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JAPE 91 : INFLUENCE OF TERRAIN MASKING ON THE ACOUSTIC PROPAGATION OF HELICOPTER NOISE[1]

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ABSTRACT

The acoustic propagation in the case of a noise source masked by a small element of terrain has been investigated experimentally. These data have been measured during the "terrain masking" experiment of the NATO JAPE 91 experimental campaign. The main objective of that experiment was to study the acoustic detection of a helicopter masked by a small hill. Microphones have been placed at different locations on the shadow zone of the hill to study the effect of the terrain obstruction on sound propagation. The results presented come from data measured by *Atlas Elektronik* and by *ISL*, and have been processed together. The terrain obstruction causes an excess attenuation of the SPL (Sound Pressure Level) for all the frequencies, but this attenuation is more effective for the high frequencies than for the low frequencies. Results typical of diffraction phenomena have been observed; the SPL is minimal at the foot of the hill and is relatively constant beyond it.

INTRODUCTION

Results of acoustic data measured during the NATO JAPE (Joint Acoustic Propagation Experiment) campaign are presented in this paper. Approximately 15 teams have taken part in this field trial hosted by the US Army White Sands Missile Range during the summer of 1991 (ref. 1).

The main objective of our experimental set-up is to study the physical phenomena which occur when an acoustic wave propagates around a small hill (figure 1). It is especially interesting to study the characteristics of the diffracted waves received by the microphones. This experiment also has some operational interest to evaluate the capability of the acoustic detection of helicopters for non line-of-sight configurations.

[1] This work has been done under a contract of "Direction des Recherches Etudes et Techniques", Paris (France).

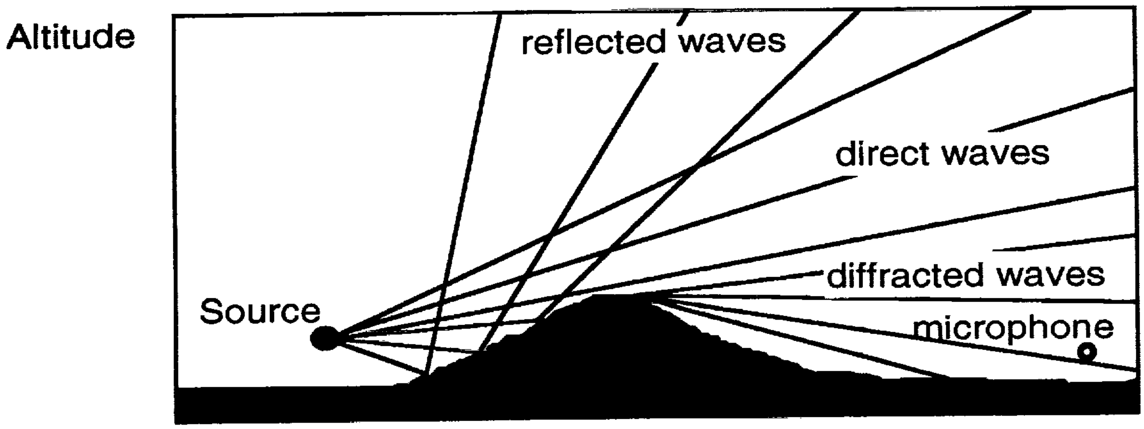

Figure 1. Trajectories of the acoustic waves

TEST SET-UP

For this experiment, the installation of the microphones and the recording of the acoustic data have been carried out by the German team of AE (Atlas Elektronik) and by the Franco-German team of ISL. The microphones are located along the profile of the hill on the north-south axis (AE) and on a perpendicular axis following the foot of the hill (ISL) (figure 2).

