the status of the facility to authorized personnel.
c. Preparing flight inspection report. Flight inspection reports shall be accurate and clear in describing performance and facilities characteristics. Report shall be completed in accordance with this Manual (see 3.5.1.2).

### 3.5.1. Flight Inspection Result (Classification), Certificate and Report

**3.5.1.1.** Flight Inspection Result.

The result of facility flight inspection shall be an operational status of facility, and classified as follows:

a. *Usable*; Available for the operational use, defined as:

   1) *Unrestricted*: Providing safe, accurate signals-in-space conforming to established standards within the coverage area of the facility.

   2) *Restricted*: Providing signals-in-space not conforming to established Standards in all respects or in all sectors of the coverage area, but safe for use within the restrictions defined. The facility that may be unsafe shall not be classified as limited or restricted under any circumstance.

b. *Unusable;* Not available for operational use as providing (potentially) unsafe or erroneous signals, or providing signals of an unknown quality

The operational status of the facility as mentioned in above paragraph shall be determined by the Authority.

The status determination by authority shall be referred to judgement (by the pilot) of the flyability of the signal-in-space, analysis of airborne measurements of the facility by flight inspector and the statement of readiness by authorized ground maintenance personnel of ANSP.

The flyability of the instrument procedures is assessed as part of the validation activity conducted in accordance with the *Quality Assurance Manual for Flight Procedure Design* (Doc 9906), *Volume 5 — Validation of Instrument Flight* The facility status classification and NOTAM indicate the boundaries that can be applied to the facility. The facility status classification shows facility performance in general based on flight inspection results. This classification only intended for maintenance and / or facility users. NOTAM is required to inform the user of any restrictions on the facility.

When the range of equipment cannot be checked according to the standard the volume of flight inspection services due to state borders or limited airspace, this facility shall be classified as Restricted, with notes on reports to fly a limited range due border of the country. NOTAM and publication actions shall indicate facilities as unusable in areas is not inspected.

**3.5.1.2.** Flight Inspection Report

The flight inspection report serves as the basic means of documentation and dissemination of the results of each flight inspection. The flight inspector in charge is responsible for initiating the report and ensuring that it clearly records the results of each parameter measured, along with an assessment of the conformance of the facility performance to the required standards. This assessment will normally involve an analysis of the data recordings and a review of the computer-aided analysis carried out on the data gathered during the inspection.

Flight inspection reports should allow for "before" and "after" results to be entered into routine documentation of the adjustments made to the facilities

Flight inspection reports shall contain the following minimum information:

a. General information with basic report, crew and facility items, such as:

(1) date(s) of inspection and next inspection due
(2) type of inspection, e.g. routine, annual, commissioning, site proofing and special;
(3) name and facility designation;
(4) facility identification, frequency assigned, nominal angle and nominal width (for ILS)
(5) manufacturer and type of system being inspected
(6) Type of antenna of system being inspected
(7) category of operation (facility);
(8) serial number of report/unique identifier;
(9) aircraft registration;
(10) wind conditions, to allow crosswind to be established;
(11) names and functions of all personnel involved in the inspection;

b. Method of making each measurement (where alternatives are available); these may be referenced to the operating instructions;

c. Results and tolerances;

d. Details of associated attachments, e.g. recordings (chart or graph)

e. Details of extra flights made necessary by system adjustments;

f. Assessment by the flight crew of the navigation facility performance;

g. Comments by the flight inspector;

h. Details of any immediately notifiable deficiencies;

i. Status section indicating the operational status of the facility;

j. Statement of conformance/nonconformance; and

k. Signatures of appropriate personnel.

To reduce transcription errors, the report shall be computer-generated by the flight inspection system and include explanation of events, remarks and status of the equipment.

From the inspection report it shall be possible to trace back the utilized facility database settings, system calibration, antenna calibration diagrams, antenna lever arm corrections, cable loss and all relevant data involved in or related to the calculations used.

Flight Inspection Service Provider shall submit Flight Inspection Interim/preliminary Report to the Air Navigation Service Provider and Authority after completion the flight inspection, before leaving the site.

**3.5.1.3.** Final Flight Inspection Report

The Final Flight Inspection Report shall be finalized after due consideration and incorporation, as appropriate, of any comments on the flight inspection results provided by the Service Provider and/or the AuthorityFlight Inspection Certificate

Flight Inspection Certificate shall be provided by Flight Inspection Service Provider as summary of the implementation of flight inspection including performance and operational status for each flight navigation facility.

Flight Inspection certificate shall content minimum the following information:

a. basic identification items such as the aircraft tail number, facility name, facility identifier, frequency, category and type of inspection, date and time of inspection, names of the pilot and engineer or technician;
b. an assessment reference conducted by the flight crew of the navigation facility performance;
c. comments by the flight inspector/equipment operator;
d. details of any immediately notifiable deficiencies;
e. statement of conformance/nonconformance; and
f. signatures of appropriate personnel.

The Final Report as well as Flight Inspection Certificate for the facility shall be submitted by Flight Inspection Service Provider to Air Navigation Service Provider and Authority within 14 working days after completion of the Flight Inspection.

**3.5.1.4.** NOTAM of Facility

a. The NOTAM of Facility Status.
   (1) Air Navigation Service Provider shall immediately draft NOTAM action whenever there is cause of the facility classification to be restricted (Restricted) or revised from previous status.
   (2) NOTAM of facility shall include name, type, component, and area/height that cannot be used. The absence of elevation information or special distances will refer to all the altitude and distance available; it is important to enter the information certain to avoid confusion.
   (3) A NOTAM shall be issued if the restriction will affect instrument flight procedures, minimum approach, or ILS category authorization (CAT) II or III.
   (4) Air Navigation Service provider shall verify that the NOTAM issued is appropriate and correct and published in the publication.
b. Notification of Change of Status
   (1) Notification of a permanent change of the facility status is to be done through

the appropriate Aeronautical Information Publication (AIP); differences from Standards are to be notified to ICAO and in the AIP.

(2) Notification of temporary changes in the status of facilities are to be promptly and efficiently declared. A change in the status of a commissioned facility as a direct result of ground or flight inspection procedures and resulting in a change of operational status ("unrestricted/restricted/unusable") or "unusable" designation, shall be advertised immediately by air traffic control (ATC) personnel, and promptly by a Notice to Airmen (NOTAM).

(3) A facility having an "unusable" status shall be removed from service and can operate only for test or troubleshooting purposes. In such cases the facility identification shall be transmitted as TST

(4) Particular attention shall be given to periodic or corrective maintenance procedures that involve false guidance signals being temporarily radiated. These conditions shall be coordinated with ATC and promulgated to users by NOTAM, before the procedures commence.

c. Out-of-Tolerance backup equipment.

If one of the transmitters (of dual system equipment) has out of tolerance parameters, the normal operation transmitter can be operated without NOTAM. However, the NOTAM data describing the restriction shall be reserved for maintenance technicians/engineer. In case of limited transmitter Is used, the operation may issue a NOTAM.

d. Restricted Facilities.

The following rules shall be used in preparing NOTAM of facility Restrictions:

(1) Describe Radials or unusable bearing.
(2) Describes height and distance that cannot be used.
(3) VOR / DME / DF / NDB
Draw a radial / bearing from station in a clockwise direction (CW) direction, altitude in terms of at above and below an MSL altitude, and distance in terms of outside or inside in units of nautical miles (nm).
(4) Localizer / LDA / SDF / TLS azimuth.
Draw laterally in terms of degree of left or right inbound only and within nm of the threshold if effect of signal limitation limits can be used closest to the threshold limit. Use the distance (in nm) of the antenna to illustrate the restriction which affects the distance the facility uses. Describe the height in the above or below the height (MSL). Additional reference of DME distance can be used if DME is part of SIAP.
(5) Glide Slope / TLS Elevation.
Draw in degrees left or right only and inbound nm from threshold. Limitations related to altitude shall be in above or below of the MSL height. Make sure it is correct reflecting restrictions on the volume of the original service. Additional reference to DME

**3.5.1.5.** Record Retention

a. The interim and final flight inspection reports, raw data (where applicable), flight inspection certificates, operational restrictions, and corrective action records shall be retained in the approved records management system.

b. As a minimum, all flight commissioning reports and associated data recordings shall be retained in the facility records, together with the flight commissioning reports and associated data recordings for the preceding five years.

c. Records of periodic flight inspections shall be retained for a minimum of the five most recent periodic flight inspections for each facility.

d. Deficiencies identified during flight inspection shall be tracked to closure by the responsible service provider and made available to the Authority upon request.

### 3.5.2. INSTRUMENT FLIGHT PROCEDURE

The flyability of the instrument procedure of Ground NAV-AID is assessed as part of the flight validation activity conducted in accordance with Quality Assurance Manual for Flight Procedure Design (Doc 9906), Volume V – Validation of Instrument Flight Procedure.

The flight inspection crew shall coordinate with the ANSP if the restrictions on NAVAIDs may have an effect on the published instrument's flight procedures. The Specialist procedures shall:

a. Determine the impact of published instrument flight procedures.
b. Initiatives to propose NOTAMs for amendment or change delay the procedure.
c. Evaluating the NAVAID restrictions to determine whether such limits will have an effect on the instrument flight procedure.

**INTENTIONALLY LEFT BLANK**

# 4. VERY HIGH FREQUENCY OMNIDIRECTIONAL RADIO RANGE (VOR)

This part provides guidance on the flight inspection requirement applicable to both CVOR and DVOR type VHF Omnidirectional Range (VOR). Since the means by which VOR signals are produced vary from one manufacturer to the other, broad guidelines are provided and adaptation to specific equipment will be required.

## 4.1. GENERAL

VORs should meet all requirements to be classified as unrestricted. The Air Navigation Service Provider shall, after proper coordination, prescribe the use of the facility on a restricted basis and issue Notice to Airmen (NOTAM) accordingly when a specific area of a facility does not meet these operating tolerances.

## 4.2. FLIGHT Inspection performance parameter.

Summary of VOR Flight Inspection Requirement is listed in Table 4.

| *Parameter* | *Annex 10, Volume I, reference* | *Doc 8071, Volume I, reference* | *Measured* | *Tolerance* | *Uncertainty* | *Inspection type* |
|---|---|---|---|---|---|---|
| **Rotation** | **3.3.1.1** | **2.3.4** | **Clockwise** | **Correct** | | **C, P, S** |
| **Sensing** | **3.3.1.3** | **2.3.3** | **Correctness** | **Correct** | | **C, P, S** |
| **Polarization** | **3.3.3.1** | **2.3.5** | **Deviation** | **±2.0°** | **0.3°** | **C, P, S** |
| **Pattern**<br>**accurac**<br>**y**<br>**Alignme**<br>**nt**<br>**Bends (PFE/PFN)**<br>**Roughness and scalloping (CMN)**<br>**Flyability** | **3.3.3** | **2.3.9 to 2.3.11**<br>**2.3.12 (2.3.47)**<br>**2.3.13 (2.3.47)**<br>**2.3.14** | **Deviation** | **±2.0°**<br>**±3.5°**<br>**±3.0°**<br>**Flyable** | **0.6°**<br>**0.6°**<br>**0.3°**<br>**Subjective** | **C, P, S** |
| **Coverage**<br>**Power density or field strength** | **3.3.4** | **2.3.15**<br>**2.3.16** | **Power density** | **-107 dBW/m²**<br>**(90 µV/m)***<br>**At limits or operational requirements**<br>***(recommendation)** | **3 dB** | **C** |
| **Modulation**<br>**9 960 Hz modulation (VOR without voice modulation)**<br>**9 960 Hz modulation (VOR with voice modulation)**<br>**30 Hz modulation** | **3.3.5** | **2.3.17** | **Modulation depth up to 5º elevation** | **See Note.**<br>**20 to 55%**<br>**20 to 35%**<br>**25 to 35%** | **1%** | **C, P, S** |
| **Modulation**<br>**30 Hz FM**<br>**deviation ratio**<br>**CVOR**<br>**DVOR (below 5º elevation) DVOR (5º to 40 º elevation)** | **3.3.5** | **2.3.17** | **Deviation ratio** | **16 ±1°**<br>**16 ±1°**<br>**>11°** | | **C, P** |
| **Voice channel** | **3.3.6.2** | **2.3.18** | **Clarity** | **Clear** | | **C, P** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Identification** | **3.3.6.5** | **2.3.20**<br>**2.3.21** | **Clarity** | **Clear** | | **C, P** |
| | | | | | | |
| **Speech effect on navigation Bearing**<br>**Modulation** | **3.3.6.7** | **2.3.19** | **Deviation**<br>**Modulation** | **No effect** | **0.3°**<br>**1%** | **C, P** |
| **Bearing monitor** | **3.3.7.1** | **2.3.22 to 2.3.25** | **Deviation** | **±1.0°** | **0.3°** | **C** |
| **Reference checkpoint** | | **2.3.26 to 2.3.27** | **As required** | | | **C,P** |
| **Standby Power** | | **2.3.28 to 2.3.29** | **Normal operation** | | | **C,P** |
| **Standby Equipment** | | **2.3.30** | **As required** | | | **C,P** |

**Table 4. Summary of VOR Flight Inspection Requirement**

*Note. — When modulation is measured during Flight inspection under strong dynamic multipath conditions, variations in the received modulation percentage are to be expected. Short-term variations beyond these values may be acceptable.*

*Legend: C = Commissioning*
*P = Periodic as per flight inspection periodization 1.3 (b)*
*S = Site proving*

## 4.3. FLIGHT INSPECTION PROCEDURE

### 4.3.1. SENSING

This check is required at the beginning of the flight inspection and need not be repeated. The bearing of the aircraft from the station shall be known. Select an appropriate radial and when the cross-pointer is centered, the indicator should indicate “FROM”.

### 4.3.2. ROTATION

Begin an orbit. The radial bearing as indicated should continually decrease for a counterclockwise orbit or increase for a clockwise orbit. Sensing should be checked before rotation. Incorrect sensing might cause the station rotation to appear reversed.

### 4.3.3. POLARIZATION EFFECT

The polarization effect results from vertically polarized RF energy being radiated from the antenna system. The presence of undesired “vertical polarization” should be checked by the “attitude effect” and may be further investigated by either the “360” turn method” or the “heading effect” method.

### 4.3.4. ATTITUDE EFFECT METHOD

The vertical polarization effect should be checked when flying directly to, or from, the facility, at a distance of 10 to 20 NM. The aircraft should be rolled to a 30” bank, first to one side, then to the other, and returned to a straight level flight. Track and heading deviations should be kept to a minimum. Course deviation, as measured on the recording, is the indication of vertical polarization effect.

### 4.3.5. 30° BANK, 360° TURN METHOD

a. Vertical polarization maybe checked by executing a 30° bank, 360° turn, 18.5 to 37 km (10 to 20 NM) from the antenna. The turn should begin from an “on-course” (toward the station) position over a measured ground checkpoint.

b. The recording should be marked at the start of the turn and at each *90*° of heading change until the turn is completed. The turn should be completed over the starting point and the recording marked. The recording should show a smooth departure from and return to the “on-course’’ position, deviating only by the amount that the aircraft is displaced from the original starting point when the vertical polarization effect is not present. Other excursions of the cross-pointer may be attributed to the vertical polarization effect. The effect of the wing shadowing the aircraft antenna should be considered in evaluating the recording

### 4.3.6. PATTERN ACCURACY

**4.3.6.1.** Alignment

a. Alignment can be determined by flying an orbit or by flying a series of radials. The altitude selected for the flight should place the aircraft in the main lobe of the VOR.

b. The orbit should be flown at a height and range that allows the position reference system to accurately determine the position of the aircraft. This will require low, close-in orbits for theodolite-based position systems. Other automated systems will require the orbits to be conducted at a greater range to achieve the required accuracy. The orbit should have sufficient overlap to ensure that the measurement covers the complete 360°. The alignment of the VOR is determined by averaging the error throughout the orbit. Judgement may be exercised where the tracking of the orbit is interrupted to determine the effect of the lost information on the average alignment.

c. Alignment can also be determined by flying a series of radial approaches. These approaches should be conducted at equal angular displacements around the facility. A minimum of eight radials is considered necessary to determine the alignment of the VOR.

**4.3.6.2.** Bends

A bend is determined by flying a radial pattern and comparing the indicated course against a position reference system. The error is measured against the correct magnetic azimuth of the radial. Deviations of the course due to bends shall not exceed 3.5° from the computed average course alignment and shall remain within 3.5° of the correct magnetic azimuths.

**4.3.6.3.** Roughness and scalloping error

**a.** Scalloping is a cyclic deviation of the course line. The frequency is high enough so that the deviation is averaged out and will not cause aircraft displacement. Roughness is a ragged irregular series of deviations. Momentary deviations of the course due to roughness, scalloping or combinations thereof should not exceed 3.0" from the average course.

**b.** One way to systematically define and measure VOR accuracy is to consider that scalloping and roughness correspond to control motion noise (CMN) while bends and alignment errors are linked to path following error (PFE) and path following noise (PFN), where CMN, PFE and PFN are defined as the outputs of different filters. In order to filter short duration disturbances, a 40-second sliding window technique may be applied to the resulting filtered error components.

The default tolerances are applied as:
**— Bias or Alignment: ± 2°**
**— PFE and PFN: ± 3.5°**
**— CMN: ± 3°**

**4.3.6.4.** Flyability

Flyability is a subjective assessment by the pilot flying the inspection. Assessment of flyability shall be performed on operational radials and during procedures based on the VOR, using the VOR as the track guidance source

**4.3.7. COVERAGE**

a. Coverage of the VOR is the usable area within the operational service volume and is determined during the various checks of the VOR Additional flight checks are required to determine the distance from the facility at which satisfactory coverage is obtained at the specified altitudes.

b. The coverage of a VOR can be affected by factors other than signal strength. Where out-of-tolerance roughness, scalloping, bends, alignment, and/or interference render the facility unusable in certain areas, a restriction should result which should be handled in the same manner as restricted coverage due to lack of signal.

### 4.3.8. MODULATION

The modulation of the 30 Hz reference, 30 Hz variable and 9 960 Hz subcarrier shall be measured during the flight inspection. Note that the roles of the FM and AM signals are reversed between the CVOR and the DVOR.

### 4.3.9. IDENTIFICATION

a. The identification signal shall be inspected for correctness, clarity, and possible detrimental effect on the course structure. This check should be performed while flying on-course and within radio line-of-sight of the station. Observe the course recording to determine if either code or voice identification affects the course structure. If course roughness is suspected, the identical track shall be flown again with the identification turned off. Maintenance personnel shall be advised immediately if it is determined that the course characteristics are affected by the identification signal.

b. The audible transmission of simultaneous voice/code identification signals shall appear to be equal in volume to the user. The voice identification is not utilized during ground-to-air broadcasts on the VOR frequency, but the coded identification shall be audible in the background.

### 4.3.10. BEARING MONITOR

The requirements for checking the monitor are as follows:

a. during commissioning inspections; and
b. during subsequent inspections, if the alignment at the reference checkpoint has changed more than one degree from the alignment last established and the monitor has not alarmed

The check is made over the reference checkpoint at the same altitude as that used to establish the reference checkpoint. Position the aircraft inbound or outbound and activate the event mark exactly over the checkpoint while the following course condition exists:

a. with the course in the normal operating condition;
b. with the course shifted to the alarm point;
c. with the course shifted to the alarm point to the opposite direction from b) above; or
d. with the course returned to the normal operating condition.

The course alignment shall be compared, in each of these conditions, by reference to the recordings to determine the amplitude of shift to the alarm point and to verify the return to normal.
Check both transmitters in the same manner when dual monitors are installed. Both should be checked on a systematic basis. Follow the procedure for single monitor check above, except in steps b) and c) the course should be shifted in each direction until both monitors alarm. Determine the amplitude of course-shift required to alarm both monitors

### 4.3.11. REFERENCE CHECKPOINT

A checkpoint shall be selected during the commissioning inspection on or close to the monitor radial (usually 090 or 270 degrees) and located within 18.5 to 37 km (10 to 20 NM) of the antenna. This checkpoint shall be used in establishing course alignment and shall serve as reference point for subsequent inspections of alignment, monitors, course sensitivity and modulation measurements. Course alignment and sensitivity shall normally be adjusted with reference to this checkpoint. Adjustments made elsewhere will require a re-check of these parameters at this reference checkpoint.

The flight inspector shall record a description of the reference checkpoint that includes the azimuth to the nearest tenth of a degree, the distance from the facility, and the mean sea level (MSL) altitude, which is usually 460 m (1 500 ft) above the antenna. This data shall be revised any time the reference check point is re-established.

The final course alignment error, measured at the reference checkpoint, shall be recorded on the facility data sheet for subsequent reference in order to determine the necessity for a complete monitor check.

### 4.3.12. STANDBY POWER.

Stand by power, when installed, shall be checked during the commissioning inspection.

The following items shall be evaluated while operating on standby power:

a. course alignment (one radial);
b. course structure; and
c. modulations.

The inspections are to be performed when flying a portion of a radial with the station operating on normal power and then repeating the check at the same altitude and over the same ground track with the station operating on standby power.

### 4.3.13. STANDBY EQUIPMENT

Both transmitters shall be checked against each required item of Table 4. These checks may be performed using radial flights and a single alignment orbit.

### 4.3.14. COMPLEMENTARY FACILITY.

Facilities associated with the VOR that complement operational use (such as marker beacons, DME, lighting aids that support the visibility minima of an approach procedure, communications, etc.) shall be inspected concurrently with the VOR and in accordance with applicable procedures.

### 4.3.15. EVALUATION OF OPERATIONAL PROCEDURES.

#### 4.3.15.1. Radials

Radials used, or proposed for use, for IFR shall be inspected to determine their capability to support the procedure. On commissioning inspections, a selection of radials proposed for IFR use shall be inspected. The selection shall be based on the following criteria:

a. All radials supporting instrument approach procedures shall be selected.
b. Radials shall be selected from areas of poor performance indicated by the orbit inspection.
c. Any radials where the coverage may be affected by terrain shall be selected.
d. At least one radial should be selected from each quadrant, if appropriate. In general, this should include the longest and lowest radials.
e. Routine inspection requirements are contained in the following paragraphs.

**4.3.15.2.** En-route radials (airways, off-airway routes, substitute routes)

En-route radials shall be flown either inbound or outbound, along their entire length from the facility to the extremity of their intended use, at the minimum altitude for the associated airway or route as published. The minimum altitude for flying en-route radials, predicated on terminal facilities, is 300 m (1 000 ft) above the highest terrain or obstruction along the radial to a distance of 46.3 km (25 NM). The aircraft shall be flown on the electronic radial and the position of the aircraft shall be recorded using a position reference system.

Reference, variable and 9 960 Hz modulations and the vertical polarization effect shall be checked at least once on each airway and direct-route radial. Signal strength, course deviation and aircraft position should be recorded throughout the radial flight.

Course structure and alignment shall be determined by analysis of the recordings. The recordings shall also be analyzed for possible undesirable close-in or over-station characteristics *to* determine that use of the facility for approach, holding, etc., is not adversely affected.

**4.3.15.3.** Terminal radials (approach, missed approach, standard instrument departure (SID)

Approach radials shall be evaluated at a distance that includes the procedure turn, holding pattern and missed approach on commissioning inspections. The approach radial shall be flown 30 m (100) ft below specified altitudes. Site and commissioning inspections require two additional radials 5° either side of the approach radial to be flown and analyzed with the same criteria as the approach radial. This needs to be performed only if the approach radial shows performance near the set accuracy requirement. Radials used to support SID procedures shall be evaluated to the extent to which they are used.

**4.3.15.4.** Intersections

Adjacent facilities that provide intersections shall be inspected to determine their capability to support the intersection. Reliable facility performance and course guidance at the approved minimum holding altitude (MHA) shall exist. Minimum signal strength shall exist for the radial(s) forming the intersection within 7.4 km (4 NM) or 4.5°, whichever is greater, each side of the geographical location of the intersection fix.

Identification from each facility forming the intersection shall be clear and distinct. The signal from each facility shall be free from interference at all altitudes below the maximum authorized altitude for holding. A minimum reception altitude shall be established for the intersection, which is normally determined by the facility providing the weakest signal.

*Note: All minimum en-route altitudes are to be corrected to and reported as true altitudes above mean sea level. All intersections prior to being published and authorized for use are to be flight inspected against the requirements stated above. Routine inspections of intersections can be accomplished adequately by recording an airway radial of one facility and the transition from other facilities forming the fix. Routine inspections can therefore be conducted concurrently with airway radials. Departure from the airway radial that is being inspected to evaluate another radial which is part of the fix is not required, unless detailed investigations become necessary.*

**4.3.15.5.** Cross-check radials

Commissioning and routine flight inspections of cross-check radials are not required, provided there is sufficient flight inspection data to support the publication of these radials. The radial(s) shall be inspected prior to being authorized for use if cross-check radials are requested for use in areas outside of the operational service volume of the facility(ies) for which supporting flight inspection data is not available. Thereafter, flight inspections are not required.

**4.3.16. ANALYSIS**

**4.3.16.1.** Course Structure.

**Roughness, scalloping, and bends** are displayed as deviations of the cross-pointer. Roughness will show as a series of ragged irregular deviations; scalloping, as a series of smooth rhythmic deviations. The frequency of each is such that it is not flyable and must be averaged out to obtain a course. Modern flight inspection systems can automatically carry out the analysis of a course structure.

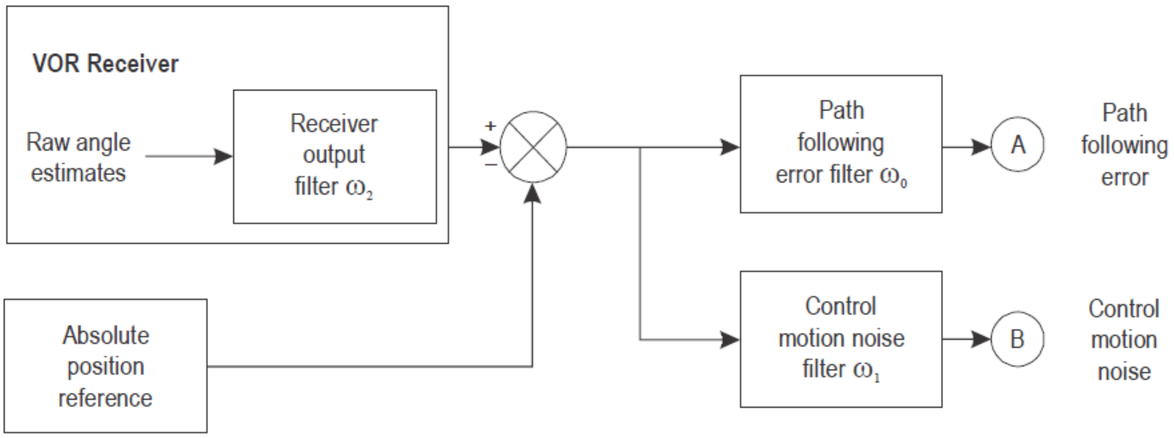
A manual method to measure the amplitude of roughness and scalloping, or combinations thereof, is to
draw two lines on the recording which are tangential to and along each positive and negative peak of the course deviation. The number of degrees, or microamperes, between these lines will be the total magnitude of course deviations; one half of this magnitude will be the plus and minus deviation. A third line is drawn equidistant from these lines to obtain the average "on-course" from which alignment is measured. The alignment error may be computed from the course recordings at any point where an accurate checkpoint has been marked on the recording. An alignment error should be referred to the nearest tenth of a degree. Misalignment in the clockwise direction is considered positive. The error is positive when the magnetic azimuth of the measured (ground) checkpoint is greater than the electronic radial.

**A bend** is similar to scalloping except that its frequency is such that an aircraft can be maneuvered throughout a bend to maintain a centered cross-pointer. A bend might be described as a brief misalignment of the course. It is therefore important to the analysis of a bend to consider aircraft heading and radial alignment deviations. Bends are sometimes difficult to discern, especially in those areas where good ground checkpoints or other means of aircraft positioning are not available. A smooth deviation of the course over a distance of 3.7 km (2 NM) two miles would manifest itself as a bend for a flight inspection aircraft at a ground speed of 140 knots. An aircraft of greater speed would
not detect such smooth deviations of the course as a bend, unless it was over a much greater distance. The analysis of bends should further consider the flight levels and speeds of potential users.

