External electromagnetic simulation for radio electric systems in the close environment of the airport

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Abstract: The target of the SIRENA project is to provide a set of simulation tools enabling one to compute the high frequencies ElectroMagnetic (EM) radiation environment of current and future airport vicinity. Sirena aims at mastering a technique for airport/aircraft diagnosis and recommending it for safe exploitation.

Keywords: Numerical modelling of terrain, Airport mock-up, EM simulation.

1. Introduction

The goal of the SIRENA research is to analyse the level of availability of radio links between the aircraft and its communication and guidance services and to assess EM impact in and around the airport.
More precisely, SIRENA tackles safety matters in terms of reliability of communication, dysfunction risks, but addresses security problems too, for example: assessing the airport/aircraft level of immunity to EM hostile actions (intentional EMI).
The simulation will deal with all external sources such as MLS (Microwave Landing System), ILS (Instrument Landing System), VOR-DME (VHF Omnidirectional Radio beacon, Distance Measurement Equipment), GPS (Global Positioning System), GSM (Global System for Mobile communications), TN (Telecommunications Network), beacons, radars, and TV emitters. It includes the receiving antennas and radars of the selected aircraft, at take off and landing phases.
The outcome of the research will assess the interactions of all external EM sources with the environment (masking, multiple reflections, etc.), the interactions of all these sources with the aircraft structure itself and the interactions between emitting and receiving antennas of the aircraft during approach and on the airfield.

2. Scientific and technical objectives

In order to achieve the general assessments, the research focused on intermediate scientific and technical objectives. This implies a realistic 3D model of the airport environment, a particularly accurate 3D design of the aircraft and the airport buildings, a realistic model of antennas sources in the environment and on the aircraft and an efficient processing of EM propagation in 3D space.

2.1 Airfields mock up

The database modelling consists in building a complete 3D synthetic environment through airports and EM sources modelling coupled with a physical EM characterisation of this environment. A terrain modelling tool, AGETIM, turns geographical data into 3D meshed triangles associated with physical attributes, in the most automatic way as possible. The real case of experimentation is the 3D virtual database of Toulouse Blagnac airport, including the runways, the current Airbus buildings, the passenger terminal and the parking areas. It is composed of hundreds of thousands of polygons.

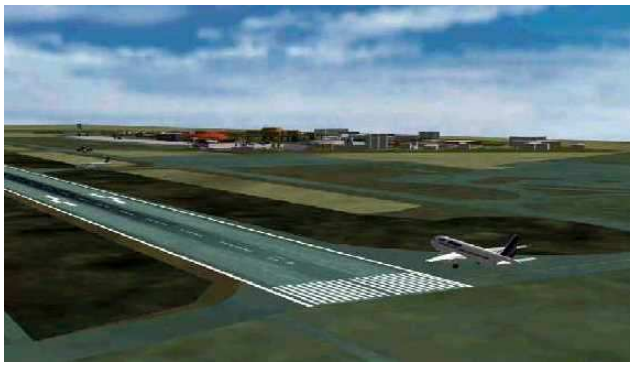

Figure 1: Blagnac airport mock up

2.2 EM sources modelling

An inventory of the types of EM sources located inside the airport area and "hostile" sources outside the airport area has been assessed. The work on EM sources modelling is focused on the ways to make the database generic and to be easily adapted to any other airport peculiarities. Specific scenarios requiring rigorous ILS and MLS modelling have been defined.

