RADIO COMMUNICATIONS PERFORMANCE FORECASTING

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Abstract: One of the main concerns for a helicopter manufacturer is the correct integration of electronic systems on board an aircraft.

Indeed, because technological developments tend to introduce ever more sophisticated systems, compatibility problems have arisen.

In the field of radio communications, these problems range from minor interferences (reduction in reception quality) to situations which may potentially be serious (total loss of reception).

Eurocopter has put in place a working method which is based on the quality criteria set down in a document known as “PEGASE”.

PEGASE takes into account results from radiation patterns of radio communications antennas (in-flight tests), and also electromagnetic interference measured by these antennas (ground tests).

The results of these tests are used to rapidly determine whether the helicopter meets the requirements of PEGASE, and if a confirmation flight is required or not.

Keywords: Antenna radiation patterns, radio communications performance forecasts.

1. Introduction

Modern helicopters are increasingly being equipped with radio communication and radio-navigation systems.
The addition of optional equipment and customisation are liable to modify the antenna radiation pattern and, as a result, the performance of radio equipment.
The space which is available for setting up the antennas becomes more and more limited, and in this context, in order to eliminate any problem with interference, careful positioning proves vital.
At Eurocopter, the validation of an antenna set-up on an aircraft starts with a simulation of the radiation patterns.
Despite the simulation, in-flight tests are always necessary for validating the simulated patterns, but also for acquiring a non-negligible parameter: the maximum electromagnetic field emitted by the antenna during testing.
This maximum field value is used to quantify the maximum attenuation of the diagram, and consequently to obtain reliable forecasts for the performance of radio communications equipment.

In practice, the antenna radiation patterns are not sufficient to qualify a radio receiver.

It is also necessary to integrate the electromagnetic interference generated by the on-board equipment which may impair radio communications performance by desensitising (or even rendering unusable) the channels of a frequency band.

2. Antenna radiation patterns

2.1 The simulation

Eurocopter uses software known as ASERIS-BE, which was developed by the EADS Joint Research Centre.
This tool can model antenna radiation patterns and also simulate strong field tests or radar stealth tests.
Like the majority of applications associated with electromagnetic waves, the method used in our case for plotting radiation patterns is called “exact” because it is based on solving the Maxwell equations by means of boundary finite elements.
To make the calculations as straightforward as possible, we have assumed that the helicopter is a perfect conductor.
According to the instructions provided by the user, the computer describes the helicopter in a regular triangular mesh structure (fig.1).
It is to be notified that the windows and radomes are not taken into account in the calculation of the meshed structure.

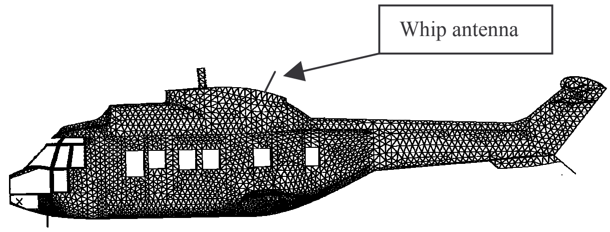

Figure 1

The antenna placed on the sliding cover acts as a voltage generator linked to a radiating element (whip). The wave emitted by the antenna propagates and interacts with the helicopter structure, depending on the type and shape of the material encountered.
The induced surface currents are calculated at each node of the mesh.
Once they have been computed, the application supplies the user with a 2- or 3-dimensional radiation pattern or map (fig. 2; 3-D diagram).
The colour, which goes from red to blue, represents the calculated field level
(red = maximum field level).

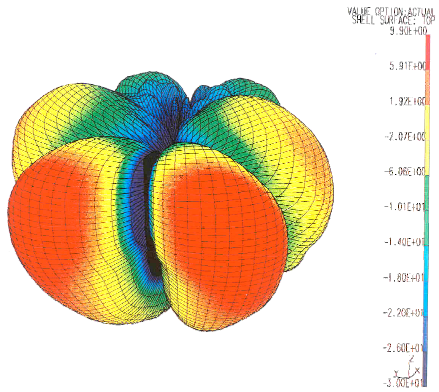

Figure 2: 3-D Antenna radiation pattern

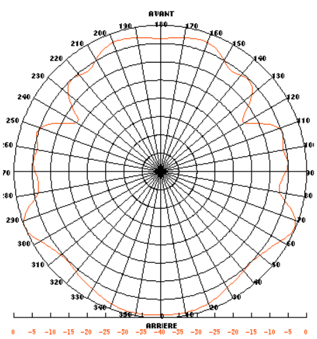

Figure 3: Simulation in horizontal plan

2.2 In-flight testing

Although simulation provides reliable results and reduces costs, in-flight testing is still necessary.
These tests are performed on a "clean" helicopter (without optional equipment), and the operating principle is as follows:
The helicopter rotates through 360° in stationary flight, at a given distance and altitude.
Using its antenna to be tested during the rotation, the aircraft emits a signal with a frequency (f) which is modulated by the information about the helicopter's heading.
Heading data are acquired by an in-flight testing installation on board the aircraft.
On the ground, the station receives the signal, decodes the helicopter heading data, and a computer plots the radiation pattern in real-time in polar coordinates (field level in function of heading).

From the diagrams obtained, certain informations can be derived, such as:

- the field factor (the maximum measured field value),
- the form factor (attenuations).

In-flight testing is also used to validate the radiation patterns from the simulation and to forecast the performance of the radio communication equipment.

2.3 Comparison of simulation and in-flight testing

The radiation patterns from the simulation and from flight tests are presented in the same way. Therefore, it is very easy to compare the various plotted diagrams (figures 3 and 4).

