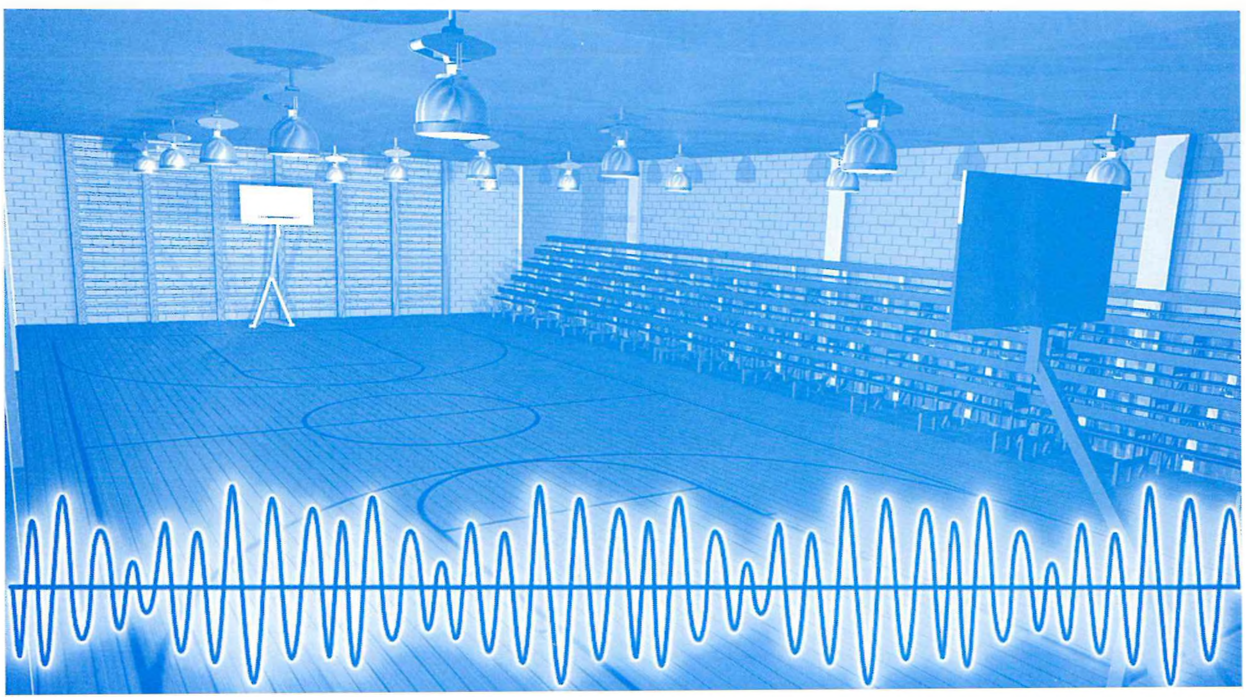
ISSN 0711-6659

canadian acoustics
acoustique canadienne

DECEMBER 1999 DECEMBRE 1999
Volume 27 -- Number 4 Volume 27 -- Numéro 4



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CANADIAN ACOUSTICS publishes refereed articles and news items on all aspects of acoustics and vibration. Articles reporting new research or applications, as well as review or tutorial papers and shorter technical notes are welcomed, in English or in French. Submissions should be sent directly to the Editor-in-Chief. Complete instructions to authors concerning the required camera-ready copy are presented at the end of this issue.

ACOUSTIQUE CANADIENNE publie des articles arbitrés et des informations sur tous les domaines de l'acoustique et des vibrations. On invite les auteurs à soumettre des manuscrits, rédigés en français ou en anglais, concernant des travaux inédits, des états de question ou des notes techniques. Les soumissions doivent être envoyées au rédacteur en chef. Les instructions pour la présentation des textes sont exposées à la fin de cette publication.

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MESSAGE FROM THE PRESIDENT / MESSAGE DU PRÉSIDENT

Just a few words about the current healthy state of CAA. We have just had a very successful annual meeting in Victoria. Stan Dosso and his team put on an impeccably organised meeting that was a complete success. Great hotel, beautiful location as well as interesting and smoothly run sessions; what more could one ask for? Next September we are to meet in Sherbrooke. Noureddine Atalla's plans for a number of interesting technical sessions are already well advanced. I am sure there will be a different emphasis and flavour and it should be another memorable CAA event that I am looking forward to.

Some years ago Don Jamieson started the CAA web site. Because of his foresight and continuing efforts we already have a web site that is comparable to other acoustical organisations. However, being the dynamic and forward thinking organisation that we are, CAA would like to further develop our web site. A web site offers so many possibilities for a small national organisation spread across a very large country. It could act as a focus for our organisation; a virtual head office perhaps?

Doug Whicker and Barry McKinnon have agreed to help us launch a new push to an even better and more accessible web site. It is difficult to imagine where this may eventually lead us, but we want to get started now and be part of the future. It could be a source of acoustical news, technical information and links to related organisations. Perhaps we could include links to our sustaining subscribers? Will there be overlap with our journal? Will *Canadian Acoustics* one day become an electronic publication? Can we imagine where this will take us? No, maybe not, but it is certainly timely and prudent to put effort and resources into an improved web site. We welcome your ideas and suggestions.

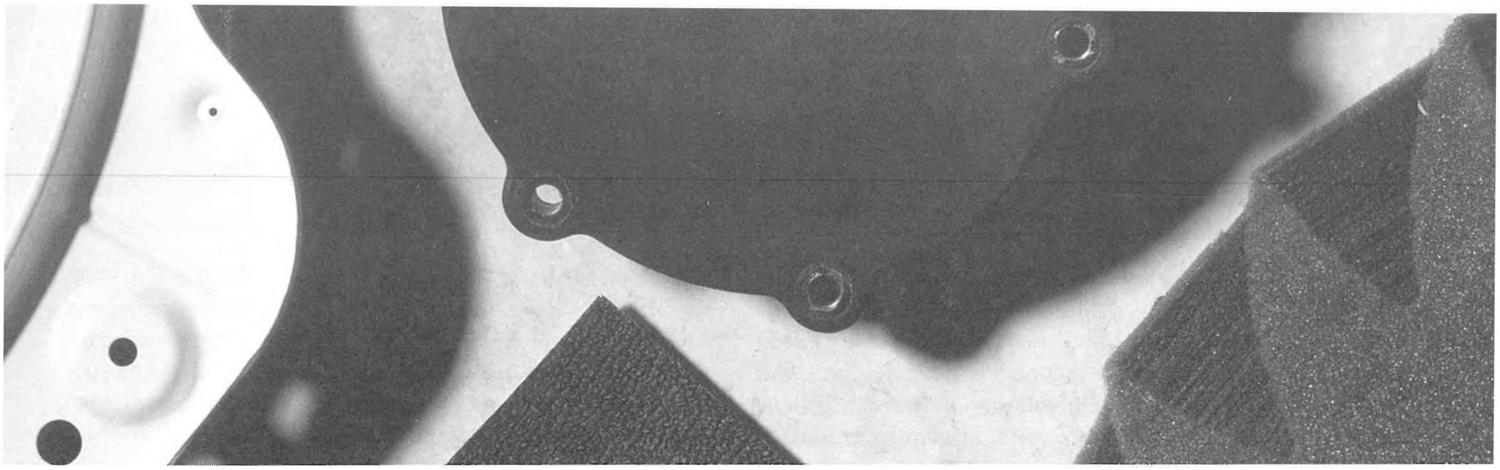
J'aimerais vous transmettre quelques mots sur la bonne santé de l'ACA. Nous venons de tenir une rencontre annuelle bien réussie à Victoria. Stan Dosso et son équipe ont organisé une rencontre impeccable, qui s'est avérée un grand succès. Grand hôtel, bel emplacement, ainsi que des sessions intéressantes et menées en douceur : quoi demander de plus? En septembre prochain, nous nous rencontrerons à Sherbrooke. Noureddine Atalla a déjà entamé les démarches dans le but d'offrir un certain nombre de sessions techniques intéressantes. Je suis convaincu qu'il y aura une emphase et une saveur différentes et cette rencontre devrait compter parmi les événements mémorables de l'ACA, que j'attends avec plaisir.

Il y a quelques années, Don Jamieson a mis sur pied le site web de l'ACA. À cause de sa prévoyance et de ses efforts continus, nous pouvons déjà compter sur un site web qui se compare avantageusement aux sites de d'autres organisations dans le domaine de l'acoustique. Cependant, compte tenu du dynamisme et de l'avant-gardisme de notre organisation, l'ACA aimerait développer davantage ce site. Un site web offre plusieurs avantages à une petite organisation nationale qui se trouve dispersée à travers un immense pays. Il pourrait devenir le point central de notre organisation : un bureau chef virtuel peut-être?

Doug Whicker et Barry McKinnon ont accepté de donner un second souffle à l'idée, afin d'avoir un meilleur site qui soit plus accessible. Il est difficile d'imaginer où cela nous mènera éventuellement, mais nous aimerions débuter dès maintenant et suivre la voie du futur. Le site web pourrait être la source de nouvelles en acoustique, d'information technique ainsi qu'un lien avec les autres organisations. Peut-être pourrons-nous inclure des liens avec nos abonnés de soutien? Y aura-t-il un chevauchement avec notre journal? Est-ce que *l'Acoustique Canadienne* deviendra un jour une publication électronique? Pouvons-nous imaginer où cela nous mènera? Non, peut-être pas, mais il est certainement opportun et prudent d'investir les efforts et les ressources nécessaires pour améliorer notre site web. Nous attendons vos idées et suggestions.

EDITOR'S NOTE

We experienced growing pains with QuarkExpress, the industry standard for publishing. The non-standardized formatting used by our authors for their articles (Word, Wordperfect, Post Script, PDF etc.) gave us hiccups. The problem became acute with the proceedings issue with more than 60 summaries to handle. The two articles by our President received the most embarassing treatment. We are, therefore, reprinting four two-page summaries from the last issue in this issue. We hope we have rectified our mistakes of the past. We should be ready for the Year 2000 proceedings issue.



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REVERBERATION IN GYMNASIA

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ABSTRACT

Gymnasia for public use are constructed and renovated on a regular basis, but the acoustical results are not always satisfactory or consistent. This paper examines this situation by presenting and discussing two case studies. In the first study, measurements of reverberation inside five public school gymnasia were carried out in the Mississauga area. The gymnasia were all geometrically alike, and had been constructed from typical building materials. Four of the gymnasia had been acoustically treated and were considered by the teaching staff of each to provide an adequate acoustical environment for typical activities. The remaining gymnasium was acoustically untreated, and its acoustic environment was considered by the staff to seriously impede its use. A brief literature review conducted to determine criteria specific to gymnasia revealed a notable lack of published information, both in terms of the traditional descriptor, the reverberation time (RT60), and in terms of more recently developed descriptors based on early/late arrival ratios. The measurement results and the subjective opinions expressed by each school's staff were used to determine reverberation criteria for a gymnasium, and to investigate the effectiveness of typical control measures. A second similar case study is presented. The results are discussed in terms of the relevance of various descriptors and potential building code implications.

SOMMAIRE

Des gymnases pour l'usage public sont construits et rénovés de façon régulière, mais les résultats acoustiques ne sont pas toujours satisfaisants ou conformes. Cet article examine cette situation en présentant et en discutant deux cas étudiés. Dans la première étude, des mesures de la réverbération à l'intérieur de cinq gymnases d'école publique ont été effectuées dans la région de Mississauga. Les gymnases étaient tous géométriquement semblables, et avaient été construits de matériaux de construction typiques. Quatre des gymnases avaient été acoustiquement traités et ont été considérés par le corps enseignant de chacun de ces établissements comme fournissant un environnement acoustique adéquat pour des activités typiques. Le gymnase restant n'était pas acoustiquement traité, et son environnement acoustique a été considéré par le personnel comme sérieusement empêcher son utilisation. Une brève revue de littérature conduite pour déterminer des critères spécifiques aux gymnases a indiqué un manque notable d'information publiée, en termes d'indicateurs généraux et en temps de réverbération (RT60), et en termes de d'indicateurs plus récemment développés basés sur des taux d'arrivée d'early/late. Les résultats de mesure et les avis subjectifs exprimés par le personnel de chaque école ont été employés pour déterminer des critères de réverbération pour un gymnase, et pour étudier l'efficacité des mesures de contrôle typiques. Une deuxième étude de cas semblable est présentée. Les résultats sont discutés en termes de la pertinence de divers indicateurs et l'implication potentielle du code du bâtiment.

1.0 INTRODUCTION

The reverberation time (RT60) of a room has traditionally been a key factor in quantifying its acoustic environment. Setting an objective, numeric design criteria for a room which must accommodate varied activities within a restricted budget is not straightforward. In the case of a public school gymnasium, the room must be able to house important sporting events, student assemblies, drama productions and band concerts, as well as provide the physical education instructor with a suitable environment to conduct classes.

Although it is a frequency-dependant quantity, the RT60 and other more recent acoustical descriptors are typically quoted as a function of the room volume and in terms of its mid-range (500 Hz and/or 1000 Hz) value, as this is the centre of the crucial range for speech intelligibility. Sources in the literature [1], [2] list the optimum range for the RT60 for good speech intelligibility at being around 1.5s, while the optimum range for a symphonic ensemble is anywhere from 1.6s to 2.4s. The optimum ranges for rock band concerts, drama productions, and multipurpose auditoriums lie somewhere in between.

An RT60 at the low end of the range may provide acceptable speech intelligibility for an instructor in a classroom-like setting with students at a relatively close distance, but is likely to detract from the excitement of an athletic competition or the enjoyment of a musical recital. The opposite is more common, in that unless they are specifically treated, gymnasiums typically suffer from an RT60 that is too high and consequently render the intelligibility of speech very difficult for all types of room uses and result in an overly noisy acoustic for the enjoyment of energetic events.

Varying the amount of acoustically absorbent materials in the room (particularly on the interior surfaces of the walls and ceilings) is the basic method of controlling the RT60. It is thus essential to account for the nature of the activities within the room when evaluating potential surface treatments. For example, it can be expected that all interior surfaces will be subjected to a considerable amount of physical abuse from basketballs, and volleyballs, in a gymnasium environment, and thus durability is of primary importance. Conversely, ease of cleaning and/or immunity to moisture may not be important at all.

Furthermore, while achieving the correct amount of absorption is crucial from an acoustical perspective for the reasons discussed above, budgetary factors also play an important role in the decision making process.

The challenge is to determine an RT60 that will be acceptable within a wide variety of conflicting uses, and that can be achieved with an affordable level of suitable absorptive treatment.

2.0 First Case Study

HGC Engineering was retained to provide recommendations for the treatment of the gymnasium of Valleys Senior Public School in Mississauga, Ontario. The room had been initially designed and constructed with sprayed-on absorbent material on the upper walls and on the underside of the roof deck to control the reverberation. The material had been subsequently removed by the school administration, as large quantities of the material regularly fell down during classes from numerous impacts from balls. The acoustic environment in the gym was found to be unacceptable subsequent to the removal of the absorption, and was the alleged cause of much contention and several staff resignations over the years.

3.0 Acoustical Description of Target Gymnasia

Four other gymnasia in the same school boards were identified for studying in terms of representing a target acoustical environment to use in defining appropriate reverberation criteria.

The gymnasia were all deemed to have an acceptable acoustical environment by their respective school administration and staff.

The gymnasia were all geometrically identical (90' x 70' x 24'), and had been treated with a variety of acoustically absorptive materials.

The gymnasia were all constructed with tile floors, painted concrete block walls, and exposed steel deck roofing. They were treated with various acoustically materials including sprayed-on absorbent, steel roof deck with perforated flutes and acoustical fill (acoustic roof deck), and acoustical panels comprised of a wood fibre and epoxy mixture.

The acoustically absorbent surface treatment type(s) for each are summarised in the following table along with the surface area covered by each. The gymnasia are listed in the order of the most reverberant to the least.

School	Treatment	Area (ft^2)
R.H. Lagerquist	Sprayed-on absorbent on ceiling between joists	6300
	Light curtain covering the stage opening	290
Fairwind	Acoustical panels on side & back walls	1980
	Acoustical roof deck	6300
Fletcher's Creek	Acoustical panels on side & back walls	1980
	Light curtain covering the stage opening	290
	Acoustical roof deck	6300
Sir J. A. MacDonald	Acoustical panels on side walls, above stage on front wall & between joists on ceiling	9080
	Light curtain covering the stage opening	290

Table 1 - Surface Treatment Types

4.0 Reverberation Measurements

To establish appropriate criteria, RT60 measurements were performed at the four treated gymnasia.

The measurements were performed using the impulse method at each of the gymnasium, which involved the excitation of the room by slamming a large book against the ground or bursting balloons. A microphone was positioned approximately at ear height at five locations per room, and connected to a real-time analyser to capture the time and frequency characteristics of the decaying sound field, and to determine the RT60. The individual and mean average of all four measurements are reported in Table 2.

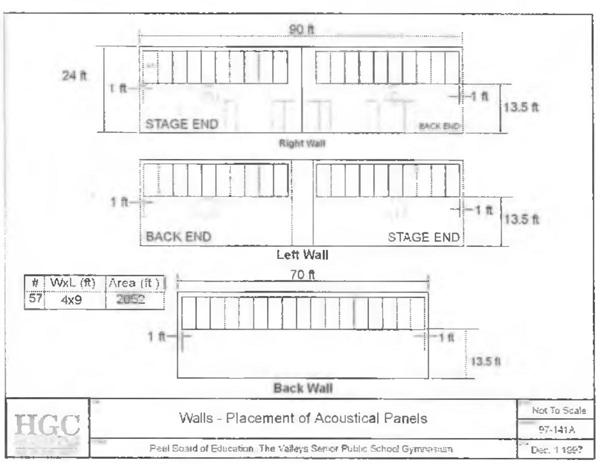
School	Octave Band Centre Frequency (Hz)					
	125	250	500	1000	2000	4000
Lagerquist	2.5	2.9	2.8	3.0	2.5	2.1
Fairwind	1.7	2.6	2.7	2.7	2.3	2.0
Fletcher	2.0	1.9	2.2	2.2	2.0	1.7
MacDonald	2.1	2.0	1.9	1.6	1.7	1.4
Mean	**2.1**	**2.4**	**2.4**	**2.4**	**2.1**	**1.8**
Untreated	3.5	3.2	4.2	4.9	4.5	3.4

Table 2: Reverberation Measurements – RT60 (s)

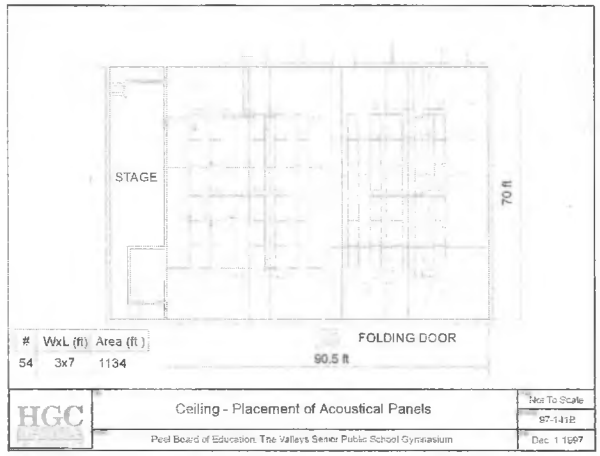
5.0 Discussion

It was evident both from the measurements and from subjective auditory evaluation that the gymnasium in question was excessively reverberant. The reverberation time in the 500 and 1000 Hz octave bands was in excess of 4s, and was a serious impediment to clear speech. The measurements of the other gymnasia further revealed that reducing the RT60 to approximately 2.4s would provide an environment that was likely to be acceptable to the staff.

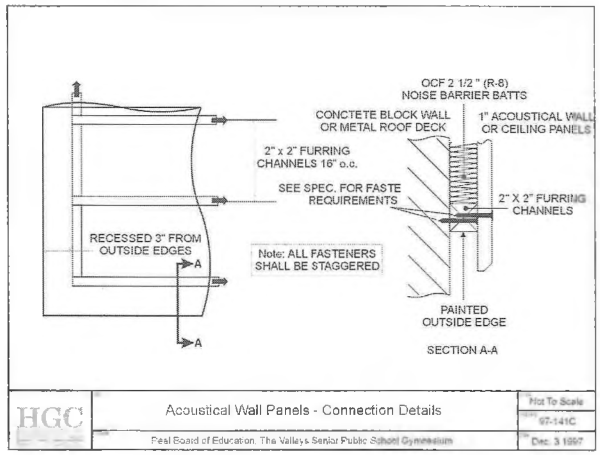
Figure 1. Acoustic Treatment of Gymnasium.



a) Wall Treatment Details



b) Ceiling Treatment Details



c) Wall Panel Details

It was decided that treating the interior surfaces of the gymnasium with absorptive materials to reduce the reverberation time was necessary. A wood fibre and resin product was chosen, primarily for its impact resistance. Calculations indicated that a 1000 Hz reverberation time of 2.4s could be achieved by the installation of 2500 sq. ft of the material. The panels were stood off from the wall on 2" x 2" wooden furring channels. Light density fibreglass insulation was

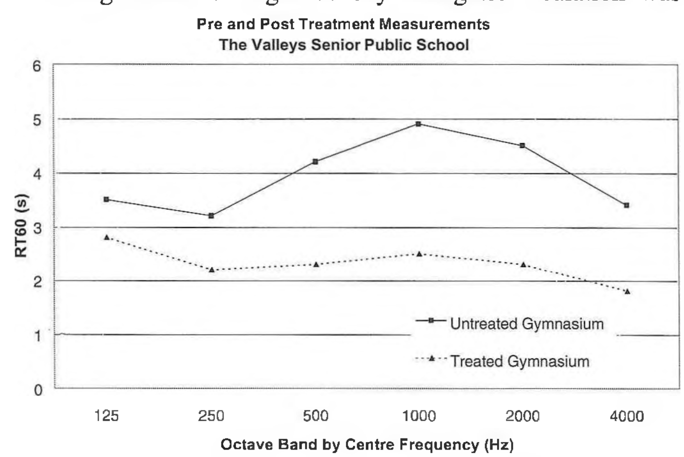


Figure 2. Results of Reverberation Time Measurements.

installed in the airspace behind the panels, to increase the low-frequency absorption as much as possible. The treatment details are shown in Figure 1.

6.0 Post-Treatment Measurements

Following the installation of the absorptive treatment, the staff noted a large improvement in the acoustic environment of the gymnasium. Speech intelligibility and overall comfort were substantially improved.

We revisited the site and conducted reverberation measurements for quality assurance purposes and to verify the calculation methods. The results are compared to the criteria in the Figure 2. The results indicate excellent correlation and verify the predictability of RT60 in this class of space.

7.0 A Second Case Study

The Central Memorial Recreation Centre in Hamilton contains an older gymnasium used for many years for community athletic events. The room was recently renovated with a hard vinyl tile floor, concrete block walls with several coats of paint and painted plaster ceiling.

These acoustically hard surfaces absorbed little sound energy. Measurements indicated that the reverberation time, after the renovation, had increased to over 8 seconds in the 1000 Hz frequency band.

The owner, in this case, decided to use acoustical panels constructed of 7.5 lb. pcf fibreglas covered with a microperforated vinyl material for durability, cleanability and light reflectance. Calculations based on the maunufacturer's published acoustical specifications indicated that a coverage area of 3500 ft. was required to reduce the reverberation time into an acceptable range.

The panels were fairly evenly distributed around the upper

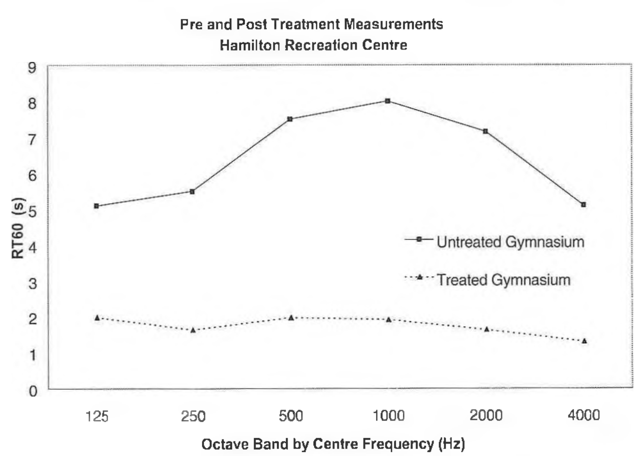


Figure 3. Results of Reverberation Time Measurements.

walls and ceiling. Post installation measurements indicated good results, again confirming the applicability and predictability of the RT60 with regard to this general class of space. The results of the measurements are presented in Figure 3.

8.0 Alternate Acoustical Descriptors

The RT60 is a general descriptor of the acoustical conditions in a space. It describes the decay of the overall energy distribution, which is determined through integration. No consideration is given to the fine detail of the decay trace.

Any location in a gymnasium could either be a sound source or a point of reception, and gymnasia are often constructed without distinct architectural orientation. All the wall surfaces are similar and spatially homogeneous sound field with a linear time decay is often the result. A general descriptor in terms of overall energy decay (the RT60) is arguably the most appropriate.

This is not necessarily the case for spaces with a distinct physical orientation of source and receiver, such as classrooms, lecture rooms and theatres. The choice of room volume, the specific location of reflective surfaces with respect to the source and the judicious location of absorptive and diffusing elements are required to obtain the proper arrival of early and late energy. Early reflections (less than 30-50 ms) provide clarity, definition and intimacy while the later reflections can detract from intelligibility.

In these spaces more recently developed acoustical criteria such as the C50, which is based on the ratio of early to late arriving energy, find significant application and investigation. [3], [4], [5]

An investigative analysis of the C50 for the typical gymnasium space was performed using a commercially available ray-tracing software package. The results indicate negative values of C50. Less energy arrives at a typical receiver within 50 ms of the acoustical stimulus than after 50 ms. This can be understood geometrically since a surface must be located within close proximity of the source or receiver to contribute strong early reflections. At many locations in a gymnasium, the only such surface is the floor and perhaps one nearby wall, because of the large volume.

A typical decay trace from a gymnasium is shown in Figure 4. It indicates a logarithmically linear time decay with no particularly interesting detail. In this space, the 60 dB decay time calculated from early portions of the decay trace (T20, T30 and T40) are essentially equivalent and any could be used to gain the same information. In practical terms, it may be necessary to utilise the shorter time window descriptor to

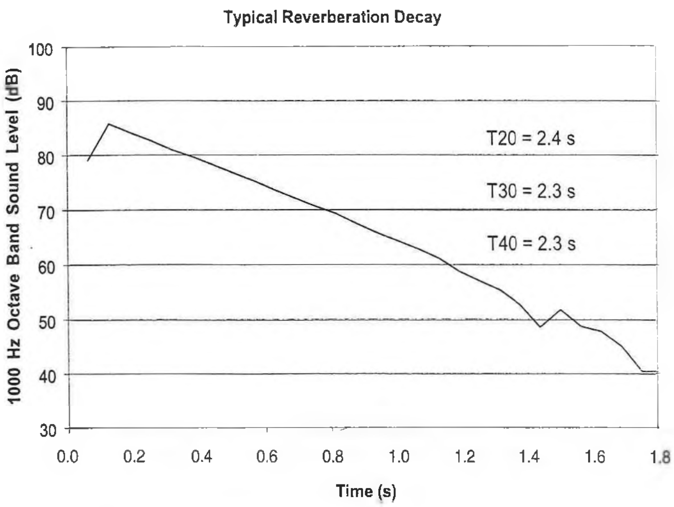


Figure 4. Decay Trace at 1000 Hz band.

obtain meaningful results with higher levels of background sound. It may not always be practical to generate a sufficiently robust sound stimulus to measure a full 60 decibels of decay.