These various course aberrations are usually caused by reflections of the RF signal from terrain, trees,
power lines, hangars, fences, etc. The character of the deviation can indicate the type of reflecting objects, i.e. rough objects such as trees may cause roughness, smooth objects such as power lines and hangars may cause scalloping and bends. A study of flight inspection recordings and the surrounding terrain will often disclose the source of the

course aberrations. These conditions (roughness, scalloping, bends) can occur alone or in any combination.

An alternate way to analysis VOR errors is to filter the VOR error using PFE and CMN filters as defined in Figure 1. The VOR error is the result of the subtraction of the low-pass filtered output of the VOR receiver and the absolute position reference obtained by the tracking system. The characteristics of these filters are indicated in Figure 2.




| GUIDANCE FUNCTION | CORNER FREQUENCIES (RADIANS/SEC) | | |
|---|---|---|---|
| | $\omega_0$ | $\omega_1$ | $\omega_2$* |
| VOR | 1.5 | 0.5 | 10 |

RECEIVER OUTPUT FILTER $\frac{\omega_2}{S + \omega_2}$

PATH FOLLOWING FILTER $\frac{\omega_n^2}{S^2 + 2\zeta\,\omega_n S + \omega_n^2}$ $\zeta = 1; \omega_0 = .64\,\omega_n$

CONTROL MOTION NOISE FILTER $\frac{S}{S + \omega_1}$

* This corner frequency may be less than 10 rad/sec for some applications.

Figure 1. Block diagram for alternative way to analyze VOR errors

*Notes:*

1. *Receiver output filter: First order low-pass filter with a corner frequency of 3 rad/s (ω2). This receiver filter is added when analysing the error if it is not included in the VOR receiver.*
2. *Alignment plus bend/bend only (PFE/PFN) filter: Second order low-pass filter with a corner frequency of ω0 = 0.125 * (Vground/140) rad/s, where Vground is the ground speed (in knots) of the flight inspection aircraft during the measurement.*
3. *Scalloping and roughness (CMN) filter: First order high-pass filter with a corner frequency of ω1= 0.125 * (Vground/140) rad/s, where Vground is the mean ground speed (in knots) of the flight inspection aircraft during the measurement.*
4. *The analysis is conducted in the direction of use of the VOR (inbound or outbound). If the flight inspection is*

*not conducted in the published direction, a post analysis has to be done in order to analyse the accuracy performance in the right direction.*

5. *A 40-second sliding window technique is then used to apply the tolerances (Figure 3).*
6. *The VOR PFE and CMN filter implementation need to be customized to the acquisition sampling rate of the flight inspection receiver. A typical value for the VOR signal-in-space sampling rate is 5 Hz. As the signal-in-space is sampled, the effects of the position reference output rate must also be taken into account.*

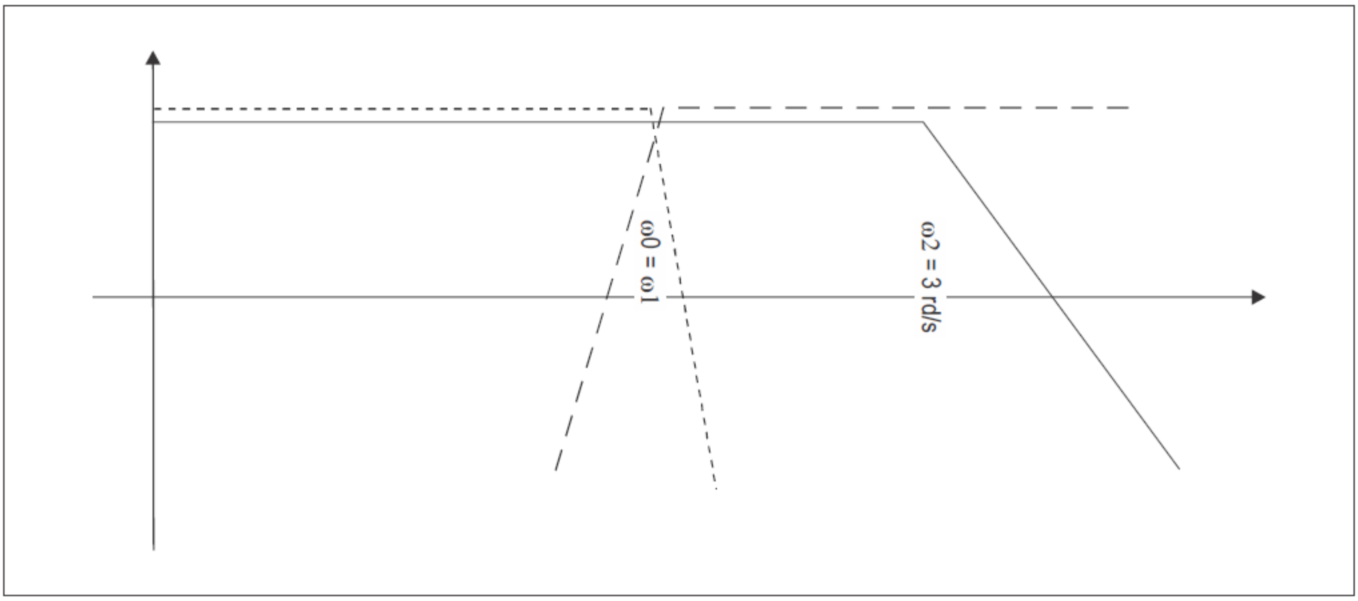



Figure 2. Characteristics of analysis filters

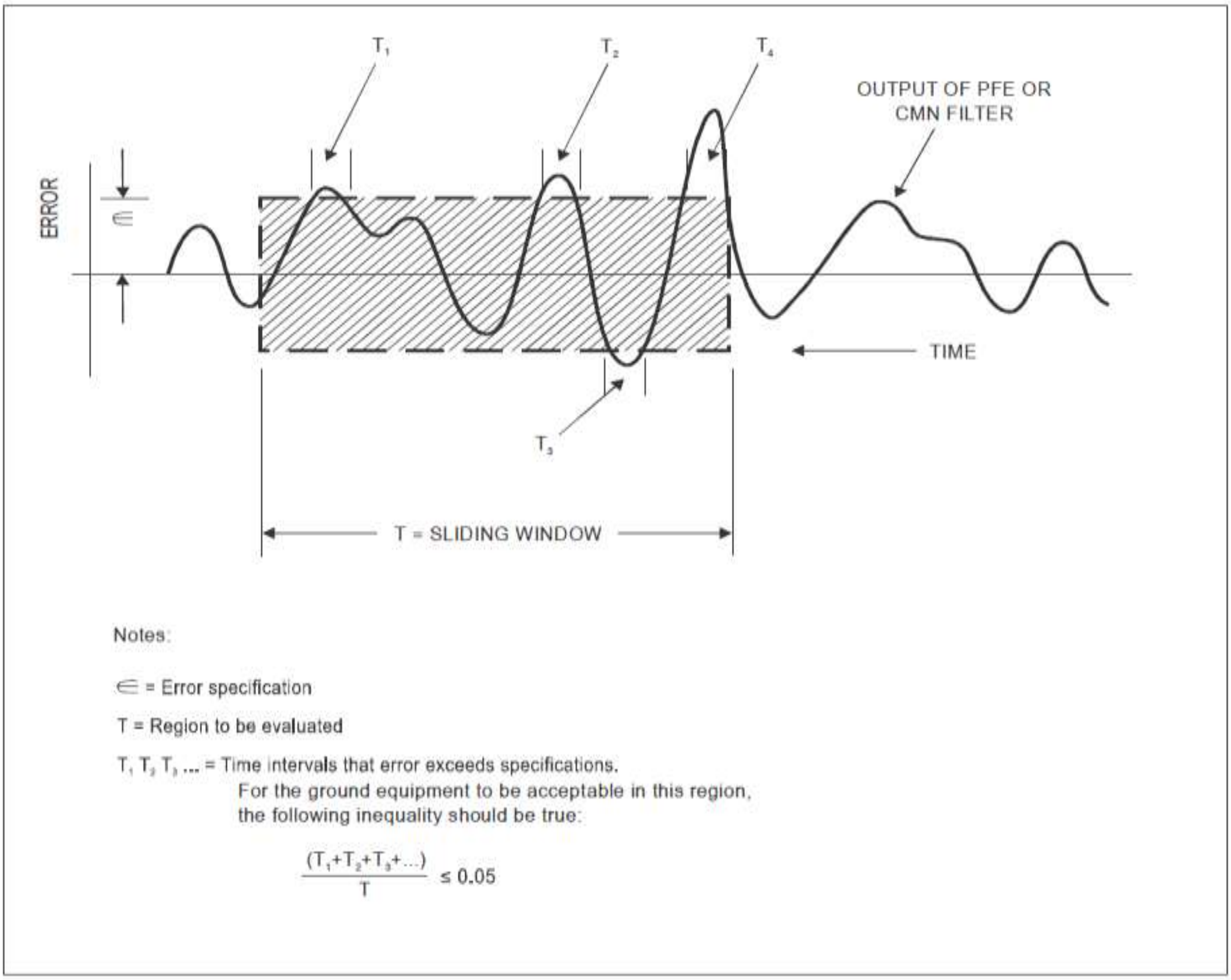



Figure 3. Sliding window technique

**4.3.16.2.** Application of Tolerance.

The application of bend criteria shall consider the navigation system accuracy, which is based partly on the typical maximum course displacement of 3.5° (bend tolerance) and the maximum distance an aircraft is expected to depart from an established course. The displacement of the course by a bend shall not exceed 3.5° from either the correct magnetic azimuth or the on-course average, as provided by the facility, in order to satisfy these factors. The following two examples are offered for clarification:

**a.** A radial that has zero alignment error — the maximum bend tolerance of 3.5° is allowable on both sides of the "on-course" line whether the bend occurs singly or in series.

b. A radial that has an alignment error of +2.0° — further displacement of the course by a bend of +1.5°is allowable. This results in a +3.5° displacement from the correct magnetic azimuth. Since a bend displacement of the course of –3.5° from the "on-course" average is allowable; this results in a –1.5° displacement from the correct magnetic azimuth.

When roughness, or scalloping, or a combination is superimposed on the bend, the average "on-course"
s**hall** be determined by averaging the total amplitude of such aberrations. This can result in a momentary displacement of the course of 6.5° where 3.0° of roughness is superimposed on a bend of 3.5°. Such a condition is highly unlikely; however, consideration should be given to the suitability of the facility in the areas of such occurrence.

The criteria for roughness and scalloping sh**all** not be applied strictly as a plus and minus factor, but as a maximum deviation from the course. Roughness and scalloping normally occur in a series. Where it is apparent that a rapid deviation occurs only on one side of the course, rather than in a series, the criteria shall be applied as a plus factor, or a minus factor, as applicable. (See Figures 4 and 5.)

When using the PFE/PFN/CMN technique, the following defaults are applied:
— Alignment error tolerance: 2°
— PFE tolerance : ± 3.5°
— PFN tolerance : ± 3.5°
— CMN tolerance : ± 3°

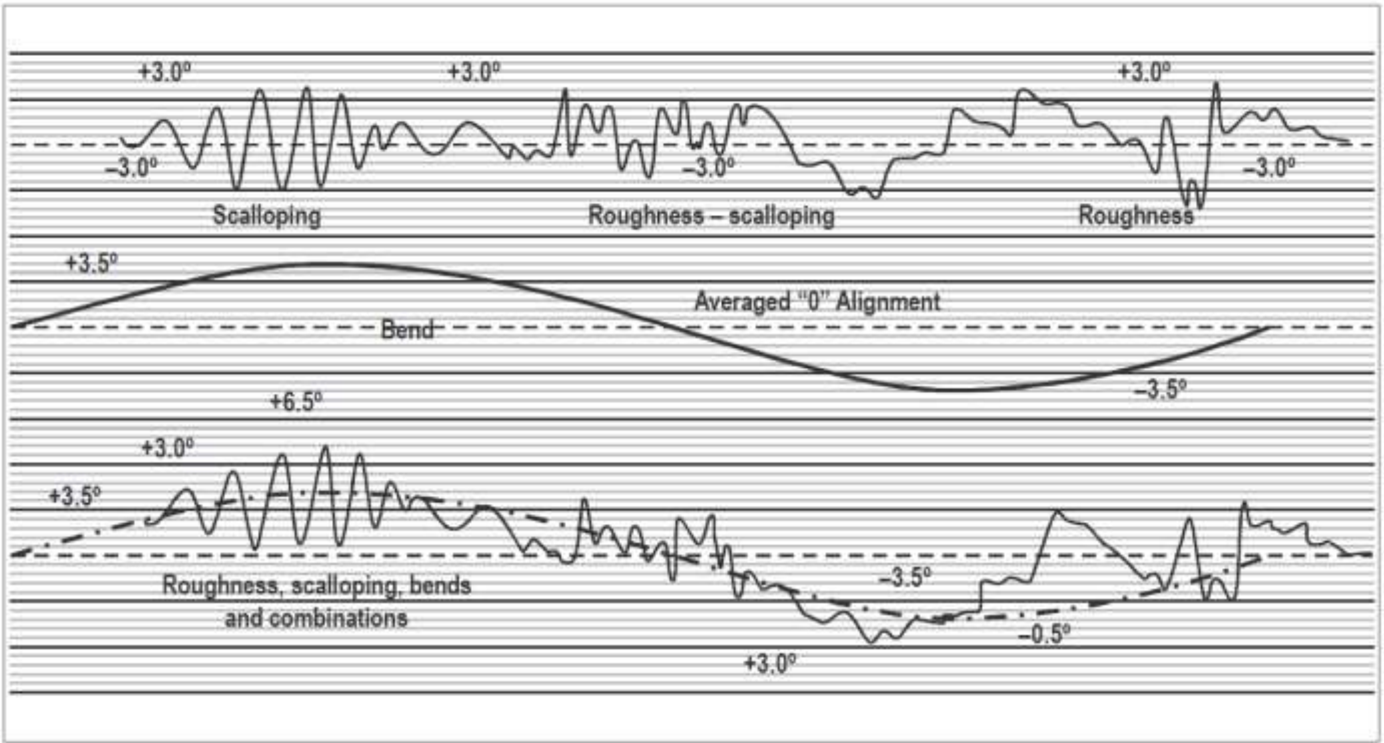



Figure 4. Roughness, scalloping, bends and combinations

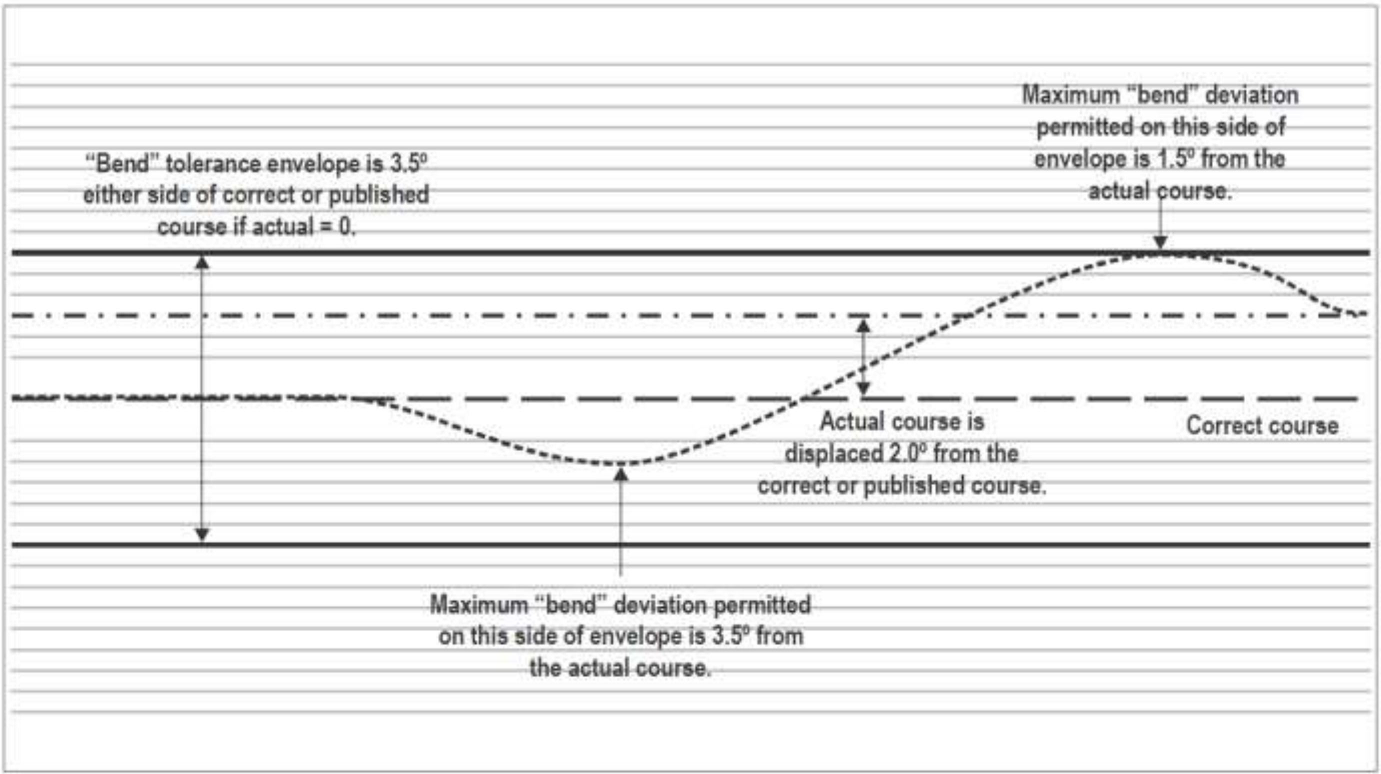



Figure 5. Bend tolerance envelope

## 4.4. TEST EQUIPMENT

The aircraft shall be fitted with a dedicated VOR receiver and antenna system for Flight Inspection. The power level into the receiver is used as the normal reference parameter for the determination of field strength. The power level into the receiver can be converted to absolute field strength if the antenna factor and cable losses are known. Refer to Attachment A, for guidance on determining Flight Inspection Aircraft antenna performance.

INTENTIONALLY LEFT BLANK

# 5. DISTANCE MEASURING EQUIPMENT (DME)

This chapter provides guidance on Flight Inspection requirements applicable to the standard distance measuring equipment (DME), as specified in Annex 10, Volume I, 3.5.

## 5.1. GENERAL

The DME system provides continuous distance information to an aircraft during execution of approach, departure, or en-route phases of flight in accordance with published procedures. The signals can be interpreted either by the pilot from the display or input directly into the flight management system (FMS).

The flight inspection aircraft shall be equipped with a precision three-dimensional reference system, a high quality DME interrogator, an oscilloscope with good timing capability, and a signal processing capability. The flight inspection of DME can be performed separately or in parallel with the more detailed check of the associated ILS, MLS, or VOR facility.

Important DME parameters will normally be checked on the ground. In many cases, a DME is installed at the site of a VOR or ILS facility that is already operational. The DME shall not be brought into unrestricted operational use until a commissioning flight inspection has been performed.

## 5.2. FLIGHT INSPECTION PERFORMANCE PARAMETERS

When conducting a flight inspection of DME, independent of an associated facility, check the following:

1. Accuracy
2. Identification
3. Coverage

Summary of DME Flight Inspection requirement are listed in Table 5.

| *Parameter* | *Annex 10, Volume I, reference* | *Doc 8071, Volume I, reference* | *Measured* | *Tolerance* | *Uncertainty* | *Inspection type (See Notes 1-3)* |
|---|---|---|---|---|---|---|
| **Coverage**<br>**Power density or field strength** | **3.5.3.1.2**<br>**3.5.4.1.5.2** | **3.3.5 to 3.3.8** | **Power density** | **Signal strength such that field density ≥–89 dBW/m² (690 μV/m) at limits or operational requirements** | **5 dB** | **S ,C** |
| **Accuracy** | **3.5.4.5** | **3.3.9** | **Distance** | **≤150 m**<br>**≤75 m for DME associated with landing aids** | **50 m** | **S, C, P** |
| **Pulse shape** | **3.5.4.1.3** | **3.3.10** | **Time, Amplitude** | **Rise time ≤3 μs**<br>**Duration 3.5 μs, ±0.5 μs**<br>**Decay time ≤3.5 μs**<br>**Amplitude, between 95% rise/fall amplitudes, ≥95% of maximum amplitude** | **0.1 μs**<br>**1%** | **S, C, P** |
| **Pulse spacing** | **3.5.4.1.4** | **3.3.11** | **Time, Amplitude** | **X channel: 12 ±0.25 μsY channel: 30 ±0.25 μs** | **0.05 μs** | **S, C, P** |
| **Identification** | **3.5.3.6** | **3.3.13** | **Identification** | **Correct, clear, properly synchronized** | **N/A** | **S, C, P** |
| **Reply efficiency** | **3.5.4.6** | **3.3.14** | **Change in efficiency, position** | **Note areas where this changes significantly** | **N/A** | **S, C, P** |
| **Unlocks** | | **3.3.15** | **Unlocking, position** | **Note where unlocking occurs** | **N/A** | **S, C, P** |
| **Standby equipment** | | **3.3.16** | **Suitability** | **Same as primary transmitter** | **N/A** | **S, C, P** |
| **Standby power** | | **3.3.17** | **Suitability** | **Should not affect transponder parameters** | **N/A** | **S, C, P** |

**Table 5. Summary of DME Flight Inspection requirement**

*Notes:*

1. *Site proving tests (S) are usually carried out to confirm facility performance prior to final construction of the site.*
2. *Commissioning checks (C) are to be carried out before the DME is initially placed in service. In addition, recommissioning may be required whenever changes that may affect its performance (e.g. variations or repairs to the antenna system) are made.*
3. *Periodic checks (P) are typically made as per flight inspection periodization 1.4 (b).*

## 5.3. FLIGHT INSPECTION PROCEDURES

### 5.3.1. COVERAGE

DME coverage shall be recorded or annotated and evaluated to the same coverage requirements as the service (ILS/ VOR/ NDB, etc.) it supports.

The coverage is measured by recording the power density or field strength. When combined with the reference system, a horizontal and vertical pattern can be plotted. A high assurance of continuous coverage should be established for all flight procedures based on the use of DME..

**5.3.1.1.** Horizontal coverage

The aircraft is flown in a circular track with a radius depending on the service volume of the associated facility around the ground station antenna at an altitude corresponding to an angle of elevation of approximately 0.5° above the antenna site, or 300 m (1000 ft) above intervening terrain, whichever is higher. If there is no associated facility, the orbit may be made at any radius greater than 18.5 km (10 NM). Since this flight is performed close to the radio horizon, it is possible to evaluate variations in the recorded power density or field strength values. Flight inspection of the coverage at maximum radius and minimum altitude, as prescribed by the operational requirements for the selected transponder, is usually necessary only on commissioning checks, when major modifications are made in the ground equipment, or if large structures are built in the vicinity of the antenna. The signal strength at the aircraft is generally adequate to maintain the interrogator in the tracking mode. Thus, the equipment itself can be used by the pilot for the desired orbit track guidance.

*Note: Checking of the associated VOR can be performed on the same flight.*

**5.3.1.2.** Vertical Coverage

The following flight inspection may be made to evaluate the lobe pattern of a DME transponder. The Flight Inspection aircraft is used to perform a horizontal flight at approximately 1500 m (5000 ft) on a bearing found suitable. The flight inspector records power density from the flight inspection system. Airspace procedures based on the use of DME are evaluated at the minimum flight altitude. The flight inspector verifies that the distance information is properly available in the aircraft at ATC reporting points, along air routes.

It is possible to check that the interrogator-transponder system is operating properly at every point of the airspace under consideration by recording the power density. The measurements made in flight provide data for plotting a graph showing the range in relation to the altitude. This graph makes it possible to:

**a.** form a clear picture of the different lobes of the radiation pattern and thus evaluate the characteristics of the antenna and its environment;

b. show the cone as seen from directly overhead; and

**5.3.1.3.** Accuracy

The accuracy of the system can be evaluated by comparing the measured DME slant range with a three-dimensional reference. It is good practice to make the calculations in three-dimensional space to avoid errors based on differences between slant range and the range on the ground. The accuracy can be checked on both orbital and radial flights.

The DME transponder's contribution to the total error budget is principally the main delay. The most accurate calibration of this parameter is by ground measurement..

**5.3.1.4.** Pulse Shape

It is not easy to measure the pulse shape of the DME transponder signal in orbital or radial flight, as the amplitude of the RF signal will vary along the flight path. One method is to store and examine a waveform of the pulse pair on a digital oscilloscope. Such specific flight test analysis is only recommended if reply efficiency and coverage (field strength) measurements indicate multipath or other propagation problems.

**5.3.1.5.** Pulse Spacing

The same technique applies for the measurement of the pulse space as for the pulse shape

**5.3.1.6.** Pulse transmission rate

The pulse transmission rate contains replies from interrogations, identification pulses and squitter. The pulse transmission rate can be counted with the oscilloscope to test that the values are those set at commissioning. The aircraft may be positioned in orbital or radial flight.

**5.3.1.7.** Identification

The identification shall be checked for correctness and clarity, with the aircraft either in orbital or radial flight. A DME associated with an associated facility will be checked for correct synchronization of the two identification signals.

**5.3.1.8.** Reply efficiency

Throughout the flight inspection, the reply efficiency should be monitored and recorded. This provides data on the service provided by the ground transponder to the aircraft within the service area. It can be used to indicate problem areas due to multipath and interference. Examination of received pulse shape using a digital oscilloscope may assist in identification of these effects.

**5.3.1.9.** Unlocks

Areas where persistent unlocks occur should be investigated by further flight inspection to determine whether engineering action or promulgation is necessary.

**5.3.1.10.** Standby Equipment

The standby DME transponder shall be spot-checked at the maximum orbit or radial distances in order to ensure that it meets the same tolerances and is comparable to the primary equipment. There shall be no appreciable difference in the characteristics of the transponder (spectrum of pulses, energy radiated, etc.) between the primary and standby equipment.

**5.3.1.11.** Standby Power

The standby power check can normally be performed satisfactorily on the ground. During commissioning and periodic inspections, this provision may be checked by observing operation and noting any appreciable differences in radiated signal characteristics that result from a changeover to standby power. The transponder characteristics (spectrum of pulses, energy radiated, etc.) shall not be degraded when switched to standby power.

#### 5.3.1.12. Chart and Report

The parameters from a DME inspection shall be plotted on a graph relative to the distance or azimuth from the DME under test.
When the DME is associated with ILS, MLS, or VOR, the DME details can be added to the report of this facility. In other cases, a separate report can be issued.

## 5.4. TEST EQUIPMENT

### 5.4.1. EQUIPMENT

In addition to the test equipment required to perform the VOR and ILS flight inspection, the following equipment is needed for a DME:

a. A DME interrogator or, if possible, two. Having a second interrogator in the aircraft provides standby equipment and makes it possible to compare the information given by the two interrogators in case of difficulties. It is desirable for the interrogators to have a certain number of outputs in order to:
    1) measure and record digital output with distance, and AGC voltage, from which the signal strength at the receiver input may be deduced. (Signal level errors of the order of 3 dB may be expected from the interrogator receiver and this should be taken into account when evaluating data from this source); and
    2) make observations on an oscilloscope of the video signal before and after decoding; the suppression pulses, indicating that the transmitter is operating; and the coding signals of the interrogator, a particularly useful observation in case of anomalies during flight inspection.
b. The corresponding antenna, the characteristics of which should be known, particularly its radiation pattern. Accurate calibration of the antenna radiation pattern may be arduous, and determination of the antenna gain with an accuracy better than 3 to 5 dB may be difficult to achieve. However, it is recommended that this calibration is performed.
c. An oscilloscope with good performance for time measurement. Digital oscilloscopes have the capability to store waveforms and built-in functions for calculating the pulse shape parameters. Parameters and graphs should be recorded and documented.