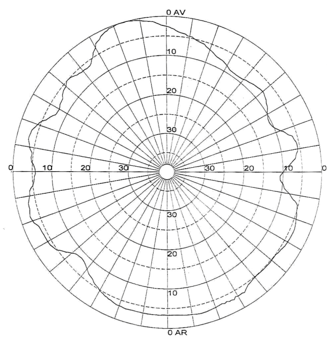

Figure 4: Flight measurement

As you will notice, the diagrams for figures 3 and 4 are relatively similar. The attenuation of the front right-hand sector during in-flight testing is certainly the result of the helicopter pitching or rolling.
This anomaly in the diagram can be later confirmed during the radio performance flight.

3. Performance forecasts

Eurocopter devised this method some 20 years ago. Performance forecasts are used for validating (or otherwise) the position of the testing antenna.
These forecasts are obtained from data on the maximum field level, the maximum attenuations which appear on the diagrams, and the receiver squelch threshold.
For the example given in figure 4, you can see that performance will not be obtained at the top of the band because the curve goes below the receiver squelch level (dotted lines). The position of the antenna, apart from its performance, does not meet the requirements of PEGASE.

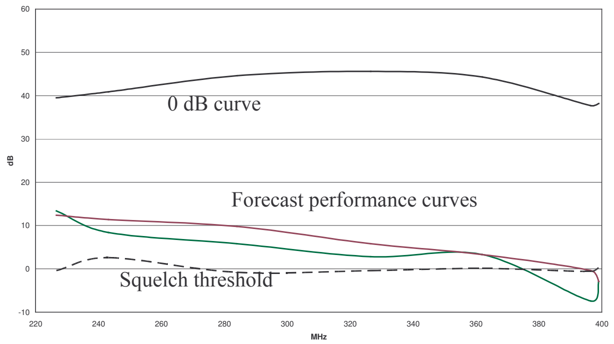

Figure 5: UHF-band radio communications performance forecast

4. Electromagnetic interferences

The arrival in the world of electronics of switching power supplies, and computers in particular, has generally generated a fair amount of electromagnetic interferences.
First of all, to remedy the problems associated with electromagnetic compatibility, the equipment used must comply with current standards. Secondly, these systems need to be properly integrated, according to good engineering practices associated with electromagnetic compatibility.
One of Eurocopter's criteria in this field is to provide its customers with "airworthiness" – in other words, another system should not interfere with the VHF, VOR, Glide and Marker receivers.
To this end, electromagnetic interference measurements are taken to ensure that the electromagnetic compatibility has been mastered and that this criterion is satisfied.
These measurements are taken by an automatic acquisition bench.
The measuring receiver is directly connected to the helicopter antennas, instead of to the airborne receivers.
In this way, we obtain a frequency spectrum (level/frequency) of the interference picked up by the testing antenna (figure 6).

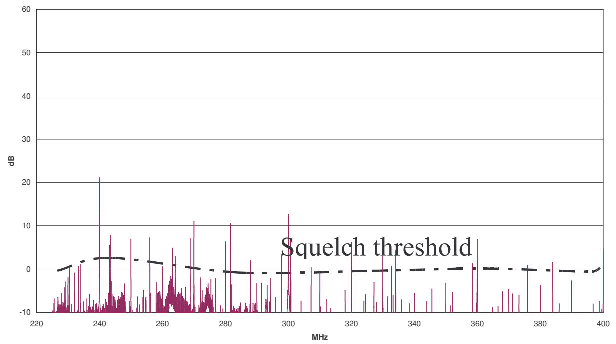

Figure 6: EMI Measurement

In theory, interference over the squelch threshold is annoying because it causes the receiver squelch system to be switched on and makes the frequency unusable. Depending on the type of receiver that is being used (squelch related to signal/noise ratio) and the type of interference (broadband or narrowband), the squelch may not be triggered. On the other hand, there will be a desensitisation (loss of performance when the helicopter flies away from the broadcasting source) of the frequency that is used.
In order to be able to qualify and quantify the interference, the source of interference first needs to be identified, and then the channel at fault needs to be listened to on-board the helicopter.
The corrections needed to eliminate the interference will be applied as a function of the results obtained.

5. PEGASE

This testing method applies both the radio performance forecasts and the electromagnetic interference measurements. It came into being when inconsistencies were discovered between the results of ground-testing and in-flight testing. The result is shown in the following way:

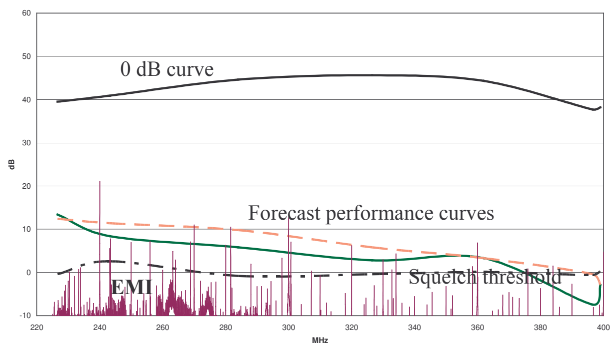

Figure 7: UHF-band radio communications performance forecast with EMI measurement

The graph in figure 7 has several advantages. It provides an idea about the performance of the helicopter during testing (in terms of the expected requirements), provides information about the frequencies which cannot be used,

or those which will be desensitised, and enables the flight test engineer to accurately target the work to be carried out during flight (saves time).
Finally, and most importantly, this graph tells us whether the helicopter must be flown or not in order to qualify the equipment under test.

6. Conclusions

Eurocopter's experience in the field of radio communications has made it possible to establish performance forecasts between 30 and 400 MHz.
Electromagnetic interference measurements have been used in conjunction with the performance forecast curves for around 10 years. This method has proved satisfactory, both in terms of confirming agreement between the results from ground and flight test and of saving time, which means lower flying time costs.