9.0 Conclusions

These case studies illustrate that reverberation times in the general range of 2 – 2.8 seconds were judged to be acceptable by teaching and administrative staff for a broad range of activities including athletic events and student gatherings. Simple measurements and calculations of RT60 in Octave bands proved to be sufficiently accurate to specify a number of optional remedial acoustical treatments to meet this criterion. Such analysis is well within the capabilities of many architects and consultants and suitable acoustical absorption data is available from reputable suppliers.

We conclude that there is no technical reason that poorly performing spaces should be built or created through renovation. The fact that poorly performing spaces continue to be created suggests that acoustics is not given sufficient consideration in the project design criteria.

In order to obtain an acceptable acoustical space, it may be useful to include a section in the National Building Code addressing gymnasia and other similar places of public assembly. Simple reverberation time criteria should be adequate for such multifunction spaces.

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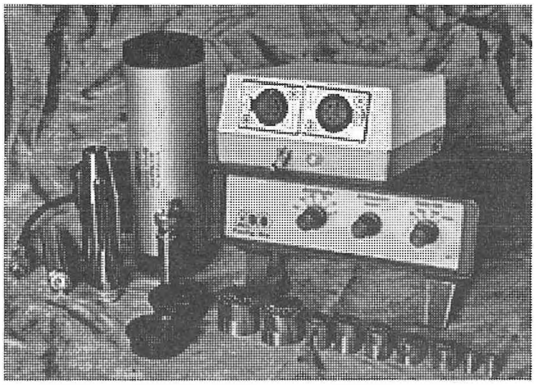

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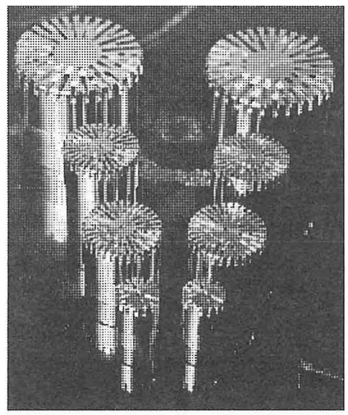

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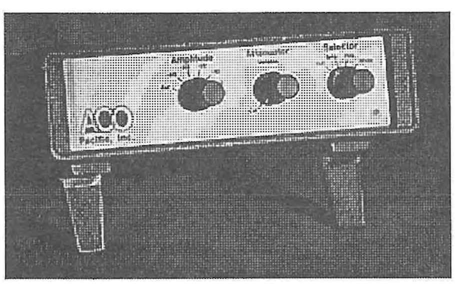

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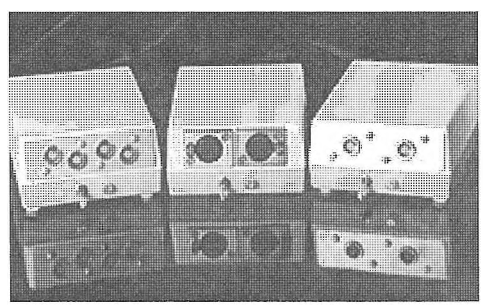

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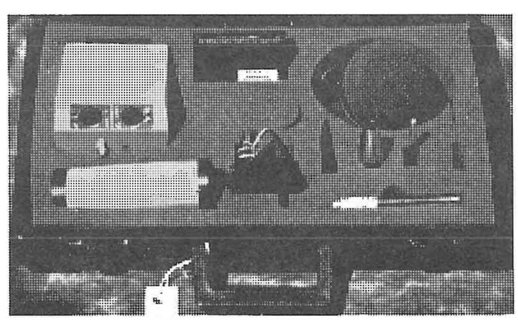

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Quelques propos sur le logarithme et le décibel

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Abstract

It is very trite and classical to use decibels in acoustics, but when one looks in detail this definition may call us for several historical and methodological points, and more may render us puzzled. All of this because decibels are based upon logarithm function in order to define levels from adimensional ratios, and because there are many different ways in order to explain the presence of logarithm. The paper gives a short recall of logarithm properties and investigate the mean reasons, in mathematical and physical fields, in human and environmental sciences also. The conclusion is rather severe about the revelancy of Fechner law in Psychophysics, while very pregnant in decibels and levels definition.

Résumé

Le décibel est d'usage courant en acoustique, cependant il s'agit d'une construction mathématique qui peut appeler de nombreux commentaires historiques et méthodologiques, et peut-être aussi quelques sujets d'interrogation. En particulier la définition s'appuie sur le logarithme pour définir les niveaux de grandeurs mais l'on rencontre différentes autres raisons pour expliquer ou justifier cette présence. Après un bref rappel des propriétés essentielles du logarithme le texte aborde les principaux arguments qui sont régulièrement évoqués, du ressort des mathématiques, de la physique et des sciences humaines, sans oublier un point de vue environnementaliste qui renouvelle le regard porté sur le décibel. Les conclusions sont assez sévères quant à la pertinence de loi de Fechner pour expliquer la définition logarithmique des niveaux.

1.0 Introduction

Le logarithme est une application mathématique qui a émergé durant le XVII^e siècle, depuis la publication des tables de John Napier (ou Neper) en 1614 jusqu'à la formule intégrale $\int dx/x$ qui figure dans le mémoire de Calcul différentiel de Gottfried Leibniz en 1684. Pour sa part, le décibel est le nom d'une unité très particulière en physique car elle s'applique à des grandeurs sans dimension, et c'est avant tout un label chargé d'identifier un «procédé de fabrication», ou encore *"une manière de compter"* comme dit Liénard (1978), qui a sans doute vu le jour dans les années vingt du XX^e siècle.

Les acousticiens savent bien que le logarithme entre dans la formule de définition du décibel, mais il possède tant de facettes étonnantes et diverses que l'on peut se méprendre sur celle qui en est à l'origine. On rencontre en effet des explications de différentes natures dans la littérature acoustique, certaines paraissant bonnes et d'autres étant davantage du ressort d'une confusion.

Nous essayons ici de suivre le fil qui a conduit du logarithme au décibel. Il se compose d'une première partie à connotation mathématique et physique, puis d'un développement plus orienté vers les Sciences Humaines, lui-même en plusieurs étapes. Mais tout ceci n'est-il pas à l'image de l'Acoustique dont l'objet principal est l'étude des sons physiques qui sont perçus par l'oreille de l'Homme ? Le développement est illustré par un certain nombre de citations, elles sont signalées en *italique*.

2.0 Le logarithme

A cause de ses propriétés plusieurs disciplines scientifiques, dont l'acoustique, utilisent souvent le logarithme. Nous notons ln le logarithme népérien, log le logarithme décimal et $\log_a$ le logarithme en base a, (a nombre réel positif), et nous considérons ci-dessous que les arguments x, y ... sont uniquement des nombres réels positifs, de sorte que chaque transformée ln x soit encore un nombre réel (mais positif ou négatif).

2.1 Les propriétés

La propriété la plus connue des logarithmes est la formule

$$\ln xy = \ln x + \ln y \qquad (1)$$

x et y nombres réels positifs, et puisqu'ils se déduisent les uns des autres par un coefficient multiplicatif de la forme générale $\log_a x = \ln x / \ln a$, (le coefficient $\mu = 1/\ln a$), ils vérifient tous cette propriété. L'interprétation est immédiate et très importante, la relation (1) signifie que si x et y sont deux grandeurs multiplicatives leur deux images ou transformées par un logarithme sont des quantités additives dont la somme est égale à la transformée du produit.

Les autres propriétés du logarithme sont étudiées dans les livres d'Analyse, et nous nous limitons ici à souligner qu'elles constituent une palette étonnante de propriétés qui sont nécessairement attachées au logarithme ; comme le dit

Penrose dans un contexte analogue "*(les propriétés) sont déjà là !*" (Penrose 1993). Citons pour mémoire la monotonie croissante, la concavité, et bien entendu la formule de Leibniz indiquant que le logarihme est la primitive de l'application 1/x. Une autre propriété peut-être un peu moins connue mais importante est due à Cauchy, parmi toutes les applications h qui vérifient la relation,

$$h(xy) = h(x) + h(y) \qquad (1')$$

le logarithme (et tous ses multiples) est la seule à être continue (Falmagne 1985, Roberts 1979, Verley 1990). On sait aussi que le mot "logarithme" est un néologisme dû à Napier qui a associé "logos" et "arithmos" pour tenir un discours sur les nombres (son mémoire de 1614).

2.2 Lois additives et multiplicatives

Si u et v sont deux éléments d'un ensemble E doté d'une loi de composition interne [u,v] à valeur dans E, on appelle loi additive toute application notée "add" de E dans la droite R des réels qui vérifie

$$add([u,v]) = add(u) + add(v) \qquad (2),$$

et loi multiplicative toute application "mult" de E dans la demi-droite R^+ de réels positifs qui vérifie

$$mult([u,v]) = mult(u)\ mult(v) \qquad (3).$$

Le résultat suivant est immédiat, voire trivial, toute application composée $h_o mult$ avec h vérifiant (1') est une loi additive. En effet quand on applique (1') sur (3) on obtient

$$h_o mult([u,v]) = h_o mult(u) + h_o mult(v) \qquad (4),$$

ce qui permet de se ramener au schéma additif (2) à partir d'une loi multiplicative. La relation (4) est la clef d'un grand nombre de transformations de lois multiplicatives en lois additives, c'est évidemment le cas avec un logarithme pour h, la continuité et ses autres propriétés en sus.

3.0 Niveaux de grandeurs et décibels

Il semble qu'au départ les niveaux de grandeur en décibels (en abrégé dB) proviennent d'une situation pratique dans laquelle il s'est révélé utile de comparer diverses grandeurs physiques homogènes sous la forme de leur rapport, c'est à dire à l'occasion de l'introduction convenue d'une forme particulière de loi multiplicative (3). Leur présentation ainsi que celle de leur mode d'introduction commence donc par un discours qui relève de la Physique et des Sciences de l'Ingénieur.

3.1 Un essai de reconstitution historique

Il n'est pas aisé de retrouver dans la littérature l'acte de naissance précis et daté des décibels, mais on rencontre à l'occasion des bribes historiques et méthodologiques telles que "*La notion de décibel, qui doit son origine à l'étude de la transmission des signaux le long d'une ligne téléphonique, s'est révélée extrêmement commode dans la pratique, et son usage s'est répandu dans toutes sortes de domaines, en particulier en acoustique*" (Riéty et Ottié 1986). Ces auteurs poursuivent en disant "*En principe le décibel se rapporte à la comparaison de deux énergies, soit que l'on compare deux états énergétiques différents d'un même système, soit que l'on étudie la transmission d'une certaine quantité d'énergie d'un système à un autre*".

On lit également "*Rappelons simplement qu'il est toujours permis (et même recommandé) d'exprimer une grandeur physique par son rapport à une grandeur semblable prise pour unité, et qu'il est commode si l'étendue de mesure est grande, de prendre le logarithme de ce rapport*" (Liénard 1978), qui poursuit en évoquant à son tour les télégraphistes, tout en ajoutant qu'on peut appliquer ce procédé "*à n'importe quoi*" ; ou encore lorsque c'est appliqué à l'acoustique "*the intensity of one sound can be compared to that of another of the same frequency by taking the ratio of their powers*" (sound intensity entry 1992).

Tout cela signifie qu'il a été jugé pertinent de comparer des énergies deux à deux de manière relative par l'intermédiaire de leur rapport E_2/E_1, ce qui a introduit de la sorte une multiplication, ainsi que la relation multiplicative plus générale $E_3/E_1 = E_3/E_2\ E_2/E_1$. Dans ces conditions il n'est pas surprenant que le logarithme ait été mis en oeuvre, comme nous l'avons rappelé dans la relation (4). Le nombre $\ln E_2/E_1$ est ainsi ce qui a été retenu pour caractériser le passage de l'état 1 à l'état 2 ; il s'agit d'un nombre sans dimension physique mais on lui a malgré tout attribué un nom et une sorte d'unité pour bien identifier ce procédé. Ce nombre s'appelle un niveau, il est noté L (pour level, parfois N pour niveau chez des auteurs francophones, Didier 1993, Habault 1994, Migneron 1980, Riéty et Ottié 1986), et on l'exprime en "bels" quand on prend le logarithme décimal, ou en décibels avec la relation de définition $L = 10 \log E_2/E_1$; le nom de l'unité étant choisie "*in honour of the US inventor Alexandre Graham Bell*" (sound intensity entry 1992). D'après des conversations informelles diverses, le décibel aurait été créé dans les années vingt dans les murs des Bell Laboratories.

Bien entendu le logarithme et l'additivité résultante vont de pair, "*Le succès de l'utilisation des décibels est dû à la propriété suivante : si l'on met bout à bout plusieurs lignes, la perte totale, exprimée en décibels, est égale à la somme des pertes correspondant aux différentes lignes ; de même, le gain total d'un amplificateur, exprimé en décibels, est égal à* *la somme des gains partiels de chaque étage. Cette propriété découle des propriétés générales des logarithmes*" écrivent Riéty et Ottié en 1986. On doit pouvoir ajouter que dans cette citation il serait sans doute plus exact de remplacer "décibel" par "niveau", et penser aussi qu'il paraît plus pertinent d'inverser le sens des implications causales, en disant plutôt que c'est parce que l'on a pris l'habitude de faire des comparaisons d'énergie avec des rapports (en substance une relation multiplicative) que l'on a très certainement éprouvé la nécessité d'un homomorphisme de H (implicitement continu). Dans ces conditions il n'y a pas lieu de s'étonner de la propriété de l'additivité des niveaux en décibels. Dans le même temps ce succès révèle l'attente explicite ou latente qui est manifestée vis-à-vis de lois additives.

Cette imbrication entre rapport de grandeurs et additivité associée est tout autant manifeste dans les présentations complémentaires suivantes "*Dès que les ingénieurs conçurent des systèmes électro-acoustiques ils jugèrent plus pratiques d'utiliser, pour exprimer la grandeur d'une pression et d'une intensité acoustique, des valeurs logarithmiques plutôt que des grandeurs physiques. ... C'est ainsi qu'ils créèrent des niveaux*" (Josse 1973), "*Le décibel étant d'un usage commode en raison de ses propriétés logarithmiques, on est tenté de l'utiliser par extension pour exprimer n'importe quel rapport entre deux quantités de la même espèce*" (Riéty et Ottié 1986), "*accordingly the relative intensity of two sounds in bels is equal to the logarithm of the intensity ratio*" (sound intensity entry 1992), ou encore "*We note ... that the sound-power level for the product of two ratios is equal to the sum of the levels for the two ratios*" (Beranek 1971).

3.2 Des grandeurs de référence

A la suite de ces diverses justifications, il est patent que le logarithme a été introduit pour définir ce que l'on nomme des niveaux. Et l'on peut ajouter un complément immédiat qui résulte du caractère bijectif du logarithme. En effet si l'on pose $L = \ln E_2/E_1$ on est tenté d'écrire $L = \ln E_2 - \ln E_1$. Malgré les apparences l'homogénéité dimensionnelle de cette relation est respectée puisque le logarithme est de dimension unité quelle que soit la dimension de son argument (Maurin 1999 Annexe 2), cependant les niveaux disparaissent de la formule. Peut-être est-ce pour cela que l'on a complété avec une grandeur de référence E_0 constante qui permet d'écrire le rapport E_2/E_1 sous la forme d'un produit $E_2/E_0 \;\; E_0/E_1$, de telle sorte que le niveau $L = \ln E_2/E_1$ devient une différence de niveaux $\ln E_2/E_0 - \ln E_1/E_0$; nous rappelons à ce propos que le rapport à une grandeur de référence est l'option de départ chez Liénard (1978).

Après un choix conventionnel de E_0 il en résulte une bijection entre les grandeurs proprement dites E_i et leur niveau $\ln E_i/E_0$, ce qui permet ainsi parler du niveau d'une grandeur à la place de la grandeur elle-même. Cela suppose simplement que la grandeur de référence, la base du logarithme et la constante multiplicative éventuelle dans m ln soient fixées de manière conventionnelle, consensuelle et cohérente.

3.3 D'autres justifications

Tout compte fait la création des niveaux et des décibels est une opération «qui se passe bien» compte tenu des ingrédients initiaux qui sont rappelons-le une relation multiplicative dictée par les pratiques de comparaison relative et l'attente d'une relation additive. Et l'on doit pouvoir ajouter que les bonnes raisons ainsi introduites pourraient être en partie masquées, ou mal identifiées, et de ce fait assez mal mises en avant, à cause de la simplicité quasi-triviale de l'opération.

Les justifications classiques - Mais il arrive aussi que les acousticiens évoquent assez fréquemment d'autres justifications ou explications qui viennent en partie jeter la confusion de manière plus ou moins malencontreuse ; on rencontre à ce sujet l'un ou l'autre de deux arguments suivants:

i) Le premier concerne la réduction de l'étendue numérique entre les grandeurs E_i/E_0 étudiées, "*it is convenient in acoustics to express sound intensity in logarithmic units because the wide range of pressures to which the ear is sensitive*" (Kryter 1987), ou "*The range of sound pressure ... is so wide it is convenient to employ sound pressure level, ..., this is because a logarithmic scale compresses the range ...*" (Harris 1979).

Ceci est tout à fait exact, cela constitue un facteur non négligeable de commodité, Fleury et Mathieu (1955) soulignent qu'en acoustique les grandeurs proprement dites varient dans le rapport de 1 à 10^{14}. Cependant il faut ici se rappeler que la réduction de l'étendue est une propriété technique attachée au logarithme (la monotonie et la concavité), et qu'elle peut tout à fait ne pas être la raison principale de la définition des niveaux. Il suffit pour s'en convaincre de constater que dans d'autres disciplines qui pourtant travaillent avec des champs de grandeurs numériques très étendus comme les distances en Astronomie ou les durées en Géologie ou Paléontologie, il n'est cependant guère habituel de parler de niveaux de longueurs ou de niveaux de temps. On peut sans trop de risque d'erreur conjecturer que cela est dû au fait que dans ces disciplines il n'y a pas de relation multiplicative qui se soit naturellement introduite.

À l'inverse l'idée de la réduction de l'étendue se rencontre en Chimie de l'acidité et des solutions ioniques et aqueuses diluées. La concentration $[H^+]$ des ions de l'hydrogène varie de 1 à 10^{-14} et on y a dès 1909 défini le $pH = -10 \log[H^+]$ qui varie de 0 à 14. Cependant il y a aussi en Chimie la loi d'action de masse qui se traduit par les relations multiplicatives $[H^+]$ $[OH^-] = K_e \approx 10^{-14}$ pour l'eau, $[H^+]$ $[OH^-] = K_a$ pour les acides et $[B^+]$ $[OH^-] = K_b$ pour les bases (Gallais et Rumeau 1961). Ceci fait que l'on retrouve les deux arguments de réduction de l'étendue et des relations multiplicatives comme en Acoustique ; il y a malgré tout quelques différences, les concentrations ioniques sont d'emblée des nombres sans dimension qui n'ont pas besoin d'être réduits par une grandeur de référence, et sur le plan du vocabulaire on ne parle pas de «niveau de concentration».

ii) Le second argument est en provenance des Sciences Humaines avec ses "lois" des sensations ; par exemple *"(sound level in decibel) is a logarithmic scale well suited to human hearing which is logarithmic rather than linear in its behaviour"* (Ford 1987), ou bien "*il semble qu'autour de 1000 Hz la sensibilité de l'oreille suive la loi logarithmique*" (Liénard 1978).

Plus précisément il s'agit de la fameuse loi de Fechner qui possède sa logique et son histoire propre, et qui fait la part belle au logarithme. Et puisque l'acoustique est essentiellement la discipline des sons audibles avec un fort enracinement psycho-physiologique, le logarithme qui figure chez Fechner est venu s'immiscer dans les raisons que l'on évoque couramment pour justifier la définition des niveaux. La discussion de cette loi avec ses implications et confusions en acoustique, son caractère inutile et fâcheux, et le rattrapage final qui est intervenu lorsqu'est apparue une autre loi des sensations plus opérationnelle (celle de Stevens) fait l'objet de la section 4.

Il arrive encore à ces deux raisons d'être combinées, comme par exemple dans cette présentation "*En application de la "pseudo-loi" de Weber Fechner ..., le fait qu'il existe un rapport élevé entre les valeurs de la pression acoustique au seuil d'audition et au seuil intolérable ... a conduit tout naturellement à adopter une notation logarithmique*" (Didier 1993), ou encore "*ces rapports élevés, (ainsi que la soi-disant loi de Weber Fechner signalée ci-aprés) ont conduit à utiliser couramment une notation logarithmique*" (Fleury et Mathieu 1955).

Un argument récent - La question peut être abordée autrement en s'interrogeant sur la "meilleure" transformation possible $f(E_i/E_0)$ pour relier un rapport d'énergie à un indice acoustique. En suivant un argument de nature statistique et formelle il s'avère que c'est précisément l'application logarithme qui l'emporte, et vient conforter ainsi sur un plan technique le choix des télégraphistes ; la démonstration s'appuie en substance sur la "galaxie" des propriétés du logarithme (Maurin 1994).

Une autre démarche encore - Pour tenter de terminer cet état des lieux, on peut ajouter que chez certains auteurs les niveaux et les décibels sont simplement définis en une ou deux lignes sans préoccupation de justification (Beranek 1971, Habault 1994, Lefebvre 1994, Migneron 1980).

3.4 Les savarts ou millibels de fréquence

Curieusement il se présente en Acoustique une autre introduction historique, indépendante et antérieure du logarithme, qui concerne la fréquence de chaque son pur et les relations qui se manifestent entre les fréquences et leur perception musicale.

Par définition l'intervalle de deux notes est le rapport de leur fréquence $i = f_2/f_1$ (Fleury et Mathieu 1955, Matras 1990), et une telle définition n'est nullement quelconque puisque "*en Grèce, en Chine, en Egypte, au Moyen-Age ou de nos jours*" (Matras 1990) les sons dont les fréquences sont dans le rapport de 1 à 2 ont été considérés comme des sons particulièrement consonants. Le rapport $i = 2$ correspond à la définition de l'octave, et l'on sait bien que d'autres valeurs de rapport se rencontrent aussi dans les harmonies consonantes, 3/2 pour la quinte, 4/3 pour la quarte, 5/4 pour la tierce ... (Fleury et Mathieu 1955, Matras 1990) ; Matras ajoute que "*les physiciens ont constaté qu'un intervalle est d'autant plus consonant que le rapport des fréquences composantes est réductible à une fraction plus simple*".

Le rapport des fréquences revient à introduire une relation multiplicative, laquelle peut être à son tour suivie de l'intervention usuelle du logarithme comme en (4) ; Fleury et Mathieu (1955) ne signalent-ils pas que "*il suffit de caractériser un intervalle par son logarithme*", et plus loin "*qu'il est commode de représenter chaque intervalle par son logarithme décimal*". Il en est résulté la définition des savarts pour intervalle de fréquence avec la relation $h_s = 1000 \log f_2/f_1$, ou plus récemment celle du "cent" $h_c = 1200 \log_2 f_2/f_1$ en prenant le logarithme en base 2. De la sorte les savarts sont des "millibels" (pour des rapports de fréquence), un savart vaut pratiquement 4 cents et un décibel 400 cents ; n'est-ce pas là une belle illustration du "*n'importe quoi*" de Liénard (1978), avec l'antériorité du procédé de fabrication en sus.

Mais bien que les fréquences et les énergies s'appliquent à deux aspects tout à fait différent des sons, on peut lire que "*la loi de Weber Fechner étendue à la mesure de la hauteur h d'un ton pur de fréquence f donne la relation $h = 1000 \log f/f_0$ (f_0 fréquence de référence)*" (Matras 1990). Cette fameuse loi se retrouve ainsi, indûment, sur le chemin des décibels de fréquence, et vient en rajouter à la confusion autour de la présence du logarithme ; mais cette fois-ci c'est plus manifeste encore puisque Félix Savart mourut en 1841, soit 20 ans avant que Fechner ne formulât sa loi (section 4). Cela exhibe surtout le défaut de vision nette que l'on peut porter sur la présence de l'application logarithme, ainsi que la trop grande influence que l'on a laissé prendre à la loi de

Fechner avec sans doute une certaine complaisance passive.

4 La loi de Fechner et la Psychophysique

De nombreuses justifications du décibel nous condusient vers la Psychophysique. C'est une discipline qui appartient aux Sciences Humaines et qui s'est chargée notamment d'établir des correspondances (sous-entendu numériques) entre les stimulations physiques et les sensations qui en résultent. Elle s'est notamment appuyée à l'origine sur des observations d'astronomes soucieux des erreurs qu'ils commettaient (Benzécri 1982), et a ensuite été baptisée et fondée par Fechner quand il a énoncé et formalisé sa loi en 1860 (au départ un physicien prolixe, Falmagne 1985). D'une manière générale le stimulus étudié est une grandeur physique x qui prend ses valeurs sur un continuum, et il est convenu de lui faire correspondre une sensation sur un continuum subjectif mais néanmoins numérique, décrit par une autre variable u ; une expression de la forme u(x) est une "loi" qui répond à toutes ces questions.

4.1 La loi de Fechner

La démarche de Fechner - Ce pionnier s'appuie sur la notion de "Jnd" (just noticeable difference, différence juste perceptible en Français). En premier il est supposé que pour tout stimulus de valeur x, un Jnd Δu_F (sur le continuum subjectif de Fechner u_F) correspond au plus petit incrément de stimulus Δx qui permet au sujet de distinguer les sensations respectivement dues à x et à $x + \Delta x$ (un Jnd de grandeur physique). Le raisonnement reprend ensuite un résultat antérieur de Weber en 1831 (Bonnet 1986), qui stipule que les Δx sont proportionnels aux stimulations x, ce qui signifie que le rapport $\Delta x/x$ est constant ; en dernier Fechner ajoute l'hypothèse que les Δu_F sont égaux.

De ces deux relations $\Delta x/x = K$ et $\Delta u_F = C$ il en déduit $\Delta u_F/\Delta x = C/Kx$, puis la version différentielle $du_F/dx = C/Kx$ et la solution immédiate $u_F = C' \ln x + C''$ (d'après la formule de Leibniz). C'est ce qui a longtemps fait dire que la sensation varie comme le logarithme de la stimulation ; ce continuum u_F est communément dit de "confusion-discrimination" en fonction de son mode de construction. On peut signaler que Benzécri (1982) et Bonnet (1986) font remonter l'énoncé de Weber aux astronomes et physiciens Bouguer, Lambert, … vers 1760, et qu'on l'appelle aussi la loi de Bouguer Weber.

Les suites de cet énoncé - On a souligné que la loi de Fechner a été "*widely defended but not widely applied since his day*" (Luce Edwards 1958). Le fait est que si elle a longtemps été imposée et protégée par l'opiniâtreté de son initiateur elle a fini par être battue en brèche par des approches différentes (Bonnet 1986, Falmagne 1985, Roberts 1979).

Il est intéressant de noter que parmi les oppositions et contestations que la loi de Fechner a rencontrées, il y en a une qui se situe joliment sur le plan formel du logarithme et des mathématiques ; elle a donné lieu à une formulation révisée et à une solution appropriée un siècle plus tard (Luce and Edwards 1958, Annexe 1).

