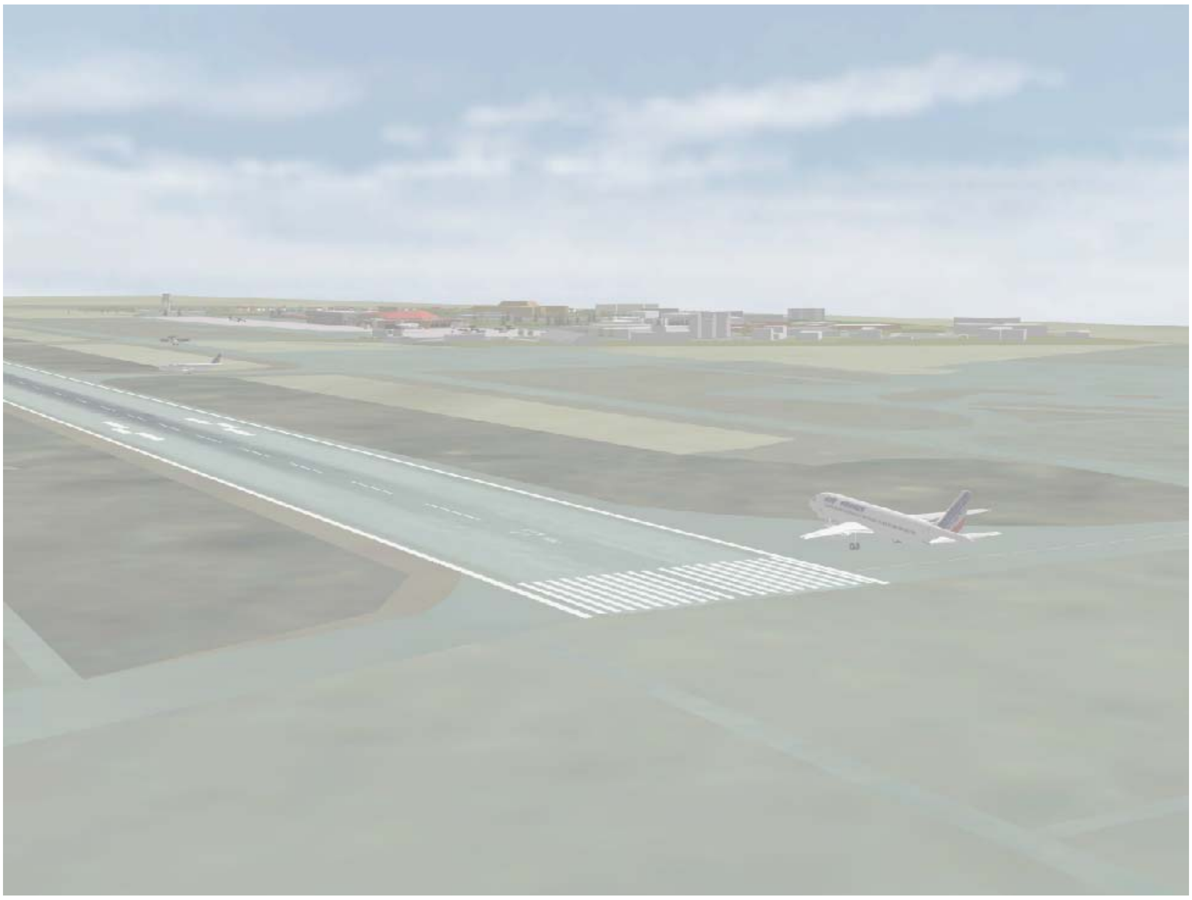
Contract N°: AST3-CT-2003-502817

Exploitation requirements



DISSEMINATION REPORT

CONTENTS

1 Introduction

1.1 Introduction

The objective of the EXPLOITATION REQUIREMENTS is to define precisely the exploitation perimeter in term of scenarios enabling to assess a wide field of situations.

The first part (chapter 2) consists in the definition of a wide range of contexts (EM sources, vehicles, buildings…) that can be used to create scenarios.

The second part (chapter 3) describes scenarios and measurements that will be performed during SIRENA project.

