The European Organisation for Civil Aviation Equipment
L'Organisation Européenne pour l'Equipement de l'Aviation Civile

MINIMUM OPERATIONAL PERFORMANCE SPECIFICATION FOR MODE S MULTILATERATION SYSTEMS FOR USE IN ADVANCED SURFACE MOVEMENT GUIDANCE AND CONTROL SYSTEMS (A-SMGCS)

ED-117

November 2003

17, rue Hamelin
75783 PARIS, Cedex 16, France
Web Site : www.eurocae.org

Tel : 33 1 45 05 71 88
Fax : 33 1 45 05 72 30
Email : eurocae@eurocae.com

MINIMUM OPERATIONAL PERFORMANCE SPECIFICATION FOR MODE S MULTILATERATION SYSTEMS FOR USE IN ADVANCED SURFACE MOVEMENT GUIDANCE AND CONTROL SYSTEMS (A-SMGCS)

ED-117

November 2003

FOREWORD

1. This document, prepared by EUROCAE Working Group 41, was accepted by the Council of EUROCAE on November 2003.
2. EUROCAE is an international non-profit making organisation. Membership is open to European manufacturers of equipment for aeronautics, trade associations, national civil aviation administrations, users, and non-European organisations. Its work programme is principally directed to the preparation of performance specifications and guidance documents for civil aviation equipment, for adoption and use at European and worldwide levels.
3. The findings of EUROCAE are resolved after discussion among its members and in cooperation with RTCA Inc., Washington DC, USA and/or the Society of Automotive Engineers (SAE), Warrendale PA, USA through their appropriate committees.
4. EUROCAE performance specifications are recommendations only. EUROCAE is not an official body of the European Governments; its recommendations are valid as statements of official policy only when adopted by a particular government or conference of governments. The inclusion of references to standards published by other standardisation bodies, or extracts from those standards, does not imply any safety or regulatory liability.
5. This document is compliant with the requirements of the surveillance function within EUROCAE ED-87A. ("MASPS for Advanced Surface Movement Guidance and Control System January 2001".)
6. Copies of this document may be obtained from:

EUROCAE

17 rue Hamelin

75783 PARIS Cedex 16

France

Tel: 33 1 45 05 71 88

Fax: 33 1 45 05 72 30

Email: eurocae@eurocae.com

Web Site: www.eurocae.org

TABLE OF CONTENTS

CHAPTER 1

GENERAL

1.1 PURPOSE AND SCOPE

This EUROCAE Minimum Operational Performance Specification (MOPS) specifies the minimum performance requirements of the Multilateration (MLAT) System which is one of the co-operative sensors for use in Advanced Surface Movement Guidance and Control Systems (A-SMGCS). Chapter 1 of this document provides the necessary information to understand the need for technical characteristics and tests of this MLAT system that are described in the following chapters. This chapter describes the typical applications of the system and the operational objectives and along with EUROCAE ED87A, *Minimum Aviation System Performance Specifications for A-SMGCS,* forms the basis for performance criteria stated in chapters 2 and 3. Definitions and abbreviations essential to the proper understanding of this document are also provided in Chapter 1.

Chapter 2 describes the different physical and technical components of the MLAT system and contains general design requirements for use as part of an A-SMGCS.

Chapter 3 contains the Minimum Operational Performance Requirements for the MLAT system, defining performance under all environmental conditions likely to be encountered.

Chapter 4 identifies laboratory means of testing performance characteristics of the MLAT equipment under conditions representative of those that may be encountered in actual operations.

Chapter 5 describes recommended test procedures for demonstrating compliance with Chapters 2 and 3 in the factory or laboratory.

Chapter 6 describes recommended test procedures for demonstrating compliance with the requirements of Chapter 2 and 3 for the installed MLAT system.

1.2 MOPS APPLICATIONS

The specifications contained in this document specify desired system characteristics that should prove useful to designers, manufacturers and users of MLAT equipment.

It should be noted that this document provides *minimum* operational performance specifications for the MLAT functions. These performance specifications are focused on the basic MLAT applications as a co-operative sensor in a multi-sensor A-SMGCS, as defined in EUROCAE ED87A. Performance standards for functions or components that apply to capabilities that exceed the stated minimum requirements are identified as optional features.

Compliance with this MOPS ensures that the MLAT will satisfactorily perform its intended functions, as given in section 1.3, during surface movement operations.

Compliance with the MOPS does not necessarily constitute compliance with regulatory requirements. Any regulatory application of this document wholly or in part is the sole responsibility of the appropriate air traffic control authority.

As the measured values of the system performance characteristics may be a function of the method of measurement, standard test conditions and methods of testing are recommended in this document.

The word “equipment” as used in this document includes all components and units necessary for the MLAT system to correctly perform its function.

1.2.1 Mandating and Recommendation Phrases

1.2.1.1 “Shall”

The use of the word “Shall” indicates mandated criteria; i.e. compliance with the particular procedure or specification is mandatory and no alternative may be applied.

1.2.1.2 “Should”

The use of the word “Should” (and phrases such as “It is recommended that …”, etc.) indicate that though the procedure or criterion is regarded as the preferred option, alternative procedures, specifications or criteria may be applied, provided that the manufacturer, installer or tester could provide information or data to adequately support and justify the alternative.

1.3 SYSTEM DESCRIPTION

1.3.1 MLAT Applications and Operational Objectives

MLAT sensor systems in an A-SMGCS are intended for use during airport ground operations to inform air traffic controllers of the presence, location and identification of aircraft and/or vehicles equipped with an operational ATC transponder or equivalent. The MLAT system is one of the sensors of the A-SMGCS.

The MLAT function is co-operative detection of stationary and moving targets on the surface or in the vicinity of the airport. This data is destined to supply a multi-sensor fusion system of an A-SMGCS.

As a sensor in an A-SMGCS, an MLAT combined with a primary sensor (SMR), can provide sufficient information to unambiguously identify and track aircraft and/or vehicles.

1.3.2 Operating Principles of the System

An MLAT system works by placing a number of receivers and/or receiver/interrogators in precisely surveyed locations in or around an airport. The system uses the spontaneous Mode S “squitter”* transmission and asynchronous transponder replies as well as the responses to interrogations elicited by the MLAT system. The system does not require any additional aircraft equipment to be installed. Multilateration is the process of determining the target location in two (or three) dimensions by solving the mathematical intersection of multiple hyperbolas (or hyperboloids). It is based on the TDOA principle, the Time Difference Of Arrival between the “arrivals” of one transponder’s signal received at several receivers. For 2D positioning 3 receivers is the minimum number of receivers (for the principle to work) and for 3D positioning at least 4.

Since airport surveillance presents a difficult RF environment due to shadowing by buildings and multi-path, the number of receivers is determined according to the airport layout and the coverage area required. Additional receivers also help to enhance positional measuring accuracy.

The system detects each transponder signal at multiple sensor locations. The signal is time-stamped either locally or sent to a Central Processing Station and time stamped, where the difference in signal arrival time, at each sensor location, is used to estimate the transponder location. If we consider only the two-dimensional problem of surface surveillance, the TDOA of a signal at each pair of sensors has a single distinct curve upon which the transponder is located. Data from three sensors permits the system to create two solution arcs—the intersection of which is the location of the transponder. Data from a fourth sensor is required to determine a three-dimensional position estimate. Alternatively, a three-dimensional positional estimate can be calculated using only three sensors when altitude can be ascertained from an outside source (such as Mode C code or 'on ground' bit from the aircraft transponder).

The identity of aircraft is obtained as follows:

The ICAO 24-bit aircraft address is integrated in the Mode S transponder "squitter" message and is therefore acquired by the MLAT system.

The aircraft address is used by the MLAT system to interrogate aircraft selectively in order to obtain:

- The aircraft identification, when reported by the Mode S transponder
- The Mode A code
- The Mode C altitude.

A correlation with the flight plan must be established to obtain or confirm the aircraft flight identity. This correlation can be made by the MLAT system or by the fusion component of the A-SMGCS.

This correlation is an option for the MLAT system.

***NOTE 1*:** *The 24-bit aircraft address shall be one of more than 16,000,000 aircraft addresses allocated by ICAO to the State of Registry or common mark registering authority and assigned uniquely to individual aircraft.*

NOTE 2: *The Mode S transponder aircraft identification reporting capability is a requirement of European Mode S implementing States from 2005 onwards, for various categories of flights. It requires an interface and appropriate input device in order to transmit the aircraft identification entered in the flight plan.*

The A-SMGCS multi-sensor fusion system should have the capability to correlate a discrete Mode A code and/or reported aircraft identification with stored flight plan data.

NOTE: *For several countries, there is direct correspondence between the mode S number and the tail number of the aircraft.*

In any case, the A-SMGCS multi-sensor fusion system should have to know the flight number of the aircraft and/or tail number.

1.4 COMPONENTS OF THE MULTI LATERATION SYSTEM

The MLAT system consists of the following units:

- The receivers installed in or around the coverage area.
- The interrogators installed in or around the coverage area.
- Interrogator and receiver Antennas
- A Central Processor System associated to the previous interrogators / receivers.
- A synchronisation system for the TDOA if necessary.
- An inter-modules communication system (except with the on-board transponders)
- An interface to the multi-sensor fusion system.
- A Local Control and Monitoring System (LCMS) (except for the on-board transponders)
- Lightning protection system
- Un-interruptible Power Supply (UPS)
- Test transponder

Other components which should be considered in defining a complete sensor system are:

