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INVESTIGATION OF DUAL CHANNEL TIME DELAY MEASUREMENTS AS AN AID TO SOURCE LOCATION

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1. INTRODUCTION

The Batho report (Ref.1) has highlighted that low frequency noise is a major contemporary problem and requires further research. Those who deal with noise complaints can be faced with the problem of locating an unknown source of low frequency noise which requires sophisticated monitoring techniques. Source location has been proposed employing the three element sensor array based on phase difference (Ref.2) and by the use of correlation methods (Ref.3). Most tonal noise giving rise to complaint is emitted by distant industrial plant of some description and is very often in the low frequency range below 500Hz. This paper deals with the investigation of the application of impulse response function as an aid to source location in the frequency range up to 500Hz.

2. METHODOLOGY AND INSTRUMENTATION

The precise direction of the source is simply deduced from a knowledge of the separation distance between two microphones and the consequent time delay which is predictable for a source inline with the two microphones. In situations where the source is offset, the corresponding time delay will be less and a function of the angle of incidence of the wavefront to the line joining the microphones. The schematic representation of this system is shown in Figure 1. The instrumentation employed consists of two condenser microphones (B&K 4155) coupled to B&K 2231 sound level meters. The signals from the input and output microphones were recorded simultaneously on a Sony D7 DAT recorder. These recordings were

subsequently analysed using the impulse response function of the CANAL system which in the configuration used here is a combination of software and hardware loaded to a p.c. enabling real time FFT signal analysis. The system is not portable but however provides a low cost tool for investigation of noise complaints.

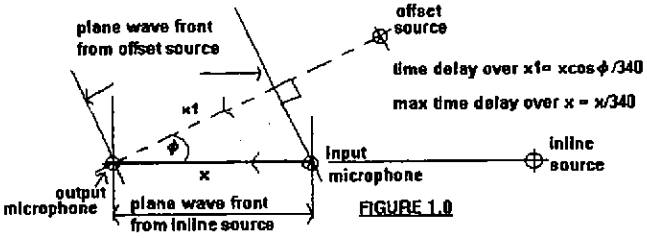


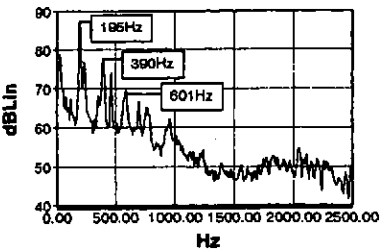
FIGURE 1.0

3. VALIDATION OF INSTRUMENTATION

Microphones were located at 60m, 100, and 140m from a sound source (B&K4224) which was a loudspeaker simulating a vacuum pump with the spectrum shown in Figure 2.

The aim was to correlate the source direction with that indicated by the time delay for different microphone reference positions. Using a fixed distance of 2m between the microphones should result in a maximum time delay of 5.9ms. This indeed was the case when the source and the two microphones were collinear. When the source is offset, however, the time delay would be less.

FIGURE 2.
VACCUM PUMP SPECTRUM



Dual channel recordings were made for each reference position and their corresponding bearings with respect to magnetic North were deduced from the visual alignment of a magnetic compass. Recording was also made of ambient noise with the source switched off to ensure that the source noise levels were above background. Subsequent analysis in the laboratory was aimed at identifying the reference position that resulted in a time delay close to the maximum expected. This confirmed that these results correlated with the known direction of the simulated source

4. RESULTS

Figure 3 shows a comparison of the frequency spectrum of the simulated source (at a distance of 140m) with that of the background noise. The pump noise spectrum is generally broadband but with a dominant peak. In particular, levels below 500Hz are in excess of background noise. The characteristic peak at 195Hz exceeds the background by 18dB. Figure 4 shows the corresponding time delay between the two microphone signals.

FIGURE 3.
SPECTRA AT 140M

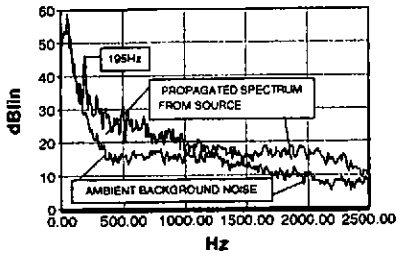
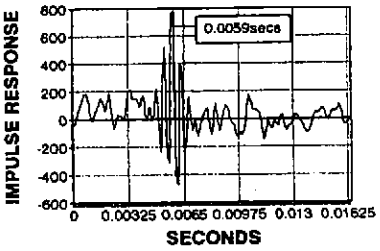


FIGURE 4.
IMPULSE RESPONSE AT 140M



The analysis of the recordings for impulse response functions yielded time delays for various microphone positions. Table 1 shows typical time delays obtained for a particular inline and offset scenario at various distances from the source. It indicates the source bearing deduced from the time delay measurements as well as the reference compass bearings from the field survey.

TABLE 1

	SOURCE INLINE			SOURCE OFFSET		
Distance from source	**60m**	**100m**	**140m**	**60m**	**100m**	**140m**
Time Delay(ms)	**5.8**	**5.88**	**5.88**	**3.5**	**4.0**	**3.5**
Microphone bearing * deduced from time delay	**N44E**	**N60E**	**N60E**	**N9W ***	**N13E ***	**N7E ***
Compass bearings from field survey	**N44E**	**N60E**	**N60E**	**N4W**	**N12E**	**N12E**

5. DISCUSSION

The results confirm the correlation between the visual compass bearings and those determined by time delay. The apparent lack of

consistency in Table 1 could be due to a combination of the following factors:- (a) errors in reading the magnetic compass, (b) errors in registered time delay due to changes in wind direction and (c) inadequate phase matching between the two microphones. Systematic quantification of these errors should lead to increased confidence level in source direction and location investigations. The results indicate that time delay using impulse response is useful for inferring the source direction of low frequency sound. The effectiveness of this approach is enhanced in circumstances wherein a clearly identifiable narrow band low frequency energy is part of an otherwise broadband spectrum (as stated in Ref 4). Wind speed and direction together with ground absorption can enhance or degrade the time delay. Ref.3 found that in any correlation methods unfavourable weather conditions can invalidate source location.

6. CONCLUSIONS

This investigation of impulse response function has shown that it can be useful in locating the direction of a low frequency noise source. The source spectrum should ideally be broadband with identifiable narrow band energy. Situations in which the method could be utilized are in location of a broadband source such as would be expected from a major industrial facility with many noise sources albeit with dominant low frequency components. Wind speed and direction can enhance or degrade the time delay. Further work is necessary to quantify these aspects and to investigate real sources.

7. REFERENCES

Ref. 1. - The Report of the Noise Review Working Party- 1990- HMSO

Ref. 2. - R. N. Vasudevan H.G.Levanthall- Annoyance Due to Environmental Low Frequency Noise and Source Location- A case Study - 1989 - Journal of Low Frequency Noise and Vibration Vol 8 No2.

Ref. 3. - D. Audoynaud et al 1975, The "Identification of a Source of Noise and the Measurement of its Effects by a Correlation Method", Review d'Acoustique, No34, 8-20 (Also RAE Library Translation No 1970, 3-28(1978)).

Ref. 4. - J.S.Bendat and A.G.Piersol - Engineering Applications of Correlation and Spectral Analysis.