    Spectrum analyzer. If it is desirable to measure the pulse spectrum with the flight inspection aircraft, a spectrum analyzer shall be carried on board. The increased pollution of the electromagnetic environment at or near our airports provides many good reasons for having an airborne spectrum analyzer.

### 5.4.2. CALIBRATION

The flight inspection DME interrogator **shall** be maintained in accordance with the manufacturer's instructions and shall conform to Annex 10 Standards and Recommended Practices. The following calibration instructions may be helpful:

**a.** Interrogator pulse repetition rate.
    The pulse transmission should be repeated at a rate of 30 pp/s, per cent of the time spent in the SEARCH mode and 95 per cent in the TRACK mode. The variation in time between successive pairs should be sufficient to prevent false lock-on.

**b.** Frequency stability.
The radio frequency of operation should not vary more than ±100 kHz from the assigned value.

**c.** Peak power output.
The peak power output measured at the interrogator should be at least 100 watts. The constituent pulses of a pulse pair should have the same amplitude within 1dB. Special care should be taken when using GPS reference systems with phase measurements and, in particular, when using the GPS L2 frequency. This frequency is close to the DME band and the maximum output power of the interrogator and the separation of the antennas should be kept in mind.

**d.** Spurious radiation.
Spurious radiation between pulses on any DME interrogation or reply frequency measured in a receiver having the same characteristics of a DME transponder receiver should be more than 50 dB below the peak radiated power of the desired pulses. The spurious continuous wave (CW) power radiated from the interrogator on any DME interrogation or reply frequency should not exceed 20 micro-watts (−47 dBW).

**e.** Sensitivity.
The signal level required at the input terminals to affect a successful end-of-search nine out of ten cycles should not exceed −82 dBm when the input signal is a DME test signal having a 70 per cent reply efficiency. The required signal level should not exceed −79 dBm when the test signal contains 6 000 random pulses 10 dB above the test signal level. The minimum signal levels are −85 and −82 dBm respectively to maintain tracking under the above conditions.

**f.** Selectivity.
The level of the input signal required to produce a successful end-of-search nine out of ten cycles should not vary in excess of 6 dB over the band 120 kHz above and below the assigned reply frequency. This includes receiver frequency stability requirements. The level of the input signal required to produce an average of not more than one successful end-of-search out of ten cycles (and that one to track for not more than five seconds) should be at least 30 dB greater than the on-frequency signal described above, and nine out of ten successful end-of-search cycles when the off-frequency signal is displaced by 940 kHz either side of the assigned channel frequency. Over the frequency range of 960 MHz to 1 215 MHz, excluding frequencies within 1 MHz of the desired channel, the equipment should not respond to nor be adversely affected by an undesired frequency DME signal having a level 50 dB above the level of the signal on the desired channel.

Note 1.— In operational use, an adjacent channel transponder would provide at least 80 dB rejection of adjacent channel interrogations. Since the transponder effectively prevents replies to adjacent channel interrogations, no lock-on can occur.

Note 2.— Spurious responses. Over the frequency range of 90 kHz to 10 000 MHz, excluding frequencies within 3 MHz of the desired channel, a CW signal having a level of −30 dBm should not adversely affect the receiver sensitivity.

**g.** Decoder selectivity. The equipment should be calibrated to indicate distance satisfactorily when the spacing of the received pulses is varied from 11.5 to 12.5 microseconds for X-channel or from 29.5 to 30.5 microseconds for Y-channel, over the input signal level range from −48 dBm to the minimum tracking level. If the spacing between pulses is less than 10 microseconds or more than 14 microseconds for X-channel, or less than 28 microseconds or more than 32 microseconds for Y-channel, and the signal level is below −48 dBm, that signal should not be decoded.

**h.** Search speed.
Search speed should be at least 10 NM per second.

i. Memory. To enable the detection of unlocks, the memory time of the equipment should be approximately 5 seconds upon the loss of the signal. The information displayed during this period should be that information which was being displayed at the time of the loss of the signal ±1.85 km (1 NM).

**j.** Calibration.
The indication “Distance = 0 NM” should correspond to a time delay in responding to an interrogation of 50 μs ± 1 μs.

**k.** Measuring accuracy.
Measuring accuracy including the distance reference system should be ≤±0.025 NM (50 m).

**l.** Identification signal.
The equipment should be capable of providing an intelligible and unambiguous aural identification signal at all usable receiver input levels.

m. Airborne antenna. The radiation pattern should be as omnidirectional as possible in the horizontal plane. It should be sited in such a way as to be free from masking effects of the aircraft structure. The use of two antennas may be a good solution. The characteristics of the antenna and associated feeder line should be taken into account when interpreting the results of measurements.

### 5.4.3. POSITIONING.

The increased accuracy requirements of the DME system require a reference system with accuracy better than 20 m (65 ft). A three-dimensional reference system suitable for calibration of the ILS will be adequate for DME calibration.

**INTENTIONALLY LEFT BLANK**

# 6. INSTRUMENT LANDING SYSTEM

This chapter provides instructions and performance criteria for inspecting localizer and glidepath which operate in the VHF and UHF band as specified in Annex 10, Volume Volume I, 2.2 and 3.1. and Doc 8071 Volume I.

## 6.1. GENERAL

The ILS provides precision guidance to an aircraft during the final stages of the approach. The signals can either be interpreted by the pilot from the instruments or be input directly into the autopilot and flight management system.

ILS facility performance is divided into three categories depending on the reliability, integrity and quality of guidance, with facility performance Category III having the strictest requirements. An ILS comprises the following elements:

**a.** the localizer, operating in the frequency band from 108 to 112 MHz, providing azimuth guidance to a typical maximum range of 46.3 km (25 NM) from the runway threshold;
**b.** the glide path, operating in the frequency band from 328 to 336 MHz, providing elevation guidance to a typical maximum range of 18.5 km (10 NM) from the runway threshold; and
c. an appropriate means to enable glide path verification checks.

Distance to threshold information to enable glide path (altitude) verification checks is normally provided by:

**a.** VHF marker beacons operating on the frequency of 75 MHz, providing position information at specific distances from the runway threshold; or
b. distance measuring equipment (DME) operating in the frequency band from 960 to 1215 MHz on channels paired with the localizer, providing continuous distance to runway information.

Note.— If other standard radio navigation aids are used for this function, appropriate ground and flight test requirements must also be determined.

Flight testing is required to confirm the correctness of the setting of essential signal-in-space parameters, determine the operational safety and acceptability of the ILS installation, and periodically correlate signal patterns observed in flight and from the ground.

However, Adequate monitoring, ground testing and maintenance on a routine and continuing basis should be the normal means of ensuring that the ILS signal-in-space performs within the specified tolerances and that the operational integrity and serviceability of the ILS facility is maintained. Both types of testing provide awareness of long-term changes in the operational environment caused by effects such as multipath from on-airport construction activities. In practice, it has been found that certain ILS performance parameters can be determined more accurately and with greater reliability by ground measurements than through flight inspection. If the ground and flight measurements show different results, the reason for the divergence should be investigated.

## 6.2. SPECIAL MEASURE PREVENTING THE OPERATIONAL USE OF TEST SIGNAL.

Some ground and flight test procedures, involve misleading guidance signals being temporarily radiated by ILS or the executive monitoring function of the equipment being inhibited. Such signals, particularly those radiated for phasing and modulation balance testing, may be perceived on board the aircraft as “on-course” and/or “on-glide-path” indications regardless of the actual position of an aircraft within the ILS coverage and with no flag or alarm indication in the cockpit.

The operational use of these signals for approach guidance can therefore result in misleading indications to the flight crew and has the potential to cause a controlled flight into terrain (CFIT) accident.

Accordingly, the appropriate State authority (or the organization authorized by the State) should develop measures to ensure that ILS test signals will not be used during normal flight operations when these signals are being radiated or the executive monitoring function of the facility is inhibited for testing/maintenance purposes. Coordination of testing procedures with ATC and the timely promulgation and distribution of relevant information by a NOTAM before the procedures commence are of paramount importance.

It is highly desirable to eliminate the possibility of any operational use to be made of the ILS guidance during the testing by administratively (e.g. by a NOTAM) removing the localizer and the glide path from service simultaneously. If this is not feasible for operational reasons, a deferral of testing should be considered. However, in case the localizer needs to remain in service while the glide path undergoes testing and the testing cannot be delayed, sufficient measures should be implemented to ensure that users are aware of the potential for false indications from the glide path facility.

**In all circumstances, the basic protective measures should include as a minimum:**

**a.** NOTAM phraseology that is specific about the possibility of false indications to the flight crew from the radiated test signals and clearly prohibits their use (suggested NOTAM wording — “RUNWAY XYZ ILS NOT AVBL DUE MAINTENANCE (or TESTING); DO NOT USE; FALSE INDICATIONS POSSIBLE”);
**b.** confirmation by maintenance personnel that such a NOTAM has been issued by the Aeronautical Information Service before the testing procedures begin;
**c.** prior to beginning the tests, suspension or alteration to an unusual tone/sequence of the transmission of the unique Morse Code facility identification on the localizer, if the localizer should radiate solely for testing purposes; and
**d.** a requirement that ATC advise, by the automatic terminal information service (ATIS) and/or by a voice advisory, each pilot on an approach to the affected runway, emphasizing the possibility of false indications.

Additional protective measures may be appropriate, especially during phasing and modulation balance conditions for the localizer or the glide path. Accordingly, when the phasing and modulation balance tests are being performed, the following options may be exercised:

**a.** when the tests are being performed on the localizer, remove the glide path from service by turning the signals off (to provide a glide path flag indication to the pilot);

b. when the tests are being performed on the glide path, remove the localizer from service by turning the signals off (to provide a localizer flag indication to the pilot); and/or

Note.— If option b) is exercised, the ATC advisories indicated in paragraph d above become redundant.

**c.** minimize the time radiating in a ground phasing condition by performing the testing with two or more technicians and radio communications.

In addition, it is essential to ensure that protective measures (in addition to the coordination and promulgation processes) are put in place to guard against single points of failure. One highly desirable measure is the installation of remote ILS status-indicating equipment such that it is visible to the air traffic controller issuing approach clearances.

## 6.3. ANALYSIS CONCERNING HARMFUL INTERFERENCE CAUSED BY OPPOSITE RUNWAY LOCALIZER TRANSMISSION

At those locations where two ILS facilities serve the opposite ends of a single runway without a means to avoid simultaneous transmission by both localizers (e.g. interlock), it is necessary to verify the absence of operationally harmful interference when both localizers are transmitting.

This verification may be done through flight test with both localizers transmitting or by geometry analysis. The second option consists in checking that the overflight of the opposite localizer (the area of harmful interference) is beyond the applicable limit at which the course structure requirements should be met

## 6.4. FLIGHT INSPECTION PERFORMANCE PARAMETERS

A summary of flight inspection requirements for ILS localizer, glide path and markers is given in Tables 6, 7 and 8.

| *Parameter* | *Annex 10, Volume I, reference* | *Doc 8071, Volume I, reference* | *Measured* | *Tolerance* | *Uncertainty* | *Inspection type* | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | *S* | *C, C* | *P* |
| **Identification** | **3.1.3.9** | **4.3.12** | **Morse code** | **Proper keying, clearly audible to the limit of the range.** | **Subjective assessment** | | **x** | **x** |
| **Voice feature** | **3.1.3.8** | **4.3.13** | **Audibility, DDM** | **Clear audio level similar to identification, no effect on course line.** | **Subjective assessment** | | **x** | **x** |
| **Modulation**<br>**— Balance**<br>**— Depth**<br>**— Sum** | **N/A 3.1.3.5**<br>**3.1.3.5.3.6.1** | <br>**4.3.14**<br>**4.3.15**<br>**4.4.8** | **DDM, Modulation, Depth SDM** | **See Note 1.**<br>**0.002 DDM**<br>**18% to 22%**<br>**<60% SDM within ±35° azimuth or actual coverage sector for systems installed post January 2000** | **0.001 DDM**<br>**±0.5%** | <br>**x**<br>**x** | **(x)**<br>**x**<br>**x** | <br>**x**<br>**x** |
| **Displacement sensitivity** | **3.1.3.7** | **4.3.16 to 4.3.20** | **DDM** | **Cat I: Within 17% of the nominal value**<br>**Cat II: Within 17% of the nominal value**<br>**Cat III: Within 10% of the nominal value**<br>**See Note 2.** | **±3 µA**<br>**±3 µA**<br>**±2 µA**<br>**For nominal 150 µA input** | **x** | **x** | **x** |
| **Off-course clearance** | **3.1.3.7.4** | **4.3.21, 4.3.22** | **DDM** | **On either side of course line, linear increase to 175 µA, then maintenance of 175 µA to 10°. Between 10° and 35°, minimum 150 µA. Where coverage required outside of ±35°, minimum of 150 µA except in back course sector.** | **±5 µA**<br>**For nominal 150 µA input** | **x** | **x** | **x** |
| **High-angle clearance** | **N/A** | **4.3.23 to 4.3.25** | **DDM** | **Minimum of 150 µA.** | **±5 µA**<br>**For nominal 150 µA input** | **x** | **x** | |
| **Course alignment accuracy** | **3.1.3.6** | **4.3.26 to 4.3.28** | **DDM, Distance, Angle** | **Equivalent to the following displacements at the ILS reference datum:**<br>**Cat I: ±10.5 m (35 ft)**<br>**Cat II: ±7.5 m (25 ft)**<br>**[±4.5 m (15 ft) for those Cat II localizers which are adjusted and maintained within ±4.5 m]**<br>**Cat III: ±3 m (10 ft)** | **Cat I: ±2 m**<br>**Cat II: ±1 m**<br>**Cat III: ±0.7m** | **x** | **x** | **x** |

| Parameter | Annex 10, Volume I, reference | Doc 8071, Volume I, reference | Measured | Tolerance | Uncertainty | Inspection type | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | S | C, C | P |
| **Phasing** | | **4.3.39, 4.3.40** | **DDM** | **10 µA of the modulation balance value. See Note 3.** | **±1 µA** | **x** | **x** | **x** |
| **DDM increase linear** | **3.1.3.7.4** | | **DDM** | **>180 µA (Linear increase from 0 to >180 µA)** | | | **x** | **x** |
| **Voice no interference to basic function** | **3.1.3.8** | | **DDM, Speech** | **No interference.** | | | **x** | **x** |
| **Phase to avoid voice null on dual frequency systems** | **3.1.3.8.3.1** | | **Speech** | **No nulls.** | | | **x** | **x** |
| **Course structure** | **3.1.3.4**<br><br>**See Annex 10, Volume I, Attachment C, Note to 2.1.2.5** | **4.3.29 to 4.3.33** | **DDM** | **Outer limit of coverage to Point A: 30 µA all categories**<br><br>**Point A to Point B:**<br><br>**Cat I: Linear decrease to 15 µA**<br>**Cat II: Linear decrease to 5 µA**<br>**Cat III: Linear decrease to 5 µA**<br><br>**Beyond Point B:**<br><br>**Cat I: 15 µA to Point C**<br>**Cat II: 5 µA to Reference datum**<br>**Cat III: 5 µA to Point D, then linear increase to 10 µA at Point E.**<br><br>**See Note 4 for application of tolerances.** | **See Annex 10, Volume I, Att. C, 2.1.5.**<br>**From Point A to B, 3 µA decreasing to 1 µA**<br><br>**From Point B to E, 1 µA** | **x** | **x** | **x** |

| *Parameter* | *Annex 10, Volume I, reference* | *Doc 8071, Volume I, reference* | *Measured* | *Tolerance* | *Uncertainty* | *Inspection type* S | C, C | P |
|---|---|---|---|---|---|---|---|---|
| **Coverage (usable distance)**<br><br>**— Power density** | **3.1.3.3**<br><br>**See Annex 10, Volume I, Attachment C, Figures C-7A and C-8A (C-7B and C-8B for the reduced coverage case)** | **4.3.34 to 4.3.36** | **Flag status, DDM**<br><br>**Power density** | **-114 dBW/m² (40 µV/m) in all parts of operational coverage volume from 25 NM, when within the LOC course sector and on GP:**<br><br>**Cat I: -107 dBW/m² (90 µV/m) on ILS from 10 NM to 30 m height**<br><br>**Cat II: -106 dBW/m² (100 µV/m) on ILS from 10 NM, increasing to -100 dBW/ m² (200 µV/m) at 15 m height above THR**<br><br>**Cat III: -106 dBW/m² (100 µV/m) on ILS from 10 NM, increasing to -100 dBW/ m² (200 µV/m) at 6 m height above THR, -106 dBW/m² (100 µV/m) along the length of the runway**<br><br>***Note.— The conversion is stated in Annex 10, Volume I, 3.1.3.3.2.*** | **±3 dB** | **x** | **x** | **x** |
| **Polarization** | **3.1.3.2.2** | **4.3.37** | **DDM** | **For a roll attitude of 20° from the horizontal:**<br><br>**Cat I: 15 µA on the course line**<br><br>**Cat II: 8 µA on the course line**<br>**Cat III: 5 µA within a sector bounded by 20 µA either side of the course line.** | **± 1 µA** | **x** | **x** | |
| **Back course**<br><br>**— Sector width** | **N/A** | **4.3.41 to 4.3.43** | **DDM, Angle** | **Not less than 3°.** | **0.1°** | | **x** | **x** |
| **— Alignment** | **N/A** | | **DDM, Distance** | **Within 60 m of the extended centre line at 1 NM.** | **±6 m** | | **x** | **x** |

| Parameter | Annex 10, Volume I, reference | Doc 8071, Volume I, reference | Measured | Tolerance | Uncertainty | Inspection type | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | S | C, C | P |
| **— Structure** | **N/A** | **4.3.79** | **DDM** | **Limit of coverage to final approach fix: ±40 μA**<br>**FAF to 1.85 km (1 NM) from threshold: ±40 μA**<br>**Decreasing at a linear rate to: ±20 μA** | **Annex 10, Volume I, Attachment C, 2.1.4** | | **x** | **x** |
| **— Modulation depth** | **N/A** | | **Modulation depth** | **18% to 22% approximately 9 km (5 NM) from the localizer.**<br>**See Note 1.** | **±0.5%** | | **x** | **x** |
| **Monitor system** | **3.1.3.11** | **4.3.38** | | **See Note 2.** | | | | |
| **— Alignment** | | | **DDM, Distance** | **Monitor shall alarm for a shift in the main course line from the runway centre line equivalent to or more than the following distances at the ILS reference datum.**<br>**Cat I: 10.5 m (35 ft)**<br>**Cat II: 7.5 m (25 ft)**<br>**Cat III: 6.0 m (20 ft)** | <br>**2 m**<br>**1 m**<br>**0.7 m** | | **x** | **x** |
| **— Displacement sensitivity** | | | **DDM, Distance** | **Monitor shall alarm for a change in displacement sensitivity to a value differing from the nominal value by more than:**<br>**Cat I: 17%**<br>**Cat II: 17%**<br>**Cat III: 17%** | <br>**±4%**<br>**±4%**<br>**±2%** | | **x** | **x** |
| **— Off-course clearance** | | | **DDM** | **Required only for certain types of localizer. Monitor shall alarm when the off-course clearance cross-pointer deflection falls below 150 μA anywhere in the off-course coverage area.** | **±5 μA**<br>**±1 dB relative** | | **x** | **x** |

| Parameter | Annex 10, Volume I, reference | Doc 8071, Volume I, reference | Measured | Tolerance | Uncertainty | Inspection type | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | S | C, C | P |
| **— Power** | | | **Power field strength** | **Monitor shall alarm either for a power reduction of 3 dB, or when the coverage falls below the requirement for the facility, whichever is the smaller change. For two-frequency localizers, the monitor shall alarm for a change of ±1 dB in either carrier, unless tests have proved that use of the wider limits above will not cause unacceptable signal degradation (>150 μA in clearance sector)** | **± 5 μA** | | **x** | |

**Table 6. Flight inspection requirements for localizer**

*Notes:*

1. *Recommended means by measurement is by ground check.*
2. *Recommended means of measurement is by ground check, provided that correlation has been established between ground and air measurement.*
3. *Optional, at the request of the ground technician, unless good correlation between airborne and ground phasing techniques has not been established.*
4. *Course structure along the runway maybe measured by flight inspection or by ground vehicle.*

*Legend:*

*S* = *Site*

*C, C* = *Commissioning, Categorization*

*P* = *Periodic — as per flight Inspection periodization*

*N/A* = *Not applicable*

| Parameter | Annex 10, Volume I, reference | Doc 8071, Volume I, reference | Measured | Tolerance | Uncertainty | Inspection type | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | S | C, C | P |
| **Angle**<br>**— Alignment** | **3.1.5.1.2.1** | **4.3.45,<br>4.3.46** | **DDM,<br>Angle** | **Cat I:** Within 7.5% of nominal angle<br>**Cat II:** Within 7.5% of nominal angle<br>**Cat III:** Within 4% of nominal angle | **Cat I: 0.75%<br>Cat II: 0.75%<br>Cat III: 0.3%<br>of nominal angle** | x | x | x |
| **— Height of reference datum** | **3.1.5.1.5<br>3.1.5.1.6<br>3.1.5.1.4** | **4.3.81** | **DDM** | **Cat I:** 15 m (50 ft) + 3 m (10 ft) (See Note 3)<br>**Cat II:** 15 m (50 ft) + 3 m (10 ft) (See Note 3)<br>**Cat III:** 15 m (50 ft) + 3 m (10 ft) (See Note 3) | **0.6 m** | | x | |
| **Displacement sensitivity**<br>— **Value**<br>— **Symmetry** | **3.1.5.6** | **4.3.47<br>to 4.3.49** | **DDM,<br>Angle** | **Symmetry:**<br>**Cat I:** Between 0.07θ and 0.14θ above and below path<br>**Cat I*:** 0.12θ above and below path, within ±0.02θ<br>**Cat II:** 0.12θ above path, within +0.02θ and -0.05θ<br>**Cat II:** 0.12θ below path, within ±0.02θ<br>**Cat III:** 0.12θ above and below path, within ±0.02θ<br>* Recommendation<br><br>**Value:**<br>**Cat I:** Within ±25% of nominal displacement sensitivity<br>**Cat II:** Within ±20% of nominal displacement sensitivity<br>**Cat III:** Within ±15% of nominal displacement sensitivity | **Cat I: 2.5%<br>Cat II: 2.0%<br>Cat III: 1.5%** | x | x | x |
| **Clearance**<br>**— Below path** | **3.1.5.6.5** | **4.3.50** | **DDM,<br>Angle** | Not less than 190 µA at an angle above the horizontal of not less than 0.3θ. If 190 µA is realized at an angle greater than 0.45θ, a minimum of 190 µA shall be maintained at least down to 0.45θ. | **±6 µA for a Nominal 190 µA input** | x | x | x |
| **— Above path** | **3.1.5.3.1** | | | Shall attain at least 150 µA and not fall below 150 µA until 1.75θ is reached. | | | | |

| Parameter | Annex 10, Volume I, reference | Doc 8071, Volume I, reference | Measured | Tolerance | Uncertainty | Inspection type | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | S | C,C | P |
| **Glide path structure** | **3.1.5.4** | **4.3.52**<br>**4.3.79** | **DDM** | **See Note 5.**<br>**Cat I: From coverage limit to Point C: 30 μA.**<br>**Cat II and III: From coverage limit to Point A: 30 μA**<br>**From Point A to Point B: linear decrease from 30 μA to 20 μA.**<br>**From Point B to reference datum: 20 μA.** | **Cat I: 6 μA**<br>**Cat II: 4 μA**<br>**Cat III: 4 μA** | **x** | **x** | **x** |
| **Modulation**<br>**— Balance**<br>**— Depth** | **3.1.5.5.1** | **4.3.53**<br>**4.3.54** | **Modulation depth** | **See Note 1.**<br>**0.002 DDM**<br>**37.5% to 42.5% for each tone.** | **0.001 DDM**<br>**0.5%** | **x** | **(x)**<br>**x** | **x** |
| **Obstruction**<br>**— Clearance** | **N/A** | **4.3.55** | **DDM** | **Safe clearance at 180 μA (Normal), or at 150 μA (wide alarm).** | **Subjective assessment** | **x** | **x** | **x** |
| **Coverage**<br><br>**— Usable distance** | **3.1.5.3.1**<br>**Attachment C, Figure 10** | **4.3.56** | **Flag status** | **Satisfactory receiver operation in sector 8° azimuth either side of the localizer centre line for at least 18.5 km (10 NM) up to 1.75θ and down to 0.45θ above the horizontal, or to a lower angle, down to 0.3θ as required to safeguard the glide path intercept procedure.** | | **x** | **x** | **x** |
| **— Power density or field strength** | **3.1.5.3.2** | | **Power density** | **-95 dBW/m² (400 μV/m)** | **±3 dB** | | | |
| **Monitor system**<br><br>**— Angle** | **3.1.5.7** | **4.3.57,**<br>**4.3.58** | **DDM,**<br>**Angle** | **See Note 2.**<br>**Monitor shall alarm for a change in angle of -7.5/+10% of the promulgated angle** | **±4 μA** | | **x** | **x** |
| **— Displacement sensitivity** | | | **DDM,**<br>**Angle** | **Cat I: Monitor shall alarm for a change in the angle between the glide path and the line below the glide path at which 75 μA is obtained, by more than 0.037θ.**<br>**Cat II: Monitor shall alarm for a change in displacement sensitivity by more than 25%.**<br>**Cat III: Monitor shall alarm for a change in displacement sensitivity by more than 25%.** | **±4 μA**<br>**±1 dB** | | **x** | **x** |

| Parameter | Annex 10, Volume I, reference | Doc 8071, Volume I, reference | Measured | Tolerance | Uncertainty | Inspection type | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | S | C,C | P |
| — Power | | 4.3.58 | Power | Monitor shall alarm either for a power reduction of 3 dB, or when the coverage falls below the requirement for the facility, whichever is the smaller change.<br>For two-frequency glide paths, the monitor shall alarm for a change of ±1 dB in either carrier, unless tests have proved that use of the wider limits above will not cause unacceptable signal degradation. | ±0.5 dB | | x | |
| Phasing | N/A | 4.3.59 to 4.3.65 | | No fixed tolerance. To be optimized for the site and equipment. See Note 4. | N/A | | x | x |

**Table 7. Flight inspection requirements for Glide Path**

Notes:

1. Recommended means of measurement is by ground check.
2. Recommended means of measurement is by ground check, provided that correlation has been established between ground and air measurements.
3. This requirement only arises during commissioning and categorization checks. The method of calculating the height of the extended glide path at the threshold is described in 4.3.81, Analysis — Reference datum height (RDH). For Category I approaches on Code 1 and 2 runways, refer to 3.1.5.1.6 of Annex 10, Volume I.
4. Optional, at the request of the ground technician.
5. Tolerances are referenced to the mean course path between Points A and B, and relative to the mean curved path below Point B.

Legend: S = Site
C, C = Commissioning, Categorization
P = Periodic — as per flight inspection periodization
N/A = Not applicable

| Parameter | Annex 10, Volume I, reference | Doc 8071, Volume I, reference | Measured | Tolerance | Uncertainty | Inspection type | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | S | C,C | P |
| **Keying** | **3.1.7.4: 3.1.7.5** | **4.3.66** | **Keying** | **Proper keying, clearly audible** | | | **x** | **x** |
| **Coverage**<br><br>**— Indications**<br>**— Field strength** | **3.1.7.3**<br><br><br>**3.1.7.3.2** | **4.3.67 to 4.3.71** | **Signal level distance**<br><br><br>**Field strength** | **Proper indication over the beacon or other defined point.**<br><br>**When checked while flying on localizer and glide path, coverage should be:**<br><br>**OM: 600 m ±200 m (2 000 ft ±650 ft)**<br>**MM: 300 m ±100 m (1 000 ft ±325 ft)**<br>**IM: 150 m ±50 m (500 ft ±160 ft)**<br>**On a normal approach, there should be a well-defined separation between the indications from the middle and inner markers.**<br>**Measurement should use the Low sensitivity setting on receiver. (Refer to Annex 10 for specific field strength requirements)** | <br><br><br><br><br>**±40 m**<br>**±20 m**<br>**±10 m**<br><br>**±3 dB** | **x** | **x** | **x** |
| **Monitor system** | **3.1.7.7** | **4.3.72, 4.3.73** | | **An operationally usable indication should be obtained for a reduction in power output of 50%, or a higher power at which the equipment will be monitored. See Note.** | **±1 dB** | | **x** | **x** |
| **Standby equipment** | | **4.3.74** | | **Same checks and tolerances as main equipment.** | | | **x** | **x** |

Table 8. Flight inspection requirements for Marker

Note. — Alternatively, this can be checked by analyzing the field strength recording.