- Remote Control and Monitoring Unit
- Obstruction Lights

Figure 1-1 is a block diagram of the basic MLAT system components

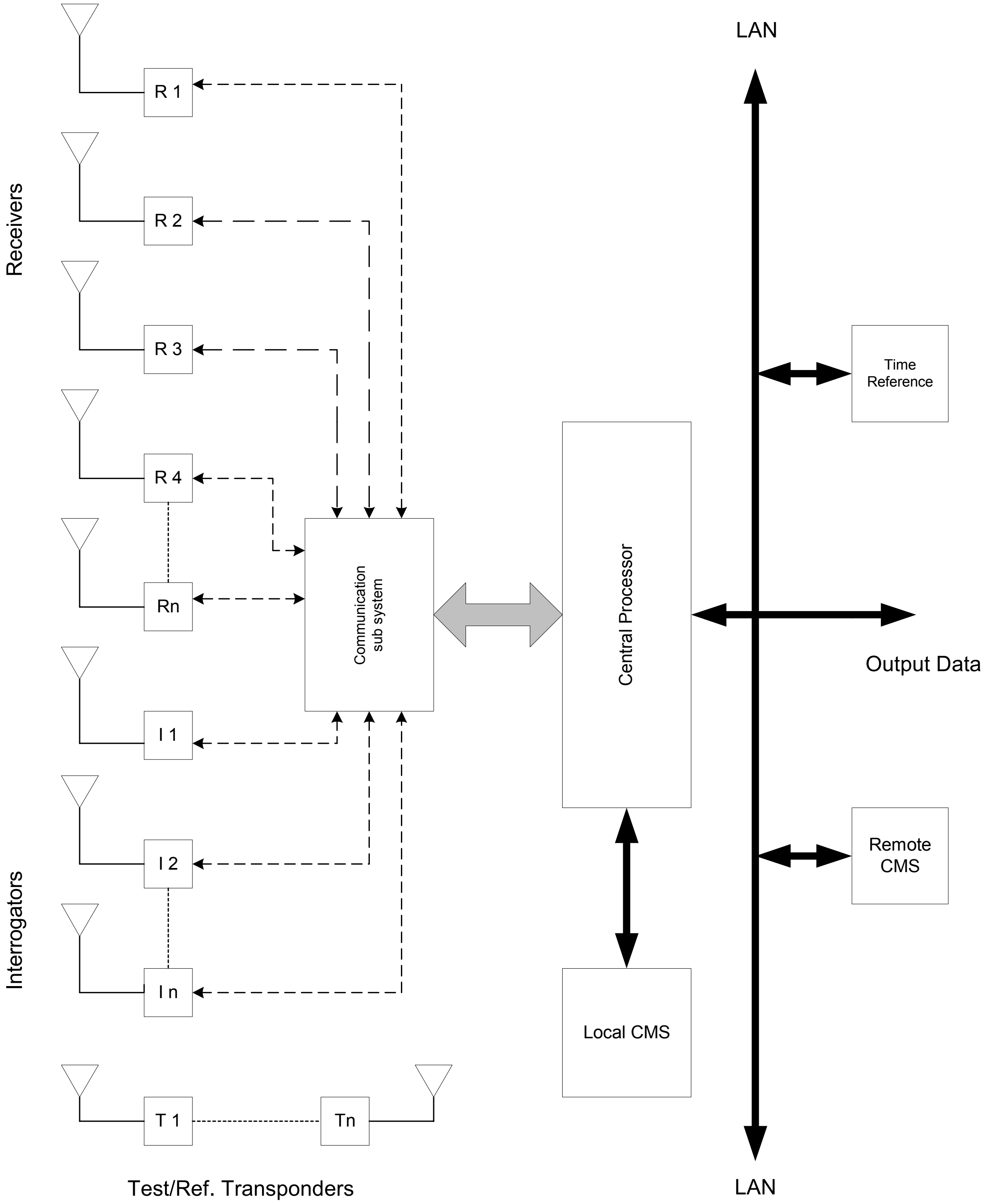


FIGURE 1-1 : BLOCK DIAGRAM

1.5 SITING OF MLAT EQUIPMENT

Except for the on-board transponders, all the other elements will be ground based and fixed.

The installed receivers / interrogators constitute the “sensors”. The sensors are installed around the airport in as many locations as required to meet the required coverage area. Consideration should be given to sites with available main power and communications.

The antennas associated with the sensors must have clear line of sight to transponder antennas of aircraft and vehicles that are in the sensors’ identified coverage area. The antenna can be mounted on existing structures or new support structures as required.

The sensor antennas must be sited such that at least 3, and preferably 4 or more of the sensors have clear line of site, simultaneously, to an aircraft or vehicle transponder antenna that is within the identified coverage area.

The synchronisation system, if used, has to be very precise and reliable as it is the basis of the quality of the positioning with the MLAT technique. If the synchronisation is based on an external reference transmitter, the sensor antennas must have clear line of site to the reference signal. This must be considered when selecting the installation site(s).

The Central Processing Station and Local Control and Monitoring equipment will normally be installed at a central location such as an equipment room at the Air Traffic Control Tower. The LCMU provides the means to configure and control the system in addition to providing status of the system for maintenance purposes. The Central Processing equipment receives data from the sensors and generates target position and identification reports to be sent to the A-SMGCS.

The Communications System is utilised to send data between the sensors and the Central Processor System. The system may be analogue or digital and make use of a variety of media such as copper wire, fibre or RF links. The system must have the bandwidth and quality to support the data rates sufficient to meet the system requirements.

1.6 DEFINITIONS AND ABBREVIATIONS

1.6.1 Definitions

The following defined terms are used within the context of this document:

Accuracy

Accuracy is defined as the ability of the system to calculate a position for a target as related to the true position of the target.

Advanced Surface Movement Guidance and Control System

Systems providing routing, guidance, surveillance and control to aircraft and affected vehicles in order to maintain movement rate under all local weather conditions within the Airport Visibility Operational Level (AVOL) whilst maintaining the required level of safety.

Aerodrome (ICAO SARPS Appendix 14)

A defined area (including any buildings, installations and equipment) intended to be used wholly or in part for arrival, departure and surface movement of aircraft.

Approach

Approach is defined as the area from the runway threshold out to a distance of 5 nautical miles and within the runway glide path.

Apron (ICAO SARPS Appendix 14)

A defined area on an aerodrome intended to accommodate aircraft for the purposes of loading or unloading passengers, mail or cargo, fueling, parking or maintenance.

Availability

Availability is the probability that a system or an item is in a functioning state at a given point in time.

Continuity of Service

The ability of a system or an item to perform its required function without unscheduled interruption throughout the duration of the intended operation.

Coverage Area

The geographic area of interest on the airport within which the system must provide surveillance of the targets. This area may further divided into sub-areas such as manoeuvring, apron and stand.

Data Fusion

A generic term used to describe the process of combining surveillance information from two or more sensor systems or sources.

Detection

Detection is defined as a valid calculated target position.

False Target

False target is defined as any spurious target report or a real target reported to be at a position more than 50 m from its true position at the time of position measurment.

GDOP (Geometric Dilution of Precision)

The relationship between the 3 dimensional position error and the TOA measurement accuracy in the receiving stations contributing to the MLAT position under the assumption that this measurement error has equal statistics for all contributing receiving stations. (Note: The GDOP describes the influence of the geometrical configuration of the MLAT system and the related target on the position accuracy for a given target position.)

Guidance

Facilities, information and advice necessary to provide continuous, unambiguous and reliable information to pilots of aircraft and drivers of vehicles to keep their aircraft or vehicles on the surfaces and assigned routes intended for their use.

Integrity

An attribute of a system or an item indicating that it can be relied on to perform correctly on demand. (It includes the ability of the system to inform the user in a timely manner of any performance degradation.

MLAT Latency

The maximum time from when a transmission from a target is received at a sensor to the time the position report is transmitted by the MLAT system.

MLAT System

An MLAT system is any group of equipment configured to provide position and identification derived from Mode S transponder signals using Time Difference of Arrival (TDOA) techniques.

Manoeuvring Area

That part of an aerodrome to be used for take-off, landing and taxiing of aircraft, excluding aprons.

Modularity

Characteristic of a system that describes its capability to be enhanced by the addition of one or more modules to improve its technical or functional performance.

Monitoring/Alerting

A function of the system that provides dynamic interpretation of the traffic situation, including the verification of planned events, as well as the detection and alerting of conflicts and other hazards.

Movement Area That part of an aerodrome to be used for take-off, landing and taxiing of aircraft, consisting of the manoeuvring area and aprons.

Plot

A plot is the position and identity of a single target obtained directly by MLAT calculation. Note: a plot is thus an untracked data set that does not necessarily contain 3 D position, velocity or state vector information.

Reference Point

A point on the geometric centerline of a target from which all positional information is measured.

Reliability

The ability of a system or an item to perform a required function under specified conditions, without failure, for a specified period of time.

Requirement

An identifiable element of a function specification that can be validated and against which an implementation can be verified.

Route

A path from a defined start point to a defined end point on the movement area.

Squitter

A spontaneous transmission generated at a pseudo random rate by a Mode S transponder.

Stand

A designated area on an apron intended to be used for the parking of an aircraft.

Surveillance

A function of the system that provides identification and accurate positional information on aircraft, vehicles and objects within the required area.

System Capacity

System capacity is defined as the minimum number of targets that the system must process within a specified time interval.

Target

For the purposes of this document,a target is specifically defined as any vehicle or aircraft equipped with an Mode S transponder or equivalent, which has been turned on and is functioning in compliance with it's Minimum Operating Performance Standards.

Target Identification

The correlation of a known aircraft or vehicle call-sign or other appropriate identity with target data.

Target Report

A data record containing all relevant information pertaining to a target detected by the Surveillance Element.

Time Difference of Arrival (TDOA)

The TDOA is defined as the difference in relative time that a reply from the same target is received at different sensor receivers.

Time of Arrival

The Time of Arrival is defined as the time a reply from a target is received at any sensor receiver.

Track

A progressive series of estimates of a target position.

Update

A renewal of target reports relating to all targets under surveillance.

Validation

The determination that the requirements for a product are sufficiently correct and complete.

Verification

The evaluation of an implementation of requirements to determine that they have been met.

1.6.2 Abbreviations

A-SMGCS	Advanced Surface Movements Guidance and Control System
ASTERIX	All Purpose Structured EUROCONTROL Surveillance Information Exchange
ATC	Air Traffic Control
ATCRBS	Air Traffic Control Radar Beacon System
BDS	Comm-B Data Selector Code
BITE	Built-in Test Equipment
CMS	Control and Monitoring System
EUROCAE	European Organization for Civil Aviation Equipment
GDOP	Geometric Dilution Of Precision
GICB	Ground Initial Comm-B
HMI	Human Machine Interface
IC	Interrogator Code
ICAO	International Civil Aviation Organization
LCMS	Local Control and Monitoring System
LRU	Line Replaceable Unit
MASPS	Minimum Aviation System Performance Specification
MLAT	Multilateration
MOPS	Minimum Operational Performance Specification
MTBCF	Mean Time Between Critical Failure
MTTR	Mean Time To Repair
PFD	Probability of False Detection
PFID	Probability of False Identification
PID	Probability of Identification
RMA	Reliability, Maintainability, Availability
RTCA	Requirements and Technical Concepts for Aviation
SMR	Surface Movement Radar
SNMP	Simple Network Management Protocol
TDOA	Time Difference of Arrival
UPS	Un-interruptible Power System

1.7 REFERENCES

The following documents are incorporated by reference. The latest issue in effect shall be the one that will apply.

