Image Cover Sheet

CLASSIFICATION	SYSTEM NUMBER 65921
UNCLASSIFIED	

TITLE

ASSESSING THE EFFICACY OF ACTIVE NOISE REDUCTION \(paper presented at Defence Science Symposium, Ottawa, Ontario, Canada, 25 - 26 April 1990\)

System Number:

Patron Number:

Requester:

Notes:

DSIS Use only:

Deliver to: JR

ASSESSING THE EFFICACY OF ACTIVE NOISE REDUCTION

by Julia M Rylands

Defence and Civil Institute of Environmental Medicine
1133 Sheppard Ave West, P.O. Box 2000,
Downsview, Ontario, M3M 3B9

Background

Active noise reduction (ANR) is an electronic technique for reducing low frequency noise reaching the operator's ears. It works on the principle of reverse phase cancellation. First, noise entering the earcup of a flight helmet, headset or ear defender is sensed using a miniature microphone (Figure 1).

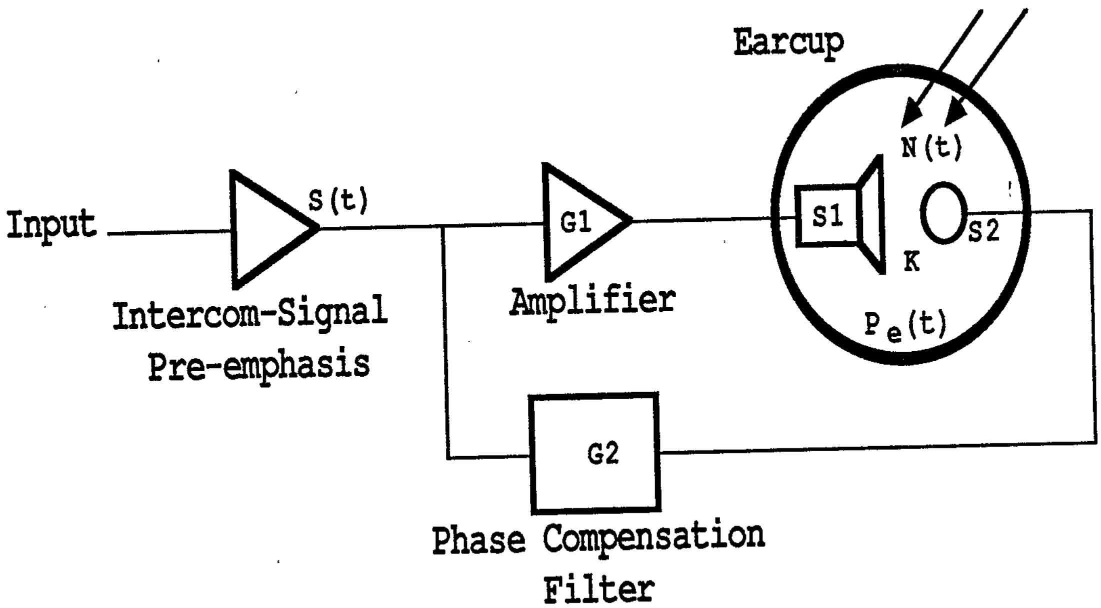

Figure 1 - Diagram of an Active Noise Reduction System

The signal from the microphone is then passed through a phase compensation filter which reverses the phase. This antiphase noise is amplified and passed back into the earcup through the helmet or headset transducer and then cancels the source waveforms. The low frequency component of any speech signal passed along the communication line is similarly affected by the ANR unless a speech pre-emphasis circuit is used to counteract this.

All the circuitry is on a chip or board fitted inside the headset earcup. The system requires is about 10 mA of current which may be delivered through the intercom cord or by self-contained battery. The ANR systems described in this paper are analogue. Digital ANR systems and 'In-ear' devices are currently under investigation by a number of organisations and promise to offer wider frequency range, adaptive filtering and better peak reductions.