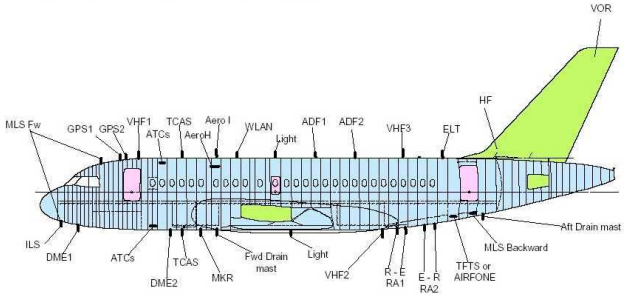

Figure 2: Example of A318 aircraft antenna location

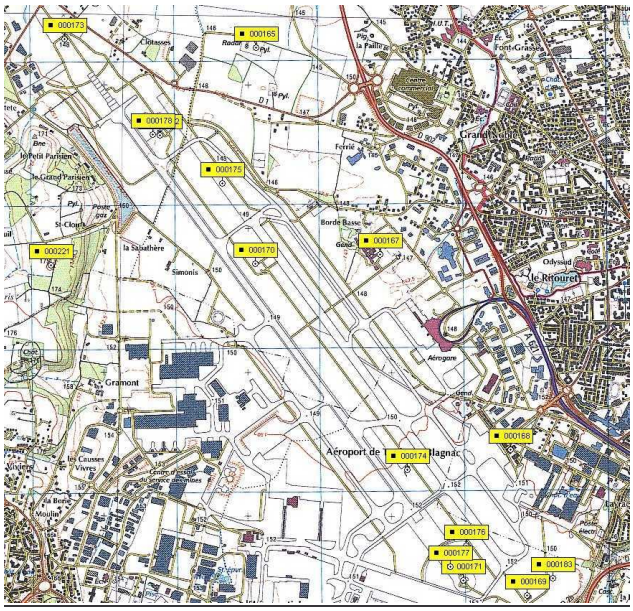

Figure 3: Some of EM Sources in Blagnac airport

- N°165 UHF-VHF deported emitter station
- N°167 Control Tower antennas
- N°168 Old Control Tower (deported receiver station)
- N°168 Fixed transponders
- N°169 ILS localizer runway 14L
- N°170 ILS glide and DME runway 14L
- N°171 ILS localizer runway 14R
- N°172 (masked by N°178) ILS glide and DME runway 14R
- N°173ILS localizer runway 32L
- N°174 ILS glide and DME runway 32L
- N°175 ILS localizer runway 32R
- N°176 ILS glide and DME runway 32R
- N°177 MLS runway 14R
- N°178 MLS runway 14R
- N°183 GBAS (DGPS)
- N°221 Primary radar

3. Technical approach

3.1. FERMAT software

SIRENA project starts from the generic FERMAT software, formerly developed under an agreement of partnership between the Electromagnetism and Radar Department of ONERA and OKTAL SE company within the framework of projects dedicated to EM modelling. It has the ambition to calculate scattered EM fields at high frequencies (i.e. the size of objects is supposed large compared to wavelength), in a virtual 3D, geometrical and physical complex environment including natural and man made objects. FERMAT associates various techniques and tools and mainly:

- An optimised technique of geometrical Shooting and Bouncing Rays (SBR), to calculate the intersections between the rays from the transmitter towards the database and back to a receiving point.
- EM models of propagation, reflection, diffraction and an operating strategy (thanks to SBR) which allows unified calculation for the near or far EM scattered fields from the scenes. These EM models (geometrical optics, physical optics and method of equivalent currents) judiciously coupled with the SBR technique, burden only very slightly the computation time even for such complicated scenes.

3.2 EM field values

The EM field computations take into account very precisely all the possible EM energy paths within the 3D scene from sources to receivers and to quantify realistically the level of received EM field. Specific efficient processing software tool has been developed in order to visualise and analyse all EM radiation impact on human, on board equipment and more generally all involved equipment in the airport and its vicinity.

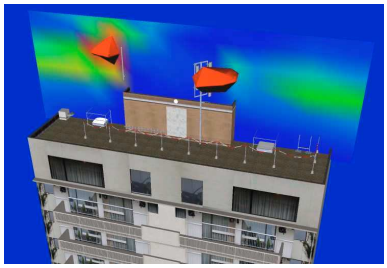

Figure 4: Example of EM field from GSM antennas

4. Conclusion

Specific scenarios dealing with main airport EM sources will be set out in the final paper but from now on, the principal achievements in this project are:

- A mastering fast methods for airfields 3D modelling and enhancement with EM physical data to achieve a virtual geometrical and physical mock up.
- An accurate EM source modelling for far and near field EM diagram in order to acquire an efficient (dealing with hundreds of thousands of polygons) and accurate method to assess the EM energy paths
- Setting up of an interactive EM field visualisation enabling global EM phenomena understanding in the scope of recommendations for standardisation and to analyse the EM field value at any location of the scene.
- Providing aircraft/equipment manufacturer with a solution to characterise the ambient EM field (input for accurate EM modelling of equipment behaviour).

5. References

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