Un premier bilan - Pour conclure sur ce point, la loi de Fechner n'est pas véritablement une loi puisqu'elle repose sur une déclaration invérifiable (l'identité des différents Δu_F). Mais cela ne l'a nullement empêché d'acquérir quelque notoriété auprès de la communauté scientifique et d'un certain public, ce qui a pu banaliser l'idée d'un lien logarithmique entre l'intensité de la stimulation physique et la sensation qui en résulte.

Il faut toutefois garder à l'esprit que le résultat de Weber précède l'intervention de Fechner, qu'aujourd'hui le Jnd Δx est remplacé de manière plus précise par la "fonction de Weber" $\Delta_\pi(x)$ définie en fonction du stimulus et d'un indice de discrimination π compris entre 0 et 1, et que les recherches se poursuivent sur $\Delta_\pi(x)$ et sur la fraction de Weber $\Delta_\pi(x)/x$ pour de nombreuses stimulations physiques (Falmagne 1985). Ceci entraîne donc que l'on commet une confusion quand on ne fait pas la distinction entre les contributions respectives de Weber (et de Bouguer) et de Fechner, et que l'on utilise le résultat de Weber pour justifier la relation logarithmique. Cependant l'habitude a souvent été prise d'appeler la loi de Fechner sous le double nom de loi de Weber Fechner comme on peut le constater dans de nombreuses citations reprises dans ce texte, ce qui confirme à sa manière le rôle surcoté de la loi de Fechner.

Dans le même temps on doit aussi remarquer que le logarithme n'intervient pas ici de manière erronée ou subreptice, mais qu'il figure au titre d'une bonne et simple réponse, que la question s'avère ou non mal formulée ou non pertinente. Et cette fois-ci sa présence n'est pas liée à la transformation d'une loi multiplicative en loi additive en suivant (4), mais à une propriété différentielle non moins classique.

4.2 La loi de Stevens

Un autre procédé de quantification des sensations a été proposé par Stevens à partir de 1935, selon une démarche tout à fait différente. En l'occurence on demande simplement à chaque sujet d'expérience exposé à une stimulation x d'évaluer numériquement la sensation $u_{St}(x)$ qu'il ressent par un nombre proportionnel à la sensation $u_{St}(x_0)$ due à une stimulation de référence x_0 ; ici l'indice $_{St}$ du continuum subjectif u rappelle cette autre procédure. Il suffisait d'y penser, et cela constitue la méthode de "l'estimation de la grandeur" (*magnitude estimation*), qui par simple construction est une méthode directe et qui produit explicitement des réponses numériques sur cet autre continuum subjectif. Stevens et ses collaborateurs ont ainsi remarqué que pour un grand nombre des stimulations physiques dites *prothétiques* le rapport des sensations varie comme une fonction puissance du rapport des excitations, selon la relation générique

$$\frac{u_{St}(x)}{u_{St}(x_0)} = \left(\frac{x}{x_0}\right)^{\alpha}$$

Les valeurs des exposants a sont diverses, par exemple 0,3 ≈ log 2 pour la sensation due au bruit de sons purs (bruyance ou sonie), 3,5 pour la sensation ressentie quand on est soumis à une différence de potentiel électrique, … ; elles sont assez bien établies pour une bonne vingtaine de stimulations différentes (Canévet 1996, Luce and Galanter b 1963, Roberts 1979, Stevens 1966).

Stevens a consolidé son édifice avec les "*cross modality matching*" (évaluations croisées de grandeurs physiques différentes) qui consistent à faire les estimations pour une grandeur en se rapportant aux valeurs d'une autre grandeur et à ne plus passer par l'intermédiaire d'une évaluation numérique (Roberts 1979). Ceci fait que l'on dispose donc ici d'évaluations directes des sensations plus opérationnelles qu'avec le cumul indirect des Jnd, et mieux validées également.

4.3 Un édifice de lois

Les lois de Fechner et de Stevens ont constitué deux grands moments de la Psychophysique, et ont pu paraître en concurrence à l'énoncé de la seconde, "*cette loi (celle de Stevens) est en contradiction avec celle de Weber Fechner*" (Josse 1973) ; et en particulier le graphe de la fonction puissance ressemble un peu à celui de la fonction logarithme lorsque l'exposant de Stevens est inférieur à 1 ! Il n'y a toutefois aucune raison ni de les confondre ni de les opposer, car chacune d'elles à sa manière évoque une procédure d'évaluation des sensations sur un continuum numérique différent (Luce and Galanter a. 1963), voir Figure 1.

En dernier Stevens évoquait la préoccupation "*nomothétique*" en Psychophysique (Stevens 1971), et l'on note que ces deux relations constituent le début d'un réseau de relations psychophysiques plus étendu, comprenant notamment une loi de Galanter et Messick de nature logarithmique entre l'échelle de Stevens et l'échelle de Fechner (Galanter and Messick 1961, Stevens 1966), Figure 1, (le réseau de ces relations figure dans Maurin 1998).

Actuellement la présentation de la Psychophysique se fonde sur la formulation d'un "*Fechner problem*" et sur une modélisation associée de la discrimination entre deux stimuli x_k et x_l , et elle conserve également les notions de fonction et de fraction de Weber (Falmagne 1985). Elle supprime ainsi toute référence aux Jnd et aux constructions qui en résultent,

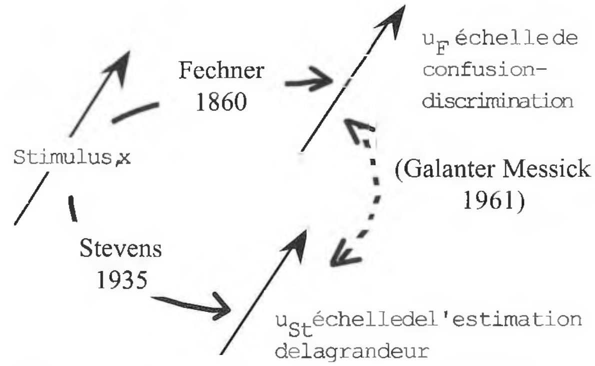

Figure 1 - Les lois de Fechner et de Stevens.

donc à la loi historique de Fechner, ainsi qu'à la révison de Luce et Edwards (en Annexe 1). Cependant il est utile de rappeler les principales étapes qui ont pu influencer les idées, et laisser des traces importantes quand on s'interroge comme ici sur la présence du logarithme dans les niveaux.

4.4 La situation en acoustique, le rattrapage

Cette trace concerne, nous l'avons vu, l'invocation répétée de la loi de Fechner jusque dans l'introduction des savarts ; et par la suite la loi de Stevens a fait aussi son entrée en acoustique.

La sonie - La cohabitation Fechner Stevens s'est opérée à propos de l'évaluation de l'intensité subjective d'un son ou sonie ou encore bruyance. On sait que pour cela on a retenu de manière opératoire l'effet que produit un son pur, puis établi les coubes de mêmes sensations sonores en fonction de la fréquence en prenant comme référence la sensation correspondant à la fréquence de 1000 Hz. Dans un repère «fréquence f - niveaux de bruit en décibels L» il en est résulté le réseau de courbes isosoniques pour sons purs de Fletcher et Munson dans les années trente, repris ensuite par Churcher et King, Robinson et Dadson. Ces courbes ne se croisent pas (réseau iso oblige), et leur repérage numérique dans le diagramme correspond à la définition de la sonie. Il s'avère en fait qu'il y a deux procédés de repérage, et que chacun d'eux est plus ou moins attaché à une loi psychophysique.

i) Le premier procédé correspond à l'évaluation de la sonie en "phones". Par définition le niveau d'isosonie en phones d'une courbe est égal au niveau de pression acoustique L en décibel du point de la courbe pour la fréquence de référence de 1000 Hz. Puisque ce réseau est établi avec des sons dont les niveaux sont compris entre 0 et 140 dB à 1000 Hz (du seuil de perception jusqu'au seuil de douleur), la phonie d'un son pur varie entre 0 et 140, et l'on voit combien cette définition est fondée sur une échelle de niveaux.

La loi de Fechner n'intervient pas directement il est vrai, mais elle figure en filigramme. Ceci est souvent justifié par le fait que la fraction de Weber ΔI/I pour l'intensité des sons purs est relativement constante entre 500 et 4000 Hz (Didier 1993, Fleury et Mathieu 1955), ce qui fait que les courbes d'isosonie restent assez bien parallèles et équidistantes dans cette zone (Liénard 1978 - lequel n'évoque d'ailleurs ni Fechner ni Weber).

Nous avons cependant rappelé l'amalgame facheux que l'on commet quand on tire argument de la validité de la loi de Weber pour justifier celle de Fechner ; et d'une manière plus générale, en acoustique comme pour d'autres stimuli, il a été constaté que la loi de Weber est valide dans les régions non extrêmes des sensations (Bonnet 1986, Luce and Galanter a 1963, Falmagne 1985). Il en résulte qu'il paraît bien erroné de tirer de la pertinence du résultat de Weber un argument en faveur de la définition logarithmique des niveaux.

ii) Le second procédé pour évaluer la sonie se fait avec les "sones", de telle sorte que la sonie d'un son évaluée en sones double lorsque la phonie augmente de 10 décibels, comme l'indique la formule de définition suivante:

$\text{sonie}_{\text{(en sones)}} = 2^{(\text{niveau d'isosonie en phones - 40})/10}$
c'est à dire
$\text{sonie}_{\text{(en sones)}} = 2^{L/10}\, 2^{-4}$
qui est de la forme $\mu\, (10^{L/10})^{\log 2}$.

La quantité $10^{L/10}$ correspond à l'énergie acoustique du son à 1000 Hz, et l'on voit apparaître l'exposant a = log 2 ≈ 0,3 sans que l'on ait ici besoin de niveau proprement dit, donc d'un quelconque pseudo recours à Fechner. On remarque aussi que la définition des sones permet simplement de traduire et d'exprimer la loi puissance de Stevens, laquelle compte tenu du grand nombre de vérifications expérimentales montre que la définition des sones est mieux établie.

Autre bilan - Pour résumer, la loi de Fechner est très discutable et pour le moins sans portée pratique, et l'on assiste avec les sones à une sorte de rattrapage qui vient inclure l'essentiel de la loi de Stevens. Les sones montrent comment la définition des phones se révèle superflue, et ce n'est que parce que les décibels sont déjà en place que les sones utilisent les niveaux dans l'expression $2^{L/10}$.

Ainsi, sans être porteurs d'erreur par eux-mêmes, les phones participent au renforcement du climat de complaisance fechnérienne en faveur de "son" logarithme, et de confusion à propos du résultat de Weber. Compte tenu de l'aspect physiologique et humain de l'audition, et faute de vigilance suffisante, on peut imaginer que c'est de cette manière que la loi de Fechner a pu devenir une sorte de cheval de Troie dans l'édifice de l'acoustique, s'en trouver mieux accréditée, et contaminer la genèse électrique et télégraphiste des niveaux par défaut d'attention comme cela semble s'être passé pour les savarts de fréquence.

5 Le décibel en Acoustique Environnementale

Notre sujet concerne la (ou les) bonne(s) raison(s) qui a (ont) prévalu pour la définition logarithmique des niveaux ainsi qu'une perception plus exacte des autres ; mais pour être un peu plus complet on ne peut pas ne pas mentionner quelques uns des aspects auxquels la pratique de l'acoustique peut conduire dans le domaine de l'environnement, ni parmi leurs conséquences une certaine remise en question de l'intérêt des niveaux.

5.1 Des relations additives

En effet quand il s'agit de déterminer le bruit (ou la pression acoustique) dans un champ créé par plusieurs sources il est habituel, et valide, de considérer que les sources sont indépendantes ou non corrélées.

Physiquement cela signifie que leur énergie ou leur puissance sont additives en tout point de réception dans un champ diffus et lointain où l'indépendance est réaliste. De manière générale une source de puissance W_1 et repérée par son niveau de puissance $L_{w1} = 10 \log W_1/W_0$ crée au point de réception M situé à la distance r_1 (champ lointain) un niveau de pression acoustique L_{p1} égal à

$$10 \log\left\{\frac{W_1}{4\pi r r_1^{\,2}} \Big/ \frac{W_0}{4\pi r r_0^{\,2}}\right\} = L_{w1} - 10 \log\{4\pi r_1^{\,2}/1(m^2)\}$$

avec les grandeurs de référence $W_0 = 10^{-12}$ Watt et r_0 = 0,282 m le rayon de la sphère d'aire unité (Beranek 1971, Harris 1979, Josse 1973, Liénard 1978, Migneron 1980). Il en est de même pour une seconde source de puissance W_2 à la distance r_2 de M, et l'on sait bien qu'en ce point le niveau de pression résultant n'est pas égal à la somme des niveaux L_{p1} et L_{p2} .

Ici la règle physique des sources indépendantes est l'additivité des puissances en M, c'est à dire que l'on considère la somme des puissances

$$\left\{\frac{W_1}{4\pi r r_1^{\,2}} / \frac{W_2}{4\pi r r_2^{\,2}}\right\} 4\pi r_0^{\,2} = (10^{L_{p1}/10} + 10^{L_{p2}/10})\, W_0 ,$$

et le niveau $L_{ptot} = 10 \log (10^{L_{p1}/10} + 10^{L_{p2}/10})$
qui en résulte alors.

Cette règle s'étend naturellement à un nombre quelconque de sources considérées comme indépendantes. C'est le cas en acoustique routière notamment, par exemple avec des véhicules situés à des abscisses x_k sur une chaussée rectiligne et de puissance W_k , le niveau global est égal à

$$L_{ptot} = 10 \log \left\{ \sum_{k=1}^{n} \frac{W_k 4\pi r_0^2}{W_0 4\pi r_k^2} \right\}$$

avec $r_k^2 = d^2 + x_k^2$ en un point récepteur à la distance d de la chaussée. La sommation peut prendre diverses formes selon la disposition des sources, d'autres exemples simples et immédiats de l'additivité des puissances et des énergies acoustiques figurent en Annexe 2.

5.2 Une nouvelle attitude vis-à-vis des décibels

Cela signifie que l'étude des phénomènes en acoustique de l'environnement introduit naturellement des relations additives de la forme (2), et que les mêmes grandeurs physiques obéissent à deux modes distincts de composition ; en l'occurence la composition multiplicative des rapports E_i/E_0 qui est à l'origine des niveaux en décibels, mais aussi la composition additive $E_i + E_j$ très importante en matière d'environnement.

Mais évidemment ces deux règles de composition ne sont pas réductibles l'une à l'autre, et la relation additive est tenue de s'intégrer dans un contexte qui a privilégié le logarithme, ce qui implique des pratiques calculatoires forcément moins commodes, "*the use of the logarithmic scale requires somewhat different arithmetic than we are accustomed to using with linear scales*" (von Gierke and Eldred 1993) (Pour le pH également l'introduction du logarithme entraîne quelques lourdeurs de calculs malgré tout). C'est bien ce qu'éprouvent les acteurs qui s'occupent d'expositions sonores d'une certaine durée, ou de problèmes de multi-expositions de toutes sortes, et qui constatent l'émergence de cette relation additive. Pour cette raison ils peuvent ne pas autant que d'autres en acoustique partager l'intérêt des niveaux, et certains ont été conduits à proposer de faire l'économie des décibels "*Sound exposure without decibels*" titre explicitement Eldred en 1986. Tout cela revient à privilégier la composition additive des énergies reçues, par exemple dans la notion de « sound exposure » dans des procédures réglementaires (Schomer 1996, von Gierke and Eldred 1993), "*Again the key factor is that we sum the sound exposure for individual events*" (Schomer 1996).

Ceci est un point de vue qui renvoie dos à dos les télégraphistes et Fechner quant à l'intérêt des niveaux et à la responsabilité de l'introduction de logarithme, et qui rend la discussion précédente sans objet. Cependant von Gierke et Eldred (1993) écrivent aussi "*This use of logarithmic scale is convenient because* ..." (en substance ils évoquent là la réduction de l'étendue numérique des grandeurs elles-mêmes). Par conséquen, quoique l'on fasse, les deux types de relation additive et multiplicative (dotée de sa traduction logarithmique) sont également signifiants et légitimes, et puisqu'il ne peut y avoir un système de transcription mathématique qui les rendent également commodes, il faut convenir d'une forme d'arbitrage entre les deux.

On sait bien que l'on a proposé le mode de conduite suivant, les caractéristiques des expositions sont uniquement traitées à l'aide de notions additives comme la « sound exposure » SE ou la « day night sound exposure » DNSE qui se limitent à faire les seules sommations avec l'économie des niveaux de grandeur chaque fois que c'est possible, à la suite de quoi tous cumuls additifs faits, on revient en dernier aux notions de « *sound exposure level* » SEL et de « *day night sound level* » DNL avec le niveau de ces grandeurs (**L**) en décibels.

Pour terminer la loi additive est naturellement valable à des constantes près, par exemple $\lambda(E_1/E_0 + E_2/E_0)$ pour tout jeu de paramètre $\{\lambda, E_0\}$, ce qui permet des aménagements avec un choix conventionnel de constantes pour définir une sorte de grandeur unité de l'exposition acoustique. C'est ainsi que si l'on désire qu'une exposition cumulée de référence E_{ref} conduise à un DNL_{ref} de référence, il suffit de retenir un jeu qui vérifie $\lambda\, E_{ref}/E_0 = 10^{DNL_{ref}/10}$ afin d'obtenir la relation $DNL = 10 \log \lambda\, E/E_0 = DNL_{ref}$ $+ 10 \log E/E_{ref}$ comme le font en substance von Gierke et Eldred (1993) ; ce sont des aménagements au sein de cet arbitrage qui bénéficient des propriétés du logarithme.

6 Conclusion

Sous le coup de sa découverte Napier nous invitait à "payer un tribut de gloire et de reconnaissance à Dieu", "... *Deoque ... laudem summam et gloriam tribuite*" (cité dans Dupuis 1885) à propos de ces merveilleux logarithmes, "*mirifici logarithmorum canonis descriptio* ..." (dans le titre du premier mémoire, celui de 1614).

Aujourd'hui nous pourrions aussi louer l'application logarithme elle-même à cause de la richesse des propriétés qu'elle recèle. La louer certes, mais dans le même temps apprendre à nous en méfier car elle peut jouer quelques bons tours à sa manière ; la preuve n'en est elle pas donnée avec la définition des décibels qui voit défiler un certain nombre de justifications, des bonnes et des moins bonnes avec leur cortège de confusions.

Parmi les bonnes il y a sans conteste le fait d'être une transformation continue qui permet de passer d'un produit à une somme, et qui s'introduit naturellement dans les disciplines qui ont jugé utile de faire des comparaisons de grandeurs par leur rapport quand on cherche malgré tout une règle finale additive. Il y a aussi la réduction de l'étendue des valeurs numériques après transformation, et plus récemment le fait que si l'on veut se livrer à des traitements statistiques, le changement de variable logarithme est celui qui facilite au mieux les traitements ultérieurs.

A côté de cela la loi de Weber semble être assez bien établie dans un grand champ intensité-fréquence à propos de la sensation auditive. Toutefois cela n'implique en rien nous l'avons vu la validité de la loi que Fechner en a déduit, et c'est là une première méprise ou confusion. Une seconde est de penser que la loi de Fechner elle-même est bien établie alors que ce n'est qu'une réponse correcte à une question non véritablement pertinente, et une troisième consiste à voir l'intervention de la loi de Fechner partout où figure un logarithme en Acoustique, sous prétexte que le loi de Fechner est logarithmique et qu'il y a un volet de physiologie. Qui plus est la loi de Fechner s'avère en pratique supplantée par la loi de Stevens.

On peut ajouter une autre raison d'ordre plus général pour prendre ses distances avec la loi de Fechner. En effet on peut rappeler que les phénomènes étudiés en physiologie ne sont pas aussi simples que cela à bien connaître, ce qui fait que les relations de la Psychophysique n'ont sans doute pas autant le label de relations exactes que peuvent l'avoir les relations que l'on établit en Physique par exemple. Malgré cela la loi (et la formule) de Fechner reste une justification courante pour la genèse logarithmique des niveaux. Et dans le même temps on ne peut manquer d'être dubitatif et surpris car finalement elle présente deux attributs assez stables dans la littérature. D'une part celui d'être assez souvent invoquée comme nous l'avons vu ; mais aussi quand on examine les justifications et citations de près, celui d'être accompagnée par des réserves, comme pour adhérer à une opinion que l'on s'empresse de citer pour ne plus avoir à y revenir.

Pour terminer il n'est jamais facile de prendre à partie une opinion assez bien consensuelle, ni de se lancer dans une reconstitution de faits avec des sources qui sont nécessairement incomplètes. L'auteur souhaite simplement que cette discussion puisse aider à mieux identifier les raisons véritables et défendables de la convention du décibel, les raisons corollaires et convergentes qui sont rendues possibles par le nombre et l'intérêt des propriétés du logarithme, et à situer les autres de manière à rendre à chacune la mesure de sa pertinence dans l'édification de l'acoustique.

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ANNEXE 1: Un avatar technique de la loi de Fechner.

Il s'agit d'une reformulation de la problématique de Fechner qui a été développée près d'un siècle après son premier énoncé par Luce et Edwards en 1958.

L'idée de ces derniers consiste à respecter l'aspect fini des Jnd, à ne plus utiliser la version différentielle comme l'a fait Fechner trop précipitamment semble-t-il (§ 4.1), et donc à écrire que sur le continuum révisé de Fechner u_{Frev} les Jnd Δu_{Frev} se mettent sous la forme d'une différence

$u_{Frev}(x + \Delta_\pi(x)) - u_{Frev}(x)$ en utilisant la fonction de Weber $\Delta_\pi(x)$. Il s'agit encore de résoudre cette équation en recherchant la fonction inconnue $u_{Frev}(x)$.

Cette nouvelle formulation conduit à problème technique très différent dont la solution est sans doute moins familière. L'équation en question est une équation fonctionnelle aux différences dite d'Abel, qui a été résolue par Koenigs en 1884 et 1885 (Luce and Edwards 1958).

On peut simplement retenir que l'équation aux différences de la forme

$$u_{Frev}(x + \Delta_\pi(x)) - u_{Frev}(x) = g(\pi) \qquad (5)$$

avec un second membre qui ne dépend pas de x ne possède pas toujours de solution en u_{Frev} (cela dépend de l'expression de $\Delta_\pi(x)$), et que lorsqu'elle existe la solution ne s'exprime pas sous une forme analytique simple.

Et l'on peut encore vérifier que dans le cas de la fonction de Weber particulière simple et classique $\Delta_\pi(x) = K(\pi)(x+x_0)$ comprenant un seuil éventuel x_0 et une constante K qui peut dépendre de l'indice de discrimination π,

$$u_{Frev}(x) = \frac{g(\pi)}{\ln(1+K(\pi))} \ln(x + x_0)$$

est solution de (5) puisque

$$u_{Frev}(x + \Delta_\pi(x)) = \frac{g(\pi)}{\ln(1+K(\pi))} \ln\{x+K(\pi)(x+x_0) + x_0\}.$$

On constate que le logarithme continue à y figurer en bonne place, et que l'on retrouve la solution de Fechner C lnx lorsque la constante seuil x_0 est nulle, mais cette fois-ci en suivant un mode de résolution qui respecte le caractère fini des Jnd, ou mieux des fonctions de Weber.

ANNEXE 2: D'autres relations additives en acoustique de l'environnement.

Lorsque les véhicules routiers ont la même puissance W et sont régulièrement espacés de la distance a avec les abscisses $x_k = x + k a$ on connaît la formule sommatoire élégante au titre de jolie illustration de l'additivité des énergies (Johnson Saunders 1968)

$$\frac{W}{W_0 4\pi} \sum_{k=-\infty}^{\infty} \frac{1}{d^2 + (x+ka)^2} = \frac{W}{W_0 4\pi} \frac{\pi\, sh(2\pi d/a)}{ad\,(ch(2\pi d/a) - \cos(2\pi x/a))}$$

cos est le cosinus ordinaire, sh le sinus hyperbolique et ch le cosinus hyperbolique.

L'additivité des puissances se rencontre de facto dans la définition de l'indice de bruit équivalent

$$Leq_{[t1,t2]} = 10 \log \left\{ \frac{1}{t_2 - t_1} \int_{t_1}^{t_2} \frac{(p_t)^2}{p_0} dt \right\}$$

dans laquelle l'intégration rend compte de l'additivité au cours du temps, et non pas dans l'espace comme dans les exemples ci-dessus avec des sources distinctes sur la même durée, (p_t la pression acoustique, de carré intégrable).

Pour illustrer la nature des calculs auxquels les niveaux et l'additivité des puissances conduisent on sait bien que l'on schématise la règle

$L_{ptot} = 10 \log (10^{Lp1/10} + 10^{Lp2/10})$

composant deux sources de bruit indépendantes qui créent en un même point les bruits de niveaux respectifs L et L - Δ décibels, (Δ positif sans réduire la généralité) pour le niveau global

$$L_{ptot} = 10 \log (10^{L/10} + 10^{(L-\Delta)/10}) = L + 10 \log (1 + 10^{-\Delta/10})$$

Le second terme est le fruit de l'addition des puissances en présence de niveaux et des propriétés du logarithme, il décroît en fonction de la différence de niveaux Δet devient pratiquement négligeable au-delà de 6 à 7 décibels; ce développement est classique et on le voit souvent accompagné de graphes, d'abaques ou de tables numériques.

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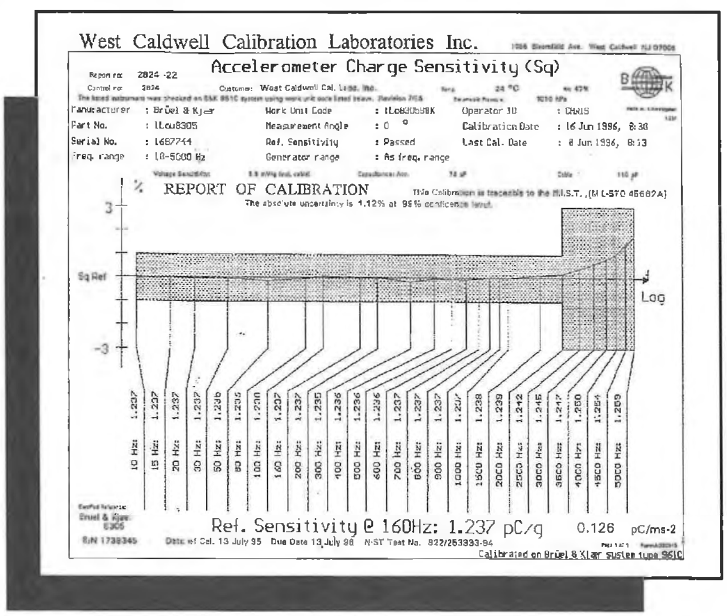

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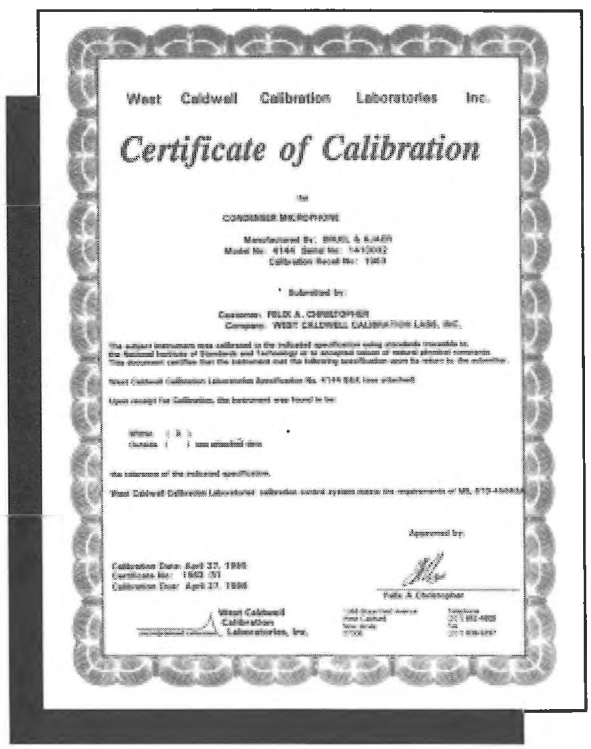

THE CURRENT STATE OF QUANTIFYING RECEPTOR ANNOYANCE RELATED TO LOW FREQUENCY NOISE IN THE ENVIRONMENT

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ABSTRACT

Environmental noise from energy industry facilities in Alberta is regulated by the Alberta Energy and Utilities Board (EUB), as described in the *Noise Control Directive, ID 99-8*. *ID 99-8* is the fourth edition of a comprehensive policy and guide, which has adopted A-weighted energy equivalent sound levels ($L_A$eq) as the measurement system with sound pressure level criterion for a receptor location. With the receptor being some distance from the energy industry noise source, the high and mid-frequency components can dissipate or be absorbed by air and ground conditions, leaving mostly low frequency noise. Consequently, A-weighted measurements do not reflect the full annoyance potential of the remaining industrial noise. This paper examines the current state of research, begun by the EUB in 1995, to quantify potential receptor annoyance and meet the current noise control directive's technical approach.