Present analogue systems work over the range 31.5 Hz to 1000 Hz with a peak reduction around 500 Hz. Attenuations can reach 25 dB as can be seen in Figure 2. Some enhancement may be seen at either end of the attenuation spectrum where noise levels are higher with ANR than without it.

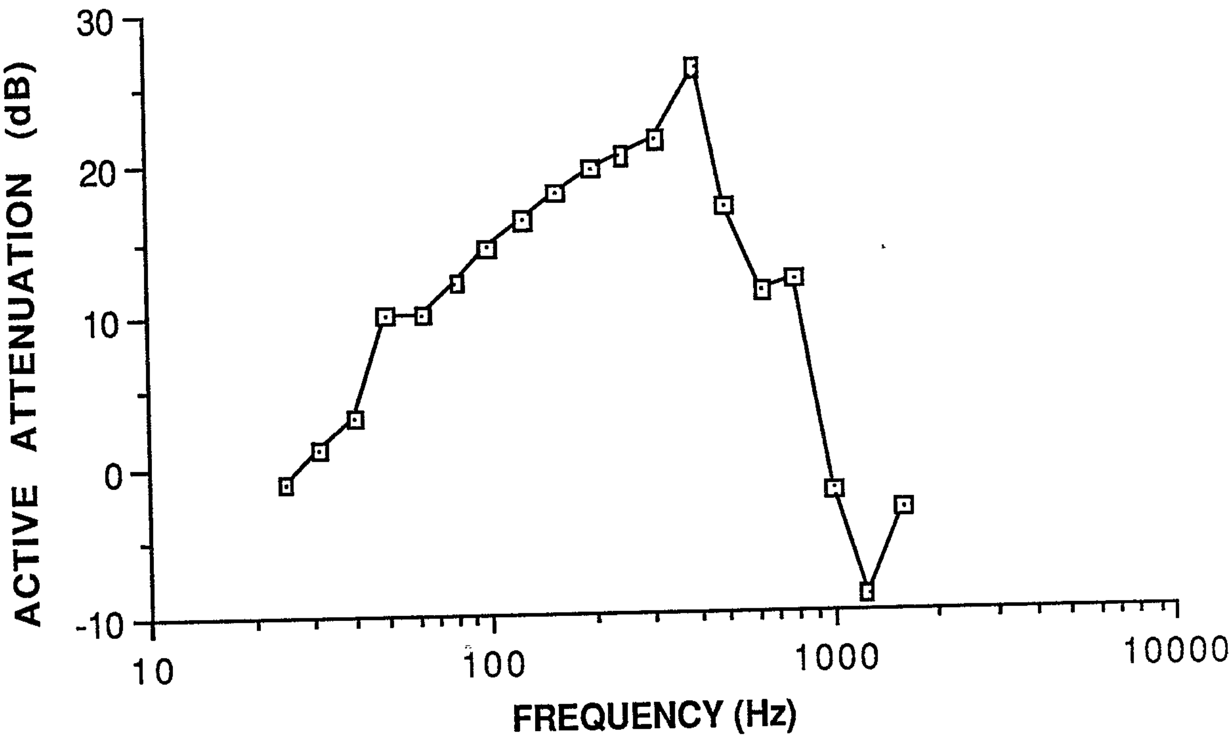

Figure 2. Attenuation provided by Active Noise Reduction

One of the major benefits offered by ANR is in the area of hearing conservation. It complements passive hearing protectors in the frequency range where they offer little attenuation. Since many military noise environments contain much energy at low frequency, ANR will allow increases in exposure times over that offered by passive means alone. One can see from Figure 3 the effect of ANR upon the low frequency attenuation of the SPH-5 flight helmet in the Chinook helicopter noise. The A-weighted noise exposure at the pilot's ear is reduced from 91.6 to 82 dBA, a reduction of 9.4 dB in overall A-weighted SPL. Because the low frequency components of the noise are de-emphasised by the A-weighting, however, the impact of ANR upon the noise reaching the pilot's ears is not fully appreciated.

