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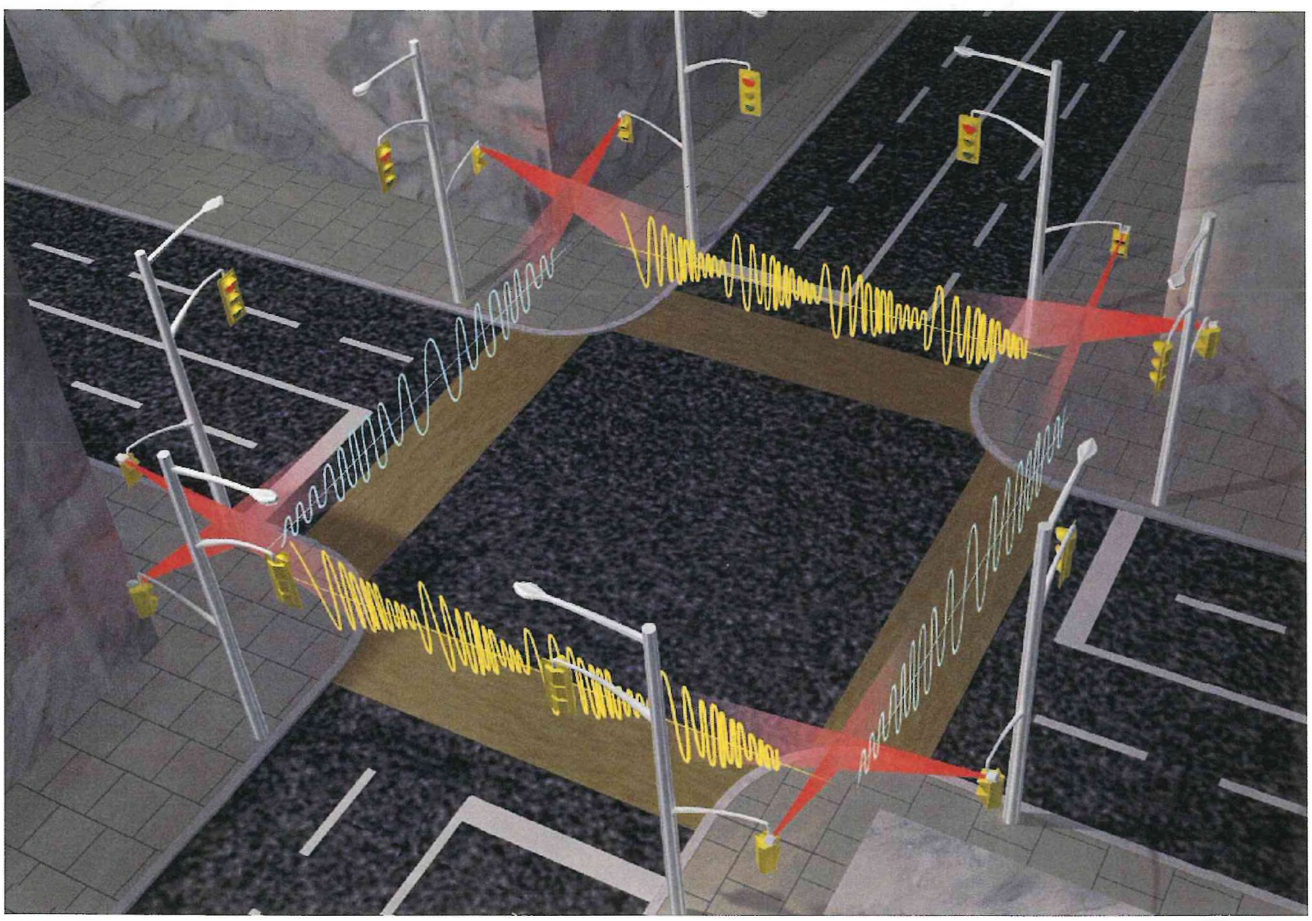

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ÉDITORIAL / EDITORIAL

Il y a un an déjà, j'avais l'honneur de signer un de mes premiers éditoriaux dans l'Acoustique Canadienne, à titre de rédactrice-adjointe. Notre rédacteur en chef, Ramani Ramakrishnan, m'avait invitée à rédiger l'éditorial du mois de juin 2002 et désirait instituer une tradition, soit que le rédacteur adjoint signe l'éditorial de juin à chaque année. J'ai accepté ce mandat avec joie et espère être à la hauteur.

