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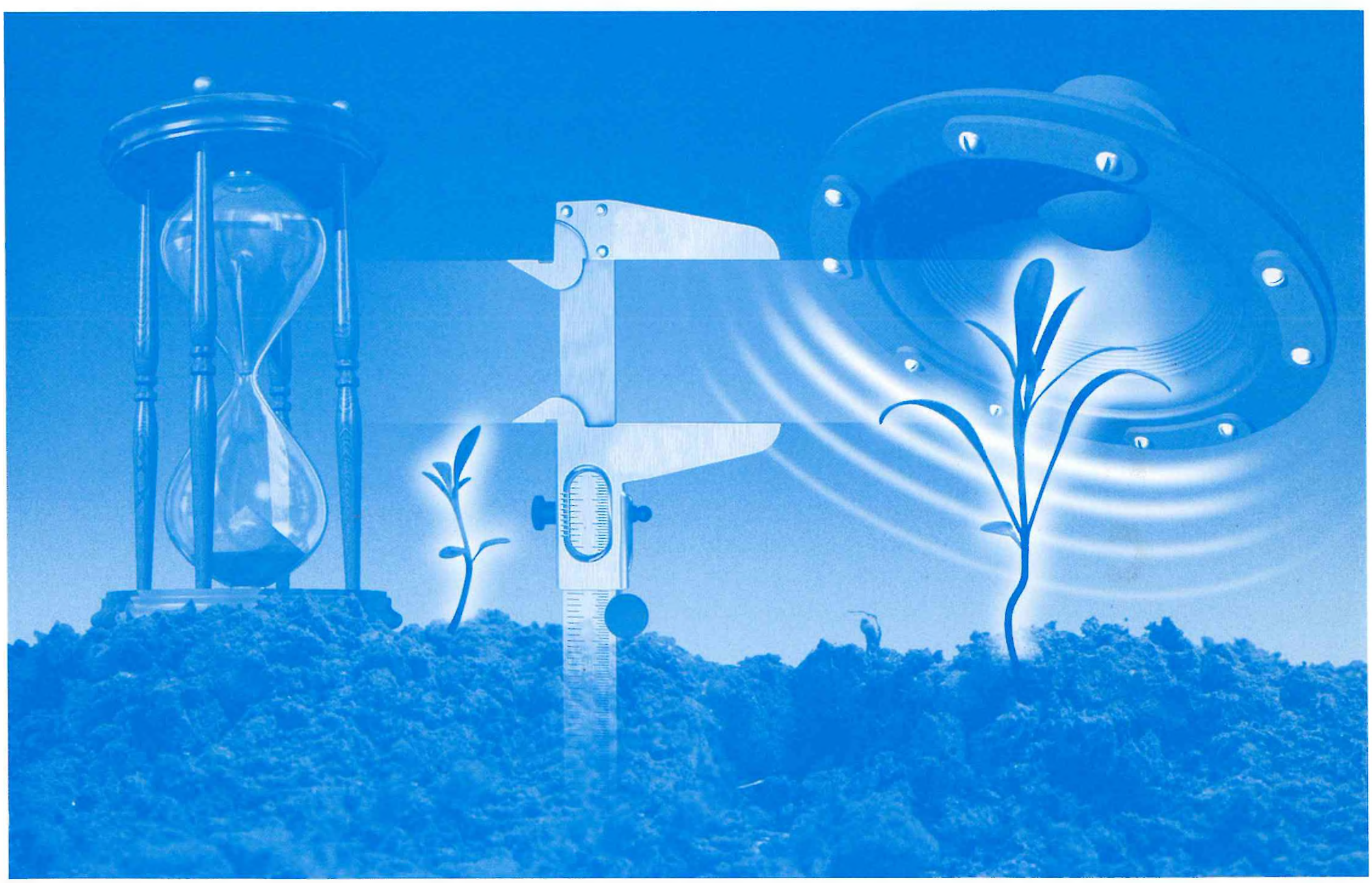

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EDITORIAL / ÉDITORIAL

Finally, we have begun. One of the tasks I had imposed on myself was to bring out brief articles on the research work undertaken by Canadian labs and academic institutions in acoustics, noise and noise control. It has taken me nearly two years to break the ice. And now, we have a brief article on the research conducted by the Institute of Biomaterials and Biomedical Engineering at the University of Toronto. Hopefully, the next article would be on the acoustic work undertaken by different institutes of the National Research Council. I implore the many other institutions to prepare similar articles and submit them to the journal. Let me hope that there is a deluge.

In the same vein, I have been attempting to collect information, such as abstracts, of the acoustic conferences that are being held in Canada. For instance, ICANOV (International Conference in the Area of Acoustics, Noise and Vibrations) conference, planned for August 2001, is to be held in Ottawa. And we are hopeful that we can publish some information on the conference in Canadian Acoustics. Unfortunately, my efforts have been unsuccessful so far. However, I am yet to give up. If any of you are organizing or part of an organizing committee of an acoustic or vibration conference to be held in Canada, please contact one of the editors to collaborate on some joint information publication.

The next Acoustics Week in Canada is to be held in Nottawasaga Inn, an hour drive north of Toronto, Ontario. It is shaping up to be a grand affair. Please do plan to attend the conference and start making your travel plans. And I hope to see you there!

Nous avons finalement commencé. Une des taches que je me suis imposé était de publier des articles courts sur les travaux de recherche en acoustique, bruit et contrôle du bruit entrepris par les laboratoires canadiens et les institutions académiques. Il m'a fallu presque deux ans pour y parvenir. Maintenant, nous avons un article sur la recherche effectuée par l'institut de l'Ingénierie des Biomatériaux et Biomédical de l'Université de Toronto. Espérant que le prochain article traitera les travaux d'acoustique effectués par les différents instituts du Centre Nationale de la Recherche. Je prie les diverses autres institutions de préparer des articles similaires et de les envoyer au journal.

Sur le même plan, je suis entrain d'essayer de collecter des informations, telle que les résumés des conférences en acoustique qui ont lieu au Canada. Par exemple, la conférence ICANOV (International Conference in the Area of Acoustics, Noise and Vibrations) planifiée pour le mois Août 2001 aura lieu à Ottawa. Nous espérons pouvoir publier quelques informations de la conférence dans le journal Acoustique Canadienne. Malheureusement, mes efforts n'ont pu aboutir. Cependant, je ne suis pas encore prêt à céder. Si quelqu'un d'entre vous est entrain d'organiser ou fait parti d'un comité d'organisation d'une conférence en acoustique ou vibration qui aura lieu au Canada, contacter, s'il vous plaît, un des éditeurs du journal.

La prochaine Semaine d'Acoustique au Canada aura lieu à Nottawasaga Inn, à une heure de route au Nord de Toronto, Ontario. La conférence est entrain de prendre forme d'un grand événement. Prenez, 'il vous plaît, vos dispositions dés maintenant pour y assister et commencer par planifier votre voyage. J'espère vous voir là-bas!

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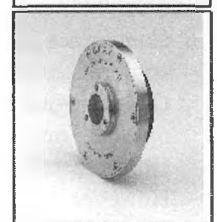

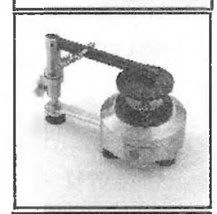

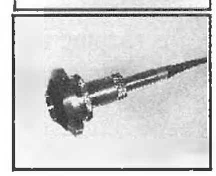

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THE EFFECT OF SOUND ON THE GROWTH OF PLANTS

Margaret E. Collins* and John E.K. Foreman
The University of Western Ontario, London, Canada
*Ms. Collins is now deceased

ABSTRACT

This project is intended to show how the rate of growth of two different plant species was affected by sounds of varying frequencies. Two plant species, beans and impatiens, were selected because of their relatively fast growing rates. Ambient conditions were regulated by environmental chambers in which the plants were housed. One chamber was used as a control for the plants, and the plants in the other chambers were subjected to sounds of different frequencies at roughly the same sound intensity. Sounds of pure tones and random [wide band] noise were used. The changes in the growth of the plants were monitored every two days for twenty-eight days. Upon completion of the tests, it was observed that optimum plant growth occurred when the plant was exposed to pure tones in which the wavelength coincided with the average of major leaf dimensions. It is suggested that this was due to the "scrubbing" action of the traversing wave, causing air particle motion on the surface of the leaf; this movement removed the stagnant air layer adjacent to the leaf, thus increasing the transpiration of the plant. It was also noted that the plant growth was less when exposed to random noise.

SOMMAIRE

Ce project avait pour but de montrer comment le taux de croissance des deux espèces de plantes être influé par une varieté d'ondes sonores. Les deux espèces, des haricots et des impatiens, ont été choisis à cause de leur croissance rapide. Les plantes furent placées dans des sailles donc les conditions ambiantes étaient réglées selon les critères environnmentales. Une salle servit de contrôle pour les plantes. Dans les autres salles, les plantes furent exposées à divers ondes sonores d'environnment à la même intensité. Des ondes sonores claires et croissant au hazard furent difusées. Les taux de croissance furent servi des près. C'est à dire, à tout les deux jours jusqu'au visit-huitième jour. A la fin de ces tests, nous avons observé été la croissance optimum a eu lieu dans les plantes exposèes aux ondies sonores claires, et que la longeur des ces ondes coincidait avec la dimension moyenne des feuilles. On suggère que ceci s'est produit quand les ondes sonores ont "balayé" les particules dans l'air sur la surface de la feuille. Ce dèplacement d'air stagnnat attenant la feille permet ensuite à celle-ci d'augmenter la transpiration végétale. Aussi, nous avons observé une baisse de croissance dans les plantes exposées aux ondes sonores choisies au hazard.

1. INTRODUCTION

Very little research has been conducted on the specific effect of the growth of plants subjected to sounds of varying intensity and frequency. Any environmental factor that places a biological system under stress can affect its performance and/or behaviour. The effect of sound on physiology and behaviour of animals and man has been studied by various researchers [1, 2, 3, 11, 13, 14]. However, only a limited amount of detailed information is available on the effect of sound on plant systems [4, 8, 9, 10, 12].

An article entitled "The Effect of Noise on Plant Growth" [4], stimulated an interest in further research in this field. The author, A.E. Lord, performed random noise experiments on coleus plants in which one group was subjected to random noise and a second group was used as a control. Lord came to the conclusion that botanists had not carried out sufficient experiments to show causes behind the effects that he observed, and he put forward the idea that the rate of water transpired out of the leaves is affected by the sound. Transpiration, in turn, affects growth. Typical leaf structures and the topic of transpiration can be found in textbooks on botany [e.g. reference 15, 18, 19, 20].

It has been reported [5, 6, 7] that music will increase plant growth, but it is not known what preferred frequencies (if any) in the music have the most pronounced effect on plant growth. Many of the papers (see above) had very little detail about the conditions under which the plants were grown, how conditions were controlled [or if they even were controlled], and exactly how the growth rates were monitored.

Singh and Ponniah [5, 6] were two of the pioneers in this work. They played obscure violin pieces intermittently to plants at certain times of the day, and they occasionally made use of tuning forks as the sound source. Very seldom, if ever, were the experimental methods or type of analysis revealed. Generally, a table of results was presented and it was left to the reader's imagination to determine how these results were obtained. Singh's work was referred to extensively in the original article by Lord. Very little constructive information was obtained from this source.

One of the more amusing accounts of sound tests on plants appeared in the May 1993 issue of Popular Mechanics, entitled "Growing Corn to Music" [7]. It was seen that the "music" plants sprouted faster, were greener, and their stems were thicker and tougher than the "silent" plants. Although the results were interesting, this article is not scientifically grounded.

An interesting paper was obtained from the Internet by Bruce M. Pixton, titled "Plant Growth in a Sound Polluted Environment" [12]. He did not use environmental chambers, but built a box with three side-by-side sections with soil in the bottoms; one section was used for control seeds, and the other two were subjected to sounds (pure tones and random) from audio speakers at the bottom of each partition under the soil. The loud sounds were audible in the room. He played sounds of 5,000 Hz and 13,300 Hz to alyssum seeds, both before their germination and after they had sprouted. He compared the number of seeds sprouted and the sprouts which were 2 cm or taller with the control group of seeds, all under similar ambient conditions, i.e. room conditions and light from a window. He concluded that loud, high frequency, sound tones increased the rate of plants sprouting and growth. He noted that the random noise had the opposite effect. He did not venture a reason for this.

Pearl Weinberger and Mary Measures, at the University of Ottawa [8, 9], experimented with spring wheat [Marquis] and winter wheat [Rideau], exposing the plants to varying frequencies either during the germination period, or during the growth period, and sometimes during both periods. They observed a marked increase in the growth stimulation of plants treated with 5 kHz sound when compared with controls (with no sound). In these experiments, their time was limited, and hence it was thought that their results were not extended over a sufficiently long period of time.

The only other paper with any relevance to this project dealt with the effects of random noise on tobacco plants [10]. Woodlief, Roysier and Huang, did not use a control group as the technique of determining the growth rate for tobacco plants. It was found that there was a significant decrease in the slope of the growth rate curve after the noise was imposed, and the conclusion was that the random noise environment was detrimental to the growth rate of the plants. To quote from their paper, "the sensitivity of the plants to the random noise environment seemed to be coupled with initial plant size in that the smaller plants seemed to be more sensitive to this environment".

Many of the papers from the literature did not have applicability to this experiment, as was the explanation of results. However, Lord's idea about the rate of water transpired out of the leaves being affected by the sound provided the basis for the analysis made in this paper.

2. APPARATUS AND PROCEDURE

The plants were housed in environmental chambers, 162 cm high, 153 cm wide, 84 cm deep with 2 cm thick walls [Figure 1]. The environmental chambers were made by Percival Co. of Boone, Iowa, U.S.A. They controlled the temperature and

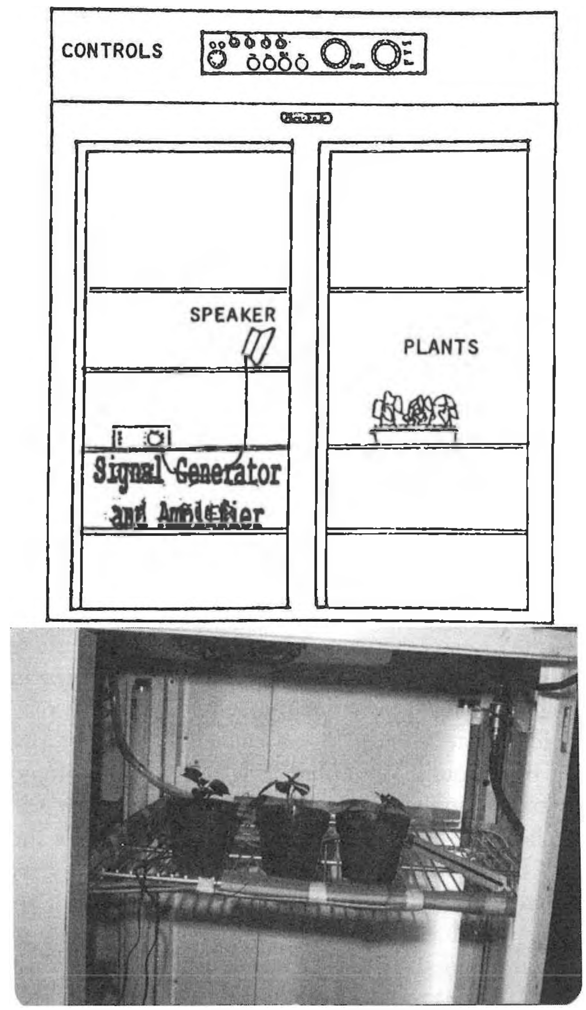

Figure 1. Environmental Chamber

lighting, and provided a constant flow of air by means of in-built fans and vents. The operating specifications of the chambers were: Photoperiod: DAY/NIGHT; Thermoperiod: 0 to 150 degrees F / 15 to 65 degrees C; and Fluorescent lighting: 6 tubes, cool white, 40 W

The chambers had separate controls to regulate light intensity, temperature and airflow. There was minimal air movement in the chambers. Either two or three of these chambers – all identical – were used during the twenty-eight day test period. The watering rate of the plants was monitored manually using a graduated cylinder. The sound was produced by a signal generator, amplifier and a speaker, which were placed inside the chamber [see Figure 1]. Each signal generator had a range of twenty to twenty thousand Hertz [cycles per second-Hz] and was capable of producing the frequency as a single sine wave or as a mixture of frequencies over a range [equal energy per unit bandwidth – white or random noise]. These signal generators and amplifiers were constructed by the Electronics Shop of the Faculty of Engineering Science. The speakers were co-axial, made by Altec and capable of a frequency response of twenty to fifteen thousand Hz. The sound pressure level was the same in all of the chambers, and averaged 91 to 94 decibels, measured on the linear scale with a Bruel and Kjaer Sound Level Meter and a one-half inch microphone. These measurements were taken at eight different positions around the plants, averaged, and monitored regularly. [See reference 16 for a description of the meter and microphone.]

The Plant Science Department at The University of Western Ontario offered its services in helping to set up an experiment, in choosing suitable plants, providing the environmental chambers, and helping to analyze the results. The Sound and Vibration Laboratory of the Faculty of Engineering Science provided the sound generating and measuring equipment.

The impatiens plants were started from cuttings four weeks before the start of the test days. From four to eight of the plants were used in each test. Cuttings from one impatiens plant were taken initially and placed in the potting beds in the greenhouse. All of the impatiens plants used later in the experiments were propagated from these initial cuttings. To take cuttings from the same plant is the only way to get plants as genetically close as possible [15]. This is termed cloning and is a fairly important genetic control. The beans, Dwarfbush Stringless Green Pod, were grown from seed seven days before the experiments started. It was not necessary to use cuttings from beans; they grow rapidly. Again, four to eight plants were housed in each chamber, along with the impatiens plants, during the testing.

It should be noted that, even though there was a reverberant sound field in the chamber [due to reflections], it is believed that the major sound which affected the plants was in the direct path of the sound from the speakers. This can be seen in the schematic drawing in Figure 1, and is explained in detail in References 1 and 13. (See Conclusions and Recommendations with regard to further study.)

Due to the fact that there was a minimum of space in the chamber, which was in the direct path of the sound, only two different species of plants were tested in each chamber. Ideally, a larger number of different species should have been tested, as the results may not be generally applicable to all kinds of plants. The ones used in this project were both green and leafy, and anything that was happening in the leaves or stem would be reflected in the subsequent height of the plant. Seven groups of plants were tested. The first four tests of sound experiments were chosen randomly. It was decided to test with random noise, a low frequency sound [500 Hz] and other higher frequency sounds. Those chosen were 5,000 Hz and 12,000 Hz. For reasons discussed later, 6,000 Hz and 14,000 Hz were selected as the last two frequencies to be tested.

The plants were watered daily, each species receiving the same quantity of water. The height measurements were taken every two days with the plant extended to its full length, and recorded. The measurements were taken over a twenty-eight day testing period.

3. DISCUSSION AND OBSERVATIONS

At the outset of these experiments, it was reasoned that there might be a relationship between the wavelength of the sound generated and a characteristic dimension of the leaf.

Figure 2 represents the outline of a bean leaf, and there is a small particle of air moving back and forth on the surface of the leaf with velocities of positive and negative "u" [11, 13]. This wave movement occurs as a result of the diaphragm of the speaker moving back and forth, setting up a travelling compression and rarefaction wave. The compression results

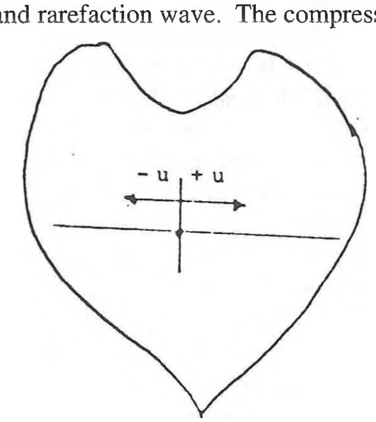

Figure 2. Sound Propgation along a leaf

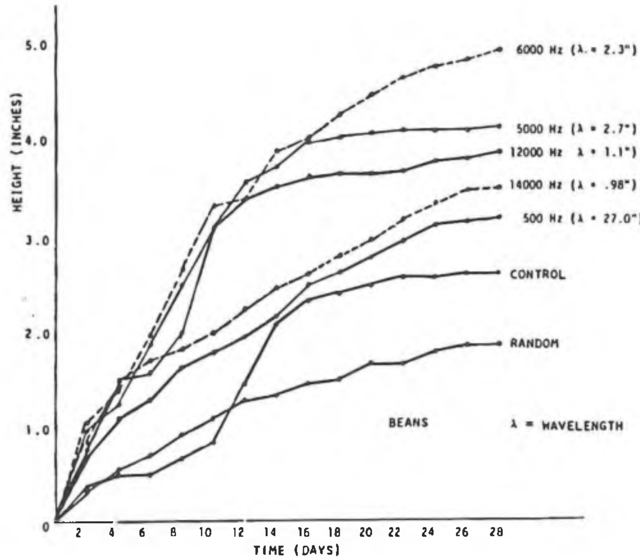

Figure 3. Plant Growth Characteristics Curves for Bean Plants

in a positive pressure [above atmospheric] and the rarefaction in a negative pressure [below atmospheric]. This is propagated across the surface of the leaf and is commonly represented as a sinusoidal air pressure variation. The particle velocity is proportional to the sound pressure [13], and a positive pressure results in a positive particle velocity, the magnitude of the velocity being proportional to the pressure at any point as it moves across the leaf. The same process results from a negative pressure, only with the particle velocity in the opposite direction. This creates a scrubbing or brushing action on the surface of the leaf, which wipes away any stagnant film of moisture and allows the plant to breathe [transpire] more freely [15, 19].

The first four sets of sound results obtained, which were for the random noise, 500 Hz, 5,000 Hz, and 12,000 Hz, seemed to bear out the contention that the relationship between the frequency [and its wavelength] and the dimension of the leaf had some effect [Figures 3 and 4]. The average dimension for the bean leaf [measured from the control group] gave values of 2.4 inches by 2.4 inches. A wavelength of 2.4 inches corresponds to a frequency of 5,600 Hz for the given conditions. The best results for the beans had been for 5,000 Hz [wavelength = 2.7 inches], so that 6,000 Hz was chosen as one of the two remaining frequencies to be tested. It has a wavelength of 2.3 inches and, as can be seen in the results [Figure 3], gave the best growth curve for the bean plants.

The average dimensions for the impatiens leaf [again measured from the control group] gave values of 1.0 inch by 1.7 inches. A wavelength of 1.0 inch corresponds to a frequency of 13,500 Hz and the 1.7 inches to a frequency of 8,000 Hz. For the impatiens, the best results had been for the 12,000 Hz frequency [wavelength = 1.1 inches], so the 1.0 inch dimension was narrowed in on [average width of leaf] and a frequency of 14,000 Hz was chosen with a wavelength of .98 inch [Figure 4]. This gave the best results for the impatiens plants.

When the growth changes, measured every two days, were plotted for the complete test period and all frequencies, the growth characteristic curves resulted [Figures 3 and 4]. The horizontal axis represents the time in days and the vertical axis the height in inches.

Higher frequencies, and hence smaller wavelength, would result in a wave with more nodal points on the leaf, which are points of zero pressure with respect to atmospheric, or points of zero velocity. This means that there are more places on the leaf surface where the film of moisture is not being removed. These higher frequencies were tested for the beans, and the results were not as good as the results for the higher frequencies close to the preferred one where the wavelength was approximately equal to the dimension of the leaf [Figure 3].

One might suspect that a wavelength that corresponds to two times the dimension of the leaf might give the best results. This has the least number of these nodal points, but there was insufficient time to test this idea.

As a result of previous work, it was expected that the effect of the random noise on the plants would cause a decrease in their growth rate [10]. Any experiments to date have found that this is the manner in which plants respond to random noise [4, 10 and 12]. The bean plants [Figure 3] responded as expected, but the impatiens plants [Figure 4] showed an improved growth rate [as compared to the control group].

Woodlief [10] did observe that the smaller tobacco plants

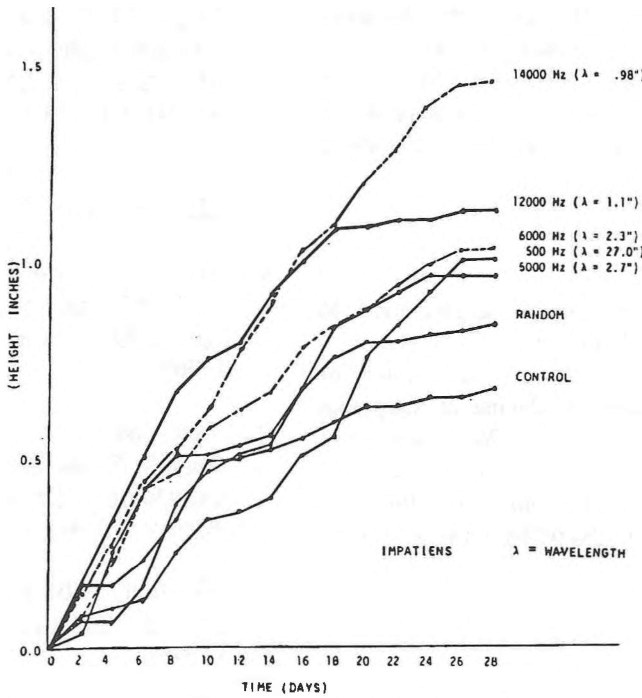

Figure 4. Plant Growth Characteristics Curves for Impatien Plants

that he tested were more affected by the sound. In this experiment, the beans were just beginning to germinate at the outset of testing, while the impatiens plants were well developed at four weeks. This could be the reason for the more pronounced effect on the bean plants. Had the testing extended further, it is possible that the random noise impatiens' growth rate would fall below that of the control group. This points warrants further investigation.

A statistical analysis of the results, as carried out by Wai Keung Li of the Faculty of Social Science, is given in reference 17. This analysis showed that of the fixed frequencies, random frequencies and control, the fixed frequencies have a significant effect on plant growth when compared with random frequencies and the control.

4. CONCLUSIONS AND RECOMMENDATIONS

From the results of the experiments as shown in Figures 3 and 4, it is clear that, in time, i.e. after 28 days of testing, the optimum growth of both the beans and the impatiens plants occurred when the wavelength of the sound coincided with the plant leaf dimension. This conclusion cannot be drawn for the growth periods of up to about 16 days. Below this the results are mixed and inconclusive. It should be noted that, for the beans, the growth with the random noise was less than the growth with any of the pure tones. There was not this marked difference between the growth in the impatiens plants when subjected to random and pure tones [Figure 4]. In the latter days of the testing, growth with the random noise was less with the bean plants [Figure 3] than with the impatiens plants [Figure 4]. This is something that warrants further testing, especially with a larger number of plants, perhaps a larger species variety, and a longer testing period.