1. EUROCAE ED-87A: Minimum Aviation System Performance Specification for Advanced Surface Movement Guidance and Control Systems (January 2001)
2. EUROCAE ED-79/SAE ARP 4754: Certification Considerations for Highly Integrated or Complex Aircraft Systems (April 1997)
3. ICAO AOPG: Manual of Advanced Surface Movement Guidance and Control Systems (A-SMGCS) in preparation.
4. EUROCAE ED-200A: Report on Surface Movement Guidance and Control Systems (February 1994)
5. EUROCONTROL: Operational Concept Document for A-SMGCS Ground Control Assistance Tools for Europe (AGATE) (Edition 1.0, February 1998)
6. EUROCONTROL: High Level Business Case Document for A-SMGCS Ground Control Assistance Tools for Europe (AGATE) (Edition 1.0, November 1998)
7. ICAO AOPG: Manual of Advanced Surface Movement Guidance and Control Systems (A-SMGCS) in preparation.
8. ICAO: SARPS Annex 14 Aerodromes
9. ICAO: Aerodrome Design Manual (Doc. 9157, 1993)
10. ICAO Annex 10 Volume IV (Radar of surveillance systems and anti-collision systems)
11. EUROCAE ED 82A: Minimum Operational Performance Specification for Mode S Aircraft Data-link Processors (November, 1999)
12. EUROCAE ED 73B: Minimum Operational Performance Specification for Secondary Surveillance Radar Mode S Transponders (January, 2003)
13. EUROCAE ED-115: Minimum Operational Performance Specification for Light Aviation Secondary Surveillance Radar Transponders (August 2002)
14. RTCA/DO-181A: Minimum Operational Performance Standards for Air Traffic Control Radar Beacon System/Mode Select (ATCRBS/Mode S) Airborne Equipment (January 1992)
15. EUROCAE ED-109: Guidelines for Communication, Navigation, Surveillance and Air Traffic Management (CNS/ATM) Systems Software Integrity Assurance (March 2002)
16. ICAO Document 9688-AN/952: Manual on Mode S Specific Services (1997)
17. EUROCONTROL: Standard Document for Surveillance Data Exchange ; Part 7 Transmission of Monosensor Surface Movement Data (Edition 0.30, November 2001)
18. EUROCAE ED-101: “MOPS for Mode S Specific Service Applications” (August 2000)

CHAPTER 2

GENERAL DESIGN REQUIREMENTS

2.1 INTRODUCTION

This chapter establishes the design criteria and general operational requirements for MLAT systems.

Other aspects of the MLAT system design are purely dependent on the manufacturer's philosophy as long as the minimum operational performance requirements specified in Chapter 3 are met.

2.2 AIRWORTHINESS AND CERTIFICATION

The MLAT system is ground-based equipment and as such has no airworthiness requirements. The system will be required to meet European EMC standards as well as maintaining emissions within ITU regulations.

MLAT system shall in no way, under normal or fault conditions, impair the airworthiness of aircraft in the vicinity.

The MLAT system shall in no way, under normal or fault conditions, impair the operation of any communication, navigation or surveillance system.

2.3 CONTROLS

MLAT system shall be designed so that controls intended for use during normal operations cannot be operated in any position, combination or sequence that would result in a condition detrimental to the reliability of the MLAT system.

2.4 TEST METHODOLOGY

Tests should be performed using a combination of modelling and simulation, direct performance measurement on site, and analysis and extrapolation of results. Normally, testing of individual items of equipment would be performed both at the factory or laboratory and on site. Whereas the complete MLAT system test can only reasonably be conducted on site, using a combination of targets of opportunity and controlled aircraft and vehicles.

2.5 EFFECTS OF TESTS

Unless otherwise stated, the design of the MLAT system shall be such that during and after the application of the tests specified in chapter 5 and 6 no condition exists which would be detrimental to the subsequent performance of the system.

2.6 SOFTWARE AND DESIGN

Software design shall follow the guidelines specified in document EUROCAE ED-109. The software criticality level will depend on the particular system function and application, however assurance level 4 should be used as a minimum.

2.7 HEALTH AND SAFETY

The MLAT system shall comply with all relevant health and safety legislation; European Standard; or Code of Practice, including but not limited to the following:

- Inflammable atmospheres
- Human Exposure (International commission on non-ionising radiation protection (ICNIRP) guidelines)
- Electro-mechanical detonators
- Hazardous Substances

2.8 MLAT SYSTEM COVERAGE

The MLAT sensor system will normally be expected to provide continuous coverage of all targets on those areas of the aerodrome where aircraft movements take place.

The coverage will include the movement area on the surface and extending to a height of 100 metres above the surface and the airspace used by arriving and departing traffic to a distance of 5 nm.

The system should be designed, installed and optimised such that the loss of data from any single receiver or interrogator does not cause a loss of the required coverage.

2.9 INTEGRITY

The system design should preclude failures that result in erroneous data for operationally significant time periods.

The system should have the ability to provide continuous validation of data and timely alerts to the user when the system must not be used for the intended operation. The validity of the data should be assessed by the system in accordance with any assigned priority given to that data.

System designers should ensure that the MLAT system includes performance and integrity monitoring based on field mounted test targets, enabling the verification of the end to end performance of the system. Appropriate action must be defined for situations where the performance is below specified minima.

2.10 ADDITIONAL PERFORMANCE CRITERIA

2.10.1 Interrogators / Receivers Installation Site

The interrogators/receivers cases and antennas should be mounted on a suitable building, mast, or tower. The chosen site should permit clear line of site to all parts of the specified coverage area.

The stability of the installation site should be sufficient to ensure system performance requirements under all specified operating weather conditions, in particular the specified operating wind speed and ice loading.

2.10.2 Obstruction Lights

Consideration should be given to the mounting of obstruction lights as required under ICAO Annex 14.

2.10.3 Lightning Protection

The MLAT system and associated data links shall include appropriate lightning conductors and transient protection to ensure continued operation during lightning storms without equipment failure.

2.10.4 Noise and Vibration

The installation of the particular components of the MLAT system shall ensure that audible noise and vibration are confined to within acceptable levels commensurate with the environment.

2.10.5 System Interfaces

The output of the MLAT system shall be a digital data output utilising standard communication protocols. The ASTERIX data format shall be used for target reports.

In addition, the system shall provide a control and monitoring interface based on standard communication protocols.

2.10.6 Power Supplies

All MLAT electrical equipment should operate from standard mains voltage and frequency at the airport.

2.10.6.1 Uninterruptible Power Supply

Consideration should be given to the need for an uninterruptible power supply both for power conditioning and to support the system in the event of a mains power failure for an appropriate time, consistent with the availability and continuity of service requirements.

2.10.7 Electromagnetic Interference and Susceptibility

The MLAT system shall have appropriate EMI/EMC characteristics for operation in an airport environment.

The MLAT system shall not interfere with other airport electrical, electronic, or communications equipment. Nor shall the performance of the MLAT system be in any way affected by other equipment on or near the airport.

2.10.8 Expandability

The MLAT system should be designed to be capable of expansion to accommodate increase target load capacity an/or additional receiver/interrogators.

2.10.9 Access Control/System Security

The MLAT system should have a security system that controls access to the command and parameter adjustment capabilities of the system. Only the highest level of access should enable all system controls.

2.10.10 System Performance Monitoring

The system shall have performance monitoring that provides information indicating the most probable failed Line Replaceable Unit (LRU).

2.10.10.1 Internal

The fault isolation monitoring shall monitor and report status on all major components in the system.

2.10.10.2 External

The fault isolation monitoring shall monitor all external interfaces and report a fault if any of these interface ceases to transfer data.

2.10.11 Availability, Reliability and Maintainability

2.10.11.1 Service Life

The MLAT system shall be appropriate for a service life of at least 15 years.

2.10.11.2 Continuity of Service

The MLAT system shall be capable of sustained operation 24 hours a day throughout the year.

The MLAT sensor system should be designed and configured for a dual redundant configuration, in order to minimise failure. In most cases, redundancy in the MLAT processing, message distribution will be necessary to ensure adequate availability and that essential maintenance could be carried out without interrupting operation.

The MLAT system should be installed and configured in such a way that essential maintenance can be carried out without interrupting operation.

2.10.11.3 Availability

The annual availabilty, excluding agreed maintenance periods, shall be 99.99% with the exception of outages for planned maintenance.

[Availability = MTBCF/(MTBCF + MTTR)]

2.10.11.4 Mean Time Between Critical Failure (MTBCF)

The MLAT system MTBCF shall be designed to support the MTBCF of the A-SMGCS to which it provides surveillance data. The MTCBF should be greater than 10,000 hours. The system will be considered to have failed when ATC can no longer provide service based on data obtained from the system.

2.10.11.5 Mean Time To Repair (MTTR)

The MTTR of the MLAT system shall be adequate to support the requirement of the overall A-SMGCS. An MTTR of less than 1 hour for any single maintenance action is recommended. This includes the time required for fault localizing, repair, test and restoration to service.

2.10.11.6 LRU Protection.

LRUs and interconnections should be designed in such a way that installation in the wrong location is physically prevented.

2.10.11.7 Technical Control and Monitoring

The MLAT system shall be equipped with a system for technical control and monitoring of all system elements and operational parameters.

2.10.11.8 System Access

System access for maintenance shall be possible both locally and remotely.

2.11 EXTERNAL INTERFACES

It is not the intention of this MOPS to mandate the physical interfaces between systems within the A-SMGCS. The recommendation is that ISO standard forms of interface be used. This section describes the data interfaces between the systems in order to assure inter-operability within the A-SMGCS.

2.11.1 ASTERIX Interface

The system shall output ASTERIX Category 10. There are two types of message. These are target reports and service messages.

2.11.1.1 Target Reports

The system shall output target reports in accordance with the proposed ASTERIX Category 10. At a minimum the message shall contain the following fields.