Ramani a aussi eu l'idée de lancer une autre mode, soit celle d'inviter spécialement les intervenants francophones dans le domaine de l'acoustique à soumettre un article rédigé dans leur langue maternelle, soit le français. Nous nous assurerons que le numéro de juin compte toujours au moins un article en français. Cette initiative ne signifie en rien que les articles francophones ne puissent être publiés à d'autres moments de l'année. Nous débutons donc cette vague avec un article rédigé par des étudiantes du programme d'audiologie et d'orthophonie de l'Université d'Ottawa, sous la supervision de Chantal Laroche. Je vous vois déjà sourire! Sans vouloir me défendre, je voulais encourager deux étudiantes qui ont réalisé un projet intéressant, soit de mesurer le bruit aux abords d'un service de garde situé le long d'une autoroute, à s'initier à la rédaction d'un article scientifique. Pour ceux d'entre vous pour qui la lecture du français présente un défi, je vous encourage à lire le sommaire en anglais. Vous réaliserez que l'implantation des milieux de garde n'est pas toujours bien réfléchie. Plusieurs enfants canadiens sont exposés à des niveaux de bruit inacceptables pour leur santé, et ce dès le bas âge. Tous les intervenants de l'acoustique peuvent être interpellés par cette problématique. Que l'on soit ingénieur, psychoacousticien, audiologiste ou psychologue, nous avons tous un rôle à jouer pour éviter que la situation relevée dans cet article ne se répète.

Un autre article rédigé en anglais par Giguère, Laroche et Poirier (malgré que tous les auteurs soient francophones!) porte sur une autre problématique multidimensionnelle. Il s'agit de l'évaluation de signaux sonores pour piétons avec troubles visuels. Un ingénieur, une audiologiste et un neuropsychologue ont uni leurs efforts afin d'améliorer le sort des piétons qui ne peuvent compter sur leur vision pour traverser de façon sécuritaire plusieurs intersections routières canadiennes. Ils doivent pouvoir localiser une source sonore afin de s'enligner dans le corridor piétonnier et ne pas dévier dans le trafic. Ce projet démontre l'impact que des intervenants du domaine de l'acoustique peuvent avoir sur la sécurité de nos concitoyens.

Vous pourrez aussi lire un article de Bradley sur l'acoustique des bureaux à aires ouvertes ainsi qu'un article sur les microphones à condensateur écrit par un collègue australien. Enfin, je vous invite à considérer sérieusement participer à la Semaine canadienne de l'Acoustique qui se tiendra en octobre 2003 à Edmonton. Ce congrès promet d'être aussi intéressant que tous ceux qui l'ont précédé.

À juin 2004 pour mon prochain éditorial!

Chantal Laroche

Last year, I had the honor of signing one of my first editorials as assistant editor of the Canadian Acoustics. Our chief-editor, Ramani Ramakrishnan had invited me to write the June 2002 editorial and wanted to initiate a tradition in which the assistant editor would sign the June editorial of each year. I gladly accepted the mandate and hope to measure up to expectations.

Ramani also had the idea of setting another trend: to invite francophone individuals specialized in the field of acoustics to submit an article in French, their native tongue. We will be sure to include at least one French article in every June issue. This initiative by no means prohibits French articles from being published at other times during the year. We thus begin this trend with an article written by students from the Audiology and Speech-Language-Pathology program at the University of Ottawa, under the supervision of Chantal Laroche. I can already see you smile! Without wanting to defend myself, I wanted to encourage these two students to share the results of an interesting study on noise levels outside a day care center located in the vicinity of a freeway, and to initiate them to the writing of a scientific article. Those of you for whom reading in French represents a challenge are encouraged to read the English summary. You will realize that the implementation of day care centers is not always well thought out. Starting at an early age, many Canadian children are exposed to unacceptable noise levels that can be hazardous to their health. Individuals specialized in acoustics should be concerned with this problem. As engineers, psychoacoustic specialists and psychologists, we all have a role to play in making sure that the situation described in this article does not repeat itself.

An article by Giguere, Laroche and Poirier, written in English despite its French authors, deals with another multidimensional problem: the evaluation of sound signals for pedestrians with visual impairment. An Engineer, an audiologist and a neuropsychologist united their efforts to improve the fate of pedestrians who can't rely on their sense of vision to securely cross many Canadian road intersections. These people must localize a sound source to cross a road and avoid wandering off course into the nearby traffic. This project is a fine example of the impact specialists in the field of acoustics can have on the security of fellow citizens.