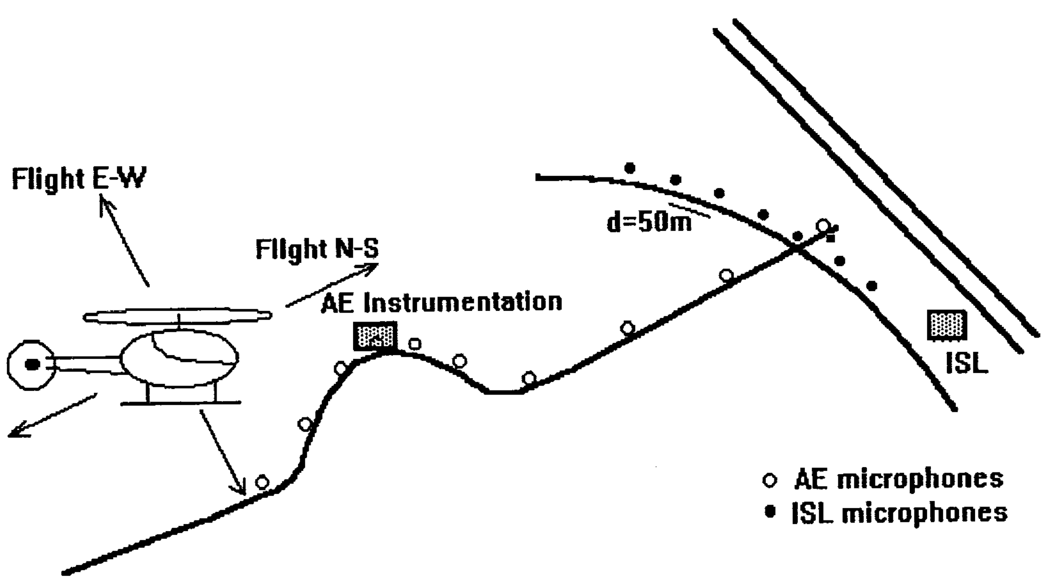

Figure 2. Experimental configuration

HOVERING POINTS

In a first series of trials, the helicopter made hovering points at different heights on the south side of the hill, the main part of the experimental set-up being situated on the opposite side. As an illustration of the effect of terrain masking, two acoustic spectra are plotted: one when the helicopter is masked and one when it is visible. On the first plot (figure 3), the helicopter makes hovering points on a vertical line. On the second plot (figure 4), the helicopter makes hovering points at the same altitudes as previously, but follows the profile of the hill (figure 4).In all these cases, the helicopter is well heard and the spectra have roughly the same shape. When the helicopter is masked, the value of the sound pressure level is lower. For the first harmonics of the main rotor frequency, the mask induces an attenuation of the SPL of approximately 10 dB. The higher harmonics do not emerge very well from the broad band noise. When the helicopter is close to the top of the hill, the acoustic level is greater than when the helicopter is at the same altitude but at the vertical of the base of the hill.