It might be assumed that the growth rate of the plants when exposed to pure tones [with a wavelength coincidental with the leaf width] at a higher sound pressure level [above 90 decibels] would be even greater than measured in these experiments. Further, it is noted that the sound tone frequency where the wavelength equals twice the plant leaf dimension might be tested to determine if this would be the optimum frequency for the best growth results. These points should be investigated in further studies.

It should be noted that the correlation between wavelength and leaf size, and resulting increase in transpiration, is but one potential explanation of the observed plant growth. However, there are many physiological processes at play in the general phenomenon of growth. The effects of sound wavelength under several regimes of light intensity and relative humidity should be studied; physiologically, it would be interesting to explore the potential effect of sound wavelength on the rate of extension of the leaf after it is formed; and biochemically, it would be interesting to look at the effect of sound wavelength on the rate of photosynthesis in leaves of varying ages.

In addition to the recommendations mentioned above, there is a further aspect of the study which bears investigation. It was assumed that the effect of reflection in the chambers would be of little consequence because the plants were placed in the direct path of the sound from the speaker. Ideally, the tests should be conducted in a non-reverberant environment (i.e. an acoustical or semi-acoustical chamber).

5. ACKNOWLEDGEMENTS

The author would like to express his appreciation to Professors D. Fahselt and A. Maun of the Department of Plant Sciences and the Sound and Vibration Laboratory of The University of Western Ontario for the use of equipment in this experiment. He is also grateful to Wai Keung Li of the Faculty of Social Sciences for his careful statistical analysis of data. Further, the author acknowledges the capable assistance of Mary Daniel in the preparation and typing of this manuscript.

6. EPILOGUE

This work was conducted in 1979 by Margaret E. Collins while she was a student in Mechanical Engineering at the Faculty of Engineering Science of The University of Western Ontario. I was her supervisor and we were assisted by the Department of Plant Sciences at the University [see Acknowledgements]. The work was recorded in her thesis as part requirement for ES 400 - Project, Thesis and Seminar. Ms. Collins is now deceased and this paper is written to her memory.
John E.K. Foreman, Professor Emeritus, May, 2001

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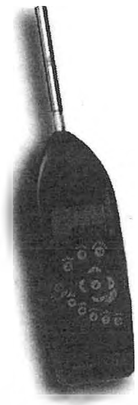

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TECHNIQUES FOR USING RAY TRACING FOR COMPLICATED SPACES

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ABSTRACT

During the last decade, the ray tracing method has contributed considerably to improve the prediction accuracy of acoustic room modelling. Ray tracing methods allow the analysis of complicated sound field for any room. However, the use of these methods and their validation are not always trivial. Even so, right and useful modelling is obtained only when each construction stage of the model is well done. The objective of this paper is to present, through a complicated example (a hydroelectric power station), some original techniques of modelling and validation. The identification of noise sources and the determination of their acoustic power, the representation of a non-single point source, the validation and some modelling techniques meant to reduce time computation will be presented. Furthermore, an efficient method for the evaluation of noise reduction provided by the various treatments will also be shown. This method, based on an evaluation of transfer functions between noise sources and different computation points in the room, can be used to choose the best acoustic treatment for a given noise reduction objective. All techniques presented in this paper have been applied and validated on an industrial case.

SOMMAIRE

Durant la dernière décennie, la méthode du tir de rayon a contribué à améliorer considérablement la qualité des prédictions en acoustique prévisionnelle. Cette méthode permet l'analyse du champ sonore de bâtiments complexes à partir de modèles géométriques. Les méthodes d'élaboration et de validation de ces modèles ne sont cependant pas toujours triviales. Pourtant, c'est la qualité de ces méthodes qui rend possible l'obtention d'un modèle juste et utile. L'objectif de cet article est de présenter, à l'aide d'un exemple de modélisation complexe (une centrale hydroélectrique), des techniques originales de modélisation et de validation. La détermination des sources de bruit et de leur puissance acoustique, la représentation des sources non ponctuelles, la validation et les différentes techniques de modélisation pour réduire les temps de calcul seront présentées. De plus, une méthode permettant d'évaluer de façon efficace les réductions de bruit apportées par les différents traitements envisagés sera exposée. Cette méthode, basée sur l'évaluation des fonctions de transfert entre les sources de bruit et les différents points de calcul du bâtiment, permet de choisir le traitement le plus performant en fonction des objectifs de réduction. Toutes les techniques présentées dans cet article ont été appliquées et validées sur un cas industriel.

1 INTRODUCTION

In the field of industrial acoustic room modelling, the main objective is the estimate of the noise reduction of treatments applied on noise sources and/or on room walls. The modelling technique and the estimation of the cost of treatments give industries the opportunity to carry out an optimum choice to reduce the noise levels in their plant. To predict the sound field, industries or acoustic consultants have many available models [1]. Simplified models, based on an empirical formulation or on a data library, can be used to rapidly obtain an estimation of the treatment performance for a simple room. However, for more complicated room cases like the one presented in this paper, the model has to be sufficiently accurate in order to do a suitable evaluation of the various acoustic treatments possible. For these cases, the use of a model that can represent a complicated geometry and frequencies dependency is essential. The ray tracing, based on a geometric method, is an example of a model with appropriate features for complicated room modelling [2 and 3]. RAYSCAT [4] software was used to build the model presented in this paper.

RAYSCAT uses only a ray tracing method and not the hybrid method (images/ray tracing). A large number of rays are launched randomly by each specified noise source. Receivers within a certain volume are used to estimate the noise generated by these sources by summing the energy of the rays passing through the receiver. The walls of the room are modelled by absorbent surfaces. For more information about techniques and hypothesis used by RAYSCAT see reference [4].

Even though the choice of the particular ray tracing model is of primary importance, the various development stages such as the location and determination of the acoustic power of the noise sources, the geometric estimation of the shape of the room, the determination of room wall absorption coefficients and the use of simplifying hypothesis of the model are all equally crucial. So, the objective of this paper is to present a systematic modelling approach in order to obtain an efficient and valid acoustic model for a complicated room. To illustrate this approach, the case of a hydroelectric power station with five floors will be analysed.

The complicated room modelling approach will be presented following these stages:

1 Presentation of the studied case
2 Development of the model and techniques of calculation time reduction
3 Validation of the model with a reference source
4 Identification and acoustic power measurement of noise sources
5 Evaluation techniques of acoustic treatments

2 CASE STUDY DESCRIPTION

Alcan's hydroelectric power station (*Chute-des-Passes*) is located 200 km north of Alma City (Québec, Canada). The building, shown in Figure 1, is underground and has five alternator groups of 250 megawatts each, distributed over five floors. Each group has one turbine and one generator (Figures 2 and 3). The generator head and control instruments are on Floor 5. The generator itself is located on Floor 4, in a large room. The shaft between the generator and the turbine is on Floor 3 and is isolated in a large volute. The turbine is distributed over the first and second floors. The water exhausts from the turbine into a very large spherical valve that takes up most of the space on the Floors 1 and 2. The building has a very complicated geometry. The noise sources are numerous and are distributed on all floors. The objective of the project is to specify what treatments to use, at a minimum cost, to obtain a noise level below 85 dB(A) on Floor 5 (station main floor) and below 87 dB(A) on Floors 1 through 4.

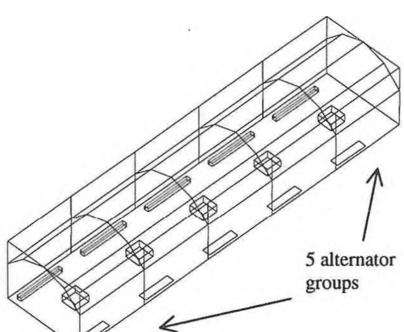

Figure 1 Global diagram of the Floor 5

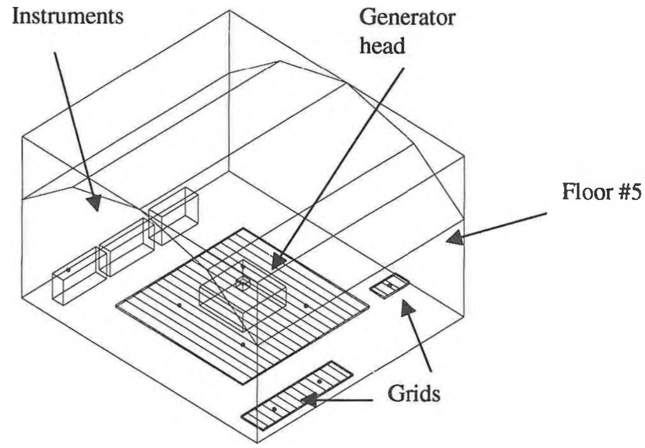

Figure 2 Detailed diagram of one station section for Floor 5

Since Floor 5 is almost totally isolated from the other four floors, the acoustic model of the station is split into two distinctive models: one for the Floors 1 through 4 and a second one for the Floor 5.

2.1 Floor 5

The Floor 5 is 100 m by 15 m and 35 m high. For this floor, the average noise level without treatment was 92.4 dB(A) measured in January 1997. The alternator head is located on this floor. Figure 2 shows a sketch of one alternator group. The noise sources of each alternator head are illustrated with small dots. Among these sources, we can particularly identify the ones associated with open metal grid floor. In fact, the Floor 5 is isolated from all other floors with a rigid floor, but this ventilation grid allows an acoustic link of the Floor 5

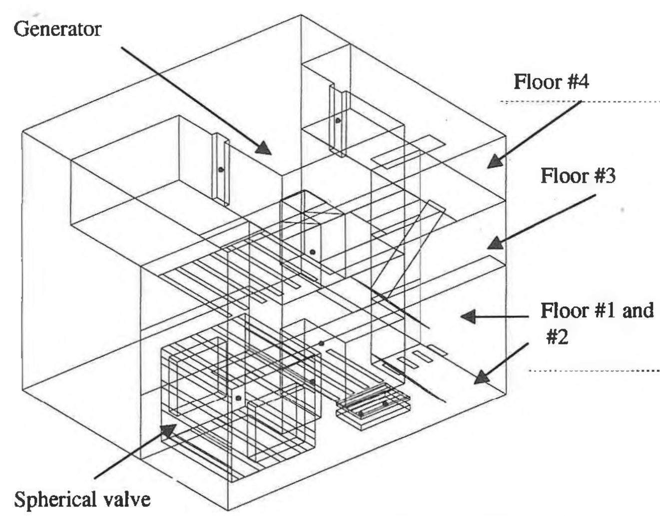

Figure 3 Detailed diagram of one group for first four floors

with the rest of the station. To allow the separation of the station model into two parts, each grid has to be considered as an acoustic source which originates from the noise of the other part of the station. Thus, the grids in Figure 2 are associated with noise sources of the Floor 1 through 4. For instance, a noise level reduction on Floor 4 will reduce the acoustic power of the grid of the Floor 5.

2.2 Floors 1 through 4

The first four floors are, for the most part, composed of open metal grid floor and hence are not isolated from one another. Figure 3 shows a diagram of this second part of the station model for the Floors 1 through 4. The dots on Figure 3 represent noise sources of the model and shows only one of five alternator groups. This group is repeated five times to form five different groups as shown in Figure 4.

The height of each floor is 15m. The noise levels for this staion without any acoustic treatment were measured in January 97 and the average levels for each floor are:

Floor 1: 101.4 dB(A)

Floor 2: 102.4 dB(A)

Floor 3: 100.1 dB(A)

Floor 4: 97.20 dB(A)

3. ACOUSTIC MODEL DEVELOPMENT

The objective of this section is to present the modelling and time calculation reduction techniques.

3.1 Noise source models

The source representation is very important while modelling a room's acoustics. Sometimes, in order to estimate the local effect of an acoustic treatment with precision, the overall dimensions of the source has to be included in the room model. The majority of the acoustic modelling method such as ray tracing (the software RAYCAT) uses only a single point source representation. To consider the overall dimensions of the source, a technique based on the source's geometric representation with spaced out surfaces is suggested. For example, the spherical valves, one of most important station noise sources, are represented as shown on Figure 5. The overall dimensions of this source are important (valve diameter of 20 m) and it cannot be represented with a single point source.

One or several single point sources, inside a spaced surface network, launch rays that are distributed in a uniform way at the source's surface. The inner surface of the non-single point source is absolutely reflective so that the ray amplitude is not reduced. To be safe, the reflection number considered in the ray tracing program can be increased to a certain number, such that after those number of reflections, the ray leaves the inside of the source. This method allows a greater representation of a source's overall dimensions and the acoustic energy distribution is better represented.

The way to validate this technique is not direct. The model validation stage allows the validation of the extended source representation. The acoustic power of the extended source has to be measured and a reference source should be used to determine the absorption coefficient of the room (see Section 4.1). The reflection number and the space left between the surfaces can then be adjusted to fit the noise levels generated by the model with experimental measurements. When the number of non-single point noise sources is large, the validation process of this representation technique is not easy and sometimes impossible. In this case, the representation can be done without validation and the adjustment of the representation parameter should be done following the experience of the model designer. We suggest increasing by 10 the number of reflections and using a spacing that opens 30% of the source surface.

This way of representing sources is not always necessary. In our case, only two types of sources are represented by spaced surfaces. The other sources are represented by single point sources. The source size compared to the room volume is the most important criterion in order to use the single point source hypothesis. If the source volume is less than 1% of

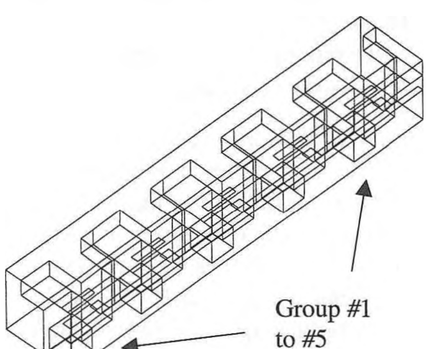

Figure 4 Global station diagram for first four floors

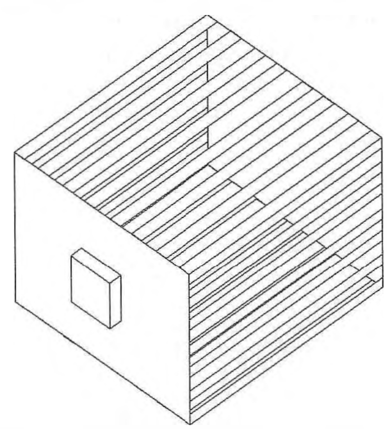

Figure 5 Example of a non-single point noise source

the room's volume, a single point representation can be used. But, if the acoustic field near the source is an important information for the designer of the model, the suggested criterion (1%) is not suitable.

3.2 Hypothesis to reduce the calculation time

When the room's geometry is complicated, the calculation time quickly becomes a major constraint. Reducing time hypotheses in the model becomes necessary. The objective of the next section is to present methods allowing time calculation reduction.

In the case of the ray tracing technique, the calculation time is linked to three parameters:

1. The size of reception cells in comparison to room dimensions
2. The number of reflections used by each ray and the number of rays
3. The room complexity (or the number of surfaces)

3.2.1 Size of reception cells

The reception cells' volume is the most important factor for calculation time. So, it is essential to choose an optimal size for receivers. The larger the cells are, the shorter the calculation time is. On the other hand, with large cells, local noise variations are not well represented. For an industrial case, the main objective is to determine the global acoustic noise reduction of treatments. To evaluate these reductions, all that is necessary are some large receivers allowing a global evaluation in a relatively large space of the room. For the case of the hydroelectric power station, the cell size has been adjusted so that cells take up the biggest space possible between each station objects (2 m). It is important that model objects (or surfaces) do not clutter the cells used to calculate the noise reduction. The cell size must be reduced to enable the calculation of the noise level in a confined space.

3.2.2 Number of rays and reflections

In a way to be sure that a sufficient number of rays, randomly launched, will be intercepted by reception cells, the number of rays for each sources has to be adjusted according to the room's free space and the cell size. A simple rule is proposed by RAYSCAT [4]:

$$NBR_{ray} = \frac{10 \cdot V_{room}}{V_{cell}}$$

where V_{room} is the free volume of the room and V_{cell} is the cell volume.

The total number of rays has to be distributed according to each sources acoustic power. For instance, with three sources of 90 dB, 90 dB and 93 dB and 20000 rays to launch, the ray distribution is given in Table 1.

Table #1 Ray distribution example according to the source power

Source	Global power (dB)	Number of rays
#1	90	5000
#2	90	5000
#3	93	10000

The number of reflections to take into account for each ray is adjusted according to many factors (room wall acoustic absorption, number of obstacles or model plans and global size of the room). To choose the number of reflections, the ray's residual level after *n* reflections can be used. But this residual level has to be 10 dB below the average level, calculated at reception cells. This way, the contribution of lost rays will be insignificant. The residual level is a standard output information of RAYSCAT. Generally, 30 reflections are correct (add 10 reflections for each non-single point source represented by spaced plans).

3.2.3 Room complexity

The room complexity increases the calculation time. The more surfaces in the room, the longer the calculation time. The model designer has to take into account the room's general geometry but he has to refrain from using a too complicated representation. For instance, the spherical form representation has to be defined with separated flat surfaces. This approach rapidly increases the number of surfaces and, consequently, the calculation time. In general, the use of a low resolution for spherical forms is enough. For example, the Floor 5 of the hydroelectric power station has a concave shaped ceiling. This ceiling form is well represented by only four (4) flat surfaces (see Figure 6).

Another way to diminish the number of surfaces of the model is to use the room's symmetry. In the case of the station, five identical posts are distributed lengthways (see Figure 1). The model of Figure 6 is for Post 3, at the station's middle. The two other posts, on both sides of Post 3 are simulated with reflective (or virtual) walls.

The hypothesis is valid only if there is symmetry for both the geometry and the noise sources. Furthermore, the model of Figure 6 considers an infinity of image posts on each sides of Post 3. Since there are only five real posts, it is important that the contribution of the image post, higher than second order, be negligible (lower than 10 dB). This constraint has been verified with the help of reference source at the time of the global model calibration (see Section 4). This last technique to reduce the calculation time is very delicate. It can be used only if there is no doubt about its validity. Furthermore, it must be pointed out that the model results are good only for the middle section of the hydroelectric power station.

4 SOURCE CHARACTERISATION

The acoustic source's characteristics have to be determined precisely to obtain good predictions of the sound field inside the room. Generally, the techniques used to identify noise sources are based on a certain acoustic industrial experience. The purpose of this section is to present a structured approach that allows the evaluation of the noise source and its acoustic power in an effective way. This approach for the hydroelectric power station is described below.

4.1 Model validation

The validation stage allows the appropriate evaluation of many parameters that give an accurate acoustic model. The general idea with this verification is to use a source with an already known acoustic power and a series of measurements of the whole room's noise level. With the measurement of the noise level generated by the reference source, it is possible to calibrate the model, that is to determine the absorption coefficients of the room wall material and to adjust the clutter of the room [4].

The noise level measurement at the time of calibration can be done with the normal noise inside the room but only if levels generated by the reference source can be distinguished from the ones generated by room sources. To make this distinction easier, the use of a multi-harmonic generator is desirable. Ideally, the harmonic frequencies should be generated at each central frequency of octave band, but these frequencies have to be different from the component of room noise sources. The reference source has to be powerful enough to be able to generate emerging rays of at least 10 dB higher in comparison with the normal noise inside the room

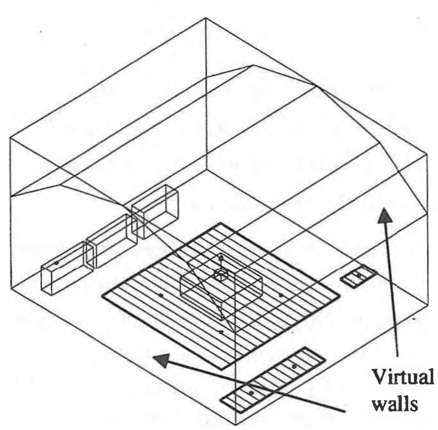

Figure 6 Model of the Floor 5

at each octave band frequency. The acoustic power of the reference source has to be determined with precision. To have great precision, the acoustic power evaluation of this source can be done outside, in free field conditions.

For the station's case, the model used to validate the absorption parameters and the room clutter is different from the one used to evaluate potential treatments. The symmetry of the station allows carrying out an important simplification since only one alternator group is taking into account (see Section 3.2). At the time of the validation, it is essential to consider the entire room, because it has only one source and the symmetry hypothesis is not appropriate. To determine absorption coefficients and clutter parameters, two preliminary models of Floors 1 through 4 and Floor 5 have been done. These two preliminary models are shown on Figures 1 and 4. For these two models, the station is entirely represented and the geometry is roughly defined. For instance, a cube represents the spherical forms and noise levels are calculated on relatively large spaces, with the intention of reducing the calculation time. At the calibration phase, only the reference source is included in the model. A priori, the standard parameters are used for the absorption parameters of the station wall. An estimation of the clutter can be done with this formula proposed by RAYSCAT [4]:

$$Q = \frac{1}{4 * V_{room}} \bullet \sum_{1}^{10} S_{obs.}$$

where, Q is the scattering coefficients, V_{room} is the room volume and $S_{obs.}$ is the obstacle surface.

Simulations with these estimations of the acoustic parameters and comparison with noise levels generated by the reference source allow the adjustment of absorption coefficients and room clutter. Most of the time the adjustments are minor (±5%). For an adjustment higher than 5%, the geometric representation must be re-evaluated.

4.2 Source identification

Almost 15 noise sources were identified on the 5 station floors during the first site visit. This first identification had been done with a simple sound level meter and hearing perceptions inside the station. At this stage, the acoustic power of the potential noise source is measured. This evaluation can be done from pressure measures if appropriate methods are used [5 and 6] or, ideally, with a conventional intensity measurement technique [7]. Often, it is difficult to take an acoustic power measure in an industrial background when sources are large or when other noisy sources are close. The techniques and the power measurement hypotheses have to be well known to obtain a precise value. After the source power measurement, the negligible sources (global power 15 dB below the average power of other sources) can be eliminated from the model. Table 2 describes station sources and their acoustic power.

Table #2 Station sources and their acoustic power

Sources	Power dB(A)
Floor #1 to #4	
Vacuum corridor	97.6
Eductors	101.5
Well door	104.1
Ventilation pipe	110.9
Spherical valve	100.6
Shutters	104.2
Stator passage	88.5
Ventilator floor #3	93
Stator door	91.5
Floor #5	
Ventilation grid	104.0
Removable floor	100.2
Control panel ventilator	96.6
Entry stairs	95.9

During the first visit, a very precise identification of all sources is not likely. To be sure that no sources are forgotten, verification with the acoustic model has to be done.

4.3 Validation of sources and their power

When the model is calibrated and principal sources are identified and quantified, some simulations can be done with all the room-identified sources. The measured noise levels (Stage 2 of the methodology) are compared with the noise level calculated with the calibrated model. For the case of the station, Table 3 shows a comparison of the global average noise level for all floors.

Table #3 Comparison of the global average noise level

Floor	Model dB(A)	Measure dB(A)	Delta
#1	101	101.4	0.4
#2	102	102.4	0.4
#3	100	100.1	0.1
#4	97	97.2	0.2
#5	92	92.4	0.4

All differences are less than 0.4 dB. So, the model is well calibrated and sources are correctly identified. At this stage, the model can be used to evaluate various acoustic treatments.

When the acoustic model validation with the help of a reference source is completed (Stage 1 of the methodology), only 2 or 3 iterations are necessary to obtain good results. At this stage, the differences are associated, most of the time, with forgotten sources. In this case, the Stage 3 of the methodology should be done again.

5 ACOUSTIC TREATMENT EVALUATION

5.1 General methodology

To obtain an optimum treatment for a particular noise reduction project, it is desirable to evaluate a maximum of potential treatments. On the other hand, the calculation time associated with each treatment evaluation becomes an important constraint. A practical way to bypass this problem is the use of an evaluation method based on transfer functions between the model sources and a receiver group chosen by the user. For a particular source, the transfer functions are simply obtained by the difference between the source power and the noise levels obtained at the receiver group.

When the calibration of the acoustic model is appropriate, a calculus for a particular geometric and acoustic configuration of the room (wall absorption coefficients and the clutter of the room) allows the evaluation of the transfer functions between each sources and different receiver groups. The position choice of the receiver group is done according to project objectives. For instance, for the case of the central area, the receiver groups have been chosen so as to obtain averages for each five floors.

The frequencies dependent transfer functions can be used with a spreadsheet to re-evaluate the global average noise levels for each receiver group with the following formula:

$$Niv_{global_i} = 10 * \log_{10}\left(\sum_{S=1}^{n}\sum_{f=1}^{m} 10^{\frac{P_{sf} - H_{sf_i}}{10}}\right)$$

where, H_{sf} represents the transfer function between the source *s* at the frequency *f* for a particular receiver group *i*, and where P_{sf} (dB) represents the measured acoustic power of the source *s* at the frequency *f*.

The above formula, with many source treatment combinations, can be used to check the redefinition of P_{sf} (source acoustic powers). This allows the rapid estimation of the complete set of source treatments. On the other hand, if the treatment consists of geometric or room absorption property modifications, the transfer functions (H_{sf}) have to be re-evaluated with the acoustic model.

Table 4 Acoustic treatment example for the first station floor

	Source power	Pressure level	Transfer function	Source treatment	Room treatment	Noise level (with treatments)
Sources	dB(A)	dB(A)	dB	dB	dB	dB(A)
Vacuum corridor	97.6	88.1	9.5	20	1.9	66.2
Eductors	101.5	93.3	8.2	20	1.9	71.4
Well door	104.1	89.2	14.9	20	3.4	65.8
Ventilation pipe	110.9	100.1	10.8	20	2.6	77.5
Spherical valve	100.6	89.2	11.4	0	2.3	86.9
Shutters	104.2	85.5	18.7	15	2.2	68.3
Stator passage	88.5	71	17.5	10	2.6	58.4
Ventilator floor #3	93	74.3	18.7	0	2	72.3
Stator door	91.5	74.2	17.3	0	2.6	71.6
					Total	**88.0**

5.2 Results for the station

Table 4 shows an analysis example carried out on a standard spreadsheet (Excel) for the first floor only. The measured global acoustic power for each source (P_S) is on Row 2. Column 3 shows the associated noise level of each source for initial conditions (without any treatments). The noise levels without treatment are calculated from the transfer functions shown on Column 4 (H_{Si}). Column 5 gives the estimated reduction of each source treatments. For instance, in the analysed case of Table 4, a treatment of 20 dB is considered to reduce the noise of the aspirator corridor. Column 6 shows transfer function reductions from a room acoustic treatment. For instance, the addition of absorbent material on some station walls reduces all the room transfer functions. In general, these reductions are different for each source because the room treatment effect varies according to the position and characteristics of the source. The evaluation of the transfer function reductions (Column 6) has to be done from the acoustic model. However, when evaluated, these reductions will be independent of the future source treatments. Column 7 gives the noise level generated by each source considering sources and room treatments. Finally, the global level of the first floor is obtained with the contribution summation of all sources. The same procedure has been used for each floor.

