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MODELING OF THE NOISE GENERATED BY A HELICOPTER ON THE GROUND DURING MAINTENANCE

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ABSTRACT

The paper presents the results of a work aimed at reducing the noise introduced into the environment by a helicopter on the ground during the phases of routine maintenance, performed near a hangar located several hundred meters from a residential area. The document describes the approach followed, the results obtained from instrumental analyses in the field and from computer simulations, as well as the study of some possible interventions for acoustic impact reduction in the surrounding area.

Keywords: *helicopter, beamforming, directivity, simulation, noise model.*

1. INTRODUCTION

The helicopter is a very complex machine that, in addition to being characterized by a very high sound power, has some peculiar emission characteristics, both as regards the frequency spectrum and as regards the directionality of the noise generated. In the specific case, since the study was limited to the analysis of the acoustic impact due to the vehicle on the ground [1], it was not necessary to investigate the variability of the emission due to the pitch of the propeller -normally present during normal flight operations- as in the condition of interest the propeller was kept constant according to the needs related to the operation of maintenance of the aircraft.

2. SOURCE IDENTIFICATION

The first step of the analysis involved the use of classic techniques for source identification, in order to understand which were the main ones. Fig. 1 shows a beamforming analysis carried out at the frequency 3500 Hz in which the emission of the turbine exhaust and its *image source* on the ground is clearly visible. Similar investigations carried out at different frequencies, have shown the emission of the main rotor, tail rotor (see Fig. 2) and transmission. Beamforming analyses were carried out 20 meters far away from the main rotor centre. For the measurements, the ACAM 120 array was used: it is equipped with 40 microphones arranged on a square planar surface of 40 centimeters on each side, and the system is able to perform surveys from about 800 Hz up to over 20 kHz

Figure 1. 3500 Hz exhaust outlet and *image source*.

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Figure 2. 18750 Hz tail rotor.

Although not relevant to the study, it is interesting to note the effect of reflection at 3500 Hz on concrete ground, during the approach phase of the helicopter, as shown in Fig. 3.

Figure 3. 3500 Hz concrete ground effect during fly

3. SOUND POWER AND DIRECTIVITY

Subsequently, the octave band sound power and the associated directivity were determined. To proceed in this direction, the aircraft was positioned on the roof of the hangar which, being at a higher height than all the surrounding buildings, allowed measurements to be carried out in free field conditions. The surveys were carried 70 meters far away from the rotor and for 8 angles of orientation of the aircraft. The survey showed a sound power of over 132 dBA. Fig. 4 shows the octave sound power spectrum

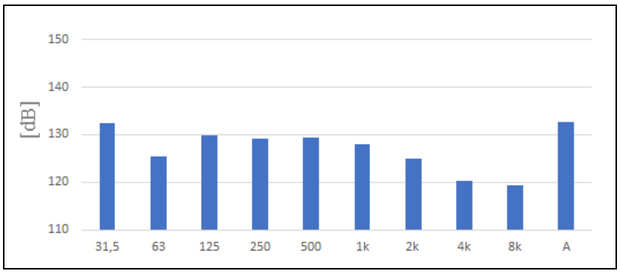

Figure 4. Sound power spectrum

Fig. 5 shows the directivity diagrams calculated in the azimuthal plane, for the octave bands between 125 Hz and 8 kHz plus overall A-weighted.