You can also read an article by Bradley on the acoustics of open-air offices as well as an article on a condenser microphone written by an Australian colleague. Finally, I would like to invite you to participate at the Canadian Acoustics Week that will be held in Edmonton in October 2003. This convention promises to be as interesting as previous ones.

See you again in June 2004 for my next editorial!

Chantal Laroche

EVALUATION OF AUDIBLE TRAFFIC SIGNALS FOR PEDESTRIANS WITH VISUAL IMPAIRMENT

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SUMMARY

Audible signals are used at several road intersections across Canada to enable pedestrians with visual impairment to cross safely. The acoustic parameters can be quite different among the different signals used and this can be the source of particular difficulties for the users. A study was conducted to identify which signal is the easiest to localize, among 6 signals proposed, and which one is judged the safest. Two of the signals (cuckoo and peep-peep) are standardized by the Transportation Association of Canada, and the remaining signals are four variations of the melody signal proposed by the Institut Nazareth et Louis-Braille (Longueuil, QC). A group of 10 subjects with normal vision and 10 subjects with visual impairment participated. Objective sound localization measurements were made outside on a quiet street using a rotating chair as angular pointer. A questionnaire was also administered to obtain an individual appraisal of the 6 signals, and a rating system allowed judging the signals relative to each other. The results for the melody signals varied substantially with the fundamental frequency and harmonic richness of the musical sequence. Two of the melodies, with the lowest fundamental frequency and richest harmonic content, emerged as the best signals overall. Among the standardised signals, the cuckoo provided acceptable performance, but the peep-peep should be abandoned because of very poor subjective assessment.

SOMMAIRE

Des signaux sonores sont utilisés à certaines intersections routières au Canada pour assurer une traversée plus sécuritaire pour les piétons atteints de déficience visuelle. Les paramètres acoustiques peuvent être très différents d'un signal à l'autre et créer des difficultés pour les utilisateurs. Une étude a été menée afin d'identifier lequel, parmi 6 signaux sonores, est le plus facile à localiser, et celui qui est jugé le plus sécuritaire. Deux des signaux (cuckoo et peep-peep) sont normalisés par l'Association des transports du Canada et les autres sont quatre variantes du signal de mélodie proposé par l'Institut Nazareth et Louis-Braille (Longueuil, QC). Un groupe de 10 sujets avec vision normale et 10 sujets avec déficience visuelle ont participé à l'étude. Des mesures objectives de localisation sonore ont été réalisées à l'extérieur sur une rue calme à l'aide d'une chaise pivotante comme pointeur d'angle. Un questionnaire d'appréciation individuelle des 6 signaux devait aussi être complété, et un système permettait de coter les différents signaux entre eux. Les résultats pour les signaux de mélodie variaient sensiblement selon la fréquence fondamentale et la quantité d'harmoniques retenus dans la séquence musicale. Deux des mélodies, possédant la fréquence fondamentale la plus basse et les plus riches en harmoniques, se sont avérées les meilleurs signaux. Parmi les signaux normalisés, le cuckoo a produit un rendement acceptable, mais le peep-peep devrait être abandonné en raison d'un très faible rendement subjectif.

1. INTRODUCTION

For several years, specialists in Orientation and Mobility and blind pedestrians have been questioning the safety of audible traffic signal systems in place at road intersections in many Canadian cities (Hall et al., 1996). An attempt was made to standardize audible traffic signals in 1992 with the A6.80 standard by the Transportation Association of Canada. This standard suggests two audible traffic signals: a 'peep-peep' for crossing East-West and a 'cuckoo' for crossing North-South. The two signals do not seem to have unanimous approval. Many people report that the signals are too similar to environmental sounds, such as the song of birds, and are difficult to hear through the background noise or traffic.

Hall et al. (1996) made an extensive survey of the literature and the audible traffic signals used in many countries, and addressed various factors that audible signals must have to ensure safe crossing at road intersections, such as the acoustic characteristics. They also consulted potential pedestrian users from the City of Montreal about these different sounds. The safety of the user has been the single most important factor to consider. Sounds that could be easily confused with those commonly found in the environment were rejected. These included bird calls, such as cuckoo and peeping sounds. Buzzing and beeping sounds were also rejected since they closely resembled the warning signals on trucks moving in reverse direction. Having considered all these factors, melody signals were recommended. Czyzewski and Kostek (1996) as well as Tauchi et al. (1998) have recently considered this alternative for Poland and Japan, respectively. Hall et al. (1996) proposed the development of an audible traffic signal consisting of a four-note melody for the walking phase of the pedestrian crossing.