1. Message Type
2. Data Source Identifier
3. Target Report Descriptor
4. Position in WGS-84*
5. Position in Cartesian co-ordinates*
6. Mode 3A Code
7. Measured Height
8. Time of Day
9. Track Number
10. Track Status
11. Aircraft Address
12. Standard Deviation of Position

NOTE *: * Only one of these fields will be populated.*

2.11.1.2 Data Source Identifier

Each sensor system forming part of the A-SMGCS will be allocated a number. This number is to be included in every message sent from the sensor system. The Data Source Identifier shall be configurable on the Data Processor.

2.11.1.3 Target Report Descriptor

Describes the source of the target information; i.e., SSR, MLAT or ADS-B and type of target, i.e. Undetermined, Aircraft or Vehicle.

2.11.1.4 Position in WGS-84

These are the co-ordinates of the transponder antenna. This will either be an absolute value.

2.11.1.5 Position in Cartesian Co-ordinates

Position in metres from a defined fixed reference point.

2.11.1.6 Mode 3A Code

Where the transponder has been interrogated for its Mode 3A code.

2.11.1.7 Measured Height

Height above aerodrome reference point in feet. This may be derived from multilateration, corrected Mode C report or ADS-B.

2.11.1.8 Time of Day

The A-SMGCS system time, accurate to 0.1 second, that the target was detected by the MLAT.

2.11.1.9 Track Number

Each track will be identified by an unique number as long as it is in the system. No track number shall be repeated at any one point in time.

2.11.1.10 Track Status

As a minimum requirement the MLAT system shall only populate bit 2 to define smoothed or measured position report. All other bits are set to 0.

2.11.1.11 Aircraft Address

The 24-bit address as received from the Mode S transponder. For an MLAT system this may also be derived from a vehicle equipped with a Mode S transmitter.

2.11.1.12 Standard Deviation of Position

An indication of the track quality based on the geometry of the outstations.

2.11.2 Target Report Output Rate

The MLAT system shall be capable of outputing a target report for each received mode S transmission. Mode S squitter reports are transmitted at an average rate of once per second. The system will also receive other transmissions in response to its own and third party interrogations. The system should also be able to filter unwanted transmission types (for example Mode A/C or certain down-link formats reports) to prevent target output rates becoming excessive for the Data Fusion system or other Data Links.

2.11.3 Service Messages

The MLAT system shall output a periodic service message at a 1 per second rate. As a minimum the system shall report 3 types of status: operational, degraded and NOGO. At a minimum the message shall contain the following fields.

1. Message Type
2. Data Source Identifier
3. Time of Day
4. System Status

2.11.4 Barometric Pressure Interface

The MLAT system should be capable of receiving barometric pressure readings for the purpose of Mode C flight level to height conversion.

2.11.5 External Time Reference Interface

The MLAT system shall be capable of interfacing with the A-SMGCS time reference for the purpose of time synchronisation.

2.11.6 Remote Maintenance Interface

The MLAT system shall be capable of interfacing with external remote maintenance system for the purpose of reporting system status. The protocol should be SNMP.

2.12 DATA RECORDING

It is highly recommended that the MLAT system should provide a capability to record and playback data in order to verify functional requirements, including time reference, performance analyses and related testing and set-up, monitoring for system evaluations and/or other conditions of interest. The recording functions shall provide the recording capabilities without loss in fidelity of the MLAT system outputs.

2.13 TECHNICAL CONTROL AND MONITORING (REMOTE AND LOCAL)

The Control and Monitoring Subsystem (CMS) provides system control, the remote monitoring of operational status and the remote monitoring of key hardware and software performance parameters to determine whether the MLAT system is operating within specified limits and provide details on the present and past the technical status.

2.13.1 Monitor

System performance monitoring on both the operating and standby modules shall be performed automatically and made available for system analysis.

All key performance parameters shall be checked at regular intervals.

The CMS shall maintain a continuous check of the integrity of the system.

Technical Surveillance of the MLAT system will provide continuous information on the condition of all of the system's various components: test targets (*if provided*), power supply to remote systems (mains / battery), host computers, processes, links with external stations and systems. It will also be required to maintain a continuous check on the integrity of the system.

2.13.2 Control

The CMS shall be capable of configuring and controlling all modules within the system.

The system should be capable of reinitialising subassemblies detected as being faulty.

2.13.3 Remote

It should be possible to perform all local Control and Monitoring functions from a remote location.

2.13.4 Analysis

The CMS should be capable of analysing the quality of the system output, in terms of target position and identification.

A menu of all the analysis programs should be provided.

2.13.5 Reporting

The CMS shall provide indication of the status of the system including power supply, individual modules, processors and other items necessary for the safe operation of the system.

A facility shall be provided to report via an external interface when a major failure is detected by the CMS. The failures that trigger the facility shall be configurable whilst the system is on-line. This facility is necessary in order to enable the reporting of system status to users.

2.13.6 Logging

The CMS shall log to a non-volatile storage when control actions are taken (either automatic or manual) and any change in status of the outstations or data processor. The CMS shall have the ability to print such information. It shall be possible to configure which status changes will be logged. All messages on the CMS shall be in natural language.

It shall be possible to store the data for archiving purposes.

Provision shall be provided to retrieve and analyse present and archived data.

CHAPTER 3

MINIMUM PERFORMANCE SPECIFICATION UNDER STANDARD CONDITIONS

3.1 SYSTEM REQUIREMENTS

3.1.1 2D/3D Calculation

The MLAT system shall be capable of calculating a 3D or a 2D-multilateration position whenever the number and/or type of replies received warrant it.

3.1.2 Mode S Interrogation

The following is an extract from Eurocontrol Clarification Mode S Transponder in an Airport/A-SMGCS Environment (EUROCONTROL/DIS/SUR MODES/SYS/002 - Ed 1.0 22).

"*9.5 Airport multi-lateration interrogator restriction requirements:*

Airport multi-lateration system that interrogate Mode S Transponders are required to be compliant with the following:

- *Any active Mode S interrogations issued by an interrogator shall be selectively addressed.*
- *Operators/owners of multi-lateration systems shall decide locally on the use of an IC or not for active selective interrogation.*
- *Selective interrogations from multi-lateration systems shall not set "lockout" on any targets. This requirement must be strictly applied.*

Multi-lateration systems shall not carry out general purpose datalink activities using any of the advanced Mode S protocols beyond short surveillance and GICB (Ground Initiated COM-B) extraction._ It is recommended that 'replies of opportunity' are used where possible in preference to active interrogation to limit the effects on the RF environment. To gather supplementary track information or to maintain or regain a track, an operator may configure the system to extract the following information using UFs 04, 05, 20 or 21 only:

- *Flight Status*
- *Aircraft identity (Mode A)*
- *Aircraft altitude*
- *Aircraft identification (from BDS register 2,0)*
- *Any GICB register available*

Multi-lateration systems shall not use dataflash functionality nor establish dataflash contracts for the extraction of event driven information.

Multi-lateration systems shall not issue Mode S only all-call interrogations using UF=11 other than on a local basis agreed with the local regulator. If it is necessary to operate in this mode, the all-calls should be sent using lockout override, preferably stochastically.

No specific limitations on the frequency that such interrogations are made but care should be taken to ensure that the omni- or quasi-directional selective interrogation rates are kept to a minimum to ensure that problems of excessive transponder occupancy do not affect the RF environment and hence Probability of detection (Pd) for ground radar systems and ACAS operation."

The MLAT system shall be designed in such a way as to allow conformance with all of the above requirements.

The MLAT system shall be capable of interrogating all mode S transponders within the coverage area. Interrogation shall be used to obtain information not available in the squitter, such as mode A code and barometric altitude. The MLAT system shall only use addressed interrogation and not mode S all-call.

The frequency of interrogation shall be kept to a minimum, consistent with the operational requirement, in order to minimise the effect on other users of SSR. The frequency of interrogation and output power shall be configurable by position, target type and phase of flight.

The interrogator(s) used as part of the MLAT system shall be fully compliant with all relevant requirements of EUROCAE ED-73B MOPS for Secondary Surveillance Mode S Transponders . And shall be tested and certified by the appropriate national authority.

3.1.3 Test and Reference transponders

Any test or reference transponders/transmitters used as part of the MLAT system shall be fully compliant with the relevant requirements of EUROCAE ED-73B MOPS for Secondary Surveillance Mode S Transponders. These test units shall have the "ground bit" set to on ground and shall not reply to any interrogations.

3.2 OPTIONAL REQUIREMENTS

3.2.1 ADS-B Decoding

In order to guarantee compatibility with future ADS-B development it is highly recommended that the MLAT system be capable of decoding ADS-B messages. If so then the system should process Mode S ADS-B replies and output the positional information, the appropriate validity time, and any quality, mode, or other information included in the ADS-B message. The system shall be able to decode the ADS-B information as defined in the most recent version of the ICAO Manual on Mode S Specific Services, or its successor. The MLAT system shall output the ADS-B reports independently from the MLAT position reports.

3.2.2 Mode A/C

Where there are aircraft at an airport that are not equipped with mode S transponders, there may be a requirement for the MLAT to be capable of interrogating mode A/C transponders within the coverage area.

If mode A/C interrogation is required, the frequency of interrogation shall be configurable by area, target type and phase of flight. The minimum interrogation rate for aircraft in the manoeuvring area should be once per second to maintain the required update rate.

The system shall use techniques to reduce the probability of garbling of mode A/C replies from adjacent aircraft.

NOTE : *Interrogation of mode A/C aircraft using these techniques will be subject to regulatory approval.*

3.3 PERFORMANCE

3.3.1 Update Rate

The minimum update rate for any target in the coverage area shall be designed to be 1 per second average, based on the squitter rate of mode S transponders. This update rate will not always be possible, due to some transmissions not being detected. The acceptable probablilities of this are stated in 3.3.2.

3.3.2 Probability of Update

3.3.2.1 Apron

The probability of achieving a 1 second average update rate for any Mode S transmitting target in the apron area shall be at least 0.7.

3.3.2.2 Stand

The probability of achieving a 1 second average update rate for any Mode S transmitting target in the stand area shall be at least 0.5.

3.3.2.3 Maneuvering Area

The probability of achieving a 1 second average update rate for any Mode S transmitting target in the manoeuvring area shall be at least 0.95.

3.3.2.4 Airborne Targets

The probability of achieving a 1 second average update rate for any airborne Mode S transmitting target in the coverage area shall be at least 0.95.