SOMMAIRE

Le bruit environant, provenant des usines de l'industrie ènergètique de l'Alberta, est règulèpar le EUB comme indiquè dans la Directive du Contrôle de bruit *ID 99-8*. *ID 99-8* est la 4 éme èdition d'une police et d'un guide complet qui ont adoptè des niveaux de son d'ènergie èquivalente pondèrèe ($L_A$eq) comme systéme de mesure comprenant un critére de niveau de pression du son pour la location d'un rècepteur. Le récepteur étant B une certaine distance de la source du bruit de l'industrie ènergètique, les composants de haute et moyenne frèquence peuvent être dissipès ou absorbès par l'air et l'ètat du sol, ne laissant pour la plus part que des sons de basse frèquence. En consèquence, les mesures pondèrèes-A ne reprèsentent pas le dèrangement potentiel total du bruit industriel rèsiduel. Cet article examine le status actuel des recherches, commencèes par le EUB en 1995, pour mesurer le dèrangement potentiel des receveurs et respecter l'approche technique de la directive actuelle du contrôle de bruit.

1.0 Introduction

The current Alberta Energy and Utilities Board (EUB*) Noise Control Directive, ID 99-8*, uses A-weighted energy equivalent sound level ($L_A$eq) as the measurement system to determine the compliance of an energy industry facility. However, A-weighting does not provide accurate free field measurements of low frequency noise (LFN). Typical LFN for energy industry related noise is in the range of 21-500 Hz. Furthermore, research has been conducted in the field of psychoacoustics to determine specifically how humans respond to LFN. The relevant psychoacoustic research to date has focused primarily on physical and mental health issues related to LFN and differences in response to LFN between genders. The psychoacoustic effects are explored in greater depth later in this paper.

Although the EUB directive attempts to minimize the negative impacts of energy industry facility noise on people living near them, it has been recognized for a number of years that some method of quantifying the annoyance level of LFN was necessary. For this reason, the EUB has been conducting research, on a limited basis, since 1995 into understanding how different measurement systems work and how they might be used within the directive. The most promising methods that were the focus of research are Loudness, C-weighted minus A-weighted sound pressure levels, and a range of other methods such as B and D-weighting, which were somewhat effective in assessing LFN. The research information will be used to modify the measurement requirements within the Noise Control Directive to account for LFN.

2.0 Assessment

Before the research could be conducted and relevant information gathered, the scope of the legislation had to be ascertained. The Noise Control Directive applies to industrial energy facilities throughout Alberta. It contains precise environmental standards regarding industrial noise to which these facilities must adhere. It was designed to ensure minimal annoyance within communities and the environment. Therefore, the methods that were researched had to apply to the far field, where the sound was assumed to come from a point source some distance away. Noise is assumed to reach the listeners' ears only from the direction straight ahead, in the open air (or non-reflecting environment).

Research was conducted with the primary intenet of properly measuring or quantifying the impact of LFN. Air, ground, and obstacles absorb sound as it proceeds to travels. This is known as the attenuation of sound. The absorption of sound in air varies with humidity and temperature. However, although these factors change quite drastically throughout the seasons in Alberta, they will, in turn, counteract one another, resulting in having little effect on noise levels in the field. Furthermore, the noise in the survey fields (receptor location) will be dominated by low frequencies. Low frequency sounds have much longer wavelengths than do high frequency sounds, allowing higher frequency noise to be absorbed more readily. Typically for rural Alberta, where most energy facilities are located, the ground that the noise travels over consists of a mixture of acoustically hard (i.e., asphalt roads), soft (i.e., grasslands), and very soft (i.e., forest) surfaces. Therefore, whatever noise reaches the survey field from an energy facility consists mostly of LFN.

3.0 Methodology

3.1 A-weighting

All sound weighting methods were developed in an attempt to alter the measured signal in a similar fashion as the human hearing mechanism. The method of A-weighting was specifically developed for human response to low sound levels. All of the different weighting techniques compress sound from a broad range of frequencies into a sound pressure level (SPL) at middle frequency (1000 Hz). However, when a measured sound spectrum has tonal components of 250 Hz or less, A-weighted Leq ($L_A$eq) measurements delete low frequency sound energy disproportionately to its impact on humans. Also, A-weighting methods are level dependent. This means that this accuracy depends on the SPL.

Another significant flaw prevalent in A-weighted SPLs is that they do not account for the effects of mutual masking among the components in a complex sound.

It is clear that when the sound is dominated by LFN, an alternate measurement method to A-weighting is required. Unfortunately, there are only a limited number which have the potential capability to deal with this problem. The growing prevalence of public concern about environmental noise demands timely action. There is no doubt that the next EUB review of the noise directive will need to seriously consider implementing the outcome of this important research.

3.2 C-weighting

The method of C-weighing was specifically developed for human response to high sound levels. It is comparable to A-weighting except for between the 0 to 250 Hz range. C-weighting does not delete low frequency sound energy to the same extent that A-weighting does. On its own, C-weighting is suitable for assessing LFN. It can also be used along with A-weighted SPLs to determine the existence of LFN. The method of dB(C) minus dB(A) has been adopted throughout many countries in Europe in order to quantify LFN more efficiently. However, Europe uses this method more so in building regulations than in the free field. The general rule in some European countries is that a dB(C) minus dB(A) measurement greater than 15 dB requires that LFN be assessed. However, this significant difference hardly identifies a LFN problem. This is due to the high slope of the hearing threshold towards lower frequencies, implying that the low frequencies may be below threshold.

If C-weighting were to be implemented within *ID 99-8*, it could be done in two ways. The first way would be to include a dB(C) minus dB(A) standard that if exceeded would require the original $L_A$eq value to undergo a Class C adjustment factor to account for LFN. For example, if the dB(C) minus dB(A) value was between 13 and 15, the $L_A$eq value could be adjusted by +2 dB. This is purely an arbitrary example and more research would have to be conducted to implement an appropriate Class C adjustment factor. Although this might assess LFN more accurately than a standard dB(A) reading, it also has some negative aspects. The most apparent being that the implementation of such a Class C adjustment factor would render some field measurement equipment obsolete. Three options to assess this problem are obvious. First, if the field surveyor is currently using a sound level meter capable of measuring dB(A) or dB(C) readings but unable to store both at the same time (i.e., B&K 2231, B&K 2236), two sound level meters would have to be used in order to measure dB(A) readings and dB(C) readings simultaneously. The second option is to purchase a sound level meter capable of storing dB(A) and dB(C) measurements simultaneously (i.e., B&K 2260). A third option is to record the survey via a high fidelity VHS tape and replay the survey sounds to a sound level meter capable of measuring dB(A) or dB(C), but not both at the same time. When the survey is replayed, the weighting that was not used in the field would be recorded so that a dB(C) minus dB(A) value could be calculated. Whatever the case, implementing a Class C adjustment factor to incorporate a dB(C) minus dB(A) calculation would likely double equipment costs or the time required to analyze the survey data.

The second way that C-weighting could be implemented into *ID 99-8* is to replace the current standard of A-weighted

SPLs. This change would redefine the Noise Control Directive, but would also account for LFN to some extent in doing so. A new SPL would have to be sought and appropriate changes to the adjustment factors would have to be calculated. The predominant negative issue that would arise if C-weighting was implemented into the Noise Control Directive would be that all past dB(A) measurements would become invalid.

3.3 Loudness

The proper method to determine loudness is described under ISO 532 Method B (Zwicker's Method). Method A (Stephen's Method) also provides a measure of loudness but is less commonly used than Method B. Method B can be determined in terms of loudness (sones – GD or GF) or loudness level (phons – GD or GF). Loudness is based upon an internationally standardized set of equal loudness contour lines. Selected phon contour lines can be inverted to obtain A, B, and C weighting curves. Loudness seems to provide an efficient means for approximating LFN. However, research now suggests that loudness may not be a good indicator of LFN annoyance. This results from the fact that loudness levels can be relatively high, while perceived annoyance can be very low.

A Class C adjustment to A-weighted energy equivalent sound levels was proposed as a way to assess LFN within the scope of *ID 99-8*. This is probably the most feasible way of including loudness into the Noise Control Directive, and it would account for LFN in survey data to some extent. However, by including such an adjustment factor, some negative issues arise. The methods for calculating loudness are very complex, time consuming, and tedious. This could mean that a significant amount of extra time would be added to the normal time that it takes to analyze survey data under the regulations of *ID 99-8*. Programs such as B&K BZ7113 are readily available to calculate loudness given one-third octave band readings and would help in calculating a Class C adjustment factor. An option to calculating loudness would be to purchase sound level meters that measure loudness, but this would be costly and less realistic.

3.4 Other Methods

In addition to A and C-weighted SPLs have been the only two weighting scales mentioned, other weighting scales exist. B-weighting was developed specifically for human response to moderate sound levels. This is not a common weighting network but could possibly be the best weighting scale to account for LFN within the free field. It does not delete low frequency energy levels to the extent that A-weighting does, but its relative response to low frequencies is still less than that of C-weighting. B-weighting has undergone very little research and virtually no equipment exists which could measure $L_B$eq values. Therefore, B-weighting would be an impractical way to account for LFN.

Other weighting networks exist but would not apply for the assessment of LFN within the free field. D-weighting was specifically developed for noise around airports. While D-weighting does not delete much low frequency energy, it does boosts the high frequency range between 1000 and 12,000 Hz. This weighting network has been researched, but has not been adopted by any international standards group. G-weighting is specifically designed for infrasonic noise (0 - 20 Hz). Other weighting networks have also been designed for very specific purposes.

Stephens' Mark VI method, as described by ISO 532 Method A, is another method for calculating loudness. This method utilizes physical measurements obtained from spectrum analysis in terms of octave bands and is specifically recommended for simplicity. However, Stephens' method can only accommodate measurements within a diffuse sound field and is, therefore, inadequate for use within the Noise Control Directive.

Some countries in Europe have designed maximum LFN levels for each octave band and incorporated them into their regulations. For example, Sweden's Health Authorities developed indoor LFN building regulations with the following sound pressure limitations for low frequency sound pressure levels measured at a receptor location:

Frequency [Hz]	**$L_A$eq [dB(A)]**
31.5	56
40	49
50	43
63	41.5
80	40
100	38
125	36
160	34
200	32

A system such as this could be incorporated into the EUB Noise Control Directive. However, research and experimentation must be conducted in order to determine proper values that would represent annoyance levels for communities affected by industrial energy facilities. One disadvantage to such a system is that such regulations may be difficult to comply with. The more regulating sound level values that are incorporated into the Noise Control Directive, the more insignificant each number becomes. If a method such as this were to be incorporated into the Noise Control Directive, the EUB would have to conduct an annoyance level survey in order to create regulations applicable to Alberta residents. A statistically significant number of rural Albertans would need to be surveyed and tested to establish some level of confidence in the outcome, not an easy or inexpensive task.

Establishing regulations similar to those in Sweden is a proven way to account for LFN in a sound survey. This method would not require the additional measurement equipment or computer program changes. Also, A-weighting would still be retained within the scope of the Noise Control Directive and, therefore, few changes would have to be made to the directive. Furthermore, the extent to which C-weighting and loudness accounts for LFN is a disputed issue, even though regulations such as Sweden's have been successful in addressing LFN problems within their country.

4.0 Psychoacoustics

4.1 Human Response to LFN

As mentioned previously, the purpose of researching psychoacoustics is to establish the need to address LFN specifically within the Noise Control Directive. This research has focused primarily on physical and mental health issues related to LFN and the differential response to LFN between genders.

As industry grows larger, the effects of noise grow more and more out of control. At the same time, peoples' expectancies for their quality of life increase. When these two facts coincide, the issues related to LFN problems grow exponentially.

The fundamental characteristic of LFN is that of "intrusiveness." After much research, it has been suggested that LFN contributes to annoyance responses by:

1. creating a sensation of pressure in the ear,
2. periodically masking effects on medium and high frequency sound with a strong modulation effect that can disturb normal conversation, and
3. by creating secondary vibrating effects typically experienced within homes.

Analysis of documented noise complaints would seem to be consistent with the above suggestions. With continuous exposure to LFN, behavioral dysfunction such as

a) task performance deterioration,
b) reduced wakefulness,
c) sleep disturbance, headaches, and irritation, can occur.

LFN does not need to be considered "loud" in order for it to cause such forms of annoyance and irritation. One significant characteristic of LFN is that it is found to be more difficult to ignore than higher frequency noise. Individuals suffering from LFN annoyance have been known to describe it as

i) omnipresent,
ii) impossible to ignore,
iii) worse indoors (due to the effects of vibration),
iv) unable to locate, and
v) difficult to tune out.

Unlike high frequency noise, LFN is difficult to suppress. Closing doors and windows in attempt to diminish the effects of LFN make the noise worse, due to the propagation characteristics of LFN and the low-pass filtering effect of structures. Individuals often become irrational and anxious as attempts to control LFN fail, serving only to increase the individual's awareness of the noise.

There is quite a significant difference between genders in their response to loudness. Experiments conducted by N. Broner and H. G. Leventhall concluded that males tend to react to loudness with a significantly higher response than females do. The annoyance response remains similar between genders, although males seem to be less sensitive to low noise levels and more sensitive to high noise levels than females.

5.0 Conclusions

The current Noise Control Directive fails to properly account for the presence of LFN in survey data. This is primarily due to the use of A-weighted energy equivalent sound levels, which do not accurately account for LFN. The psychoacoustic research that was conducted has shown that LFN can have serious negative effects on an individual's quality of life. For this reason, the EUB is committed to implement appropriate regulations that will suitably account for LFN.

To date, the most practical methods for further investigation and eventual incorporation into the Noise Control Directive remain Loudness (as described by ISO 532 Method B), C-weighting (including dB(C) minus dB(A)), and appropriate maximum SPLs for one-third octave bands below 200 Hz.

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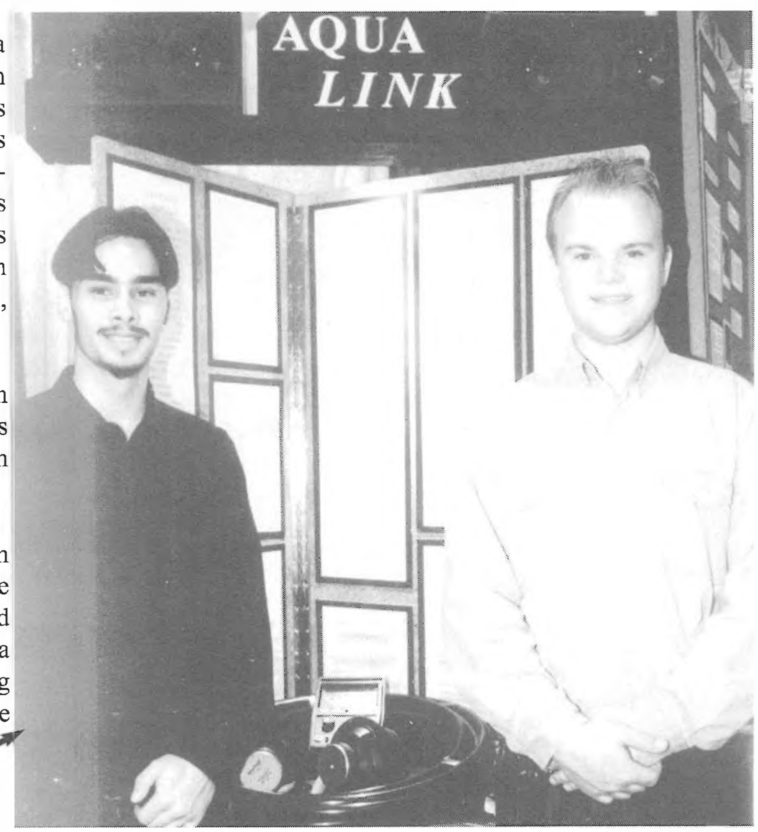
Canada Wide Science Fair
Canadian Acoustical Association - Special Award

Over 428 students participated in this year's Canada Wide Science Fair in Edmonton winning $130,000 in cash, cholarships, trips and other prizes. The students are selected from regional fairs that take place across the country. The fair was attended by judges, delegates, officials, guests, visitors, as well as thousands of visitors. The nine day event consisted of two days of judging, an opening and closing banquet, an awards ceremony, tours, public viewing of projects, cultural activities, seminars, and workshops.

The Canadian Acoustical Association provides an award for the best project in acoustics. The award is $400 plus a one-year subscription to Canadian Acoustics. The students also receive a certificate.

This year the prize was awarded to Allan Kaufman and Kodie Tober. Allan is from Clyde AB and Kodie is from Fawcett AB. Both attend St. Mary School and are in Grade 12. Their project was entitled "Aqua Link". It examined the viability of conducting acoustic signals by means of aquatic wave impulse conversion.



Alan Kaufman (L) and Kodie Tober (R)

CANADIAN STANDARDS ASSOCIATION ACTIVITY IN ACOUSTICS

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ABSTRACT

This article gives an overview of Canadian Standards activities in Canada, especially those of the Canadian Standards Association. They currently have 15 Acoustics Standards and two more with significant acoustics content. Two committees and a variety of subcommittees involving many Canadian acousticians and industry representatives write and review these standards for the Acoustics commmunity. An overview is given of the main activities and future directions of these groups

RÉSUMÉ

Cet article présente une vue d'ensemble des activités de normalisation au Canada, tout particulièrement celles de l'Association canadienne de normalisation. L'association a présentement 15 normes acoustiques et deux autres comportant des normes acoustiques détaillées. Deux comités et divers sous-comités comprenant plusieurs acousticiens canadiens et représentants de l'industrie rédigent et passent en revue ces normes pour la communauté acoustique. Une vue d'ensemble de leurs activités premières ainsi que la direction future de ces groupes y est présenté.

1.0 Introduction

This article is intended to give an overview of acoustics standards activity in Canada, concentrating on the CSA acoustical standards activities. The Standards Council of Canada oversees all Canadian standards bodies, including CGSB, CSA and the Technical Advisory Groups formulating Canada's input to ISO and IEC international standards. The Canadian Standards Association is the largest standards writing body in Canada and one of the largest in the world. There have been CSA standards in Acoustics for over 25 years and the Z107 Committee on Acoustics and Noise Control is still active in many areas.

The term Standard as used here refers to concensus standards developed by standards writing bodies such as CSA and ISO. They are written by Technical Committees, Subcommittees and Working Groups formed of volunteers representing various stakeholders and operating by concensus, that is, every reasonable effort is made to address and resolve disagreements between members. CSA and other standards writing bodies provide a framework and set of rules for developing standards, approving them and keeping them current. They also publish standards and provide testing services where required by standards. The classic example in Canada is the Electrical Code, published by CSA.

Standards are not regulations. They are developed by groups which are intended to represent diverse interests, not by regulators. In some cases, such as the Electrical Code, provincial or federal regulations may refer to standards, effectively giving them the force of law. In other cases, such as the playground safety standard, it is up to the users to decide whether they want their playground to meet the requirements of the standard.

Several Acoustics standards are referred to by regulations, notably Z107.56, Procedures for Measurement of Occupational Noise Exposure, is referred to in the Federal and BC regulations and the new draft Alberta regulation. In most other provinces its use is voluntary but measurements taken using it are accepted as valid by most regulators.

2.0 Committee Activities

There are two CSA Technical Committees in Acoustics. Z94 is responsible for the Hearing Protection Standard Z94.2 which defines Type A, B, and C type hearing protectors and is widely referred to in occupational noise regulations. They are currently undertaking a major review of this standard in light of changes to the US hearing protector standards and procedures.

Z107, the Acoustics and Noise Control Technical Committee, is responsible for all other Acoustics standards. Several members belong to both committees and provide liaison between them. Z107 is divided into 9 subcommittees. These include: Hearing Measurement, Vibration, Powered Machines Industrial Noise, Transportation Noise, Editorial (whch reviews all proposed standards), Building Acousics, Instrumentation Calibration and liaison with the Canadian Steering Committee for ISO TC43 and TC43(1). Each subcommittee is responsible for the standard or standards within its area. Z107 was one of the first CSA committees to be structured in this way. Now many other committees have the same structure.

Recently, as global harmonisation becomes more important, CSA has started to adopt and endorse international standards where possible rather than writing their own. This is not only more effective, it is also less expensive. Preparing a new standard from scratch can cost a considerable amount, even with the writing being done by volunteers. Adopting a standard, which means republishing it, with changes or additons if necessary, costs less than half. Endorsing, which means that the standard has been reviewed and found suitable for Canadian use is the least expensive option, but less useful because the standard is not so readily available. Given the international nature of many Canadian industries the use of reviewed international or US standards within the Canadian context makes eminent sense.

Table 1 shows all the Canadian Standards currently in force and also lists two standards whose Acoustics sections were written with the assistance of the Z107 committee. This table can also be found at the CAA website and will be kept up to date there.

3.0 Current Activities

Some current highlights include:

3.1 Transportation

The newest standard to be published is likely to be Z107.9, Highway Noise Barriers. It is expected out in December 1999. This standard is an adaptation of the Ontario MTO Highway Noise Barrier specification. It is intended to provide municipalities, developers, road and highway departments, railways and industry with a standard specification which can be used to define the construction of barriers intended for long term use in Canadian conditions. Specific manufacturers' barrier designs are certified as complying with the standard in such areas as: materials used, weathering and corrosion resistance testing, STC, NRC, etc.

In addition, each barrier installation is reviewed and certified for compliance with such items as footings design, material sample testing, welding, caulking, backfilling, etc. As can be seen, this is much more than simply an acoustics standard, but it fills an important need in the industry and drafts have been used by several municipalities in recent years. In addition, the US Highway Design Manual will be harmonised with the CSA standard, as will the Ontario OPS. ANSI is also looking at adopting the standard or harmonising with it. This ultimately could mean that a certified barrier would be qualified to be used anywhere in North America.

3.2 Industry

The Industrial Noise Subcommittee is the most varied and active subcommittee.

Ongoing activities include:

a) Technical review of the proposed Alberta occupational noise regulation (the committee routinely undertakes technical reviews of proposed new Acoustics regulations in Canada),
b) A working group looking at ISO and ANSI noise rating systems (for tonality and impulse corrections among others) and their use in Canadian environmental noise guidelines,
c) A writing group preparing Guidelines For The Declaration Of Machinery Noise Emission Levels, discussed below.
d) An ad-hoc writing group preparing an acoustics chapter for a new version of the CSA Office Ergonomics standard
e) A group looking at rewriting or updating the current Blasting Noise and Vibration standard
f) A group looking at adopting or endorsing ISO 9613 (2) on propagation of industrial noise and either integrating it with or replacingthe current CSA standard.

3.2.1 Guidelines For The Declaration Of Machinery Noise Emission Levels

One of the initiatives underway under the auspices of the Industrial Noise subcommittee is a writing group preparing Guidelines For The Declaration Of Machinery Noise Emission Levels which would be a voluntary guide for noise labelling of machinery for use in Canada and compatible with the European regulations to allow machinery to be sold into that market. Labels in this context refer to any statement of sound levels produced by the equipment and included with it. Measurements are made according to ISO standards and include estimates of the likely variability of the measurements. This initiative may ultimately make it much easier for Canadian industry to buy quiet machinery with confidence and for Canadian manufacturers to sell into the European market.

3.2.2 Office Acoustics

Another of the initiatives listed above is a working group formed by the Industrial Noise Subcommittee to assist the Office Ergonomics committee with a major revision to their standard. The same group assisted them at the last minute with an Acoustics chapter to the existing standard when it was published 10 years ago. This section is now being rewritten, expanded and brought up to date. It is also being aimed specifically at non-acoustical users to give them an idea of the issues involved and the resoureces available to them to provide good acoustical conditions in offices.

3.3 Building Acoustics

The Building Acoustics subcommittee is currently trying to influence the rewriting of ASTM 336 so that it can be endorsed or adopted and be compatible with our National Building Code. The alternative would be to adopt and modify it or to write a Canadian Standard.

3.4 Instrumentation and Calibration

The Instrumentation and Calibration subcommittee now have no standards of their own, instead they have endorsed or adopted IEC instrumentation standards and ANSI standards which can then be referred to in Canadian regulations and other standards. Every five years or more frequently the standards are reviewed automatically to ensure that the latest standards are being endorsed and that they are still suitable for use in Canada. In addition, the chairman, George Wong, is actively involved with the ISO and IEC working groups.

3.5 Editorial

The Eduitorial subcommittee also has no standard of their own. They have endorsed the ANSI Standard for Acoustics Terminology and have had input into it. This standard is updated regularly by ANSI and is reviewed by this subcommittee each time it is revised. The Editorial subcommittee also reviews every standard written by a Z107.9 subcommittte, both as a final technical review and to ensure it meets the CSA editorial requirements.

3.6 Main Z107.9 Committee

The committee meets twice a year, once during the Canadian Acoustics Week and once in the spring. They review progress by each subcomittee and vote on any new work proposals. These are then forwarded to CSA for approval. When working groups have drafted new docuements or made recommmendations to endorse or adopt international standards, these are reviewed by the appropriate subcommittee. They may also be circulated to a wider stakeholder group for review. Once the subcommittee is satisfied with the result, it is passed to the main committee for formal balloting. This balloting is generally done formally by mail. If there are any negative ballots, the subcommitttee chairman will work with the voter to resolve the issue, which is usually possible.

The main committee is the last technical hurdle for a standard. The CSA will then have their editors put it into final form. The steering committee, to which the main committee reports, approves work and reviews completed standards, however they cannot make technical changes.

One other initiative that the main committee has been trying to propose for some years is a Guideline to provide a standard which summarises the major Canadian and International Standards for Canadian industry users. This is intended to make Acoustical Standard more accessible to Canadian useres.

The main committee and subcommittees meet twice a year. New members are encouraged and anyone interested may contact Cameron Sherry, the Chairman, or the author, the vice chair. This article is the first in a series which will provide more information on the activities underway in all areas of Acoustics Standards in Canada.