Once implemented, the source treatments have to be checked before the evaluation of the model prediction's quality. The source treatments are tested with acoustic intensity or acoustic pressure measurements depending on which acoustic power measurement method is used. When all treatments were implanted, an average noise level measurement was taken for each station floor. Table 5 shows measurement results. The model is accurate because differences between predicted and measured noise levels are small for the entire floor.

6 CONCLUSION

This paper has presented various original techniques, which can be used to develop an acoustic model. The technique used for non-single point sources allows representing the acoustic energy distribution and the overall dimensions of a large source. Furthermore, many aspects to reduce calculation time have been displayed. The appropriate choice of calculation parameters (number of launched rays, size of reception cells and number of considered reflections) and a simplification using the room symmetry allows the reduction of the calculation time. The source identification technique is based on a structured iterative method. With this process, the noise source identification is efficient and very accurate. Since it has an important impact on all subsequent results, the noise source identification accuracy is crucial for a good acoustic model. A method based on transfer functions between the sources and different receiver groups has also

Table 5. Predicted and measured average noise levels for each station floor

Floor	Without treatment	With treatment			
	Measures dB(A)	Measures dB(A)	Prediction dB(A)	Difference dB	Reduction dB
#1	101,4	87.5	88.0	+0.5	13.9
#2	102.4	87.5	87.9	+0.4	14.9
#3	100.1	88.0	87.7	-0.3	12.1
#4	97.2	88.0	87.5	-0.5	9.2
#5	92.4	83.0	84.1	+1.1	9.4

been presented in this paper. This technique has demonstrated a greater efficiency for the rapid evaluation of the potential acoustic treatments.

All techniques presented in this paper have been evaluated on the particular case of the hydroelectric power station of Alcan. These techniques have allowed the evaluation, with success and efficiency, the optimum treatment to obtain the noise reduction objectives of the company.

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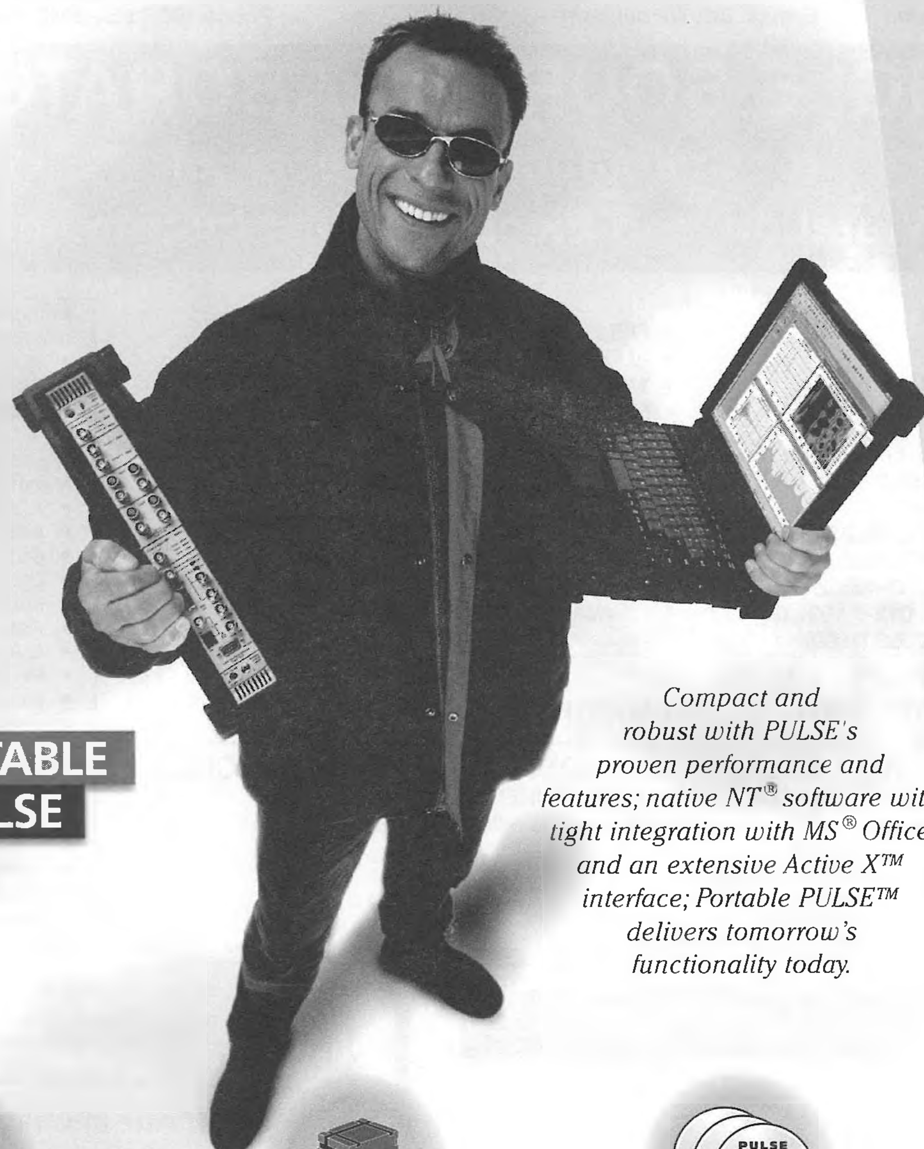

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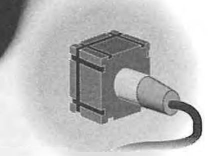

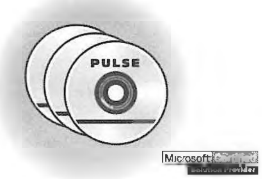

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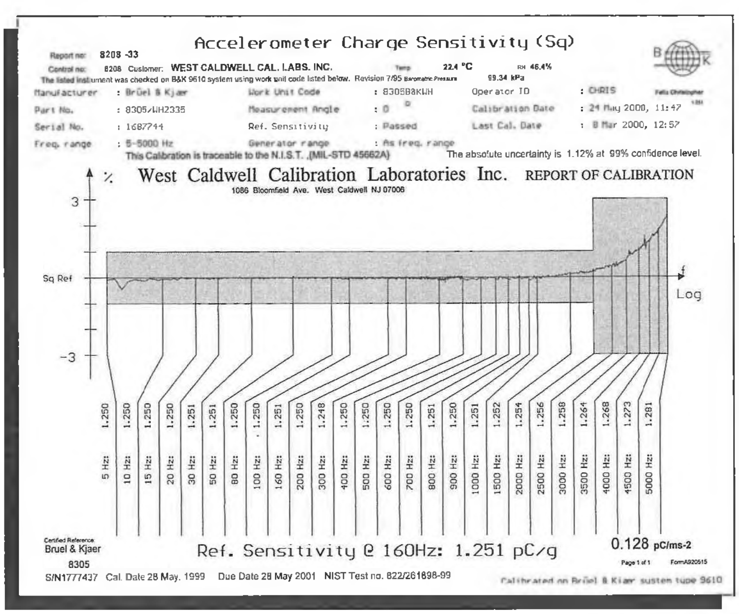

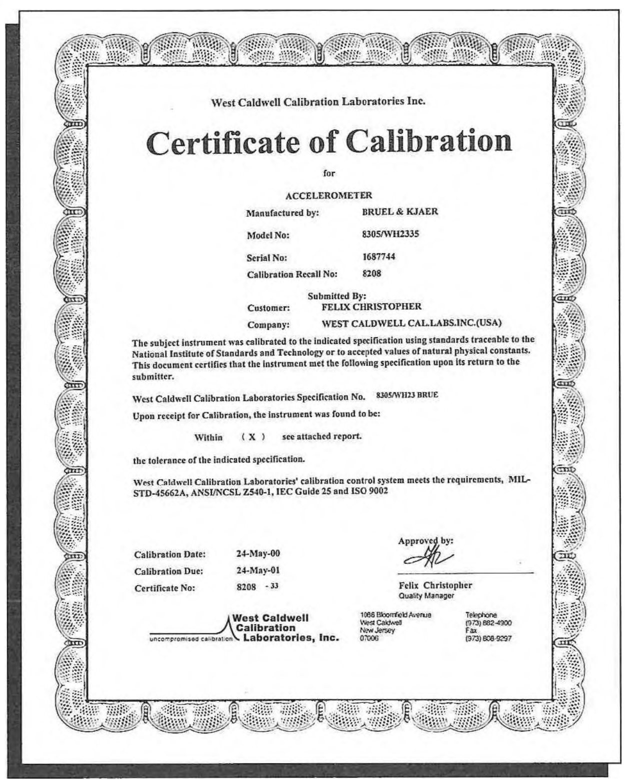
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EXPERIMENTAL STUDY OF PROPELLER-AIRCRAFT RUN-UP NOISE

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ABSTRACT

Measurements were made of the characteristics of the noise radiated by a Beechcraft 1900D twin-propeller aircraft during engine run-up. The objective was to determine the feasibility of controlling this noise using active noise control. Total noise levels varied with aircraft heading from 103 to 112 dB (100 to 109 dBA) at 73 m from the aircraft. Noise directivity plots were generated. Levels at the nearest community 3 km away varied from 74 to 77 dB (62 to 66 dBA). Near the aircraft the noise spectra comprised a series of equally-high peaks at the 112-Hz fundamental frequency and its multiples. In the community, the three lowest peaks dominated the A-weighted spectrum, with higher-frequency peaks being progressively attenuated. A coherence analysis was performed on the noises measured at 73 m and 98 m from the aircraft. The insertion loss of a blast fence near the run-up area was estimated from run-up noise measurements made on both sides of the fence. The insertion loss varied from 4 to 13 dB and was greatest at mid frequencies.

SOMMAIRE

Des mesures ont été faites des caractéristiques du bruit rayonné par un avion à deux hélices – un Beechcraft 1900D - durant des tests d'accélération des moteurs ('run-up'). L'objectif a été de déterminer s'il serait faisable de controller ce bruit par un système de contrôle actif. Les niveaux totals du bruit ont variés avec la direction de 103 à 112 dB (de 100 à 109 dBA) à 73 m de l'avion. La directivité du bruit rayonné a été déterminée. Dans la communauté voisine la plus proche, à environ 3 km de l'avion, les niveaux ont variés entre 62 et 66 dBA. Proche de l'avion, le spectre du bruit a consisté d'une série d'arrêts d'amplitudes semblables correspondant à la fréquence fondamentale de 112 Hz et de ses harmoniques. Dans la communauté voisine, les trois arrêts les plus bas ont dominés le spectre; les arrêts de plus hautes fréquences ont étés de plus en plus attenués. Un analyse de cohérence a été faite sur les bruits mesurés à 73 m et à 98 m de l'avion. La perte par insertion d'une clôture acoustique proche du site de test, estimée à l'aide de mesures prises des deux côtés de la clôture, a variée de 4 à 13 dB et a étée le plus élévée à moyenne fréquence.

1 INTRODUCTION

The work reported here was part of an investigation of the feasibility of controlling propeller-aircraft run-up noise using active noise control [1]. For active control to be feasible, the noise to be controlled must have appropriate characteristics. Furthermore, simulations of the effectiveness of an active-control system require a knowledge of the directional radiation characteristics of the propeller noise source. Thus, it is crucial to characterize the source and the noise radiated. Finally, run-up areas often have blast-fences, providing some noise attenuation, next to them. Active technology can be used alone, or in combination with the blast fence. Thus, it is of interest to determine the insertion loss of a typical blast fence.

Measurements of propeller-aircraft run-up noise were carried out in July 1999. First, noise levels generated by run-ups were measured near the aircraft, and in the nearest community, to determine levels generated and their frequency contents. Measurements were made in different directions, in order to estimate the radiation directivity of the propeller-aircraft noise source. A coherence analysis of the noise was performed. Finally, the insertion loss of an existing blast fence located near the run-up area was determined.

2. METHODOLOGY

A Beechcraft 1900D twin-engined turboprop aircraft (shown in Figure 1) was provided by Central Mountain Air for the noise measurements. It is a 19-passenger aircraft, with length of 17.7 m, wingspan of 16.6 m, and a cruising speed of 533 km/s. The aircraft has two, four-bladed propellers of 1.6-m diameter, centred 2 m above the ground. It performed full-power engine run-ups, during which both propellers

Figure 1. Beechcraft 1900D twin-engine propeller aircraft.

rotated at approximately 1700 rpm. Four microphone positions were used to measure the resulting sound-pressure levels (see Figure 2). Two Bruel & Kjaer 2230 free-field microphones, positioned at approximately 73 m (Position 1) and 98 m (Position 2) away from the aircraft, captured the near-field run-up noise. A Bruel & Kjaer 4165 free-field microphone was positioned in a community north of the airport, approximately 3 km (Position 3) from the aircraft (see Figure 3). A fourth microphone (Bruel & Kjaer 2230) was positioned on the opposite side of the blast fence (shown in Figure 4) to the aircraft, again at a distance of 73 m (Position 4). The aircraft performed 12 full-power run-ups, each for a duration of one minute, rotating by 30° in between run-ups. The headings shown in Figure 2 refer to the direction of the aircraft relative to geographic north.

Run-up noise signals, along with the ambient noise, the idle-engine noise and calibration tones, were recorded on portable Teac DAT recorders. The recordings were analyzed using a Larson Davis 2800 Real-Time Analyzer. Unweighted and A-weighted total levels were determined. Narrow-band and third-octave spectra were generated.

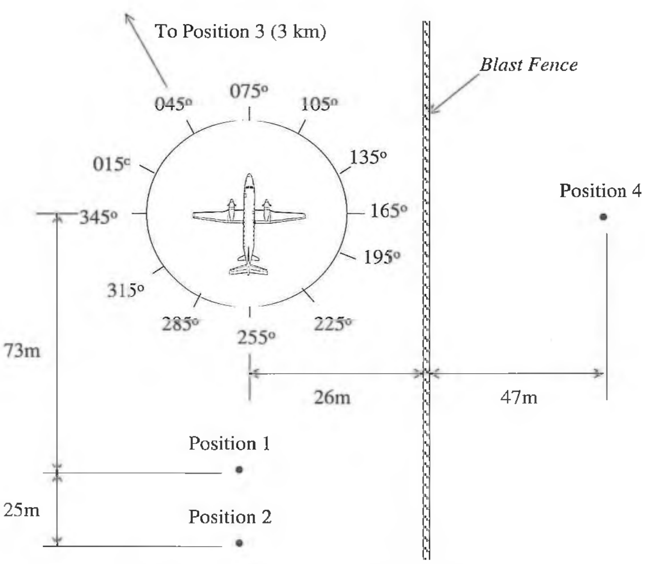

Figure 2. Noise measurement set-up.

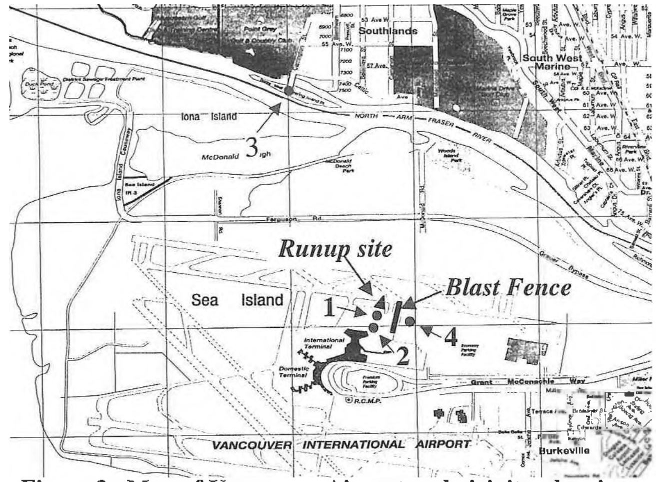

Figure 3. Map of Vancouver Airport and vicinity, showing microphone positions and blast fence. (aircraft denoted by triangle)

3. NOISE LEVELS AND SPECTRA

Figure 5 shows a typical run-up noise spectrum measured at Position 1 (heading 255°) near the aircraft where an active-control system would likely be located. Figure 5a shows the third-octave-band spectrum over the range 12.5 to 20000 Hz, without and with A-weighting. Total noise levels varied with heading from about 103 to 112 dB (100 to 109 dBA). Propeller-noise levels were significantly higher than the ambient-noise and idle-engine levels of 62 and 83 dBA, respectively. Figure 5b shows the A-weighted narrow-band spectrum over the range 0 to 1250 Hz. It can be seen that the spectra consisted of sharp peaks at multiples of the fundamental frequency of 112.5 Hz - *i.e.,* at 225, 337.5, 450 Hz, and so on. The fundamental frequency corresponds to the blade-passing frequency (BPF) of the propellers.

Figures 6a and b show similar results for Position 3. Levels varied from about 74 to 77 dB (62 to 66 dBA) at Position 3

Figure 4. Blast fence at Vancouver Airport.

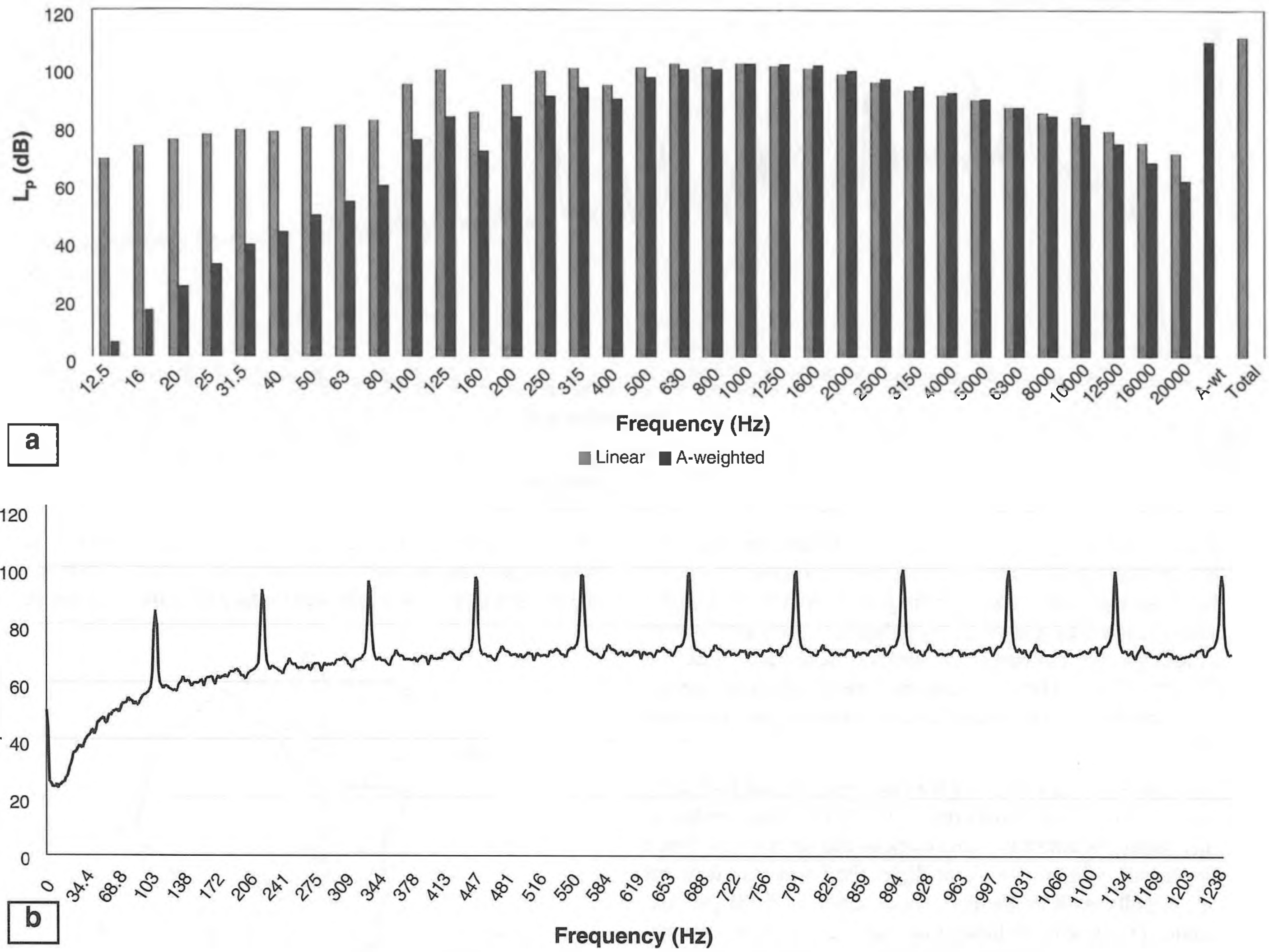

Figure 5. Typical run-up noise spectra measured at P1 (heading 255°) near the aircraft.

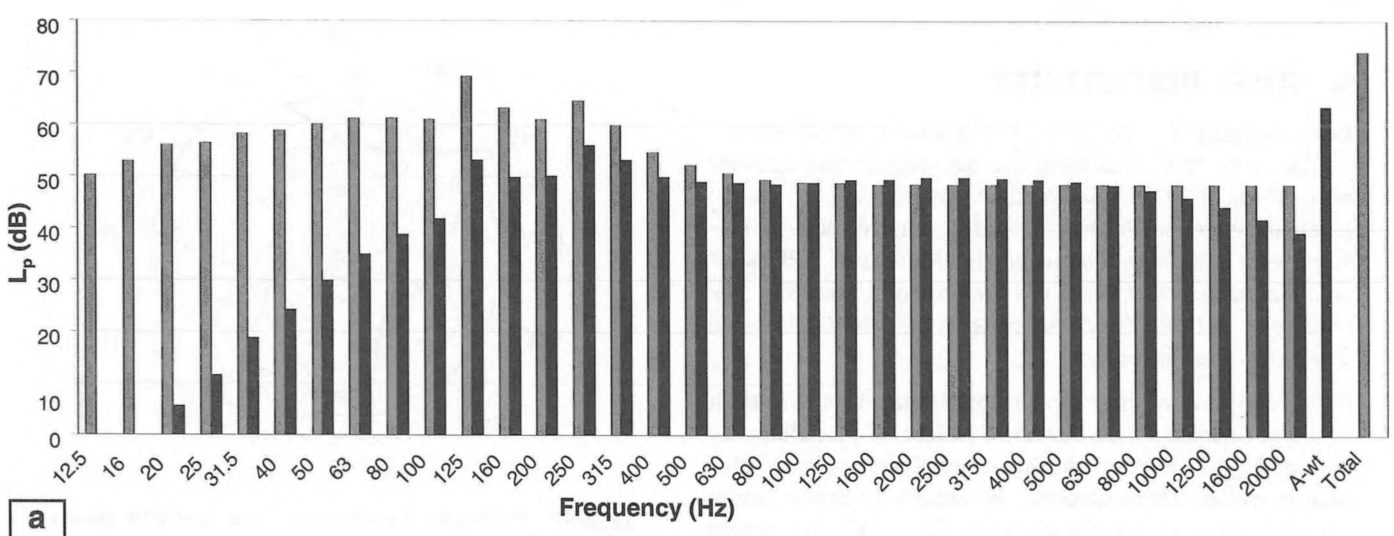

Figure 6. Typical run-up noise spectra measured at P3 in the community 3 km from the aircraft.

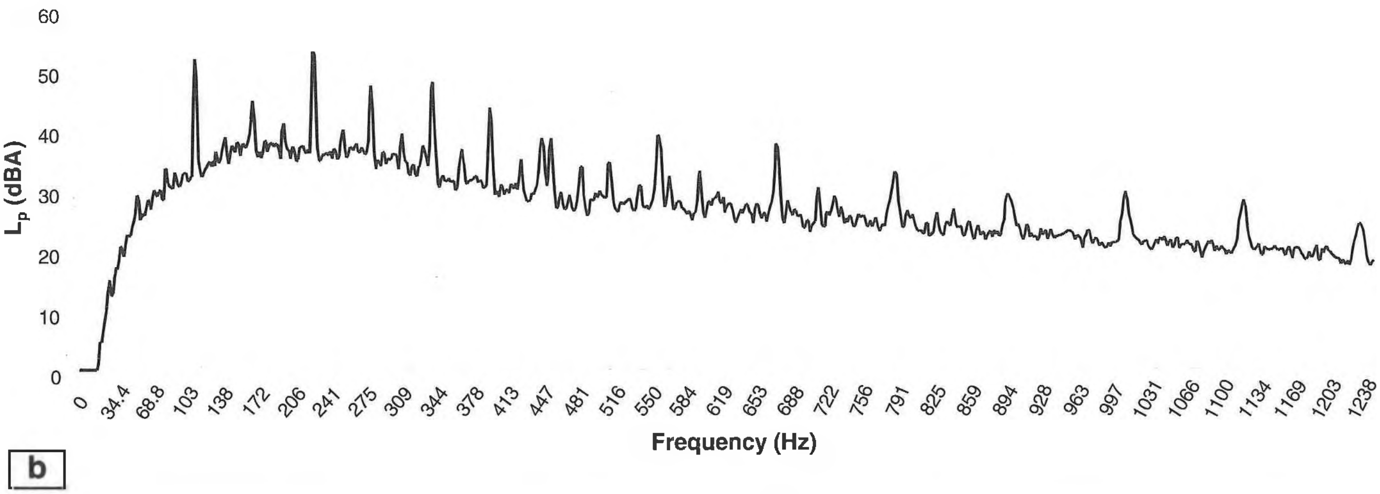

Figure 6. concluded.

in the community. Higher-frequency levels are relatively low and the fundamental and first two harmonics dominate the noise spectrum. The high-frequency components of the noise clearly suffer progressively higher attenuation due to air and ground absorption. A series of secondary peaks (at 170, 280, 390,...Hz) is evident in between the main peaks. These are believed to be due to non-linear effects, discussed below.