Legend:

S = Site

C, C = Commissioning, Categorization

P = Periodic — as per flight inspection periodization, N/A = Not applicable

## 6.5. FLIGHT INSPECTION PROCEDURE

During inspections, certain parameters require the use of aircraft positioning or tracking devices to provide accurate aircraft position relative to the localizer course or glide path for adequate analysis of the performance. The position of the tracking device with respect to the facility being inspected is critical to obtaining good flight inspection results

### 6.5.1. LOCALIZER FRONT COURSE

**6.5.1.1.** Identification

The coded identification that is transmitted from the facility shall be monitored during the various checks over all of the coverage area. The identification is satisfactory if the coded characters are correct, clear and properly spaced. The transmission of the identification signal should not interfere in any way with the basic localizer function. Monitoring the identification also serves the purpose of detecting frequency interference, which is primarily manifested by heterodyne, or noise which affects the identification.

**6.5.1.2.** Modulation

a. *Modulation balance.* Although the modulation balance is most easily measured on the ground, it shall be measured as well from the air while radiating the carrier signal only. Position the aircraft close to the runway center line and note the cross-pointer indication. Flight inspection of modulation balance should be conducted on specific engineering request only (see paragraph 6.2).
b. *Modulation depth.* The percentage of modulation shall be determined only while flying inbound and on course at a point where the receiver signal strength corresponds to the value at which the receiver modulation depth calibration was made, or on the ground during taxiing, backtracking or lining-up operations when the aircraft is close to the runway center line. Therefore, this requirement shall be fulfilled concurrently with the alignment check. If the receiver modulation depth indications are influenced significantly by the RF level, measure the modulation depth near Point A. (An adequate preliminary check of modulation can be made while the aircraft is crossing the course during the displacement sensitivity check.) Modulation percentage is determined by the use of calibration data furnished with the individual receiver.

**6.5.1.3.** Displacement sensitivity

There are two basic methods of measuring the displacement sensitivity:
a. approaches on the edges of the course sector.
b. crossovers or orbits through the course sector, at right angles to the extended runway center line.

For special and commissioning flight inspections, the approach method is recommended. For all flight inspections the discrepancy between ground and air measurement shall not exceed 10 per cent of the nominal displacement sensitivity; where this degree of correlation is not achieved, the reason for the discrepancy shall be resolved. On initial categorization, the displacement sensitivity shall be set to the nominal value for that installation.

To determine the half-sector width in degrees using the approach method, fly the aircraft on either side of the course line so that the average cross-pointer deflection is 75 (or 150) microamperes in each instance. The average angular position of the aircraft, measured by the tracking device on each side of the course line, will define the angular value of the half-sector width. The following formula shall be used to compute an equivalent angular change that corresponds to a displacement sensitivity percentage change:

$$\text{New sector width} = \frac{\text{current sector width}}{(1+\text{ change }\%)}$$

Example calculation:

Wide sector (-17% displacement sensitivity) = 6.0 /(1 + (-0.17)) = 6.0/(1 - 0.17) = 6.0/0.83 = 7.23;

Narrow sector (+17% displacement sensitivity) = 6.0 /(1 + (+0.17) = 6.0/(1 + 0.17) = 6.0/1.17 = 5.13;

Note. — Deviation of the aircraft toward the runway extended center line will reduce the accuracy of the measurements — normally the average cross-pointer deflection should be within 15 (or 30) microamperes of the intended value.

The crossover or orbital method of displacement sensitivity measurement is typically used during periodic inspections. In case of structure perturbation, the approaches on the edges of the course sector are to be used during periodic inspections to minimize measurement errors.

When the crossover or orbital method is used, the measurement is made at a convenient known distance from the localizer antenna, taking into account ground speed and the sampling rate and delay of the navigation receiver and position reference system. To best calculate the displacement sensitivity, it is necessary to use several samples from the linear DDM area and find the slope of the straight line that fits the data. In order to provide an accurate reference for subsequent use, and to correlate the results with the half-sector width measurement, this abbreviated procedure shall initially be carried out during the commissioning or major inspection.

The following is an example of measuring course displacement sensitivity by this method. Fly a track at right angles to the localizer course line so as to pass directly over the outer marker, or selected checkpoint, at a height of 460 m (1 500 ft) above the localizer antenna site elevation. The flight should begin sufficiently off course to assure stable airspeed prior to penetration of the course sector. Follow the aircraft position with the tracking device and measure the angles at which -150, -75, 0, 75 and 150 µA occur. The full sector from -150 to 150 µA should be flown so that linearity can be assessed by examining the recordings.

**6.5.1.4.** Off-course clearance

The localizer clearance is checked to determine that the transmitted signals will provide the user with the proper off-course indication and that there are no false courses. Conduct an orbital flight with a radius of 9 to 15 km (5 to 8 NM) from the facility and approximately 1 500 ft above the antenna. Where terrain is a factor, the height will be adjusted to provide line-of-sight between the aircraft and the antenna.

Clearance shall be checked within the promulgated angular limits of coverage provided on either side of the front course (typically 35 degrees), unless the back course is used for approaches. In such cases, clearances will also be checked to the angular coverage limits of the back course. Outside of the promulgated coverage, there may be false courses due to antenna pattern characteristics or environmental conditions.

**6.5.1.5.** High angle clearance

The combination of ground environment and antenna height can cause nulls, or false courses, which may not be apparent at all normal instrument approach altitudes. High altitude clearance shall therefore be investigated upon:

a. initial commissioning;
b. a change in the location of an antenna;
c. a change in the height of an antenna; or
d. installation of a different type of antenna.

Normally, High-angle clearance is investigated within the angular limit of coverage provided, in the same manner as for off-course clearance, at a height corresponding to an angle of 7 degrees above the horizontal through the antenna. If the minimum clearance at this height, in an orbit of 5 to 8 NM, exceeds 150 microamperes, and the clearance is satisfactory at 1 000 ft, the localizer will be assumed as satisfactory at all intermediate altitudes. Where the clearance is not satisfactory, additional checks will be made at lower heights to determine the highest level at and below that which the facility may be used. In such a case, procedural use of the localizer shall be restricted

If approach altitudes higher than the height of 6 000 ft above the antenna elevation are required locally, investigation shall also be made at higher heights to determine that adequate clearance is available, and that no operationally significant false courses exist.

**6.5.1.6.** Course alignment accuracy

The measurement and analysis of localizer course alignment shall take into account the course line bends. The alignment of the mean course line needs to be established in the following critical region before the appropriate decision height:

| | |
|---|---|
| Category I | : for at least 0.5 NM containing of ILS |
| Point B Category II | : ILS Point B to ILS reference datum |
| Category III | : ILS Point C to ILS Point D |

A normal ILS approach shall be flown, using the glide path, where available. The aircraft's position shall be recorded using the tracking or position-reference system. By relating the aircraft average position to the average measured DDM, the alignment of the localizer may be determined.

Where there are course line bends in the area being evaluated, they shall be analyzed so that the average localizer alignment may be calculated.

**6.5.1.7.** Course structure

This is an accurate measurement of course bends and may be accomplished concurrently with the alignment and displacement sensitivity checks. Recordings of approaches made during the course alignment check and during the course sensitivity checks can be used for the calculation of course bends.

The center, or mean, of the total amplitude of bends represents the course line for bend evaluation purposes, and the tolerance for bends is applied to that as a reference. If the evaluation is made on airborne data, low pass filtering of the position-corrected cross-pointer signal is necessary to eliminate high-frequency structure components of no practical consequence.

The total time - constant of the receiver and recorder DDM circuits for the measurements shall be referenced to an aircraft speed of 105 knots, for which the constant is approximately 0.5 second (refer to Attachment C to Annex 10, Volume I, 2.1.6, for specific filter guidance). From the recording of airborne measurements, the alignment for each zone for application of structure tolerances may be determined as the average course position between the runway threshold and Point D, and separately between Point D and Point E. To analyze the post-filtering low frequency spectral components, the guidance found in Attachment C to Annex 10, Volume I, 2.1.3 and 2.1.5, shall be used, with the structure tolerances referenced to the average course position in each zone.

For the evaluation of a course center line structure, a normal approach shall be flown, using the glide path, where available. For Category II and III localizers, the aircraft shall cross the threshold at approximately the normal design height of the glide path and continue downward to the normal touchdown point. Continue a touchdown roll until at least Point E. Optionally, the touchdown roll may be conducted from touchdown to Point D, at which point a take- off may be executed, with an altitude not exceeding 15 m (50 ft) until Point E is reached. These procedures shall be used to evaluate the localizer guidance in the user's environment. Accurate tracking or position reference shall be provided from ILS Point A to the following points:

for Category I : ILS reference datum
for Category II : ILS reference datum
for Category III : ILS Point E

For Category III bend evaluation between the ILS reference datum and ILS Point E, ground measurements using a suitably equipped vehicle may be substituted for flight inspection measurements. This is the only area where a direct comparison between the ground and flight measurement results is possible. Therefore, it is useful to perform this measurement with the flight inspection aircraft to allow a comparison between the two measurement results.

If the localizer's course is used for take-off guidance, bend measurements along the runway should be made for any category of ILS.

Guidance material concerning course structure is provided in 2.1.3 to 2.1.6 of Attachment C to Annex 10, Volume I.

*Note. — Course structure shall be measured only while the course sector is in its normal operating width.*

**6.5.1.8.** Coverage

This check is conducted to determine whether the facility provides the correct information to the user throughout the area of operational use. Coverage has been determined, to some extent, by various other checks; however, additional procedures are necessary to complete the check of the coverage at distances 18.5, 31.5 and 46.3 km (of 10, 17 and 25 NM) from the antenna.

Flights at appropriate heights are required for routine and commissioning inspections to ensure the following coverage requirements are satisfied.

The localizer coverage sector is specified as follows (Annex 10, Volume I, 3.1.3.3.1):

……………..[….]The localizer coverage sector shall extend from the center of the localizer antenna system to distances of:

46.3 km (25 NM) within plus or minus 10 degrees from the front course line;
31.5 km (17 NM) between 10 degrees and 35 degrees from the front course line;
18.5 km (10 NM) outside of plus or minus 35 degrees from the front course line if coverage is provided;

except that, where topographical features dictate or operational requirements permit, the limits may be reduced down to 33.3 km (18 NM) within the plus or minus 10-degree sector and 10 NM within the remainder of the coverage when alternative navigational means provide satisfactory coverage within the intermediate approach area.

The localizer signals shall be receivable at the distances specified at and above a height of 600 m (2 000 ft) above the elevation of the threshold, or 300 m (1 000 ft) above the elevation of the highest point within the intermediate and final approach areas, whichever is the higher; except that, where needed to protect ILS performance and if operational requirements permit, the lower limit of coverage at angles beyond 15 degrees from the front course line shall be raised linearly from its height at 15 degrees to as high as 1350 m (4 500 ft) above the elevation of the threshold at 35 degrees from the front course line. Such signals shall be receivable, to the distances specified, up to a surface extending outward from the localizer antenna and inclined at 7 degrees above the horizontal.

*Note. — Where intervening obstacles penetrate the lower surface, it is intended that guidance need not be provided at less than the line-of-sight heights.”*

In the specification above, all the localizer coverage requirements are based on the assumption that the aircraft is heading directly towards the facility. When power density measurements are gain compensated based on the aircraft antenna pattern polar diagram(s), arc profiles can also be performed for coverage checks.

At periodic inspections, it is necessary to check coverage only at 31.5 km (17 NM) and 35 degrees either side of the course, unless use is made of the localizer outside of this area. Arc profiles may be flown at distances closer than this, provided an arc profile is flown at the same distance and altitude during the commissioning inspection to establish reference values.

**6.5.1.9.** Polarization

This check is conducted to determine the effects of undesired vertically polarized signal components. While maintaining the desired track (on the extended center line), bank the aircraft around its longitudinal axis 20 degrees each way from level flight. The aircraft's position shall be monitored using an accurate tracking or position-reference system. Analyze the cross-pointer recording to determine if there are any course deviations caused by the change in aircraft (antenna) orientation.

The effects of vertically polarized signal components are acceptable when they are within specified tolerances. If this check is accomplished in the area of the outer marker, the possibility of errors due to position changes will be lessened. The amount of polarization effect measured also depends on polarization characteristics of the aircraft antenna, hence the vertical polarization effect of the aircraft antenna should be as low as possible.

**6.5.1.10.** Localizer monitors

Localizer course alignment and displacement sensitivity monitors shall be checked by flight inspection. A suggested method of flight inspection is given below:

a. *Alignment monitor.* Request the ground technician to adjust the localizer equipment to cause an alarm of the alignment monitor. Fly the aircraft on the extended center line of the runway as indicated by the position reference system and note the precise displacement in microamperes from the recording in each condition of the alarm to the right and left of the center line. After the course has been readjusted to a normal operating condition, its alignment should be confirmed.

b. *Displacement sensitivity monitor.* Request the maintenance technician to adjust the displacement sensitivity to the broad and narrow alarm limits and check the displacement sensitivity in each condition. This check should follow the normal displacement sensitivity check described in 6.3.1.3.

c. The crossover or orbital flight method shall be used only if good correlation with a more accurate approach method has been established. After the alarm limits have been verified or adjusted, it is also necessary to confirm the displacement sensitivity value in the normal operating condition.

***Note.—*** During commissioning inspection or after major modifications, clearance shall be checked while the displacement sensitivity is adjusted to its broad alarm limit. The values of 175 microamperes and 150 microamperes specified for application during normal displacement sensitivity conditions will then be reduced to 160 microamperes and 135 microamperes, respectively.

d. *Power monitor.* For single-frequency systems, the field strength of the localizer signal shall be measured on course at the greatest distance at which it is expected to be used, but not less than 33.3 km (18 NM), while operating at 50 per cent of normal power. For two-frequency carrier systems, the field strength of the localizer signal shall be measured on course at the greatest distance at which it is expected to be used, but not less than 33.3 km (18 NM), while operating at 80 per cent of normal power for the both carriers. Power monitor requirements for single-frequency and two-frequency systems are described in Annex 10, Volume I, 3.1.3.11.2 d) and e).

In addition, if ground inspections do not allow control of the structure along the center line, the structure performances have to be met on course while operating at 80 per cent of normal power for the carrier providing a radiation field pattern in the front course sector and 120 per cent for the carrier providing a radiation field pattern outside that sector. If the alarm thresholds are lower than these 1 dB values but not less than 3 dB, the structure performances have to be met at these lower values (less than 100 per cent for the front course sector carrier and more than 100 per cent for the other carrier).

The clearance areas have also to be checked, with the carrier providing a radiation field pattern in the front course sector at 120 per cent of the nominal value or at the upper alarm limit, while the carrier providing a radiation field pattern outside that sector at 80 per cent of the normal value or at the lower alarm limit.

**6.5.1.11.** Phasing

The following phasing procedure applies to typical localizer systems. Alternative phasing procedures in accordance with the manufacturer's recommendations should be followed for other types of localizers. To the extent possible, methods involving ground test procedures should be used, and airborne measurements made only upon request from ground maintenance personnel. If additional confirmation is desirable by means of a flight inspection, the following is a suitable example procedure:

*Note.— Adjustments made during the phasing procedure may affect many of the radiated parameters. For this reason, it is advisable to confirm the localizer phasing as early as possible during the commissioning tests.*

a. Measure the displacement sensitivity of the localizer if it is not already determined.
b. Feed the localizer antenna with the carrier equally modulated by 90 Hz and 150 Hz and load the sideband output with a dummy load. Note the cross-pointer deflection as X (90) or X (150) microamperes.
c. The aircraft should be flown at a suitable off-course angle (depending on the type of localizer antenna used) during the phasing adjustment and should not be closer than 5.6 km (3 NM) from the antenna.
d. Insert a 90-degree line in a series with the sideband input to the antenna and feed the antenna with sideband energy.
e. Adjust the phaser until the deviation indicator reading is the same as in b) above.
**f.** Remove the 90-degree line, used in step d) above**.**

This completes the process of phasing the carrier with the composite sidebands. As an additional check, displacement sensitivity should be rechecked and compared with that obtained in step a) above. The value obtained after the phasing adjustment should never be greater than the value obtained before the phasing adjustment.

**6.5.2. LOCALIZER BACK COURSE**

The back course formed by some types of localizers can serve a useful purpose as an approach aid, provided that it meets specified requirements and that an associated aid is available to provide a final approach fix. Although a glide path is not to be used in conjunction with the back course, landing weather minima commensurate with those of other non-precision aids can be approved. The display in the aircraft cockpit will present a reverse sensing indication to the pilot; however, pilots are well aware of this and it is not considered significant.

Under no circumstances should localizer equipment be adjusted to enhance performance of the back course, if the adjustment would adversely affect the desired characteristics of the front course.

Where the localizer back course is to be used for approaches to landing, it shall be evaluated for commissioning and at periodic intervals thereafter. Procedures used for checking the front course will normally be used for the back course, the principal difference being the application of certain different tolerances, which are given in Table 6. As a minimum, alignment, sector width, structure, and modulation depth shall be inspected as well.

Under no circumstances should localizer equipment be adjusted to enhance performance of the back course, if the adjustment would adversely affect the desired characteristics of the front course.

### 6.5.3. GLIDE PATH

Most glide path parameters can be tested with two basic flight procedures — an approach along the course line, and a level run or orbit through the localizer course sector. Variations include approaches above, below, or abeam the course line, and level runs left and right of the extended runway center line. By selecting suitable starting distances and angles, several measurements can be made during a single aircraft maneuver.

**6.5.3.1.** Glide path angle (site, commissioning, categorization and periodic)

The glide path angle may be measured concurrently with the glide path structure during these inspections. To adequately check the glide path angle, an accurate tracking or positioning device shall be employed. This is necessary in order to correct the recorded glide path for aircraft positioning errors in the vertical plane.

The location of the tracking or positioning equipment with respect to the facility being inspected is critical for accurate measurement. Incorrect siting can lead to unusual characteristics being shown in the glide path structure measurements. The tracking device shall initially be located using the results of an accurate ground survey. In certain cases, initial flight results may indicate a need to modify the location of the tracking device.

The arithmetic mean of all deviations of this corrected glide path between ILS Point A and ILS Point B represented by a straight line will be the glide path angle, as well as the average path to which tolerances for glide path angle alignment and structure will be applied. Because of the normal hyperbolic characteristics of the glide path, the portion below ILS Point B is not used in the above calculation.

At commissioning, the glide path angle shall be adjusted to be as near as possible to the desired nominal angle. During periodic inspections, the glide path angle shall be within the figures given in Table 7.

**6.5.3.2.** Displacement sensitivity (site, commissioning, categorization and periodic)

The mean displacement sensitivity is derived from measurements made between ILS Point A and Point B. Make approaches above and below the nominal glide path at angles where the nominal cross-pointer deflection is 75 µA and measure the aircraft's position using an accurate tracking device. During these measurements, the average cross-pointer deflection should be 75 ±15 µA. Note that any aircraft deviation toward the zero DDM course line will decrease the accuracy of the measurement. The displacement sensitivity can be calculated by relating the average cross-pointer deflection to the average measured angle.

**6.5.3.3.** Glide path angle and displacement sensitivity (routine periodic inspections)

The glide path angle and displacement sensitivity can be measured by using a level run or "slice" method. This is only possible where the glide path is relatively free from bends so that there is a smooth transition from fly-up to fly-down on the level run. This method shall not be used with systems that have asymmetrical displacement sensitivity above and below the glide path.

*Level run method.* Fly the aircraft towards the facility at a constant height (typically the intercept altitude), following the localizer center line, starting at a point where the cross-pointer deflection is more than 75 µA fly-up (more than 190 µA recommended). This flight is usually made at 460 m (1 500 ft) above the facility unless terrain prevents a safe flight. If a different height is used, it shall be noted on the flight inspection report and facility data sheet. During the flight, the aircraft's angular position shall be constantly tracked. By relating the recorded cross-pointer current to the measured angles, the glide path angle and displacement sensitivity may be calculated. The exact method of correlating the angle and cross-pointer measurements is dependent on the particular flight inspection system.

**6.5.3.4.** Clearance

The clearance of the glide path sector is determined from a level run, or slice, through the complete sector during which the glide path transition through the sector is recorded. This measurement may be combined with the level flight method of measuring the glide path angle and displacement sensitivity.

This flight is made using the level run method, except that the run shall commence at a distance corresponding to 0.3θ and shall continue until a point equivalent to twice the glide path angle has been passed. The aircraft's position shall be accurately measured throughout the approach. Cross-pointer current shall be continuously recorded and the recording marked with all the necessary distances and angles to allow the figures required in Table 6 to be evaluated. This recording shall also permit linearity of the cross-pointer transition to be evaluated.

**6.5.3.5.** Glide path structure

Glide path structure is an accurate measurement of the bends and perturbations on the glide path. It is most important to employ an accurate tracking or positioning device for this measurement. This measurement may be made concurrently with the glide path angle measurement. Guidance material concerning course structure evaluation is provided in 2.1.4 of Attachment C to Annex 10, Volume I.

**6.5.3.6.** Modulation

a. Modulation balance. The modulation balance is measured while radiating the carrier signal only. Position the aircraft close to the glide path angle and note the cross-pointer indication. Flight inspection of modulation balance should be conducted on specific engineering request only (see paragraph 6.2)

**b.** Modulation depth. This check can be best accomplished accurately while the aircraft is "on-path"; therefore, final measurements are best obtained during angle checks. The measurements should be made at a point where the receiver input corresponds to the value at which the receiver modulation depth calibration was made. If the receiver modulation depth indications are influenced significantly by the RF level, measure the modulation depth near Point A. For measurement systems that do not provide separate modulation level outputs, preliminary indications of modulation can be obtained during level runs at the time the aircraft crosses the glide path. The depth of modulation (in per cent) can be obtained by comparing the glide path receiver- flag-alarm-current to the receiver-flag-current-calibration data**.**

**6.5.3.7.** Obstruction clearance

Checks may be made beneath the glide path sector to assure a safe flight path area between the bottom edge of the glide path and any obstructions. To accomplish this check, it is necessary to bias the pilot's indicator or use an expanded scale instrument. Position the aircraft on the localizer front course inbound at approximately five miles from the glide path antenna at an elevation to obtain at least 180 μA "fly-up" indication. Proceed inbound maintaining at least 180 μA clearance until the runway threshold is reached or it is necessary to alter the flight path to clear obstructions. This check will be conducted during monitor checks when the path width is adjusted to the wide alarm limits during which a minimum of 150 μA fly-up is used in lieu of 180 μA. When this check has been made during broad path width monitor limit checks, it need not be accomplished after the path is returned to the normal width of the normal approach envelope, except during the commissioning inspection.

**6.5.3.8.** Glide path coverage

This check may be combined with the clearance check using the same flight profile. If a separate flight is made, it is not necessary to continue the approach beyond the intercept with the glide path lower width angle.

At site, commissioning, categorization and periodic checks this measurement shall be made along the edges of a sector 8 degrees either side of the localizer center line. Coverage will be checked to a distance of 18.5 km (10 NM) from the antenna. Coverage will be checked to a distance greater than 18.5 km (10 NM) to the extent required to safeguard the promulgated glide path intercept procedure.

*Note. — Flight inspection alone is not sufficient to extend glide path coverage beyond 10 NM (e.g. Frequency coordination).*

**6.5.3.9.** Monitors

Where required, monitor checks may be made using identical measurement methods to those described for glide path angle, displacement sensitivity and clearance. The level flight method for angle and displacement sensitivity shall not be used if there is non-linearity in the areas being evaluated.

*Note. — If checks are required, see Note 2 of Table 7.*

*Power monitor (commissioning only).* The field strength of the glide path signal shall be checked at the limits of its designated coverage volume, with the power reduced to the alarm level. Alternatively, if the monitor alarm limit has been accurately measured by ground inspection, the field strength may be measured under normal operating conditions and the field strength at the alarm limit may be calculated. This check may be made at the same time as clearance and coverage checks.

**6.5.3.10.** Phasing and associated engineering support tests

The glide path site test is made to determine whether the proposed site will provide satisfactory glide path performance at the required path angle. It is extremely important that the site tests be conducted accurately and completely to avoid re-siting costs and unnecessary installation delays. Because this is functionally a site-proving test rather than an inspection of equipment performance, only one transmitter is required.

A preliminary glide path inspection is performed upon completion of the permanent transmitter and antenna installation, but prior to permanent installation of the monitor system. This inspection is conducted on one transmitter as a preliminary confirmation of airborne characteristics of the permanent installation. Additionally, it provides the installation engineer with data that enables the engineer to complete the facility adjustment to the optimum for the commissioning inspection. This requires the establishment of transmitter settings for monitor alarm limits. These settings may be utilized by ground personnel to determine that the field monitor is installed at its optimum location and that integral monitors recombining units are correctly adjusted to achieve the most satisfactory overall monitor response.

The procedures for conducting various glide path engineering support tests are described below. These checks will be performed by ground methods prior to the flight inspection, and airborne checks will be conducted at the option of the ground technician. It is not intended that they will supplant ground measurements, but that they will confirm and support ground tests. The details of these tests will be included in the flight inspection report.

**a.** Modulation balance. Although the modulation balance is most easily measured on the ground, it may be measured from the air while radiating the carrier signal only. Fly a simulated “on-path” approach recording the glide path indications. The average deviation of the glide path indication from “on-path” should be noted for use in the phasing check. Ground personnel shall be advised of the result. The optimum condition is a perfect balance, i.e. zero on the precision microammeter. If the unbalance is 5 μA or more, corrective action shall be taken by ground personnel before continuing this test.

*Note.— Level runs are not satisfactory for this test since shifting of centering may occur in low-signal or null areas.*

**b.** Phasing — transmitting antennas. The purpose of the phasing test is to determine that optimum phase exists between the radiating antennas. There are several different methods of achieving airborne phasing and these tests shall normally be made using the manufacturer's recommended methods. Where difficulty is experienced in achieving airborne phasing to a definite reading by normal procedures, the flight inspector shall coordinate with the ground engineer to determine the most advantageous area for conducting the phasing test. When this area and track are determined, it shall be noted on the facility data record for use on future phasing tests of that facility.

**c.** Phasing — monitor system. Some types of glide path integral monitor need flight inspection checks to prove that they will accurately reproduce the far-field conditions when changes occur in transmitted signal phases. Procedures for making such checks shall be developed in conjunction with the manufacturer's recommendations.

**d.** Glide path antenna adjustment (null checks). These checks are conducted to determine the vertical angles at which the RF nulls of the various glide path antennas may occur. The information is used by ground engineer to assist them in determining the correct heights for the transmitting antennas. The test is made with carrier signals radiating only from each antenna in turn. The procedure for conducting this test is by level flight along the localizer course line. The angles of the nulls will be computed in the same manner as the glide path angle is computed. The nulls are characterized by a sharp fall in signal level.

### 6.5.4. MARKER BEACON

**6.5.4.1.** Keying.

The keying is checked during an ILS approach over the beacons. The keying is assessed from both the aural and visual indication and is satisfactory when the coded characters are correct, clear and properly spaced. The frequency of the modulating tone can be checked by observing that visual indication is obtained on the correct lamp of a three-lamp system, i.e. outer marker (OM) — blue, middle marker (MM) — orange and inner marker (IM) — white.