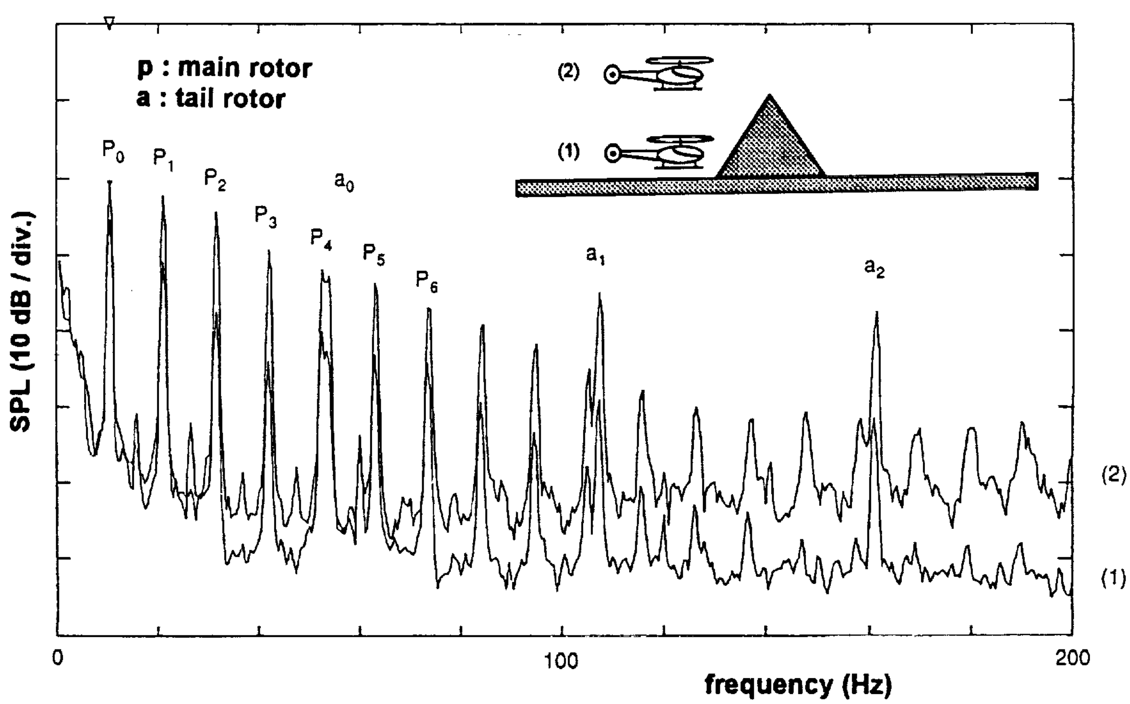

Figure 3. Acoustic spectrum

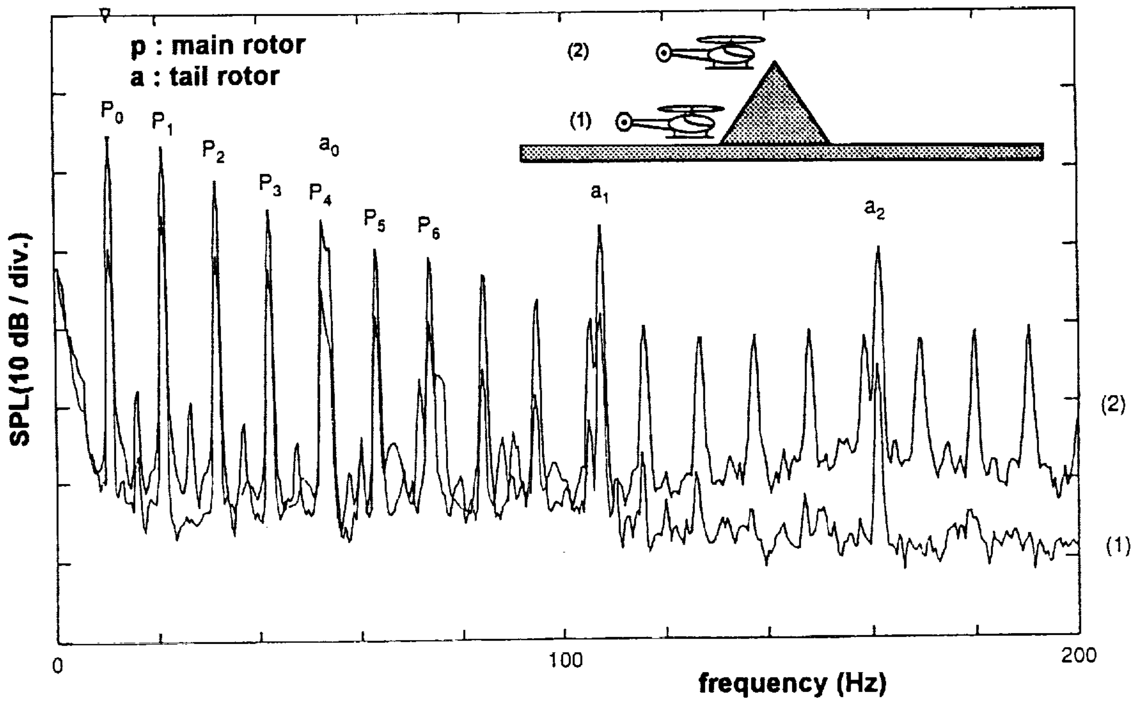

Figure 4. Acoustic spectrum

The evolution of the SPL shows a smooth and continuous variation for the main rotor frequency (f_1). For a higher frequency (f_2), approximately 400 Hz, a great variation is shown during the masked→unmasked transition (figure 5).