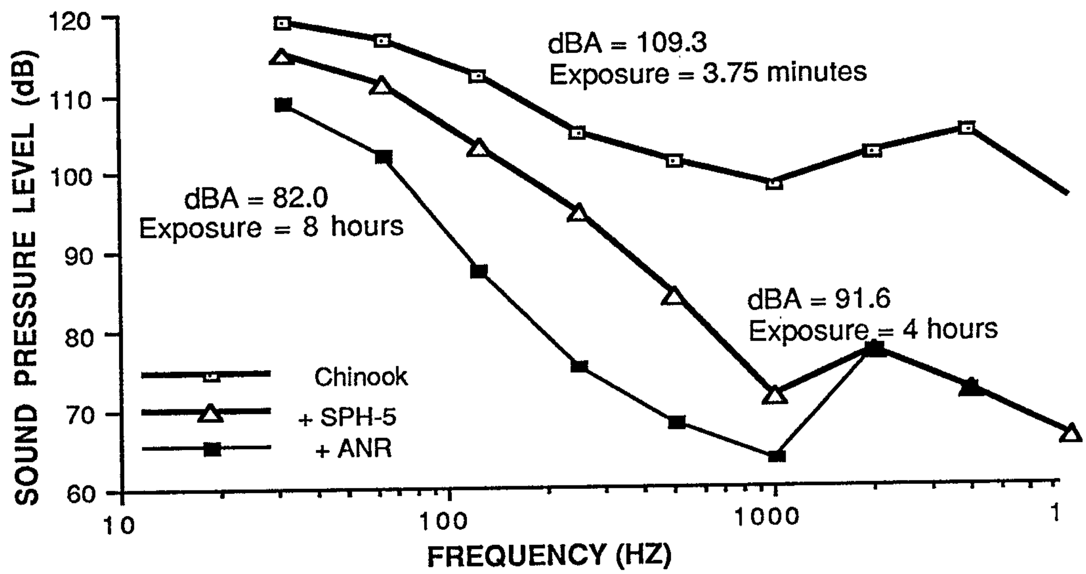

Figure 3. Noise Spectra in the Chinook helicopter

Evaluation Techniques

ANR systems have the potential to improve the attenuation characteristics of a headset or helmet and by doing so, increasing speech intelligibility and signal detection. In order to assess what attenuation these systems offer, a suitable test needs to be found. Passive attenuation is normally assessed using the Real Ear At Threshold (REAT) method. As ANR systems produce some electronic noise this will mask the hearing threshold and therefore overestimate the attenuation. Research is currently underway as to the best method of evaluation. To date, two psychoacoustic and a number of objective methods have been assessed. The psychoacoustic tests involved the measurement of loudness balance and masked threshold. The advantage of these tests is that they take bone conduction into account which will affect results at the higher frequencies. Unfortunatly, these psychoacoustic methods do not give reliable results at the low frequencies owing to the human's poor perceptual abilities at these low frequencies. As the ANR systems are still providing some attenuation below 63 Hz, it is important to find a method to measure this. In addition, psychoacoustic tests are not easily administered in the field.

On the other hand, objective tests are easy to use in the field and measurements can be made at very low frequencies. However, they do not take into account bone conduction or the effect of the ear canal and therefore show some discrepancies at higher frequencies. To date the best objective method for testing ANR systems in the field and laboratory is by using a miniature microphone mounted at the entrance to the ear canal. The microphone picks up the noise reaching the ear which is then recorded. A comparision can be made between the spectrum recorded with ANR 'Off' and 'On' to give a measure of active attenuation. Correlations of the psychoacoustic and objective measures have been made and are good at the mid range frequencies. (Figure 4).