**6.5.4.2.** Coverage.

Coverage is determined by flying over the marker beacons during a normal ILS approach on the localizer and glide path and measuring the total distance during which a visual indication is obtained from a calibrated marker receiver and antenna or during which a predetermined RF carrier signal level is obtained.

At commissioning:

a. The coverage shall be determined by making a continuous recording of the RF signal strength from the calibrated aircraft antenna, since this allows a more detailed assessment of the ground beacon performance. The visual indication distance should be noted for comparison with subsequent routine checks.
   For routine checks, measuring the distance over which the visual indication is received will be sufficient, although the above procedure of recording signal strength is recommended.

   The signal strength recording shall be examined to ensure that there are no side-lobes of sufficient signal strength to cause false indications, and that there are no areas of weak signal strength within the main lobe.

b. A check shall be made that the center of the coverage area is in the correct position. This will be over the marker beacon but in some cases, due to siting difficulties, the polar axis of the marker beacon radiation pattern may have to be other than vertical. Reference shall then be made to the operational procedures to determine the correct location of the center-of-coverage, with respect to some recognizable point on the ground. The center-of-coverage can be checked during the coverage flights described above, by marking the continuous recording when the aircraft is directly over the marker beacon (or other defined point). On a normal approach there shall be a well-defined separation (in the order of 4.5 seconds at 180 km/hr (95 kt)) between the indications obtained from each marker.

At commissioning, categorization and annual inspections, a check shall also be made to ensure that operationally acceptable marker beacon indications are obtained when an approach is made on the glide path but displaced ±75 μA from the localizer center. The time at which the indication is obtained will usually be shorter than when on the localizer center.

**6.5.4.3.** Monitor system

At commissioning, the coverage shall be measured with the marker beacon operating at 50 per cent of normal power and with the modulation depth reduced to 50 per cent. An operationally usable indication shall still be obtained; if not, the power shall be increased to provide an indication and the monitor adjusted to alarm at this level.

Alternatively, the coverage under monitor alarm conditions can be determined by analyzing the field strength recording as detailed in 6.3.4.2

**6.5.4.4.** Standby equipment

At commissioning, the standby equipment is checked in the same manner as the main equipment. It will not be necessary to check both the main and standby equipment at each routine check, if the equipment operation has been scheduled so that the routine checks are carried out on each equipment alternately.

## 6.6. CHARTS AND REPORTS

The ILS flight inspection report shall record the conformance of the facility performance to the Standards defined in Annex 10 as well as the equipment specific standards established by the authorized flight inspection organization and the responsible ground maintenance organization. Tables 6 and 7 list the parameters to be measured for localizer and glide path facilities, as well as localizer back course approaches. Table 8 summarizes the parameters to be measured for ILS Marker Beacons. It is recommended that the flight inspection report include an assessment of the parameters listed in Tables 6 through 7, which are appropriate for the type of inspection. Flight inspection reports shall allow for “As found” and “As left” results to be entered for routine documentation of the adjustments made to facilities.

### 6.6.1. REPORT CONTENTS

The ILS flight inspection report shall contain the minimum information as mentioned in Chapter 3 paragraph 3.5.1.2.

The following are additional requirement shall be established for ILS flight Inspection report:

a. Selected receivers, antennas, reference source and other selectable parameters shall be traceable for each profile.
b. Glide path (GP) aiming point offset calculations are terrain dependent and are normally calculated and compensated for during commissioning.
c. Recordings and results should be configurable for ILS ground maintenance personnel in their requested format, e.g. with DDM instead of µA, if so required.
d. A full set of applicable calculated data are presented in the result section of the enclosed report.
e. The results should be automatically checked against the tolerances specified and applied by ICAO regulations (or otherwise towards stated regulations), and any out of tolerance situations should be highlighted (i.e. * or red color).
f. The course and glide path structure calculation shall be based on a 95 per cent probability according to Annex 10, Volume 1, Figure C-2.
g. As found and as left results, with adjustments and repeated profiles, shall be properly noted and explained.
h. If specific tests are requested by ILS ground maintenance personnel, the report shall include results accordingly.
i. If any unforeseen events occur, this shall be highlighted in the remarks section.
j. Current and any new restrictions applied shall be properly referenced in the remarks section

## 6.7. ANALYSIS

This section provides brief material related to special topics involved with analysis of ground and flight testing of ILS facilities. In addition, considerable material on the analysis of ILS testing results is published in Attachment C to Annex 10, Volume I.

### 6.7.1. STRUCTURE ANALYSIS

Analysis of localizer course line and glide path angle structure is dependent upon aircraft speed, the time constant of receiver and recording equipment, and various other factors. Guidance on these topics can be found in Attachment C to Annex 10, Volume I, 2.1.3 and its preceding note, and 2.1.4 through 2.1.6.

### 6.7.2. COMPUTATION OF DISPLACEMENT SENSITIVITY

Displacement sensitivity is typically measured with orbital flights on localizers, and level inbound runs on glide slopes. Analogous measurements can be made for ground testing. In each case, the azimuth (localizer) or elevation (glide path) angles, at which nominal DDM values of 150 µA (75 µA) occur, are determined, and the sensitivity computed, taking into account the distance from the antenna system at which the measurements were taken. Particularly on glide path measurements, it is common for the DDM recording to be nonlinear if significant multipath conditions exist. In these cases, the measurements may need to be taken at DDM values other than those stated above between which linearity is maintained, and the calculated sensitivity scaled to the nominal value. Reference Datum Height (RDH)

For commissioning and categorization flight tests, it may be necessary to determine the glide path RDH. This is done using a high-quality approach recording, from which the angle and structure measurements are made. Position-corrected DDM values for a selected portion of the approach (typically Point A to Point B for Category I facilities, and the last nautical mile of the approach for Category II and III facilities) are used in a linear regression to extend a best-fit line downward to a point above the threshold. The height of this line above the threshold is used as the RDH. If the tolerances are not met, an engineering analysis is necessary to determine whether the facility has been sited correctly. A different portion of the approach should be used for the regression analysis, or another type of analytical technique should be used.

## 6.8. POSITIONING.

The evaluation of some parameters includes a combination of errors coming from the radio electrical outputs and from the positioning subsystem. By nature, these errors are independent, and it is acceptable to consider that the global statistical error on the parameter to be measured is equal to the square root of the sum of the squares of the equally weighted errors of the two parts of the system. Whatever the measured parameter is, the measurement uncertainty should be small compared with the tolerances for that parameter. A ratio of five is the minimum required.

### 6.8.1. ACCURACY REQUIRED.

The required accuracies are calculated by converting tolerances on the different ILS parameters into degrees, using the following formulas:

a. Localizer alignment tolerance = ± (tolerance in μA × nominal sector width / 150) degrees
b. Glide path alignment tolerance = θ ± (tolerance in μA × nominal sector width / 150) degrees
c. Localizer or glide path sector tolerance = nominal sector × 150/(150 ± tolerance in μA) degrees

In Table 9, the minimum accuracies of the positioning are calculated from adjust and maintain tolerances. The tables show that the accuracy of the aircraft positioning measurement has to be better than 1/100 of a degree for Category II and III localizers with narrow sector width.

For truth systems calculating linear cross track and vertical positions (e.g. differential global navigation satellite system (DGNSS) based systems), a set of cross track and vertical accuracy requirements is presented in Table 10.

| | *Category I* | | *Category II* | | *Category III* | |
|---|---|---|---|---|---|---|
| *Measurements* | *Constraint point* | *Accuracy* | *Constraint point* | *Accuracy* | *Constraint point* | *Accuracy* |
| Angular | | | | 0.0058°, 0.0173° (See Note) | D | 0.0058°, 0.0173° (See Note ) |
| — Localizer | C | 0.02°, 0.06° (See Note) | T | | T | |
| — Glide path | C | 0.0091 θ | T | 0.0055 θ | | 0.0055 θ |
| Distance | | 0.19 km (0.1 NM) | | 0.19 km (0.1 NM) | | 0.19 km (0.1 NM) |

Table 9. Minimum positioning subsystem accuracies

| | *Category I* | | *Category II* | | *Category III* | |
|---|---|---|---|---|---|---|
| *Measurements* | *Constraint point* | *Accuracy* | *Constraint point* | *Accuracy* | *Constraint point* | *Accuracy* |
| **Cross track — Localizer** | **C** | **2.17 m** | **T** | **0.61 m** | **D** | **0.33 m** |
| **Vertical — Glide path** | **C** | **0.27 m** | **T** | **0.083 m** | **T** | **0.083 m** |

Table **10.** Minimum positioning subsystem accuracies for linear truth systems

Notes:

1. Extreme localizer angular accuracy figures are calculated for localizer sector width of 2º and 6º, taking into account different runway lengths, as well as 0.5 µA airborne receiver uncertainty.
2. Extreme localizer cross track accuracy figures are calculated for localizer sector width of 2º for CAT I and 6º for CAT II and III, taking into account different runway lengths, as well as 0.5 µA airborne receiver uncertainty.
3. Extreme glide path angular tolerance figures are calculated for 286 metres of glide path setback distance and 2 µA airborne receiver uncertainty.
4. Extreme glide path vertical tolerance figures are calculated for 286 metres of glide path setback distance, 3º glide slope angle and 2 µA airborne receiver uncertainty.
5. Flight inspection systems with different receiver uncertainty values will require different positioning accuracy.

### 6.8.2. ERROR BUDGET

The different components of the error budget relative to the positioning measurement of the plane are

listed below:

a. the uncertainty on the database, describing geometrically, the field and the facility to be inspected
(definition of every characteristic point in the runway reference coordinates system);
b. the uncertainty on the platform coordinates (x, y, z) on which the positioning system is set up
(definition of some of them within one **centimeter**);
c. the care in setting up the positioning system on the ground;
d. the instrumental error within its operating limits defined by the manufacturer;
e. the error due to the atmospheric refraction if optical or infra-red tracker is used;
the error in timestamping of flight check receivers' sampled data and truth system positioning data. Timing errors between components of a truth system, when

using sensor fusion (e.g. DGNSS, attitude system, INS, laser range finder, auto tracking theodolite);

f. the parallax error due to the fact that the positioning system and the phase **center** of the facility to be measured are not collocated;

g. the error due to the fact that the reference aircraft positioning point and the localizer or glide path antenna are not collocated; and

h. the conical effect of the radiated pattern of the glide path in the final part of the approach and the fact that the ground reflection surface is not a perfect plane.

To reduce the three last components listed above, it is necessary to use high accuracy devices providing distance (to a few meters), heading and attitude (to about 0.1 degree each) information. If distance, heading, and attitude parameters are not available, a crosswind limit should be set allowing measurement accuracies to be within the limits required.

## 6.9. SAMPLE ILS FLIGHT INSPECTION REPORT

**A** typical ILS **Flight Inspection** report, including inspection of monitors, is presented together with example graphs for each type of flight profile performed. Some flight inspection systems produce several graphs that may be collected during each profile to combine measurements and save flight hours. Some of the profiles may be repeated with different settings of ground equipment to achieve results from both Tx1 and Tx2 or for wide alarm and narrow alarm. An example set of profiles is given in Table **11** below**.**

| *Run* | *Recordings, flight profile, specifics and remarks* |
|---|---|
| #1 | GP-Tx1, LOC-Tx1, DME-Tx1, Approach 8 to -1 NM |
| #2 | GP-Tx2, LOC-Tx2, DME-Tx2, Approach 8 to -1 NM |
| #3 | LOC-Tx2, Arc ±40°, 7 NM, 1500 ft, CCW |
| #4 | LOC-Tx1, Arc ±40°, 7NM, 1500 ft, CW |
| #5 | LOC-Tx1, Wide Alarm, Arc ±10°, 7NM, 1500 ft, CCW |
| #6 | LOC-Tx1, Narrow Alarm, Arc ±10°, 7NM, 1500 ft, CW |
| #7 | GP-Tx2, 90Hz Alignment Alarm, LOC-Tx2, 90Hz Alignment Alarm, Approach 5 to 0 NM |
| #8 | GP-Tx2, 150Hz Alignment Alarm, LOC-Tx2, 150Hz Alignment Alarm, Approach 5 to 0 NM |
| #9 | GP-Tx1, 90Hz Alignment Alarm, LOC-Tx1, 90Hz Alignment Alarm, Approach 5 to 0 NM |
| #10 | GP-Tx1, 150Hz Alignment Alarm, LOC-Tx1, 150Hz Alignment Alarm, Approach 5 to 0 NM |

| | |
|---|---|
| #11 | GP-Tx1, Level 12 to 2 NM, CL Az 0°, 1500 ft |
| #12 | GP-Tx1, Level 12 to 2 NM, CL Az 8°, 1500 ft |
| #13 | GP-Tx1, Level 12 to 2 NM, CL Az -8°, 1500 ft |
| #14 | GP-Tx2, Level 12 to 2 NM, CL Az 0°, 1500 ft |
| #15 | GP-Tx1, Wide Alarm, Level 6 to 2 NM, 1500 ft, Width Adjustment |
| #16 | GP-Tx1, Wide Alarm, Level 6 to 2 NM, 1500 ft |
| #17 | GP-Tx1, Narrow Alarm, Level 6 to 2 NM, 1500 ft |

**Table 11. Inspection Protocol - Inspection Id 2016-10-13 Airport ILS DME 18**

### 6.9.1. GENERAL REMARK.

a. To reduce transcription errors, the report **shall** be computer-generated by the flight inspection system and include explanation of events, remarks and status of the equipment.
b. The report heading **shall** contain a general section with basic report, crew and facility items.
c. An inspection identification key should be generated to keep track of all relevant data, graphs and records.
d. A system configuration key **shall** identify actual hardware and software versions used by the flight inspection system.
e. From the inspection report it **shall** be possible to trace back the utilized facility database settings, system calibration, antenna calibration diagrams, antenna lever arm corrections, cable loss and all relevant data involved in or related to the calculations used.
f. Selected receivers, antennas, reference source and other selectable parameters must be traceable for each profile.
g. Glide path (GP) aiming point offset calculations are terrain dependent and are normally calculated and compensated for during commissioning.
**h.** Recordings and results should be configurable for ILS ground maintenance personnel in their requested format, e.g. with DDM instead of μA, if so required.

### 6.9.2. SPECIFIC REMARK.

a. A full set of applicable calculated data are presented in the result section of the enclosed report.
b. The results **shall** be automatically checked against the tolerances specified and applied by ICAO regulations (or otherwise towards stated regulations), and any out of tolerance situations **shall** be highlighted (i.e. * or red colour).
c. The course and glide path structure calculation should be based on a 95 per cent probability according to Annex 10, Volume 1, Figure C-2.
d. As found and as left results, with adjustments and repeated profiles, should be properly noted and explained.
e. If specific tests are requested by ILS ground maintenance personnel, the report **shall** include results accordingly.
f. If any unforeseen events occur, this **shall** be highlighted in the remarks section.

g. Current and any new restrictions applied **shall** be properly referenced in the remarks section.

h. Confirmation of status of the inspection as shown in the preliminary report below **shall** be issued before leaving the site.

# Preliminary Flight Inspection Report
# ILS/DME 18 CCXX Airport, Country

Service Provider Name/Logo    Sys Config **FIS-123-02 V8.44.1**    Inspection Id **2016-10-13 Airport ILS DME 18**

| | | | | | | |
|---|---|---|---|---|---|---|
| Ident | **I-ILS** | Cal. Aircraft | **XX-ILS** | | GP | LOC |
| Frequency | **110.1 MHz** | Flight Inspector | **Kilo** | System | **Type No** | **Type No** |
| Category | **I** | Pilot | **Alpha** | Antenna | **M, 2F** | **2F** |
| Inspection Type | **Periodic Monitor** | 1st Officer | **Bravo** | Nom Angle | **3.00°** | **0.00°** |
| Date of Inspection | **13/10/2016** | Ref Source | **DGPS+INS** | Nom ½CS | **0.72°** | **1.67°** |
| Significant MET Cond. | **None** | Sel. Ref Point | **Ref1** | Nom CS | **1.44°** | **3.33°** |

**After flight inspection in accordance with ICAO Annex 10 and with reference to guidance material Doc 8071, the installation is temporarily classified for:**

X Unrestricted

Restricted
**in accordance with published restrictions:**

**Additional restrictions:**

Unusable

Remarks:

**After final evaluation of the flight inspection results, the installation will be classified in a detailed Flight Inspection Report.**

| | | | |
|---|---|---|---|
| Flight Inspector: | **Oscar Kilo** | | **OK** |
| Phone: | **+98 76 54 32 10 00** | Signature, Date: | **13/10/2016** |
| Email: | **post@amc.com** | Distribution: | **Airport Management Comp., Country** |

# Flight Inspection Report
## ILS/DME 18 CCXX Airport, Country

Service Provider Name/Logo    Sys Config **FIS-123-02 V8.44.1**    Inspection Id **2016-10-13 Airport ILS DME 18**

| | | | | | GP | LOC |
|---|---|---|---|---|---|---|
| Ident | **I-ILS** | Cal. Aircraft | **XX-ILS** | | | |
| Frequency | **110.1 MHz** | Flight Inspector | **Kilo** | System | **Type No** | **Type No** |
| Category | **I** | Pilot | **Alpha** | Antenna | **M, 2F** | **2F** |
| Inspection Type | **Periodic Monitor** | 1st Officer | **Bravo** | Nom Angle | **3.00°** | **0.00°** |
| Date of Inspection | **13/10/2016** | Ref Source | **DGPS+INS** | Nom ½CS | **0.72°** | **1.67°** |
| Significant MET Cond. | **None** | Sel. Ref Point | **Ref1** | Nom CS | **1.44°** | **3.33°** |

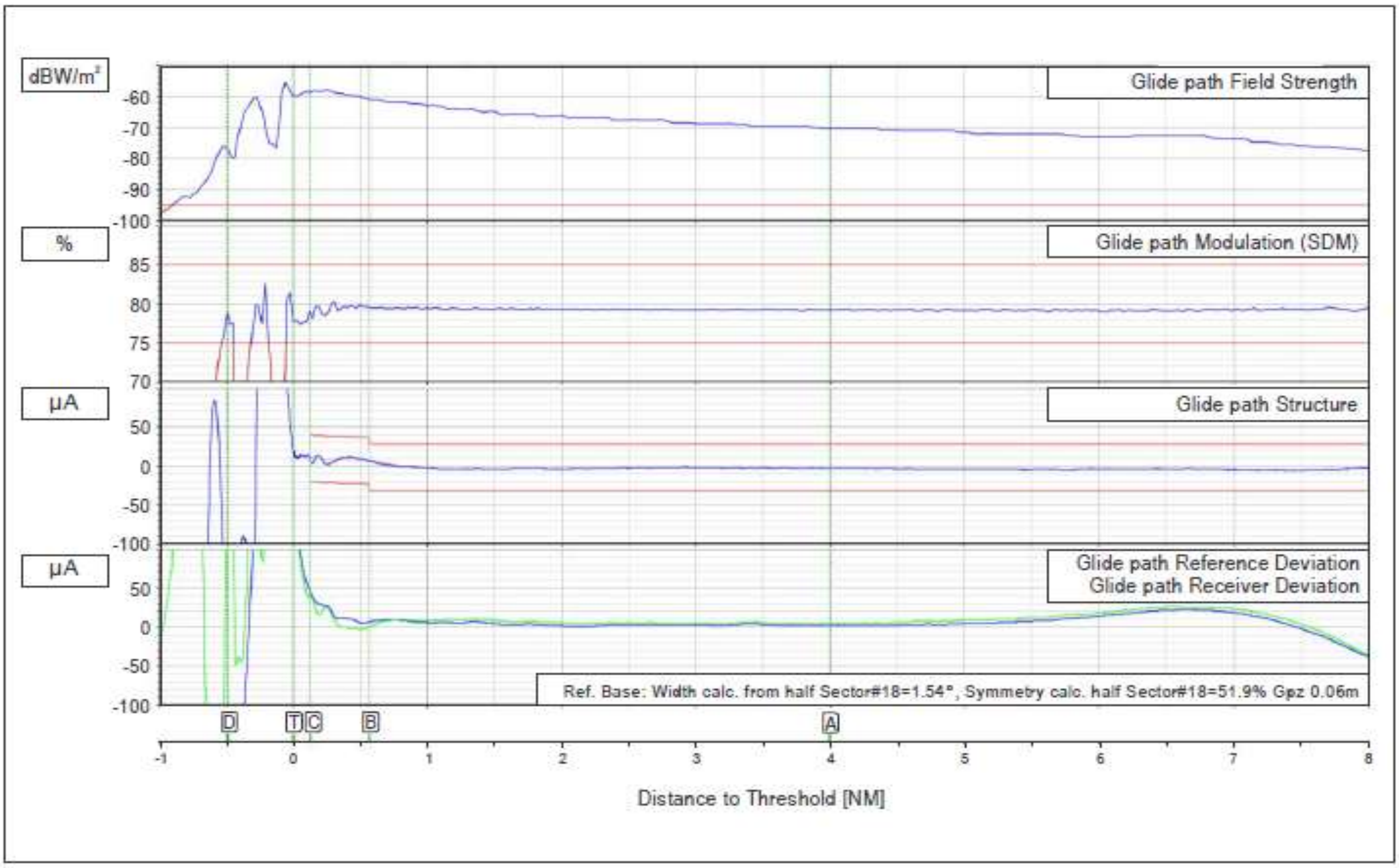
| Facility / Transmitter No / Requirements / Unit | | | | | 1 GP | 2 | 1 LOC | 2 | Tolerance | |
|---|---|---|---|---|---|---|---|---|---|---|
| **GP Angle / LOC Align.** | | **GP (°)** | **LOC** | **(µA)** | **2.99** | **2.99** | **-1.5** | **-1.8** | **2.78/3.22** | **±15.5** |
| **Alignment Monitor** | **150Hz** | **GP (µA)** | **LOC** | **(µA)** | **-36.0** | **-37.0** | **-12.9** | **-13.4** | **-47** | **-14.5** |
| | **90Hz** | **GP (µA)** | **LOC** | **(µA)** | **34.2** | **33.8** | **12.6** | **12.7** | **62** | **14.5** |
| **Modulation Depth** | | **SDM** | | **(%)** | **79.4** | **79.4** | **39.9** | **40.0** | **75/85** | **36/44** |
| **GP / Course Structure** | | | | **(%)** | **100** | **100** | **100** | **100** | **95** | **95** |
| **Zone 1** | **- A** | **GP (µA)** | **LOC** | **(µA)** | **-4.6** | **-4.8** | **-1.5** | **-1.5** | **30** | **30** |
| **Zone 2** | **A - B** | **GP (µA)** | **LOC** | **(µA)** | **8.5** | **8.2** | **-2.0** | **-2.1** | **30** | **30-15** |
| **Zone 3** | **B - C/T** | **GP (µA)** | **LOC** | **(µA)** | **7.0** | **7.3** | **-1.5** | **-1.8** | **30** | **15** |
| **Zone 4** | **T - D** | | **LOC** | **(µA)** | | | **N/A** | **N/A** | | **N/A** |
| **Zone 5** | **D - E** | | **LOC** | **(µA)** | | | **N/A** | **N/A** | | **N/A** |
| **RDH / Polarization ±20° bank** | | **GP (m)** | **LOC** | **(µA)** | **16.6** | **16.6** | **N/A** | **N/A** | **15-18** | **15** |
| **Aiming Point Offset** | | | | **(m)** | **0.33** | **0.37** | | | | |
| **Clearance** | | **GP (µA/θ)** | **LOC** | **(µA/°)** | **-320/0.45** | **-316/0.45** | **-262/21°** | **-260/20°** | **< -190** | **< -150** |
| | | **GP (µA/θ)** | **LOC** | **(µA/°)** | **370/1.75** | **380/1.75** | **278/-28°** | **276/-12°** | **> 150** | **> 150** |
| **LOC Course/Clearance Rati** | | | | **(dB)** | | | **-15** | **-15** | | **-10** |
| **DS ¼ Sector 150Hz** | | **GP (µA)** | **LOC** | **(µA)** | **72** | **75** | **74** | **72** | **56/94** | **62/88** |
| **DS ¼ Sector 90Hz** | | **GP (µA)** | **LOC** | **(µA)** | **78** | **78** | **75** | **75** | **56/94** | **62/88** |
| **Wide Monitor** | **DS ¼ 150Hz** | **GP (µA)** | | **(µA)** | **58** | **N/A** | **63** | **N/A** | **> 52** | **> 62** |
| | **DS ¼ 90Hz** | **GP (µA)** | | **(µA)** | **63** | **N/A** | **64** | **N/A** | **N/A** | **> 62** |
| **Narrow Monitor** | **DS ¼ 150Hz** | **GP (µA)** | | **(µA)** | **90** | **N/A** | **85** | **N/A** | **< 98** | **< 88** |
| | **DS ¼ 90Hz** | **GP (µA)** | | **(µA)** | **98** | **N/A** | **85** | **N/A** | **N/A** | **< 88** |
| **Field Str** | **GP/LOC** | **min at 10 NM** | | **(dBW/m²)** | **-82** | **-80** | **-85** | **-84** | **-95** | **-107** |
| **Field Str** | **LOC/LOC** | **min 17 and 25 NM** | | **(dBW/m²)** | **N/A** | **N/A** | **N/A** | **N/A** | **-114** | **-114** |
| **Ident** | | | | | | | **ok** | **ok** | **Clearly audible** | |
| **Marker** | | **OM (m)** | **MM** | **(m)** | **N/A** | **N/A** | **N/A** | **N/A** | **400-800** | **200-400** |
| **Beacon** | | | **IM** | **(m)** | | | **N/A** | **N/A** | | **100-200** |
| Facility / Transmitter No / Requirements / Unit | | | | | | | 1 DME | 2 | Tolerance | |
| **Range Error** | | | | **(m)** | | | **17** | **18** | | **75** |
| **Field Str** | | **min at 25 NM** | | **(dBW/m²)** | | | **N/A** | **N/A** | | **-89** |
| **Ident** | | | | | | | **ok** | **ok** | **Clearly audible** | |

Operational Status: Unrestricted

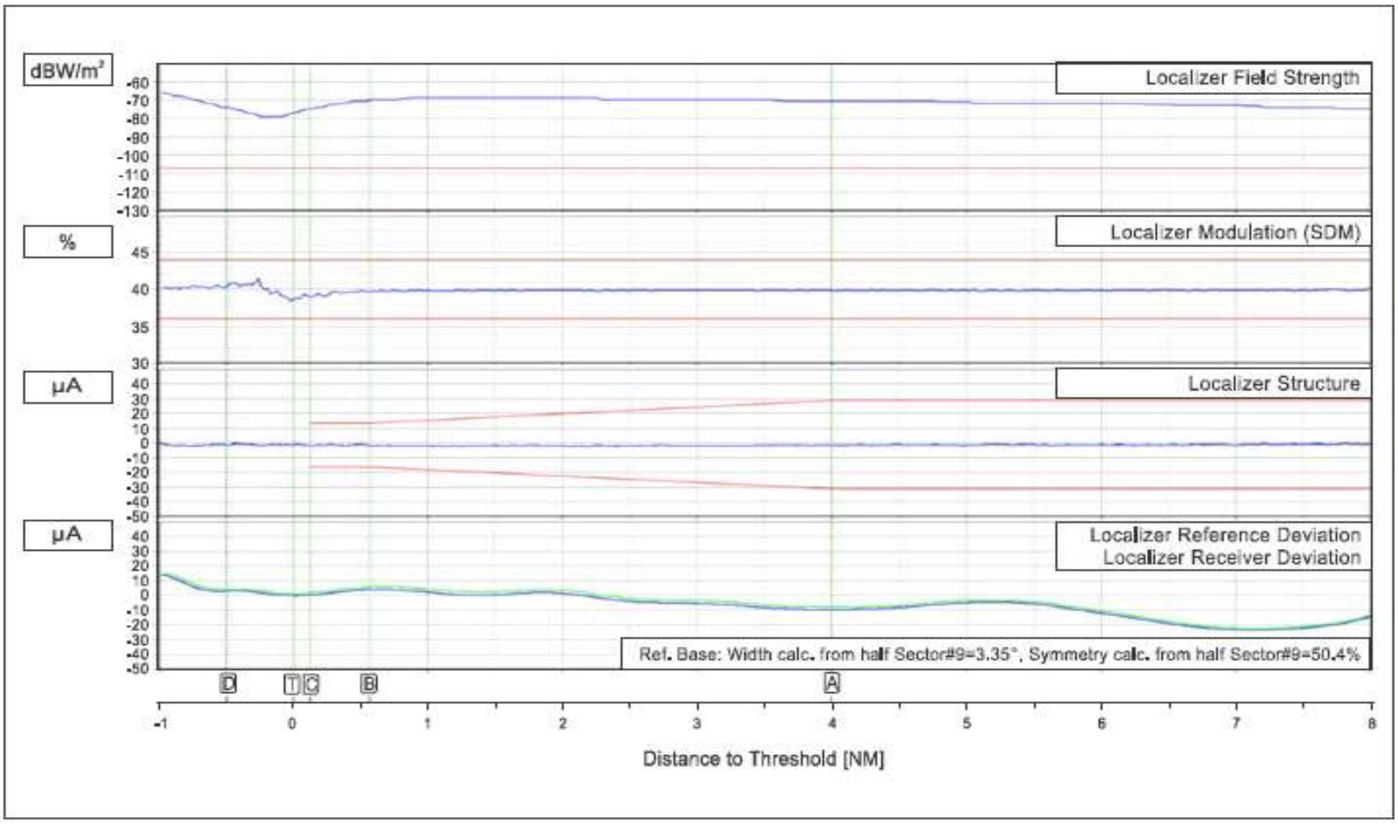
*** Out of Tolerance**
**@ Adjustment**

Remarks: **@ GP Tx-1 Wide Monitor 150Hz adjusted from 51* µA to 58 µA.**
**GP Tx1 Coverage checked satisfactory ±8° centre line azimuth.**

