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A COMPARISON OF THE RESULTS FROM GROUND-PLANE MICROPHONES WITH 1.2m MICROPHONES FOR AIRCRAFT NOISE MEASUREMENT

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INTRODUCTION

1. The current standard technique for measuring outdoor environmental noise levels is to set the microphone at a height of 1.2 metres above ground level (AGL). This is mandatory for the noise certification of aircraft. However it has been found that spectral distortion is introduced by using this technique. This is caused by reflected waves from the ground interacting with the direct wave.

2. There are also practical problems associated with mounting the microphone units at a height of 1.2m AGL. The lower frequencies being measured are masked when wind is present and this causes them to be unreliable. Also their use in remote field surveys has shown that they are prone to being blown over and damaged.

3. The Environmental Noise Department (END) at RAF IHMT now uses high quality 1/3 octave band analysis in the laboratory for most of the surveys undertaken. It has the capability to record and reproduce the measured acoustic signal without quality loss through the use of Digital Audio Tape recorders. These advances in the END's resources enable it to benefit from the use of a more accurate technique for the capture of acoustic signals.

4. An alternative to the normal 1.2 m AGL technique which does not have these disadvantages is the Ground Plane technique. This involves placing the microphone over, or coplanar with, a hard, rigid baffle positioned on or in the ground surface. This method significantly reduces spectral distortion and wind noise, with better stability also being attained. This arrangement is now a requirement in noise certification procedures for propeller driven light aircraft.

5. The END recently carried out an environmental noise trial using both 1.2m AGL and ground plane techniques, at which the differences in sound levels between the two techniques produced results which varied widely from those expected. This paper briefly summarises the comprehensive work done on the evaluation of ground plane and 1.2m techniques by Payne(1), and examines the practical aspects, and results that do not conform to the theoretical model.

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THEORETICAL BACKGROUND

1.2 metre AGL measurement method

6. Ideally the measurement technique would capture the free field spectrum, which by definition would be free from any secondary reflected waves and therefore distortion. However it is not practically possible to obtain this in an outdoor environment. The most widely accepted arrangement for measuring outdoor environmental noise is to position the microphone at a height of 1.2 m AGL. Although this height has been judged to reflect the best result, as it has been used for many years, distortion is introduced when a measurement is made.

Ground Plane Microphone technique:-

7. The technique of positioning the microphone at the ground surface would prevent any secondary reflections reaching the microphone as it acts as the boundary of reflection. At the boundary of reflection pressure doubling occurs and this is theoretically free from distortion. Pressure doubling gives an increase of 6dB over the free field situation, and thus an increase of 3dB or more on the 1.2m AGL level. For true reflection at the boundary a baffle is used as the characteristics of the ground conditions are unpredictable. The distortion introduced to the measurement system is dependant on the diffraction effects due to the baffle having different characteristics to the surrounding ground, and the microphone positioning. The amount and characteristics of the distortion is dependant on several parameters.

SUMMARY OF PREFERRED GROUND PLANE MICROPHONE TECHNIQUE FOR AIRCRAFT NOISE MEASUREMENT

8. Theoretically the use of a ground-plane microphone arrangement for aircraft noise measurement successfully reduces the effects of constructive and destructive interference which occur with the conventional 1.2 m AGL microphone location. The recommended arrangement, (1)&(2), consists of a 0.4 m diameter hard, rigid baffle placed flush with the surrounding ground. The microphone should be of an 1/2" type and be inverted over and parallel with the baffle at a height of 7mm, and offset from the centre of the baffle by three-quarters of the baffle radius and mounted such that a line drawn from it to the centre of the baffle is perpendicular to the projected line of aircraft flight. The baffle must be flush with the ground surface if possible, to ensure this it must be let into the ground surface. This arrangement produces results that approximate very closely to pressure doubling for the lower

frequencies with much reduced distortion at the higher frequencies. The pressure doubled values are 6dB above the free field levels and 3dB above the 1.2m AGL levels.

PRACTICAL RESULTS AND OBSERVATIONS

9. Distinct practical advantages of the ground plane measurement technique have been observed during recent surveys. The wind noise is recorded at a much lower level than for the standard placement, this allows more reliable measurement of the lower frequencies and therefore unweighted levels. Also during a current survey that the END is carrying out remotely using remote noise monitoring equipment two of the standard microphone units being used were, on separate occasions, blown over and severely damaged by gusting winds leading to inconvenience due to the lost time and expense. A microphone unit with a low centre of gravity placed near to the ground would be less liable to be blown over as the wind force is lower.