TABLE 1- CSA ACOUSTICS STANDARDS

Z107.0-1984
Definitions of Common Acoustical Terms Used in CSA Standards

CAN3-Z107.4-M86
Pure Tone Air Conduction Audiometers for Hearing Conservation and for Screening

Audiomètres tonals à conduction aérienne pour la préservation de l'ouïe et pour le dépistage

CAN/CSA-Z107.6-M90
Pure Tone Air Conduction Threshold Audiometry for Hearing Conservation

Z107.21-M1977 (R1993)
Procedure for Measurement of the Maximum Exterior Sound Level of Pleasure Motorboats

Z107.25-M1983
Procedure for Measurement of the Exhaust Sound Level of Stationary Motorcycles (rp: 11/83)

CAN/CSA-Z107.31-M86 (R1994)
Test Procedures for the Measurement of Sound Levels from Agricultural Machines

Méthodes d'essai pour le mesurage des niveaux de bruit émis par les machines agricoles

CAN/CSA-Z107.32-M86 (R1994)
Test Procedure for the Measurement of Sound Emitted from Construction, Forestry, and Mining Machines to the Operator Station and Exterior of the Machine (rp: 02/87)

Méthodes d'essai pour le mesurage du bruit émis par les engins de construction, forestiers et miniers, au poste de l'opérateur et à l'extérieur de la machine

Z107.51-M1980 (R1994)
Procedure for In-Situ Measurement of Noise from Industrial Equipment

Z107.52-M1983 (R1994)
Recommended Practice for the Prediction of Sound Pressure Levels in Large Rooms Containing Sound Sources

Z107.53-M1982 (R1994)
Procedure for Performing a Survey of Sound Due to Industrial,Institutional, or Commercial Activities

CAN3-Z107.54-M85 (R1993)
Procedure for Measurement of Sound and Vibration Due to Blasting Operations
Méthode de mesure du niveau sonore et des vibrations émanant des opérations de dynamitage

CAN/CSA-Z107.55-M86
Recommended Practice for the Prediction of Sound Levels Received at a Distance from an Industrial Plant
Pratique recommandée pour la prévision des niveaux sonores reçus à une distance donnée d'une usine

Z107.56-94
Procedures for the Measurement of Occupational Noise Exposure
Méthode de mesure de l'exposition au bruit en milieux de travail

Z94.2-94 CAN/CSA-Z94.3-92
Hearing Protectors
Protecteurs auditifs

Standards with Acoustics Component:

Z62.1-95
Chain Saws

CAN/CSA-Z412-M89
Office Ergonomics L'ergonomie au bureau

Reprinted from Canadian Acoustics, Vol. 27 No. 3 (1999) pp 60-61

VIBRATION TRANSMISSION AT FLOOR/JOIST CONNECTIONS IN WOOD FRAME BUILDINGS

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INTRODUCTION

Floors in wood frame buildings usually consist of a number of Oriented Strand Board (OSB) sheets supported by a series of parallel wood joists. The OSB subfloor is connected to the joists by a number of equally spaced screws. When predicting flanking transmission in wood frame buildings using statistical energy analysis (SEA), two issues need to be addressed. Firstly, one needs to determine whether the joist should be treated as a beam or as a plate strip. Secondly, the frequency dependent behaviour of the joist/floor connection should be characterized. Both topics will be discussed in the following paragraphs, which deal with structure-borne sound transmission in the direction normal to the joists.

MODELLING THE JOISTS

In SEA, beams at plate/beam junctions are often considered as undamped coupling elements and not as subsystems [1-2]. The influence of a beam is taken into account when calculating the coupling loss factor, since the presence of the beam changes the impedance of the junction and therefore also the energy flow between the coupled plates. As cross-section deformation is typically not included, this approach is particularly suited for beams having a rectangular cross-section and an aspect ratio close to 1.

However, since the aspect ratio of a joist cross-section is usually larger than 6, some deformation is likely to occur at relatively low frequencies. As a result, the impedance at the junction is considerably overestimated when the cross-section is modelled as infinitely rigid. In fact, it is more appropriate to model the joist as an undamped plate strip [3]. Also in this case, the joist is not included as a subsystem in the SEA model. Figure 1 illustrates that a plate strip model allows the joist to bend in the plane of its cross-section, whereas, in the traditional plate/beam model, the cross-section behaves as a rigid body.

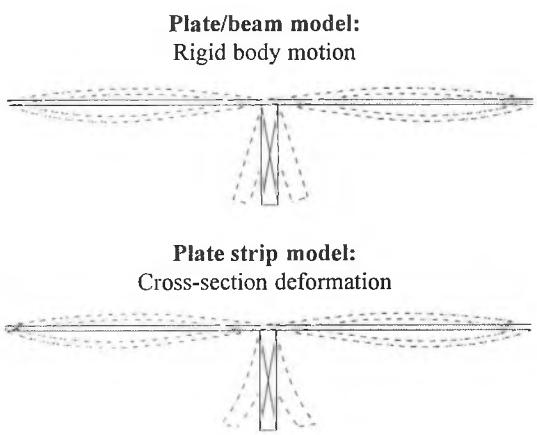

Figure 1: Plate/beam model versus plate strip model. (View: cross-section normal to the joist.)

Modelling the joist as an undamped plate strip is justified as long as the energy dissipation in the joist is negligible compared to the damping of the OSB plates. This implies that the plate strip model should be applied in a frequency range where the joists support only few modes. At high frequencies, the dissipation cannot be ignored and the joists should be modelled as plate subsystems in order to obtain the correct energy distribution in the floor. In this case, coupling loss factors are calculated by modelling the floor/joist junction as a T-joint.

The three models were applied to a subfloor/joist junction and compared to experimental data obtained in laboratory. One OSB sheet (2.4 x 1.2 x 0.0148 m) was connected to a wood joist (1.2 x 0.235 x 0.038 m) by a combination of glue and 17 equally spaced screws. The joist divided the OSB sheets into two identical plates measuring 1.2 x 1.2 m. The calculations were carried out using thin plate theory for homogeneous and isotropic plates and by assuming a line connection between the plate and the stiffener. In view of the anisotropic nature of OSB and the wood joist, the presented comparison is not entirely justified, but tendencies can still be compared.

Figure 2 shows the theoretically and experimentally obtained velocity level difference between both plates as a function of frequency. At low frequencies, the predictions of the plate/beam model and plate strip approach are essentially the same. However, the results of both models deviate at mid and high frequencies, where the plate/beam model clearly overestimates the velocity level difference. The plate strip prediction shows a pronounced maximum near 1250 Hz. A similar feature can be observed for the measured data at 1600 Hz. The T-joint model works well at high frequencies, but underestimates the transmission considerably at low and mid frequencies. In general, there is a reasonable agreement between the trends of the plate strip calculations and the measurements.

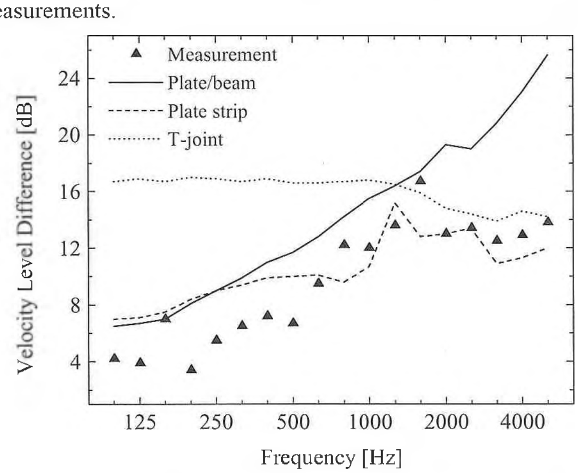

Figure 2: Predicted and measured velocity level difference for a subfloor-joist connection.

MODELLING THE JOIST/FLOOR CONNECTION

Characterizing structural connections using nails or screws represents a major difficulty of modelling flanking transmission in wood frame buildings. In the context of lightweight walls, it has been suggested to treat the joint between a gypsum board sheet and a wood stud as a line connection at low frequencies and a point connection at high frequencies [4]. The transition between both regimes was found to be the frequency at which the spacing between the nails matched half the bending wavelength in the gypsum board. This simplified approach assumes an infinitely small contact area between the plate and the beam element. In addition, it treats the plate as one entire subsystem and therefore neglects the vibration attenuation across the stud. Consequently, the simplified theory is not suited for the purposes of this paper.

The influence of the screw spacing on structure-borne sound transmission at a floor/joist connection is investigated experimentally by two series of measurements on the same floor section as considered in the previous section. In the first series, the OSB sheet was attached to the joist by 5, 9 and 17 equally spaced screws, corresponding to a screw spacing of 0.3, 0.15 and 0.075 m. In the second series of tests, the same number of screws was considered, but a thin aluminum plate (0.038 x 0.038m) was positioned between the joist and the OSB sheet at each of the fasteners. The aluminum spacers were applied to create a well defined contact area at the joint. The results of the two series are shown in Figures 3 and 4. All results were compared to a line junction, which corresponds to a combination of glue and 17 screws.

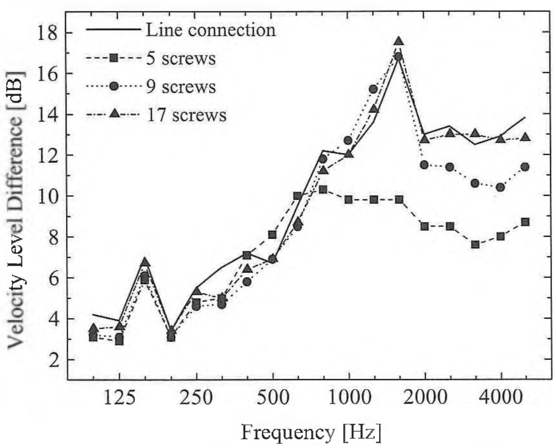

Figure 3: Measured velocity level difference between the OSB plates for the connection using screws only.

Figure 3 shows that the 17 screw connection behaves as a line junction over the entire frequency range. The case with 9 fasteners approximates a line connection up to 2 kHz, whereas the case with 5 screws does the same up to 800 Hz. Above these cut-off frequencies, the velocity level difference drops, indicating a weakened coupling between the joist and the plate. By comparing Figures 3 and 4, it can be observed that the connections with spacers are characterized by a considerably lower cut-off frequency. This leads to the conclusion that the transition from line to 'local' connection is not determined exclusively by the spacing between the fasteners. Moreover, the results indicate that the effective contact area between the joist and the plate is considerably greater that the thickness of the fastener.

As a first step toward modelling the effective contact area, the measured data for the junctions with spacers are compared to calculated results based on the theory presented in [5]. The agreement between measured and predicted data in Figure 5 for the cases with 17 and 5 fasteners is reasonable, but large discrepancies can be observed for the remaining case. However, further research is required to determine the influence of the anisotropy of the materials.

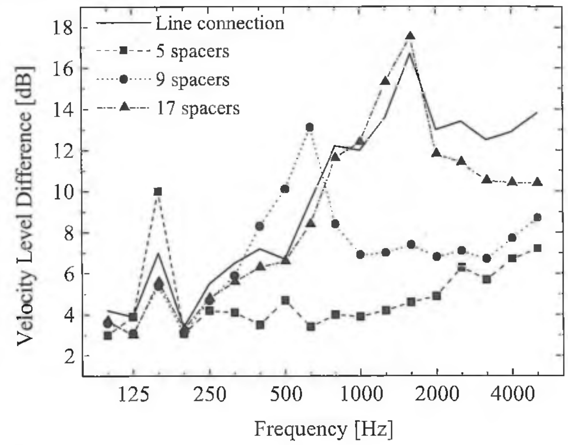

Figure 4: Measured velocity level difference between the OSB plates for the connection using screws and spacers.

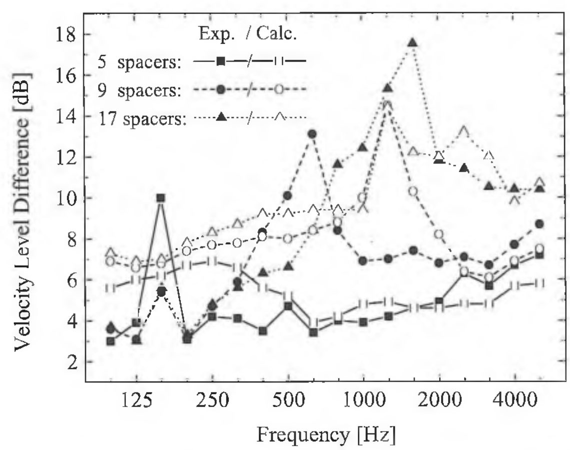

Figure 5: Measured and predicted velocity level difference for the three cases with spacers.

CONCLUSIONS

Structure-borne sound transmission at a floor/joist connection was studied theoretically and experimentally. It was shown that the joist should be treated as a plate strip rather than as a beam. It was further demonstrated that the transition from line to local connection is not only determined by the fastener spacing but also by an effective contact area between the plate and the joist. However, a more complete analysis is required to include anisotropic characteristics of the subfloor and joist material.

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Reprinted from Canadian Acoustics, Vol. 27 No. 3 (1999) pp 62-63

SkyDome Acoustical Model

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INTRODUCTION

In 1996, Engineering Harmonics was retained to investigate, test and re-tune the current sound system for Toronto's SkyDome. On the basis of this work and insight into the sound system, in 1997 SkyDome retained Engineering Harmonics again to prepare cost estimates and a plan to upgrade the systems. After receiving approval, Engineering Harmonics began a project to upgrade, replace and improve the system. This project involved the replacement and addition of loudspeakers, replacement of amplifiers and implementation of a digital audio transportation and DSP system. This article discusses the EASE computer model that was used to model the new loudspeakers for the lower two tiers of seating.

The existing sound system has long suffered from a balanced coverage problem. Due to architectural concerns during the construction of the building, the loudspeakers for the 100 and 200 Levels were not optimally placed. The loudspeaker placement lead to the creation of "hot spots" underneath the balconies and very poor coverage by the field.

While a centre cluster could easily cover the entire stadium, the moveable roof does not allow a speaker cluster to be permanently hung. Thus, a distributed system was designed. A series of loudspeakers were to be placed on the front of the 500 Level. These would provide coverage to the 100 and 200 Levels below. Each loudspeaker cabinet would have several drivers to cover the areas. As balconies obscure part of the 100 and 200 Levels, additional loudspeakers were to be installed underneath these overhangs. These speakers provide coverage for areas not covered by the new main loudspeakers.

In order to assist in the placement and design of the custom loudspeaker cabinets, the EASE computer program was used.

MODEL DEVELOPMENT

The model was constructed from architectural plans of the building. Using the AutoCad program, a complete three-dimensional model was developed. Once completed in AutoCad, the model was then imported into the EASE program. Once in EASE, the painstaking process of defining acoustic surfaces began. Although the model only used a small number of different acoustic surfaces, for example smooth concrete, glass and Hussey Seating, the total number of surfaces totalled over 1500. Each one had to be set by hand.

After all of these surfaces were labelled, approximately eighty audience investigation areas were defined. However, once all of these acoustic surfaces and audience areas were defined it was determined that there was not sufficient memory left to add any of the loudspeakers.

Based on the symmetry of the building, it was thought that the building could be chopped in half along its North-South axis. As this would cut the surface and volume in half, it would have no effect on any reverberation calculations from the model. An acoustical mirror was added along the cut-axis; it had an absorption co-efficient of zero and hence did not add any surface area to the model.

A series of loudspeakers were then added to the model. Several areas were under investigation; they include the uncovered and covered parts of Level 100 and 200 and some loudspeakers at the North end of the building. These North end speakers were dropped from the project. Loudspeakers were added to the face of the 500 Level to cover the majority of Levels 100 and 200. As the areas near the concourse are covered, separate speakers were to be installed in those areas. Although two rings of speakers were designed for Level 100, for simplicity only one was modelled.

Each loudspeaker's exact position was computed using a spreadsheet program. Data for each loudspeaker type was supplied by the manufacturer from an existing product. Although these would not be the exact loudspeakers installed, the data would allow for an initial gauge of their placement and aiming.

Figure 1 shows the model as a wire frame; this gives a rough idea of its shape.

INITIAL USE

Once all of the acoustic properties were defined and all of the various types of loudspeakers were entered, the model was useable. As a test of the model, an existing loudspeaker pair was entered into the model. It showed that there was an extreme build-up of energy near the top of the sections, especially 121. Closer to the field, the coverage dropped off drastically, as shown in Figure 2, for Sections 121 and 219. In all of these figures, the field is at the top of the picture. The bottom corresponds to the area closest to the con-course. Level 100 is the first seating level above the field; in the figure it is

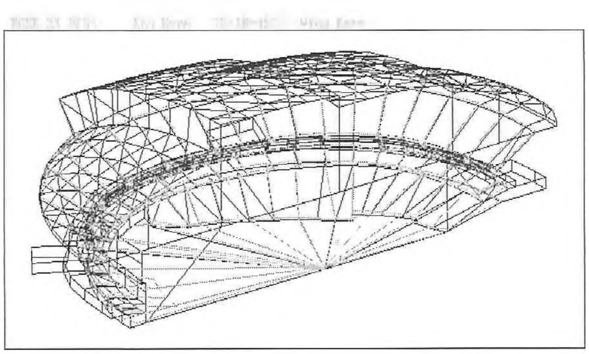

Figure 1: Wireframe Model

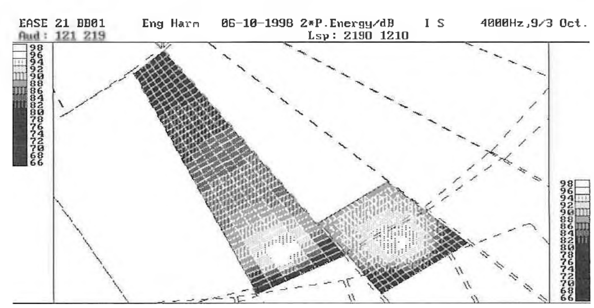

Figure 2: Coverage of Existing System

the larger of the two. The loudest areas correspond to the light colour, the quieter areas are darker. It is easy to see that the Level 100 coverage has a severe hotspot close to the loud-speaker. Patrons close to the field would not hear the program very well.

For the proposed system, initial runs indicated that the system would be able to cover both the 100 and 200 Levels with no more than a 5 dB variance. Figure 3 shows the predicted coverage with the new system for Sections 121 and 219. The drop-off of coverage in Section 121 near the concourse is expected. Two rings of underbalcony speakers will be installed in that area; only the inner ring appears in the model. Thus, the coverage drops, as this loudspeaker is not in the model. Note that the overall coverage is even throughout the whole section.

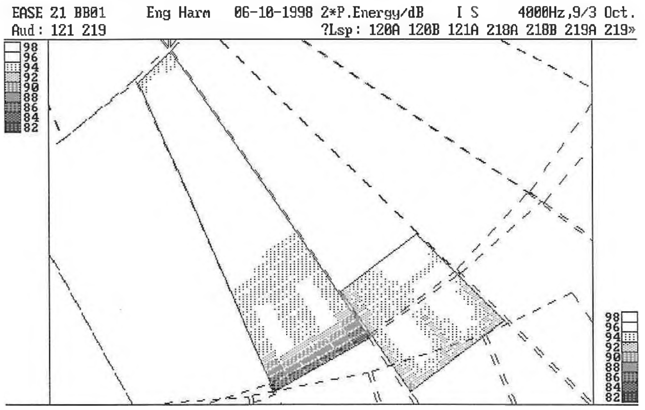

Figure 3: Predicted Coverage of New System

SOUND TESTS

To gauge the effectiveness of the model, the companion program to EASE, called EARS, was used. A ray-tracing reflectogram was created in the EASE model. This was then imported into the EARS program. It is then possible to convolve this room response with a "dry" signal. This process took approximately 36 hours of computation on our computer. The initial result was less than satisfactory.

As we were familiar with the room response of the SkyDome, we were able to listen to the model and realise that it was not as reverberant as the actual room. We determined that the model was simply not carrying the ray-tracing far enough. It was truncating the result, which caused it to underestimate the reverberation time. We adjusted the settings and forced EASE to follow through on the rays until they were really "gone". Once this was done, EARS was much better able to show the interaction of the loudspeaker system with the room.

REFINEMENTS

Having obtained results from the model and thoroughly examining them to determine their validity, we were assured that the model was predicting correctly. The manufacturer had now constructed the custom cabinet for the loudspeaker drivers. Up until this point, we were using "prototype data". The drivers for the cabinet were existing and well documented but in the model, they were in a standard cabinet - not the custom one for this project.

After they were constructed, the manufacturer measured them in their plant and we received new data for the main loudspeaker. Various tests were then conducted with this data. It led us to believe that the cabinets were not angled properly. The cabinets were about 5 degrees off; the coverage pattern did not reach to the end of the 100 Level well enough.

Various tests were run by changing the down angle of the loudspeaker enclosure. It was determined that they would need to be roughly 4 degrees steeper. While the coverage for the mid-range driver was fine at the built angle, the more directional horn was not achieving its target level of coverage. With this information, we realised that they would have to be mounted differently. A wedge was developed that would allow the loudspeaker to be moved out such that the entire level would be covered properly.

Figure 4 shows the coverage for the 100 and 200 Levels with the face aimed down 36 degrees. The coverage is much stronger near the field and drops off by the concourses. This is of concern because the loudspeaker would be too loud on the field. At 42 degrees, as in Figure 5, the coverage is more even. After careful examination of the coverage over all frequency bands, it was determined that the optimal angle was around 42 degrees.

CONCLUSIONS

The model was a massive undertaking. It frequently taxed the limits of the EASE program. It was not used as the end authority for loudspeaker placement. It was used as a design tool to quickly evaluate different placements and aiming angles. It was also used to evaluate the performance of loudspeakers from several different manufactures.

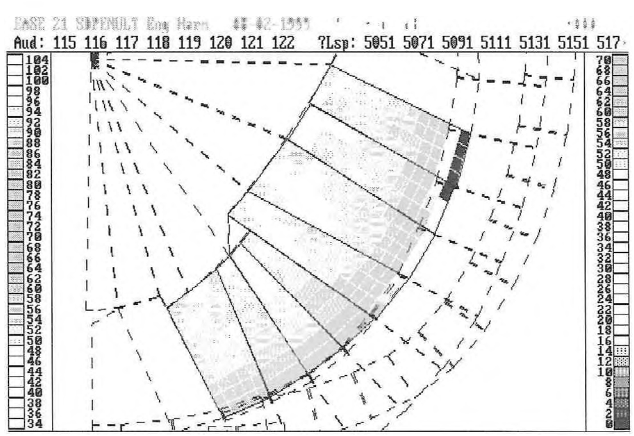

Figure 4: 4kHz at 36 degrees

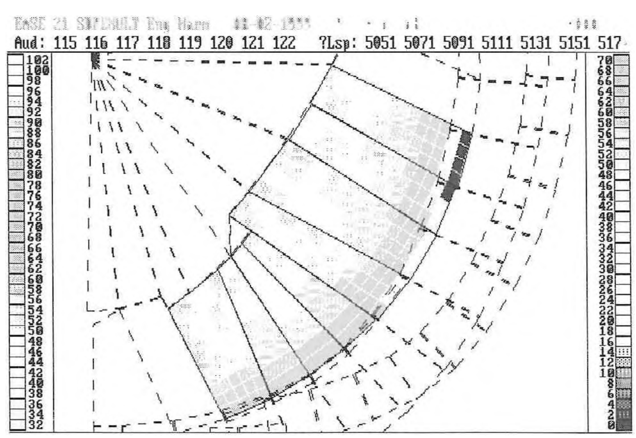

Figure 5: 4kHz at 42 degrees

Reprinted from Canadian Acoustics, Vol. 27 No. 3 (1999) pp 70-71

IBANA - Insulating Buildings Against Noise from Aircraft

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INTRODUCTION

IBANA is a new research project to develop a computer-based procedure for designing the sound insulation of a building against aircraft noise. Work in the 1970s led to a design guide [1] that has been widely used in Canada to design the sound insulation of residential buildings against aircraft noise. Unfortunately it is now very much out of date. Aircraft noise has changed, construction techniques have changed and it is now possible to produce a more accurate and a more convenient computer based procedure. This paper is a status report of this ongoing new project.

There are three main components to this project: (1) laboratory measurements of sound transmission loss (TL) of building façade components, (2) field measurements of TL, and (3) development of the computer software for sound insulation calculations. Laboratory measurements of TL are made for approximately diffuse field conditions and are more precise than field measurements. However, aircraft noise is incident on building facades from particular angles of incidence. It is known that TL varies with angle of incidence and it is intended to derive corrections for the laboratory TL results so that they are representative of the reduction of aircraft noise by real buildings. This will be accomplished by systematic comparisons of laboratory measurements with those in a simple test structure at Ottawa airport.

LABORATORY MEASUREMENT PHASE

The laboratory measurements of a large number of exterior wall and roof constructions are now complete and will be compiled into a data report. There are many combinations of construction details to be found in exterior walls and roofs of buildings near Canadian airports. The list of constructions to be tested was developed with advice from Canadian consultants (See acknowledgements). The focus of these measurements was on common types of residential constructions. However, a few tests related to commercial buildings were also included.

Table 1 lists the construction variables that were considered for four basic types of roof-ceiling systems. Not all possible combinations were tested but a total of 43 different roof-ceiling systems were measured. Both 2" by 10" wood joist and 14" wood truss systems were tested where the outer and inner surfaces were parallel as in flat roofs and cathedral ceilings. The raised heel wood truss (RHWT) was a sloping roof as illustrated in Figure 1. The steel deck roof systems were representative of light-weight commercial roof systems.

Type	Outer layer details	Insulation	Inner surface
2" by 10" wood	Shingles	None	1 gyp
14" wood truss	Steel sheet	R20	2 gyp
Raised heel wood truss (sloping)	Roofing - membrane	R40	RC+1 gyp
Steel deck	Roof vents		RC+2 gyp
	Ridge vent		

Table 1. Roof Construction Variables

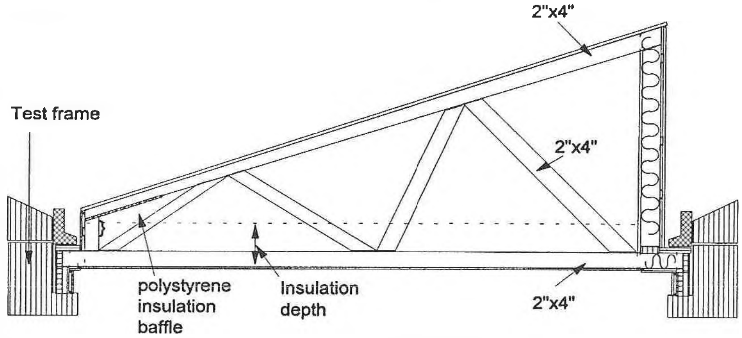

Figure 1. Section of RHWT Roof.

Figure 2 is one example of these roof-ceiling system tests and illustrates the effects of various ceiling treatments for the roof illustrated in Figure 1. Increased layers of gypsum board and the addition of resilient channels (RC) both have the expected effects on the measured TL. Figure 3 shows the change in measured TL for this same roof system with the addition of roof vents. The effect of the roof vents is quite dependent on the amount of attic insulation.

Table 2 summarises the construction details that were considered for the wood stud exterior walls tested in the laboratory. Although most walls were built using 2" by 6" wood studs at 406 mm (16") spacing, tests also included 610 mm (24") spacing and 2" by 4" stud constructions. A total of 29 different exterior wall constructions have been tested. In addition 6 different conventional windows have been tested, some both with and without an additional storm window. The windows included aluminum, wood, vinyl and vinyl clad wood frames and the double glazing units from the windows were also tested separately to help to identify the effects of the different window frame constructions.

