Evaluation of the effects of Large aircraft on ILS and MLS protection areas

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INTRODUCTION

During bad weather conditions and in particular during Low Visibility Procedures, the final stage of the precision approach is generally flown in auto-coupled mode i.e. the guidance of the aircraft is only using the landing system signals. As long as the landing system transmitters and antennas are located in the vicinity of the runway, it is necessary to define and clear areas around these antennas in order to protect the quality of the signals to be used by the airborne systems. These areas are known as the sensitive and critical areas and defined in the ICAO Annex 10. During Low Visibility Procedures, these areas need to be cleared from any moving object to guarantee the ILS and MLS signal in space.

These areas have been defined and validated by the ICAO All Weather Operations Panel in the 80's and 90's. The B727 and B747 aircraft and the typical on-the-shelf ILS systems were used to define these areas.

The introduction of larger version of these aircraft or new generation of aircraft in parallel with the introduction of higher performance ILS or MLS raise the question about the validity of these protection areas. DSNA, the French ATM service provider, in cooperation with other major European ATSP, has launched a program to confirm the size of these ILS/MLS areas through intensive simulations, ground and flight checks campaigns involving several partners like Airbus, the Toulouse and Paris airport authorities and some European Navigation Systems Providers. Other activities have been conducted in a coordinated manner at Frankfort by DFS, or at London Heathrow by NATS.

The results of these test campaigns and their analysis will be used to prepare contributions to the ICAO Navigation Systems Panels who has been charged by the Air Navigation Commission to review the Annex 10 guidance materials on ILS/MLS protection areas.

This paper focus on the Toulouse campaign while the Frankfurt tests are briefly presented. At the time this paper was written, complete analysis of the tests results was not available and a further version will be prepare to present this complete analysis.

ILS and MLS campaigns have been conducted. This paper presents in details the ILS trials.

METHODOLOGY

Typical ILS and MLS Critical and Sensitive Areas (CSA) are defined in Attachments C and G of the ICAO Annex 10. These areas are used by States to define the relevant CSA to protect the users knowing the airport layout, the ILS or MLS characteristics and the type of aircraft which operate on the airport. The methodology used during this typical CSA update and validation effort takes into account this airfield dependency characteristics of the CSA. In order to be able to define typical CSA dimensions based on real measurements gathered on a limited number of airports, it was decided to use in a first step these real data to validate a software signal propagation tool and in a second step to use this validated tool to define typical CSA. Further, this tool may also be used to adapt the typical areas to a specific airport case.

Several signal propagation tools exist for the ILS case. They differ from the mathematical heart used to calculate the propagation and they need different level of obstacle description. Two different ILS tools were evaluated during the Toulouse campaign. Two others were used during a previous campaign in Paris CDG and in Frankfurt but pre-tests results were not available before the Toulouse ground sessions. The major characteristics of these tools are summarized in Table 1.

Method	Mathematical heart	Description of obstacle	Availability of pre-tests results
A	Optical Physic	Single plate	No
B	Optical Physic	Single plate	Yes
C	Optical Physic	Multiple plates	Yes
D	Method of Moments	Aircraft model	No

Table 1 : Signal propagation tools

The signal propagation tool used for MLS was based of the Uniform Theory of Diffraction and the reflecting aircraft was simulated by its 3D tail fin description.

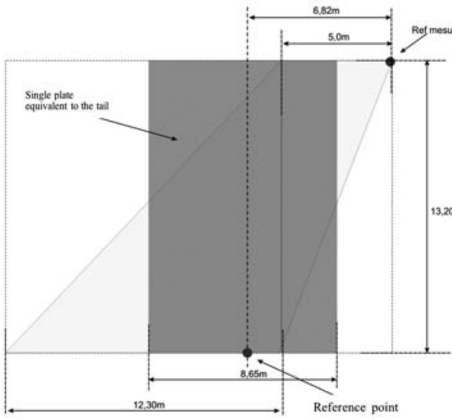
AIRCRAFT DESCRIPTION :

As presented in Table 1, different methods used different type of aircraft description. For the tests conducted in Toulouse Blagnac and Frankfurt airports, an A380 test aircraft was made available by Airbus.