A study conducted by Ratelle et al. (1998) at a busy intersection in the east of Montreal (Sherbrooke and Fletcher streets) showed that pedestrians with visual impairment display good performances in crossing after only a few trials, and that they judge the melody system adequate in terms of mode of operation, choice of melody, and sound intensity. Following this study, Laroche (1998) was asked to verify the acoustic characteristics of the system generating the melody at this intersection. The principal objective was to verify the acoustic pressure level generated by the system in order to ensure optimal audibility of the melody in the background noise likely to happen at this location.

Analysis of the data collected in March 1998 highlighted several elements that needed further consideration (Laroche, 1998). The audible traffic signal generated by the studied system had several shortcomings. The level did not seem equivalent on both sides of the intersection. A 9 dB difference was noted between the average level generated at the Northeast corner and the one generated at the Southeast corner. Moreover, each note of the melody did not seem to be sufficiently rich in harmonics to ensure good sound localization, based on accepted knowledge (Laroche, 1994; Canévet, 1998). Good sound localization of the audible traffic signal can be critical to blind pedestrians to maintain proper alignment during crossing. Actually, each note of the tested melody signal had only the fundamental frequency and one harmonic (the third), and the level of this harmonic was at least 6 dB softer than the fundamental. Finally, the rise and fall times of 10 ms for each note could be briefer to facilitate localization (Rakerd and Hartmann, 1986).

The aim of the present study was to collect further information on the contribution of different acoustic parameters (frequency spectrum, rise/fall time) of the audible traffic signals necessary to ensure a sufficiently accurate sound localization and pedestrian safety. Six different audible traffic signals that are presently used or could be used to facilitate crossings of road intersections by pedestrians with visual impairment were assessed. The final goal was to identify the signal(s) that display(s) the best results in terms of sound localization performance and that the participants judged to be acceptable.

2. METHODOLOGY

2.1 Audible traffic signals

The following audible signals were tested in this project:

Signal 1 — This is the 'cuckoo' proposed in the Canadian standard on audible traffic signals for blind pedestrians (Transportation Association of Canada, 1992). The signal consists of a sequence of two complex sounds, the first having a duration of 70 ms and being of higher pitch (fundamental frequency F_0 @ 1100 Hz), and the second having a duration of 140 ms and being of lower pitch (F_0 @ 900 Hz). Each sound contains harmonics of the fundamental up to approximately 8000 Hz. The level of the harmonics decreases at a rate of about 6 dB per harmonic. There is a pause of about 200 ms between the two sounds. The signal is repeated every 1.5 seconds.

Signal 2 — This is the 'peep-peep' proposed in the Canadian standard on audible traffic signals for blind pedestrians (Transportation Association of Canada, 1992). The signal, of a duration of 140 ms and repeated every 1.0 second, sounds like a bird chirp and consists mainly of a downward frequency sweep between 4200 Hz and 1900 Hz, for the fundamental, and between 8400 Hz and 3800 Hz, for the second harmonic.

Signal 3 — This is the original melody recommended by the Institut Nazareth et Louis-Braille of Longueuil, Quebec (Hall et al., 1996). It consists of a sequence of 4 notes, each lasting 300 ms (with rise/fall times of 10 ms), without pauses between notes. Spectral analysis indicated a fundamental frequency of about 1325 Hz, 1125 Hz, 1000 Hz and 900 Hz for notes 1 through 4, respectively, and the presence of the third harmonic component for each note at a level at least 6 dB lower than the fundamental. Each 4-note melody sequence lasts for 1.2 seconds and can repeated without pause to generate a signal of any desired length.

Signal 4 — This is similar to signal 3, except that all the possible harmonic components are included for each note up to 8000 Hz. The level of the harmonics decreases at a rate of 3 dB per successive harmonic. Signal 4 has the same pitch as signal 3, but has a different timbre reflecting a richer harmonic content.

Signal 5 — This is similar to signal 4, except that the fundamental frequency is decreased by a factor 2. Therefore, this is signal 4 played one octave lower.

Signal 6 — This is similar to signal 5, except that the duration of each note is decreased to 250 ms and a pause of 50 ms is introduced between notes. The rise/fall times of each note are decreased to 1 ms. Compared to signal 5, there is a more definite temporal separation between notes.

2.2 Experimental subjects

Recruitment of the subjects started after approval of the project by the Ethics committee for research with human subjects at the University of Ottawa. Subjects had to meet the following hearing criteria: (1) audiometric thresholds better than 15 dB HL from 500 to 8000 Hz, (2) normal external auditory canals, (3) normal tympanograms, and (4) no history of otologic problems.