Harmonics with levels as high as the fundamental BPF are a characteristic of propellers operating under static conditions - *i.e.,* when the aircraft is stationary, as during run-ups. When the aircraft is in motion, or in flight, the harmonics drop off very rapidly with frequency - by as much as 8 dB per harmonic. This results in lower total noise levels when the aircraft is in motion. The high levels of the harmonics during a run-up (static conditions) are created by non-uniform inflow to the propellers, including naturally occurring turbulence in the atmosphere, ground vortices, as well as by wakes from fuselages, wings, nacelles or test stands [2].

4. NOISE DIRECTIVITY

Levels measured at Position 2 (98 m away) varied between 94 and 108 dBA, exceeding the idle-engine and ambient noise levels of 79 dBA and 62 dBA, respectively. Using the levels measured at Positions 1 and 2, noise directivity patterns were generated. The unweighted-total and BPF noise contours measured at Position 1 are shown in Figure 7. The total noise and BPF directivity patterns measured at Position 2 are shown in Figure 8.

In order to analyze these directivity patterns, it is of interest to try to understand the radiation pattern of propellers, by considering the mechanisms that generate noise from a spinning propeller. These mechanisms include thickness noise, loading noise and quadrupole noise [2, 3, 4]. Thickness noise arises from the transverse periodic displacement of the air by the volume of a passing blade element. This mechanism creates linear noise characteristics, meaning that it is the mechanism responsible for creating harmonics at integer

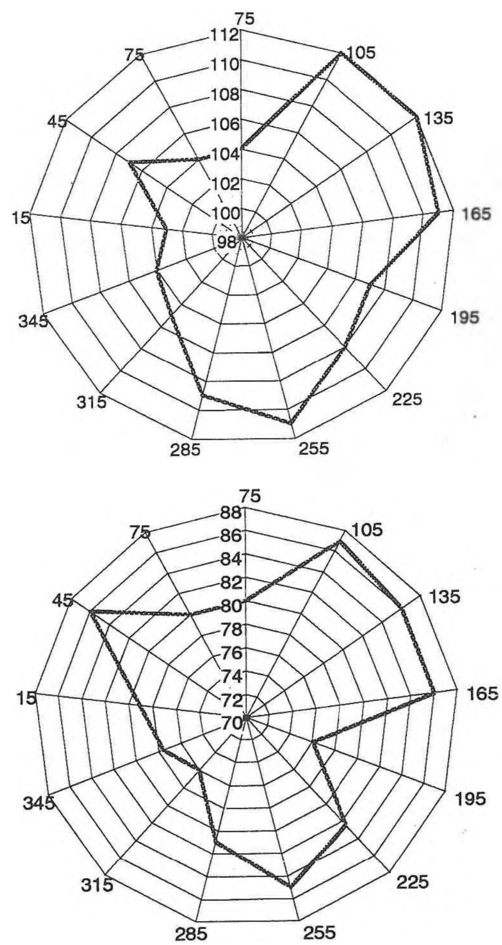

Figure 7. Unweighted-total (upper plot) and BPF (lower) sound-pressure-level directivity patterns of the Beechcraft 1900D at P1.

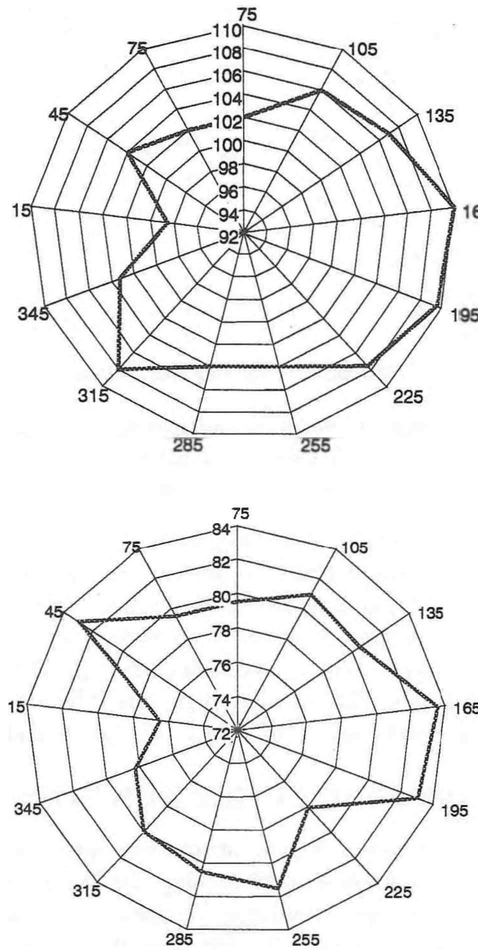

Figure 8. Unweighted-total (upper plot) and BPF (lower) sound-pressure-level directivity patterns of the Beechcraft 1900D at P2.

multiples of the fundamental BPF. Thickness noise can be represented by a monopole source distribution and becomes important at high rotational speeds. Loading noise is a combination of thrust and torque (or lift and drag) components which result from the pressure field that surrounds each blade as a consequence of its motion. This type of noise can be represented as a dipole and is an important mechanism at low to moderate speeds. Quadrupole noise arises from turbulent airflow over the blade sections, and can be used to account for all of the viscous and propagation effects not represented by thickness and loading sources. This creates nonlinear radiation characteristics, meaning that it will generate tones which are not at integer multiples of the BPF (as seen in Figure 6, for example) [2]. Quadrupole noise is the main component of aerodynamic noise arising from turbulent airflow.

A propeller operating during a run-up encounters a great deal of non-uniform inflow, including naturally occurring turbulence from the atmosphere and ground vortices, and wakes from various parts of the aircraft [2]. Since run-up propeller speeds vary from one aircraft to another, it is not possible to draw general conclusions as to which mechanism will govern the generated run-up noise.

By observing Figures 7 and 8, it can be seen that at Position 1 (73 m away) there is a strong directionality towards the right of the aircraft for the 105° to 165° headings, and towards the 45° and 255° headings in both cases. At Position 2, the directionality towards the right of the aircraft is still prevalent, as is the directionality towards the 45° heading. At Position 2 there is also a stronger directionality towards the 315° heading than at Position 1. None of these radiation patterns is symmetrical; this could be due to ground reflection, reflection from the blast fence, or the two propellers' spinning out-of-phase with one another – detrimental factors which could not be controlled. A dipole from the left propeller appears to be present at Position 2, but not at Position 1. This could indicate that radiation patterns are sensitive to distance from the aircraft, probably due to the turbulent nature of the wind blast generated by the propellers during a run-up. An inclined dipole appears to be present for the two BPF contours, with the null shifting from the 195° heading at Position 1 to the 225° heading at Position 2. The directivity appears to rotate as the receiver position moves further away from the aircraft.

From these results, it is difficult to pinpoint exactly which noise mechanism is governing the radiation patterns, since no clear monopole, dipole or quadrupole radiation patterns can be seen. It is important to note that such patterns are generally associated with in-flight noise, making the analysis more difficult when attempting to study run-up noise directivity. In addition, the turbulent airflow over the blades, and reflections from the ground and blast fence, distort the directivity, further increasing the complexity of the analysis. Clearly, a more detailed investigation of propeller noise radiation and how to model it is required.

5. COHERENCE ANALYSIS

If an ANC system is to attenuate noise effectively, the error signal must continuously send 'correction' signals to the controller, to account for fluctuations in the sound field. A way to quantify how much fluctuation occurs is to perform a coherence analysis. If the reference signal is strongly correlated with the control signal sent to the control source, it is deemed 'coherent', and the need for an error signal is minimized. A coherence analysis was therefore performed, in order to quantify the randomness of the recorded run-up noise and determine if a qualified reference signal is available [5].

Coherence is a statistical measure that determines how similar the sound pressures at different positions in space are to each other. In acoustics, it is the direct measure of to what extent two functions (*e.g.*, X and Y) are linearly related, the functions being two random sound-pressure fluctuations [6]. The degree of coherence is represented by values between 0 and 1 (1 representing perfect coherence) that indicate to what extent function X corresponds to function Y at each frequency. For this run-up noise study, the functions are the noise signals measured at two different points in space; this is called the 'auto-correlation'- the degree to which the noise correlates with itself at the two points. The noise data recorded at Positions 1 and 2 were used for this analysis. Positions near the aircraft were chosen since a local active-control system would likely have to be located in this region if it is to create a large quiet zone.

The noise data measured at Positions 1 and 2 were recorded simultaneously on the left and right channels of the DAT recorder. These were input to a computer, and digitized into functions X and Y. The method used for the coherence analysis was Welch's averaged periodogram method [7]. The functions X and Y were divided into overlapping sections, then windowed to a given length. The squared magnitude of the Discrete Fourier Transforms (DFTs) of the sections of X and the sections of Y were averaged to form P_{xx} and P_{yy}, the Power Spectral Densities of X and Y, respectively. The products of the DFTs of the sections of X and Y were then averaged to form P_{xy}, the Cross Spectral Density of X and Y. The coherence C_{xy} is given by,

$$C_{xy} = \frac{|P_{xy}|^2}{P_{xx} P_{yy}}$$

This analysis was performed for various headings, and similar results were obtained at all headings. The coherence for the 105^{o} heading is shown in Figure 9. The results in Figure 9 show a coherence of 0.7 to 1.0, indicating a very good correlation between the two positions. The 0 to 350 Hz range was chosen in order to display the fundamental frequency

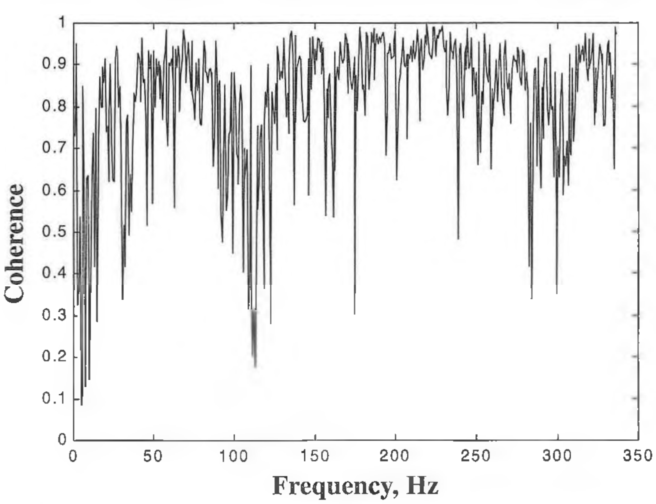

Figure 9. Coherence-analysis results for the 105o heading, for the 0-350 Hz range.

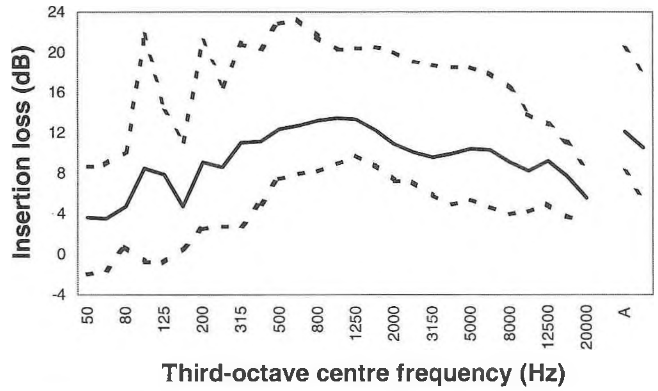

Figure 10. Range (dashed lines) and average (solid line) of the apparent insertion loss of the blast fence for all aircraft headings.

(112 Hz) and the first harmonic (224 Hz), which are the frequencies that would likely be selected for active control. The coherence graph shows a dip in the 112-Hz region, while the coherence appears to be stronger (close to 1.0) in the 224-Hz region. This would indicate that an ANC system optimized for the 224-Hz wavelength might be more effective than a system optimized for the 112-Hz wavelength.

6. BLAST-FENCE INSERTION LOSS

The blast fence next to the run-up area was approximately 4-m high. It was made of steel decking, the lower half being solid, the upper half consisting of metal slats with gaps between them (see Figure 4). The microphone at Position 4 was positioned 73 m away from the aircraft, on the other side of the blast fence, so that the levels could be compared with those measured at Position 1, thus estimating the blast-fence insertion loss. Since Positions 1 and 4 were at 90 ^{o} to one another relative to the aircraft, the spectrum at Position 4 had to be compared with that at Position 1 for a 90^{o} difference in headings. Figure 10 shows the range and average of the apparent third-octave-band insertion losses provided by the blast fence for all headings, over the frequency range 50-20000 Hz.

A similar pattern emerged at every heading. The blast fence appeared to provide an average insertion loss of 4 to 14 dB, with the average being around 10 dB. Most of the attenuation appears in the 500 to 8000 Hz range, with an attenuation of at least 8 dB for all headings, and as much as 24 dB in the case of the heading of 225 ^{o}. A small dip at 400 Hz, where less attenuation occurs, can be seen for most headings. A more noticeable dip, at which little or no insertion loss occurs, exists at 160 Hz for all headings.

If more attenuation is required, an active-noise system could be integrated into the blast fence, creating an active-noise barrier, in order to increase the low-frequency insertion loss of the blast fence [8].

7. CONCLUSION

Measurements have been made of the characteristics of the noise radiated by a twin-propeller aircraft during engine run-up, in order to characterize the noise source and its radiation for possible active noise control. Results show that the A-weighted noise in the nearest community is dominated by fundamental and harmonic peaks with frequencies in the range 100 to 400 Hz, making active control an interesting option. The insertion loss of the run-up area blast fence was shown to be low at low frequencies, suggesting that incorporating active technology to create an active noise barrier with better low-frequency performance could be an interesting option.

8. ACKNOWLEDGEMENTS

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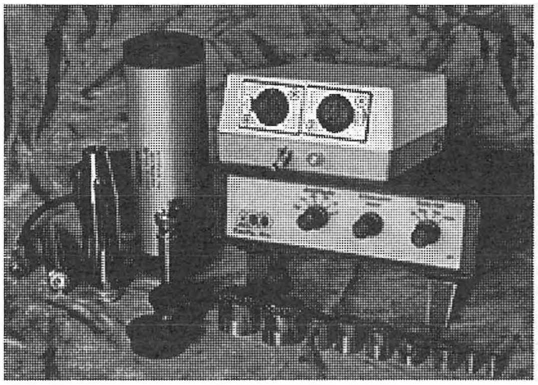

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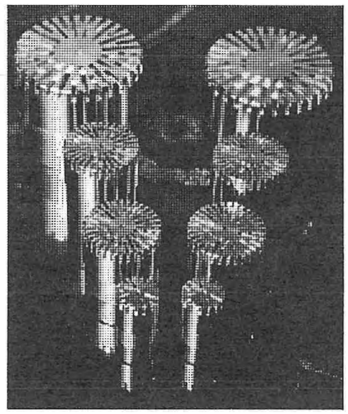

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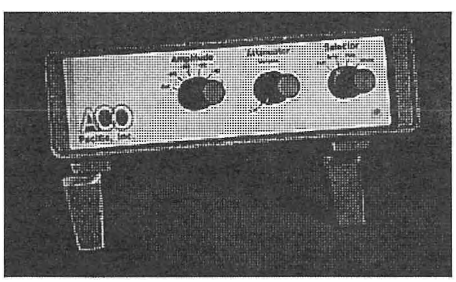

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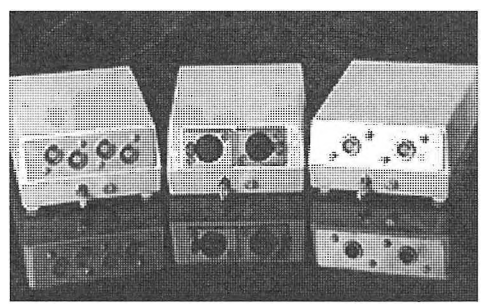

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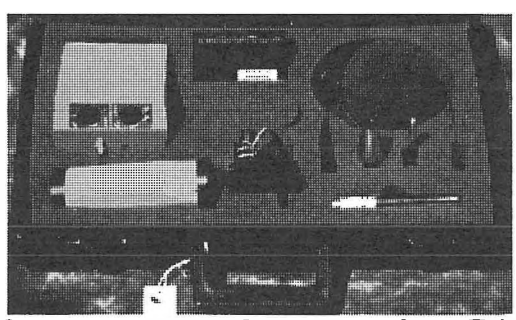

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OUTDOOR NOISE LEVELS AT YILDIZ TECHNICAL UNIVERSITY ISTANBUL, TURKEY

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80750 Besiktas, Istanbul-TURKEY

ABSTRACT

In this study, noise measurements for relevant 22 outdoor points and some indoor ambience for sensitive places such as kindergarten, classrooms, library and exhibition centre at the central campus area of Yildiz Technical University were made. A map developed evaluated hourly noise values obtained for 5 months. By using the map, noise control measures that have to be taken for subject area were determined. Measurements were performed in accordance with the Turkish Standards, by using HD 9019 Sound Level Meter. The map consisting from isoline curves of noise levels (Leq dBA) was developed by the Spherical Krigging method. The study showed that Barbaros Boulevard side of the area (front side of the University) generally has 78 dBA originated from traffic noise completely. Unfortunately, in front of the University there was much heavier traffic jam due to stops, crossroads and an overpass for vehicles. Therefore, higher noise isolines were obtained at the front of the University. This level noise is not adequate for an education purpose area. 76 per cent of the all campus area had higher noise levels than 55 dBA standard.

SOMMAIRE

Dans cette étude, les mesures de bruit pour les 22 points extérieurs appropriés et un certain ambience d'intérieur pour les endroits sensibles tels que le jardin d'enfants, les salles de classe, la bibliothèque et le centre d'exposition à la zone centrale de campus de l'université technique de Yildiz ont été faits. Une carte développée a évalué des valeurs horaires de bruit obtenues pendant 5 mois. En utilisant la carte, des mesures de lutte contre le bruit qui doit être prise pour le domaine ont été déterminées. Des mesures ont été exécutées selon les normes turques, en utilisant le mètre de niveau sonore de HD 9019. La carte consistant des courbes d'isoline des niveaux de bruit (Leq dBA) a été développée par la méthode sphérique de Krigging. L'étude a prouvé que le côté de boulevard de. Barbaros de la zone (partie antérieure de l'université) a généralement 78 dBA provenus du bruit du trafic complètement. Malheureusement, devant l'université il y avait bourrage de circulation beaucoup plus dense dû aux arrêts, au carrefour et à un passage supérieur pour des véhicules. Par conséquent, de plus hauts isolines de bruit ont été obtenus à l'avant de l'université. Ce bruit de niveau n'est pas adéquat pour une zone de but d'éducation. 76 pour cent de la toute la zone de campus ont eu des niveaux plus élevés de bruit que la norme de 55 dBA.

1 INTRODUCTION

Classroom is a type of room that has to meet a suitable level of acoustical quality. In general, teachers aim to say everything in their mind to students, without getting bored. Meanwhile students intend to understand everything what teacher says. Therefore, background noise level in a classroom should be obtained for high acoustical standards in terms of noise criteria values. (Sargent, *et al.* 1980)

Acoustical quality requirements of classroom in various European Countries vary between 30-45 dBA Leq (Bel: 30-45, Fra: 38, Ger: 30, Ita: 36, Por: 35, UK: 40, Swe: 30 and Tur: 45 dBA). For these countries, acoustical quality requirements in other education related places like library, office, dinning room etc. are almost similar. (Vallet, 2000)

Noise from outdoor sources penetrates through windows and other weak parts of building structures. Adequate isolation precautions should be considered during project and construction of educational buildings to be built in areas having high outdoor noise levels.

In this study, a survey to investigate the effect on classrooms and other educational places at the university campus of outdoor noises (mainly traffic originated) is investigated. Following a field study, a noise map for the area was developed as a tool in order to evaluate the effect of existing outdoor noises.

2 OUTDOOR NOISE SURVEY

Central campus of Yildiz Technical University, which is located on the Barbaros Boulevard in Besiktas district of Istanbul, has a capacity of 15,000 students. There are two daily education periods at the university - day and evening classes. Total area of the central campus is 113,400 m^2. The Barbaros Boulevard is one of the most crowded main roads in Istanbul. Hourly vehicle counts on the boulevard for different day times were determined as shown in Table 1. The table indicates that traffic through the day on the boulevard changes in a wide range, during day's hours.

There is also a connection highway to the First Bosphorus Bridge, which connects the European side to Asian side of Istanbul and is just beside of the central campus. As can be seen from Figure 1, the campus is located in heavily congested arteries connecting commercial parts to residential parts of Istanbul. In this study, a total of 22 noise measurement points representing influences of various noise sources is shown on the map in Figure 1. These measurement points were both inside and near the surrounding area of the campus.

The measurement studies were carried out for a period of five-months, from August to December in 1997. Measurements were made for two days per month during the study. Noise levels were measured in 16 points in the first days and 6 points in the second days of the months. At all points, daily measurements were made for five time intervals as: 06.00-08.00 a.m., 10.00-12.00 a.m., 14.00-16.00 p.m., 18.00-20.00 p.m. and 24.00-02.00 a.m. Thus, noise level fluctuations during the whole day were obtained. During the study, acoustic measurements were made according to the Turkish Standards Institute method no TS.9315. (Turkish Standards Institute, 1991)

Table 1. Vehicle/hour values for different day times on the Barbaros Boulevard

	Time of the day		
	8.00-9.30	**12.00-13.00**	**18.00-19.00**
Number of measurements	20	20	20
Max	7068	5844	7056
Min	564	708	1008
Mean	2791	2723	3053

For all these out-door acoustic measurements, taking into consideration almost similar local meteorological conditions such as wind velocity, wind direction, temperature and humidity has been a governing factor to get meaningful measurement data. All the measurements were performed

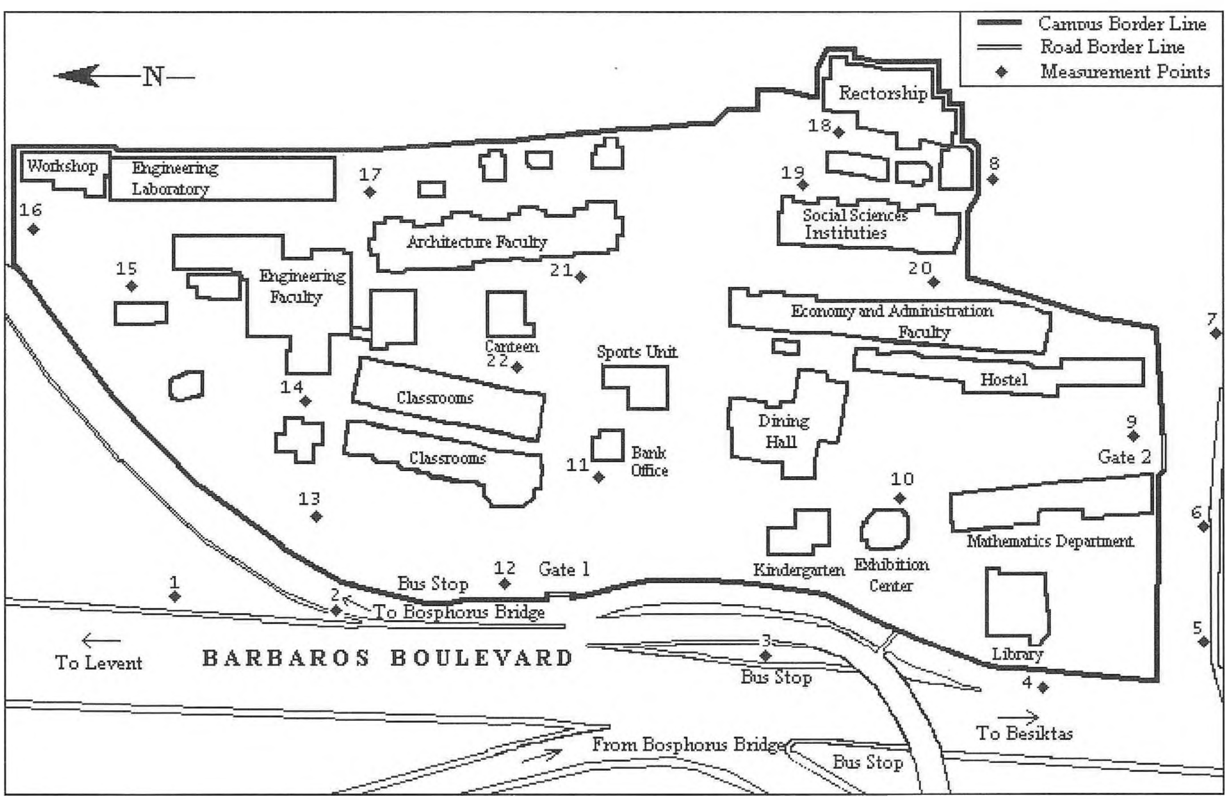

Figure 1. Map of Yildiz Technical University Campus and Noise Measurement Points

when there was no precipitation (rain or snow). Daily meteorological parameters were obtained from Istanbul Division of State Meteorological Works Department.

According to the measurement standard, a measurement point must be at least 1 meter away from reflective surfaces to prevent interference of sound waves. Therefore, while the noise levels on a point close to a reflective building or materials were measured, a distance of at least 1-meter from these surfaces was maintained.

On the other hand, for road traffic noise measurements, related Turkish Standard numbered TS 10713 was used (Turkish Standards Institute, 1993). According to the Sstandard, noise measurement points should be 3.5m from road, and height of the microphone of the equipment should be between 1.20 and 1.50 m.

The minimum measuring time for each point was 5 minutes. Noise level determinations were made with HD 9019 Sound Level Meter Class 1, HD 9102 Calibrator, a ½"condenser microphone and a tripod.

Noise map developing process for subject area was made by spherical krigging method by means of software. The method generates visually appealing contour and surface plots from irregularly spaced data. During gridding process, average noise values of five months (L_{Aeq}) at measurement points were used.

3 RESULTS AND ANALYSIS

Noise level values measured as L_{Aeq}, L_{10}, L_{50} and L_{90} through 5 months at the 22 points are presented in Figure 2a to 2d, respectively. The figures include averages of the five months' L_{10}, L_{50}, L_{90} and L_{Aeq} values in dBA. Since the physical character of each noise measurement point is not same, measured noise levels obtained for each point are different from other points. This variation is obviously related to proximity of the point to the Barbaros Boulevard. First 5 points having the highest noise levels shown in Figure 1 are near or quite close to the Boulevard. On the contrary, last 6 points (17, 18, 19, 20, 21, and 22) have the quietest part because of being inside the campus. There is no educational activity at these points, and they are recreational area. Noise values are quite hight at point 12, just inside the campus near the boulevard. Figure 3 indicates max, mean and min values for each measurement point, and describes above the reasoning much more clearly.