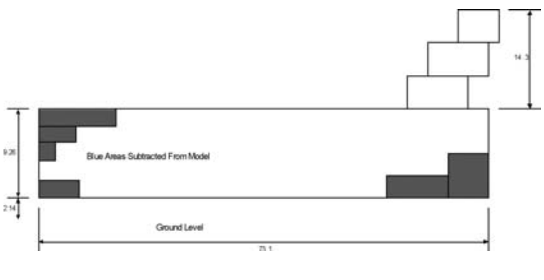
Figure 1 :
A380 n°4 used during the second test session in Toulouse Blagnac

This aircraft was described in the B and C propagation tools by the following model :

Method B :

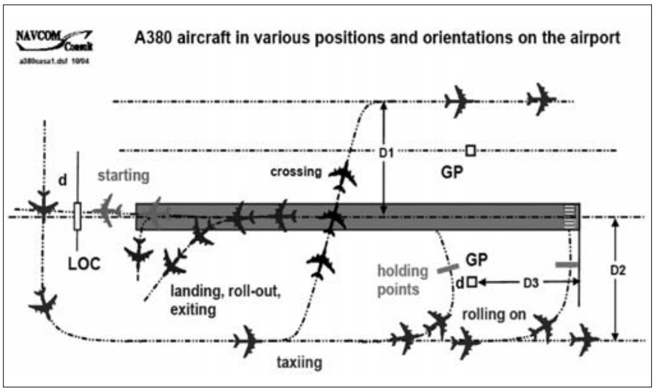


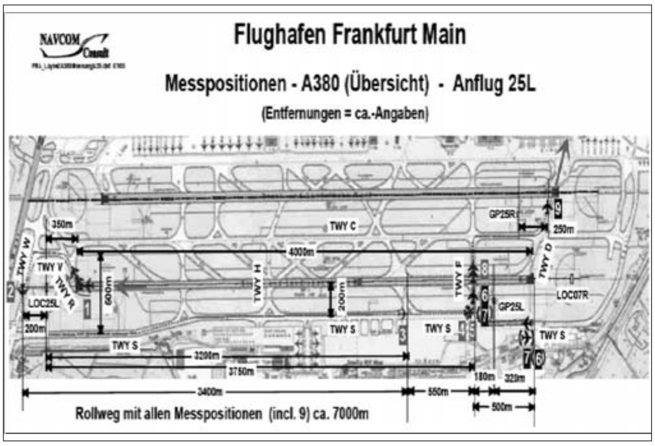
Method C :



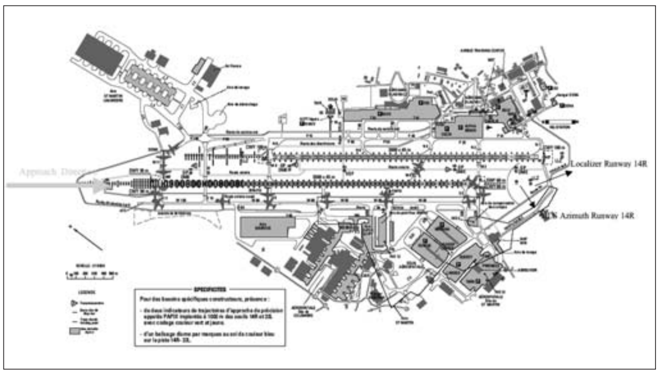
TEST POINTS :

At Frankfurt airport : for information only





At Toulouse Blagnac Airport :



For the Toulouse Blagnac tests plan, twenty two A380 tests positions were defined and subject to ground or in-flight recordings. The Table 2 summarizes the position, heading of the A380 and the main objectives of the test points.