Sixteen blind subjects and ten subjects with no visual problems were invited to participate. Six blind subjects were eliminated because they did not meet the screening criteria. Thus, a total of 20 subjects (10 subjects with normal vision and 10 blind subjects) completed the experimental procedure. The average age was 25 years for the group of normal subjects, and 41 years for the group of blind subjects. Among the blind subjects, half were blind from birth and half developed blindness after birth. One blind subject did not complete the entire experimental procedure.

The walking methods and mobility abilities of the subjects were not taken into account at the time of recruitment. Moreover, use of a guide dog and cane were not considered during the experimentation. Finally, familiarity with the existing audible traffic signals (e.g. 'cuckoo' and 'peep-peep') was not a part of the selection criteria. It would have been very difficult to recruit blind subjects meeting all these criteria. Also, there is no evidence in the literature that a familiar sound is easier to localize than a new sound. Finally, the objective was to identify the easiest audible traffic signals to localize by the subjects as a whole, and not to compare the inter-subject performance or mobility.

2.3 Experimental set-up

The experiment took place in the middle of a dead-end street in the Municipality of Hull, Quebec. No obstacles (houses, cars or others) were present under 15 metres of the experimental set-up, as to eliminate any reflection of the sound waves, except for those due to the paved road (asphalt). The subject sat on a rotating chair placed over a vinyl carpet having a 1.15-meter radius and lying on the pavement. The carpet was graduated in 1-degree steps, from 0 to 360°. The chair was equipped with a pointer attached to the backrest. The pointer was suspended vertically down to a distance of about 3 cm from the carpet. The device was used to facilitate the reading of the angular data on the carpet (Figure 1).

The audible traffic signals were presented with a loudspeaker (JBL Pro3) mounted on a tripod, itself mounted on a cart. The loudspeaker was plugged to an amplifier (SCS 2150A), itself plugged to a portable computer (Toshiba T6600C). The centre of the loudspeaker was 2.25 metres above the ground. The horizontal distance between the loudspeaker and the centre of the rotating chair was 8.63 metres (Figure 1). Once seated, the subject's head was about 1.12 metre above the ground.

The frequency response of the loudspeaker system, measured at one metre in front of the speaker, is uniform at ± 5 dB between 100 Hz and 10000 Hz. This response is larger in bandwidth and more uniform than the typical commercial speakers used for generating the audible traffic signals for pedestrians. Within the scope of this study, we preferred to use a high-fidelity loudspeaker in order to obtain results that are as much as possible independent from the spectral characteristics of a particular speaker.

The frequency response of the entire experimental set-up from the electric signal at the input of the loudspeaker amplifier to the sound pressure at the position of the subject's head, the subject being absent, is illustrated in Figure 2. This

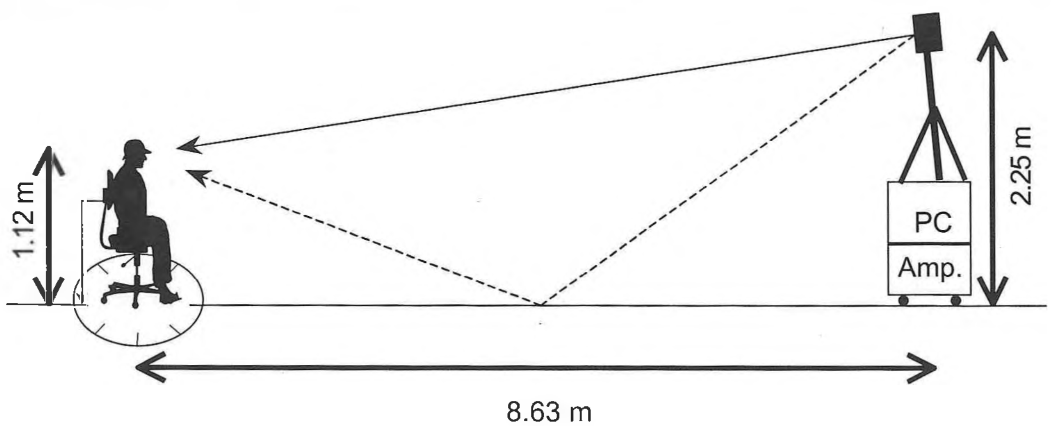

Figure 1. Schematic Diagram of the experiment set-up. The direct wave is shown with a solid line and the wave reflected from the road is shown with a dashed line.