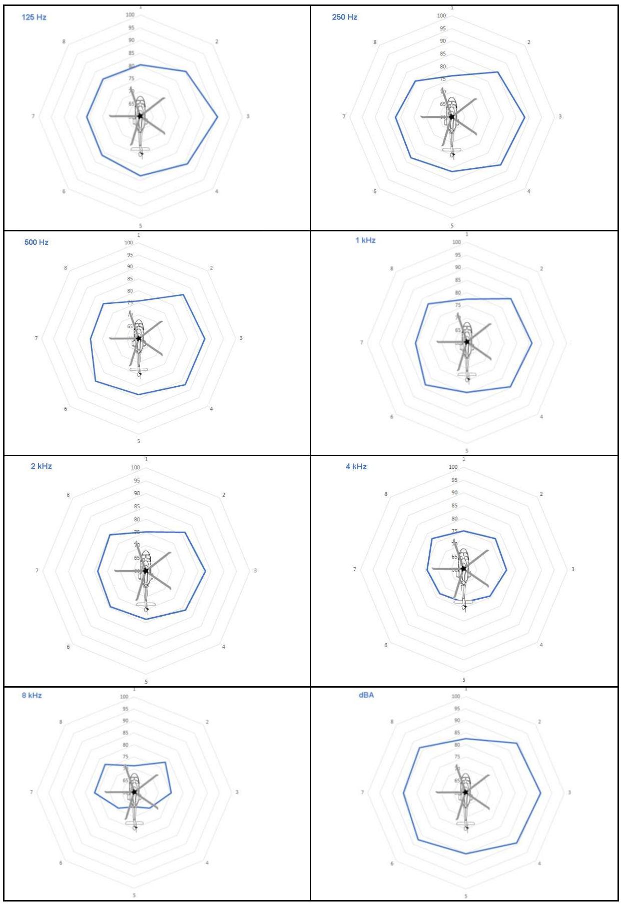

Figure 5. Directivity patterns

4. NOISE MODEL AND CALIBRATION

By means of the SoundPLAN software, a 3D model of the territory was created, in which the 'helicopter source' was inserted with the previously calculated power spectrum and directivity parameters. The helicopter was treated as an industrial source with propagation according to ISO9613-2. Fig. 6 shows the Digital Ground Model of the area of interest, located in a mountainous environment.

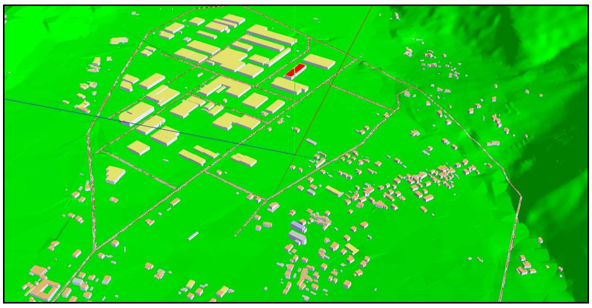

Figure 6. DGM of the area of interest

The calibration phase involved the use of two additional measuring stations in addition to the one already used for the characterization of the aircraft; the first station (100 meters far away) was employee for the calibration itself, whereas the second station (400 meters far away) was employee for validation purpose. The calibration process consisted in the minimization of deviations for all angles of the helicopter. Validation check showed a deviation less than 1.5 dB. Fig. 7 shows the acoustic map (dBA) obtained by means of the model, relating to the positioning of the helicopter in the normal maintenance position (5 dB/color).

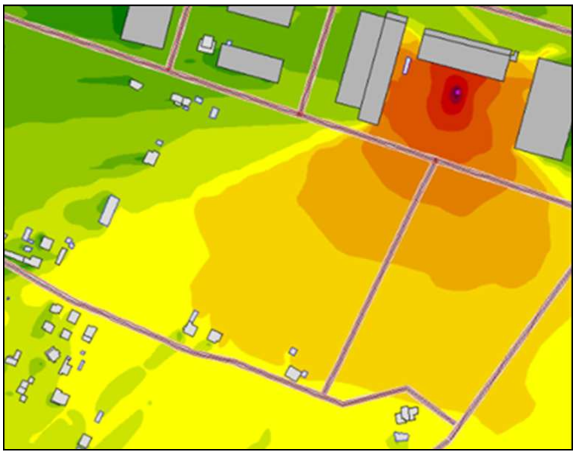

Figure 7. Present situation

5. POSSIBLE IMPROVEMENTS MEASURES

The study of possible improvement interventions has foreseen several possible scenarios. Among these, it has been hypothesized the possibility of a different orientation of the aircraft thus exploiting its lower emission in a specific direction, the possibility of using different positions on the ground and the possibility to making acoustically absorbent some surfaces close to the maintenance area.
Fig. 8 shows the simulated overall A-weighted noise map related to the helicopter placed in the same position as before, but with 45 degrees anticlockwise orientation angle. The map shows a general 5 dB reduction for the receivers in the south-west area.

