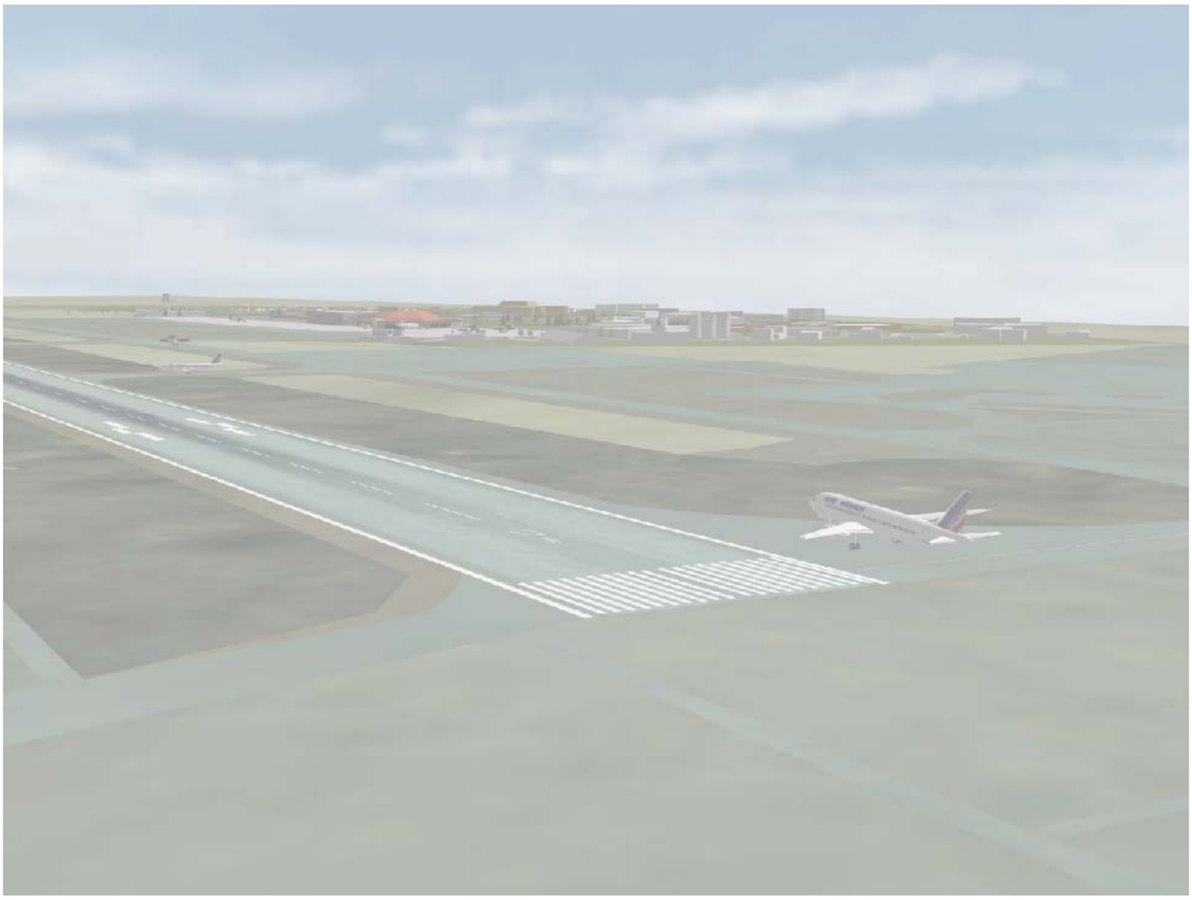
Contract N°: AST3-CT-2003-502817

Operational requirements



DISSEMINATION DOCUMENT

CONTENTS

1 INTRODUCTION

1.1 General presentation

Target: To define precisely the operational perimeter of any kind of emission/reception antennas and radars of the selected aircraft and airport.

Characteristics of the operational perimeter:

- Size of environment,
- Types of EM sources located inside the airport area,
- Unwilling or hostile sources outside the airport area
- Types of emission/reception antennas and radars of the selected aircraft.

This study consists in the review of the current electronic systems using EM signals for CNS (Communication, Navigation and Surveillance) around and at airports.