3.3.3 Position Accuracy

Manoeuvring Area

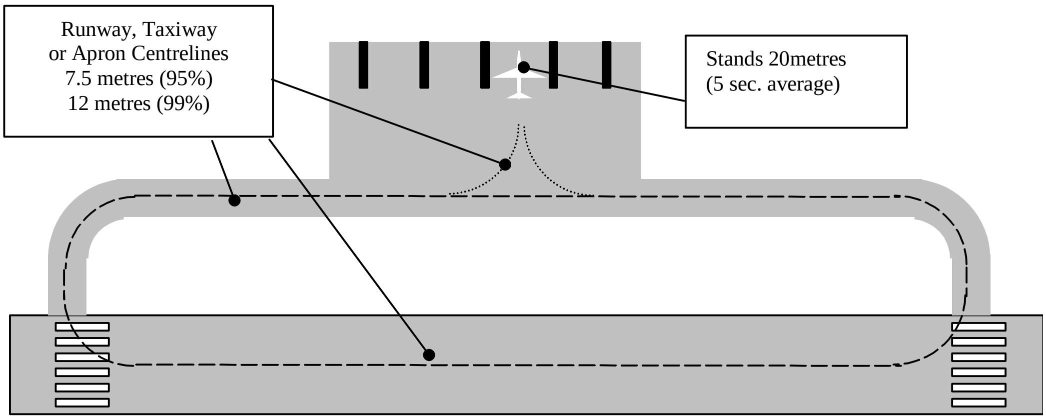
The system shall calculate the horizontal positions of targets detected on the runways, taxiways and centerlines of the apron areas to within 7.5 m with a confidence level of 95% and to within 12 m with a confidence level of 99%.

Stands

The system shall calculate the horizontal positions of targets detected on Stands to within 20 m averaged over a period of 5 seconds.

Airborne Targets

The system shall calculate the horizontal positions of airborne targets detected at a range of less than 2.5 Nm from the runway threshold to within 20 m to a confidence level of 95%. The system shall calculate the horizontal positions of airborne targets detected at a range between 2.5 Nm and 5 Nm from the runway threshold to within 40 m to a confidence level of 95%.



3.3.4 Probability of MLAT Detection

The system shall detect and calculate a position for each active Mode S transponder on runways and taxiways within any two-second period with a probability of detection better than 99.9%. For each active Mode S transponder in the stands it shall be within any 5-second period with a probability of detection better than 99.9%.

3.3.5 Probability of Identification (PID)

The system shall provide the correct target identity with a probability of better than 99.9%.

3.3.6 System Capacity

As a minimum requirement, the system shall be able to support 250 targets at a time creating one target report each per second within the given operational radio environment. The MLAT system shall report to the user if the system capacity is being exceeded to prevent unreliable data from being used operationally.

Consideration should be given to some form of graceful degradation in the event of an overload.

To determine the system capacity limit, it should be assumed that all receivers contribute to each target position calculation.

The design should consider potential for increased capacity due to airport growth.

3.3.7 Latency

The delay between Mode S signal reception and outputting the target report from the MLAT system shall not exceed 0.5 seconds.

3.3.8 Start - Up Time

The MLAT system shall be fully operational within 3 minutes of initial start-up or restart including instances of main power loss.

3.3.9 Track Initiation

The MLAT system shall initiate a track on a properly equipped aircraft within 5 seconds of either initial transponder turn on or upon entering the coverage area.

3.3.10 Probability of False Detection (PFD)

The probability of the MLAT system outputting False Targets shall be less than 10^{-4}.

3.3.11 Probability of False Identification

The probability that the MLAT system incorrectly identifies a target that correctly announces its identity shall be less than 10^{-6} over any 5-second period per target.

3.3.12 Switchover Time

For systems configured with redundant target processor systems the time for switchover from primary to backup shall be $\leq$ 3 seconds with no loss of target data.

3.4 ENVIRONMENTAL CONDITIONS

Unless otherwise stated, the operational performance requirements in this section shall be met under all specified weather conditions including fog, hail, snow, icing, wind and rainfall, and all modes of operation.

3.4.1 Temperature and Humidity

MLAT equipment that is to be installed exterior to buildings shall be designed to operate from -25°C to +55°C, and relative humidity up to 100% non-condensing. In certain parts of Europe, where extremes of temperature are experienced, this should be specifically addressed.

All equipment installed in equipment rooms, suitably protected from the outside environment, shall be designed to operate from +10°C to +30°C, and a relative humidity from 10% to 80%.

3.4.2 precipitation

Typical requirements:

Rainfall: up to 16mm/hr

Hail: up to a diameter of 12mm at 17m/s

3.4.3 Icing

Typical requirements:

Icing: up to 10mm thick

3.4.4 Wind Speed

The maximum wind speed (3-second gust) for operation of the outdoor equipment shall be not less than 80 knots (41 m/s).

The maximum wind speed (3-second gust) for survival of the outdoor equipment shall be not less than 120 knots (62 m/s).

3.5 POWER SUPPLY

The system shall fully comply with the following one or more power mains systems:

1. Public “Alternating Current” (AC) net providing nominal voltage 1x230V with tolerance ±10%, nominal frequency 50Hz (tolerance ±0,5%). It should be in preference TN-S system distribution net. Alternative distribution systems should be: TN-C-S, TN-C. In case of power supply from local or mobile sources - distribution systems TT and IT should be used; in this case the tolerance of the frequency shall be within the range ±5%.
2. Public “Alternating Current” (AC) net providing nominal voltage 3x230V/400V with tolerance ±10%, nominal frequency 50Hz (tolerance ±0,5%). It should be in preference TN-S system distribution net. Alternative distribution systems should be: TN-C-S, TN-C. In case of power supply from local or mobile sources - distribution systems TT and IT should be used; in this case the tolerance of the frequency shall be within the range ±5%.
3. Local “Direct Current” (DC) net providing nominal voltage 24V or 48V (tolerance ±20%). When backup batteries are used, then the tolerance of fluctuation of nominal voltage should be adapted to battery type.

CHAPTER 4

MINIMUM PERFORMANCE SPECIFICATION UNDER ENVIRONMENTAL TEST CONDITIONS

4.1 INTRODUCTION

a. Some parameters, which cannot be adequately verified once the system is installed, will need to be verified through laboratory and environmental chamber tests.The environmental test conditions and performance criteria described in this section provide a laboratory means of determining the overall performance characteristics of the MLAT system under conditions representative of those that may be encountered in actual operation.

b. Unless otherwise specified, the test procedures applicable to the determination of the MLAT system performance under environmental test conditions are contained in European standard documents and apply for non-airborne equipment.

c. Some of the environmental tests contained in this section do not have to be performed unless the manufacturer wishes to qualify the MLAT system for that particular environmental condition; these tests are identified by the phrase “If Required”. If the manufacturer wishes to qualify the MLAT sensor system to these additional environmental conditions, then the “If Required” tests shall be performed.

4.2 ENVIRONMENTAL TESTING

The following tests determine whether the MLAT system can comply with the listed environmental test conditions and applicable test procedures described in the corresponding standard.

The MLAT manufacturer shall provide sufficient functional test data to show compliance of the equipment before, during and after the various tests detailed in the following tables.

In most cases, it is acceptable to demonstrate that a particular model and modification state of MLAT system meets these requirments, together with evidence that the equipment being provided exactly conforms to that model and modification state.

4.2.1 Test Plan and Procedures

A test plan and test procedures document shall be prepared, and may be submitted to the appropriate authorities for review.

Except where tests are obviously GO/NO GO in character (e.g. the determination of whether or not mechanical devices function correctly), the actual numerical values obtained for each of the parameters tested shall be recorded.

4.2.2 Test Article

The tests shall be conducted with a MLAT system that is in full conformity with production build.

If the tested item incorporates features that are still experimental or in the development stage, any tests involving the non-production features shall be repeated later on a production item, or evidence presented to substantiate that the test results are valid for the production system.

For EMC testing, the test regime should be validated with a “Notified Body” and subsequent units that are covered by the testing shall be “CE” marked. The aim of the EMC tests is to document compliance in accordance with the council directive 89/336/EEC, article 10(5). The levels are indicative and should be verified by a Notified Body.

TEST	CONDITION	LIMIT INDOOR/OUTDOOR	CORRESPONDING STANDARD
LOW TEMP.	STORAGE: OPERATE:	-40^{O} C/-65^{O} C 10^{O} C/-25^{O} C	IEC 68-2-1TeAd IEC 945
HIGH TEMP.	STORAGE: OPERATE:	65^{O} C/65^{O} C 30^{O} C/55^{O} C	IEC 68-2-2 Bd IEC 945
ENV. PROTECTION	OPERATE:	NA/IP 52	IEC 529
ACOUSTIC NOISE	OPERATE:	55dB(A) REF 1pW	DS/ISO 3743, 3746 IEC 945
Radiated and conducted Emission	Function	Class B	EN55022
Current harmonics, Emission	Function		EN61000-3-2
Voltage Fluctuations, Emission	Function		EN61000-3-3
Electro-static Discharges Susceptibility	Function	± 4 kV Contact discharge ± 8 kV Air discharge	EN61000-4-2

<table>
<tr><td>Radiated Susceptibility</td><td colspan="2">Function</td><td colspan="2">10 V/m
80% AM
27 – 1000 MHz
and
1000 – 2000 MHz</td><td>EN61000-4-3</td></tr>
<tr><td>Bursts Susceptibility</td><td colspan="2">Function</td><td colspan="2">AC power port ± 2kV
Signal ports ± 2kV
(only wire > 3m)</td><td>EN61000-4-4</td></tr>
<tr><td>Surges Susceptibility</td><td colspan="2">Function</td><td colspan="2">AC power port ± 4kV CM, 12Ω
± 2 kV DM, 2Ω
Shielded signal cables ±2 kV CM, 2Ω</td><td>En61000-4-5</td></tr>
<tr><td>Conducted Susceptibility</td><td colspan="2">Function</td><td colspan="2">AC power ports 10VRMS
80 % AM
Separate earth connection 10VRMS
80% AM
Signal and data lines
10 VRMS 80% AM
(only cables > 3m)</td><td>EN61000-4-6</td></tr>
<tr><td>Supply Voltage Interruptions/Dips, Susceptibility</td><td>Function</td><td>Port:
AC power input</td><td>Reduction
[%]
3
60
< 950</td><td>Time
[ms]
10.00
100.00
5000.00</td><td>EN61000-4-11</td></tr>
<tr><td>Sand and Dust</td><td colspan="2"></td><td colspan="2"></td><td>If required</td></tr>
<tr><td>Fungus</td><td colspan="2"></td><td colspan="2"></td><td>If required</td></tr>
<tr><td>Salt Spray</td><td colspan="2"></td><td colspan="2"></td><td>If required</td></tr>
<tr><td>Icing</td><td colspan="2"></td><td colspan="2"></td><td>If required</td></tr>
<tr><td>Magnetic effect</td><td colspan="2"></td><td colspan="2"></td><td>If required</td></tr>
</table>

TABLE 4.1 : ENVIRONMENTAL TEST REQUIREMENTS

CHAPTER 5

FACTORY TEST PROCEDURES

5.1 INTRODUCTION

This chapter specifies the conditions for testing and the test procedures for verifying the performance of the MLAT in the factory or other premises prior to installation at site. The performance criteria are those contained in Chapters 2 and 3.