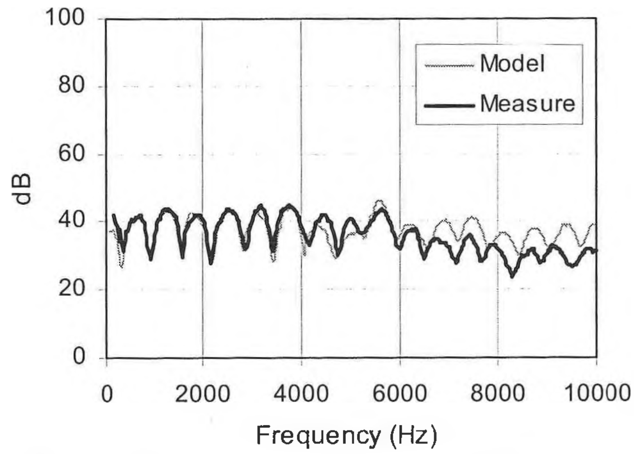

Figure 2: Frequency response of the experimental set-up measured at the subject's position. The model response is the spectrum of a direct wave with reflected wave delayed by 1.6 ms. The reflection coefficient on the road is 0.65 up to 4000 Hz and 0.40 beyond 4000Hz. The electroacoustic response of the loudspeaker is included in the model.

response consists of a series of resonance peaks and troughs with a frequency spacing of about 625 Hz between adjacent peaks or troughs. The level difference between the resonance peaks and troughs is around 14 dB up to 4000 Hz and 7-8 dB beyond this frequency.

Figure 2 also shows that the measured frequency response corresponds closely to the spectrum of a direct wave and a reflected wave of smaller amplitude arriving later at the measurement point. The 625 Hz frequency spacing indicates that the reflected wave is late by 1.6 ms, which is exactly the anticipated delay of the reflection on the asphalt pavement given our experimental set-up. Moreover, the level difference between the resonance peaks and troughs indicates that the reflection coefficient on the pavement is around 0.65 up to 4000 Hz and 0.40 beyond this frequency. In Figure 2, the frequency response of the loudspeaker system has been incorporated to the model to enhance the correspondence between the measurements and the model. On the other hand, the atmospheric attenuation effect was not incorporated, which could explain the slight gap between the measurements and the model beyond 7000 Hz.

During the experiment, the sound pressure level of the audible traffic signals was set to a comfortable level of 65 dB(C) at the subject's location. Measurements were made with an Alcan SLS95 sound level meter. The surrounding environmental noise level was about 50 dB(A), which allowed a sufficiently high signal-to-noise ratio in the frequency bands of each audible traffic signal to ensure good audibility (Tran Quoc and Hétu, 1996).

2.4 Experimental procedure

The subject was blindfolded to eliminate any visual cues. Each signal was presented through a fixed source, but was received by the subject from 12 different starting chair rotations spaced 30° apart in a random order. Between each presentation, the subject was disoriented by slowly rotating the chair, while ensuring that she/he did not become dizzy, and positioned at one of the selected starting angles. The subject then listened to the audible traffic signal, and had to turn the chair in direction of the perceived fixed sound source, stopping the rotation when confident that she/he was well oriented. The total duration of each traffic signal was fixed at 6 seconds. The subject was allowed to start the rotation during the signal presentation. The pointer attached to the back of the chair allowed the reading of the angle at which the subject had stopped. The graduated carpet was positioned in such a way that the 0-degree angle corresponded to an orientation of the subject directly in front of the speaker (no angular error). The sign and size of any localization error was noted from this reference. For instance, if the subject stopped at position 5° (too much to the left), the researcher recorded a value of +5°. If the subject stopped instead at 357° (too much to the right), a value of -3° was recorded.

Finally, the subjects were asked to assess the audible traffic signals. A short questionnaire was completed for each traffic signal to allow identification of the signals that were perceived as acceptable or effective to ensure safe crossings at road intersections. This questionnaire was based on the one devised by Ratelle et al. (1998). A relative appraisal of the localizability of signals was also made by asking the subjects to position each signal on a graded scale, while cross-comparing them (Figure 3).

Figure 3: Tactile scale used by the subjects to indicate their level of confidence in judging the localization of the signals.

3. RESULTS

3.1 Localization of audible traffic signals

For each subject and signal, we characterized the performance in sound localization based on the method proposed by Rakerd and Hartmann (1986). This method involves the calculation of three distinct measures of localization error.

Constant error — It is the simple average of the 12 individual measurements of error for each subject for a given signal.

For this calculation, we keep the sign of the error, i.e. whether the subject responded on the left (+) or right (-) of the true speaker position. Thus, the constant error indicates if there is a tendency to respond in a preferential manner on either side of the loudspeaker.