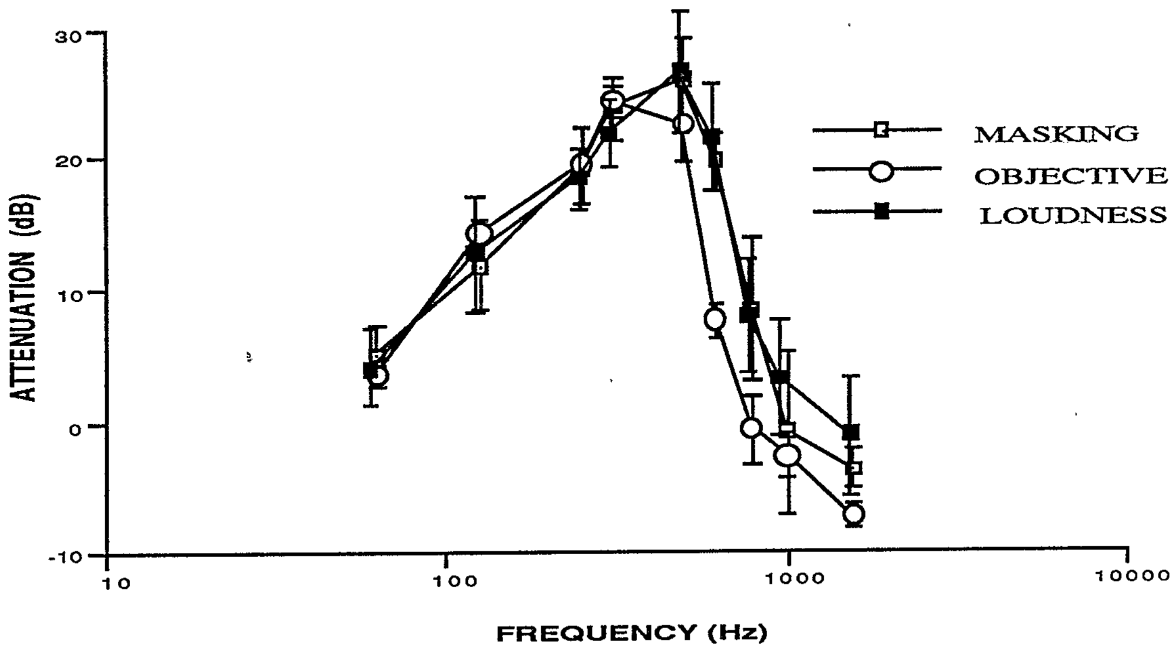

Figure 4. Comparison of Active Noise Reduction Assessment Techniques

A strategy is being developed to use the strengths of both methods and if the objective method is adopted for use in the laboratory and field, then an algorithm will be developed to account for bone conduction and the effect of the ear canal volume. Hence values of attenuation at the higher frequencies which are measured using the objective method will be adjusted according to the algorithm.

Signal Detection Effects

Improvement in noise attenuation is not the complete story. ANR has also shown to improve signal detection. This was assessed using the masked threshold test. Pure tones signals were delivered at typical auditory sonar display frequencies (750, 1000, 1250, 1500, 1750 Hz) with the masking noise field being typical of a Sea King helicopter. A comparison of objective noise attenuation with improvement in signal detection performance in Sea King helicopter noise (Figure 5) shows no direct relationship. Whereas ANR attenuation (improved S/N) is generally greatest (>20 dB) between about 300 and 600 Hz, improvements in detection performance (>25 dB) extend up to at least 1000 Hz. This is due partly to a reduction in the upward spread of masking (Figure 6) by the intense energy in the low-order harmonics of the main-rotor noise.

It is important, when assessing the effects of ANR on signal detection to remember that parameters such as the signal pre-emphasis, noise field and communication link will affect the result. Hence results obtained in the laboratory cannot be directly extrapolated to the field or to other systems. At present a more realistic sonar detection task, which takes into account reverberations as well as the helicopter noise, is being developed. The task can be used in the field as well as the laboratory. The effect of ANR on the doppler shift aspect of the sonar operators task will also be assessed.