1.2 Abbreviations

AM	Amplitude Modulation
ANFR	FRequencies National Agency (Agence Nationale des FRéquences)
APU	Auxiliary Power Unit
ATC	Air Traffic Control
BF or LF	Low Frequency (30 KHz – 300 KHz)
CEV	Flight Tests Centre (Centre d’Essais en Vol)
COM/NAV	Communication / Navigation
CS	Critical Safety
CW	Continuous Wave
DGPS	Differential Global Positioning System
DME	Distance Measurement Equipment
EMC	Electro Magnetic Compatibility
EM	Electro Magnetic
FAA	Federal Aviation Administration
FAF	Final Approach Fix
FAP	Final Approach Path
FM	Frequency Modulation
GBAS	Ground Based Augmentation System
GHz	Giga Hertz
GLS	GNSS (Global Navigation Satellite System) Landing System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GSM	Global System for Mobile communications
HIRF	High Intensity Radiated Field
IAF	Initial Approach Fix
ICAO	International Civil Aviation Organization
IFR	Instruments Flight Rules
ILS	Instrument Landing System
IM	Inner Marker
KHz	Kilo Hertz
LVP	Low Visibility Procedure
MF	Medium Frequency (300 KHz – 3 MHz)
MHz	Mega Hertz
MLS	Microwave Landing System

MM	Middle Marker
Mode S	Mode Select Beacon System
NM	Nautical Miles
OM	Outer Marker
PA	Precision Approaches
PLL	Phase Lock L
PSR	Primary Surveillance Radar
RAD	Radio Alignement de Descente
RF	Radio Frequency
RAP	Radio Alignement de Piste
RHCP	Right Hand Circular Polarization
RNAV	Radio NAVigation
2RC	shared independent radio electric network
2RP	independent radio electric network of private use
RPM	Rotate Per Minute
SATCOM	SATellite COMmunication
SICASP	Secondary surveillance radar Improvement and Collision Avoidance System Panel
SID	Standard Instrument Departure
SSR	Secondary Surveillance Radar
STAR	Standard Terminal Arrival Route
TCAS	Traffic Collision Avoidance System
TDZE	Touch Down Zone Elevation
TRSB	Time Reference Scanning Beam
TRX	Transmitter
TWR	Tower
UHF	Ultra High Frequency (300 MHz – 3000 MHz)
US	United States
VDF	Very High Frequency (VHF) Data Broadcast
VDL	VHF Data Link
VHF	Very High Frequency (30 MHz – 300 MHz)
V/M	Volt/Metre
VOR	VHF Omni directional Radio beacon

2 General definition of scenarios

2.1 Aircraft configuration

2.1.1 Presentation

Scenarios directly linked to SIRENA objectives :

- Scenarios related to Communication / Navigation systems
- Scenarios related to High Intensity Radiated Field environment

2.1.2 Definition of scenarios for Communication / Navigation system analysis

2.1.2.1 Instrument Landing System, Microwave Landing System

Two kinds of scenarios are defined hereafter: on-ground and in-flight scenarios.

2.1.2.1.1 On ground

ILS, MLS and echoes with buildings

The computation of the field emitted by the localizer and glide system will be done on the runway.

Echo with a mobile

The same computation will be done with a vehicle/plane on the taxiway.
Two cases will be considered:

- First with an aircraft on an exit taxiway after landing
- Second with an aircraft at a holding point

Distorsion with the aircraft

The direct signal coming from ILS (Localizer and Glide) or from MLS can be distorted by the aircraft itself.
The computation of the field emitted by the ILS and MLS system will be done near the nose of the aircraft.

2.1.2.1.2 In flight

Several positions of the aircraft in flight have been determined to assess the distortion of the ILS and MLS signal:

- Effect of buildings or ground vehicles.
- Effect of the aircraft.

2.1.3 Scenarios related to the airport EM environment analysis

2.1.3.1 Overview

The airport EM environment is composed of :

- The aeronautic radio systems for navigation communication with the aircraft and surveillance of the airfield.
- The non aeronautic emitters for TV, broadcast and other services.