Variable error — It is the standard deviation of the 12 individual measurements of error for each subject for a given signal. The variable error indicates the precision or consistency of the subject's responses once the lateral bias introduced by the constant error is eliminated

Total error — It is the root-mean-square average of the 12 individual measurements of error for each subject for a given signal. The total error indicates the global error of localization without taking into account the sign of the error of individual measurements.

A subject who would make large errors of localization, but whose responses would be symmetrically distributed on the left and right of the speaker, would have a zero constant error and a high variable error. A subject who would have a clear tendency to respond on one particular side of the speaker, but who would be very consistent in his/her responses, would have a large constant error and a small variable error. In both cases, the total error would be large.

The sound localization results are summarised in Table 1. For each of the three error measures, we present the localization performance for the two groups of subjects and each signal. The performance calculated over all subjects is also presented. For each signal, the reported error value is the simple average of the error (constant, variable or total) of all the subjects of a same group.

The constant error ranges between -6.2° (right side) and 9.0° (left side) across subjects. This indicates that some subjects have a clear tendency to respond on a preferential side. However, when we calculate the mean over all the subjects of a same group (Table 1), the positive and negative errors cancel out and the constant error oscillates around 0°. For the subjects with normal vision, it is -0.3° on average over the six signals. For the blind subjects, the constant error is slightly positive (towards the left) for each signal and 2.0° over the six signals. The constant error over the total subject pool and signals is 0.79°. A repeated measures (2 factors) ANOVA statistical analysis shows that there is no group or signal effect for the measure of the constant error and no group-by-signal cross effect ($p>0.05$).

Table I: Sound localization results by subject group and signal. Mean (standard deviation)

Constant error (degrees)								
Group	n	Signal 1	Signal 2	Signal 3	Signal 4	Signal 5	Signal 6	Ave.
Normal	10	+0.18 (3.4)	-1.0 (4.5)	-0.92 (5.1)	+0.40 (3.9)	-0.27 (3.6)	-0.19 (3.7)	-0.30
Blind	9	+2.6 (5.0)	+2.1 (5.0)	+2.2 (5.3)	+2.3 (5.8)	+0.57 (4.1)	+2.4 (4.9)	+2.0
Total	19	+1.3 (4.3)	+0.45 (4.9)	+0.54 (5.3)	+1.3 (4.8)	+0.13 (3.8)	+1.0 (4.4)	+0.79

Variable error (degrees)								
Group	n	Signal 1	Signal 2	Signal 3	Signal 4	Signal 5	Signal 6	Ave.
Normal	10	4.7 (2.8)	3.7 (0.5)	5.2 (1.5)	3.8 (1.6)	3.7 (0.9)	3.8 (2.3)	4.1
Blind	9	3.7 (1.6)	4.0 (1.4)	4.7 (2.2)	4.0 (1.8)	3.5 (1.4)	3.8 (1.7)	4.0
Total	19	4.2 (2.3)	3.8 (1.0)	5.0 (1.8)	3.9 (1.7)	3.6 (1.1)	3.8 (2.0)	4.0

Total error (degrees)								
Group	n	Signal 1	Signal 2	Signal 3	Signal 4	Signal 5	Signal 6	Ave.
Normal	10	5.6 (2.8)	5.5 (1.7)	6.9 (2.5)	5.1 (2.2)	4.9 (1.4)	5.1 (2.4)	5.5
Blind	9	6.1 (3.0)	5.9 (3.3)	6.9 (3.1)	6.4 (3.9)	4.9 (2.5)	5.9 (3.3)	6.0
Total	19	5.9 (2.8)	5.7 (2.5)	6.9 (2.7)	5.7 (3.1)	4.9 (1.9)	5.5 (2.8)	5.8

The variable error is similar for the subjects with normal vision and the blind subjects, or approximately 4.0° on average over all signals. Over all subjects, the variable error varies as a function of signal between 3.6° (signal 5) and 5.0° (signal 3). A repeated measures (2 factors) ANOVA shows that there is no group effect ($p>0.05$), but that there is a significant difference between signals ($p=0.02$). There is no group-by-signal cross effect ($p>0.05$). A Fisher PLSD type post-hoc analysis shows that, with a confidence criterion of 95%, signal 3 is significantly different (larger error) from signals 2, 4, 5, and 6.