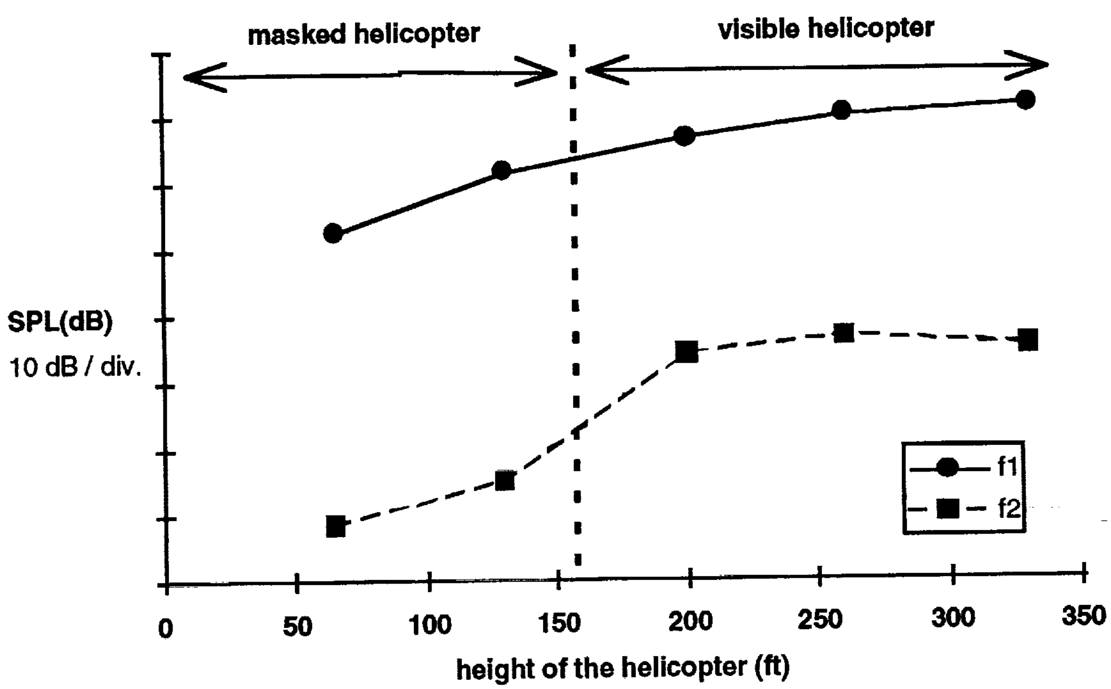

Figure 5. Influence of the altitude of the flight

The evolution of the SPL along the profile of the hill shows a fast decrease on the shadow side of the hill, and is relatively constant beyond it (figure 6). The maximum of the attenuation (minimum value of the curve) is reached at the foot of the hill. These two characteristics are typical of diffraction phenomena and are well known for the application of noise reduction by screens. The difference of the SPL values for the first point of the curve is explained by the helicopter-microphone distance which is quite different for the two heights of flight. For a better understanding, the profile of the hill is schematically plotted in the lower part of the graph.

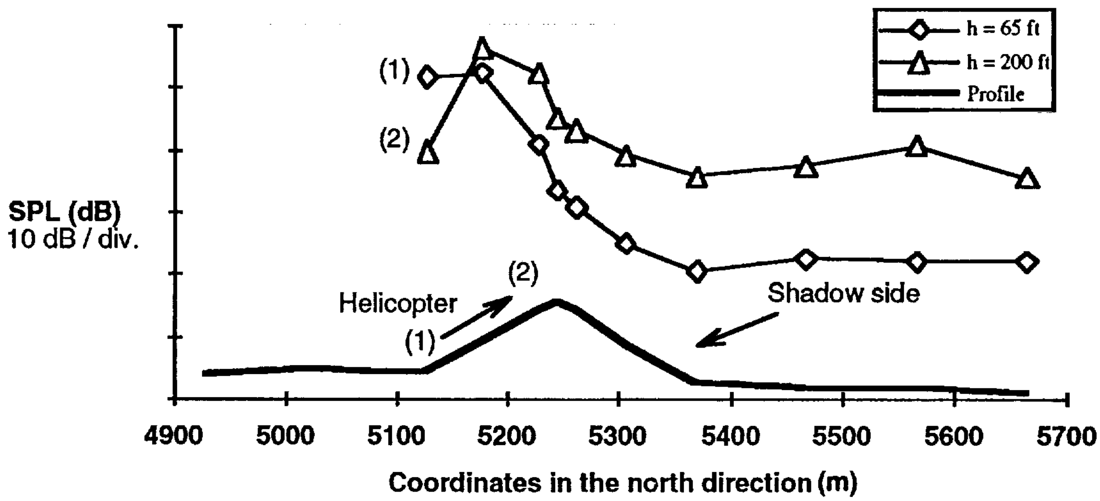

Figure 6. Influence of the altitude of the flight on the shadow zone (f=10.5 Hz)

The variations of the SPL along the profile for different discrete frequencies have all the same shape (Figure 7). If we take as references the SPL values measured at the top of the hill, the smallest frequency is less attenuated. As shown previously (figure 6), the SPL is relatively constant beyond the foot of the hill; we find again this characteristic for all the frequencies.