Figures 4a to 4e also present additional measured data that show noise variations in the area for 24 hours. These data clearly show the effect of traffic jam. Especially during the early day times it is much more silent. After the start of working hours, noise values increase. The highest values were measured between 6 and 8 p.m. It is clear that evening traffic generates more noise than morning traffic. This is due to proximity of the Bosphorus Bridge to the University. In the morning, there is congested traffic at the Asian side of the bridge. On the other hand, there is congested evening traffic in front of the University in the evening, especially before the bridge. Another cause of higher evening noise level is obviously due to upward slope of 4-6% of the Boulevard, increasing to the University from Besiktas.

Data that are obtained from average L_{Aeq} value of the five months were used to develop noise map of the central campus. The noise map developed is presented in Figure 5. Traffic originated noise propagation in the university campus area can be seen clearly from the noise map. As can be

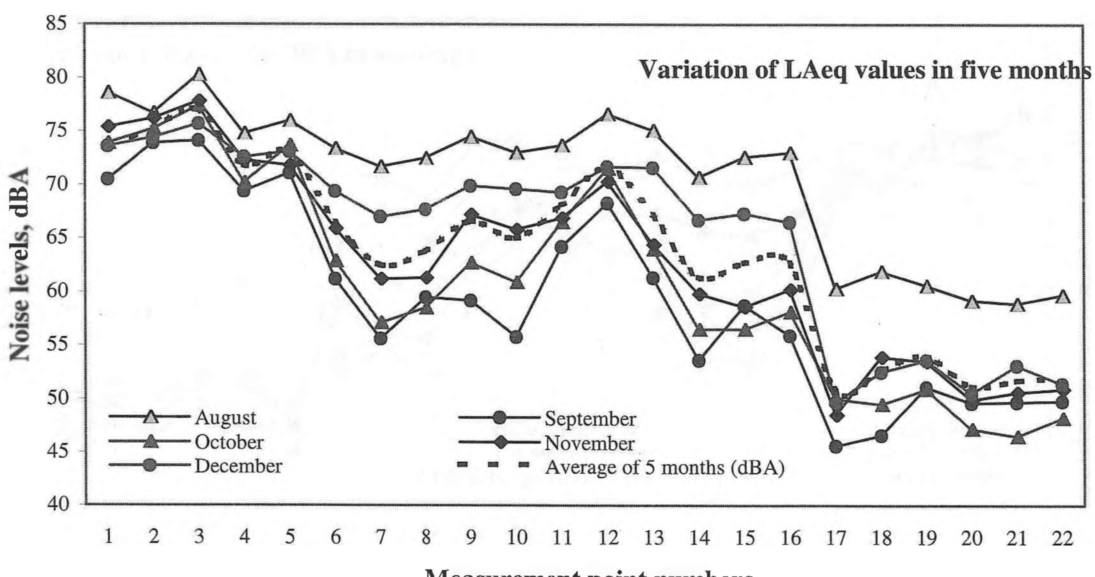

Figure 2a. Noise level values measured through 5 months at the 22 points as L_{Aeq}

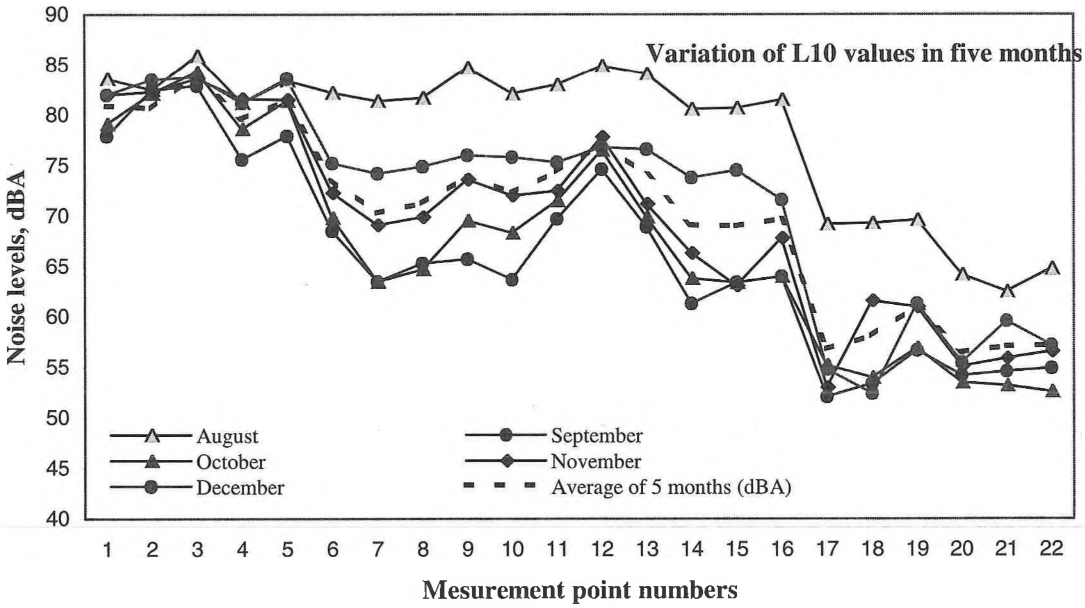

Figure 2b. Noise level values measured through 5 months at the 22 points as L_{10}

seen from the map, 76 per cent of the campus area has higher noise level than 55 dBA for standard outdoor levels. The highest noise contour is on the boulevard upto 78 dBA, just near to side of the university. The noise resulted from the boulevard effects buildings of classrooms, kindergarten, library and Engineering faculty negatively. University staff and students do complain about annoying sound level. Measured indoor noise values (L_{Aeq}) with open or closed windows are given in Table 2. All these media have higher values than 45 dBA standard value.

4 CONCLUSION

The outdoor and indoor noise measurements indicate that the noise levels are not acceptable for a university or other type educational areas.

According to the Turkish Noise Control Regulation, acceptable outdoor noise levels at educational areas, for daytime and evening time are 55 and 50 dBA, respectively. By comparison with these outdoor standards, noise levels that traffic originated in majority, at the central campus of the University are not acceptable. (Noise Control Regulation of Turkish Republic 1986)

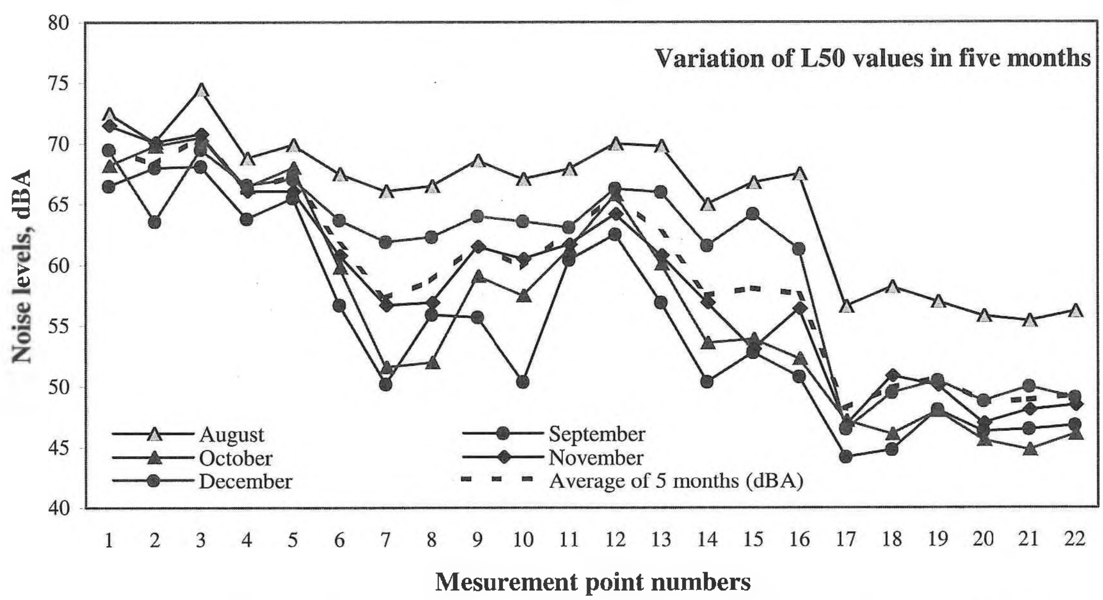

Figure 2c. Noise level values measured through 5 months at the 22 points as L_{50}

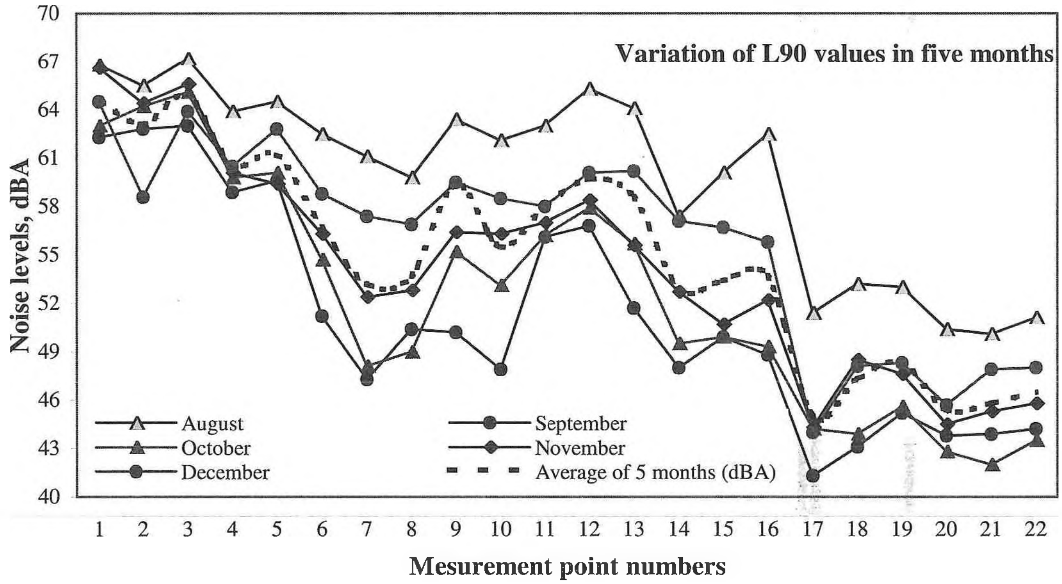

Figure 2d. Noise level values measured through 5 months at the 22 points as L_{90}

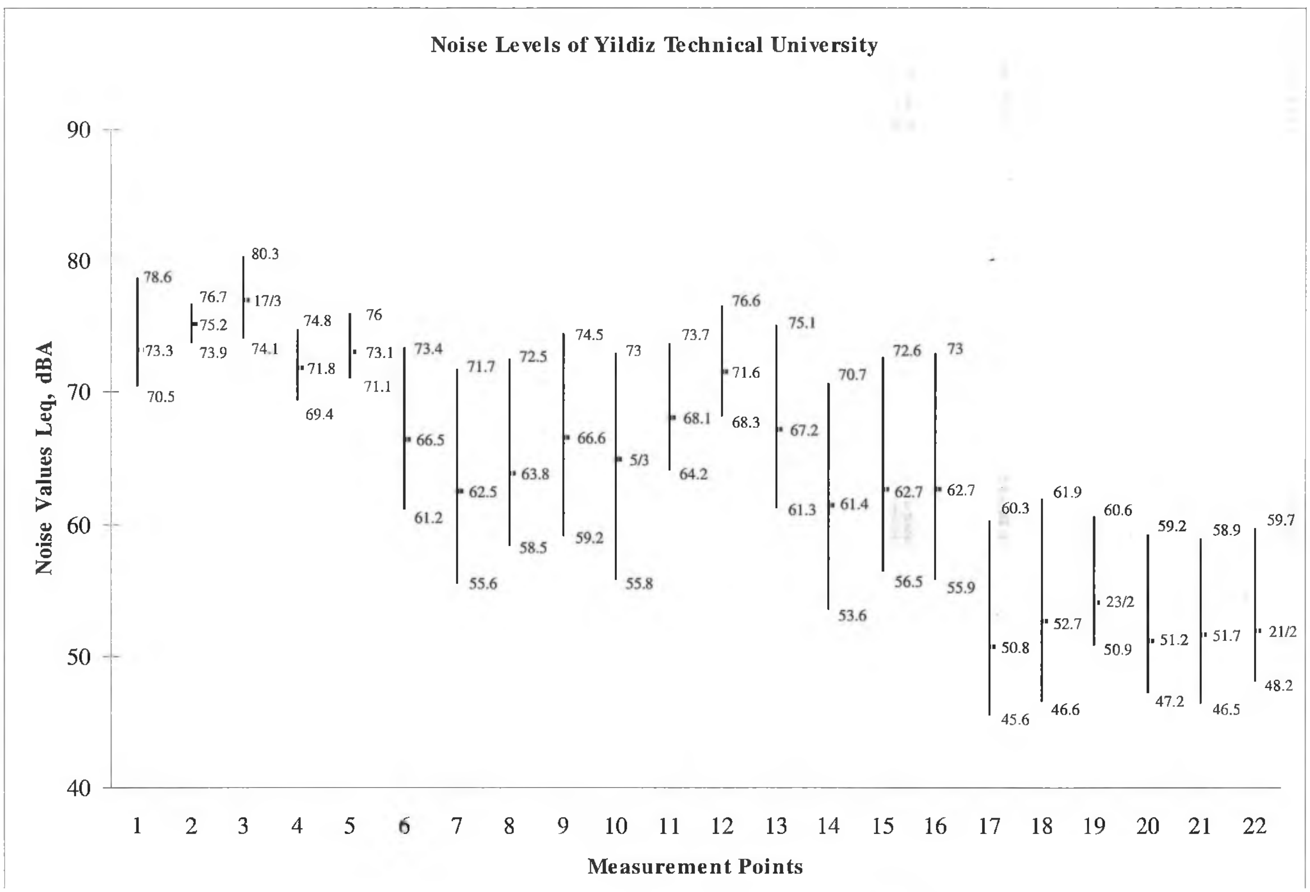

Figure 3. Max, min and average noise values of five months for each point.

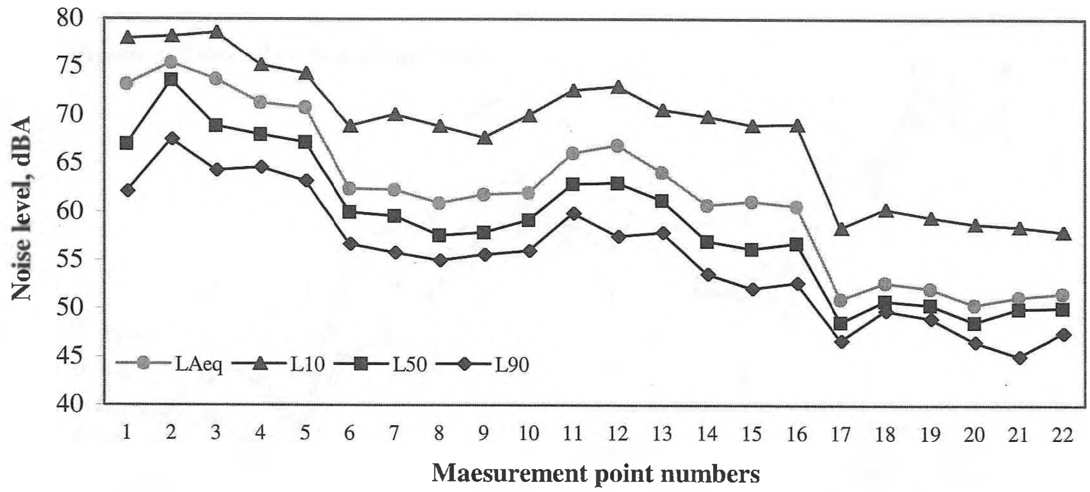

Figure 4a. Variation of statistical noise levels hourly in a day at 06.00-08.00 a.m

In order to reduce the high noise levels reaching the campus area, some control measures could be applied are summarised below:

1. Border wall height of the central campus should be increased.
2. Trees should be planted between Barbaros Boulevard and the central campus.
3. Dimensions of the windows at the boulevard side of the university can be made smaller.
4. Double windowpanes for these windows can be used.
5. In the central campus of the university, there is an open-air car park, which also causes a noise problem. To attenuate this noise cause, underground level-flatted parking lots inside of the campus should be constructed.

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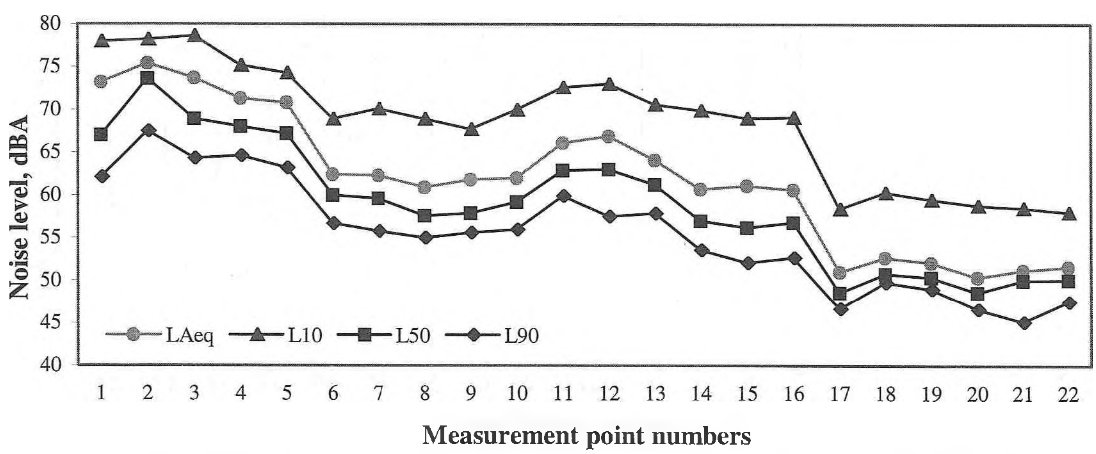


Figure 4b. Variation of statistical noise levels hourly in a day at 10.00-12.00 a.m

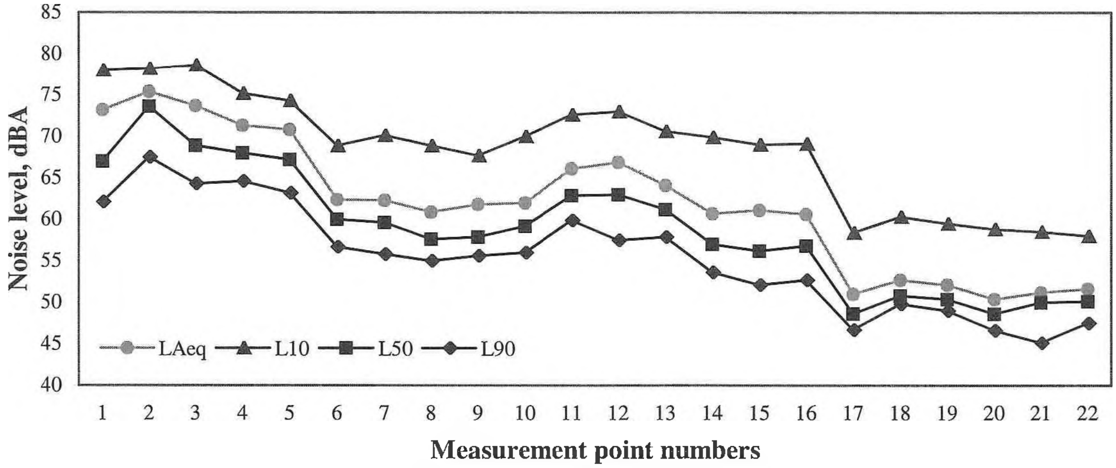


Figure 4c. Variation of statistical noise levels hourly in a day at 14.00-16.00 p.m.

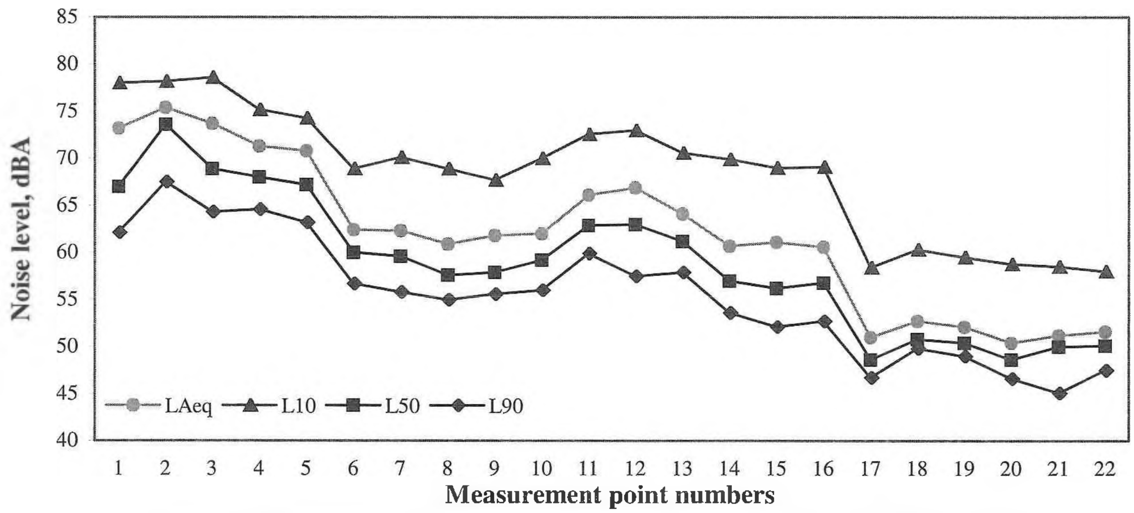


Figure 4d. Variation of statistical noise levels hourly in a day at 18.00-20.00 p.m.

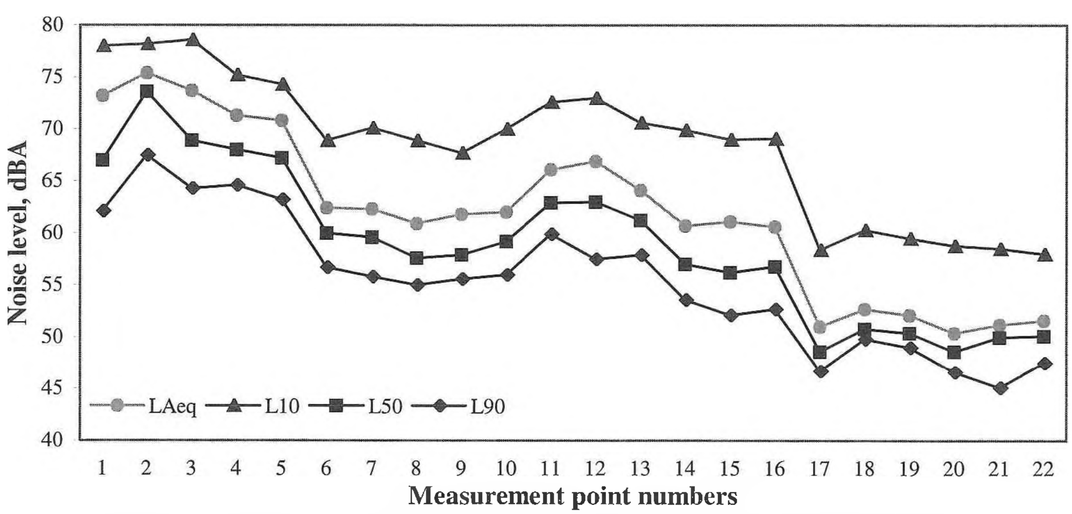


Figure 4e. Variation of statistical noise levels hourly in a day at 00.00-02.00 a.m.

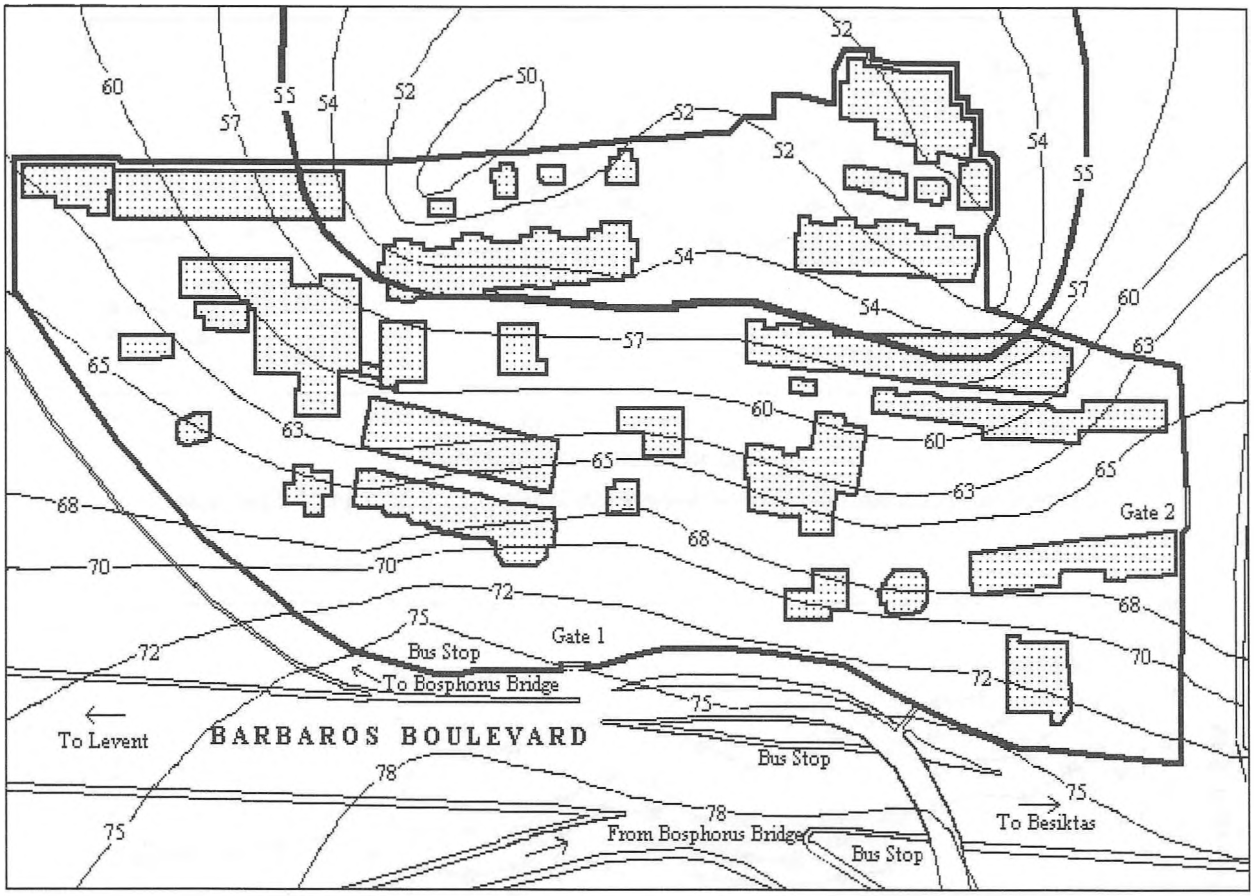
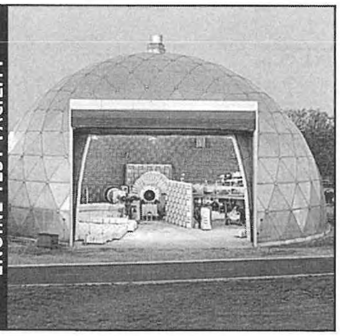


Figure 5. Noise contours map of the University.