An analysis the airport EM environment was studied and consequently Normal take-off and landing routes have been defined.

2.2 Ground vehicles

2.2.1 Models available

Models of vehicles are proposed by OKTAL SE. These models are built with polygons and textures, for simulations in the visible spectral band.

2.2.2 Validity for simulation

The validity of simulation relies on the precision required for the description of the objects.

In order to use asymptotic formulations to model the interactions between EM waves and the structures surrounding the airport, the starting point is the comparison between the size of the analysed object and the wavelength λ.

In the framework of SIRENA, we will focus our modelling on high frequency asymptotic technique.

This leads to the following constraints for the modelling of the scene for the high frequencies and low ones:

- At the high frequencies the precision on the physical details of the scene can be limited, with this value of 3λ.
- At the low frequencies, 3λ is the smallest size for objects which could be correctly modelled.

Specific features and textures related to infrared, optics and electromagnetic are provided for each polygon of the scene database and for each polygon of the objects.

Generally, for EM analysis of the objects, two classes of materials can be defined: the metallic and dielectric materials.

2.3 Operational aspects

The approach control authority delivers clearances to controlled aircraft in order to:

- prevent collision between aircrafts
- accelerate and to arrange the air traffic in:
  - Organizing departure traffic;
  - Preparing approach sequences;
  - Realising approach sequences;
  - Participating in flow regulation.

2.3.1 Takeoff: aircrafts in departure

In controlled airspace, IFR (Instruments Flight Rules) departures can be organized following routes with corresponding procedures (noiseless, slope, flight level, speed and so on) defined by qualified air traffic authority and transmitted to users by aeronautical information channel. These routes are called SID (Standard Instrument Departure).

There are many SID procedures for each runway (for departure along north, south …). Departure clearance of an IFR flight is composed of:

- The available runway;
- The SID indication or the turns, the route or the first point on the route
- The flight levels to use before continuing the rise towards the assigned cruise level;
- The time of takeoff;
- The transponder frequency.

2.3.2 Landing: aircraft in arrival

Same principle as SID: it concerns IFR approach trajectories which guide towards the airport. These procedures are called STAR (Standard Terminal Arrival Route).

2.3.3 Emergency

Emergency procedures are required in case of failures during the various flight phases: landing, cruise or takeoff and on-board or on-ground.

<u>On ground failures</u>

- Equipments (failures, jamming …)
- Meteorological environment (ice, fog …)
- Vehicles on runways
- Human failures

<u>On-board failures</u>

- Equipments (failures, jamming, motors …)
- Meteorological environment (daylight, night, ice, fog …)
- Objects close to aircraft (aircrafts, birds …)
- Human failures

We noted that these emergency procedures are rare: additional equipments are installed to minimise risks.

2.4 Aircraft trajectories

The final approach path is generated from a flight point (altitude and Mach) and from user defined attitudes (yaw, pitch …). The main parts constituting the path are:

- Time (with a frequency defined at 10 Hz in SIRENA's frame)
- The aircraft position (X, Y and Z)
- The attitudes angles (yaw, pitch and roll).

2.4.1 Arrival trajectory on runway 14R

This trajectory respects the ILS procedure on runway 15R (actually 14R).

Chronology until TDZE (Touch Down Zone Elevation) is:

- Rallying above the beacon TN 378 located at 13 NM from the beacon TOU at an altitude of 4000 ft;
- Descent with 191° yaw (corrected from the magnetic variation) and a -3° slope;
- Turn in descent with -3° of slope to 9 NM of beacon TOU until the yaw equals 146° and altitude is 2000 ft;
- Interception and ILS beam guiding starting from 1.9 NM of the beacon TOU.

The chronology of taxiing is as follows :

- Taxiing until the end of runway 15R/33L (actually 14R/32L);
- Turn towards runway 33R/15L (actually 32R/14L) on M2;
- Stop twenty seconds before crossing runway 33R/15L (32R/14L); this stop makes it possible to let pass a plane which runs on the second runway;
- Crossing of second runway 33R/15L (32R/14L) and taxiing on N2;
- Turn and taxiing on P 20;
- Turn and taxiing on T 40;
- Turn and taxiing on T 41;
- Stop in front of terminal.