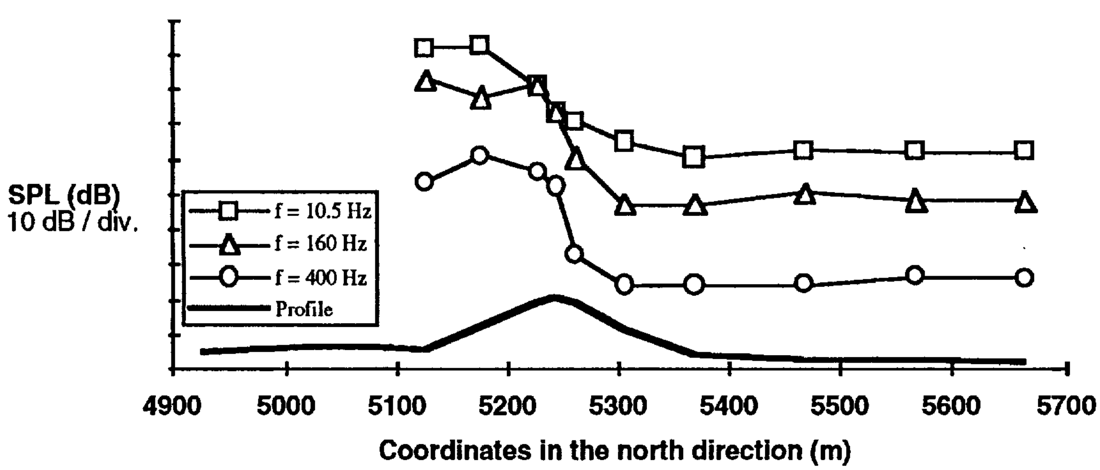

Figure 7. Characteristics of the shadow zone: influence of the frequency (h=65 ft)

The development of the spectrum over time yields more information on translation flights. The acoustic level represented in pseudo-colours, as a function of frequency and time, allows the construction of an image with characteristics specific to the helicopter (line structure, Doppler shift), and specific to the effect of terrain masking.

Two different helicopter paths have been investigated. During the east-west flight, the helicopter path is partially behind the hill. The excess attenuation corresponds graphically to the gap visible in the line structure beginning at the 4th harmonic (figure 8). The maximum of this gap corresponds to the closest point of approach of the helicopter; it also corresponds to the inflection point of the Doppler shift pattern.

During the NOE (Nap of the Earth) flights in the north-south direction, the effect of the mask is not easily visible, because of the opposite effects which occur during this experiment (figure 9). The attenuation induced by the mask is partially compensated by the increase of the level of the noise source when the helicopter has to climb to avoid the hill.