1.2 Abbreviations

ADS-B	Automatic Dependant Surveillance – Broadcast
AFTN	Aeronautical Fixed Telecommunication Network
AM	Amplitude Modulation
AMSL	Above Mean Sea Level
ATC	Air Traffic Control
ATCRBS	Air Traffic Control Radar Beacon System
BF or LF	Low Frequency (30 KHz – 300 KHz)
CCE	Advisory Commission of Compatibility
CNS	Communication Navigation Surveillance
COFDM	Coded Orthogonal Frequency Division Multiplex
CPDLC	Control Pilot Data Link Communication
CS	Critical Safety
DAB	Digital Audio Broadcast
DF	Direction Finders
DIFF	DIFFraction
DME	Distance Measurement Equipment
EM	Electro Magnetic
ER	En-Route
ES	Extended Squitter
FI	Flight Ident
FM	Frequency Modulation
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile communications
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
IM	Inner Marker
IMC	Instrument Meteorological Conditions
INMARSAT	International Maritime Satellite Organization
ITU	International Telecommunication Union

KHz	Kilo Hertz
LAAS	Local Area Augmentation System
LNAV/VNAV	Lateral NAVigation/Vertical NAVigation
MF	Medium Frequency (300 KHz – 3 MHz)
MLS	Microwave Landing System
MM	Middle Marker
Mode S	Mode Select Beacon System
NM	Nautical Miles
OM	Outer Marker
PA	Precision Approaches

2 COMMUNICATION SYSTEMS

It is able to maintain an orderly and safe traffic flow within his sector of airspace.
Communication can be either by voice or by data link.

2.1 Ground-Air communication and SATCOM

Air communication is dedicated to communications between air traffic controllers and pilots on-board an aircraft.

2.1.1 Voice communication and SATCOM

Voice communication has been the primary mean for ground - air communication.
Beside communication via Very High Frequency (VHF), communication via High Frequency (HF) and more recently via SATCOM is being used. HF and SATCOM are mainly used in transoceanic areas where VHF radio waves cannot be received because aircraft are outside the line of sight.

2.1.1.1 SATCOM presentation

SATCOM is a SATellite COMmunication system for aircrafts, ships and earth vehicles. This is a network composed of eight geo stationary satellites (36000 km) and ten ground stations.

2.1.1.2 Satellite network

Company INMARSAT owns 4 SATELLITES (geo stationary 36000Km).

- A.O.R. W N°0 Atlantic Ocean Region West
- A.O.R. E N°1 Atlantic Ocean Region East
- P.O.R. N°2 Pacific Ocean Region
- I.O.R. N°3 Indian Ocean Region

2.1.1.3 Aircraft antenna

Different possibilities exist for antennas:

- 2 side antennas (1L/1R) high gain.
- 2 side antennas (1L/1R) high gain + 1 TOP Antenna (Low gain) (spare).
- 1 TOP antenna high gain + 1 TOP antenna Low gain.
- 1 TOP antenna high gain (The most widespread today).
- 1 TOP antenna medium gain.

2.1.2 Data Link Communication

Data link can be used in addition to voice communications.
Controller Pilot Data Link Communications (CPDLC) is a mean of communication between Controller and Aircrew, using data link for Air Traffic Control (ATC) communication.

2.2 Ground –Ground communications

It is used between air traffic controllers of different ATC sectors and / or centres.

2.2.1 Voice communication

Voice communication between controllers of different ATC sectors or centres is used for non-routine co-ordination purposes and is generally performed by direct telephone connections.

2.2.2 Data link communications

Ground - ground data link communication is used for the transfer of estimations of aircraft entering an ATC sector from an adjacent ATC centre.

2.2.3 GSM & DCS (UMTS) networks

2.2.3.1 Cellular network principles

EM radio communication enables to communicate signals between mobile phone and cellular radio base stations using basically X frequencies.
Cellular radio base stations emitters have a limited range due to EM field distance attenuation.

2.2.3.2 GSM/DCS signal shape

GSM and UMTS use basically the multiple access technique called TDMA (Time Division Multiple Access) that enables several users to share the same bandwidth.

2.2.4 <<TV>> radio diffusion

Frequency bands: bands I, III, IV et V
Bandwidth: X
Modulation: Analogical AM or Numerical QAM/COFDM

2.2.5 Sound radio diffusion

	FM	AM	DAB
Frequency bands	band II X	X	X
Bandwidth	X	X	X
Modulation	FM	X	QAM/COFDM

2.2.6 Independent radio electrical networks

- Bands used: X
- Bandwidth: X

2.2.7 TETRA type networks

Near from GSM, this radio communication means is reserved to professional activity.
Frequency bands.
TETRA is also a TDMA (Time Division Multiple Access) system.