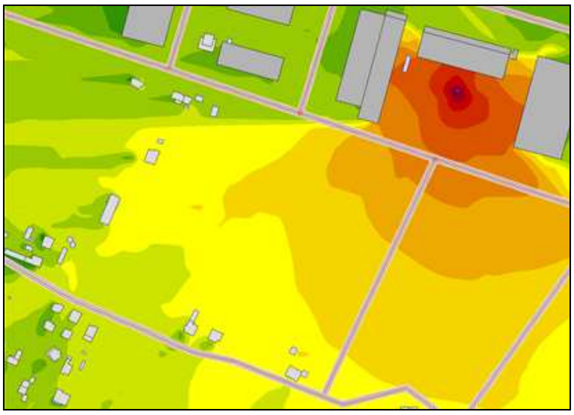

Figure 8. Same position, different orientation

However, operations with aircraft are subject to various technical and procedural limitations, and consequently some interventions are not in fact feasible or would involve authorization not quickly obtainable and operational difficulties that make very complicate the operations; for this reason the study, in its final phase, was focused only on interventions that could be implemented in short time.
Fig. 9 shows, as example, the simulated overall A-weighted noise map obtained by considering a different position of the helicopter maintaining a similar orientation to the present one. In the map is possible to identify the shielding effect by the building laying in the left of the aircraft parking area, with respect to the receptors of interest placed to the south-west of the area.

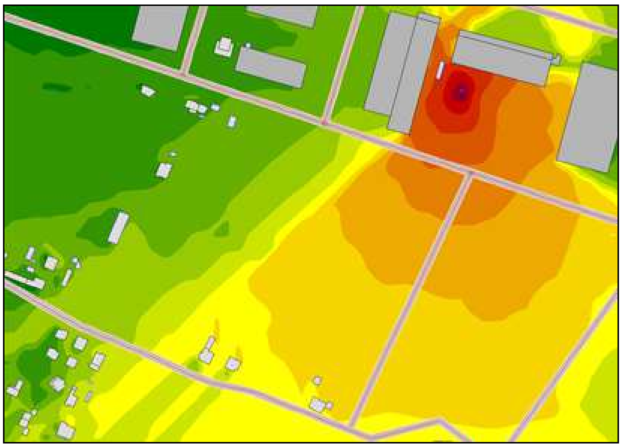

Figure 9. Map for different position of the aircraft

Fig. 10 shows the map obtained by subtracting the present map (present position) from the new one (new position). The color scale shown in the figure, from green to red, extends from -12 dBA to + 12 dBA; areas not colored (white) refer to reductions of more than 12 dBA. The image shows that with this configuration is possible to obtain benefits between 9 dBA and 12 dBA for the receptors of interest, located in the south-west, at the expense of an increase in levels towards the industrial area to the north and towards some uninhabited ruins located to the south.

Figure 10. Difference dBA map

In addition to the above, the study also considered the possibility to build some noise barriers in the down-left corner of the operation area (insulating and absorbing barriers, 4 meters high and 16 meters per side long); for those barriers the model showed that their effect is very limited, also considering the limited permitted height both for safety rules and for local authorisation procedures, as well as the reciprocal position of the sources and the receivers.

6. CONCLUSIONS

The investigation of the main sources of the helicopter, together with the determination of aircraft detailed emission characteristics, has made possible to create an accurate acoustic model to simulate the benefits due to some possible interventions aimed at reducing the acoustic impact in a specific direction of the surrounding territory.

With the aim of obtaining an accurate acoustic model and providing data that would lead to a serious design of the possible interventions, particular care has been taken in model calibration and verification, as well as in the calculation of the uncertainty of the model itself.

More specifically, the study highlighted the importance of the accurate determination of the sound power spectrum of the source and of the related directivity diagram. Thanks to this information and thanks to the use of a calibrated noise model, it was possible to simulate different scenarios, favoring those with the best ratio between the realization times, costs and obtainable acoustic benefits.

7. REFERENCES

[1] Andrea Cerniglia, Gelsomina Di Feo, Alice Cerniglia, “Modellazione del rumore generato da un elicottero a terra durante la fase di manutenzione e conseguente studio dei possibili interventi di bonifica” in *Atti del 49° Convegno Nazionale della Associazione Italiana di Acustica,* (Ferrara, Italy)