It should be noted that some performance parameters might be affected by processing load, dependent on the number of targets being handled. When undertaking the prescribed tests, consideration should be given to providing representative scenarios.

5.2 GENERAL CONDITIONS FOR TESTING

5.2.1 Test Plan and Procedures

A test plan and test procedures shall be prepared, and may be submitted to the appropriate authorities for review.

Except where tests are obviously GO/NO GO in character (e.g. the determination of whether or not mechanical devices function correctly), the actual numerical values obtained for each of the parameters tested shall be recorded.

5.2.2 Test Article

The tests shall be conducted with the MLAT system to be delivered, which should be in full conformity with production build.

If the tested item incorporates features that are still experimental or in the development stage, any tests involving the non-production features shall be repeated later on a production item, or evidence presented to substantiate that the test results are valid for the production equipment.

5.2.3 Testing of Spare Units

Where a system is to be supplied with spare units, representative system tests shall be repeated with the spare units installed.

5.2.4 Effects of Tests

The test articles shall complete all tests without maintenance and without the necessity to re-calibrate the test articles.

5.2.5 Test Equipment

Any test equipment requirements shall be specified for each test procedure. Items of test equipment shall have been calibrated prior to the commencement of the test.

5.2.6 Test Report

A summary report shall be produced declaring the following:

1) The time and date of testing, and the participants and their roles in the testing.
2) The part numbers and serial numbers of all identified line replaceable units of the MLAT system as tested, with revision numbers and (software) configuration status if applicable.
3) The environmental conditions, where applicable.
4) The part number and serial numbers of each item of test equipment used and its calibration status.
5) A statement of all performance tests that have been successfully completed.
6) A specific statement for each performance test that was not performed or successfully completed.
7) A specific statement for each declared or identified operational limitation.

5.2.7 Safety Precautions

Any unusual characteristics or hazards to personal or property (e.g. RF radiation, etc.) resulting from operation of the MLAT system shall be analyzed and documented before the test.

While the materials, methods, applications, and processes described or referenced in this procedure may involve the use of hazardous materials, this procedure does not address the hazards that may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and processes, and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

5.2.8 Power Input

The test(s) shall be conducted with the MLAT system powered by a source representative of the installed equipment electrical power system.

5.2.9 Adjustment of Equipment

The circuits of the equipment under test shall be properly aligned and adjusted in accordance with the manufacturer’s recommended practice prior to application of the specified tests.

5.2.10 Test Instrument Precautions

Precautions shall be taken during conduct of the tests to prevent the introduction of errors resulting from the improper connection of test instruments across the input and output impedances of the equipment under test.

5.2.11 Environment

During the test(s), the environmental conditions shall not exceed those specified.

5.2.12 Connected Loads

Unless otherwise specified, all tests shall be performed with the equipment connected to loads having impedance values for which it is designed.

5.2.13 Warm-Up Period

All tests shall be conducted after a warm-up period as specified.

5.3 BASIC CONFORMITY TESTS

Degradation is not allowed as a result of exposure to the conditions listed.

5.3.1 Conformity Inspection

The MLAT system shall be inspected to determine conformity with acceptable workmanship and engineering practices, that proper mechanical and electrical connections have been made, and that the equipment is complete in accordance with the specifications.

5.3.2 System Operations

The MLAT system shall be operated according to the documented system operating procedures. Proper function shall be verified.

5.3.3 Power Supply

Under test conditions, verify the proper operation of the equipment throughout the specified range of supply voltage.

5.3.4 Displays and Controls Accessibility

Demonstrate that all equipment controls and displayed data are readily accessible, intuitive and easily interpreted.

5.3.5 Data link interruption

Demonstrate that the MLAT system recovers automatically after a data link interruption.

5.3.6 Switchover time

Where dual redundant systems are used to meet availability requirements, demonstrate that a means is provided to allow automatic and manual switchover within 3 seconds (including detection time) in the event of a channel failure or temporary removal of one channel for maintenance, without interruption to the MLAT system operation.

Manual changeover time is measured from the time the switchover command is initiated by the operator to the time when switchovover is completed.

5.3.7 Materials and Finish

Demonstrate that outdoor equipment, including the MLAT antenna assemblies, any enclosures, and all external RF cables and accessories, utilise materials, coatings and finishes which are resistant to weathering and to industrial pollutants such as sulphur dioxides and/or nitric oxides.

5.3.8 Equipment Interfaces

Demonstrate that the output of the MLAT system utilises the ASTERIX Category 10 data format for target reports.

Demonstrate that the MLAT system provides a monitoring interface based on standard communication protocols, and that the interface functions as specified.

5.4 PERFORMANCE TESTS

In the following test descriptions each performance test is presented under a separate heading in the following format:

- Requirement - definition of parameter to be tested
- Test Equipment – description of any test equipment needed to perform the test
- Test Procedure - description of test method, including analysis of test data

5.4.1 System Capacity

As a minimum requirement, the system shall be able to support 250 targets at a time creating one target report each per second within the given operational radio environment. The MLAT system shall report to the user if the system capacity is being exceeded to prevent unreliable data from being used operationally.

5.4.1.1 Test Equipment Required

- ❑ A means of simulating in excess of 250 targets at an appropriate stage of the system to ensure all possible problem areas are tested.
- ❑ A means of monitoring the system output.

5.4.1.2 Test Procedure

1. The system should be tested at the maximum system capacity to demonstrate that this can be achieved without any errors or exceeding specified delays.
2. The system should then be tested at a loading which exceeds the maximum to demonstrate that the user is notified of the overload before any erroneous data is presented.
3. Following the overload test, the loading should be reduced to within the maximum capacity to ensure that the system recovers and that the overload indication is removed.

5.4.2 Latency (Paragraph 3.3.7)

The delay between outputting the target report from the MLAT system and Mode S squitter reception shall not exceed 0.5 seconds.

5.4.2.1 Test Equipment Required

- A means of simulating the maximum MLAT system capacity of targets at an appropriate stage of the system to ensure all significant delay elements are included.
- A data analyser or similar equipment to trap and record the timing of a specific input and its associated output.

5.4.2.2 Test Procedure

1. Simulate inputs to the system which enable the system to be operating at its maximim capacity
2. Monitor the input and output using a suitable data analyser to establish the delay between a specific input signal and its associated output message
3. The measured time difference shall be less than 0.5 sec.

5.4.3 Start Up Time and re-start

The MLAT system shall be fully operational within 3 minutes of initial start-up or re-start.

5.4.3.1 Test Equipment Required

- Stopwatch
- RF Simulator or Test target (transponder)

5.4.3.2 Test Procedure

1. Set up and activate the simulator or test target.
2. Start the stopwatch on the action of starting or re-starting the system.
3. Measure the time taken until the first output message is generated.
4. The measured time shall be less than 3 minutes.

5.4.4 Mean Time To Repair

The mean time to repair (MTTR) shall not exceed 1 hour for any single maintenance action, including time required for fault localising, repair, test and restoration to service. This does not include travel time to remote unit site.

5.4.4.1 Test Equipment Required

- System under test
- Set of faulty LRU’s

5.4.4.2 Test Procedure

1. Using manufacturers recommended method, a faulty LRU is installed in the system without the knowledge of the intended maintenance technician.
2. The system is offered to a trained maintenance technician for repair and the time noted (t1).
3. Note the time (t2) after repairing, testing and restoration to service. (Travel time should be allowed for where appropriate).
4. Repeat for a representative set (n) of faulty LRU’s

Calculate the MTTR using the formula below:

$MTTR = \sum (t2 - t1)/n$

CHAPTER 6

SITE TEST PROCEDURES

6.1 INTRODUCTION

This chapter specifies the conditions for testing and test procedures for verifying the performance of the MLAT system when installed at site.

It should be noted that some performance parameters might be affected by processing load, dependent on the number of targets being handled. When undertaking the prescribed tests, consideration should be given to providing representative scenarios. Some parameters, particularly those concerning system reliability, availability, and continuity of service, will need to be tested over an extended period of time. This may impose constraints on the initial operational use of the system until adequate statistical evidence has been obtained to provide the necessary degree of confidence. The length of time required to gather sufficient evidence may be reduced where the equipment is simultaneously in use, operationally or in pre-operational mode, at a number of sites.

6.2 GENERAL CONDITIONS FOR TESTING

6.2.1 Test Plan and Procedures

A test plan and test procedures shall be prepared, and may be submitted to the appropriate authorities for review.

Except where tests are obviously GO/NO GO in character (e.g. the determination of whether or not mechanical devices function correctly), the actual numerical values obtained for each of the parameters tested shall be recorded.

6.2.2 Effects of Tests

The test articles shall complete all tests without maintenance and without necessity to re-calibrate the test articles.

6.2.3 Test Equipment

Any test equipment requirements shall be specified for each test procedure. Items of test equipment shall have been calibrated prior to the commencement of the test.

6.2.4 Test Report

A summary report shall be prepared detailing the following:

1) The time and date of testing, and the participants and their roles in the testing.
2) The part numbers and serial numbers of all identified line replaceable units of the MLAT system as tested, with revision numbers and (software) configuration status, if applicable.
3) The environmental conditions, where applicable.
4) The part number and serial numbers of each item of test equipment used and its calibration status.
5) A statement of all performance tests that have been successfully completed.

6) A specific statement for each performance test that was not performed or successfully completed.

7) A specific statement for each declared or identified operational limitation.

6.2.5 Safety Precautions

Any unusual characteristics or hazards to personal or property (e.g. RF radiation, etc.) resulting from operation of the MLAT shall be analyzed and documented before the test.