3 NAVIGATION SYSTEMS

3.1 Landing systems

3.1.1 Instrument landing System

The ILS is a system for the landing help. ILS indicates (from an electromagnetic stand point) an approach path with exact alignment and descent slope, for an aircraft during the final approach.

3.1.2 Microwave landing system

3.1.2.1 Principle

MLS is a system that was standardized by ICAO. It provides precision navigation guidance for exact alignment and descent of aircraft on approach to a runway. It provides azimuth, elevation, and distance.

3.1.2.2 Heathrow's New MLS - A World First

It gives the potential to improve capacity in bad weather and minimise the need for aircraft to divert to other airports.

3.1.2.3 Microwave Landing System THALES MLS 480

The THALES MLS 480 product features:

- Transmitter
- Antenna

3.2 Beacons

3.2.1 Distance Measurement Equipment

3.2.1.1 Principle

DME measures the distance directly from the aircraft to the ground station. This measurement is referred to as slant range distance.

3.2.1.2 Interrogator on board

It is composed of:

- A HF emitter
- An UHF receiver

3.2.1.3 Transponder on ground

Its mission is to fix the origin point on the ground, to re-generate interrogation signals and to answer with a frequency that is different from the receiver's one.

3.2.1.4 Performances

Range:

- Theoretic: radio electric horizon
- Operational: 200 or 300 nautical miles.

3.2.1.5 Example: 2020 DME

It operates with all standard omni directional, unidirectional and bi-directional antennas.

3.2.2 Non Directional Beacon

3.2.2.1 Main characteristics

Its characteristics are:

- Low-frequency non-directional beacon X
- Power X
- Frequency range X
- The reception range of the radio beacon is at least X
- A propagation and field MF versus range

3.2.2.2 Example: 2060 NDB

The FERNAU range of Non-Directional Beacons provides guidance to pilots.

3.2.3 Tactical Navigation

3.2.3.1 Principle

The Tactical Air Navigation System (TACAN) is an ultra high-frequency (UHF) omni-directional navigational aid that provides slant distance, in nautical miles from a ground station to an aircraft, and the azimuth in degrees from the station

3.2.3.2 Example: 2010 TACAN

The 2010 TACAN is operational in NATO and throughout the world.

3.2.4 VHF Omni directional Range

The VOR is a ground based short distance navigation aid, which provides continuous azimuth information in the form of 360 radials to or from a station. It is used for en route navigation as well as non-precision Q approaches.

3.2.5 Principle

The VOR radiates a carrying frequency modulated in order to transmit simultaneously and independently two BF signals.

3.2.5.1 Ground station

Diagrams of radiation in azimuth: the diagram is obtained by addition of two electrical fields:

- Omni directional diagram radiating the carrier.
- Double circle diagram radiating a part of the carrier.

3.2.5.2 On board equipment

It includes:

- Horizontal polarization antenna and omni directional diagram
- VHF receiver

3.2.5.3 Range

The power of the VOR en route allows the receiving until 200 nautical miles and the airport VOR have a minimal range of 25 NM.

3.2.5.4 Example: 2050 DVOR

The antenna array comprises the single carrier antenna and the 48 side-band antennas, these being divided into two groups of 24 each group being switched by a distribution switch mounted above the equipment rack.

3.2.6 Radio-goniometers

A radio-goniometer is a VHF receiver, which allows at TWR to determine aircraft azimuth location when it uses its VHF radio.

3.2.6.1 Example: 2030 DF

The 2030 DF system is capable of receiving signals in the VHF and/or UHF frequency range and determining the bearings of these signals with a resolution of 0.1 degrees.

3.3 Radio altimeter

The radio altimeter or terrain-clearance indicator is an absolute altimeter; it indicates the actual altitude over water or over terrain.

3.4 On board weather radar

Weather radar is the primary radar used to monitor for hazardous weather conditions. While weather radar, cannot be used by the controller to control air traffic, it can be and is used to assist in the selection of routes, approaches and the production of weather advisories.

3.4.1 Main characteristics

3.4.1.1 Signal

Main characteristics are:

- Impulsion length: X
- Frequencies: X
- PRF: X
- Power peak: X some kW

3.4.1.2 Emitter/Receiver diagram

This diagram is known as cosec.

Beams in emission or reception are:

- Conical with weak beam opening (3 to 5°): “pencil beam”
- Moving in azimuth: one scanning every 5 seconds until ± 90°
- In ground vision, it is interesting to widen the beam site until -20° in the downwards direction.

3.5 Global navigation satellite system / Local area augmentation system (GNSS/LAAS)

Satellite Navigation is based on a global network of satellites that transmit radio signals in medium earth orbit.