Table 2. Indoor noise values for sensitive places located front side of the campus

Location	Indoor noise values L_{Aeq}, dB	
	Windowpane closed	Windowpane opened
Classrooms		
Entrance flat	44	47.6
The first flat	45.3	49.5
The second flat	45.5	51.7
Other		
Kindergarten	44.7	50.3
Library	45.3	48.2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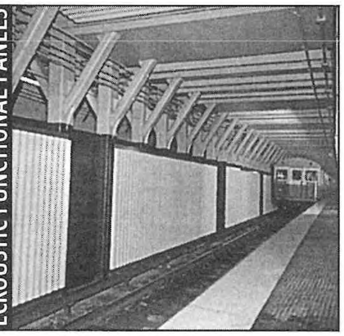
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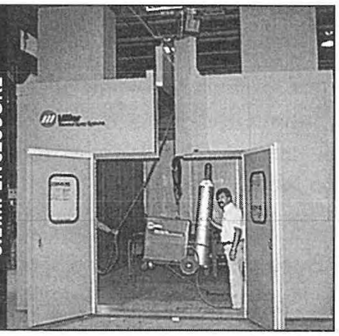
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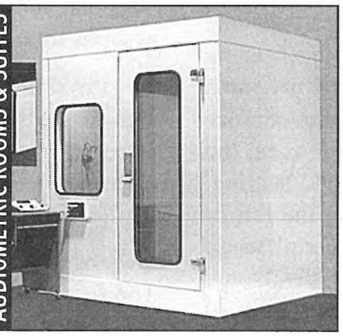
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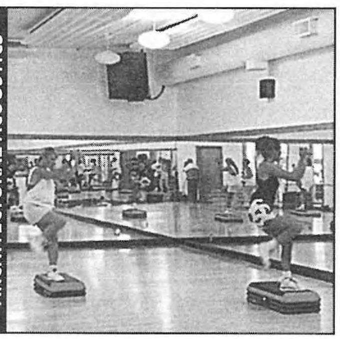
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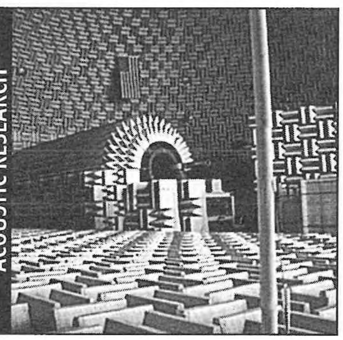
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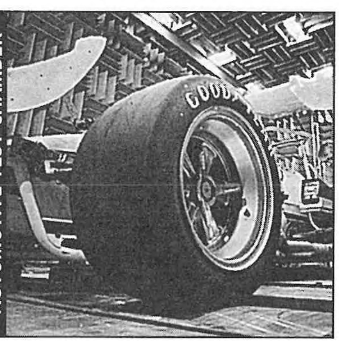
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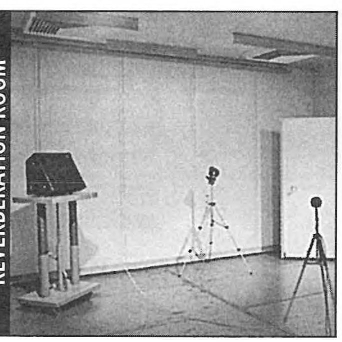
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THE BIOMEDICAL ACOUSTICS GROUP AT THE UNIVERSITY OF TORONTO

Alberto Behar, Hans Kunov and David Purcell
IBBME, University of Toronto

1. INTRODUCTION

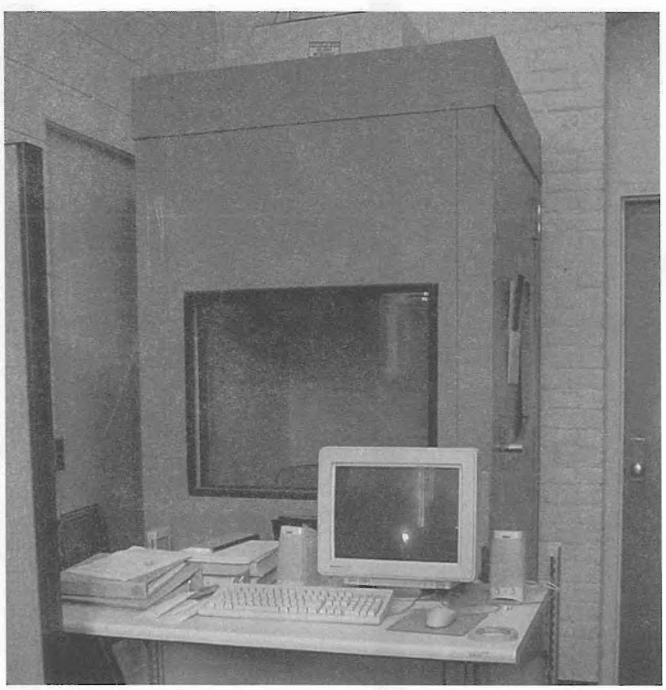
The Biomedical Acoustics Group is a part of the Institute of Biomaterials and Biomedical Engineering (IBBME). It is located on the main campus of the University. Its main field of research is centered on the human sensory processes, particularly auditory processes as well as on the scientific and engineering aspects of acoustics and hearing. Prof. Hans Kunov established the Group during the fall of 1985. The senior members of the group are Alberto Behar, Hans Kunov, Ken Norwich, Yuri Sokolov, and Willy Wong. Over the years, more than 40 graduate students and 20 undergraduate students have worked in the group.

The group has collaborated with a number of industrial companies, notably Madsen Electronics, Poul Madsen Medical Devices, and Vivosonic, the latter being a spin-off company that was incorporated in 1999.

2. SUMMARY OF RESEARCH ACTIVITIES

Acousto-mechanical models of the inner ear, with particular reference to signal processing.

Studies on Otoacoustic emissions: These active, nonlinear processes in the inner ear, intimately associated with the sensitivity and selectivity of the auditory function, are of clinical and physiological importance.



Instrumentation for Otoacoustic emissions: Development of specialized methods and equipment to measure the acoustic energy from the cochlea, recorded as acoustic vibrations in the ear canal.

Instrumentation and measurement of auditory function: This includes signal processing, hardware, software, and systems to measure different parts of the auditory system.

Physiological acoustics: Processing of complex acoustic signals by the ear, acoustic immitance of the ear, and the effect of magnetic fields on hearing. The focus is in the effect of otologic disorders on these phenomena.

Information and theoretical aspects of sensation: The laws of sensation can be derived from information theory. The focus here is on the theory itself as well as in practical applications.

Acousto-mechanical modeling of the human head: The shape of the human head and the acoustical and mechanical properties of the skin and soft tissues are complex. Accurate physical models were designed to enable direct measurement of the performance of hearing protectors, communication headsets, close-talking microphones, etc.

Multimedia: Security and data hiding in multimedia communications. The focus of this project is to protect intellectual property by "marking" multimedia content without perceptually altering its content or form

Biological computers: The analogy of the human brain as a computer and the sensory system as the input device. Exploration of how the brain performs computations based upon sensory inputs.

Auditory pattern recognition: Integration of information and pattern recognition in the auditory system. We study the human ability to recognize familiar patterns. The goal is to apply this knowledge in improving machine recognition of auditory patterns like speech.

Presently, the Laboratory is undertaking changes in the orientation of its activities that will probably be reflected in a new name.

3. FACILITIES IN THE LAB

The Biomedical Acoustics Laboratory is housed in Room 422 of the Rosebrugh Building, located just north and West from College and University Ave.

The laboratory houses one small and one large IAC double-walled acoustic soundproof chamber and state-of-the-art acoustic instrumentation. There is a network of computers with LabView© (a graphical instrumentation software package) to create virtual audiometric instruments. The flexibility and power of this system with associated peripherals allows a wide range of ideas to be tested quickly, before committing development time to special-purpose setups.

Among the instrumentation used in the Lab, and besides the conventional sound level measuring and analyzing equipment, there is a Human Head Simulator and Acoustic Test Fixture (developed in the Lab), containing a Zwislocki coupler and a precision microphone that allows for the measurement of hearing protectors and related devices.

4. STATUS OF CURRENT RESEARCH

Oto-Acoustic Emission Measurements:

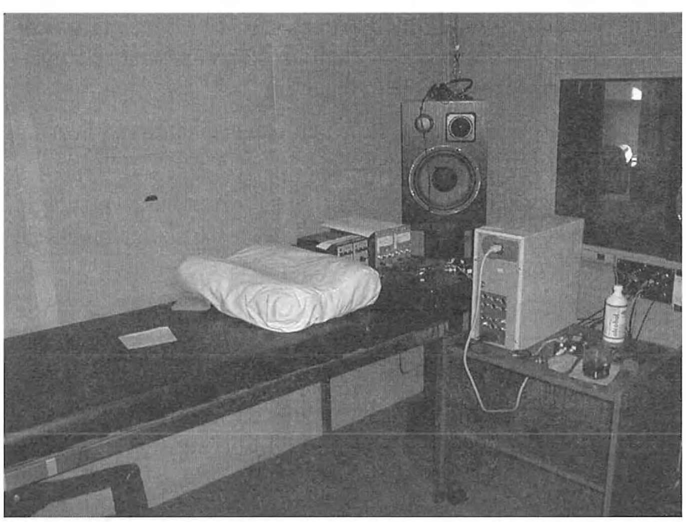
Several novel techniques and instruments were developed for measuring otoacoustic emissions.

Vibration Measurements Using Laser Interferometry:

Measurement of micro-mechanical vibrations, either mechanically or acoustically induced, is possible with the non-invasive non-loading technique of optical interferometry. A Michelson interferometer, consisting of a helium-neon laser, a cube beam splitter, two precision plane mirrors and a photodetector assembly, all mounted on a vibration isolating optical table was assembled to enable the measurements of vibration amplitudes, mode shape patterns and phase angle data of polished or diffusely reflecting surfaces. The vibrational characterization of insert hearing protectors cn thus be studied and can be correlated with acoustical attenuation measurements.

Effect of magnetic fields on hearing:

It was hypothesized that magnetic fields interfere with the process of binaural integration, which relies on extremely accurate timing of the arrival of action potentials from the two cochleae.



Objective measurement of loudness:

There is a variable that can be measured *objectively* in the acoustics lab that is an accurate measure of loudness of a tone. Participants are required to identify tones to the nearest dB that are presented binaurally through headphones, and that lie in the range one (1) to R dB. Clearly, the participant makes errors. For example, a tone of I dB presented 14 times may be identified twice as $I \pm 2$ dB, three times as $I \pm 1$ dB, and four times (correctly) as I dB. The distribution of errors associated with the stimulus tone of I dB is very nearly normal about the mean value of I dB with variance σ^2. The critical feature is that this objectively measured value of variance can be shown to be a good measure of the subjective quantity, loudness. The power function exponent obtained from the subjective measure of loudness can be obtained equally well using the new, objective measure of loudness.

Human Head Simulator and Acoustic Test Fixture:

An accurate acousto-mechanical model of the human ear has been devloped. This is used to assess the performance of hearing protection devices and communication headsets. This Acoustic Test Fixture (ATF) has been designed to model the human hearing system from the pinna and circumaural surface through the ear canal to the eardrum. Lining the entire ear canal is a layer of simulated intra-aural skin designed to establish proper coupling with earplugs. Inside the head an adapter seals the external ear module against a Zwislocki coupler, which simulates middle ear resonances and terminates in a Bruel & Kjaer microphone. A Human Head Simulator (HHS) with an articulatory tract, artificial voice and breathing has also been dresigned. The headform is designed on CAD/CAM and is covered with artificial skin. It is applied to measurements of speech intelligibility through respirators and other devices in close contact with the head. The work was carried out in collaboration with the Defense and Civil Institute for Environmental Medicine (DCIEM).

Voice Simulation and Speech Transmission Indices:

In connection with the Human Head Simulator, we designed an artificial vocal tract and an adaptation of the STIDAS index for use with the Head. Because the head simulator will be used with acoustic loads (such as flight helmets or respirators) it is important to simulate the source impedance of the speech sounds.

Phase Audiometry:

The intelligibility of speech signals depends greatly on temporal processing by the auditory system, and this ability is not normally measured directly (except by so-called speech testing which are limited in the information they provide).

"Phase audiometry" [our term] is a means of measuring temporal acuity, using continuous signals. This provides the potential for more in-depth and varied analysis of temporal processing, and is achieved by representing the "gap" as a complex noise signal having a special phase relationship among the components. Investigating the various mechanisms responsible for the ear's phase sensitivity is an important part of this work.

Peripheral Vision as an Information Channel and its use in an Aid for the Hearing Handicapped.

The visual periphery can be used as an information channel to substitute for other sensory handicaps. We have concentrated on the development of a pair of eyeglasses fitted with a small two-dimensional array of light-emitting diodes mounted inconspicuously in the frame. Psychophysical tests on normal and deaf subjects indicate that considerable benefits can be derived from the display of carefully chosen signals derived from processed acoustical data. Associated work is going on related to the measurement of peripheral visual information channel capacity, binocular rivalry, learning effects, and designs for cosmetic acceptability.

Graduate students theses in progress

Jan Rubak: *Tracking Speech Recognition*, M.Sc. (Physics),

Ewen MacDonald: *Signal processing for a lipreading aid*, M.A.Sc.

Hilmi Dajani: *Audition-inspired time-varying spectral analysis*, Ph.D

Taha Jaffer: *"Modeling the interconnective tissue of the cochlear partition and otoacoustic emission*, Ph.D.

E.Sagi: *Objective appraisal of loudness,* PhD

6. Completed theses

David Purcell: Otoacoustic emissions and bone-conduction, Ph.D. 2000

Victoria Wai-Chi Young: Pre-clinical testing of real-time distortion product otoacoustic emission devices, M.A.Sc. 2000

Martin Pienkowski: Evidence for a relationship between the suppression of distortion product otoacoustic emissions and hearing threshold, M.Sc. 2000

Taha Jaffer: Longitudinal elasticity of the cochlear partition and distortion product otoacoustic emissions, M.A.Sc. 2000

Peter Picton: Multiple-tone pair distortion product otoacoustic emissions, M.A.Sc. 1999

Tony Orsi: Investigation into steady-state auditory brainstem response detection: weighted time avaraging and autoregressive spectral estimation, M.A.Sc. 1998.

Elad Sagi: Absolute identification of loudness: Theory and experiment, M.Sc. 1998.

Vitold Bielinski: Maximum length sequences for transient otoacoustic emissions: feasibility study, M.Eng., 1997

Nicholae Schiopu: Transient evoked otoacoustic emissions elicited by bone-conducted ultrasonic stimuli, M.A.Sc. 1997

George Fung: The effect of vestibular stimulation on distortion product otoacoustic emissions M.Sc. 1997

Nathanael Kuehner: Extension of transiently evoked otoacoustic emission measurements to cover the entire audiometric range, M.A.Sc., 1997

Willy Wong: On the Physics of Perception Ph.D. 1996

Robert Kulik: A synchronous averaging instrument for the measurement of distortion product otoacoustic emissions, M.A.Sc. 1995

Bayla Barron: The application of speech recognition to emergency response systems, M.A.Sc. 1995

Murugathas (Thas) Yuwaraj: Stimulus artifact reduction in transient evoked otoacoustic emissions testing, M.A.Sc. 1995

David Crotin: Standardization and scaling of anthromometric, M.A.Sc. 1994

Hassan Refaee: Application of the Continuous Wavelet Transform to analyzing otoacoustic emissions, M.A.Sc. 1994

Rong-Kai Hong: Temporal Characteristics of Electrocochlear channel in Single-electrode cochlear Implant Patients, Ph.D. 1993

Danyal Ibrahim: Plasticity of tonotopic maps in auditory midbrain following partial cochlear damage in developing chinchilla, M.Sc 1993

Willy Wong: On the Physics of Perception, M.Sc. 1993.

Rob Grant: Myoelectric Signal Processing for Control of Limb Prostheses, M.A.Sc. 1992.

Ilan A. Arnon: The influence of duration on formant transition detection and its effect on stop consonant identification, M.A.Sc. 1992

Niles Burbank: The informational categorization of hearing impairment, M.A.Sc. 1991

Hilmi R. Dajani: The influence of low frequency magnetic fields on the nervous system, with particular reference to binaural hearing, M.A.Sc. 1991

Edmund Joseph Sim: The Application of Monaural Phase Sensitivity Testing to the Study of Temporally-Based Hearing Mechanisms, M.A.Sc. 1991

Terry A. Gerritsen: A source impedance compensated artificial voice for speech intelligibility testing, M.A.Sc. 1990.

Kenneth Richard Tough: Investigation of Interaural Cochlear Mechanisms using Oto-acoustic Emission Phenomena, M.A.Sc. 1989

Rong-Kai Hong: Development of a Real-Time Digital Speech Processor for Single Channel Cochlear Prostheses, M.A.Sc. 1989

Alton Ing: Mechanical Shear Impedance Measurements Intra-aural Tissue, M.A.Sc. 1988

Gary Thomas Doswell: Vibrational Analysis of Intra-Aural Hearing Protectors Occluding Model Ear Canals, M.A.Sc. 1988

Prem Chand Pandey: Speech Processing for Cochlear Prostheses, Ph.D. 1988

Kristiina M. Valter: The Entropy Theory of Perception as Applied to Intensity Discrimination of Auditory Pure Tones. M.Sc. 1988.

Jorge Alberto del Rio Guzman: Design of a Transducer for the Measurement of Middle Ear Immittance at the Eardrum, M.A.Sc. 1987

Daryush Ebrahimi: Preliminary Research on a Peripheral Vision Lipreading Aid, M.A.Sc. 1987

Hoda Kamel: Morphological Measurements and Indices for Characterizing the Shape of the Ear Canal, M.A.Sc. 1987

Christian Giguère: An Acousto-mechanical Model of the Hearing System with Appl. for Hearing Protection, M.A.Sc. 1986.

D. John Doyle: Signal-Processing Techniques for Estimation of the Auditory Brainstem Response, Ph.D. 1986

Evan B. Friedman: Evaluation of the Effects of Industrial Noise on the Peripheral Auditory Apparatus Using a Computer Simulation, M.Sc. 1984

Bannu Hurtig: Feasibility Study of a New Two-Microphone Method for Measuring Acoustic Impedance, M.A.Sc. 1982

John S. Taylor: A System for Measuring Jitter and Shimmer in Sustained Vowels, M.A.Sc. 1981

Ian D. Parson: Complex Acoustic Impedance of the Human Ear, Ph.D. 1980

Review of "Fundamentals of Acoustical Oceanography" by Medwin and Clay, Academic Press, 1998

Fundamentals of Acoustical Oceanography authored by Herman Medwin and Clarence S. Clay, published by Academic Press, 1998, is a wide-ranging text on acoustic fundamentals, propagation, and scattering. It is a part of a series of books in *Applications of Modern Acoustics*, edited by Richard Stern and Moises Levy. The book is printed on over 700 acid-free pages and is composed of an 11-page Table of Contents, brief prefaces and acknowledgements, 14 topic chapters, extensive 30-page References and Bibliography sections, a 16-page list of symbols, and a fine-print, 5-page index. In short, the book, which is entirely in reproduced in black and white, with the exception of 5 colour plates results in a pleasing appearance and well-made, comfortable feel.

Having described the package, it is now time to look inside and describe the contents for prospective readers. I'll briefly describe each chapter's contents and my impressions of it. I'll also summarize any errors I found. Each chapter concludes with a problem set related to the subject matter. I didn't actually work any of these problems, but they appear to cover the material and range of difficulty.

Chapter 1 is a motivational chapter that illustrates the scope and applications of acoustical oceanography. It is a light and easy read, and it contains a large number of figures, 16 in fact – an average of one figure per page. This chapter is quite well done despite the fact that the colour plates were obviously added to dress up the book. I found four trivial errors in the text and captions. The colour plates were obviously added late in the book's creation, as their inclusion introduces a number of referencing errors in later chapters.

Chapter 2 introduces basic concepts of propagation and provides the mathematical background. Overall it is quite easily followed, although some parts are weak, in particular, the description of Huygen's principle, which is invoked throughout the book. I found 14 errors and several areas where, as an editor, I would have wanted changes, in this chapter. The errors are mostly trivial, however, they do result in at least three incorrect equations and lead to reader confusion. Typical errors include bad references to figures or equations, missing bold-face where required, or similar but different symbols substituted in text and equations. Finally, this chapter illustrates some of the worst equation type-setting I have ever seen.

Chapter 3 continues with propagation topics and is largely concerned with ray propagation and attenuation. I felt that this chapter was quite instructive and I liked the approach of multiplicative factors that was taken in the calculation of sound intensity. I found myself drawing parallels between Urick's 'Principles of Underwater Sound for Engineers' where the sonar equation terms in decibels are used to introduce each factor. Concepts of tomography and Doppler are briefly introduced. Unfortunately, the equation type-setting remains poor, if not worse than previously. I found a dozen minor errors, including one wrong variable in an equation and a '2' used as a subscript, rather than as a superscript.

Chapter 4 describes conceptual acoustic sources and receivers. Mono-pole and dipole sources, and arrays of sources and receivers are introduced. Near-field and far-field expressions are developed and calibration of transducers is discussed. In this chapter, I only found 1 error in the axis labelling of a figure.

Chapter 5 is about high-intensity acoustics. Here explosive sources and non-linear effects are described. Cavitation is introduced and parametric sources and receivers are discussed. I found this chapter quite instructive as I have never used parametric sources or receivers. I only noticed two minor errors, both simple misspellings.

Chapter 6 is about the signal processing of ocean sounds. This chapter describes the filtering, transformation, and correlation processes most commonly applied to transmitted and received signals. From a signal processing standpoint the material here is all basic information, it is the application to underwater acoustics that is most relevant. The final section in this chapter deals with the types of sounds in the ocean. I found 3 trivial errors, all misspellings, and had one minor comment about consistent style.

Chapter 7 introduces scattering from bodies, the real meat of the text. This is a very informative chapter and despite a lot of mathematics I only found 7 trivial errors. This chapter describes the Helmholtz-Kirchhoff methods and various approximations to the theory. It introduces facets, cylinders, and spheres under varying physical conditions. The chapter wraps up with introducing modal methods to obtain the diffracted components of scattered energy.

Chapter 8 continues with scattering, but is centred on the topic of bubbles. There is a lot of information in this chapter and I found it quite valuable. After reading this chapter, I found myself planning experiments involving bubbles. Again, there were 7 errors, all completely trivial, but still there.

Chapter 9 continues even further with scattering topics, this time biomass echoes and reverberation. This chapter describes the process of building simplified models of fish and zooplankton, and describes the process of using echoes to determine fish populations. There is a great deal of material covered here, perhaps too briefly. Many of the topics are difficult and often the treatments are brief and quote results from elsewhere. This chapter, and the two previous, are good starting points for scattering topics. They provide an overview and some details. I found 16 errors in this chapter, 10 of them spelling mistakes! The others tended to be bad references to figures or equations.

Chapter 10 is about sonar systems and how to make measurements and inversions for collected data. I rather liked this chapter, but I personally think that there could have been more detail spent on the hardware of the transducers and the sonar systems themselves. Before long the chapter turns to inverting reverberant echoes for fish population densities and essentially becomes another chapter on scattering. There were 14 errors in this chapter, again mostly minor items.

Chapter 11 is about wave-guides composed of layers and wedges. It is a good starting point for understanding the modal solution of wave-guide propagation and it introduces some advanced signal processing concepts, albeit very briefly, such as matched field processing. I had 5 minor complaints about errors in this chapter, but there could be more as many results were copied from references and I didn't check the equations. I found that the modal solution part of the chapter was easy enough to follow, maybe because of familiarity, but I had more difficulty with the Biot-Tolstoy solutions.

Chapter 12 brings us back to scattering, this time from edges and rough surfaces. I found two spelling mistakes and one bad figure reference in this chapter. This chapter makes extensive use of the Biot-Tolstoy solutions for scattering from corners and prisms. It draws heavily on material from external references. It is a difficult chapter with a lot of material.

Chapter 13 continues with scattering, this time introducing statistically rough surfaces – the ocean surface and bottom. Here the material becomes increasingly more of an overview of the subject. The overview is quite detailed and includes physical, scaled analogue, and computer models.

Finally, Chapter 14 provides a brief introduction to the use of backscattered energy in mapping the sea floor. This chapter includes descriptions of various sonar systems, techniques, examples, and mathematical treatments for data involved in the production of sea-bottom and sub-surface maps.

So, what do I think of this book? I think it is a very good reference book for a professional in the field of underwater acoustics or physical oceanography. I don't think it is a particularly good book to use as a text book for a course. The reason for this latter statement is that the material goes from fairly straight-forward to very difficult. The change occurs at about Chapter 8! I think that if this book if used for teaching, it would have to be aimed at a senior course level and the instructor would have to be careful about the material included from the later chapters, or perhaps, the book could be used for two separate courses, one introductory and the second more specialized and probably on the topic of scattering. On the other hand, this book is an excellent starting point for the professional entering a new area or refreshing memories. Indeed, in the two months that I have owned a copy, it has been the most-often-borrowed book on my shelves. The extensive bibliography and references provide many paths to follow on subjects requiring further details.