During the landing, the final approach path parameters are locations (X, Y and Z) in the database frame, as well as yaw and pitch.

The visible sensor is oriented following the aircraft axis.

The summary of this trajectory is:

- Before the glide, the yaw of the aircraft is 140.7° and the pitch equals 4.80° (average values).
- After the landing, the aircraft follows the axis runway where yaw precisely equals 142.6°.

The full representation of this trajectory is available both at OKTAL SE and ONERA. It will be used for simulations.

2.4.2 Arrival path on runway 32R

Arrival path on runway 32R follows a south approach. The final approach path simulated on runway 14R can be used on runway 32R.

2.5 Safety/security critical cases

It seems important to focus on the following sensible EM equipments (classed like Strong EM critical safety) for simulations:

- Analogical VHF
- ILS
- MLS (new equipment which tends to replace ILS)
- GNSS

2.5.1 Civil EM equipments

It is interesting to identify some equipments like:

- Measurement of strength fields;
- Radiotelephony (GSM …);
- Broadcast (AM, FM …);
- Other stations.

2.5.2 Analogical VHF

At airports interference between different radios is an usual problem. Receivers tuned to one channel may hear transmitters on other channels. For service vehicle radios, interference may be severe at some locations of the airport, and negligible at other locations. A radio may be nearly useless when close to the antenna of a strong transmitter. ATIS and commercial FM transmitters are particularly troublesome because they broadcast continuously.

Furthermore, some vehicles contain several radios. A usual combination is an AM VHF radio and an FM radio. The FM transmitters often have relatively high power and induce extremely strong radio frequency signal voltages into the antenna of the aircraft radio.

Service vehicle radios have more interference than the base stations whose antennas are usually located farther from interference sources.

All radio receivers are subject to interferences. The best receivers may withstand stronger interfering signals before communications are impaired. Stronger signals result from higher power transmitters and closer antennas.

2.5.3 ILS

ILS (Instrument Landing System) encounters integrity problems due to FM interference and multi path reflections, degrading landing capabilities under low visibility conditions.

2.5.4 MLS

MLS (Microwave Landing System) is a system that was standardised by ICAO for precision guidance during approach and landing, up to CATEGORY III.

MLS allows a reduction of critical and sensitive areas.

In low visibility conditions (LVP), the liberation of an arriving or departing aircraft from ILS sensitive areas directly conditions the clearance issued for the next landing aircraft.

2.5.5 GNSS (GALILEO)

The use of GALILEO frequency range by aeronautical radio navigation services is reserved worldwide for:

- airborne electronic aids to air navigation and any directly associated ground based facilities,
- radio navigation satellite services.

This multiple allocation causes interferences, which have to be assessed carefully to allow the use of GPS/GALILEO navigation signals for safety critical applications.

2.5.6 Recommendations

For simulations, it is important to take into account the EM devices:

- Located near safety radio navigation equipments;
- Susceptible to interfere with emergency procedures equipments.

2.6 Environmental conditions

For each known system, the main characteristics such as central frequency and bandwidth are in the operational requirements we focuse here are focused on specific EM devices such as ILS, MLS and GNSS.

2.7 Airport layout

2.7.1 Buildings

On the buildings of TOULOUSE-BLAGNAC airport, many antennas are installed. All these buildings are well referenced in the virtual mock-up (product OKTAL SE) used for simulations.

2.7.2 Runways and taxiways

Two runways are available in TOULOUSE-BLAGNAC airport 14L/32R and 14R/32L.

Many taxiways are also available.

2.7.3 Vehicles

The vehicles allowed in airside deal with security and services. Almost all these vehicles are equipped with radio and cellular phone (TALKY-WALKY).

2.7.4 EM equipments

2.7.4.1 Radio navigation inside airport

New data (June 2002) from ANFR are available for the identification of EM equipments

All EM equipments details will be integrated, if possible, in the mock-up for simulations.