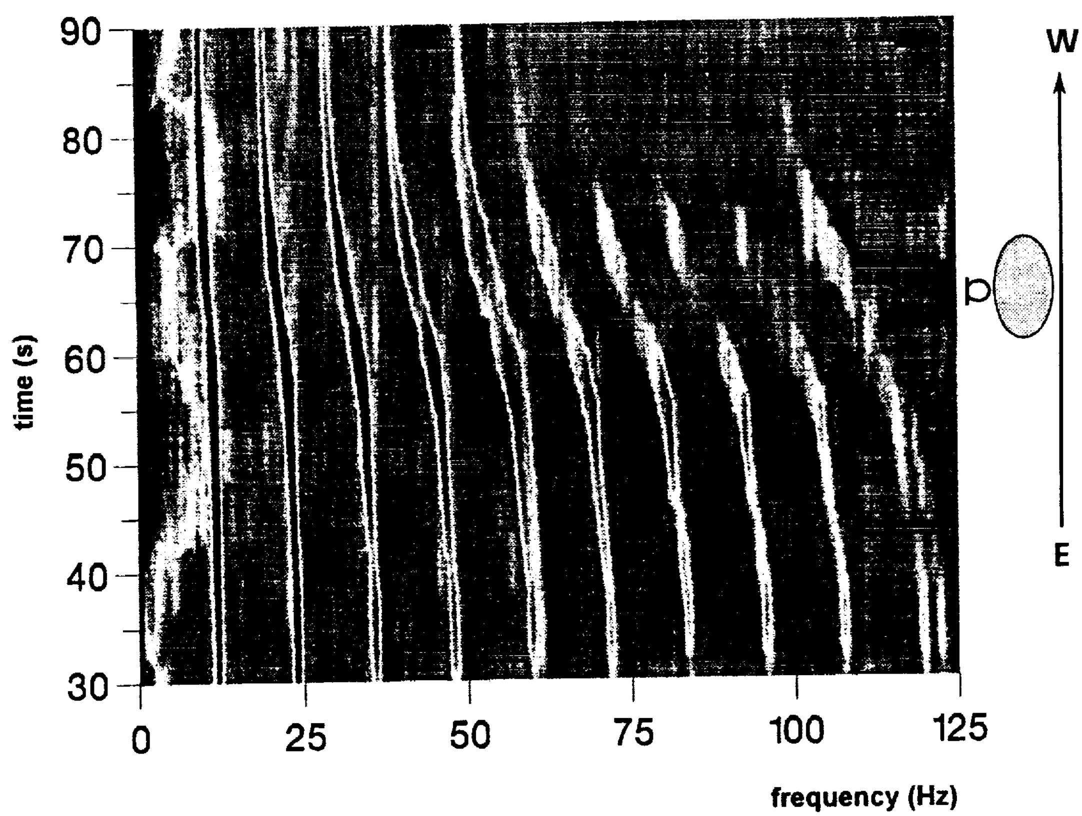

Figure 8. Evolution of the acoustic spectrum (east-west flight)

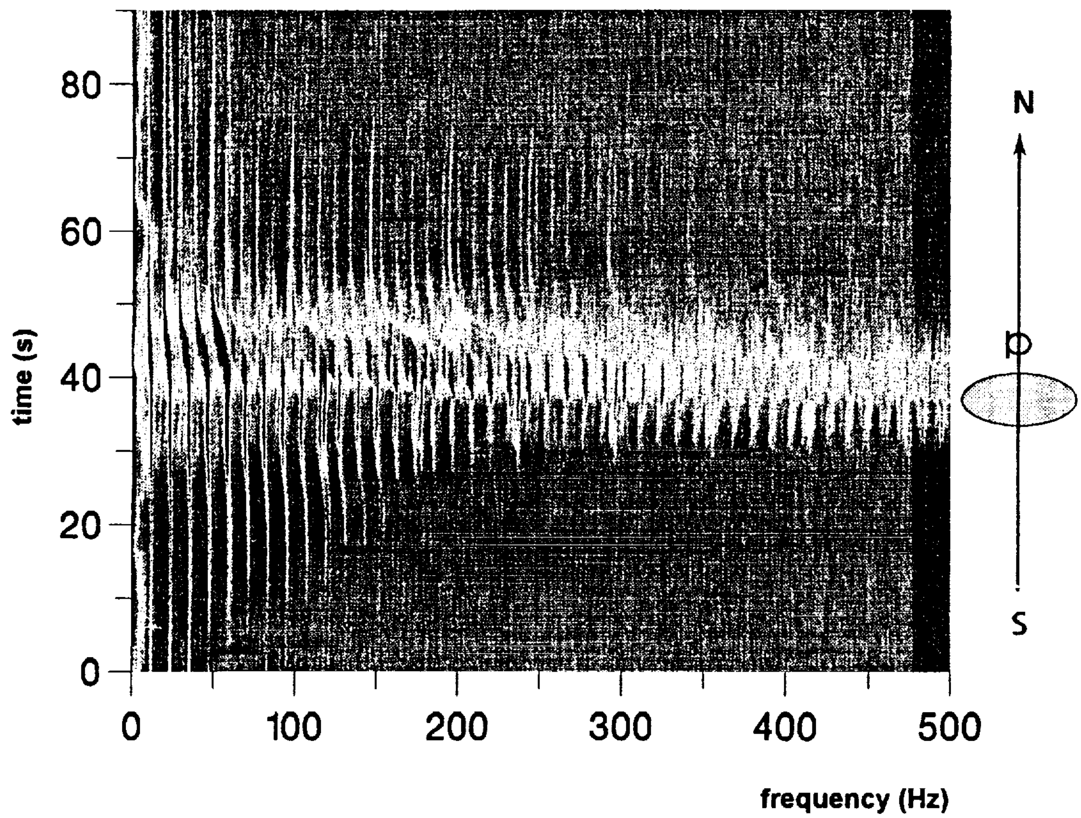

Figure 9. Evolution of the acoustic spectrum (east-west flight)

CONCLUSION

The influence of a small element of terrain on the acoustic propagation of the helicopter noise has been investigated experimentally. The characteristics of the shadow zone have been quantified. The attenuation due to the hill is relatively low for the main rotor frequency and its first harmonics. Consequently the helicopter is well heard, even on the shadow side of a small hill.

REFERENCE

1. B.W. Kennedy, R. Olsen, et al.
Joint Acoustic Propagation Experiment Project Summary
ASL, September 91