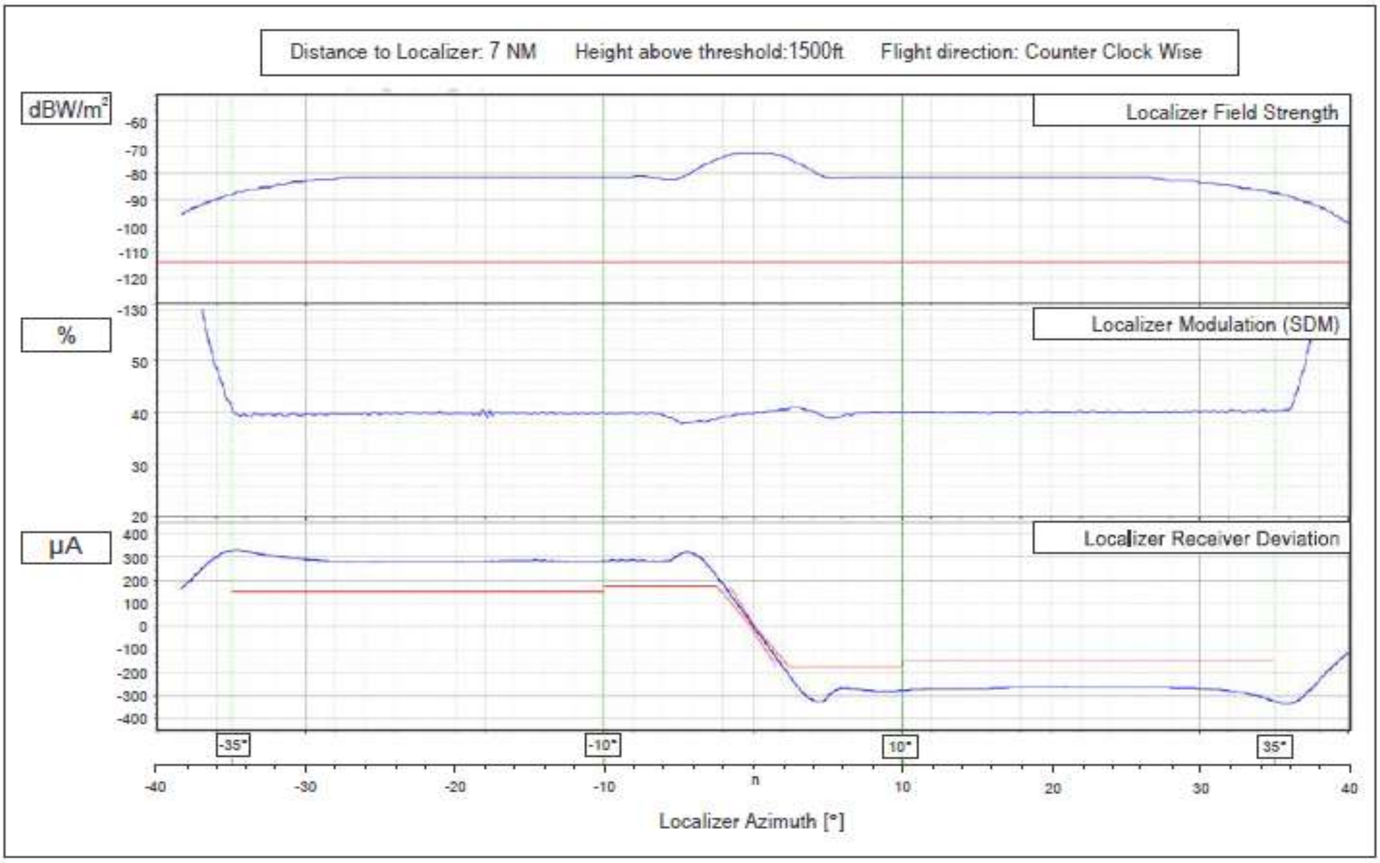
| | | | |
|---|---|---|---|
| Flight Inspector: | **Oscar Kilo** | | **OK** |
| Phone: | **+98 76 54 32 10 00** | Signature, Date: | **14/10/2016** |
| Email: | **post@amc.com** | Distribution: | **Airport Management Comp., Country** |



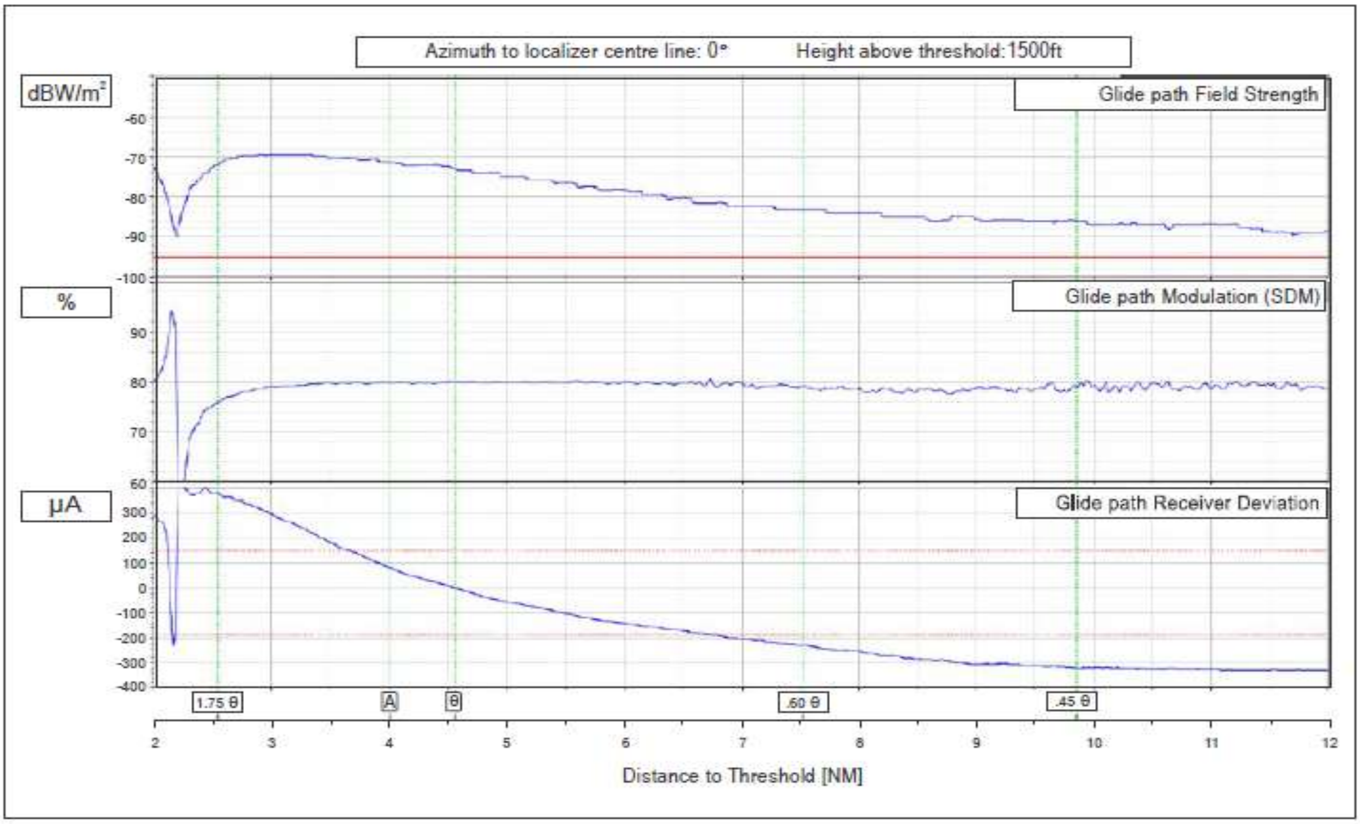

**GP Approach**



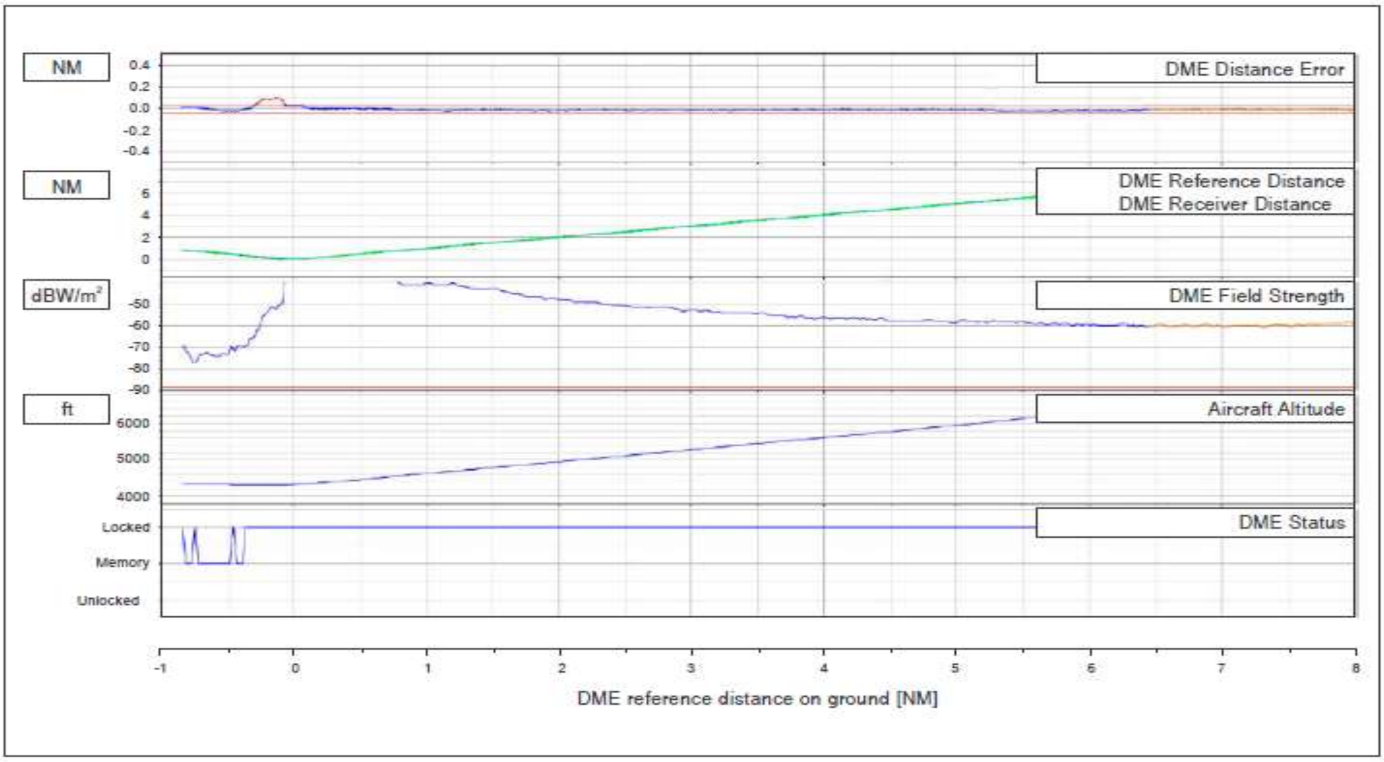

**LLZ Approach**




**LLZ Arc**




**GP level**




**ILS/DME Approach**

**INTENTIONALLY LEFT BLANK**

# 7. ENROUTE VHF MARKER BEACON (75 MHz)

(RESERVED)

INTENTIONALLY LEFT BLANK

# 8. PRECISION APPROACH RADAR (PAR)

(RESERVED)

**INTENTIONALLY LEFT BLANK**

# 9. NON-DIRECTIONAL BEACON (NDB)

(RESERVED)

**INTENTIONALLY LEFT BLANK**

# 10. PERFORMANCE BASED NAVIGATION (PBN)

This chapter deals with the assessment and flight inspection of conventional navigation aids supporting instrument flight procedures. This concerns mainly the use of DME in supporting PBN.

## 10.1. VOR FOR PBN

The use of VOR in PBN is limited to VOR/DME supporting RNAV5. While multi-sensor avionics are normally capable of using VOR/DME for an RNAV solution, actual operational use is very limited.

## 10.2. DME for PBN

Use of DME for PBN. Further guidance on the use of DME/DME to support RNAV is contained in Annex 10, Volume I, Attachment C, 7.2.3. The main role of DME in PBN is to support RNAV1 and RNAV5 as a complementary terrestrial infrastructure alongside GNSS Ground Analysis

### 10.2.1. INFRASTRUCTURE ASSESSMENT FOR PBN.

VOR and DME are identified in the *Performance-based Navigation Manual* (Doc 9613) and in Annex 10, Volume I, Attachment H, as sensors which may support PBN operations and procedures. This may lead to VOR or DME signals being used in areas that are not normally flight inspected as part of the facility specific testing, since the link between PBN and its supporting infrastructure is less direct.

If an air navigation service provider (ANSP) wishes to offer PBN procedures based on conventional facilities, an infrastructure assessment should be conducted to ensure that a minimum set of facilities is available which can be expected to support all equipped users.

### 10.2.2. LINKING INFRASTRUCTURE ASSESSMENT AND FLIGHT INSPECTION

To support a particular PBN procedure using conventional radio navigation aids, the ANSP shall perform an assessment to determine if sufficient facilities are available to support a given area or procedure with suitable geometry in accordance with the relevant PBN navigation specification. This may require reliance on facilities being used in areas where they are not normally flight inspected and where providing sufficient coverage (including accuracy) may be an issue. This assessment can be done with desktop software using a terrain and navigation facility database to determine coverage and resulting RNAV performance. If the assessment concludes that sufficient VOR or DME facilities are being relied on only in areas which are either part of facility-specific inspection or where performance can be expected to be good based on engineering judgement, no RNAV-specific flight inspection may be required.

If the assessment concludes that there are areas where performance should be verified, the assessment should specify which facilities should be flight inspected in which areas. This normally concerns the use of facilities either at low altitudes (near line-of-sight taking into account terrain) or at extended ranges, where multipath and signal blockage are more prevalent. Because this may concern multiple facilities, the assessment should be used to plan the flight inspection in as efficient a manner as possible. Flight inspection results should be fed back into the infrastructure assessment. It may also be useful to note which DME facilities need to be operational to support a particular PBN procedure (when using conventional navigation aids).

## 10.3. FLIGHT TESTING

### 10.3.1. FLIGHT INSPECTION PARAMETERS AND PROCEDURES

To evaluate if VOR or DME facilities are able to support PBN, both coverage (stable minimum field strength) and accuracy should be verified using the methods specified in Chapters 4 and 5. Additional parameters may be useful, such as reply efficiency in the case of DME. However, it must be noted that some of the parameter limits and associated measurement procedures have been defined only for radial or orbital flights. PBN specifications assume that the facility requirements in Annex 10 will be met, regardless of the orientation of the aircraft. If flight inspection of multiple facilities is needed (such as several DME), the use of multi-channel DME test sets is encouraged to reduce operational impact. When multi-channel DME measurement capabilities are used, it should be ensured that they provide sufficient information to indicate adequate signal coverage.

### 10.3.2. PERIODICITY OF PBN-SPECIFIC FLIGHT INSPECTION.

Once VOR and DME have been assessed and flight inspected where needed to show that they support a particular PBN procedure, there is normally no further need for periodic inspection in most environments. This assumes that safeguarding and/or appropriate facility-specific ground and/or flight testing is established to ensure the signals supporting the PBN procedure remain valid for use.

If the navigation facilities supporting the procedure or the procedure itself changes, the need for renewed flight inspection should be assessed. However, if flight validation is performed with a flight inspection aircraft, it is good practice to also verify the signals of the associated navigation aids

**INTENTIONALLY LEFT BLANK**

# 11. SURVEILLANCE RADAR SYSTEM

## 11.1. GENERAL

A surveillance system may encompass a number of technologies using various ground-based and airborne sensors and emitters (e.g. primary surveillance radar (PSR), SSR, automatic dependent surveillance (ADS), multiliterate technologies) together with the data fusion systems at the air traffic control center (ATCC). The techniques used depend upon the air traffic service (ATS) provider requirement, the appropriateness of technologies and the environmental (e.g. oceanic, continental or high density) demands.

Each surveillance sensor system may consist of a PSR sensor or an SSR sensor, a dependent surveillance sensor (DSS) or a combined (PSR and SSR, PSR and DSS, SSR and DSS, or PSR, SSR and DSS) sensor installation. The sensors may be for en-route or terminal area surveillance purposes. The signals from various surveillance sensors may be used directly with simple plan position displays, or more commonly with a surveillance data processing system (SDPS), in an ATCC. Data processing can include mono-sensor track processing, or multi-sensor track processing in circumstances where a number of sensors are supplying data to the center.

Surveillance system flight inspection and evaluation shall be conducted in accordance with the applicable provisions of ICAO Annex 10, Volume IV, ICAO Doc 8071, Volume III, ICAO Doc 9924 and approved national surveillance performance criteria.

## 11.2. FLIGHT TESTING METHODS

The following sections outline the methods applied for evaluation and flight testing of primary and secondary radar to commission a facility. The procedures for radar flight inspection differ from the procedures for navigation systems in that most of the data collection and analysis is conducted on the ground. The flight inspector's role in the radar environment consists largely of providing a known target in a required area. Presently, digital techniques allow for the evaluation of many radar parameters by the use of statistical sampling of target reports and SSR replies from the regular day-to-day site environment. The techniques provide the capability for reporting flight inspection results with greater accuracy than previously. Although certain requirements must be completed using a flight inspection aircraft, engineering personnel should use targets of opportunity, radar analysis tools, and other test equipment to the extent practicable for completing all checklist requirements.

Engineering personnel shall normally evaluate and document all radar facility performance except for those parameters specifically evaluated by the flight inspector.

### 11.2.1. PREFLIGHT REQUIREMENTS.

a. Engineering and operational personnel **shall prepare** an outline of operational requirements, describing in detail all routes, fixes, holding patterns, approach and departure procedures including specified altitudes, distances and other information pertinent to the flight inspection. Air traffic personnel will coordinate with the engineering personnel responsible for the site assessment.

**b.** Prior to a flight inspection ensure that the radar equipment is tuned within facility operating specifications. Ensure that the participating engineering and operations personnel are experienced and that they are familiar with the objectives of the inspection and the requirements in this manual. Participation by the same personnel in each flight inspection results in a more consistent evaluation of facility performance.

**c.** Flight personnel are expected to obtain information from engineering personnel relative to operational requirements, expected facility performance, and performance evaluations obtained by use of targets of opportunity, and to define the extent of flight inspection necessary. The servicing flight inspection office **shall** appoint a qualified flight inspection pilot as coordinator for all commissioning inspections. Flight inspection personnel **shall** assist in determining which checklist requirements have been met at those facilities using targets of opportunity to partially fulfil flight inspection requirements. Where targets of opportunity are used, the inspection record shall demonstrate that the targets, geometry, altitudes, data quality and recording arrangements are sufficient to validate the intended surveillance coverage and operational performance.

**d.** Flight inspection will use small aircraft equipped with an approved transponder for all radar flight inspections. Small aircraft are considered to be the Beechcraft Bonanza, Cessna 182, and other aircraft of similar size which represent nearly the same reflecting surface. The Sabreliner, Jet Commander, Jetstar and other jets of similar size are also regarded as small aircraft for the purpose of radar flight checks.

e. Use a flight inspection aircraft with a calibrated transponder for SSR power optimization and GTC curve establishment. Flight inspection aircraft provide the pilot with a selection of any one of the following two combinations of power and sensitivity for the altitude at which the test is to be flown:

**(1)** **Transponder equipment for aircraft not permitted to fly higher than 15 000 feet** Measurements at the antenna end of the cable:
18.5 dB +1dB/–0dB above 1 W RF power output and –71 ± 1 dBm sensitivity (low/normal) 18.5 dB +1dB/–0dB above 1 W power output and –69 + 1 dBm/–0 dBm sensitivity (low/low); or

**(2)** Transponder equipment for aircraft permitted to fly higher than 15 000 feet Measurements at the antenna end of the cable:
**21** B +1dB/–0 dB above 1 W RF power output and –71 ± –1 dBm sensitivity (low/normal)

21 dB +1dB/–0 dB above 1 W power output and –69 + 1 dBm/–0 dBm sensitivity (low/low).

**Normally the low power should be used**

### 11.2.2. FLIGHT INSPECTION PROCEDURES

A radar flight inspection may be a single (special inspection) requirement to determine coverage over a new air traffic “fix” or may consist of a full radar commissioning inspection. The number of personnel, coordination, preparation, and reporting involved between the two extremes varies widely.

A commissioning inspection (or a special inspection following significant modifications to existing equipment) consists of three distinct parts; planning, engineering and documentation. The engineering, or equipment, portion includes the tests necessary to ensure that the radar system performs according to design specification. Some tests in the engineering phase will require a flight inspection aircraft.

The documentation or flight inspection portion determines to what extent the air traffic user requirements are met and establishes a radar coverage baseline. Air traffic user requirements shall be outlined in the facility siting and inspection plan. The detailed procedures covered are devoted primarily to the flight inspection phase.

**11.2.2.1.** Commissioning Inspection

The objective of the commissioning inspection is to evaluate system performance, determine and document the site coverage, and provide a baseline for the detection of future deterioration in equipment performance. Data obtained during this inspection will be used as a basis for periodic comparison of facility performance as well as subsequent inspections. Major events of commissioning inspection include:

a. pre-inspection planning (develop a technical plan);
b. measurement of equipment parameters as per specification;
c. equipment optimization;
d. site integration;
e. flight inspection (data collection and analysis);
f. documentation of results;
g. generation of a database (baseline);
h. record of all equipment measurements; and
i. preparation of final report.

**Figure 6 below provides a flow chart of the sequence of events for a typical radar inspection.**

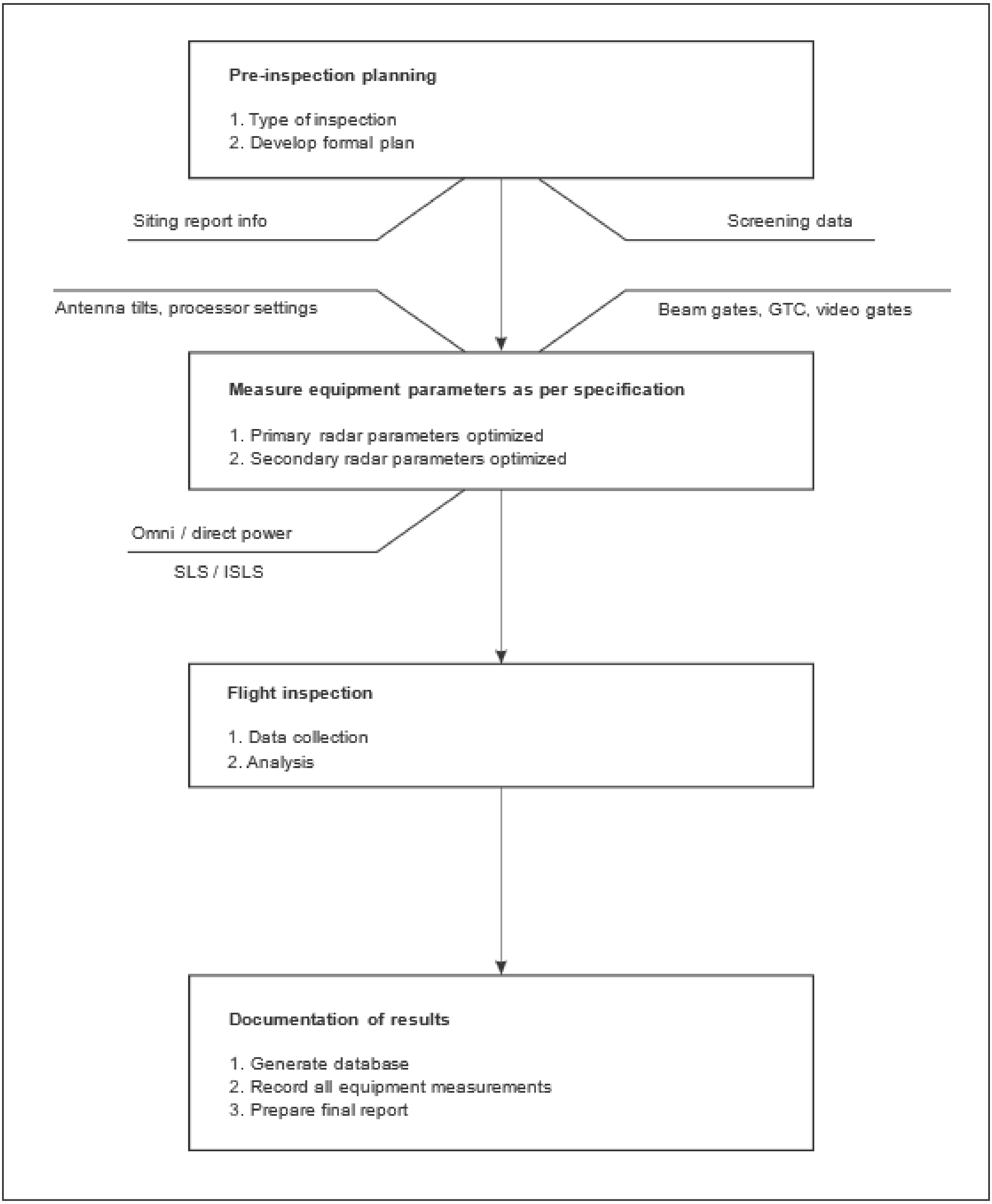



**Figure 6. Typical radar inspection events sequence**

**11.2.2.2.** Periodic Inspection

Civil ATC PSR and SSR facilities, after being commissioned and set into operational service, do not require a periodic flight inspection. Instead, the radar performance parameters described in this manual shall be re-assessed at regular intervals by RTQC or by preventive/ corrective maintenance. Only in cases of specific problem investigation should it thus be necessary to perform measurement campaigns including flight checks.

**11.2.2.3.** Special Inspection

Special inspections are conducted to fulfil a particular need and may be very limited in scope. The limited inspection may not require a formal written plan, but only a short report. Examples of testing events include development of a starting baseline (as found), identification of problem areas (quantity, if possible), correction of the problem or recommendations for solutions, revision of performance, and generation of a new database.