To conclude, I feel I need to mention the errors and equation type-setting problems in this book. First, none of the errors are particularly significant, most are simply spelling mistakes. I really don't understand how these sorts of errors can remain in the final version, almost any spelling checker would have caught the vast majority of them. Second, the equation type-setting in the book is very poor. Some equations are hard to read or ambiguous because this type-setting. I think more effort should have been spent to improve this feature in a book that has 14 pages devoted to the list of symbols used in the hundreds of equations.

Garry J. Heard
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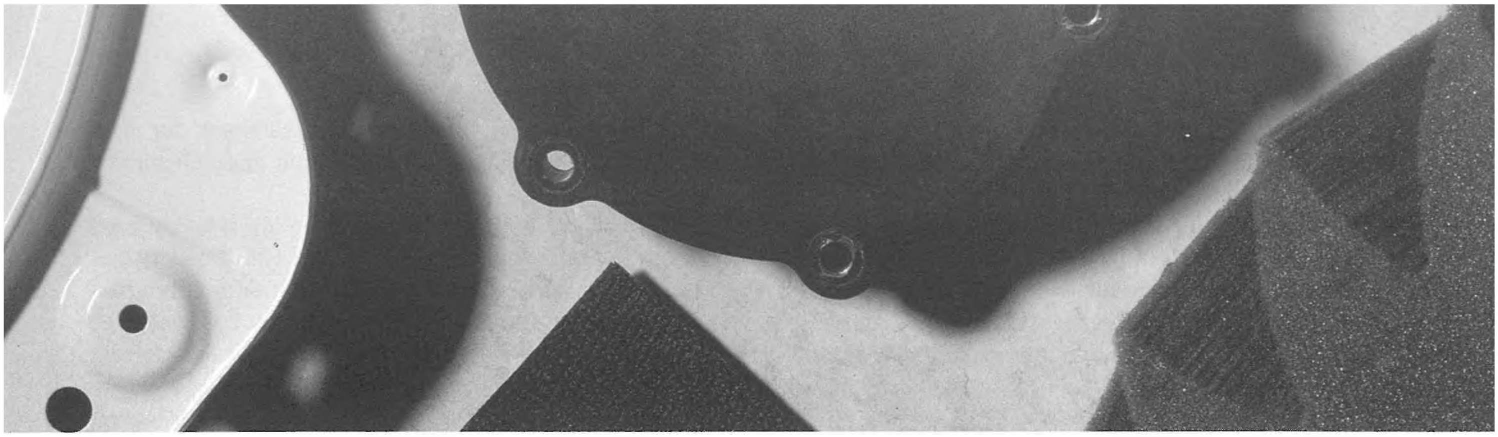

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NEWS / INFORMATIONS

CONFERENCES

The following list of conferences was mainly provided by the Acoustical Society of America. If you have any news to share with us, send them by mail or fax to the News Editor (see address on the inside cover), or via electronic mail to desharnais@drea.dnd.ca

2001

4-8 June: 141st Meeting of the Acoustical Society of America, Chicago, IL. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; Email: asa@aip.org; Web: asa.aip.org

7-9 June: International Hearing Aid Conference VI. Novel Processing and Fitting Strategies, Iowa City, IA. Contact: Rich Tyler, Tel: 319-356-2471, Email: rich-tyler@uiowa.edu, Web: www.medicine.uiowa.edu/otolaryngology/news/news

2-5 July: Ultrasonics International Conference (UI01), Delft, The Netherlands. Contact: W. Sachse, T&AM, 212 Kimball Hall, Cornell University, Ithaca, NY 14853-1503, USA; Fax: +1 607 255 9179; Web: www.ccmr.cornell.edu/~ui01/

2-6 July: 8th International Congress on Sound and Vibration, Kowloon, Hong Kong. Fax: +852 2365 4703; Web: www.iiav.org

9-13 July: 2001 SIAM Annual Meeting, San Diego, CA. Contact: Society for Industrial and Applied Mathematics (SIAM), Tel.: 215-382-9800; Fax: 215-386-7999; Email: meetings@siam.org; Web: www.siam.org/meetings/an01/

6-8 August: 2nd International Conference on Acoustics, Noise and Vibrations (ICANOV2001), Ottawa, ON, Canada. Email: information@icanov.org; Web: www.icanov.org

9-11 August: SMPC2001 — Meeting of the Society for Music Perception and Cognition, Queen's University, Kingston, ON, Canada. Email: smpc@psyc.queensu.ca; Web: http://psyc.queensu.ca/~smpc/

15-19 August: ClarinetFest 2001, New Orleans, LA. Contact: Dr. Keith Koons, ICA Research Presentation Committee Chair, Music Dept., Univ. of Central Florida, P.O. Box 161354, Orlando, FL 32816-1354; Tel.: 407-823-5116; E-mail: kkoons@pegasus.cc.ucf.edu

19-24 August: Asilomar Conference on Implantable Auditory Prostheses, Pacific Grove, CA. Contact: Michael Dorman, Dept. of Speech and Hearing Science, Arizona State Univ., Tempe, AZ 85287-0102, Tel.: 480-965-3345; Fax: 480-965-0965; Email: mdorman@asu.edu

CONFÉRENCES

La liste de conférences ci-jointe a été offerte en majeure partie par l'Acoustical Society of America. Si vous avez des nouvelles à nous communiquer, envoyez-les par courrier ou fax (coordonnées incluses à l'envers de la page couverture), ou par courrier électronique à desharnais@drea.dnd.ca

2001

4-8 juin: 141e rencontre de l'Acoustical Society of America, Chicago, IL. Info: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; Courriel: asa@aip.org; Web: asa.aip.org

7-9 juin: Conférence internationale sur les audiophones VI. Nouveautés en traitement de signal et stratégies d'ajustement, Iowa City, IA. Info: Rich Tyler, Tél: 319-356-2471, Courriel: rich-tyler@uiowa.edu, Web: www.medicine.uiowa.edu/otolaryngology/news/news

2-5 juillet: Conférence internationale sur les ultrasons (UI01), Delft, Pays-Bas. Info: W. Sachse, T&AM, 212 Kimball Hall, Cornell University, Ithaca, NY 14853-1503, USA; Fax: +1 607 255 9179; Web: www.ccmr.cornell.edu/~ui01/

2-6 juillet: 8e Congrès international sur le son et les vibrations, Kowloon, Hong Kong. Fax: +852 2365 4703; Web: www.iiav.org

9-13 juillet: Rencontre annuelle SIAM 2001, San Diego, CA. Info: Society for Industrial and Applied Mathematics (SIAM), Tél.: 215-382-9800; Fax: 215-386-7999; Courriel: meetings@siam.org; Web: www.siam.org/meetings/an01/

6-8 août: 2e Conférence internationale sur l'acoustique, bruit et vibrations (ICANOV2001), Ottawa, ON, Canada. Courriel: information@icanov.org; Web: www.icanov.org

9-11 août: SMPC2001 — Rencontre de la Société pour la perception et cognition de la musique, Université Queen, Kingston, ON, Canada. Courriel: smpc@psyc.queensu.ca; Web: http://psyc.queensu.ca/~smpc/

15-19 août: ClarinetFest 2001, Nouvelle Orléans, LA. Info: Dr. Keith Koons, ICA Research Presentation Committee Chair, Music Dept., Univ. of Central Florida, P.O. Box 161354, Orlando, FL 32816-1354; Tél.: 407-823-5116; Courriel: kkoons@pegasus.cc.ucf.edu

19-24 août: Conférence Asilomar sur les implants de prothèses auditives, Pacific Grove, CA. Info: Michael Dorman, Dept. of Speech and Hearing Science, Arizona State Univ., Tempe, AZ 85287-0102, Tél.: 480-965-3345; Fax: 480-965-0965; Courriel: mdorman@asu.edu

28-30 August: Inter-Noise 2001, The Hague, The Netherlands. Email: secretary@internoise2001.tudelft.nl; Web: internoise2001.tudelft.nl

2-7 September: 17th International Congress on Acoustics (ICA), Rome, Italy. Fax: +39 6 4976 6932; Web: www.ica2001.it

10-13 September: International Symposium on Musical Acoustics (ISMA 2001), Perugia, Italy. Contact: Perugia Classico, Comune di Perugia, Via Eburnea 9, 06100 Perugia, Italy; Fax: +39 75 577 2255; Email: perugia@classico.it

7-10 October: 2001 IEEE International Ultrasonics Symposium Joint with World Congress on Ultrasonics, Atlanta, GA. Contact: W. O'Brien, Electrical and Computer Engineering, Univ. of Illinois, 405 N. Mathews, Urbana, IL 61801; Fax: 217-244-0105; WWW: www.ieee-uffc.org/2001

17-19 October: 32nd Meeting of the Spanish Acoustical Society, La Rioja, Spain. Contact: Serrano 144, Madrid 28006, Spain; Fax: +34 91 411 76 51; Web: www.ia.csic.es/sea/index.html

25-26 October: Fall meeting of the Swiss Acoustical Society, Wallis, Switzerland. Contact: Suva Akustik, P.O. Box 4358, 6002 Luzern, Switzerland; Web: www.sga-ssa.ch

29-31 October: NOISE-CON 2001 — 2001 National Conference on Noise Control Engineering, Portland, ME. Contact: INCE/USA, P.O. Box 3206 Arlington Branch, Poughkeepsie, NY 12603. Email: hq@ince.org

21-23 November: Australian Acoustical Society Annual Meeting, Canberra, Australia. Contact: Acoustics 2001, Australian Defense Force Academy, Canberra, ACT 2600, Australia; Email: nit@adfa.edu.au

3-7 December: 142nd Meeting of the Acoustical Society of America, Ft. Lauderdale, FL. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; Email: asa@aip.org; Web: asa.aip.org

2002

4-8 March: German Acoustical Society Meeting (DAGA 2002), Bochum, Germany. Contact: J. Blauert, Institute of Communication Acoustics, Ruhr-Universität Bochum, 44780 Bochum, Germany; Fax: +49 234 321 4165; Web: www.ika.ruhr-uni-bochum.de

3-7 June: 143rd Meeting of the Acoustical Society of America, Pittsburg, PA. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; Email: asa@aip.org; Web: asa.aip.org

28-30 août: Inter-Noise 2001, La Haye, Pays-Bas. Courriel: secretary@internoise2001.tudelft.nl; Web: internoise2001.tudelft.nl

2-7 septembre: 17e Congrès international sur l'acoustique (ICA), Rome, Italie. Fax: +39 6 4976 6932; Web: www.ica2001.it

10-13 septembre: Symposium international sur l'acoustique musicale (ISMA 2001), Perugia, Italie. Info: Perugia Classico, Comune di Perugia, Via Eburnea 9, 06100 Perugia, Italy; Fax: +39 75 577 2255; Courriel: perugia@classico.it

7-10 octobre: Symposium international IEEE 2001 sur les ultrasons, combiné avec le Congrès mondial sur les ultrasons, Atlanta, GA. Info: W. O'Brien, Electrical and Computer Engineering, Univ. of Illinois, 405 N. Mathews, Urbana, IL 61801; Fax: 217-244-0105; WWW: www.ieee-uffc.org/2001

17-19 octobre: 32e rencontre de la Société espagnole d'acoustique, La Rioja, Espagne. Info: Serrano 144, Madrid 28006, Spain; Fax: +34 91 411 76 51; Web: www.ia.csic.es/sea/index.html

25-26 octobre: Journées d'automne de la Société suisse d'acoustique, Valais, Suisse. Info: Suva Akustik, C.P. 4358, 6002 Luzerne, Suisse; Web: www.sga-ssa.ch

29-31 octobre: NOISE-CON 2001 — Conférence nationale 2001 sur le génie du contrôle du bruit, Portland, ME. Info: INCE/USA, P.O. Box 3206 Arlington Branch, Poughkeepsie, NY 12603. Courriel: hq@ince.org

21-23 novembre: Rencontre annuelle de la Société australienne d'acoustique, Canberra, Australie. Info: Acoustics 2001, Australian Defense Force Academy, Canberra, ACT 2600, Australia; Courriel: nit@adfa.edu.au

3-7 décembre: 142e recontre de l'Acoustical Society of America, Ft. Lauderdale, FL. Info: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tél: 516-576-2360; Fax: 516-576-2377; Courriel: asa@aip.org; Web: asa.aip.org

2002

4-8 mars: Rencontre de la Société allemande d'acoustique (DAGA 2002), Bochum, Allemagne. Info: J. Blauert, Institute of Communication Acoustics, Ruhr-Universität Bochum, 44780 Bochum, Germany; Fax: +49 234 321 4165; Web: www.ika.ruhr-uni-bochum.de

3-7 juin: 143e rencontre de l'Acoustical Society of America, Pittsburg, PA. Info: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tél: 516-576-2360; Fax: 516-576-2377; Courriel: asa@aip.org; Web: asa.aip.org

4-6 June: 6th International Symposium on Transport Noise and Vibration, St. Petersburg, Russia. Contact: East-European Acoustical Association, Moskovskoe Shosse 44, St. Petersburg 196158, Russia; Fax: +7 812 127 9323; Email: noise@mail.rcom.ru

10-14 June: Acoustics in Fisheries and Aquatic Ecology, Montpellier, France. Contact: D.V. Holliday, BAE SYSTEMS, 4669 Murphy Canyon Road, Suite 102, San Diego, CA 92123-4333,

19-21 August: Inter-Noise 2001 — 31st International Congress and Exposition on Noise Control Engineering, Dearborn, MI. Contact: Inter-Noise 2002 Congress Secretariat, Dept. Mechanical Engineering, Ohio State University, 206 West 18th Avenue, Columbus, OH 43210-1107, USA. Email: peersen.1@osu.edu; Web: www.internoise2002.org

19-23 August: 16th International Symposium on Nonlinear Acoustics (ISNA16), Moscow, Russia. Contact: O. Rudenko, Physics Department, Moscow State University, 119899 Moscow, Russia; Email: isna@acs366b.phys.msu.su

16-21 September: Forum Acusticum 2002 (Joint EAA-SEA-ASJ Meeting), Sevilla. Fax: +34 91 411 7651; Web: www.cica.es/aliens/forum2002

2-6 December: Joint Meeting: 9th Mexican Congress on Acoustics, 144th Meeting of the Acoustical Society of America, and 3rd Iberoamerican Congress on Acoustics, Cancun, Mexico. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; Email: asa@aip.org; Web: asa.aip.org/cancun.html

4-6 juin: 6e Symposium international sur le bruit et vibrations des transports, Saint-Pétersbourg, Russie. Info: East-European Acoustical Association, Moskovskoe Shosse 44, St. Petersburg 196158, Russia; Fax: +7 812 127 9323; Courriel: noise@mail.rcom.ru

10-14 juin: Acoustique des pêches et écologie aquatique, Montpellier, France. Info: D.V. Holliday, BAE SYSTEMS, 4669 Murphy Canyon Road, Suite 102, San Diego, CA 92123-4333, USA; Web: www.ices.dk/symposia/

19-21 août: Inter-Noise 2001 — 31e Congrès international et exposition sur le génie du contrôle du bruit, Dearborn, MI. Info: Inter-Noise 2002 Congress Secretariat, Dept. Mechanical Engineering, Ohio State University, 206 West 18th Avenue, Columbus, OH 43210-1107, USA. Courriel: peersen.1@osu.edu; Web: www.internoise2002.org

19-23 août: 16e Symposium international sur l'acoustique non-linéaire (ISNA16), Moscou, Russie. Info: O. Rudenko, Physics Department, Moscow State University, 119899 Moscow, Russia; Courriel: isna@acs366b.phys.msu.su

16-21 septembre: Forum Acusticum 2002 (Rencontre conjointe EAA-SEA-ASJ), Séville. Fax: +34 91 411 7651; Web: www.cica.es/aliens/forum2002

2-6 décembre: Rencontres combinées: 9e Congrès mexicain d'acoustique, 144e rencontre de l'Acoustical Society of America, et 3e Congrès ibéro-américain d'acoustique, Cancun, Mexique. Info: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tél: 516-576-2360; Fax: 516-576-2377; Courriel: asa@aip.org; Web: asa.aip.org/cancun.html

FUNDAMENTALS OF NOISE CONTROL

A short course introducing the basic principals of noise control will be offered over the internet this summer. The course will be offered on-site at the Purdue University Campus, and on the Web through Continuing Engineering Education. The topics covered will include: basic acoustics, human response to noise, frequency analysis, sound sources and sound fields, room acoustics, sound transmission, noise control materials, mufflers and silencers, active noise control, and principles of noise control. Laboratory exercises will be included and will illustrate aspects of sound pressure measurements, sound propagation in ducts, room acoustics, and mufflers and silencers. There will be an optional final exam required only for those taking the course for academic credit.

The instructors are Dr. Luc Mongeau, Associate Professor of Mechanical Engineering, and Dr. J. Stuart Bolton, Professor of Mechanical Engineering, both with the Ray W. Herrick Laboratories, Purdue University.

For more information, please contact:
Mrs. Virginia Freeman, Purdue University
1077 Ray W. Herrick Laboratories
West Lafayette, IN, 47907-1077 USA, Tel: 765-494-6078; Fax: 765-494-0787
E-mail: herlconf@ecn.purdue.edu; Web: http://tools.ecn.purdue.edu/~me413/

ACOUSTICS CONFERENCE IN CANADA 2001
SEMAINE CANADIENNE D'ACOUSTIQUE 2001

GENERAL INFORMATION

The CAA Acoustics Conference in Canada 2001 is fast approaching. This year we have gone to a slightly different format and have introduced, in addition to the full three day conference rate, a daily rate. With the introduction of a daily rate we are hoping to attract people from the Toronto area who may not be able to attend for all three days.

The Conference is to be held at the beautiful Nottawasaga Inn, in Alliston, Ontario, which is located just north of Toronto, Ontario. The Inn is fully equipped with indoor swimming pool, 45 holes of golf, spa facilities, restaurants, indoor mini-golf area and games room. Visit the Nottawasaga website at www.NottawasagaResort.com, to obtain further details.

We urge everyone to book their hotel rooms before July 3, 2001 to guarantee availability. When booking indicate that you are coming for the Canadian Acoustical Association Conference.

Visit the CAA2001 Website for the most up to date information, including the Registration Form and a list of the exhibitors and sponsors for this year's Conference. The program for the three day Conference will be varied, interesting and cover many areas of acoustics. The program will also be posted on the website and updated regularly.

For those wishing to arrive early, we are planning a 9-hole golf tournament for the Sunday afternoon. This is a chance to socialize with colleagues you may not have seen recently or just to relax with round of golf.

The banquet also promises to be very unique and exciting. This year we have the pleasure of being entertained by Ms.Atarah Ben-Tovim. Ms. Ben-Tovim is a musician, speaker and above all an entertainer. If you wish to bring along your favourite instrument feel free to do so. For those less musically inclined "instruments" will be provided. Visit our website for additional information regarding Ms. Ben-Tovim and this fun filled evening.

The Canadian Acoustical Association — l'Association Canadienne d'Acoustique

SEMAINE CANADIENNE D'ACOUSTIQUE 2001

Informations d'ordre général

La Semaine Canadienne d'Acoustique 2001 approche à grands pas. Cette année nous avons légèrement modifié les modalités d'inscription en introduisant un tarif à la journée. Par cette solution, nous espérons attirer les gens de la région de Toronto qui ne seraient pas en mesure d'assister à l'ensemble de la conférence.

La conférence se tiendra dans un cadre agréable, l'auberge Nottawasaga à Alliston (Ontario), au nord de Toronto. L'Auberge est équipée d'une piscine intérieure, d'un parcours de golf (45 trous), d'un centre d'entraînement avec massage, pédicure, manucure, de restaurants, d'un mini-golf intérieur et de salles de jeu. Pour plus de détails, veuillez consulter le site Internet www.NottawasagaResort.com.

Nous encourageons vivement tous les participants à réserver leur chambre à l'auberge avant le 3 juillet 2001. Passé cette date la disponibilité n'est plus garantie. Lorsque vous faites vos réservations, indiquez que vous venez pour la conférence de l'ACA 2001.

Le site Internet de la Semaine Canadienne d'Acoustique 2001 contiendra les informations les plus récentes sur la conférence, les différents formulaires d'inscription et la liste des exposants et commanditaires de l'événement. Le programme de la conférence sera varié, attrayant et couvrira de nombreux domaines de l'acoustique. Il sera également disponible sur le site Internet et mis à jour régulièrement.

Pour les personnes qui arrivent à l'avance, nous prévoyons un tournoi de golf sur un parcours à 9 trous le dimanche 30 septembre après-midi. C'est une occasion unique de lier connaissance, de rencontrer des collègues que vous n'avez pas vu depuis longtemps ou tout simplement de vous détendre.

Le banquet de mardi soir s'annonce très amusant. Cette année nous serons en compagnie de Atarah Ben-Tovim. Atarah Ben-Tovim est musicienne, humoriste et nous divertira durant la soirée. N'hésitez pas à apporter votre instrument de musique préféré. Si vous n'êtes pas musicien, vous trouverez des "instruments" sur place. Visitez notre site Internet pour plus d'informations sur Atarah Ben-Tovim et sur la soirée du banquet.

Call for Papers
Acoustics Conference in Canada 2001
Nottawasaga Inn, Alliston, Ontario
October 1, 2 and 3, 2001

Organizing Committee

The Acoustics Conference in Canada 2001 will be held at the Nottawasaga Inn located in Alliston, Ontario, which is approximately 45 minutes to an hour from the Toronto Airport. The Conference will commence on Monday October 1, 2001 and end on Wednesday October 3, 2001. Members of the CAA located in the Greater Toronto Area will organize the conference sponsored by the Canadian Acoustical Association. The conference chair is Dalila Giusti of Jade Acoustics Inc. The technical chairs are Tim Kelsall of Hatch Associates and Alberto Behar.

Conference e-mail: caa2001@jadeacoustics.com
Web site: http://www.caa2001.com

Scientific and Technical Papers

The emphasis for the 2001 Conference will be to ensure that all areas of acoustics are represented. The sessions will include opening plenary lectures, invited and contributed papers, panel discussions and exhibits. In order to ensure that all areas of acoustics are represented the technical chairs are putting together a group of highly skilled and motivated individuals to act as session chairs. They can only be successful if the membership, including students, attend the conference and present papers.

The following technical areas are proposed to be included:

- Industrial Noise
- Outdoor sound Propagation
- Hearing Protection
- Physiological Acoustics
- Canadian Standards
- Community Noise
- Legislation/Environmental Noise
- Building Acoustics
- Speech Perception
- Acoustic Materials
- Sound Quality
- Instrumentation
- Musical Acoustics
- Vibration
- Occupational Hearing Loss
- Underwater Acoustics
- Computer Applications
- Transportation Noise

The Canadian Acoustical Association — l'Association Canadienne d'Acoustique

Abstracts

Abstracts of a maximum of 250 words must be submitted by June 1, 2001. The abstract should be prepared and sent in accordance with the instructions appearing in this issue of *Canadian Acoustics*. Submission by e-mail is strongly encouraged; files can be prepared in any word processing software. For those without access to e-mail, digital files on diskette or paper copy should be mailed to the address given below. Notification of acceptance of abstracts will be sent to the authors by June 20, 2001 along with a registration form. Summary papers are due by July 31, 2001. This deadline will be strictly enforced in order to meet the publication schedule of the proceedings issue of *Canadian Acoustics*.

For specific information regarding the technical topics contact:

Tim Kelsall
Hatch Associates Ltd.
2800 Speakman Dr.
Mississauga, Ontario L5K 2R7
e-mail: Tkelsall@Hatch.ca
Telephone: (905) 403-3932 Fax: (905) 855-8270

Alberto Behar, Noise Control
45 Meadowcliffe Dr.
Scarborough, Ontario
M1M 2X8
e-mail: albehar@trigger.net
Telephone/fax: (416) 265-1816

Students

Student participation at the CAA 2001 Conference is strongly encouraged. Awards are available to students whose presentations at the Conference are judged to be particularly noteworthy. To qualify students must apply by enclosing an *Annual Student Presentation Award* form with their abstract. Students presenting papers may also apply for a travel subsidy to attend the Conference if they live at least 150 km from Alliston, Ontario. To apply for this subsidy, students must submit an *Application for Student Travel Subsidy* included in this issue.

Accommodations

Accommodations and meeting space for the delegates of the 2001 Conference will be at the Nottawasaga Inn (www.NottawasagaResort.com) located just north of Toronto, Ontario. The Conference rate will be $110.00 per night. Upgraded rooms are available upon request. To reserve accommodations, contact the Inn directly at (416) 364-5068 and indicate you are with the Canadian Acoustical Association.

It is important to note that the rooms are only guaranteed for the CAA Conference up to **July 3, 2001.** After that date the rooms are subject to availability. This is extremely important because there are not many alternative accommodations in the area.

Transportation

There are several options available for transport from Lester B. Pearson International Airport (Toronto) to the Nottawasaga Inn. These include:

Rent a car
Flat rate limousine service located outside the arrival terminals: approx. cost $69.00 one way
Shuttle service (mini vans): to be booked directly with Mr. Les Cook (705) 435-0385
Approx cost: $45 minimum for 1, 2 or 3 people (one way)
$15/person for 4, 5 or 6 people (one way)
Private limousine service: Avonguard Limo 1-800-749-0829

All transportation to be arranged by delegates directly with the desired service.

Exhibits

A permanent exhibition showcasing the latest technology in acoustics and vibration equipment, instrumentation, materials and software will be open continuously during the Conference. Space will be available for exhibits by companies and organizations in the field of acoustics. Sponsorship of the breaks and/or lunches is also welcome. If you are interested in either of these opportunities please contact David Hunt or Bill Gastmeier at (905) 826-4044 or dhunt@hgcengineering.com.

Important Dates

June 1, 2001 Deadline for submission of abstracts June 20, 2001 Notification of acceptance of abstracts July 3, 2001 Deadline for guaranteed rooms July 31, 2001 Deadline for receipt of summary papers & early registration October 1 to 3, 2001 Acoustics Conference in Canada 2001

For more information contact:

Dalila Giusti, Jade Acoustics Inc.
545 North Rivermede Rd. Ste 203
Concord, Ontario L4K 4H1
e-mail: dalila@jadeacoustics.com
Telephone: (905) 660-2444; Fax: (905) 660-4110

Appel à Communications
Semaine Canadienne d'Acoustique 2001
Nottawasaga Inn, Alliston, Ontario
1, 2 et 3 octobre 2001

Comité Organisateur

La Semaine Canadienne d'Acoustique 2001 aura lieu à l'auberge Nottawasaga à Alliston, en Ontario. Alliston se situe à environ 50 minutes de l'aéroport de Toronto. La conférence se tiendra du lundi 1er octobre 2001 au mercredi 3 octobre 2001 inclus. Elle sera organisée par les membres de l'ACA de la région de Toronto et commanditée par l'Association Canadienne d'Acoustique.
La présidente du congrès est Dalila Giusti de la compagnie Jade Acoustics Inc. Les conseillers techniques sont Tim Kelsall de Hatch Associates et Alberto Behar.