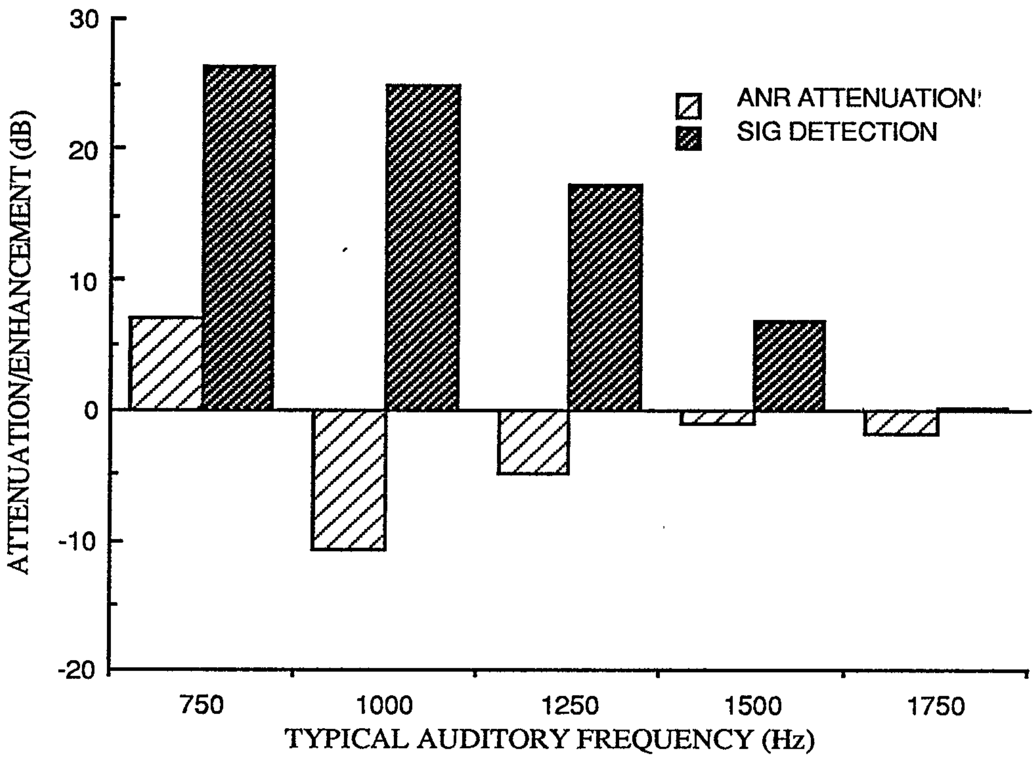

Figure 5. Effect of Active Noise Reduction on Signal Detection

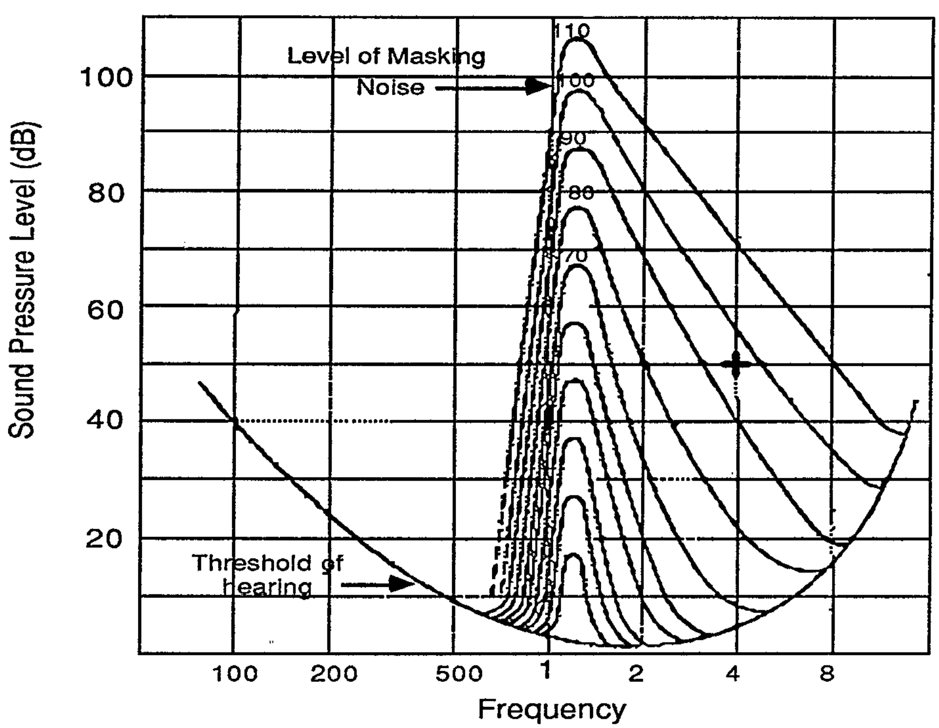

Figure 6. Upward spread of masking (after Zwicker,1954)

Speech Intelligibility Effects

ANR can also offer improved intercom speech intelligibility in a high noise environment, again by reducing the upward spread of masking and adding speech pre-emphasis. Speech intelligibility can be tested using subjective or objective methods. One of the objective methods that can be used is STIDAS (Speech Transmission Index Device using Artificial Signals) system (Steeneken, et al 1980). This system produces a simulated speech signal in terms of the frequency and tempòral characteristics. The signal is passed to the earphone of the helmet/headset on a subject who is in a broadband diffuse noise field. The return signal from a miniature microphone mounted at the ear is passed back to the STIDAS for computation of the Speech Transmission Index. This can be related to subjective intelligibility scores. This method, although expedient in terms of time will likely underestimate the true improvement in intelligibility from ANR, as it does not take into account upward spread of masking. If time permits subjective intelligibility tests should be used to assess the benefits of ANR in this area.

Summary