If equipment changes/modifications to commissioned facilities change the coverage pattern, document the changes in the inspection report. The new coverage pattern will then become the basis for comparison during subsequent inspections. Special inspections include the following:

**a.** Engineering support.
Engineering support is performed to help engineers and air traffic personnel determine whether the radar meets equipment certification requirements. This data may be used for commissioning purposes, provided that no major equipment modifications are made prior to the commissioning inspection. Requirements for specific checks will be determined by engineering personnel and need not conform to a specific format;

**b.** Antenna change.
The checklist, Table **12**, indicates the requirements for installation of a new antenna, a new generation dual beam antenna, or an antenna with a different radiation pattern. A flight inspection is not required following an antenna pedestal or rotary joint replacement if the ground measurements of the reflector position, feedhorn alignment, and antenna tilt of the replacement pedestal are satisfactory;

| | *Commissioning* | *PSR/SSR antenna change* | | | | |
|---|---|---|---|---|---|---|
| | | PSR | | SSR | | |
| **Check** | | **same type** | **different type** | **same type** | **different type** | **transponder mode** |
| **Orientation** | x | x | x | x | x | normal |
| **Tilt** | x | x | x | x | x | normal |
| **PSR optimization**<br>— STC/GTC<br>— beam crossover<br>— false target optimization | x<br>x<br>x<br>x | x | x<br>x x<br>x | | | normal<br>normal<br>normal<br>normal |
| **SSR optimization**<br>— power<br>— SLS/ISLS<br>— modes/codes<br>— GTC/STC establishment | x<br>x<br>x<br>x<br>x | | | x<br>x<br>x<br>x | x<br>x x<br>x x | low<br>normal<br>normal<br>low/low* |
| **PSR/SSR integrity** | x | | | x | x | normal |
| **Vertical coverage** | x | | x | | x | normal |
| **Horizontal screening** | o | | | x | x | normal |
| **Airways/route coverage** | x | | | x | x | normal |
| **FIX/MAPt accuracy** | x | | | | | normal |
| **Fixed target identification** | x | | | | | normal |
| **Surveillance approach** | x | x | x | | x | normal |
| **Communications** | o | | | | | |
| **Standby equipment** | x | | | | | normal |
| **Standby power** | x | | | | | normal |

**Table 12. Inspection test checklist**

**Note.— x = mandatory test; o = optional —**

**at engineering/maintenance/controller request**

**c.** Major modifications (other than antenna change).
This inspection should be confined to the parameters necessary to confirm facility performance. The radar engineer shall determine the extent of a special inspection during preparation and coordination of the plan. Depending upon the extent of the modification, an inspection using radar evaluation tools and targets of opportunity may satisfy the requirements;

**d.** Near-miss inspections.

(1) These inspections are conducted at the request of the air traffic manager of the facility involved and are used to determine the radar coverage in the area in which the incident occurred. The flight inspection should be conducted as soon as possible following a near-miss, duplicating the **maneuvers**, altitude, and direction of the aircraft incident. The flight inspector shall use an aircraft of the same type (or reflective surface) as the smaller aircraft involved. To the extent practicable, operate the radar in the same configuration as it was at the time of the incident. Accomplish flight inspection reports concerning near-miss collisions in the same manner as after-accident reports**;**

(2) Near-miss or incident-related inspections shall be coordinated with the relevant safety/occurrence management process and shall replicate, to the extent practicable and safe, the radar configuration, traffic geometry, aircraft characteristics and operational conditions relevant to the event.

e. Future requirements. New PSR and SSR systems being developed may introduce features not common to existing radar and may require techniques and procedures substantially different from those described below. Inspection procedures for future systems will be included as they become available.

Note 1.— For guidance materials on flight testing of ADS-B and WAM systems, refer to Aeronautical Surveillance Manual (Doc 9924), Appendix P and Appendix O respectively.

Note 2.— For information on Mode S specific testing (site monitor), refer to Aeronautical Surveillance Manual (Doc 9924), Appendix D, section 2.7.3.

**11.2.2.4.** Checklist

The inspection tests required to complete a full commissioning flight inspection are contained in Table 12. The procedures presented here are also those to be used singly when the requirements for a special inspection may be satisfied with one or more of the individual tests. Those items identified with an “x” are mandatory. The radar engineer shall perform the test by one or more of the methods listed, depending upon the radar type and resources available. Flight and engineering personnel shall evaluate the data obtained using targets of opportunity to determine if further evaluation by a dedicated flight inspection aircraft is needed. As the exact checks required may vary from one facility to another, the flight inspector must consult with the radar engineer prior to departing the area to ensure that all checklist requirements have been completed. The column labelled “transponder mode” denotes the proper aircraft transponder configuration for the specific test.

**11.2.2.5.** Vertical coverage/operational capability

The purpose of this test is to determine and document the primary and secondary radar system vertical coverage.

**a.** All radars.

Evaluate the inner and outer fringes on all primary and secondary radars using a flight inspection aircraft with a calibrated transponder;

**b.** Radars without radar analysis tools.
Evaluate primary and secondary radar coverage within the fringe envelope using a flight inspection aircraft or rental aircraft;

**c.** Radars with radar analysis tools.
Evaluate primary and secondary radar coverage within the fringe envelope using radar analysis tools, targets of opportunity, cooperating aircraft, or flight inspection aircraft. Radar analysis data recordings and analysis of the vertical coverage test are used as a continuing database for a permanent record, and as a legal document certifying facility performance.

11.2.2.5.1. Vertical coverage radial

A significant portion of the inspection is conducted on a reference bearing from the radar site. Conduct the commissioning inspection, and all subsequent inspections concerning facility performance on the same bearing for valid comparison. The radial should be free of clutter, dense traffic and populated areas, and influences created by line-of-site.

11.2.2.5.2. Commissioning Procedure

Determine the outer fringe by evaluating tail-on targets and the inner fringe by nose-on targets. Aircraft reflective surface and transponder antenna characteristics vary between inbound and outbound flight; consequently, some difference in coverage can be expected. Using map checkpoints, a navigation system radial, or radar vectors to remain on vertical coverage radial, the flight inspector should complete the coverage check. Fly all pattern altitudes described herein as height above the radar antenna.

Note.— In order to produce a meaningful database, the flight inspector must compute and fly true altitudes (corrected for pressure and temperature).

**a. Commissioning profile — terminal PSR/SSR radars without radar analysis**

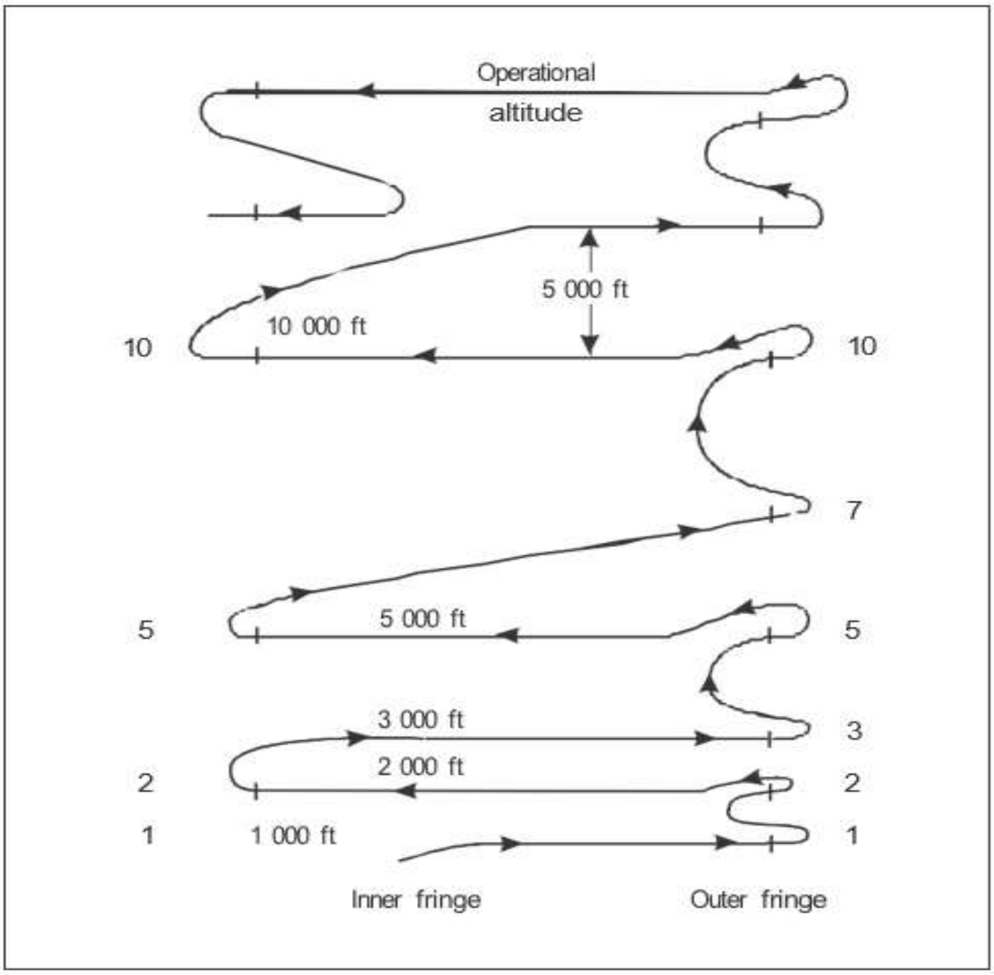



Figure 7. Commissioning profile for terminal radars

Refer to figure 7 and proceed as follows:

(1) determine the inner fringe at 300 m (1 000 ft). Then fly outbound at 300 m (1 000 ft) and establish the outer fringe;
(2) climb to 600 m (2 000 ft) and establish the outer fringe. Then proceed inbound at 600 m (2 000 ft) and establish the inner fringe;
(3) climb to 900 m (3 000 ft) and establish the outer fringe;
(4) climb to 1 500 m (5 000 ft) and establish the outer fringe;
(5) repeat the outer fringe check at 1 500 m (5 000 ft) (or lower if necessary) as required in order to complete the overall quality test and to evaluate radar auxiliary functions (linear polarization, PIN diode, integrators, etc., for primary and GTC/STC for secondary). Most auxiliary functions produce a decrease in receiver sensitivity which is indicated by a decrease in cut-off range. Conduct the test by marking the outer fringe with the function on, then off, while noting the difference in range. Then proceed inbound at 1 500 m (5 000 ft) and establish the inner fringe;
(6) climb to 2 100 m (7 000 ft) and establish the outer fringe;

(7) climb to 3 000 m (10 000 ft) and establish the outer fringe. Then proceed inbound at 3 000 m (10 000 ft) to establish the inner fringe;

(8) if the required operational altitude is greater than 3 000 m (10 000 ft), check the outer fringe in 1 500 m (5 000 ft) increments up to the operational altitude; e.g. if 5 100 m (17 000 ft), check the outer fringe at 4 500 m (15 000 ft) and 5 100 m (17 000 ft), then proceed inbound at the operational altitude and establish the inner fringes. If adequate radar coverage is not maintained during the inbound run, conduct flights through the coverage pattern to establish the maximum usable altitude;

(9) check the inner fringe at the altitudes used to establish the outer fringe back down to 3 000 m (10 000 ft) level; and

**b. Commissioning profile — en-route PSR/SSR without radar analysis tools**

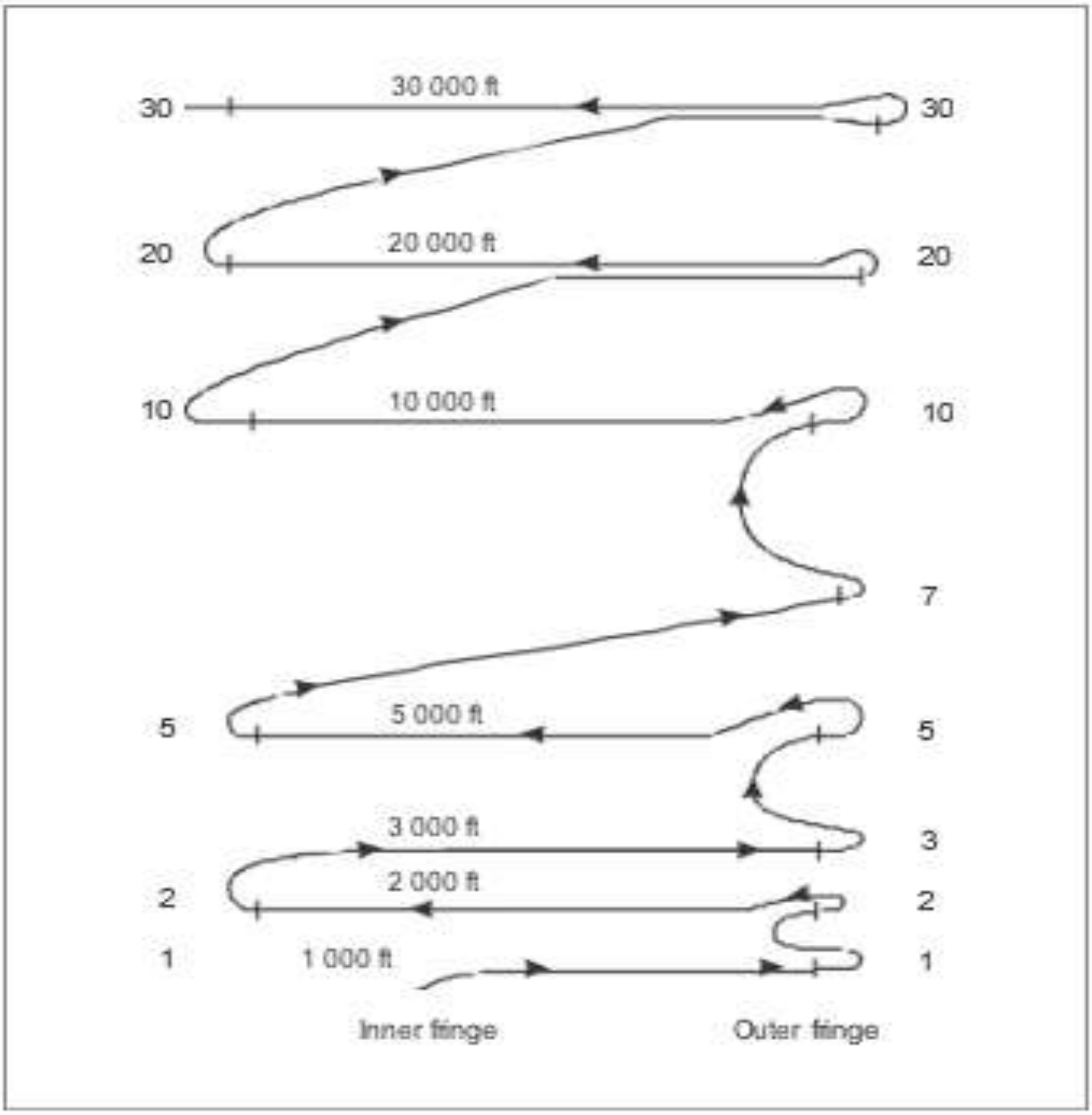



Figure 8. Commissioning profile for en-route radars

Refer to Figure 8 and proceed as follows:

(1) complete steps **i** through vii of the terminal PSR/SSR commissioning profile procedures;

**(2)** climb to 4 500 m (15 000 ft) and establish the outer fringe;

**(3)** climb to 6 000 m (20 000 ft) and establish the outer fringe. Then proceed inbound at 6 000 m (20 000 ft) and establish the inner fringe;

**(4)** climb to 7 500 m (25 000 ft) and establish the outer fringe;

**(5)** climb to 9 000 m (30 000 ft) and establish the outer fringe;

**(6)** repeat the outer fringe as required to complete the overall quality and auxiliary tests;

**(7)** then proceed inbound at 9 000 m (30 000 ft) and establish the inner fringe; and

**(8)** if operational or engineering requirements are greater than 9 000 m (30 000 ft), or if this level conflicts with air traffic, climb to a mutually agreeable altitude (to a maximum of 12 000 m (40 000 ft)) and establish the outer and inner fringes.

**c. Commissioning profile — terminal/en-route PSR/SSR, radars with radar analysis tools**

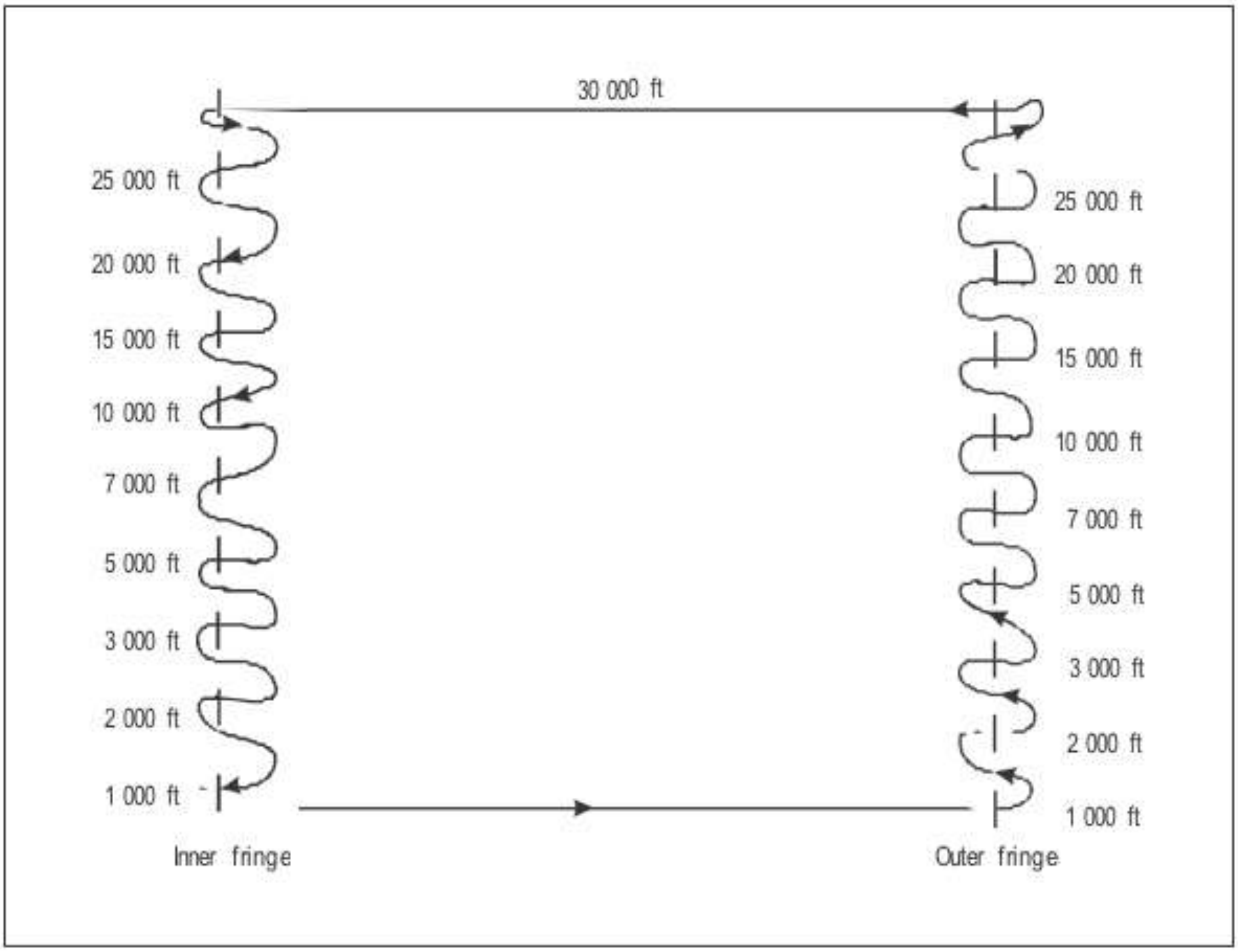



Figure 9. Commissioning profile for terminal/en-route radars

Refer to Figure 9 and proceed as follows:

(1) Fringe envelope check. The flight inspector shall fly outbound from the site at 300 m (1 000 ft) above the antenna to the outer fringe, up to the outer fringe to the required altitude, across the top inbound to the inner fringe, then down the inner fringe to the 300 m (1 000 ft) inner fringe. Probe and score the primary and secondary fringes at 300, 600, 900, 1 500, 2 100, 3 000, 4 500, 6 000, 7 500 and 9 000 m (as required) (1, 2, 3, 5, 7, 10, 15, 20, 25 and 30 (as required) thousand ft). Establish the ascending (outer) fringes by turning inbound and climbing to the next higher level, flying inbound at the higher level until solid primary and secondary reports are received, then turning outbound to establish the primary and secondary reports at that level. Evaluate the inner fringes in the same manner, with the directions reversed. Conduct the overall quality and auxiliary functions test at 1 500 m (5 000 ft) or 9 000 m (30 000 ft) as per the previous procedures.

(2) Coverage within the fringe envelope. Engineering personnel shall use radar analysis tools and targets of opportunity to determine the coverage inside the fringe envelope and identify the location and extent of holes and other lobing related anomalies. Coverage can be determined with analysis of plots on series of recording. Limit the tracks to a 20° wedge, centered on the vertical coverage azimuth and filtered for the altitudes of concern. The SSR delay should be active during the recordings to provide a better separation of primary and secondary tracks for independent analysis. Lobing will be evident as primary and secondary tracks, exhibiting decreasing run lengths as they enter a "hole", disappear in the null, then reappear with progressively higher run lengths as they clear the fringe on the opposite side. Include the printout plots in the facility permanent database.

Note.— "SSR delay" refers to the technique of delaying the SSR signal beyond the merge window of the plot combiner.

### d. En-route/terminal PSR antenna change

When the en-route/terminal PSR antenna is changed, fly the profile depicted in Figures **10**a and A**10**b, as applicable.

**(1)** Repeat the outer fringe checks as necessary in order to complete an overall quality and auxiliary functions test as requested by engineering personnel. Conduct the remainder of the coverage check in the original configuration; and

**(2)** checks of additional facility equipment configurations and additional altitudes may be conducted at the option of engineering personnel.

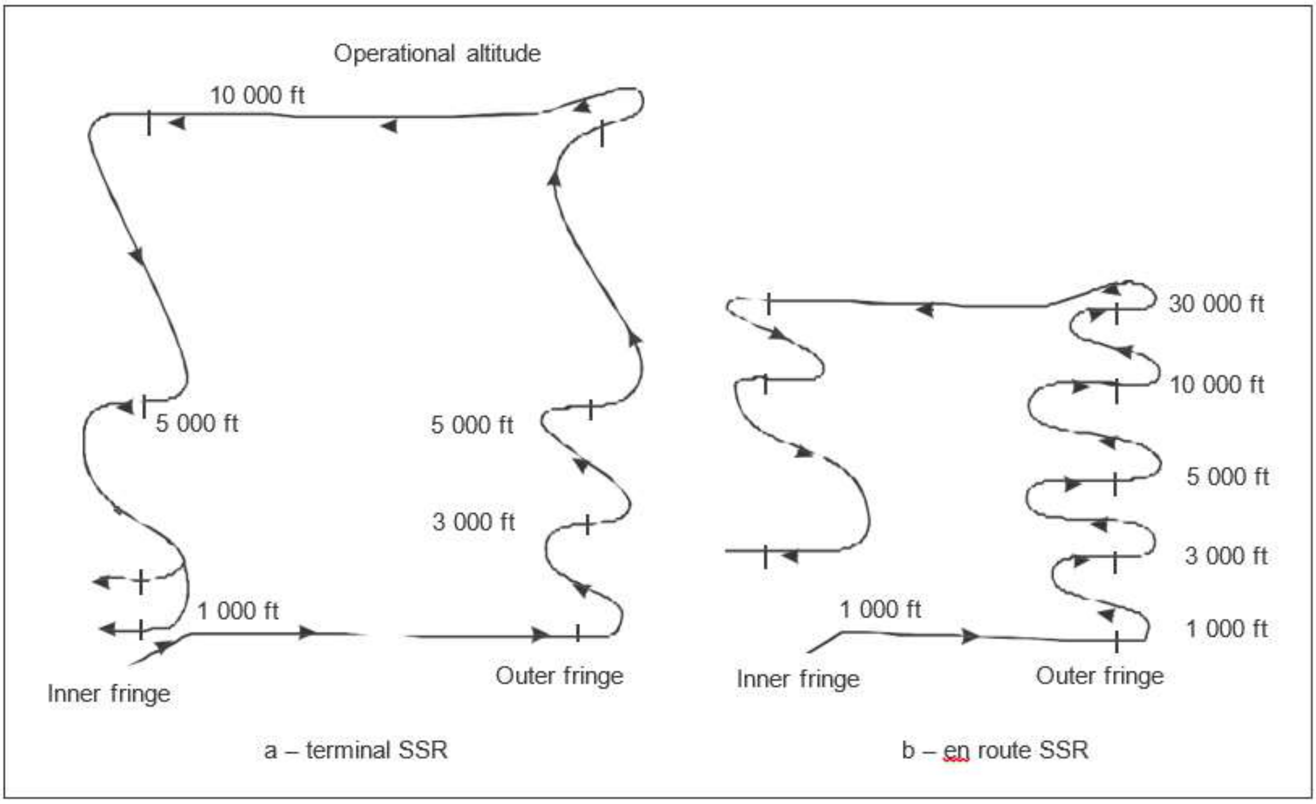



Figure 10. Commissioning profile for terminal/en-route SSR

**e. SSR antenna change**

For the same type of antenna, all requirements may be completed using targets of opportunity. Comparison analysis is performed on the historic solar data, SSR parameters and performance measurements (targets of opportunity) to ensure that the same performance (commissioned) can be expected with new antennas. When the antenna is replaced with a different type, or targets of opportunity are not available, checklist requirements shall be completed using a flight inspection aircraft.

**(1)** Terminal SSR. Fly the profile for a primary antenna change as illustrated in Figure **10**a.

**(2)** En-route SSR. Fly the profile for a primary antenna change as illustrated in Figure **10**b.

**f. Evaluation**

Engineering personnel shall record target strength as defined in Table **13** **(**Tolerance/limit), on each scan, aircraft position every five miles, and aircraft altitude for each fringe check and level run. Where available, engineering personnel shall document results of the vertical coverage check using radar analytical/diagnostic programmes for inclusion in their facility report and permanent records.

| Parameters | Tolerance/Limit |
|---|---|
| **Target Strengths**<br>**(1) Broadband** | |
| **2 – Usable**<br><br>**1 – Unusable**<br>**0 - Unusable** | **Target shows each scan, remains on the scope for at least 1/3 of the scan.**<br>**Weak target, barely visible, possible miss**<br>**No visible target.** |
| **(2) Narrowband** | |
| **1- Usable**<br>**2- Unusable** | **Visible target, satisfactory for ATC purposes.**<br>**No visible target.** |

Table 13. Tolerance for Target Strength

### 11.2.2.5.3. Horizontal screening

The purpose of this test is to verify the indicated coverage on the horizontal screening charts. The test is optional depending upon local requirements, and may be accomplished by one or more of the following methods:

**a.** using either flight inspection or rental aircraft, fly an orbit at an altitude and distance which corresponds to the lowest screening angle at which coverage is expected. Do not use an orbit radius of less than 18.5 km (10 NM). DME or headings provided by the controller may be used to maintain the orbit. Select “Normal” on the aircraft transponder. MTI, if used, should be gated to a range inside the orbit radius, except those locations where ground clutter will obscure the target unless MTI is used. If MTI must be gated outside the orbit, the radius of the orbit should be constantly changed to avoid target cancellation due to tangential blind speed. For example, vary the pattern on a 22.2 km (12 NM) orbit between 18.5 km (10 NM) and 25.9 km (14 NM) so as to average a 22.2 km (12 NM) orbit. Engineering personnel shall record target strength on each scan and target azimuth/distance position each 10°; and

**b.** horizontal screening can also be determined by running the radar analysis programmes on pre-recorded data. Limit the data input on successive runs to azimuth sectors with a constant screening angle for each run. Compute the screening angle for any given run (azimuth sector) from the lowest coverage returns at a given range. Then, coverage at any given range beyond the screen can be predicted and a comparison drawn between values on the horizontal screening chart of actual coverage. Limit tests to elevation angles near the expected horizon.