While the materials, methods, applications, and processes described or referenced in this procedure may involve the use of hazardous materials, this procedure does not address the hazards that may be involved in such use. It is the sole responsibility of the user to ensure familiarity with the safe and proper use of any hazardous materials and processes, and to take necessary precautionary measures to ensure the health and safety of all personnel involved.

6.2.6 Power Input

The test(s) shall be conducted with the MLAT system powered by the installed equipment electrical power system.

6.2.7 Associated Equipment and Systems

All other electrical or mechanical equipment likely to be operated simultaneously on ground shall be activated for the test(s).

6.2.8 Environment

During the test, the environmental conditions shall not exceed those specified.

6.2.9 Warm-Up Period

All tests shall be conducted after a warm-up period as specified.

6.2.10 General Guidelines for Test Vehicles

The Site Performance Tests require the use of a transponder and/or ADS-B equipped test target. It is more convenient to use a ground vehicle in place of an aircraft. The following minimum guidelines should be followed when using a vehicle other than an aircraft as the test target.

- ❑ The vehicle must be equipped with a MOPS (ED-73B) compliant avionics set.
- ❑ The transponder antenna must be installed at a minimum height of 2 metres above ground in order to emulate an aircraft bottom mounted antenna.
- ❑ The vehicle should be equipped with a means of voice communication.
- ❑ The vehicle should have some high precision position reference system such as DGPS.

6.3 BASIC CONFORMITY TESTS

6.3.1 Conformity Inspection

The installed MLAT system shall be inspected to determine conformity with acceptable workmanship and engineering practices, that the equipment is complete in accordance with the specifications, that proper mechanical and electrical connections have been made, and that the equipment is installed in accordance with the manufacturer's recommendations.

6.3.2 Maintainability

Verify access and removal of the equipment in accordance with the prescribed maintenance practices.

Verify that it is not possible to incorrectly install or connect any Line Replaceable Unit (LRU).

6.3.3 System Operations

Proper functioning of the installed system shall be verified according to the documented system operating procedures.

6.4 PERFORMANCE TESTS

In the following test descriptions each performance test is presented under a separate heading in the following format:

- Requirement - definition of parameter to be tested
- Test Equipment – description of any test equipment needed to perform the test
- Test Procedure - description of test method, including analysis of test data

The parameters to be tested are those defined in Chapter 3.

6.4.1 2D/3D Calculation

The MLAT system shall be capable of calculating a 2D or a 3D-multilateration position whenever the number and/or type of replies received warrant it.

6.4.1.1 Test Equipment Required

- Aircraft of opportunity with active Mode S transponder.
- Recorder (logger) of MLAT output messages.

6.4.1.2 Test Procedure

1. Record data from aircraft of opportunity (both airborne and on the ground)
2. Analyse the data from the recorder of MLAT output messages relevant to the aircraft of opportunity. All plots must have valid values in both position and height.

6.4.2 Mode S Interrogation Capability

The MLAT system shall be capable of interrogating all mode S transponders within the coverage area. Interrogation shall be used to obtain information not available in the squitter, such as mode A code and barometric altitude. The MLAT system shall only use addressed interrogation and not mode S all-call.

The frequency of interrogation shall be kept to a minimum, consistent with the operational requirement, in order to minimise the effect on other users of SSR. The frequency and output power of interrogation shall be configurable by position, target type and phase of flight.

The probability of receiving and decoding a reply from any transponder within the coverage area shall be better than 95% per interrogation

6.4.2.1 Test Equipment Required

- Test vehicle equipped with Mode S transponder.
- Recorder of MLAT output messages.

6.4.2.2 Test Procedure

Measurement at a fixed place:

1. Place test vehicle inside the coverage area and switch on transponder.
2. Put MLAT system into operation and set the interrogation mode to elicit replies in periodic intervals. (Note the time of these intervals.)
3. Switch on the recorder of MLAT output messages.
4. Wait until sufficient amount of data is recorded for post test analysis.

Measurement in movement areas:

5. Position test vehicle in fixed location.
6. Put MLAT system into operation.
7. Select a fixed rate of interrogation of the test transponder.
8. Switch on the recorder of MLAT output messages.
9. Carry out movements within various movement areas. Note the route of movements.

Data analysis:

1. Select the specific output messages with the identification of the test transponder and valid reply, in all records.
2. Analyse replies from the step to verify all replies shall comply with interrogations used.
3. Verify frequency of interrogation by deriving from the frequency of replies.
4. Evaluate probability of receiving and recording a reply.

5. Analyse the record from the step in the following way. From the times of the last reply, first reply and the length of interrogation interval evaluate the number of supposed interrogations (NSI). Count the number of replies, i.e. number of output messages (NR). Evaluate “the probability of receiving and decoding a reply” (PRR) in percentage according to following formula:

$$PRR=(NR/NSI)*100.$$

6. PRR shall be greater than 95 %.

6.4.3 ADS-B Decoding

Where ADS-B functionality is provided, the system shall process Mode S ADS-B replies and output the positional information, the appropriate validity time, and any quality, mode, or other information included in the ADS-B message. The system shall be able to decode the ADS-B information as defined in the most recent version of the ICAO Manual on Mode S Specific Services, or its successor. The MLAT system shall output the ADS-B reports independently from the MLAT position reports.

6.4.3.1 Test Equipment Required

- Aircraft of opportunity or test vehicle with full ADS-B capability.
- Recorder of MLAT output messages.

6.4.3.2 Test Procedure

1. Arrange to record the output of the MLAT system with the ADS-B target operational and within the coverage area.
2. Record data for a significant period.
3. Analyse the data in the MLAT output messages recorder in the following way.
4. Select messages in MLAT record with the identification of the test equipment. Remove others.
5. Compare the sequence of ADS-B messages to the associated MLAT messages in the Asterix output.
6. Ascertain that all items in the ASTERIX output message correspond in positional information, validity time, etc. to ADS-B messages.
7. Repeat this procedure for each coverage area requirement.

NOTE : *Where a test vehicle is used it is preferable to record GPS positions in the vehicle which are derived from the same source as the ADS-B transmissions. These can then be compared with the output ADS-B messages instead of using the MLAT messages. This will remove the possible effects of significant GPS errors giving large differences between MLAT and ADS-B positions.*

6.4.4 Mode A/C Interrogation

Where there are aircraft at an airport that are not equipped with mode S transponders, there may be a requirement for the MLAT to be capable of interrogating mode A/C transponders within the coverage area.

If mode A/C interrogation is required, the frequency of interrogation shall be configurable by area, target type and phase of flight. The minimum interrogation rate for aircraft in the manoeuvring area should be once per second to maintain the required update rate.

The system shall use techniques to reduce the probability of garbling of mode A/C replies from adjacent aircraft.

NOTE : *This could be implemented using TCAS Whisper-Shout Interrogation schemes and/or directional antennas. Interrogation of mode A/C aircraft using these techniques will be subject to regulatory approval.*

6.4.4.1 Test Equipment Required

- Test vehicle equipped with Mode A/C transponder and recording capability.
- Recorder (logger) of MLAT output messages.

6.4.4.2 Test Procedure

1. Test vehicle must have a mode A/C transponder switched on in the coverage area with assigned identity (Mode A identity).
2. Configure the MLAT system to perform Mode A/C interrogations at a 1per second rate.
3. Make sure that the MLAT system is switched on and in operation and start recording output messages.
4. Collect data for a minimum of 100 seconds
5. The number of replies in recorded ASTERIX messages received from the test transponder should equal or exceed* the number of interrogations.

****NOTE:*** *Since transponders will reply to other interrogations as well as the test interrogations it can be expected that the number of replies will exceed the number of test interrogations.*

6.4.5 Update Rate

The minimum update rate for any target in the coverage area shall be designed to be 1 per second average, based on the squitter rate of mode S transponders. This update rate will not always be possible, due to some transmissions not being detected. The acceptable probabilities of this are stated as :

Apron -The probability of achieving a 1 second average update rate for any Mode S transmitting target in the apron area shall be at least 0.7.

Stand -The probability of achieving a 1 second average update rate for any Mode S transmitting target in the stand area shall be at least 0.5.

Manoeuvring Area -The probability of achieving a 1 second average update rate for any Mode S transmitting target in the manoeuvring area shall be at least 0.95

Airborne Targets -The probability of achieving a 1 second average update rate for any airborne Mode S transmitting target in the coverage area shall be at least 0.95

6.4.5.1 Test Equipment Required

- Test vehicle with Mode S transponder or Target of opportunity
- Asterix Recorder.

6.4.5.2 Test Procedure

1. Position test target in coverage area of interest.
2. Record target data using the MLAT data recorder for minimum 100 seconds.
3. Repeat for each area.
4. Analyse the data to determine update rate probability.

6.4.6 Position Accuracy

Manoeuvring Area

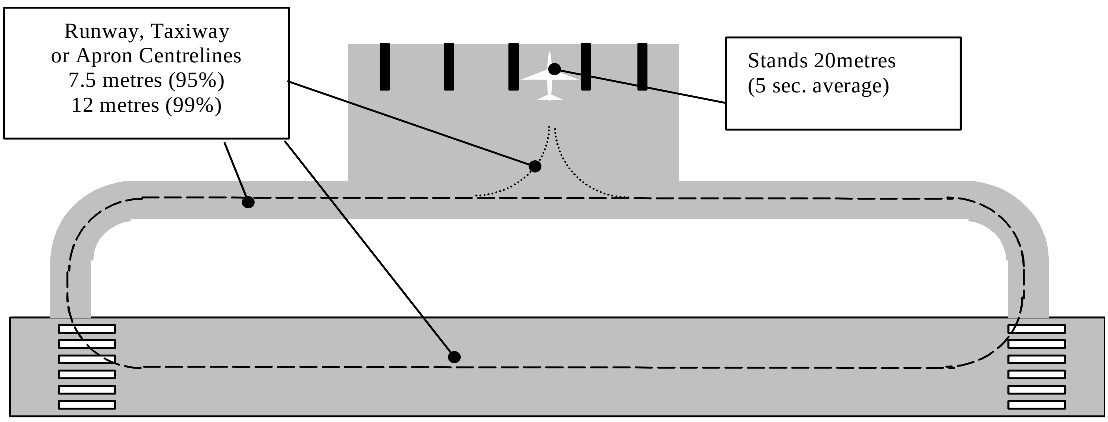
The system shall calculate the horizontal positions of targets detected on the runways, taxiways and centerlines of the apron areas to within 7.5 m with a confidence level of 95% and to within 12 m with a confidence level of 99%.