10. A recent survey carried out at RAF Keevil by the END has yielded unpredicted results. Several helicopters were coordinated to fly pre-arranged flight patterns including hovering on and above the ground cushion. The subsequent data obtained is to be used in the AIRNOISE suite of noise contour prediction programs for future use in calculating Helicopter Landing Site noise impact statements. In the survey both the ground plane and 1.2m AGL measurement techniques were used together to measure the helicopter noise. The difference in sound pressure levels between the two methods measured by the END has been analyzed and correlated with the angle of sound incidence as shown in figure 1.

11. The theory predicts a difference of 3dB, though Payne(3) has shown this to be nearer to 4dB. As can be seen from figure 1 this relationship holds true for angles of incidence over 20 degrees from horizontal, but at angles of incidence lower than this the results were not coherent. The low angles of incidence were generated when the helicopters hovered at low levels, and it was only in this position that such anomalies occurred. The distortion at these low angles of incidence is due to the nature of the acoustic properties of the medium in which the sound travels. When the helicopters are hovering above the ground large volumes of air are disturbed and the great amount of turbulence around the source diffracts the sound waves in an unpredictable fashion. The ground plane lies in the direct field and the sound reaches the microphone from one direction. If the sound wave is diffracted upwards by the wind and temperature gradients induced by the helicopter there can be great differences between the levels as the 1.2m AGL position is situated in a diffuse field receiving sound from multiple directions. Another point to consider is that when sound waves reach the

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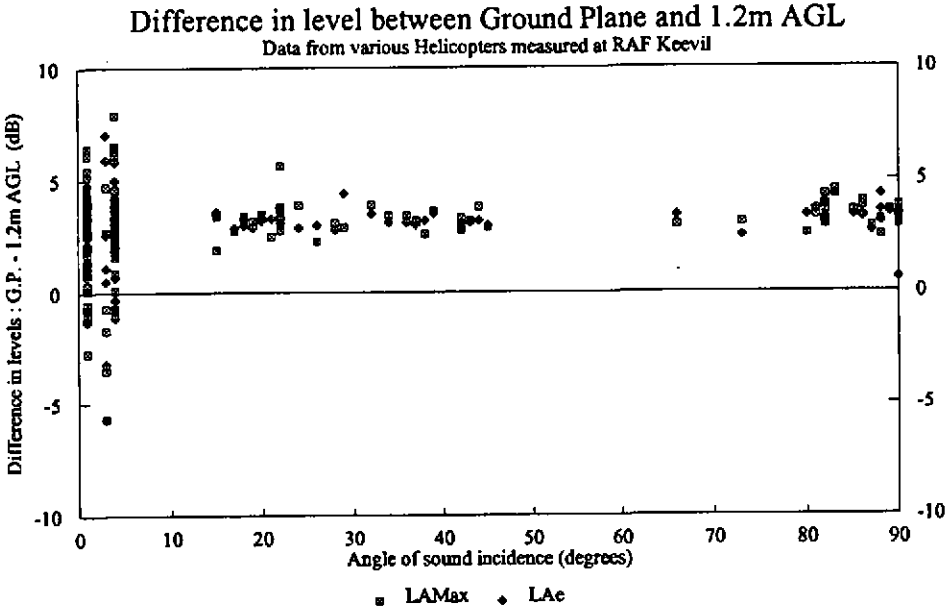

Figure 1.

microphone at zero angle of incidence the microphone does not act uniformly. There is a high frequency roll off due to resonance effects within the microphone, this does not occur when the sound acting on the microphone is of random incidence as in the 1.2m AGL position and may contribute to the deviation.

CONCLUSION

12. The ground plane measurement technique has been shown to be reliable and accurate when used under certain conditions. When measuring the noise from helicopters in flight, the difference between noise levels measured using ground plane and 1.2m AGL techniques is almost constant for angles of sound incidence of 20 to 90 degrees above horizontal. At angles of sound incidence in this range the results from the ground plane technique are reliable and approximate to pressure doubling. At angles of sound incidence below 20 degrees the variability of the ground plane/1.2m AGL relationship shows that one or both techniques are unreliable, it is unclear which method is distorting therefore caution should be

used. The ground-plane technique has advantages over the 1.2m AGL method in having low wind noise effects and therefore an extended signal to noise ratio over a wider frequency range. It also has a practical handling advantage for environmental noise surveys.

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