Courriel pour la conférence : caa2001@jadeacoustics.com Site Internet : http://www.caa2001.com

Articles Scientifiques et Techniques

Il est important que la conférence couvre tous les domaines de l'acoustique. Les séances incluront des exposés pléniers, des communications (invitées et proposées), des discussions ainsi qu'une exposition.
Afin que tous les domaines de l'acoustique soient représentés pendant la conférence, les conseillers techniques ont approché un groupe de professionnels motivés et expérimentés qui agiront en tant que responsables de sessions. Cependant, le succès du congrès dépend fortement de la participation active de tous les membres de l'ACA y compris les étudiants.
Les domaines techniques suivants sont proposés:

Bruit industriel	Acoustique du bâtiment	Vibrations
Propagation du son à l'extérieur	Perception de la parole	Protection de l'ouïe
Matériaux acoustiques	Normes canadiennes	Instrumentation
Acoustique sous-marine	Acoustique physiologique	Qualité du son
Applications informatiques	Bruit communautaire	Acoustique musicale
Bruit lié aux moyens de transport	Pertes auditives en milieu professionnel	
Législation reliée au bruit environnemental		

The Canadian Acoustical Association — l'Association Canadienne d'Acoustique

Résumés

La date limite de soumission des résumés (maximum 250 mots) est le 1er juin 2001. Ils doivent être préparés et soumis selon les instructions données dans la présente édition de l'*Acoustique Canadienne*. Les soumissions par courriel sont vivement recommandées; les fichiers peuvent être préparés à l'aide de n'importe quel logiciel de traitement de texte. Les personnes n'ayant pas accès au courriel, peuvent expédier par la poste des fichiers électroniques sur disquette ou des copies sur papier à l'adresse indiquée ci-dessous. Un avis, accompagné d'un formulaire d'inscription, sera envoyé d'ici le 20 juin 2001 aux auteurs des résumés qui auront été acceptés. Les articles devront nous parvenir avant le 31 juillet 2001.
Afin que les Actes de la Semaine Canadienne d'Acoustique 2001 soient prêts pour le Congrès, cette date limite doit absolument être respectée.

Pour obtenir de plus amples informations au sujet des thèmes techniques, veuillez vous adresser à:

Tim Kelsall, Hatch Associates Ltd
Courriel: Tkelsall@Hatch.ca
Téléphone: (905) 403-3932
Télécopieur: (905) 855-8270

Alberto Behar, Noise Control
Courriel: albehar@trigger.net
Téléphone/Télécopieur: (416) 265-1816

Étudiants

La participation des étudiants à la conférence de l'ACA 2001 est fortement encouragée. Des prix seront remis aux étudiants dont la présentation aura été jugée particulièrement remarquable. Afin d'être éligibles à ces prix, les étudiants doivent remplir le formulaire du Prix Annuel de Présentation Étudiante disponible sur le site Internet de la Semaine Canadienne d'Acoustique ou dans la présente édition de l'*Acoustique Canadienne*. Ce formulaire doit être envoyé avec le résumé. Les étudiants qui habitent une région suffisamment éloignée d'Alliston (plus de 150 km) et qui désirent présenter leur article à la conférence, peuvent faire une demande de subvention pour leurs frais de déplacement en complétant la section B du formulaire.

Hébergement

Les participants à la conférence séjournerons à l'Auberge Nottawasaga (www.NottawasagaResort.com), située au nord de Toronto. Le tarif pour la conférence est de 110 $ par nuit. Pour réserver une chambre, contactez l'auberge au (416) 364-5068 et mentionnez votre participation à la Semaine Canadienne d'Acoustique 2001. Il est important de noter que les chambres seront garanties aux participants jusqu'au **3 juillet 2001**. Après cette date, la disponibilité est plus aléatoire. Les autres options de logement étant limitées dans la région, il est extrêmement important de faire les réservations avant cette date.

The Canadian Acoustical Association

l'Association Canadienne d'Acoustique

Exposants

En marge de la conférence, se tiendra une exposition permanente, ouverte à tous, portant sur les dernières technologies de l'acoustique et des vibrations: équipement, instrumentation, matériaux et logiciels. Un espace sera réservé aux exposants provenant d'organismes et de compagnies spécialisés dans les domaines de l'acoustique. La commandite des pauses et/ou des collations serait très appréciée. Si l'une ou l'autre de ces suggestions vous intéresse, veuillez contacter David Hunt ou Bill Gastmeier au : (905) 826-4044, dhunt@hgcengineering.com.

Transport

Pour se rendre à l'Auberge Nottawasaga depuis l'aéroport international Lester B. Pearson (Toronto), plusieurs options de transport se présentent :

Location d'une voiture
Service de limousine situé devant le terminal des arrivées : le forfait est d'environ $ 69.00 aller simple
Service de navette (mini vans): Les réservations se font directement auprès de M. Les Cook (705) 435-0385. Tarif approximatif: $45 minimum pour 1, 2 ou 3 passagers (aller simple)
$15 par personne pour 4 à 6 passagers (aller simple)
Service de limousine privé: Avonguard Limo 1-800-749-0829

Les participants à la conférence doivent organiser leur voyage en contactant directement le service choisi.

Dates à Retenir

Le 1er juin 2001 Date limite de soumission des résumés Le 20 juin Avis pour les résumés acceptés Le 3 juillet 2001 Date limite de réservation des chambres garanties Le 31 juillet 2001 Date limite de soumission des articles et de l'inscription à l'avance Du 1er au 3 octobre 2001 Semaine Canadienne d'Acoustique 2001

Pour de plus amples informations, veuillez communiquer avec:

Dalila Giusti,
Jade Acoustics Inc.
545 North Rivermede Rd. Ste 203
Concord, Ontario L4K 4H1
Courriel: dalila@jadeacoustics.com
Téléphone: (905) 660-2444
Télécopieur: (905) 660-4110

Acoustics Conference in Canada 2001 / Semaine Canadienne d'acoustique 2001
Nottawasaga Inn, Alliston, Ontario
October 1, 2 and 3, 2001 / 1, 2 et 3 Octobre 2001

Message from the Technical Committee

The organization of the technical portion of the Conference is in full swing. Following is the list of sessions already set up and the names of the session chairmen:

SESSION	CHAIRMAN
Industrial Noise	Cameron Sherry cwsherry@aol.com
Occupational Hearing Loss and Hearing Protection	Sharon Abel Abel.Sharon@torontorehab.on.ca
Vibration	Tony Brammer tony.brammer@nrc.ca
Architectural Acoustics	John Swallow John.swallow@attglobal.net
Speech Perception	Luc de Nil luc.denil@utoronto.ca
Hearing Aids and Rehabilitation of Hearing Impairment	Marshall Chasin mchasin@chass.utoronto.ca
Legislation/Environmental Noise	Chris Krajewsky krajewch@ene.gov.on.ca
Transportation Noise	Soren Pederson sorenp@home.com
Product noise	Steven Bly S_Bly@hc-sc.gc.ca
Computer Applications	Noureddine Atalla noureddine.atalla@gme.usherb.ca
Perception	Robert Arabito robbie.arrabito@dciem.dnd.ca

If you are interested in organizing a session (and chairing it), we will be happy to hear from you. Please contact Alberto Behar (albehar@trigger.net) or Tim Kelsall (tkelsall@hatch.ca)

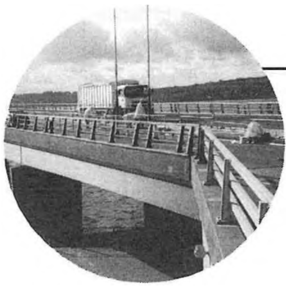
The Canadian Acoustical Association

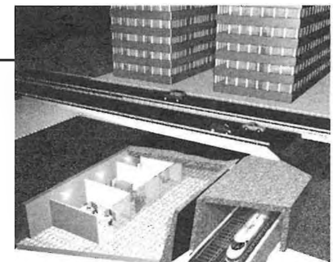
l'Association Canadienne d'Acoustique

Vibration Insulation

2 ways Regupol Regufoam

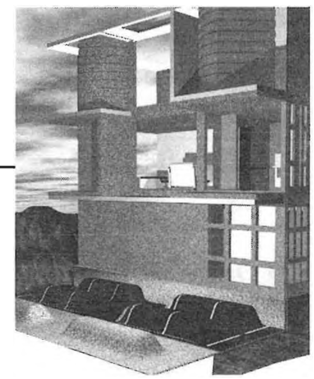
1 goal **Optimal vibration absorption and insulation of structure-borne sound using recycled rubber and foam materials.**





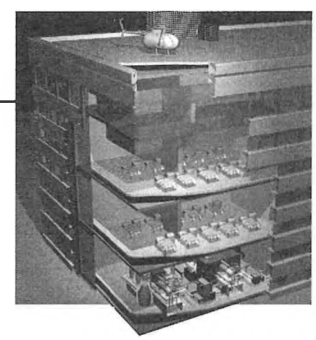
Road Construction

For rail and tunnel construction, as well as for road and bridge construction, Regupol and Regufoam are used for vibration insulation and shockproofing.



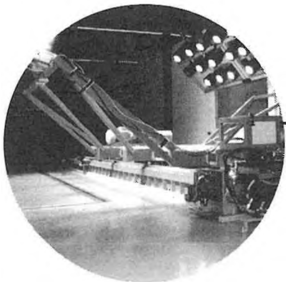
Foundations

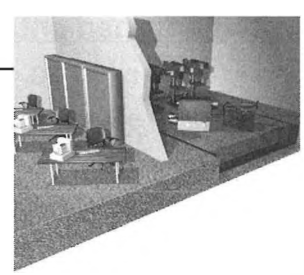
To protect against ground vibration, Regupol and Regufoam insulate large buildings with appropriate load distribution slabs.



High-Rise Building

Whether for elevator motors, pumps, ventilation systems or block-type thermal power stations, structure-borne sound insulation and vibration absorption with Regupol and Regufoam are simple and permanent.





Industry

Here Regupol and Regufoam are used for the active insulation of machines and passive insulation of floor slabs for precision measuring instruments, laboratory facilities or measuring chambers. Both sub-critical and supercritical bearings are possible.

For more information and technical data call:
Paul Downey, B. Eng.
Business Development Manager

DODGE-REGUPOL
INCORPORATED
Leaders in recycled products technology

www.regupol.com

Phone: 416.440.1094
Toll free: 800.322.1923
Fax: 416.440.0730
Email: pcd@regupol.com

ACOUSTICS CONFERENCE IN CANADA 2001
SEMAINE CANADIENNE D'ACOUSTIQUE 2001

1, 2 and 3 October, 2001/*du 1er au 3 octobre 2001*
Nottawasaga Inn, Alliston, Ontario

REGISTRATION FORM / *FORMULAIRE D'INSCRIPTION*

(1) Full Three Day Registration. Includes:

Conference

Breakfast & Lunch each day for 3 days

Dinner Monday night

Banquet Tuesday night (not included for students)

All taxes & gratuities

(1) Inscription complète. Comprend:

La participation à la conférence

Le déjeûner et le dîner pendant 3 jours

Le souper lundi soir

Le banquet mardi soir (sauf pour les étudiants)

Les taxes & pourboires

Registration/ ***Inscription***	**CAA Members** ***Membres***	**Students** ***de l'ACA Etudiant(e)s***	**Non-members** ***Autres***
Before July 31/ **Avant** le 31 juillet	$300.00	$75.00	$350.00
After July 31/ **Après** le 31 juillet	$300.00	$75.00	$350.00

(2) Daily Rates. Includes:

Conference
Breakfast & lunch each day
All taxes & gratuities

(2) Tarif à la journée. Comprend:

Une journée à la conférence
Le déjeûner et le dîner pour une journée
Les taxes & pourboires

CAA Members ***Membres de l'ACA***	**Students** ***Etudiant(e)s***	**Non-Members** ***Autres***
$130.00	$50.00	$150.00

Note: All Conference passes are non-transferable.
Les tickets d'accès à la conférence sont personnels et ne peuvent être transférés.

(3) Extras/ Suppléments

Banquet Ticket/Participation au Banquet: $55.00 each/par personne
$25.00 each student/par étudiant(e)

(4) Golf Tournament/ Tournoi de golf

Sunday September 30, 2001. 9 holes commencing at 3:00 pm.

Dimanche 30 septembre 2001. Parcours 9 trous débutant à 15h00.

Cost/Prix: approx. $20.00/pers. Cart: $9.00/pers.

The scheduling of this event will depend on number of people showing an interest.

La programmation de cette activité dépendra du nombre de personnes intéressées.

REGISTRATION FORM / FORMULAIRE D'INSCRIPTION

Name/Nom:____

Company/Institution:____________________________________

Address/Adresse:____________________________________

__________________________Postal Code/Code Postal:__________

Tel:______________________E-mail:____________________

Full 3 day Conference	$__________	**Inscription complète** Participation(s)
Additional banquet ticket(s)	$__________	Supplémentaire(s) au banquet
Total	$__________	Total

Daily Rate Check applicable day(s)	Monday *Lundi*	Tuesday *Mardi*	Wednesday Mercredi	**Inscription à la journée** Entourez le(s) jour(s) choisi(s)
Daily rate	$__________			Montant
Banquet ticket(s)	$__________			Participation(s) au banquet
Total	$__________			Total

Golf

Please indicate number of people interested in golfing on Sunday September 30, 2001 :__________

Merci d'indiquer le nombre de personnes intéressées par le golf le 30 septembre 2001: __________

Fee will be payable on day of event/Le montant sera acquitté sur place.

Payable by cheque in Canadian Funds made out to Canadian Acoustical Association or payable by VISA / Payable par chèque, en dollars canadiens, à l'ordre de l'Association Canadienne d'Acoustique ou par carte VISA.

Visa Number/Numéro:____________________ Expiry Date/Date d'expiration:______

Name on VISA Card/Nom sur la carte VISA:________________________

Signature (if paying by VISA/en cas de paiement par VISA):____________________

Mail/Fax to: Dalila Giusti
Expédier ou faxer à: Jade Acoustics Inc.
545 North Rivermede Road Ste 203
Concord, Ontario L4K 4H1 Fax: (905) 660-4110

Please note: Hotel rooms must be booked by July 3, 2001 to guarantee availability.
Pour des questions de disponibilité, les chambres doivent être réservées avant le 3 juillet 2001.

CAA 2001/ACA 2001
Tentative Schedule of Events/Programmation provisoire

Time/Heure	Monday/Lundi	Tuesday/Mardi	WednesdayMercredi
Early morning Tôt le matin	Welcome Accueil	Plenary Speaker Séance plénière	Plenary Speaker Séance plénière
Morning Début de matinée	Papers Exposés	Papers Exposés	Papers Exposés
Mid-Morning Milieu de matinée	Coffee Break Pause-café	Coffee Break Pause-café	Coffee Break Pause-café
Remainder of Morning Fin de matinée	Papers Exposés	Papers Exposés	Papers Exposés
	Lunch Dîner	Lunch with AGM Dîner et assemblée générale annuelle	Lunch with Student Awards Dîner et remise des prix aux étudiants
Afternoon Début d'après-midi	Papers Exposés	Papers Exposés	Papers Exposés
Mid-Afternoon Milieu d'après-midi	Coffee Break Pause-café	Coffee Break Pause-café	Coffee Break Pause-café
Remainder of Afternoon Fin d'après-midi	Papers Exposés	Papers Exposés	Papers Exposés
Early Evening Début de soirée		Cocktail	
Evening Soirée	CSA Meeting Réunion de la CSA	Banquet	

Board of Directors' Meeting to be held on Sunday September 30, 2001.
La réunion du Comité Directeur se tiendra le dimanche 30 septembre 2001.

The Canadian Acoustical Association

l'Association Canadienne d'Acoustique

CAA Student Travel Subsidy and Student Presentation Award
Application Form
DEADLINE FOR RECEIPT 1, August, 2001

Procedure

- Complete and submit this application at the same time as the abstract to the Technical Chair of the Conference. Both must be received on or before deadline listed above.
- By 31 August 1999, the CAA Secretary will notify you of the Travel Subsidy funding that you can expect to receive.
- Subsidy cheques will be mailed directly to you within 30 days of the end of the Conference

Eligibility Requirements

In order to be eligible for the Travel Subsidy you must meet the following requirements:
1. Full-time student at a Canadian University;
2. Student Member in good standing of the Association;
3. Distance traveled to the Conference must exceed 150 km (one way);
4. Submit a summary paper for publication in the Proceedings Issue of Canadian Acoustics with the applicant as the first author;
5. Present an oral paper at the Conference. Due to limited funding, a travel subsidy can only be given to the presenter of the paper even though there may be more than one student authors.

Section A: All applicants must complete this section

Name of Student:______________________________

Address:______________________________
(where the cheque is to be sent)

Title of the proposed paper:______________________________

Is the paper to be judged in the Student Presentation Award(s) [Yes/No]:______________________________

Name and Location of the University: ______________, ______________

Faculty and Degree Being Sought: ______________, ______________

Section B: Complete this section only if you are applying for the CAA Student Travel Subsidy

I hereby apply for a travel subsidy from the CAA

Proposed Method of Transport to conference:______________________________
Brief description of the route and method of transportation (e.g., bus, train, air, etc.)

Estimated Cost of Transportation:______________________________
Provide least expensive transportation cost.

Date of Departure to, and Return from the Conference: ______________, ______________

Other Sources of Travel Funding:______________________________
List other sources of travel funding and the amount

Signature of Applicant

____

I certify that the Information provided above is correct

____

Print Name

Signature of University Supervisor

____

I certify that the applicant is a full time student

____

Print Name

Subvention de l'ACA pour les Frais de Déplacement des Etudiants et Prix Récompensant les Présentations d'Etudiants - Formulaire d'Inscription
DATE LIMITE DE RÉCPTION, 1 AOUT 2001

Procédure

- Compléter le formulaire et le soumettre en même temps que le sommaire au Président Technique de la Conférence. Tous deux doivent être reçus avant la date limite indiquée ci-dessus.
- Le Secrétariat de l'ACA vous enverra une note avant le 31 Août 1999 indiquant la Subvention que vous êtes susceptible de recevoir.
- Les chèques de Subvention vous seront directement envoyés dans les 30 jours suivant la fin de la Conférence.

Conditions d'Eligibilité

1. Pour avoir droit à la Subvention pour les Frais de Déplacement, vous devez remplir les conditions uivantes:
2. Etre étudiant à temps plein dans une Université Canadienne;
3. Etre Membre de l'ACA;
4. La distance parcourue jusqu'à la Conférence doit être supérieure à 150km (aller simple);
5. Soumettre un sommaire en vue de sa publication dans les actes d'Acoustique Canadienne, l'étudiant doit être le premier auteur du som maire;
6. Présenter une communication orale pendant la conférence. En raison du financement limité, une Subvention pour les Frais de Déplacement ne peut être attribuée qu'à l'étudiant présentant la communication même si plusieurs étudiants sont auteurs du sommaire.

Section A: Tous les candidats doivent remplir cette section

Nom de l'étudiant:________________________________

Adresse: ________________________________
(où le chèque doit être envoyé)

Titre de la communication proposée: ________________________________

La communication est elle inscrite au concours pour le Prix Récompensant les Communications d'Etudiants [Oui/Non]: __________

Nom et adresse de l'université: ________________________________

Faculté et niveau d'étude en cours: ________________________________

Section B: Compléter cette section si vous postulez pour une Subvention des Frais de Déplacement

Je postule par le présent document à une Subvention de l'ACA pour des Frais de Déplacement

Moyen de Transport proposé pour se rendre a la conférence: ________________________________
Brève description du trajet et du moyen de transport (i.e bus,train,avion etc.)

Coût estimé du Transport: ________________________________
Fournir le coût de transport le moins élevé
Date de Départ pour la Conférence et de Retour: ________________________________

Autres sources de financement pour le transport:________________________________
donner la liste des sources de financement et leur montant

Signature du candidat

____

Je certifie que les informations fournies ci dessus sont correctes

____

Nom

Signature du superviseur

____

Je certifie que le signataire est un étudiant à temps plein

____

Nom

INSTRUCTIONS TO AUTHORS FOR THE PREPARATION OF MANUSCRIPTS

Submissions: The original manuscript and two copies should be sent to the Editor-in-Chief.

General Presentation: Papers should be submitted in camera-ready format. Paper size 8.5" x 11". If you have access to a word processor, copy as closely as possible the format of the articles in Canadian Acoustics 18(4) 1990. All text in Times-Roman 10 pt font, with single (12 pt) spacing. Main body of text in two columns separated by 0.25". One line space between paragraphs.

Margins: Top - title page: 1.25"; other pages, 0.75"; bottom, 1" minimum; sides, 0.75".

Title: Bold, 14 pt with 14 pt spacing, upper case, centered.

Authors/addresses: Names and full mailing addresses, 10 pt with single (12 pt) spacing, upper and lower case, centered. Names in bold text.

Abstracts: English and French versions. Headings, 12 pt bold, upper case, centered. Indent text 0.5" on both sides.

Headings: Headings to be in 12 pt bold, Times-Roman font. Number at the left margin and indent text 0.5". Main headings, numbered as 1, 2, 3, ... to be in upper case. Sub-headings numbered as 1.1, 1.2, 1.3, ... in upper and lower case. Sub-sub-headings not numbered, in upper and lower case, underlined.

Equations: Minimize. Place in text if short. Numbered.

Figures/Tables: Keep small. Insert in text at top or bottom of page. Name as "Figure 1, 2, ..." Caption in 9 pt with single (12 pt) spacing. Leave 0.5" between text.

Line Widths: Line widths in techincal drawings, figures and tables should be a minimum of 0.5 pt.

Photographs: Submit original glossy, black and white photograph.

Scans: Should be between 225 dpi and 300 dpi. Scan: Line art as bitmap tiffs; Black and white as grayscale tiffs and colour as CMYK tiffs;

References: Cite in text and list at end in any consistent format, 9 pt with single (12 pt) spacing.

Page numbers: In light pencil at the bottom of each page.

Reprints: Can be ordered at time of acceptance of paper.

DIRECTIVES A L'INTENTION DES AUTEURS PREPARATION DES MANUSCRITS

Soumissions: Le manuscrit original ainsi que deux copies doivent être soumis au rédacteur-en-chef.

Présentation générale: Le manuscript doit comprendre le collage. Dimensions des pages, 8.5" x 11". Si vous avez accès à un système de traitement de texte, dans la mesure du possible, suivre le format des articles dans l'Acoustique Canadienne 18(4) 1990. Tout le texte doit être en caractères Times-Roman, 10 pt et à simple (12 pt) interligne. Le texte principal doit être en deux colonnes séparées d'un espace de 0.25". Les paragraphes sont séparés d'un espace d'une ligne.

Marges: Dans le haut - page titre, 1.25"; autres pages, 0.75"; dans le bas, 1" minimum; latérales, 0.75".

Titre du manuscrit: 14 pt à 14 pt interligne, lettres majuscules, caractères gras. Centré.

Auteurs/adresses: Noms et adresses postales. Lettres majuscules et minuscules, 10 pt à simple (12 pt) interligne. Centré. Les noms doivent être en caractères gras.

Sommaire: En versions anglaise et française. Titre en 12 pt, lettres majuscules, caractères gras, centré. Paragraphe 0.5" en alinéa de la marge, des 2 cotés.

Titres des sections: Tous en caractères gras, 12 pt, Times-Roman. Premiers titres: numéroter 1, 2, 3, ..., en lettres majuscules; sous-titres: numéroter 1.1, 1.2, 1.3, ..., en lettres majuscules et minuscules; sous-sous-titres: ne pas numéroter, en lettres majuscules et minuscules et soulignés.

Equations: Les minimiser. Les insérer dans le texte si elles sont courtes. Les numéroter.

Figures/Tableaux: De petites tailles. Les insérer dans le texte dans le haut ou dans le bas de la page. Les nommer "Figure 1, 2, 3,..." Légende en 9 pt à simple (12 pt) interligne. Laisser un espace de 0.5" entre le texte.

Largeur Des Traits: La largeur des traits sur les schémas technique doivent être au minimum de 0.5 pt pour permettre une bonne reproduction.

Photographies: Soumettre la photographie originale sur papier glacé, noir et blanc.

Figures Scanées: Doivent être au minimum de 225 dpi et au maximum de 300 dpi. Les schémas doivent être scannés en bitmaps tif format. Les photos noir et blanc doivent être scannées en échelle de gris tifs et toutes les phoots couleurs doivent être scannées en CMYK tifs.

Références: Les citer dans le texte et en faire la liste à la fin du document, en format uniforme, 9 pt à simple (12 pt) interligne.

Pagination: Au crayon pâle, au bas de chaque page.

Tirés-à-part: Ils peuvent être commandés au moment de l'acceptation du manuscrit.

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Subscription for the current calendar year is due January 31. New subscriptions received before July 1 will be applied to the current year and include that year's back issues of Canadian Acoustics, if available. Subscriptions received from July 1 will be applied to the next year.

FACTURE D'ABONNEMENT

L'abonnement pour la présente année est dû le 31 janvier. Les nouveaux abonnements reçus avant le 1 juillet s'appliquent à l'année courante et incluent les anciens numéros (non-épuisés) de l'Acoustique Canadienne de cette année. Les abonnements reçus après le 1 juillet s'appliquent à l'année suivante.

Check ONE Item Only: / Cocher la case appropriée:

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Faites parvenir ce formulaire à l'adresse suivante en prenant soin d'y joindre un chèque fait au nom de L'ASSOCIATION CANADIENNE D'ACOUSTIQUE:

Make cheques payable to THE CANADIAN ACOUSTICAL ASSOCIATION. Mail this form with payment to:

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Secretary, Canadian Acoustical Association
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The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

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L'Association Canadienne d'Acoustique tient à témoigner sa reconnaissance à l'égard de ses Abonnés de Soutien en publiant ci-dessous leur nom et leur adresse. En amortissant les coûts de publication et de distribution, les dons annuels (de $150.00 et plus) rendent le journal accessible à tous nos membres. Les Abonnés de Soutien reçoivent le journal gratuitement. Pour devenir un Abonné de Soutien, faites parvenir vos dons (chèque ou mandat-poste fait au nom de l'Association Canadienne d'Acoustique) au secrétaire de l'Association.

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