The basic concept of ANR has been outlined along with what it is capable of and a few of the approaches to assessing its efficacy. The technique is undoubtedly a great enhancement to hearing protection development and on the operational side to signal detection and enhanced communications. As far as the Canadian Forces are concerned various ANR systems will be tested in the laboratory, in the Sea King, Chinook and tracked vehicles. Although the emphasis is, at present, on providing a good acoustic environment for the sonar operator in the New Shipboard Aircraft, we hope the systems get wider acceptance in the CF in terms of improving hearing protection and enhancing communications.

References

Steenekin, H.J.M., and Houtgast, T. (1980). A physical method for measuring speech-transmission quality. J. Acoust. Soc. Am. 67, 318-326.

Zwicker, E. (1954). Die Verdeckung von Schmalbandgerauschen durch Sinustone. Acustica 4, Beiheft 1.415

JUL JUIL 26 1990

NO. OF COPIES NOMBRE DE COPIES	COPY NO. COPIE Nº	INFORMATION SCIENTIST'S INITIALS INITIALES DE L'AGENT D'INFORMATION SCIENTIFIQUE
1	1	BC
AQUISITION ROUTE FOURNI PAR ▶	DCIEM	
DATE ▶	25 July 90	
DSIS ACCESSION NO. NUMÉRO DSIS ▶	90-03678	

DND 1158 (6-87)

National Defence Défense nationale

[redacted]

DIRECTOR
SCIENTIFIC INFORMATION SERVICES
NATIONAL DEFENCE
HEADQUARTERS
OTTAWA, ONT. - CANADA K1A 0K2

DIRECTEUR
SERVICES D'INFORMATION SCIENTIFIQUES
QUARTIER GÉNÉRAL
DE LA DÉFENSE NATIONALE
OTTAWA, ONT. - CANADA K1A 0K2

#65921