4 SURVEILLANCE SYSTEMS

4.1 Approach radar

4.1.1 THALES STAR 2000

The STAR 2000 is a high performance S-band primary radar. Designed to deal with dense air traffic situations, within approach or extended approach control area, it supports reduced separation between aircraft and features a high processing capacity.

4.1.2 Mode S transponder and secondary radar

Secondary Radar requires a rotating SSR antenna on the ground and a transponder onboard the aircraft.

4.1.2.1 Transponders

4.1.2.1.1 Mode-A

A mode-A transponder returns a unique 4-digit octal-code, defined by ATC, to the SSR antenna, which enables a controller to identify an aircraft more easily.

4.1.2.1.2 Mode-C

Mode-C requires a mode-C transponder onboard the aircraft, which provides additional information on flight altitude.

4.1.2.1.3 Mode-S

The mode-S transponder is capable to receive and to transmit data and it also enables to give each aircraft a unique code.

4.1.2.2 SSR: THALES RMS 970 S

The RSM 970 S stands as the most advanced Monopulse Secondary Surveillance Radar (MSSR/Mode S).

4.2 Automatic dependence surveillance broadcast: ADS-B

It is a surveillance technique in which aircrafts automatically provide, via a broadcast mode data link, data derived from on-board navigation and position-fixing systems, including aircraft identification, four-dimensional position, and additional appropriate data.

4.3 Surface mouvements airport monitoring

4.3.1 A-SMGCS Techniques

The first technical stage for a surveillance system is to have situational awareness of the position and identification of all moving vehicles and aircraft in real time, with top reliability and integrity.

4.3.2 Sensors

- Non-cooperative sensors: can detect a moving vehicle or aircraft without any action on its behalf

- Cooperative sensors: can provide personal, richer information.

- Dependent sensors: the moving vehicle or aircraft that generates the information and transmits it.

4.3.3 Primary surface radar

It remains the most effective way of obtaining information on the position of moving vehicles and aircraft in the whole airport area.
ASTRE and SCANTER are two examples of SMR (Surface Movement Radar).

4.4 Cooperative sensors

It requires a transponder to be installed in the moving vehicle or aircraft.

4.4.1 Vehicle equipment

A specific beacon can be placed inside vehicles, which transmits or replies to a specific frequency in the UHF or VHF range. The vehicle is localised by triangulation.

SYLETRACK system allows to track and identify moving vehicles operates in a UHF range.

4.4.2 A/C Secondary radar

The A/C secondary radar transponder allows aircraft to be identified on the approach path by correlation with the flight plan data.

4.4.3 Triangulation or Mode S multilateration

Multilateration is a cooperative surveillance technique for aircrafts equipped with ATCRBS, Mode S or ADS-B transponders. A passive multilateration system measures the times of arrival (TOAs) of the same aircraft transmission at three or more ground stations and uses the TOAs to calculate and present on a user display, the aircraft's 3-D position.

4.5 Meteo, vortex and wind shear radar

4.5.1 RODIN-SANAGA

The RODIN-SANAGA weather radar is a system designed for meteorological and hydrological operations. The system is designed for weather observation, storm detection and tracking, storm vertical analysis, hail detection, rainfall intensity mapping, flash flood warning.

4.5.2 Terminal Doppler Weather Radar

TDWR provides timely and accurate detection of hazardous wind shear in and near airport terminal approach and departure corridors.

4.5.3 Wind profiler

Ground-based radar systems have been used to study the atmosphere and the weather. They have also been collecting data for several decades, measuring atmospheric phenomena such as wind velocities, turbulence, atmospheric waves, energy exchange between different layers of the atmosphere and the drift of ionisation trails left by meteors as they fall through the atmosphere.

5 MODELLING AIRPORT EM SYSTEMS DATABASE WITH UML

UML is an object-oriented notation; it can be used as the basis of communication between Java developers, C++ developers, Smalltalk developers, and so on. By using such a modelling language, you can analyse and specify the system before beginning coding.

UML is the starting point which allows to describe and capitalise the important characteristics of EM systems on airports and on-board.

Two main functionalities are identified:

- “Computes EM field”: results obtained about all EM sensors located inside and outside airport and on-board aircraft

- “Create Emitter”: upgraded sensors and optimal features.

For each of these Use Cases, we have identified the main actors with which interactions are possible:

- “EM receiver”
- “EM emitter”
- “Meteo”
- “Airport Infrastructure”