Stands

The system shall calculate the horizontal positions of targets detected on Stands to within 20 m averaged over a period of 5 seconds.

Airborne Targets

The system shall calculate the horizontal positions of airborne targets detected at a range of less than 2.5 Nm from the runway threshold to within 20 m to a confidence level of 95%. The system shall calculate the horizontal positions of airborne targets detected at a range between 2.5 Nm and 5 Nm from the runway threshold to within 40 m to a confidence level of 95%.



6.4.6.1 Test Equipment Required

- Vehicle equipped with Mode S transponder and differential GPS equipment

  (With a means of recording reference data for the test vehicle with time reference.)

- Known surveyed positions if truth system not available
- Asterix Recorder

6.4.6.2 Test Procedure (Stationary Target)

1. Position the test target within the coverage area of interest.
2. Start a recording of target data using MLAT data recorder.
3. Collect target data at fixed position.
4. Repeat for as many fixed positions as required.
5. Compare MLAT positions to reference.

6.4.6.3 Test Procedure (Moving Target)

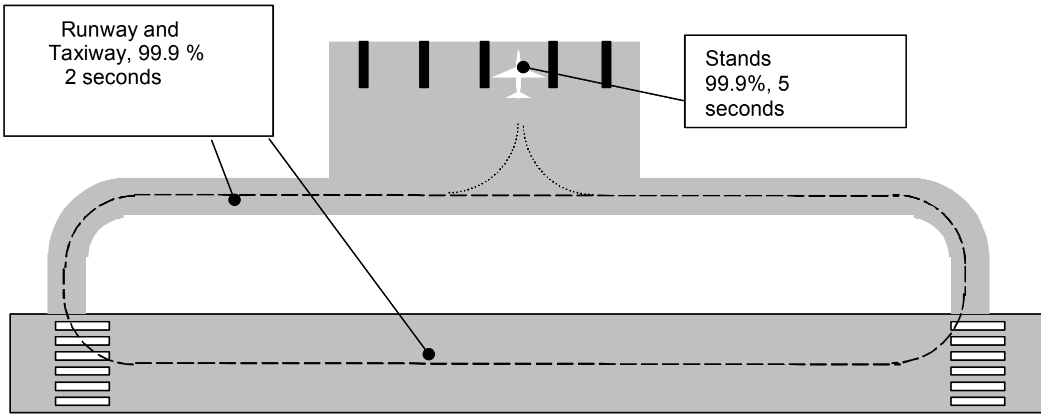
The planned coverage routes Test Procedure will be defined to cover a majority of the airport surface including runways, taxiways. In addition to the runways and taxiways, the test vehicle should stop at several available parking areas. The test vehicle should adhere to following guidelines:

The test vehicle should stay on the centerline of all runways, taxiways, and parking areas.

1. Establish a predetermined route for the test vehicle within the coverage area of interest.
2. Position the test vehicle at start point of route.
3. Start a recording of target data using the MLAT data recorder.
4. Commence along the route with the test vehicle.
5. Collect reference data for the test vehicle with time reference.
6. Post process the data collected and compare MLAT position data with truth system data accounting for any time offsets.
7. Repeat the procedure for each route required.

6.4.7 Probability of MLAT Detection

The system shall detect and calculate a position for each active Mode S transponder on runways and taxiways within any two-second period with a probability of detection better than 99.9%. For each active Mode S transponder in the stands it shall be within any 5-second period with a probability of detection better than 99.9%.



NOTE: *The MLAT System is an event driven sensor. The actual number of transponder squits is unknown. The system only generates a position when a Mode S transmission is detected by sufficient receivers. This test assumes the probability of detection is defined as the probability that the system detects a target and outputs a position report in which the measured position lies within 50 meters of the target's true position.*

6.4.7.1 Test Equipment Required

- Test vehicle equipped with a Mode S transponder or target(s) of opportunity.
- Recorder of MLAT output messages.

6.4.7.2 Test Procedure

1. Set the recorder of MLAT data messages in operation.
2. Start the test vehicle on its designated route and begin recording all target data on the MLAT recorder.
3. Collect target data for the test vehicle during the entire course of the test run.
4. Stop recording target data when the test vehicle run is completed.
5. Playback the recorded target data and use analysis tools to determine the probability of MLAT detection.

6.4.8 Probability of Identification

The system shall provide the correct target identity with a probability of better than 99.9%.

6.4.8.1 Test Equipment Required

Test vehicle equipped with a Mode S transponder.

Recorder of MLAT output messages.

6.4.8.2 Test Procedure

1. Set the recorder of MLAT data messages in operation.

2. Start the test vehicle on its designated route and begin recording all target data on the MLAT recorder.

3. Select output messages from the MLAT system records with the identification of the test transponder.

4. Analyze the data to verify the requirement is met.

6.4.9 Track Initiation

The MLAT systems shall initiate a track on a properly equipped target (aircraft) within 5 seconds of either initial transponder turn on or upon entering the coverage area.

6.4.9.1 Test Equipment Required

- Test vehicle equipped with a Mode S transponder.
- Recorder of MLAT output messages.

6.4.9.2 Test Procedure

1. The test vehicle can be at fixed location or moving.

2. Position the test vehicle within the coverage area, put the transponder in “standby”.

3. Start the recorder of MLAT messages.

4. Switch the transponder on “operate”.

5. Verify that the test vehicle track is initiated within 5 seconds of transponder operation.

6.4.10 Probability of False Detection (PFD)

The system shall output false targets with a probability less than 10^{-4}.

6.4.10.1 Test Equipment Required

- Recorder of MLAT output messages.

- Test vehicle equipped with a Mode S transponder and DGPS or equivalent truth system.

6.4.10.2 Test Procedure

1. Start the recorder of MLAT messages.

2. Start the test vehicle on its designated route and simultaneously start the DGPS or equivalent truth system.

3. Collect the MLAT data for the entire vehicle run.

4. Analyze the MLAT data and compare results to the truth data accounting for any time differences between the two sets of data.

5. Any test target position reported by the MLAT more than 50 metres from its true position is a false detection.

6.4.11 Probability of False Identification

The probability that the system incorrectly identifies a target that correctly announces its identity shall be less than 10^{-6} over any 5-second period per target.

6.4.11.1 Test Equipment Required

- Recorder of MLAT output messages.

- Test vehicle equipped with a Mode S transponder.

6.4.11.2 Test Procedure

1. Start the recorder of MLAT messages.

2. Record the Mode A ID, Mode C altitude, Flight ID and Flight Status (on ground/airborne) of the test vehicle.

3. Start the test vehicle on its designated route and record all target data on the MLAT recorder.

4. Stop recording target data when the test vehicle run is completed.

5. Analyze the data collected to verify that the requirement is met.

LIST OF EUROCAE WG-41 MEMBERS

Mr. C.	Diggins	NATS	Chairman
Mr. A	Gilbert	Park Air Systems	Successive Secretaries
Mr. B	Panchal	Qinetiq	

Mr. P	Adamson	Eurocontrol
Mr. J	Ansell	EASAT Antennas
Mr. C	Axelsson	LFV
Mr. C.	Bernabei	European Commission
Mr. P	Bharat	Qinetiq
Mr. D.	Bowen	Qinetiq
Dr. A.	Brown	EASAT Antennas
Mr. P	Calin	ABB Airport Technologies
Mr. J-P	Cochet	Aeroport de Paris
Mr B	Collin	Eurocontrol
Mr E.	De Lutio	Sensis Corporation
Mr. J	Drapalik	ERA a.s.
Ms. S	Fairbank	Sensis Corporation
Mr. F	Grimal	EUROCAE
Mr. G.	Henderson	NATS
Mr. O	Horton	BAE Systems Avionics
Mr. G.	Hunt	EUROCAE
Mr. J	Hunter	Primagraphics
Dr .K.	Jones	Alenia Marconi Systems
Mr. K	Klein	DLR
Mr. D	Langejan	HITT
Mr. R.	Lens	CHL Netherlands
Mr. A	Lobrutto	Sensis Corporation
Mr. F	Matus	Sensis Corporation
Mr. D.	Miller	Lockheed Martin
Mr. F.	Monzel	Airsys Navigation Systems
Mr. H.	Neufeldt	Airsys Navigation Systems
Mr. D	Olster	Sensis Corporation
Mr. S.	Porfiri	Alenia Marconi Systems
Mr. B	Rode	DLR
Mr. V	Sotona	ERA a.s.
Mr. Z	Svoboda	ERA a.s.
Mr. P.	Taylor	Alenia Marconi Systems
Mr. G	Tesi	Galileo Avionica
Mr. J	Tolstrup	Terma
Mr. C	Tsiampalidis	Aeroport de Paris
Mr. J-C	Vallee	STNA
Ms. A.	Varona	AENA

LIST OF WG-41 MLAT SUBGROUP MEMBERS

Mr. E.	De Lutio	Sensis Corporation	Chairman
Mr. J-P.	Cochet	ADP	
Mr. C.	Diggins	NATS	
Mr. G.	Henderson	NATS	
Dr. K.	Jones	AMS	
Mr K.	Klein	DLR	
Dr. H.	Neufeldt	Thales ATM	
Mr. B.	Panchal	Qinetiq	
Mr. B.	B. Rode	DLR	
Mr. Z.	Svoboda	ERA	
Mr. C.	Tsiampalidis	ADP	
Mr. J-C.	Vallee	STNA	

ED-117 IMPROVEMENT SUGGESTION FORM

Name: ______________________________ Company: ___________________________

Address: ____

City: ______________________________ State, Province: ______________________

Postal Code, Country: __________________________ Date: ______________________

Phone: ______________________________ Fax: ______________________________

Email: ______________________________

DOCUMENT : ED-117 SEC: ___________ PAGE: __________ LINE: ________

[ ] Documentation error (Format, punctuation, spelling)

[ ] Content error

[ ] Enhancement or refinement

Rationale (Describe the error or justification for enhancement): ___________________________

____

____

Proposed change (Attach marked-up text or proposed rewrite): __________________________

____

____

____

____

Please provide any general comments for improvement of this document:

____

____

____

____

____

Please, return completed form to:

EUROCAE
17 rue Hamelin
Paris Cedex 75783, France
Email: eurocae@eurocae.com

or

Web: www.eurocae.org
Free workspace
Comments on published documents
ED-117 Comments