Table 2 : A380 test point

Position number	A380 location	Distance from runway axis	Magnetic heading	Objectives
P0	Parking			Reference recording
P1	On the runway axis taking a turn on the right	Maximum shift of the tail fin to the left side of the axis	180°	Assessment of effect on following aircraft by previous landing aircraft leaving the RWY axis close to the stop-end
P2	Taking runway exit on S2	Tail fin at the runway border 22.5m from axis	234°	Assessment of effect on following aircraft by previous landing aircraft leaving the RWY axis close to the stop-end
P3	Taking runway exit on S2	Tail fin at 90m	234°	MLS/AZ sensitive area confirmation
P4	On W20	A/C axis at 200m	317°	ILS/LOC sensitive area confirmation
P5	Intersection S4/S40 W30/W40	A/C axis at 200m	324°	ILS/LOC sensitive area confirmation
P7	M4	Tail fin at 60m	114°	MLS/AZ sensitive area confirmation
P8	M4	Nose at 90m from RWY14L centre line	84° (according to taxiway axis)	ILS/LOC French sensitive area confirmation
P12	Intersection S8/W60/W80	A/C axis at 200m	354°	ILS/LOC sensitive area confirmation
P16	S11	A/C Nose at 90m	054°	MLS/AZ sensitive area confirmation
P19	M11	A/C Nose at 90m	234°	MLS/EL sensitive area confirmation
P6 quat	S4	Tail fin at 22.5 m	234°	ILS critical area confirmation
P6	S4	Tail fin at 60m	234°	MLS/AZ sensitive area confirmation ILS critical area confirmation
P6 Bis	S4	Tail fin at 80m	234°	MLS/AZ sensitive area confirmation ILS critical area confirmation
P6 Ter	S8	Tail fin at 60m	234°	MLS/AZ sensitive area confirmation ILS critical area confirmation
P9	S6	Tail fin at 120m	234°	ILS/LOC UK sensitive area confirmation
P11	Intersection S8	Tail fin at 122m	324°	ILS/LOC sensitive area confirmation
P11 Bis	Intersection S8	A/C axis at 122m	354°	ILS/LOC sensitive area confirmation
P13	sur W90 à 90m au sud de S10	A/C axis at 200m	324°	ILS/LOC sensitive area confirmation
P14	S11	Tail fin at 200m	354°	ILS/LOC sensitive area confirmation
P15	S11	Tail fin at 60m	234°	ILS/LOC sensitive area confirmation
P17	P101	Tail fin at 250m	114°	ILS/LOC French sensitive area confirmation
P18	M11	A/C Nose at 150m	234°	ILS/GP sensitive area confirmation

Figure 2 : Ready for test point 13

For the majority of test points, flight and ground checks were sequentially conducted. Some points were not ground checked (P16, P19) while some other (P11, P12) were ground checked at several vehicle speeds.
The accurate position and heading of the A380 were measured after each runs with high- accuracy infra-red and DGPS tracking systems.

Figure 3 : Rear Reference point

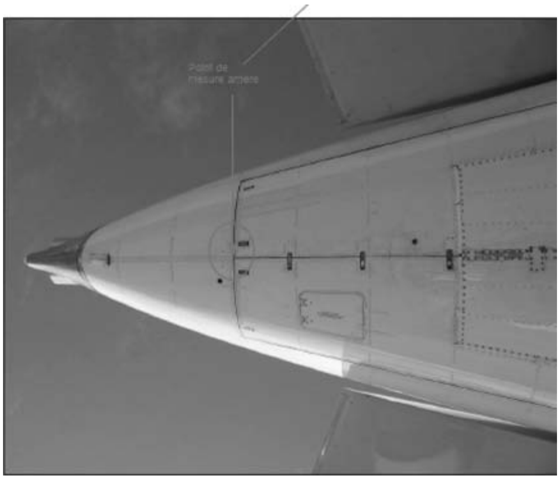


Figure 4 : Front Reference point

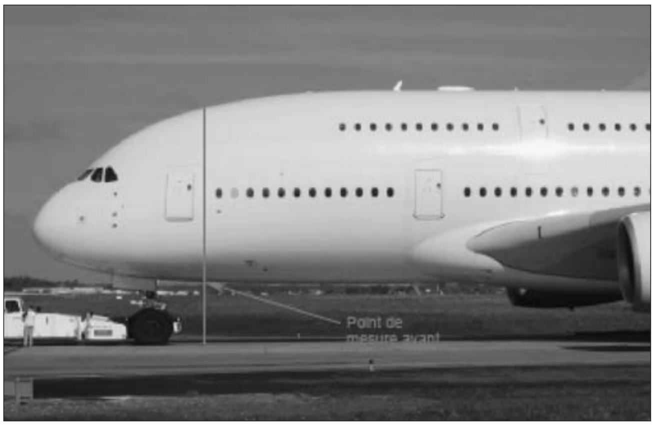
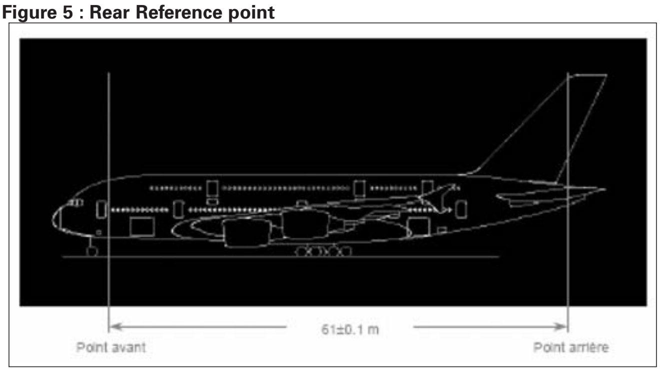