As an example of these measurements, Figure 4 compares the effects of three different types of resilient channels (RC) when added to a wood stud wall construction. The differences among the different designs of RC are much less than the average effect of adding the RCs.

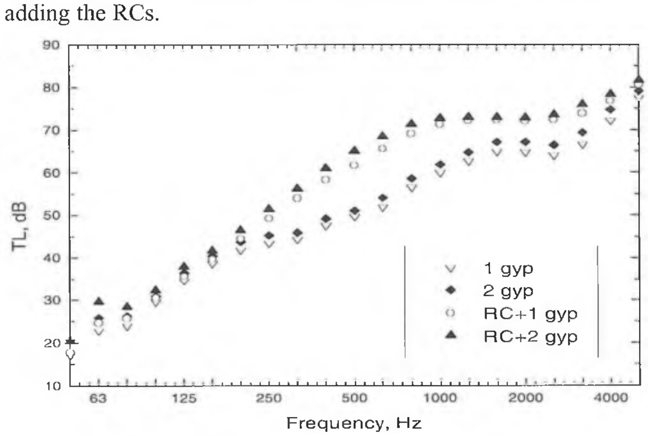

Figure 2. RHWT Roof with varied ceiling treatment.

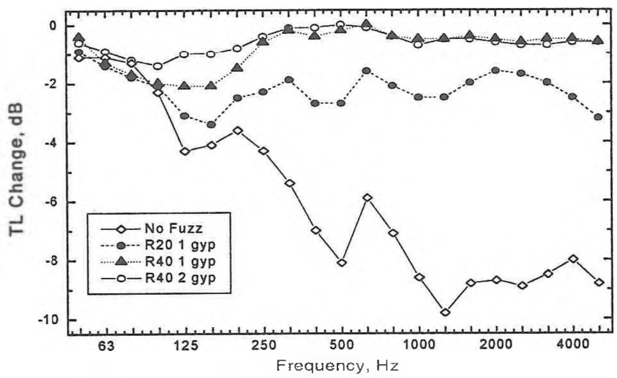

Figure 3. Effects of roof vents on RHWT roof.

FIELD MEASUREMENTS

The project will include two different types of field measurements. The first is intended to make it possible to derive conversions from laboratory TL measurements to the attenuation of aircraft noise by real buildings. A simple test structure has been constructed at Ottawa airport and a systematic series of tests will compare the TL of a number of constructions obtained for aircraft noise with results from the same constructions tested in the laboratory. Measurements in the test structure are recorded using two exterior microphones and 3 microphones in each of the two receiving rooms. All equipment is battery powered. The plan of the test structure is illustrated in Figure 5 showing a configuration that includes windows.

Outer layer	Outer insulat-ion	Ext. Sheath-ing	Insulati on	Inner layer
Vinyl	none	OSB	Glass fibre	1 gyp
Aluminum	air	Fibre board	Cellu-lose fibre	2 gyp
Brick	glass fibre		Mineral fibre	RC+1 gyp
Stucco (cement)	Styrofo am			RC+2 gyp
Stucco (acrylic)				

TABLE 2. Wall Construction Variables.

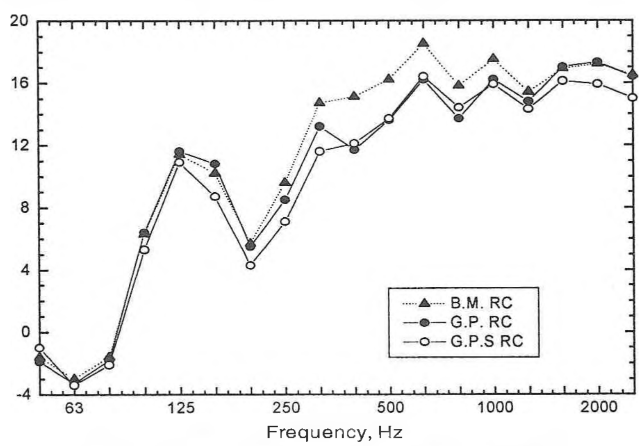

Figure 4. Incremental effects of 3 types of RCs.

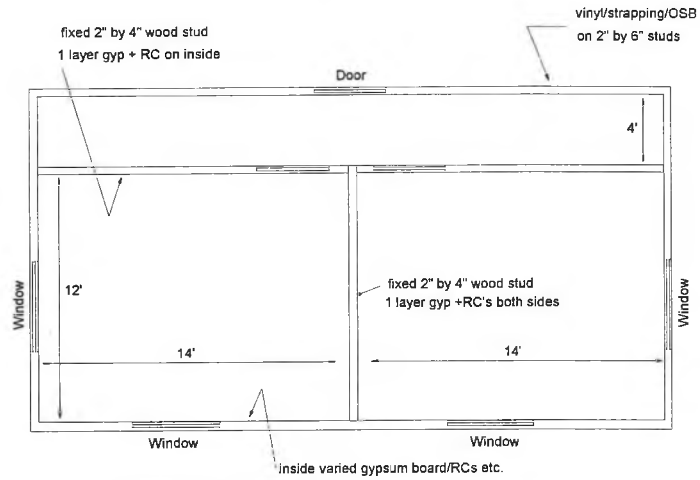

Figure 5. Plan of Ottawa airport test structure.

The second type of field measurements that are planned will consist of sound insulation measurements in homes near a major airport. The purpose is to validate the complete computer based design procedure under completely realistic conditions. The same measurement equipment and procedures as used at the Ottawa airport test structure will be used.

COMPUTER PROGRAM

The computer design software is intended to perform quite simple calculations but in a very convenient manner so that the design process is both more accurate and more efficient. The program is written in Visual Basic and is intended to have the look and feel of typical Windows based software. Users first select details describing the type and level of the source. They then calculate a sound insulation scenario by selecting combinations of façade elements from lists. Calculations are performed for all 1/3 octave band frequencies from 50 to 5000 Hz and the expected indoor sound levels are determined. Multiple scenarios can be compared so that the user can rapidly determine the desired combination of façade elements to meet the design goals. The program will include a data base of TL measurements including those obtained as part of this project. The software has been beta tested and its development is now mostly complete.

CONCLUSIONS

It is hoped that the data base, field measurements and design software will be complete and available for use by the summer of 2000.

ACKNOWLEDGEMENT

This project is jointly sponsored by Transport Canada, the Department of National Defence and the National Research Council. The helpful advice of the following consultants is very gratefully acknowledged: Valcoustics Canada Ltd., Aercoustics Engineering Ltd., BKL Ltd. and Griffiths Rankin Cook Architects.

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Reprinted from Canadian Acoustics, Vol. 27 No. 3 (1999) pp 118-119

Aggregate Subjective Ratings of Airborne Sound Insulation

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Institute for Research in Construction, National Research Council, Montreal Rd. Ottawa, K1A 0R6

Introduction

This paper reports the results of a survey of sound insulation between homes in multi-family dwellings. The survey included interviews of 600 subjects and airborne sound insulation measurements of their 300 party walls. The subjects lived in both row housing and multi-floor apartment buildings in three different Canadian cities. The questionnaire first asked about general issues concerning the subjects building followed by more specific questions rating the sound insulation and the audibility of various noises. Sound transmission loss measurements were made in 1/3-octave bands from 100 to 4000 Hz. In addition to the standard ISO and ASTM single number ratings, 20 other single number sound isolation measures were calculated.

Acoustical Data

Figure 1 summarises the results of the sound transmission loss measurements of the 300 walls. This figure shows the average, ± 1 standard deviation and the complete range of transmission loss values in each frequency band. Measured effective STC values varied from 38 to 60 with an average of 49.7 and a standard deviation of ± 4.7 dB. (In this paper responses are primarily related to the standard The effective Sound transmission Class value which is referred to as STC1 to discriminate from other non-standard versions.).

The average noise levels recorded in the 600 homes and their standard deviations were LeqD 47.5 ±8.9 dBA, LeqN 39.8 ±8.4 dBA, Leq24 46.2 ±7.9 dBA. A summary of the acoustical measurements was published some time ago [1].

Principal Survey Results

Subjects were first approached by letter and asked to participate in a neighbourhood satisfaction survey. They were subsequently interviewed in their homes. Initial questions were to obtain spontaneous responses without any mention of sound insulation or noise. These included responses concerning satisfaction with their building, whether they would like to move and how considerate their neighbours were. Subsequent questions obtained directly elicited responses concerning whether they heard various sounds and how annoying they were. For most survey questions, responses were obtained using 7-point response scales. For convenience this paper concentrates on 3 principal responses: the single question response giving a subjective evaluation of the residents' sound insulation and composite response scales concerning sounds that they heard (HEAR) and the resulting annoyance (ANOY).

A number of spontaneous responses were significantly related to STC1 values. (STC1 is the ASTM standard STC rating including the 8-dB rule). Residents with party walls having lower sound insulation were more likely to want to move and less likely to be satisfied with their building. There was also a statistically significant relationship between STC1 values and how considerate neighbours were rated. That is, people with poor sound insulation tended to blame the resulting disturbance on inconsiderate neighbours rather than on poor sound insulation.

The principal elicited responses were also significantly related to measured sound insulation. Figure 2 plots aggregate subjective ratings of sound insulation as a function of measured STC1 values. For the 2nd order polynomial fit shown in this figure the associated R^2 value was 0.939 and there is clearly a strong relationship between objective and subjective ratings of sound insulation. On average, people can accurately evaluate the amount of sound insulation between them and their neighbours. Composite ANOY responses were similarly related to measured STC1 values. (R^2 = 0.960). Annoyance decreased with increasing values of STC1 and appeared to approach a rating of 1 (Not at all annoyed) at approximately STC1 = 65 dB.

Figure 3 shows the relationship between the composite HEAR responses. Again there is a very strong relationship with STC1 val-

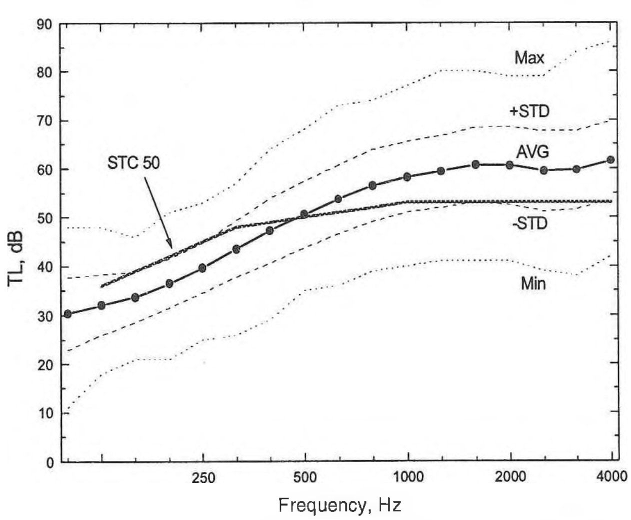

Figure 1. Transmission loss values of the 300 walls and STC rating contour of the average wall

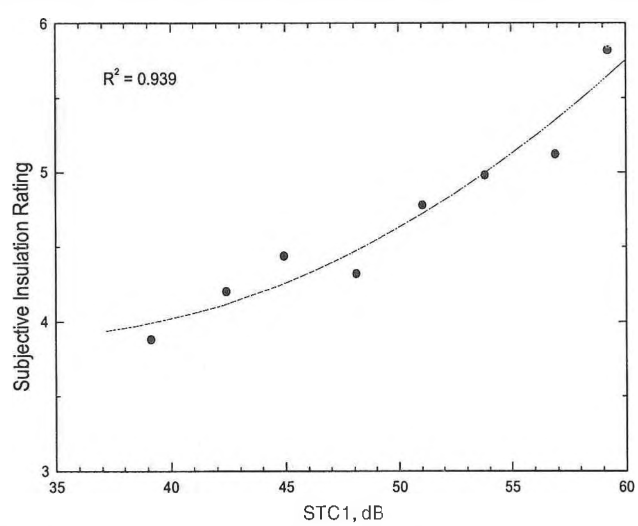

Figure 2. Mean subjective ratings of sound insulation versus aggregate STC1 values.

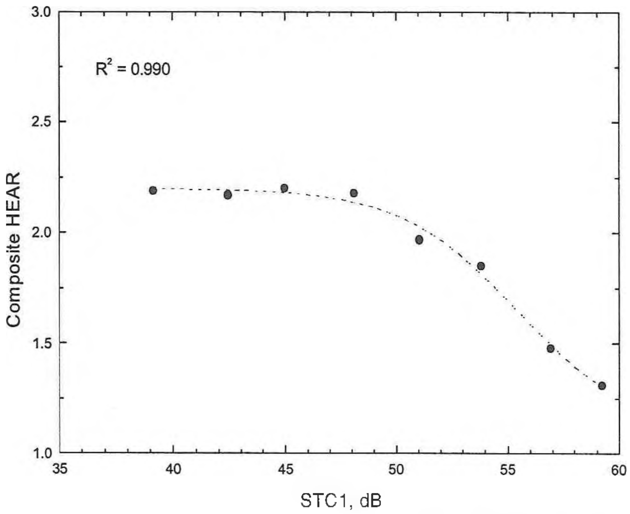

Figure 3. Figure 3. Mean subjective ratings of the composite HEAR scale versus aggregate STC1 values.

ues but the form of the relationship is quite different than for the previous two cases. Above about STC1 = 50, residents report hearing the sounds from their neighbours less often as STC1 values increase. That is, when there is better sound insulation they hear their neighbours less often. Extrapolating this trend would suggest that between an STC1 60 and 65 they would not hear their neighbours at all. However, below about STC1 = 50 this HEAR response does not vary with STC1. This is because how often they hear their neighbours depends not only on sound insulation but also on how often neighbours typically make audible sounds. It appears that below an STC1 of about 50 responses are not influenced by sound insulation but only by how frequently neighbours make audible sounds. For a party wall to minimize this disturbance it must have an STC1 of greater than 50 and a party-wall sound insulation of STC1 = 55 or more is required to significantly reduce the disturbance that neighbours hear. Other responses led to similar relationships and support this trend.

Other Measures of Sound Insulation

The ASTM STC and the ISO R_W are now the most commonly used single number measures of sound insulation. These and a number of other measures were tested using second order polynomial fits to the principal responses. The R^2 values from these relationships are given in Figure 4. The standard STC1 measure was best correlated with all three responses. Correlations with STC2 (excluding the 8 dB rule) and variations of the ISO R_W measure were slightly less successful although the differences were not statistically significant. Various average TL values [2] were less successful. It was concluded that these results give no reason to change the standard STC measure (including the 8 dB).

Conclusions

In this study the average party wall corresponded to STC 50. This may suggests that 50% of party walls in Canada provide less insulation than the current recommendations of the National Building Code.

There is considerable evidence that residents in multi-unit buildings are disturbed by noises from there neighbours and that this disturbance decreases with increasing sound insulation between the homes. Residents even mistakenly blame neighbours for being inconsiderate when poor sound insulation is the cause of the disturbance.

Many responses do not decrease unless party-wall sound insulation exceeds STC 50 and significant reductions in these responses require party-wall sound insulation of STC 55 or more.

STC 55 is therefore recommended as a realistic goal for better sound insulation to reduce annoyance and disturbance.

STC 60 is identified as a more ideal goal for party-wall sound insulation that would essentially eliminate disturbance by noise from neighbours.

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Acknowledgements

Field measurements were made by Valcoustics Canada Ltd, Harford Kennedy Ltd and SNC Inc.

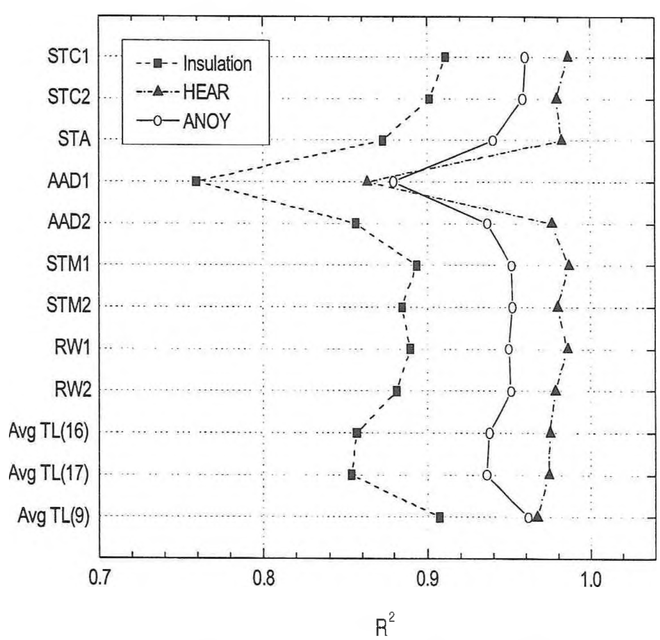


Figure 4. R^2 values associated with 2nd order polynomial fits of 3 principal survey responses with single number sound insulation measures.

Editor's Note: *Sir James Lighthill, for those of us trained in Aero-Acoustics, was the Pandit and Guru of jet noise. I had the pleasure and good fortune of listening to some of his famous seminars on jet noise during my graduate studies at NASA-Langley Research Center, Hampton, VA, USA. I was moved when I read the following obituary by Prof. Crighton of Cambridge University. It is reprinted here with permission from the Acoustical Society of America.*

Sir James Lighthill • 1924–1998

Sir James Lighthill died at age 74 as he was just completing—for the seventh time—a swim round the Channel Island of Sark, having 25 years ago been the first person to manage this marathon in which the swimmer has to cope with massive waves and treacherous currents. No doubt he was putting on a finishing spurt, but sadly that exertion at the end of 10 h in unusually heavy seas revealed a mitral valve condition leading to his sudden death in the water; but no doubt this was also one of the ways in which this so-much-larger-than-life figure would have wished to go.

Lighthill was one of the greatest scientists of this century in fluid mechanics, acoustics, and applied mathematics, initiating whole new fields, contributing very many novel and seminal ideas, and inspiring scientific communities by his personal example and commitment. Born in 1924 in Paris, he went to school in England at Winchester (a contemporary there of Freeman Dyson), excelled there across the board, and at age 17 went up to Trinity College Cambridge for the then-standard two-year wartime mathematics course, during which he met Nancy Dumaresq, also a mathematician, whom he married in 1945. He then went to the National Physical Laboratory at Teddington, to work on supersonic aerodynamics. His earliest papers have all the hallmarks of the roughly 160 to follow: the clearest imaginable presentation of the scientific issue at stake, the most cogent arguments behind the mathematical model and the necessary approximations (always motivated by physical reasoning rather than by formal asymptotics), the most elegant and powerful mathematical analysis, and the most compelling interpretation—in scientific and practical terms—of the outcome.

From NPL Lighthill went quickly to Manchester, and at age 26 succeeded Sydney Goldstein as Beyer Professor of Applied Mathematics. Lighthill's time (1946–1959) at Manchester was one of extraordinary creativity and productivity. He worked ingeniously and prolifically on a huge range of topics in fluid mechanics and applied mathematics, and supervised many Ph. D. students while discharging a heavy administrative load, teaching with great verve and gusto ~his beautiful 1958 book *An Introduction to Fourier Analysis and Generalised Functions* was prepared for Manchester undergraduate courses!, and assuming major national and international responsibilities. Leaving Manchester in 1959, he went directly to the Royal Aircraft Establishment, Farnborough, in the exciting days of Concorde design. He managed a staff of 8000, of whom 1400 were professional scientists and engineers. All were astonished to find each and every report and paper emanating from RAE subjected to the eagle eye of the Director, a Director, moreover, whose personal scientific output was sufficiently voluminous and distinctive to warrant a special series of RAE technical reports. Rarely indeed has there been a major applied scientific institution of this scale in which the Director had such complete technical mastery of its scientific output—although naturally Lighthill did not confine himself simply to that, but immersed himself in all aspects of RAE finance, administration, and management.

In 1964 Lighthill took a Royal Society Research Professorship at Imperial College London (he had been elected FRS at the very early age of 29), and left the world of aerodynamics for those of waves, geophysics, biomechanics, and mathematical biology. My colleague Julian Hunt conjectures, perceptively, that Lighthill was so disillusioned by the massive cuts inflicted on all civil and military aerospace funding by the 1964 Wilson government that his interests in all things aeronautical largely ceased (and this reaction to the Wilson government appears to have been punished by a delay until 1971 in the award of a knighthood to Lighthill). Among those interests, regrettably, was that in *aeroacoustics*, the subject which he founded with his famous 1952 paper "On sound generated aerodynamically. Part I. General theory," a quite remarkable paper neither containing nor needing a single reference to any prior work.

From Imperial College Lighthill went to take the Lucasian Professorship of Mathematics in Cambridge in 1969, succeeding Dirac and, three centuries earlier, Newton, relinquishing the Chair to Stephen Hawking in 1979 for the office of Provost of University College London. Retiring ten years later, after impressive development and expansion of UCL in the number and quality of its students and academic staff no less than in its physical facilities, Lighthill devoted his last nine years to biological mechanics, to geophysics, and to Chairmanship of the Special Committee on the International Decade for Natural Disaster Reduction. His achievements were recognized by innumerable awards and medals, by 24 Honorary Degrees, and by membership of the most prestigious academies worldwide.

His launching of the field of *aeroacoustics* in 1952 is well known. To be emphasized is the fact that his theory has underpinned *all subsequent work*, analytical, experimental, and computational, in this field; and that his theory is so versatile and all-embracing that it has been used to predict not only the noise from jets, propellers, and turbomachinery, but also that from the convective turbulence in the atmosphere of the sun, and that from the splashing of spray, the splitting of bubbles and the interaction of surface water waves. And although J. S. Mendousse [J. Acoust. Soc. Am. **25**, 51–54 (1953)] had already, unknown to Lighthill, made the connection between Burgers' equation and finite-amplitude effects in sound, and Z. A. Gol'dberg [Sov. Phys. Acoust. 3, 340–347 (1957)] had recognized the competition between nonlinear steepening and linear diffusion effects, it was Lighthill's 100-page 1956 article "Viscosity effects in sound waves of finite amplitude, " in honor of the 70th birthday of G. I. Taylor, that really launched the field of *nonlinear acoustics*, dealing, as it did, with shock formation, propagation, and decay in plane and other quasi-one-dimensional geometries, and with thermoviscous and relaxation effects on shocks, pulses, and periodic waves in the "nonlinear acoustics approximation." Lighthill's 1997 work on "shock bunching" in randomly irregular shocked flows provides a seamless continuation of the 1956 paper.

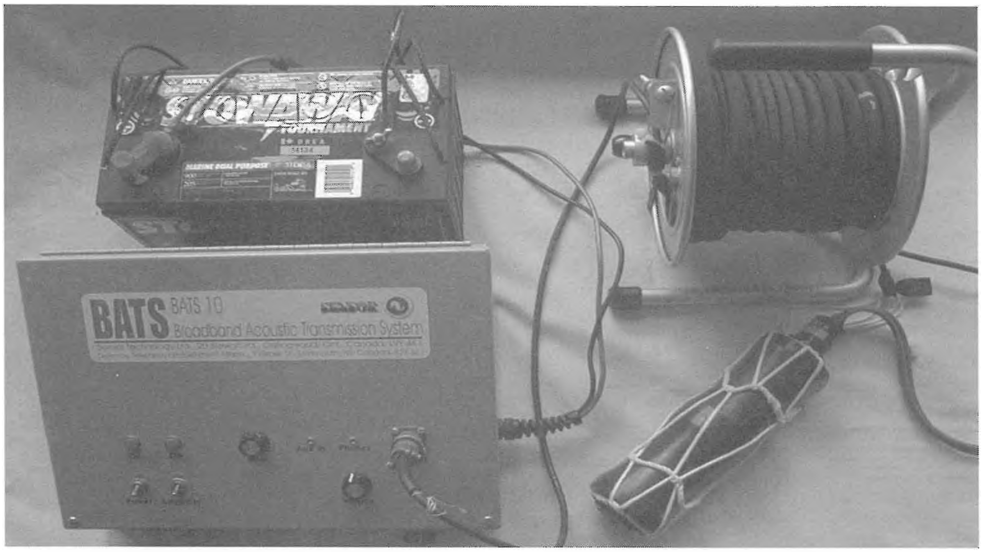
But Lighthill's contributions to acoustics go further than these two major efforts. He supervised, among many others, N. S. Curle (solid surface effects in aeroacoustics), G. B. Whitham (shock dynamics and shock diffraction), M. A. Swinbanks (pioneering work on active control of sound in ducts), and M. S. Howe (whose notable contributions to acoustics are simply too wide-ranging and numerous to itemize here); and he himself worked on acoustic streaming, streaming in the ear itself, on cochlear mechanics, on biochemical feedback at low auditory levels, and on the mathematical theory of wave generation and propagation, linear and nonlinear, in dispersive and possibly anisotropic, inhomogeneous and moving media.

He served as founding President of the Institute of Mathematics and its Applications (1965–67), as President of the International Union for Theoretical and Applied Mechanics (1984–88), and as founding President, from 1995 to the time of his death, of the International Institute of Acoustics and Vibration.

His contributions to acoustics are to be set alongside those of Rayleigh, and while his contributions to fluid mechanics and applied mathematics have similar permanence and status, he would have been content with this accolade.

D. G. CRIGHTON

J. Acoust. Soc. Am. **106** (3), Pt. 1, September 1999, page 1225.



Broadband Acoustic Transmission System (BATS)

from Dennis Jones, Transducer Designer, DREA, jones@drea.dnd.ca

Recently, a broadband acoustic transmission system (BATS) for underwater acoustics applications was developed as a joint collaboration between the Defence Research Establishment Atlantic (DREA) in Dartmouth, Nova Scotia and Sensor Technology Limited in Collingwood, Ontario. The BATS consists of a unique 1-14 kHz Class III barrel-stave flextensional transducer driven by commercial audio components housed in a splash-proof control box which is supplied by a 12 volt marine battery. Input signals can be generated from a variety of audio devices including PC sound cards, CD players, and cassette players.

In the summer of 1999, cetacean biologists from the Whitehead Laboratory at Dalhousie University in Halifax, Nova Scotia used the BATS as a playback system to investigate vocal mimicry in long-finned pilot whales (*Globicephala melas*) in Cape Breton, Nova Scotia. Owing to its compact size, the BATS was easily stowed aboard and deployed from a 12 meter sailing yacht. In the year 2000, the BATS will be used off northern Chile to study possible dialects associated with the codas (repeated patterns of broadband clicks) produced by sperm whales (*Physeter macrocephalus*).

Photo: The BATS components include a marine battery, control box, cable and reel, and broadband flextensional transducer.

Système de transmission acoustique à large bande (BATS)

de Dennis Jones, Concepteur de transducteurs, CRDA, jones@drea.dnd.ca

Un système de transmission acoustique à large bande (BATS) pour des applications acoustiques sous-marines a été développé récemment par le Centre de recherches pour la Défense Atlantique (CRDA) de Dartmouth, en collaboration avec Sensor Technology Limited de Collingwood, Ontario. Le BATS consiste d'un unique transducteur flextensionnel à douves de classe III de 1-14 kHz, commandé par des composantes audio commerciales situées dans une boîte de contrôle protégée contre les projections d'eau, et alimenté par une batterie marine de 12 volts. Les signaux d'entrée peuvent être générés par une variété d'appareils audio, y compris les cartes de son d'ordinateurs personnels, lecteurs de disque CD ou de cassettes.