### 11.2.2.5.4. Airway/route coverage

The purpose of this check is to document coverage along all routes and airways required by air traffic, and may be accomplished by one or a combination of the following methods:

a. flight inspection aircraft; and
**b.** radar analysis/targets of opportunity.

Approved procedures: select “normal” on the flight inspection/rental aircraft transponder. Configure the primary radar in circular polarization. Fly the minimum coverage altitude not lower than the minimum obstruction clearance altitude (MOCA), on airway centre line. Maintain course guidance by reference to ground checkpoints, navigation system signals, or radar vectors. Fly terminal arrival/departure routes and other areas of interest identified in the flight inspection, via radar vectors at the MOCA.

Radar analysis programmes and targets of opportunity: targets may consist of one cooperating aircraft or an assortment of aircraft reports on a particular airway. Targets included in the output data must be Mode C- or S-equipped for essential altitude information. Scoring may be accomplished either with radar analysis programmes or manually. Document the fix positional coverage by filtering a data run with the start/stop azimuth and high/low altitude that effectively "boxes" in the fix. Good coverage within the box constitutes adequate coverage at the position fix.

#### 11.2.2.5.5. Way-point/map accuracy

The purpose of this test is to verify the accuracy of all airways, routes, fixes and centre lines displayed on the video map. This test may be accomplished by either of the following methods:

a. flight inspection aircraft; and
b. targets of opportunity.

Approved procedures: since the object of the test is to compare the displayed video map feature against indicated target reports, radar configuration (MTI, antenna polarization, transponder settings, etc.) does not affect the test results. The procedure is the same whether using a flight inspection aircraft or targets of opportunity; compare reported aircraft position on or over an airway, route or fix, with video map presentation. Similarly, verify runway center line-to-video map alignment by observing landing and departing aircraft. However, when using targets of opportunity, numerous target reports are required to verify the accuracy of any particular airway, route or fix. Verify accuracy with a flight inspection aircraft. Replacement map overlays, video maps or digitally generated maps do not require flight inspection if engineering personnel are satisfied through evaluation of targets of opportunity or by comparison to an existing map, that the new map is accurate.

#### 11.2.2.5.6. Fixed target identification

The purpose of this test is to identify prominent primary broadband targets used for range and azimuth accuracy checks when solar and radar analysis programmes are not available. Identify the permanent echo (PE) by one of the following methods:

a. cooperating aircraft; and
b. flight inspection or rental aircraft.

Approved procedures: select identifiable features from comparison of the ground clutter reports and geo graphic maps (islands, mountain peaks, towers, etc.); and direct the pilot to the PE return. If the pilot can identify and describe the ground target, and the target is a permanent feature, record the PE in the inspection report.

#### 11.2.2.5.7. Surveillance approaches

All terminal PSR approaches must be checked for accuracy and coverage by a flight inspection aircraft during commissioning inspections or any time a new approach procedure is developed. The flight inspector shall confirm with engineering personnel that the approach is conducted on a surveillance radar scope. Conducting a terminal PSR approach on a precision approach radar (PAR) scope is not acceptable for flight inspection purposes. Terminal PSR approaches are not authorized using SSR only; and the SSR should be offset for this check.

**a.** Approach to a runway.
The approach course shall coincide with the runway centre line extended and shall meet accuracy and coverage tolerances.

b. Approach to an aircraft
The approach course shall be aligned to the missed approach point (MAPt) as determined by procedures and engineering personnel. Helicopter-only final approach courses may be established to a MAPt no further than 780 m (2 600 ft) from the centre of the landing area for a point-in-space approach to a MAPt from which flight to the landing area must be accomplished by visual reference to a prescribed route along the surface. In each instance, approach guidance shall be provided to the prescribed MAPt.

c. Approach procedure
Fly an 18.5 km (10 NM) terminal PSR final approach as directed by the controller. Fly at the lowest prescribed altitudes until reaching the final approach segment. Between the final approach fix (FAF) and the MAPt, fly 30 m (100 ft) below any stepdown fix altitudes, recommended altitudes and/or the minimum descent altitude (MDA). During the approach, the flight inspector shall evaluate the approach procedure, note the aircraft position relative to the runway center line extended/airport, and determine at the MAPt whether a landing can be successfully performed without excessive maneuvering.

d. Evaluation
Terminal PSR approach radars shall meet flight inspection tolerances or be cancelled; however, cancellation of a terminal PSR approach radar does not constitute a restriction on the radar facility. When the use of MTI is required for a terminal PSR approach, the flight inspection report should be so annotated. A requirement to use MTI does not constitute a facility restriction, however, terminal PSR approaches which require the use of MTI are not authorized when the MTI feature is inoperative

#### 11.2.2.5.8. Communication

The purpose of the optional check is to evaluate the VHF/UHF communications capability within the radar coverage area. All required checks can normally be completed by using participating aircraft. If additional requirements are identified by engineering personnel, conduct the inspection concurrent with the radar inspection.

#### 11.2.2.5.9. Standby equipment

The purpose of this is to evaluate the performance of standby equipment during the flight inspection activity. This check shall be conducted as an integral part of the flight inspection and may be accomplished using targets of opportunity, where applicable. For radar systems engineered to meet reliability requirements through the use of redundant parallel units, the flight inspection activity shall be structured to ensure that all redundant units are individually and thoroughly tested and verified under operational conditions. Where a standby antenna (duplicate) is installed to provide continued radar service in the event of antenna failure, the standby antenna shall be included in the flight inspection scope, and its commissioning and operational verification shall be completed in accordance with the applicable antenna checklist and associated acceptance criteria prior to being placed into operational service.

### 11.2.2.5.10. Analysis

a. Testing precautions

Radar inspections should not be attempted during heavy precipitation, temperature inversion, or other atmospheric conditions which either increase or decrease radar coverage from the expected norm. Investigate any system deficiency or deterioration noted during inspection. When a system parameter does not meet the specified tolerances and cannot be adjusted within a reasonable length of time, discontinue the flight inspection until the discrepancy can be resolved. However, this does not preclude the continuation of testing in an effort to resolve the problem

b. Evaluation

Continuous radar detection (one usable target report on every scan at every azimuth and all altitudes) is a difficult requirement to meet due to antenna lobing, physical limitations (line-of-sight), aircraft altitude, and antenna tilt. Therefore, expect isolated or non-recurring misses. After three or more consecutive misses in the radar pattern, investigate to determine whether a hole exists and, if so, its size. Reference is made to Figure **11.**

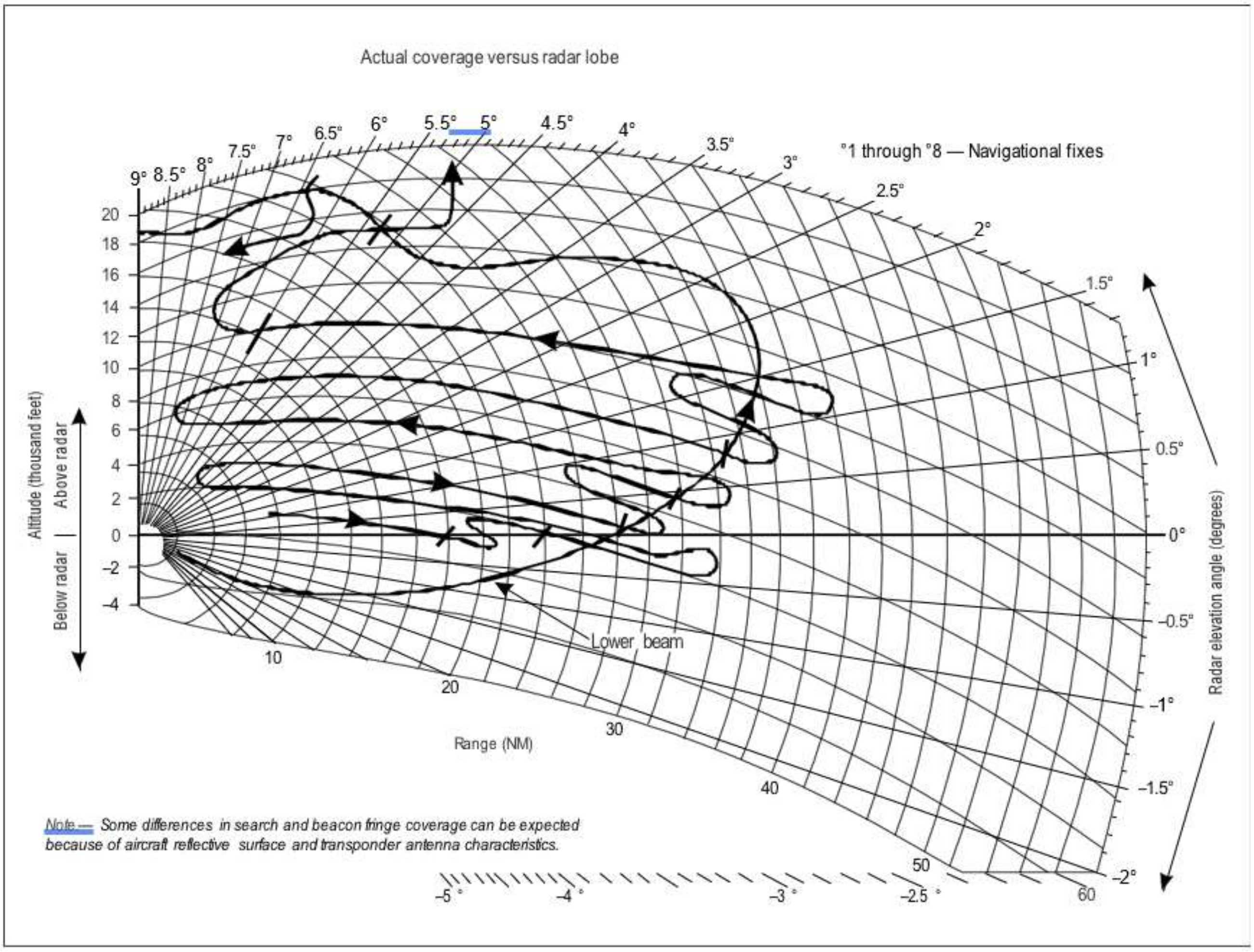



**Figure 11. Actual coverage versus radar lobe**

c. Lobing
Lobing is caused by the summation of radar energy at a point in space. The energy components at that point may consist of both direct and reflected energy. As the reflected and direct path lengths to that point differ, the two signals arrive with a different phase relationship. With an opposite phase from a strong reflection, the out-of-phase component may cancel the direct, resulting in a coverage hole. As reflected energy is the source of all lobing problems, preventing **or altering** the reflected energy component is the way to minimize the problem. Lobing in a critical area can occasionally be reduced, but usually at the expense of performance in other areas. Adjustments to the antenna tilt (primary and secondary) and secondary transmit power are the two most effective measures in combatting nulls. Use care in making tilt and powe**r** changes, since either can introduce additional problems. Optimizing antenna tilt and reducing the ground radiation may be all that is required to reduce a lobing problem.

d. Probing
Holes in radar detection are probed in a similar manner to VOR or TACAN. The following procedures may be used as a guide; refer to Figure **12**:

**(1)** Horizontal.

Fly through the area in question to determine the inner and outer limits of the hole. Vary aircraft position by 10° of radar azimuth until the lateral limits of the hole are determined;

**(2)** Vertical.
Fly through the centre of the pattern (established in the horizontal probing procedure) at 300 m (1 000 ft) increments to determine the upper and lower limits of the pattern.

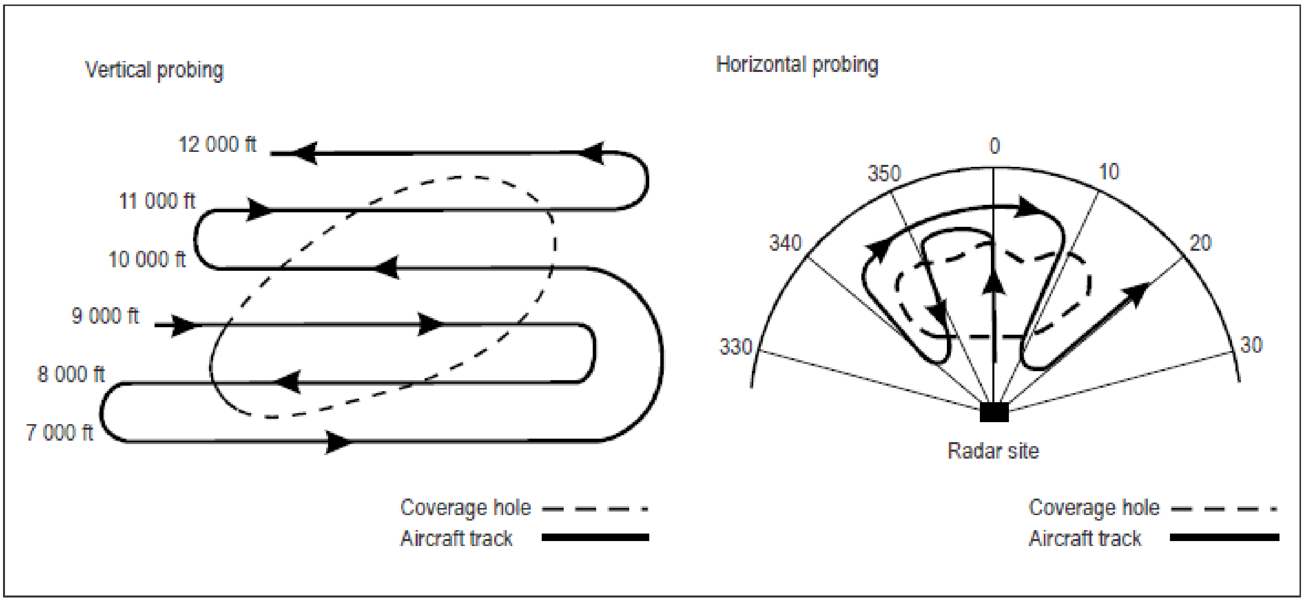



Figure 12. Vertical and Horizontal Probing

Intentionally Left blank

# 12. SECONDARY SURVEILLANCE RADAR

The object of the flight inspection is to determine the coverage characteristics and accuracy of the SSR system. Any deterioration from specifications established in Table 14 noted during inspections must be reported to the ANSP and CAA. Normally the inspection should be discontinued if system performance falls below minimum operational standards.

SSR flight inspections shall be performed in conjunction with primary radar inspections when it is collocated. When primary and secondary radars are inspected simultaneously, discrimination on the display between the two replies can be obtained by introduction of a known time delay in the SSR signal, otherwise the SSR shall be checked by turning it alternatively "off" and "on", because SSR, if left "on" continuously, might blank out the primary radar returns.

Site trials are conducted to check the extent to which a proposed site will enable operational requirements to be achieved.

Commissioning flight inspections are conducted to supply engineering personnel with sufficient data to determine if the SSR meets operational requirements and/or equipment design specifications. These inspections will be extensive enough to provide required data and a basis for comparison of periodic data to detect future deterioration in the performance of the radar.

Special flight inspections may be conducted as part of a measurement campaign after major equipment modifications or for specific problem investigation.

## 12.1. PREFLIGHT REQUIREMENTS

Preflight requirements are as follows:

a. Engineering and operational personnel should prepare an outline of operational requirements, describing in detail all fixes, holding patterns, approach and departure procedures, including specified altitudes, distances, and other special information pertinent to the flight inspection. This material may be depicted on an aeronautical chart to present a pictorial display of the operational requirements which can be used by ground and flight crews so that a well-coordinated, orderly flight inspection, can be conducted.
b. Prior to the flight inspection, engineering personnel will conduct equipment checks.
**c.** Flight personnel will ensure that the transponder is properly calibrated according to the specifications given in Annex 10, Volume IV.

## 12.2. DETAILS OF FLIGHT INSPECTION PROCEDURE.

### 12.2.1. COVERAGE

a. Vertical.
The radial selected for this evaluation **shall** be one which is as free from ground clutter as possible, is in an area where negligible lobing exists, and is free of the effects of shielding or reflection. It should also be one on which the progress of

flight inspection work is not likely to be unduly hindered by ATC difficulties. The same radial will always be used for vertical coverage checks. Level flights should be made inbound and outbound at the following heights above the site: 300 m (1 000 ft), 900 m (3 000 ft), 1 800 m (6 000 ft), 3 000 m (10 000 ft). Generally, above 3 000 m (10 000 ft) level flight should be made in 1 500-metre (5 000-foot) increments to the maximum altitude required dependent on the specific type of equipment (but where adequate information is available on antenna performance, the increments may be at 3 000 m (10 000 ft) intervals). In the absence of an aircraft capable of flight at the greater heights, it is possible to extrapolate results by use of a calibrated attenuator in the aircraft antenna feeder while the aircraft is flying at lower heights. This method does not give the accuracy which might be expected (errors of the order of ±6 dB may be experienced) and this should be borne in mind when evaluating results obtained by this method.

Each flight will extend to just beyond the point where cover is lost on outbound flight along the established radial to determine the outer fringe; flight is then made inbound on the same radial over the ground antenna cone of silence and continuing to a point where cover is just re-established flying outbound on the reciprocal radial.

If adequate cover is not maintained at the maximum operational altitude, the maximum height at which adequate cover is obtainable must be established by additional flights below the specified maximum operational altitude.

Radar contact on routes, approaches, etc., is considered lost when the target is missed for any three consecutive scans.

b. *Route cover.*
During commissioning inspections all airways and/or routes should be checked to the maxi mum distance for which coverage is required at the mini mum instrument altitude for the route. For routine inspections, only one route, in addition to the vertical coverage radial, need be flown. Target description should be recorded on every scan, and range in 5-mile increments should be recorded.
In addition to airways routes, all departure and arrival routes should be flown in the directions and lowest altitudes at which they are normally used to determine that adequate coverage exists. On routine inspections only one route need be checked.

c. Fix coverage.
Fixes, or reporting points, should be checked at minimum instrument altitude. All fixes should be checked during routine inspection. This check can be combined with the route cover check.

d. Azimuth cover.
This inspection should be made only on commissioning flights. The following orbital flights may be made as required for engineering purposes:

i. Orbit of 10 NM at 1 500 m (5 000 ft) above site;

ii. Orbit of 20 NM at 3 000 m (10 000 ft);
iii. Orbit of 30 NM at 10 700 m (35 000 ft).

This check is made to verify coverage in the horizontal plane as determined by panoramic photos, transits and computed measurements throughout 360°.

### 12.2.2. Height encoding

During the vertical coverage checks, Mode C will be used for a sufficient period of time at each height to compare the decoded height with that being noted in the aircraft. It is desirable that the pressure transducer used to operate the aircraft encoder also provides a display in the aircraft. The decoded height shall be within ±38 m (±125 ft) of the altitude displayed in the aircraft relative to standard sea level pressure (1013 hPa, or 29.92 in. Hg.).

### 12.2.3. Mode/code check

a. Satisfactory operation of all modes intended to be used by the installation will be checked during the course of the flights previously described. Representative codes may be validated during coverage checks. A limited test could be made by checking the following codes: 0557, 1557, 2557, 3557, 4557, 5557, 6557, 7557, and IDENT. This applies to the 4096 select code transponder. Caution must be exercised in checking codes 7600 and 7700 due to the probability of "alarming" adjacent radars.
b. SSR inspection shall verify, as applicable, Mode A/C/S performance, code and altitude reporting, detection performance, coverage, false replies, garbling, reflection and multipath effects, data display performance, standby equipment operation, and operational suitability for the intended ATS application. Verification shall be conducted using an appropriate combination of flight inspection, ground-based testing, surveillance monitoring, and engineering analysis or simulation tools, as applicable to the surveillance system and inspection objective

### 12.2.4. Side lobe suppression

Side lobe suppression (SLS), installed to improve beacon performance, might possibly degrade facility performance. For example, flat terrain within 300 m (1 000 ft) of the antenna can cause lobing; and other circumstances can cause "ring around" or false targets.

Perform SLS inspection as follows:

a. Select an azimuth in an area considered by the controller to have been a side problem in the past. A radial should be flown at 300 m (1 000 ft) above the antenna elevation to coverage limits.
b. Select an azimuth which was a source of lobing from a siting **standpoint and** perform check in same manner as above.
c. Fly radials in other areas as determined necessary by engineering and operational

personnel.

d. Fly complete radar surveillance approaches to ensure reliable beacon coverage.

e. Record target description, ghost targets, “ring around”, etc., to determine all possible effects of the SLS installation.

***With an antenna system which has been initially designed to the ICAO Standard for side lobe suppression, the mismatch between control and interrogate antenna which gives rise to the above difficulties, should not occur and therefore in such cases the above check is not necessary. However, during all checks it will be necessary to ensure that the side lobe suppression requirements are being met.***

| *Requirements* | *Commissioning* | *Routine* | *Purpose of flight check and tolerances* |
|---|---|---|---|
| **Coverage**<br><br>**(i) Vertical** | **x** | **x** | **This check is performed to determine the size, shape, and continuity of the vertical radiated pattern. It will establish the outer fringe of coverage at various altitudes, and should remain within 15 per cent of the coverage pattern obtained during the commissioning inspection.** |
| **(ii) Route** | **x** | **x** | **On commissioning checks, all ATC controlled routes (airways) will be checked for coverage to the maximum distances that radar contact can be maintained at minimum instrument altitude for the route. Coverage should remain within 15 per cent of that obtained on the commissioning check.** |
| **(iii) Fix coverage or cover at report ing points** | **x** | **x** | **This inspection is conducted to determine that adequate cover is provided at the minimum operational height required or to establish the minimum height at which adequate cover is obtainable. Accuracy should be such that an aircraft reported over the fix will be within 300 m (1 000 ft) of the fix or 3 per cent of the fix-to-station distance, whichever is greater.** |
| **(iv) Azimuth cover** | **x** | | **This check is performed on commissioning inspections to establish relative coverage at all azimuths by orbital flights at various heights and ranges.** |
| **(v) Height encoding** | **x** | **x** | **Where Mode C is in use, checks will be made on its operation during vertical coverage checks. The decode height should be within ±38 m (±125 ft) of the flight level altitude information displayed in the cockpit (relative to<br>1 013 hPa or 29.92 in. Hg.) and must correspond exactly with the coded input to the transponder.** |
| **(vi) Mode and mode check** | **x** | **x** | **This check is performed to confirm correct functioning in required Modes (other than C). These checks may be conducted any time during the vertical coverage, fix or route checks.** |

| | | | |
|---|---|---|---|
| **(vii) Side lobe suppression** | **x** | | **Side lobe suppression added to existing radars is checked to ascertain if expected improvement has been obtained and that no adverse effects have resulted.**<br>**Flight check is a special** requirement **on commissioning checks.** |

**Table 14. Summary of Flight Inspection Requirement**

**INTENTIONALLY LEFT BLAN**

# ATTACHMENT A : FLIGHT INSPECTION AIRCRAFT ANTENNA PERFORMANCE.

## A.1 ANTENNA

Calibration and extensive testing to verify performance are normally required for antennas used to inspect navigation aid coverage.

Calibration of the antenna system gain is required for antennas used to measure field strength and **shall** be considered early in the installation planning stage. Antenna system gain characteristics (including all feed cables, switches and power splitters) must be determined in order to measure the field strength with reasonable accuracy. The characteristics must be measured over the range of frequencies to be used and at the aircraft orientations experienced during the measurement procedures. These antennas gain characteristics must then be applied either in real-time as data is input and displayed, or post-processed to generate the final report data.

The above methods may be used to correct absolute or relative field strength measurements, however, there are some flight inspection applications for which gain errors cannot be corrected. These place additional constraints on the achieved airborne antenna patterns. An example is course structure measurements for localizer, glide path, and VOR, for which the contributing multipath errors may propagate to the aircraft from a widely different azimuth than the desired direct signal. In this case, variations in gain from an omnidirectional pattern will affect the measured amplitude of the course structure, with or without aircraft attitude variations, and flight measurements, by differing aircraft types, will vary. Flight inspection organizations should make every reasonable effort to achieve antenna patterns that represent the antennas used by the fleet operating on the airport — this is particularly important for Category II and III measurements.

The flight inspection provider shall maintain controlled evidence of aircraft antenna installation, calibration, antenna pattern information, lever-arm corrections, cable losses and configuration changes affecting measurement validity.

## A.2 ANTENNA MEASUREMENT TECHNIQUES

Many techniques, including mathematical modelling, reduced-scale modelling, full-scale ground testing and flight testing, are available for optimizing the location of antennas and characterizing their gain in a given location on an aircraft. The complexity and cost are generally proportional to the number of azimuth and elevation angles to be measured as well as the accuracy required of the measurements. The overall cost is reduced if a combination of modelling and ground testing is used to establish expected performance; flight inspection would then be used as the final confirmation stage.

Flight test techniques capable of full azimuth or lower hemisphere characterization with high accuracy are now available through many flight test ranges, these should be the preferred methods used to provide confirmation of antenna patterns. Procedures that provide ongoing confirmation of antenna performance are still required and some form of ramp-based check should be established.

Consideration should also be given to characterizing the localizer antenna pattern over the FM broadcast band (88–107.9 MHz), if the aircraft is to be used in resolving electromagnetic compatibility (EMC) problems from FM broadcast stations. A separate broadband antenna may be fitted if the aircraft is to be used for general interference investigation.

Antenna and measurement-system performance shall be reviewed or revalidated following aircraft modification, antenna relocation, receiver/equipment change, software/database change, or any event that may affect measurement accuracy.

## A.3 ANTENNA INSTALLATION CONSIDERATION

Antenna installation can affect the flight inspection measurements and the operational use of the aircraft in many ways. The following are a few examples:

a. Propeller modulation effects can interfere with the received ILS localizer signal over a range of engine power settings. This can severely limit the use of the aircraft for flight inspection. Improving the antenna location is the best solution to this problem, followed by the modification of the propeller frequency. The formula below shows the propeller modulation frequency**:**

   Propeller Modulation Frequency (Hz) = Shaft Rotation Speed (RPM) x Number of Propeller Blades/60

   Examples:
   3-blade propeller at 1800 RPM: 1800 x 3 / 60 = 90 Hz > BAD for ILS
   4-blade propeller at 1800 RPM: 1800 x 4 / 60 = 120 Hz > OK for ILS

b. Physical movement of other antennas, such as the weather radar, may affect the signal received from a glide path antenna located nearby. The weather radar may have to be parked in a known orientation to obtain stable glide path signals.
c. Cross-coupling between aircraft transmitter antennas and receiving antennas can easily occur. Car**e must** be taken to ensure adequate separation between potential interfering sources, such as VHF communications antennas and VOR/ILS localizer antennas.
d. Aircraft structures must be taken into account when selecting antenna locations. The mounting of
   antennas near discontinuities in material types should be avoided if a good ground plane is required. Metallic support rods stowed inside a composite material nose cone can act as re-radiators affecting the performance of a nearby antenna.
e. When one antenna is used to feed two or more receivers there is potential for receiver interaction resulting in an uncalibrated change to the antenna system gain. **Flight Inspection Aircraft shall have** separate antennas be provided for the flight inspection receivers.
f. Changes in aircraft attitude will affect the relative positions of the antenna and tracking reference point if the aircraft measuring antennas are not located at the same point as the reference for the tracking system as seen from the ground. Certain flight inspection systems correct this by using software and inputs from the aircraft navigation sensors.
g. The position of the phase **center** for some types of antennas will vary according to the direction of arrival of the signals. Measurements have shown that the effective phase **center** may move outside the physical area of the antenna. This change in

position of the phase **center** should be included in any correction algorithms which may be used.

h. Any proposed aircraft installation limitation affecting measurement accuracy, coverage, polarization, masking, or repeatability shall be documented in the approved Flight Inspection Organization documentation. Such limitations shall be subject to CAA review and approval prior to their application and shall be considered during the evaluation and interpretation of flight inspection results.