EM characteristics (frequency, geometry, dimensions …) are stored in the EM database managed by ONERA.

2.7.4.2 Radio navigation outside airport

VOR (VHF Omni directional Radio beacon) and NDB, which are used for navigation in the vicinity of the airport, are identified and located.

2.7.4.3 Others equipments

2.7.4.3.1 Fixed equipments

From the available maps, it is possible to identify the devices that are located in the vicinity of EM radio navigation equipments.

2.7.4.3.2 Moving equipments

The vehicles must be located in realistic places where they could jam the emission of safety equipments like ILS.

3 Scenarios performed in SIRENA

3.1 Synthesis of all possible scenarios

All scenarios possible concern:

- Simulated frequencies
- Observer (measurement or simulation point)
- Line of sight
- EM equipment on airport
- Civilian EM equipment on and around airport
- Buildings on airport
- Vehicles on airport infrastructure

3.2 Selected test cases for simulation versus measurements

Test cases for the validation of simulation are selected because:

- physical limitations of the underlying physical models are to be expected in these configurations
- they enable to check the proper functioning of safety-critical systems.

Main physical limitations of ray-tracing methods are edge diffraction effects where physical lengths of conductive edges are in the wavelength range of radiation.

An especially important, safety-critical system for airplanes approaching the airport is the instrument landing system, working also in the VHF frequency range. A worst-case-scenario has to be analysed, in which an ILS-transmitter-signal from ground is reflected by large metallic structures in the transmitter vicinity.

3.2.1 Indoor measurements scenarios on specific test case

3.2.1.1 Overview

In order to assess the validity of the computation of the EM field, a specific test case has been defined by the partners. The great advantage of this case is the possibility to perform measurements on it in TUBS (Technical University of BRAUNSCHWEIG) facilities.

3.2.1.2 Test case definition

The validation will be performed through the comparison of simulation and measurements results from the diffraction of a plane wave by a set of perfectly conducting half sphere and cylinder located over a perfectly conducting infinite surface.
Only monostatic RCS will be compared.

3.2.2 Outdoor experimental general test conditions

- passive measurements

The passive measurements of electromagnetic field strengths made at BLAGNAC airport due to installed transmitters in the surrounding (radar, ILS, GSM etc) are an integral result of all reflections; they must also be regarded as just an integral validation of corresponding integral simulation data.

- active measurements

A better interpretation will become possible if active measurements are performed, in order to determine reflection behaviour in specific, controllable geometric configurations according to the selected test cases.

3.2.3 Experimental scenarios definition

For studying edge diffraction effects, the methods described in 3.2.2 will be applied on the BLAGNAC airport at special positions to elucidate reflection properties of airport building structures in selected frequency ranges. These measurements must be performed in tight cooperation with the air control at the airport since there is, though nearly negligibly small, a risk for EMC interference:

- EMC-interference to other receivers in the airport surroundings could in principle occur, but due to the experience of TU BRAUNSCHWEIG in that field it is rather unlikely that noticeable distortions will be reported.
- Though the interference risk is very small, some precautions should be taken:
  - Measurements are performed only with fine weather conditions,
  - Measurements are stopped if disturbances are recognized.

Reflection properties of ILS signals on large metallic structures in the vicinity of the ILS transmitter will be elucidated principally in the same way. The special scenario to be studied here are the reflection properties of a large on-ground-airplane ready for take off or just landed, which is therefore in the vicinity of the ILS transmitter.

The tests for validation are categorized as for the simulation: scenario for aircraft COM/NAV system, scenario for the EM characterisation on the airport.

3.3 Description of scenarios

In the following paragraphs, the scenarios are detailed, and the cases where measurements are scheduled are indicated. Two scenarios deal with ILS, two other with VHF, two other with MLS.

4 Conclusion

This report presents all elements in order to provide simulations and validations on TOULOUSE-BLAGNAC airport and in particular:

- An important database on the EM equipments on airport and in vicinity of airport;
- A trajectory for landing on airport;
- A database of airport infrastructures.

All these elements must be used in an EM real or simulated environment including VHF communications and ILS (MLS).