Durant l'été de 1999, des biologistes en cétacés du Laboratoire Whitehead de l'Université Dalhousie à Halifax, Nouvelle-Écosse, ont utilisé le BATS comme système de reproduction sonore pour étudier le mimétisme vocal du globicéphale noir (*Globicephala melas*) au Cap-Breton, Nouvelle-Écosse. Grâce à son format compact, le BATS a facilement été arrimé et déployé d'un voilier de 12 mètres. En l'an 2000, le BATS sera utilisé au large de la côte nord du Chili pour étudier les dialectes possiblement associés aux codas (combinaisons répétitives de clics à large bande) produits par les cachalots macrocéphales (*Physeter macrocephalus*).

Photo: Le BATS inclue une batterie marine, une boîte de contrôle, câble et dévidoir, et le transducteur flextensionnel à large bande.

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

2000

17-18 February: Measuring Noise Outdoors, Home Counties Venue, UK. Contact: Institute of Acoustics, 77A St. Peter's Street, St. Albans, Herts AL1 3BN, UK; Fax: +44 1727 850 553; Email: ioa@ioa.org.uk

17-19 February: National Hearing Conservation Association (NHCA) 25th Annual Conference, Denver, CO. Contact: NHCA, 9101 E. Kenyon Ave., Suite 3000, Denver, CO 80237; Tel.: 303-224-9022; Fax: 303-770-1812; Email: nhca@gwami.com; Web: www.hearingconservation.org

6-9 March: Society of Automotive Engineers Congress, Detroit, MI. Contact: SAE Headquarters, 400 Commonwealth Dr., Warrendale, PA 15096-0001; Fax: 724-776-1830; Email: congress2000@sae.org

15-17 March: Acoustical Society of Japan Spring Meeting, Tokyo, Japan. Contact: Acoustical Society of Japan, Ikeda-Building, 2-7-7, Yoyogi, Shibuya-ku, Tokyo, 151-0053 Japan; Fax: +81 3 3379 1456; Email: kym05145@nifty.ne.jp

19-22 March: 25th International Acoustical Imaging Symposium, Bristol, UK. Contact: 25th IAIS, Medical Physics and Bioengineering Department, Bristol General Hospital, Bristol BS1 6SY, UK; Web: www.bris.ac.uk\depts\medphys

20-24 March: Meeting of the German Acoustical Society (DAGA), Oldenburg, Germany. Contact: DEGA, FB Physik, Universität Oldenburg, 26111 Oldenburg, Germany; Fax: +49 441 798 3698; Email: dega@aku.physik.uni-oldenburg.de

3-4 April: Structural Acoustics 2000, Zakopane, Poland. Contact: AGH, Al.Mickiewicka 30, 30-059 Krakow, Poland; Fax: +48 12 423 3163; Web: www.cyf-kr.edu.pl/ghpanusz

16-19 April: 3rd Biennial Spring Conference on Environmental & Occupational Noise for the Energy Industry, Calgary, Alberta, Canada. Contact: Glynn Jones (occupational noise), Fax: (403) 244-3234, Email: ehp@cadvision.com, or Nigel Maybee (environmental noise), Fax: (403) 259-6611, Email: nigel@hfpacoustical.com

17-19 May: 9th International Meeting on Low Frequency Noise and Vibration, Aalborg, Denmark. Contact: W. Tempest, Multi-Science Publishing Co. Ltd., 5 Wates Way, Brentwood, Essex CM15 9TB, UK; Fax: +44 1277 223453.

23-26 May: Meeting of the Russian Acoustical Society, Moscow, Russia. Contact: N.N. Andrejev Acoustical Institute, 4 Shvernika ul., Moscow 117036, Russia; Fax: +7 095 126 8411; Email: ras@akin.ru

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

2000

17-18 février: Mesures de bruit en plein air, Home Counties Venue, Royaume-Uni. Info: Institute of Acoustics, 77A St. Peter's Street, St. Albans, Herts AL1 3BN, UK; Fax: +44 1727 850 553; Email: ioa@ioa.org.uk

17-19 février: 25e conférence annuelle de l'Association nationale de la conservation de l'audition (NHCA), Denver, CO. Info: NHCA, 9101 E. Kenyon Ave., Suite 3000, Denver, CO 80237; Tél.: 303-224-9022; Fax: 303-770-1812; Email: nhca@gwami.com; Web: www.hearingconservation.org

6-9 mars: Congrès de la Société des Ingénieurs d'autos, Détroit, MI. Info: SAE Headquarters, 400 Commonwealth Dr., Warrendale, PA 15096-0001; Fax: 724-776-1830; Email: congress2000@sae.org

15-17 mars: Rencontre de printemps de la Société d'acoustique du Japon, Tokyo, Japon. Info: Acoustical Society of Japan, Ikeda-Building, 2-7-7, Yoyogi, Shibuya-ku, Tokyo, 151-0053 Japan; Fax: +81 3 3379 1456; Email: kym05145@nifty.ne.jp

19-22 mars: 25e Symposium international d'imagerie acoustique, Bristol, Royaume-Uni. Info: 25th IAIS, Medical Physics and Bioengineering Department, Bristol General Hospital, Bristol, BS1 6SY, UK; Web: www.bris.ac.uk\depts\medphys

20-24 mars: Rencontre de la Société allemande d'acoustique (DAGA), Oldenburg, Allemagne. Info: DEGA, FB Physik, Universität Oldenburg, 26111 Oldenburg, Germany; Fax: +49 441 798 3698; Email: dega@aku.physik.uni-oldenburg.de

3-4 avril: Acoustique structurale 2000, Zakopane, Pologne. Info: AGH, Al.Mickiewicka 30, 30-059 Krakow, Poland; Fax: +48 12 423 3163; Web: www.cyf-kr.edu.pl/ghpanusz

16-19 avril: 3e conférence de printemps bisannuelle sur le bruit occupationnel et environnemental pour l'industrie de l'énergie, Calgary, Alberta, Canada. Info: Glynn Jones (bruit occupationnel), Fax: (403) 244-3234, Email: ehp @cadvision.com, or Nigel Maybee (bruit environnemental), Fax: (403) 259-6611, Email: nigel@hfpacoustical.com

17-19 mai: 9e rencontre internationale sur le bruit et les vibrations de basse fréquence, Aalborg, Danemark. Info: W. Tempest, Multi-Science Publishing Co. Ltd., 5 Wates Way, Brentwood, Essex CM15 9TB, UK; Fax: +44 1277 223453.

23-26 mai: Rencontre de la Société d'acoustique russe, Moscou, Russie. Info: N.N. Andrejev Acoustical Institute, 4 Shvernika ul., Moscow 117036, Russia; Fax: +7 095 126 8411; Email: ras@akin.ru

24-26 May: Joint International Symposium on Noise Control & Acoustics for Educational Buildings and 5th Turkish National Congress on Acoustics, Istanbul, Turkey. Contact: Turkish Acoustical Society YTU Mim. Fak., 80750 Besiktas-Istanbul, Turkey; Fax: +90 212 261 0549; Web: www.takder.org

30 May-3 June: 139th Meeting of the Acoustical Society of America, Atlanta, GA. 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

5-9 June: International Conference on Acoustics, Speech and Signal Processing (ICASSP-2000), Istanbul, Turkey. Contact: T. Adali, EE and Computer Science Department, University of Maryland Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250; Fax: +1 410 455 3639; Web: icassp2000.sdsu.edu

6-9 June: 5th International Symposium on Transport Noise and Vibration, St. Petersburg, Russia. Contact: East-European Acoustical Association, Moskovskoe Shosse 44, 196158 St. Petersburg, Russia; Fax: +7 812 1279323; Email: noise@mail.rcom.ru

14-17 June: IUTAM Symposium on Mechanical Waves for Composite Structures Characterization, Chania, Crete, Greece. Contact: IUTAM 2000, Applied Mechanics Laboratory, Technical University of Crete, Chania 73100, Greece; Fax: +30 821 37438; Web: www.tuc.gr/iutam

4-7 July: 7th International Congress on Sound and Vibration, Garmisch-Partenkirchen, Germany. Contact: H. Heller, DLR, Postfach 3267, 38022 Braunschweig, Germany; Fax: +49 531 295 2320; email: hanno.heller@dlr.de; WWW: www.iiav.org/icsv7.html

28-30 August: Inter-Noise 2000, Nice, France. Contact: SFA, 23 avenue Brunetière, 75017 Paris, France; Fax: +33 1 47 88 90 60; Web: www.inrets.fr/services/manif

31 August – 2 September: International Conference on Noise and Vibration Pre-Design and Characterization Using Energy Methods (NOVEM), Lyon, France. Contact: LVA, INSA de Lyon, Bldg. 303, 20 avenue Albert Einstein, 69621 Villeurbane, France; Fax: +33 4 7243 8712; Web: www.insa-lyon.fr/Laboratoires/lva.html

3-6 September: 5th French Congress on Acoustics — Joint meeting of the Swiss and French Acoustical Societies, Lausanne, Switzerland. Contact: M.-N. Rossi, Ecole Polytechnique Fédérale, 1015 Lausanne, Switzerland; Fax: +41 21693 26 73.

17-21 September: Acoustical Society of Lithuania First International Conference, Vilnius, Lithuania. Contact: Acoustical Society of Lithuania, Kriviu 15-2, 2007 Vilnius, Lithuania; Fax: +370 2 223 451; Email: daumantas.ciblys@ff.vu.lt

3-5 October: WESPRAC VII, Kumamoto, Japan. Contact: Computer Science Dept., Kumamoto Univ., 2-39-1 Kurokami, Kumamoto, Japan 860-0862; Fax: +81 96 342 3630; Email: wesprac7@cogni.eecs.kumamoto-u.ac.jp

3-6 October: EUROMECH Colloquium on Elastic Waves in Nondestructive Testing, Prague, Czech Republic. Contact: Z. Prevorovsky, Institute of Thermomechanics, Dolejskova 4, 182 00 Prague 8, Czech Republic; Fax: +420 2 858 4695; Email: ok@bivoj.it.cas.cz

24-26 mai: Symposium international conjoint sur le contrôle du bruit et acoustique pour les immeubles d'éducation, et 5e Congrès national turc d'acoustique, Istanboul, Turquie. Info: Turkish Acoustical Society YTU Mim. Fak., 80750 Besiktas-Istanbul, Turkey; Fax: +90 212 261 0549; Web: www.takder.org

30 mai-3 juin: 139e rencontre de l'Acoustical Society of America, Atlanta, GA. Info: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tél.: 516-576-2360; Fax: 516-576-2377; Email: asa@aip.org; Web: asa.aip.org

5-9 juin: Conférence internationale sur l'acoustique, la parole et le traitement de signal (ICASSP-2000), Istanboul, Turquie. Info: T. Adali, EE and Computer Science Department, University of Maryland Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250; Fax: +1 410 455 3639; Web: icassp2000.sdsu.edu

6-9 juin: 5e symposium international sur le bruit et vibrations du transport, St Petersbourg, Russie. Info: East-European Acoustical Association, Moskovskoe Shosse 44, 196158 St. Petersburg, Russia; Fax: +7 812 1279323; Email: noise@mail.rcom.ru

14-17 juin: Symposium IUTAM sur les ondes mécaniques pour la caractérisation de structures composites, Chania, Crète, Grèce. Info: IUTAM 2000, Applied Mechanics Laboratory, Technical University of Crete, Chania 73100, Greece; Fax: +30 821 37438; Web: www.tuc.gr/iutam

4-7 juillet: 7e Congrès international sur le son et les vibrations, Garmisch-Partenkirchen, Allemagne. Info: H. Heller, DLR, Postfach 3267, 38022 Braunschweig, Germany; Fax: +49 531 295 2320; email: hanno.heller@dlr.de; WWW: www.iiav.org/icsv7.html

28-30 août: Inter-Noise 2000, Nice, France. Info: SFA, 23 avenue Brunetière, 75017 Paris, France; Fax: +33 1 47 88 90 60; Web: www.inrets.fr/services/manif

31 août – 2 septembre: Conférence internationale sur l'utilisation des méthodes d'énergie pour la prévision vibroacoustique (NOVEM), Lyon, France. Info: LVA, INSA de Lyon, Bldg. 303, 20 avenue Albert Einstein, 69621 Villeurbane, France; Fax: +33 4 7243 8712; Web: www.insa-lyon.fr/Laboratoires/lva.html

3-6 septembre: 5e Congrès français d'acoustique — Rencontre conjointe des Sociétés suisse et française d'acoustique, Lausanne, Suisse. Info: M.-N. Rossi, Ecole Polytechnique Fédérale, 1015 Lausanne, Suisse; Fax: +41 21693 26 73.

17-21 septembre: 1e Conférence internationale de la Société d'acoustique de Lithuanie, Vilnius, Lithuanie. Info: Acoustical Society of Lithuania, Kriviu 15-2, 2007 Vilnius, Lithuania; Fax: +370 2 223 451; Email: daumantas.ciblys@ff.vu.lt

3-5 octobre: WESPRAC VII, Kumamoto, Japon. Info: Computer Science Dept., Kumamoto Univ., 2-39-1 Kurokami, Kumamoto, Japan 860-0862; Fax: +81 96 342 3630; Email: wesprac7@cogni.eecs.kumamoto-u.ac.jp

3-6 octobre: Colloque EUROMECH sur les ondes élastiques pour les tests non-destructifs, Prague, République tchèque. Info: Z. Prevorovsky, Institute of Thermomechanics, Dolejskova 4, 182 00 Prague 8, Czech Republic; Fax: +420 2 858 4695; Email: ok@bivoj.it.cas.cz

16-18 October: 2nd Iberoamerican Congress on Acoustics, 31st National Meeting of the Spanish Acoustical Society, and EAA Symposium, Madrid, Spain. Contact: Spanish Acoustical Society, c/Serrano 144, 28006 Madrid, Spain; Fax: +34 91 411 7651; email: ssantiago@fresno.csic.es

16-20 October: 6th International Conference on Spoken Language Processing, Beijing, China. Contact: ICSLP 2000 Secretariat, Institute of Acoustics, PO Box 2712, 17 Zhong Guan Cun Road, 100 080 Beijing, China; Fax: +86 10 6256 9079; Email: mchu@plum.ioa.ac.cn

4-8 December: 140th Meeting of the Acoustical Society of America, Newport Beach, CA. 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

2001

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. Contact: A. Alippi, Dipartimento di Energetica, Universita di Roma "La Sapienza," Via A. Scarpa 14, 00161 Rome, Italy; Fax: +39 6 4424 0183; WWW: www.uniroma1.it/energ/ica.html

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

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

16-18 octobre: 2e congrès ibéro-américain sur l'acoustique, 31e Rencontre nationale de la Société d'acoustique espagnole, et Symposium de l'EAA, Madrid, Espagne. Info: Spanish Acoustical Society, c/Serrano 144, 28006 Madrid, Spain; Fax: +34 91 411 7651; email: ssantiago@fresno .csic.es

16-20 octobre: 6e conférence internationale sur le traitement de la langue parlée, Beijing, Chine. Info: ICSLP 2000 Secretariat, Institute of Acoustics, PO Box 2712, 17 Zhong Guan Cun Road, 100 080 Beijing, China; Fax: +86 10 6256 9079; Email: mchu@plum.ioa.ac.cn

4-8 décembre: 140e recontre de l'Acoustical Society of America, Newport Beach, CA. Info: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tél.: 516-576-2360; Fax: 516-576-2377; Email: asa@aip.org; Web: asa.aip.org

2001

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

2-7 septembre: 17e Congrès international sur l'acoustique (ICA), Rome, Italie. Info: A. Alippi, Dipartimento di Energetica, Universita di Roma "La Sapienza," Via A. Scarpa 14, 00161 Rome, Italy; Fax: +39 6 4424 0183; WWW: www.uniroma1.it/energ/ica.html

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; Email: perugia@classico.it

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

Looking for Canadian contributions:

NATO/RTO/AVT has proposed a specialist meeting on "Developments in Computational Aero- and Hydro- Acoustics". The topics will focus on recent and current developments in computational methods and simulations applicable to propulsion noise generation and propagation of air and sea vehicles, fluid-flow/airframe noise, cavity noise and prediction of acoustic fatigue loads. The location and dates are still to be determined (~2002). For more information, contact Louis Chan (louis.chan@nrc.ca); Tel: (613)998-0503.

Recherche contributions canadiennes:

NATO/RTO/AVT a proposé une rencontre de spécialistes sur les "Développements en aéro et hydro acoustique". Les sujets concernés sont les développements récents et actuels sur les méthodes de calcul et simulations applicables à la génération et propagation de bruit de propulsion de véhicules en milieux aérien et aquatique, le bruit d'écoulement et d'intéraction fluide/structure, bruit de cavité, et prédiction de charge de fatigue acoustique. L'emplacement et dates sont encore à déterminer (~2002). Pour plus d'information, contactez Louis Chan (louis.chan@nrc.ca); Tél: (613)998-0503.

The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

PRIZE ANNOUNCEMENT

A number of prizes, whose general objectives are described below, are offered by the Canadian Acoustical Association. As to the first four prizes, applicants must submit an application form and supporting documentation to the prize coordinator before the end of February of the year the award is to be made. Applications are reviewed by subcommittees named by the President and Board of Directors of the Association. Decisions are final and cannot be appealed. The Association reserves the right not to make the awards in any given year. Applicants must be members of the Canadian Acoustical Association. Preference will be given to citizens and permanent residents of Canada. Potential applicants can obtain full details, eligibility conditions and application forms from the appropriate prize coordinator.

Edgar and Millicent Shaw Postdoctoral Prize in Acoustics

This prize is made to a highly qualified candidate holding a Ph.D. degree or the equivalent, who has completed all formal academic and research training and who wishes to acquire up to two years supervised research training in an established setting. The proposed research must be related to some area of acoustics, psychoacoustics, speech communication or noise. The research must be carried out in a setting other than the one in which the Ph.D. degree was earned. The prize is for $3000 for full-time research for twelve months, and may be renewed for a second year. Coordinator: Sharon Abel, Mount Sinai Hospital, 600 University Avenue, Toronto, ON M5G 1X6. Past recipients are:

1990	*Li Cheng*	*Université de Sherbrooke*	*1995*	*Jing-Fang Li*	*University of British Columbia*
1993	*Roland Woodcock*	*University of British Columbia*	*1996*	*Vijay Parsa*	*University of Western Ontario*
1994	*John Osler*	*Defense Research Estab. Atlantic*	*1999*	*Jingnan Guo*	*University of British Columbia*

Alexander Graham Bell Graduate Student Prize In Speech Communication and Behavioural Acoustics

The prize is made to a graduate student enrolled at a Canadian academic institution and conducting research in the field of speech communication or behavioural acoustics. It consists of an $800 cash prize to be awarded annually. Coordinator: Don Jamieson, Department of Communicative Disorders, University of Western Ontario, London, ON N6G 1H1. Past recipients are:

1990	*Bradley Frankland*	*Dalhousie University*	*1995*	*Kristina Greenwood*	*University of Western Ontario*
1991	*Steven D. Turnbull*	*University of New Brunswick*	*1996*	*Mark Pell*	*McGill University*
	Fangxin Chen	*University of Alberta*	*1997*	*Monica Rohlfs*	*University of Alberta*
	Leonard E. Cornelisse	*University of Western Ontario*	*1998*	*Marlene Bagatto*	*University of Western Ontario*
1993	*Aloknath De*	*McGill University*	*1999*	*William Hodgetts*	*University of Western Ontario*
1994	*Michael Lantz*	*Queen's University*			

Fessenden Student Prize in Underwater Acoustics

The prize is made to a graduate student enrolled at a Canadian university and conducting research in underwater acoustics or in a branch of science closely connected to underwater acoustics. It consists of $500 cash prize to be awarded annually. Coordinator: David Chapman, DREA, PO Box 1012, Dartmouth, NS B2Y 3Z7.

1992	*Daniela Dilorio*	*University of Victoria*	*1996*	*Dean Addison*	*University of Victoria*
1993	*Douglas J. Wilson*	*Memorial University*	*1999*	*Nicolle Collison*	*University of Victoria*
1994	*Craig L. McNeil*	*University of Victoria*			

Eckel Student Prize in Noise Control

The prize is made to a graduate student enrolled at a Canadian academic institution pursuing studies in any discipline of acoustics and conducting research related to the advancement of the practice of noise control. It consists of a $500 cash prize to be awarded annually. The prize was inaugurated in 1991. Coordinator: Murray Hodgson, Occupational Hygiene Programme, University of British Columbia, 2206 East Mall, Vancouver, BC V6T 1Z3.

1994	*Todd Busch*	*University of British Columbia*	*1997*	*Andrew Wareing*	*University of British Columbia*
1995	*Raymond Panneton*	*Université de Sherbrooke*	*1999*	*Pierre Germain*	*University of British Columbia*
1996	*Nelson Heerema*	*University of British Columbia*			

Directors' Awards

Three awards are made annually to the authors of the best papers published in *Canadian Acoustics.* All papers reporting new results as well as review and tutorial papers are eligible; technical notes are not. The first award, for $500, is made to a graduate student author. The second and third awards, each for $250, are made to professional authors under 30 years of age and 30 years of age or older, respectively. Coordinator: Delila Giusti, Jade Acoustics, Concord, ON L4K 4H1.

Student Presentation Awards

Three awards of $500 each are made annually to the undergraduate or graduate students making the best presentations during the technical sessions of Acoustics Week in Canada. Application must be made at the time of submission of the abstract. Coordinator: Karen Fraser, CN Rail, Toronto ON , Tel: (416) 217-6466.

The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

ANNONCE DE PRIX

Plusieurs prix, dont les objectifs généraux sont décrits ci-dessous, sont décernés par l'Association Canadienne d'Acoustique. Pour les quatre premiers prix, les candidats doivent soumettre un formulaire de demande ainsi que la documentation associée au coordonnateur de prix avant le dernier jour de février de l'année durant laquelle le prix sera décerné. Toutes les demandes seront analysées par des sous-comités nommés par le président et la chambre des directeurs de l'Association. Les décisions seront finales et sans appel. L'Association se réserve le droit de ne pas décerner les prix une année donnée. Les candidats doivent être membres de l'Association. La préférence sera donnée aux citoyens et aux résidents permanents du Canada. Les candidats potentiels peuvent se procurer de plus amples détails sur les prix, leurs conditions d'éligibilité, ainsi que des formulaires de demande auprès du coordonnateur de prix.

Prix Post-Doctoral Edgar et Millicent Shaw en Acoustique

Ce prix est attribué à un(e) candidat(e) hautement qualifié(e) et détenteur(rice) d'un doctorat ou l'équivalent, qui a complèté(e) ses études et sa formation de chercheur, et qui désire acquérir jusqu'à deux années de formation supervisée de recherche dans un établissement reconnu. Le thème de recherche proposée doit être relié à un domaine de l'acoustique, de la psycho-acoustique, de la communication verbale ou du bruit. La recherche doit être menée dans un autre milieu que celui où le candidat a obtenu son doctorat. Le prix est de $3000 pour une recherche plein temps de 12 mois avec possibilité de renouvellement pour une deuxième année. Coordonnatrice: Sharon Abel, Mount Sinai Hospital, 600 University Avenue, Toronto, ON M5G 1X6. Les récipiendaires antérieur(e)s sont:

1990	*Li Cheng*	*Université de Sherbrooke*	*1995*	*Jing-Fang Li*	*University of British Columbia*
1993	*Roland Woodcock*	*University of British Columbia*	*1996*	*Vijay Parsa*	*University of Western Ontario*
1994	*John Osler*	*Defense Research Estab. Atlantic*	*1999*	*Jingnan Guo*	*University of British Columbia*

Prix Étudiant Alexander Graham Bell en Communication Verbale et Acoustique Comportementale

Ce prix sera décerné à un(e) étudiant(e) inscrit(e) dans une institution académique canadienne et menant un projet de recherche en communication verbale ou acoustique comportementale. Il consiste en un montant en argent de $800 qui sera décerné annuellement. Coordonnateur: Don Jamieson, Department of Communicative Disorders, University of Western Ontario, London, ON N6G 1H1. Les récipiendaires antérieur(e)s sont:

1990	*Bradley Frankland*	*Dalhousie University*	*1995*	*Kristina Greenwood*	*University of Western Ontario*
1991	*Steven D. Turnbull*	*University of New Brunswick*	*1996*	*Mark Pell*	*McGill University*
	Fangxin Chen	*University of Alberta*	*1997*	*Monica Rohlfs*	*University of Alberta*
	Leonard E. Cornelisse	*University of Western Ontario*	*1998*	*Marlene Bagatto*	*University of Western Ontario*
1993	*Aloknath De*	*McGill University*	*1999*	*William Hodgetts*	*University of Western Ontario*
1994	*Michael Lantz*	*Queen's University*			

Prix Étudiant Fessenden en Acoustique Sous-marine

Ce prix sera décerné à un(e) étudiant(e) inscrit(e) dans une institution académique canadienne et menant un projet de recherche en acoustique sous-marine ou dans une discipline scientifique reliée à l'acoustique sous-marine. Il consiste en un montant en argent de $500 qui sera décerné annuellement. Coordonnateur: David Chapman, DREA, PO Box 1012, Dartmouth, NS B2Y 3Z7.

1992	*Daniela Dilorio*	*University of Victoria*	*1996*	*Dean Addison*	*University of Victoria*
1993	*Douglas J. Wilson*	*Memorial University*	*1999*	*Nicolle Collison*	*University of Victoria*
1994	*Craig L. McNeil*	*University of Victoria*			

Prix Étudiant Eckel en Contrôle du Bruit

Ce prix sera décerné à un(e) étudiant(e) inscrit(e) dans une institution académique canadienne dans n'importe quelle discipline de l'acoustique et menant un projet de recherche relié à l'avancement de la pratique en contrôle du bruit. Il consiste en un montant en argent de $500 qui sera décerné annuellement. Ce prix a été inauguré en 1991. Coordonnateur: Murray Hodgson, Occupational Hygiene Programme, University of British Columbia, 2206 East Mall, Vancouver, BC V6T 1Z3.

1994	*Todd Busch*	*University of British Columbia*	*1997*	*Andrew Wareing*	*University of British Columbia*
1995	*Raymond Panneton*	*Université de Sherbrooke*	*1999*	*Pierre Germain*	*University of British Columbia*
1996	*Nelson Heerema*	*University of British Columbia*			

Prix des Directeurs

Trois prix sont décernés, à tous les ans, aux auteurs des trois meilleurs articles publiés dans l'*Acoustique Canadienne.* Tout manuscrit rapportant des résultats originaux ou faisant le point sur l'état des connaissances dans un domaine particulier sont éligibles; les notes techniques ne le sont pas. Le premier prix, de $500, est décerné à un(e) étudiant(e) gradué(e). Le deuxième et le troisième prix, de $250 chacun, sont décernés à des auteurs professionnels âgés de moins de 30 ans et de 30 ans et plus, respectivement. Coordonnateur: Delila Giusti, Jade Acoustics, Concord, ON L4K 4H1.

Prix de Présentation Étudiant

Trois prix, de $500 chacun, sont décernés annuellement aux étudiant(e)s sous-gradué(e)s ou gradué(e)s présentant les meilleures communications lors de la Semaine de l'Acoustique Canadienne. La demande doit se faire lors de la soumission du résumé. Coordonnateur: Karen Fraser, CN Rail, Toronto ON, Tel: (416) 217-6466.