Figure 5 : Rear Reference point



RECEIVING EQUIPMENT CHARACTERISTICS DURING TOULOUSE CAMPAIGN :

The Toulouse Blagnac tests were split in two sessions. During the first session, four ground vehicles fitted with different receiving equipments (receiver and antenna) were used.
One vehicle was MLS equipped. An IN-SNEC Portable Maintenance Receiver and a Thales TLS755 multimode receiver were used. A RAYAN directional antenna installed at 2.3 m above the ground was split between these two receivers. ARINC data and Video signal outputs were recorded.
The three remaining vehicles were ILS-equipped. Table 3 summarizes vehicle equipment.

	Receiver type	Antenna type
Vehicle 1	ARTUS 324 and Rodhe&Schwarz EVS200	SCALA (omni-directional)
Vehicle 2	Rodhe&Schwarz EVS200	R&S HF108 gain at 112MHZ = 1.2 Left to Right and Rear to Front attenuation : 6 dB
Vehicle 3	ARTUS 324	YAGI (directional)*

* During the second session, the directional antenna of the Vehicle 3 was 45° oriented toward the right side of the vehicle to get the same gain at 0° and 90° bearing angles.

Table 3 : ILS vehicle equipment

During the second session, vehicles 1 and 3 were used.
The flight calibration aircraft was equipped with an IN-SNEC MLS Inspection Receiver and a Rockwell & Collins RV4 ILS receiver. The truth position reference system was based on Differential GPS.

Figure 6 : Vehicle 1 with the SCALA antenna

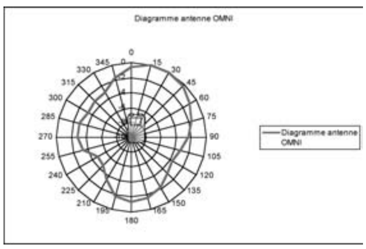


Figure 7 : SCALA antenna Horizontal Diagram

Figure 8 : Vehicle 1 with the SCALA antenna

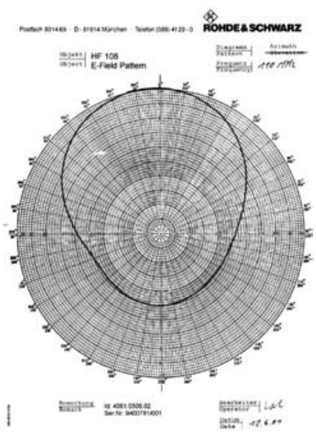


Figure 9 : R&S HF-108 antenna Horizontal Diagram

Specific characteristics of the ILS tests receivers are still under evaluation. In particular, the sample frequency and the output filter characteristics are under evaluation in order to be able to analyse the test measurements properly.

FURTHER STEPS :

At the time this article is written, the analysis of the trials is not finalized and additional time is necessary to complete this task.

The next steps will consist in a close comparison between the available software propagation tool pre-test results and the ground and in-flight measurements. When correct correlation will be obtained, the simulation tool will be considered as validated. Additional validation materials will be provided by additional test results already conducted (Paris CDG with A310 and B747-200, Frankfurt with A380 and B747), or scheduled in the near future (London Heathrow with A380). For MLS purpose, additional measurements were conducted in Toulouse Blagnac with A320, A340 and in London Heathrow with B757 and B747-400.

After this validation effort, the validated signal propagation tool will then be used to assess the typical dimensions of ILS and MLS critical and sensitive areas for large aircraft to be presented to ICAO Navigation System Panel for Annex 10 guidance materials update.

Figure 10 : A380 n°1 during its first flight on 26th of April 2005