Canadian Acoustical Association
l'Association Canadienne d'Acoustique

1999 PRIZE WINNERS / RÉCIPIENDAIRES 1999

Edgar and Millicent Shaw Postdoctoral Prize in Acoustics
Prix Post-Doctoral Edgar et Millicent Shaw en Acoustique

Jingnan Guo, University of British Columbia

"Active noise control in non-diffuse sound field"

Alexander Graham Bell Prize in Speech Communication and Behavioural Acoustics
Priz Alexander Graham Bell en Communication Verbale et Acoustique Comportementale

William Ernest Hodgetts, University of Western Ontario

"The effects of modulation spectrum phase distortion on speech intelligibility for hearing impaired listeners"

Fessenden Student Prize in Underwater Acoustics
Prix Étudiant Fessenden en Acoustique Sous-marine

Nicolle Ellen Collison, University of Victoria

"Source localization using regularized matched-mode processing"

Eckel Student Prize in Noise Control
Prix Étudiant Eckel en Contrôle du Bruit

Pierre Germain, University of British Columbia

"Feasibility of using active noise control techniques to further manage run-up noise at Vancouver international airport"

Directors' Awards / Prix des Directeurs

Professional ≥30 years / Professionel ≥30 ans:

Sid-Ali Meslioui, Aiolos Engineering Corporation

"Analytical formulation of the radiation of sound from a rectangular duct"

Student / Étudiant(e):

Rebecca Reich

"Optimizing classroom acoustics using computer model studies"

Student Awards / Prix Étudiant

Pierre Germain, University of British Columbia

"Feasibility of using active noise control techniquesto further manage run-up noise at Vancouver international airport"

Michael Riedel, University of Victoria

"AVO Investigations of shallow marine sediments"

Nathalie Hubert, University of British Columbia

"The perception of spoken language by elderly listeners: contribution of auditory temporal processes"

CONGRATULATIONS / FÉLICITATIONS

Appel de Communications
Semaine canadienne d'acoustique 2000
Hôtel Delta, Sherbrooke, Qc
28-29 septembre, 2000

COMITÉ D'ORGANISATION

GAUS
GROUPE D'ACOUSTIQUE DE L'UNIVERSITÉ DE SHERBROOKE

La semaine de l'acoustique canadienne de l'an 2000 se déroulera à l'hôtel Delta de Sherbrooke, Québec, du 28-29 septembre 2000. La semaine sera organisée, sous l'égide de la société canadienne d'acoustique, par le groupe d'acoustique de l'Universite de Sherbrooke. Le professeur Noureddine Atalla de l'université de Sherbrooke agira comme président et le professeur Alain Berry de l'université de Sherbrooke agira comme directeur du programme technique.

Courriel : caa2000@gaus.gme.usherb.ca
Site web : http://www-gaus.gme.usherb.ca

PROGRAMMES SCIENTIFIQUES ET TECHNIQUES

Le comité d'organisation planifie un programme technique de grand calibre avec une emphase particulière sur **le contrôle du bruit industriel**. Le congrès comprend des conférences générales et des communications sur invitation , des sessions et des expositions techniques. Les sujets traités recouvrent :

Le contrôle actif du bruit et des vibrations
Les méthodes analytiques et numériques
Acoustique architecturale
Propagation du son
Perception et production du langage
Audiologie

Contrôle du bruit industriel
L'acoustique structural et les vibrations
Aéroacoustique
Psycho-acoustique
Acoustique musicale
Normalisation canadienne

Matériaux acoustiques
Acoustique sous-marine
Physio-acoustique
Qualité du son
Règlements et bruit environnemental

Enseignement et démonstration en acoustique et Vibrations, **et tout autre sujet relevant de l'acoustique.**

RÉSUMÉS

Les résumés de 250 mots maximum doivent être soumis avant le 30 avril 2000. Les résumés devront être préparés suivant les instructions incluses dans ce numéro d'*Acoustique Canadienne*. Les soumissions par courrier électronique sont fortement encouragées; les documents peuvent être édités avec n'importe quel traitement de texte. Pour ceux qui n'ont pas accès au courrier électronique, les documents digitaux sur disquette ou papier devront être envoyés à l'adresse indiquée dans les instructions. Une notification d'acceptation des résumés sera envoyée aux auteurs avant le 15 mai 2000 avec un formulaire d'inscription. Un sommaire de la présentation devra être envoyé avant le 15 juillet 2000. Cette échéance sera strictement respectée afin de pouvoir publier le programme dans les actes d'*Acoustique Canadienne.*

Les propositions pour les sessions spéciales sur un sujet particulier en acoustique sont les bienvenues. Contactez Dr A. Berry (alain.berry@gme.usherb.ca) avant le 31 mai 2000 si vous désirez organiser une session spéciale durant la conférence de cette année.

La participation d'étudiants à cette Semaine Canadienne d'Acoustique est fortement encouragée. Des prix seront attribués aux meilleures présentations. Les étudiants doivent indiquer leur intention de participer en complétant le formulaire « Prix annuels relatifs aux communications étudiantes » et en le joignant à leur résumé. Les étudiants présentant une communication peuvent aussi faire une demande de subvention pour leur frais de déplacement si ils résident à plus de 150 km de Sherbrooke, Qc. Pour demander cette subvention, les étudiants doivent soumettre le formulaire de demande de remboursement pour frais de déplacement inclus dans ce numéro.

HÉBERGEMENT

L'hébergement des participants à la Semaine Canadienne d'Acoustique et les communications se tiendront à l'hôtel delta (http://www.deltahotels.com/properties/sherbrk.html), située au centre ville de Sherbrooke.
Les participants bénéficient de tarifs spéciaux pour les chambres commençant à 95$ par nuit. Pour réserver votre chambre, contacter l'hôtel delta par téléphone (1 800 268-1133) ou fax (819-822-8990) en mentionnant votre participation à la Semaine Canadienne d'Acoustique 2000. Les tarifs préférentiel est garantie jusqu'au 27 août 2000.

Pour d'autres hôtels et auberges visiter le site web de la ville de Sherbrooke au http://www.sders.com/tourisme.

EXPOSITIONS

Une exposition permanente présentant les développements récents des techniques sur les équipements en acoustique et vibration, les instruments, les matériaux et les logiciels se tiendra en parallèle aux autres présentations.
Des espaces seront disponibles pour des Expositions de sociétés et d'organisations dans le domaine de l'acoustique. Des **sponsors** pour les causes alimentaires et/ou déjeuners sont aussi les bienvenus. Si vous êtes intéressés par l'une de ses offres, contacter Rémy Oddo (819) 821-8000 x1965, remy.odd@gme.usherb.ca

DATES IMPORTANTES

31 mai, 2000	Échéance pour la soumission des résumés
15 juin, 2000	Notification d'acceptation des résumés
31 juillet, 2000	Échéance pour la réception des sommaires et les premières inscriptions
28-29 septembre, 2000	Semaine Canadienne d'Acoustique 2000

Pour plus d'informations contacter :

Semaine Canadienne d'Acoustique 2000
c/o Dr. Noureddine Atalla
Génie mécanique, Université de Sherbooke
Sherbooke (Qc), Canada J1K 2R1
Téléphone : (819) 821-8000 x1209 Fax : (819) 821-7163
Noureddine.atalla@gme.usherb.ca

Call for papers
Acoustics Week in Canada 2000
Delta Hotel, Sherbrooke, Qc
2000, September 28-29

ORGANISING COMMITTEE

GAUS
GROUPE D'ACOUSTIQUE DE L'UNIVERSITÉ DE SHERBROOKE

Acoustics Week in Canada 2000 will be held at the Delta hotel, in Sherbrooke, Quebec, in 2000 september. The week will open on Thursday, September 28 and will conclude in the afternoon of September 29. The conference, sponsored by the Canadian Acoustics Association, will be organized by the groupe d'acoustique de l'Universite de Sherbrooke. Professor Noureddine Atalla of l'université de Sherbrooke is the president of CAA2000. Professor Alain Berry of l'université de Sherbrooke is the Technical Program Chair.

Conference Email : caa2000@gaus.gme.usherb.ca
Web Site : http://www-.gaus.gme.usherb.ca

SCIENTIFIC AND TECHNICAL PROGRAMS

The organizing committee is planning a high caliber and motivating technical program. The program will deal with topics from throughout the field of acoustics and vibrations with a special emphasis **on industrial passive and active control**. The meeting will consist of an opening plenary lecture, invited and contributed papers and exhibits. Technical papers in all areas of noise control engineering will be considered for presentation at the conference. The following technical areas are of particular interest:

Active Noise Control for Industry
Analytical and Numerical prediction tools in Acoustics
Building acoustic
Outdoor sound propagation
Speech perception and production
Occupational Hering Loss and Hearing protection
Industrial Noise Control - case studies
Structural acoustics and vibrations
Aeroacoustics
Psycho-acoustics
Musical acoustics
Canadian Standards
Acoustic materials
Underwater acoustics
Physiological acoustics
Sound quality
Legislation /Environmental Noise
Education and Demonstration in Noise Control Engineering, **and other related topics**

ABSTRACTS

Abstracts of a maximum 250 words must be submitted by May 31, 2000. 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 in the instructions. Notification of acceptance of abstracts will be sent to authors by Mai 15, 2000 along with a registration form. Summary papers are due July 15, 2000. This deadline will be strictly enforced to meet the publication schedule of the proceedings issue of *Canadian Acoustics*.

Proposals for **Special Sessions** on a particular topic in acoustics are welcome. Contact Dr. Alain Berry (alain.berry@gme.usherb.ca) prior to Mai 31, 2000 if you are interested in having a special session at this year's meeting.

Student participation in Acoustics Week in Canada 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 meeting if they live at least 150 km from Sherbrooke, Qc. To apply for this subsidy, students must submit an *Application For Student Travel Subsidy*, included in this issue.

ACCOMMODATION

Accommodation and meeting space for delegates of Acoustics Week in Canada 2000 will be at the Delta Hotel (http://www.deltahotels.com/properties/sherbrk.html) located in downtown Sherborooke, Qc. The special room rate for delegates are at $95.00 per night. To reserve your accommodation, please contact the hotel directly by telephone (1 800 268-1133), Fax (819-822-8990) and mention the identification code: GPACOU. The reservation cut-off date is August 27, 2000. After these dates, the special rates are subject to availability.

There are several other hotels for every budget, located within walking distances from the conference site. For details, check the toursit web site of Sherbrooke : http://www.sders.com/tourisme.

EXHIBITS

A permanent exhibition showing the latest technologies in acoustics and vibration equipment, instrumentation, materials and software will be open continuously during the congress.

Space will be available for **exhibits** by companies and organizations in the field of acoustics. **Sponsorship** of nutrition breaks and/or lunches is also welcome. If you are interested in either of these opportunities, please contact Rémy Odd (819) 821-8000x1965, remy.odd@gme.usherb.ca

IMPORTANT DATES

May 31, 2000	Deadline for submission of abstracts
June 15, 2000	Notification of acceptance of abstracts
July 31, 2000	Deadline for receipt of summary paper and early registration
September 28-29, 2000	Acoustics week in Canada 2000

For more information contact :

Acoustics Week in Canada 2000
c/o Dr. Noureddine Atalla
Génie mécanique, Université de Sherbooke
Sherbooke (Qc), Canada J1K 2R1
Téléphone : (819) 821-8000 x1209 Fax : (819) 821-7163
Noureddine.atalla@gme.usherb.ca

CAA Student Travel Subsidy and Student Presentation Award
Application Form
DEADLINE FOR RECEIPT 1, August, 2000

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	**Signature of University Supervisor**
____________________	____________________
I certify that the Information provided above is correct	I certify that the applicant is a full time student
____________________	____________________
Print Name	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 2000

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	**Signature du superviseur**
______________________________	______________________________
Je certifie que les informations fournies ci dessus sont correctes	Je certifie que le signataire est un étudiant à temps plein
______________________________	______________________________
Nom	**Nom**

Canadian Acoustical Association
Minutes of the Annual General Meeting
18 October 1999
Laurel Point Inn
Victoria, BC

Meeting called to order at 8:10 p.m.

Minutes of the 30 October 1998 Annual General meeting were approved as written in the December 1998 issue of Canadian Acoustics. (Moved by A. Behar, seconded by C. Andrew, carried).

President's Report
J. Bradley discussed the recently revised Operations Manual which, contains the by-laws of the corporations and describes the positions and responsibilities of Board and Executive. The issue of quorum at board meetings was discussed and was differed until later in the meeting. (Currently, five of the eight directors must be in attendance to achieve quorum: the Executive may voice opinions but can not vote). (Acceptance of the President's report was moved by R. Ramakrishnan, seconded by D. Giusti, carried).

Secretary's Report
T. Nightingale reported that the membership is up slightly over the same time last year. The total paid membership (including non-voting journal subscriptions) is 346 as of 14 October 1999. Secretarial operating costs for the fiscal year (01 August 1998 to 01 August 1999) were $1070. (Acceptance of the Secretary's report was moved by T. Kelsall, seconded by D. Giusti, carried).

Treasurer's Report
J. Bradley read a written report prepared by the Treasurer. The Treasurer's report indicated that the finances have stabilized since the membership fee increase in 1996. The sum of $20,000 was transferred from the operating account to the capital account. The Treasurer's regrettably included notice of his resignation. J. Bradley thanked him for his service as Treasurer. (Acceptance of the Treasurer's report was moved by C. Sherry, seconded by A. Behar, carried).

Membership Chair's Report
The Chair reported of the continuing work on the CAA Website (located on the server of the University of Western Ontario at WWW://uwo.ca/hhcru/caa/). There was much discussion as how the organization could best attract and retain new members. Ideas included regional chapter meetings, contacting non-traditional areas such as planners, and regulators.

Editor's Report and New Initiative on Canadian Acoustics
R. Ramakrishnan reported that the subcommittee to enhance the journal had several ideas to enhance the journal and that some of these had already be implemented, e.g., publishing Ph.D. abstracts. It was also reported that the new publishing software used to produce the September issue caused some problems with the figures in some papers. It was also reported that due to a mistake at the printers a small number of journals were printed without pages 60 and 61. Unfortunately, there are no extra copies from the printing to replace the incomplete issues.

Past and Future Conferences
1998 London: D. Jamieson reported that the conference books have been closed. In summary, 83 persons registered and a surplus of $735 was realized. D. Jamieson and M. Cheeseman were thanked for making the London Conference a success.
1999 Victoria: S. Dosso reported that things had gone very smoothly due in part to the help of Susan Dunlop of the University of Victoria. It was reported that there should be sufficient persons registered to ensure a small surplus. The board thanked the organizing committee for their work.
2000 Sherbrooke: J. Bradley read from a written report provided by N. Atalla which indicated that organization for next year's conference is well underway.
2001 Toronto: It was announced that D. Giusti agreed to chair the conference.
2002: An East Coast venue might be desirable. Volunteers are welcome.

Award Coordinator's Report
A. Cohen provided a written report summarizing the Awards activities this year. The following is a summary by prize:

Edgar and Millicent Shaw Postdoctoral Prize in Acoustics: The prize was awarded to Jingnan Guo. S. Abel is the prize coordinator.

Alexander Graham Bell Graduate Student Prize in Speech Communication and Behavioural Acoustics: The prize was awarded to Hodgetts. D. Jamieson is the prize coordinator.

Fessendon Student Prize in Underwater Acoustics: The prize was awarded to Nicole Ellen Collison. D. Chapman is the prize coordinator.

Eckel Student Prize in Noise Control: The prize was awarded to Pierre Germain. M. Hodgson is the prize co-ordinator.

CAA Canada-Wide Science Fair Award (Youth Science Foundation): Alan Kaufman and Kodie Taber (Edmonton): Project Title Aqua-link. A. Cohen is the prize co-ordinator.

Raymond Hetu Memorial Undergraduate Award: Book prize: Advertisement of this new prize was not undertaken this year. The committee will develop a description of the competition for inclusion in the brochure next year. The final wording of the description can be brought to the Board of Directors at the spring meeting. Meantime the committee will select a member of Board to administer the prize.

Directors' Awards: For best papers in *Canadian Acoustics*. D. Giusti is the prize co-ordinator. Best student paper: Rebecca Reich (with john Bradley) Best paper by a professional over 30: Sid-Ali Meslioui

Student Presentation Awards: Pierre Germain, Michael Rideau, and Natalie Haubert were the recipients. R. Ramakrishnan was the co-ordinator.

Both the Award Co-ordinator and the Board thanked S. Dosso and the local organising committee for taking the initiative to have certificates printed for each of the prizes. The certificates will be awarded to the prize recipient at the banquet of the Victoria Conference. It was recommended that certificates be awarded in the future.

New Initiatives

a). Possible by-law changes
J. Bradley reported that changing the by-laws was very complex and that the quorum issue could not be resolved at one meeting. He added that the Board agreed to differ by-law changes to a sub-committee consisting of J. Bradley, D. Whicker, C. Sherry and T. Nightingale who will create a proposal for change that will be tabled at the spring board meeting.

b). Outreach and the CAA Website
T. Nightingale reported on activity to increase the appeal and number of hits to the web site. Activities included T. Nightingale investigating the cost of registering "Canadian Acoustical Association" as a domain name and D. Whicker approaching a seasoned website designer for volunteered services. Progress reports would be given at the spring BoD.

Nomination Committee
Departing directors A. Cohen and W. Sydenborgh were thanked. The Committee recommended the following slate of candidates for (re)election:

President: J. Bradley
Treasurer: D.Giusti
Secretary: T. Nightingale
Editor: R. Ramakrishnan
Membership Chair: D. Jamieson
Board Members: N. Atalla, M. Cheeseman, D. DeGagne, K. Fraser, T. Kelsall, K. Pichora-Fuller, D. Stredulinsky, D. Whicker.

Nominations from the floor were invited. None were received. The slate as forwarded by the Committee was elected by acclamation.

Other Business
C. Sherry moved that the membership fees remain fixed at FY98/99 levels. Motion seconded by D. Whicker, carried.

There was general discussion regarding the preparation of an operating budget for FY99/00. The newly elected Treasurer, D. Giusti, was asked to prepare a budget to be tabled at the Spring BoD meeting

J. Bradley reported that INCE USA had approached CAA to participate in the December 2002 conference to be held in Dearborn MI. The Board had agreed that CAA would provide announcement space in Canadian Acoustics if INCE would provide similar space in Noise New International for an upcoming CAA conference.

Adjourn
D. Whicker moved to adjourn the meeting. A. Behar seconded the motion, carried. Meeting adjourned at 9:39 p.m.

Canadian Acoustical Association
Minutes of the Board of Directors Meeting
17 October 1999
Laurel Point Inn
Victoria, BC

Present: J. Bradley, T. Nightingale, D. DeGagne, D. Giusti, R. Ramakrishnan, D. Jamieson, K. Pichora-Fuller, S. Dosso, D. Whicker, T. Kelsall

Regrets: J. Hemingway, A. Cohen, N. Atalla, W. Sydenborgh.

Meeting called to order at 12:10 p.m.

Minutes of the 05 June Board of Director's meeting were approved as written in the June 1999 issue of Canadian Acoustics. (Moved by D. Giusti, seconded by S. Dosso, carried).

President's Report

J. Bradley made available copies of the recently revised Operations Manual that contains the by-laws of the corporation, and describes the positions and responsibilities of Board and Executive. The issue of quorum at board meetings was discussed and was differed until later in the meeting. (Currently, five of the eight directors must be in attendance to achieve quorum: the Executive may voice opinions but can not vote). (Acceptance of the President's report was moved by R. Ramakrishnan, seconded by K. Pichora-Fuller, carried).

Secretary's Report

T. Nightingale was very pleased to report that the membership is up slightly over the same time last year. The total paid membership (including non-voting journal subscriptions) is 346 as of 14 October 1999. The same time one year earlier the number was 341. Two years earlier it was 346. The membership is holding reasonably constant. There was considerable discussion regarding the potential benefit(s) of CAA obtaining a Visa and/or MasterCard vendor's account so that CAA can accept membership dues and conference registration fees using credit cards. D. Whicker moved that, "the new treasurer investigate the costs associated with obtaining a vendor's account and report to the Board at the spring meeting." The motion was seconded by D. DeGagne and carried. Secretarial operating costs were higher this year than last due to a one-time cost associated with integrating the student awards mailing list with the membership database. This integration will make announcements of student awards and travel subsidies much easier. Operational costs for the fiscal year (01 August 1998 to 01 August 1999) were $1070. (Acceptance of the Secretary's report was moved by R. Ramakrishnan, seconded by D. Jamieson, carried).

Treasurer's Report

The Treasurer provided a written report, which included a copy of the auditor's report. Both the Treasurer's and the Auditor's reports indicate that the finances of the CAA have stabilized since the membership fee increase in 1996. The sum of $20,000 was transferred from the operating account to the capital account (as per the instruction made by the board at the June meeting). The Treasurer indicated his intention to resign at the Annual General Meeting. Board members expressed their thanks to John for his work as Treasurer. The board requested that the new Treasurer, upon accepting office, prepare a business plan for the next fiscal year. (Acceptance of the Treasurer's report was moved by R. Ramakrishnan, seconded by D. Giusti, carried).

Membership Chair's Report

Improvement of the CAA Website (located on the server of the University of Western Ontario at WWW://uwo.ca/hhcru/caa/) continued throughout the year. There was much discussion as how the organization could best attract and retain new members. Ideas included regional chapter meetings, contacting non-traditional areas such as planners, and regulators. J. Bradley informed the board that he was in the process of writing a letter to members of the Acoustical Society of America who lived in Canada but were not CAA members. This represents over 150 persons.

Editor's Report and New Initiative on Canadian Acoustics

R. Ramakrishnan reported that the new publishing software can be awkward when importing windows metafiles or files containing a table. This affected some of the summary papers appearing in the September journal. It was also reported that due to a mistake at the printers a small number of journals were printed without pages 60 and 61. Unfortunately, there are no extra copies from the printing to replace the incomplete issues. R. Ramakrishnan reported that the subcommittee to enhance the journal had several ideas. These included publishing Ph.D. abstracts, overviews of acoustics groups/departments in Canada, publishing table of contents of each issue on the website, biographies of persons receiving awards and of persons that have made a very significant contribution to the Association. T. Kelsall agreed to collect biographies. It was also suggested that the recipient of the Shaw Prize publish their annual progress report in the journal. (Acceptance of the Treasurer's report was moved by T. Kelsall, seconded by K. Pichora-Fuller, carried).

Past and Future Conferences

1998 London: D. Jamieson reported that the conference books have been closed and that there was nothing new to report beyond what had already been reported in June, namely that 83 persons registered for the London conference and that after all expenses a surplus of $735 was realized. The Board thanked D. Jamieson and M. Cheeseman for making the London Conference a success.

1999 Victoria: S. Dosso reported that things had gone very smoothly due in part to the help of Susan Dunlop of the University of Victoria. It was reported that there should be sufficient persons registered to ensure a small surplus. The board thanked the organizing committee for their work. (Acceptance of the Convener's report was moved by D. DeGagne, seconded by R. Ramakrishnan, carried).

2000 Sherbrooke: N. Atalla provided a written report which indicated that organization for next year's conference is well underway.

2001 Toronto: D. Giusti agreed to chair the conference.

2002: There was some discussion of possible locations and it was thought that an East Coast venue might be desirable. Volunteers are welcome.

Award Coordinator's Report

A. Cohen provided a written report summarizing the Awards activities this year. The following is a summary by prize:

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CAA Canada-Wide Science Fair Award (Youth Science Foundation): Alan Kaufman and Kodie Taber (Edmonton): Project Title Aqua-link. A. Cohen is the prize co-ordinator.

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Best student paper: Rebecca Reich (with John Bradley)
Best paper by a professional over 30: Sid-Ali Meslioui

Both the Award Co-ordinator and the Board thanked S. Dosso and the local organising committee for taking the initiative to have certificates printed for each of the prizes. The certificates will be awarded to the prize recipient at the banquet of the Victoria Conference. It was recommended that certificates be awarded in the future. The Board thanked all the co-ordinators for their work administrating the prizes especially A. Cohen who steps-down this year as Award Coordinator. K. Pichora-Fuller agreed to assume the role.

New Initiatives

a). Possible by-law changes

J. Bradley discussed the need to change the by-laws to make it easier for quorum to be obtained at Board meetings. Five, or more, of the eight board of directors must be present at a meeting if motions are to be voted upon. The Executive can not vote. The existing by-laws were discussed at great length and resulted in the acceptance that the issue was too complex to be resolved at one meeting. The issue was differed to a sub-committee consisting of J. Bradley, D. Whicker, T. Nightingale and C. Sherry who were charged with the responsibility of creating a proposal for change and tabling it at the spring board meeting.

b). Outreach and the CAA Website

T. Nightingale reported that a list of persons who cancelled their membership in the last three years was circulated to the Board. Attempts to contact several of these persons but nearly 80% had moved and failed to inform CAA of their new address, phone number and e-mail, etc. The Board requested that a list of cancelled members be circulated each year. There was considerable discussion regarding the website and how to make it more accessible. One possible method would be to register "Canadian Acoustical Association" as a domain name. This should increase the number of 'hits' at our site. T. Nightingale volunteered to investigate the procedure and cost in registering a domain name. Ideas for improving the appeal included listing Canadian universities having courses and offering degrees in acoustics, listing the abstracts of papers appearing in Canadian Acoustics, providing summaries and application notes for CSA standards, etc. The board felt that we must assess the cost and difficulty associated with expanding the scope of our site. D. Whicker agreed to approach a person who had created and maintains several web sites to obtain this information. Both T. Nightingale and D. Whicker agreed to report their findings at the spring board meeting.

Other Business

W. Sydenborgh announced his intention to resign as a member of the board. The Board thanked him for his service.

D. DeGagne reported on efforts of the newly formed Alberta Acoustical Society to promote acoustics awareness in Alberta. It was stressed that the AAS did not wish to compete with the CAA, but rather wished to support the CAA. This would, in part, be accomplished by requiring that AAS members also be members of the CAA. Currently, the AAS has 45 members and sponsors an annual conference.

Adjournment

D. Giusti moved to adjourn the meeting, seconded by D. DeGagne, carried. Meeting adjourned at 5:10 p.m.

Special Action Items Arising from the Meeting

J. Bradley

In consultation with the sub-committee, create a proposal for changing the by-laws along with a draft revision that will be circulated to Board of Directors and Executive before the spring Board meeting.

T. Nightingale

Investigate the cost of obtaining a domain name for the CAA.

D. Whicker

Investigate the cost and effort associated with expanding the CAA website by approaching a known expert.

Treasurer (to be elected at the AGM)

Prepare a business plan for FY99/00 for the spring Board meeting.

Investigate the cost to CAA in obtaining a VISA or MasterCard vendor's account and report at the spring Board meeting.

The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

MEMBERSHIP DIRECTORY 1999 / ANNUAIRE DES MEMBRES 1999

The number that follows each entry refers to the areas of interest as coded below.

Le nombre juxtaposé à chaque inscription réfère aux champs d'intérêt tels que condifés ci-dessous

Areas of interest		Champs d'intérêt
Architectural acoustics	1	Acoustique architecturale
Engineering Acoustics / noise Control	2	Génie acoustique / Contrôle du bruit
Physical Acoustics / Ultrasonics	3	Acoustique physique / Ultrasons
Musical Acoustics / Electroacoustics	4	Acoustique musicale / Electroacoustique
Psycho- and Physio-acoustics	5	Psycho- et physio-acoustique
Shock and Vibration	6	Chocs et vibrations
Hearing Sciences	7	Audition
Speech Sciences	8	Parole
Underwater Acoustics	9	Acoustique sous-marine
Signal Processing / Numerical Methods	10	Traitement des signaux / Méthodes numériques
Other	11	Autre

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