The total error is slightly less for subjects with normal vision than for blind subjects, that is 5.5° versus 6.0° in average for the six signals. Over all subjects, the error also varies as a function of signals between 4.9° (signal 5) and 6.9° (signal 3). A repeated measures (2 factors) ANOVA shows that there is no group effect ($p>0.05$), but that there is a significant difference between signals ($p=0.04$). There is no group-by-signal cross effect ($p>0.05$). A Fisher PLSD type post-hoc analysis shows that, with a confidence criterion of 95%, signal 3 is significantly different (larger error) from signals 2, 4, 5, and 6.

3.2 Subjective appraisal of audible traffic signals

For each subject and signal, we have quantified the results of the subjective appraisal. We derived two measures of the level of appreciation of the signals by the subjects.

Individual appraisal — It is a measure calculated from the short questionnaire about sound quality, intensity level, ease of localization, and the level of safety brought by each signal. Each of the 4 questions counts for 25%. The maximal value of 100% corresponds to a signal that would be judged very appropriate or very appreciated in all regards. The subjects had to judge every signal individually.

Relative appraisal — It is a measure calculated from the 0 to 100% scale in Figure 3. It relates to the level of localization confidence brought by each signal. The subjects had to judge the signals by comparing them with each other.

The results of the subjective appraisal evaluations are summarised in Table II. For each measure, we show the degree of appreciation of each audible traffic signal for each group of subjects. We also show the degree of appreciation of the signals over all the subjects.

The individual appraisal level of the signals is quite similar for both groups of subjects. Over the total subject pool, the individual appraisal score varies as a function of signals between 61% (signals 2 and 3) and 81% (signal 6). The average individual appraisal level is 72%. A repeated measures (2 factors) ANOVA revealed that there is no group effect ($p>0.05$), but that there is a very significant difference between signals ($p=0.0001$). There is no group-by-signal cross effect ($p>0.05$). A Fisher PLSD type post-hoc analysis shows that, with a confidence criterion of 95%, signals 2 and 3 are significantly different (lower appraisal score) from signals 1, 4, 5, and 6. Within those two signal categories, there are no significant differences.

The relative appraisal score varies within a very narrow range between 53% (signal 4) and 63% (signal 5) for sub-

Table II: Subjective appraisal results by subject group and signal. Mean (standard deviation)

Individual appraisal (%)								
Group	n	Signal 1	Signal 2	Signal 3	Signal 4	Signal 5	Signal 6	Ave.
Normal	10	73 (20)	67 (13)	54 (13)	75 (12)	77 (13)	79 (13)	71
Blind	10	77 (20)	55 (17)	68 (14)	79 (13)	82 (15)	84 (13)	74
Total	20	75 (20)	61 (16)	61 (15)	77 (12)	79 (14)	81 (13)	72

Relative appraisal (%)								
Group	n	Signal 1	Signal 2	Signal 3	Signal 4	Signal 5	Signal 6	Ave.
Normal	10	59 (25)	54 (25)	57 (22)	53 (33)	63 (22)	58 (26)	57
Blind	10	64 (39)	32 (29)	30 (19)	56 (32)	72 (25)	75 (19)	55
Total	20	62 (32)	43 (29)	44 (24)	54 (31)	67 (24)	66 (24)	56

jects with normal vision. For blind subjects, on the other hand, this level varies over a larger range between 30% (signal 3) and 75% (signal 6). The average relative appraisal level over all the signals is similar for both groups, namely 55-57%. A repeated measures (2 factors) ANOVA revealed that there is no group effect ($p>0.05$), but that there is a very significant difference between signals ($p=0.006$) and a barely significant group-by-signal cross effect ($p=0.049$). A Fisher PLSD type post-hoc analysis made with the total pool of subjects shows that, with a confidence criterion of 95%, signals 2 and 3 are significantly different (lower appraisal score) from signals 1, 5, and 6. Signal 4 is not significantly different from any other signal. A post-hoc analysis made with the blind subjects only shows the same results, except for signal 4, which is also different from signal 3. With the subjects with normal vision, there is no significant difference between the six signals.

4. DISCUSSION

4.1 Choice of optimal audible traffic signal

The principal aim of this study was to determine which audible traffic signal would be the most appropriate to facilitate crossings at road intersections by blind pedestrians. The factors studied for the choice of signal were the ease of localization of the sound, as measured by an objective test (Section 3.1), and the subjective appraisal of the signals by the normal vision and blind subjects participating in this experiment (Section 3.2).

Sound localization performance was analyzed using three different measures. For the constant error, we noted important variations from one subject to the other, but on the whole, there were no significant differences between the different signals or between the two groups of subjects. Over all the subjects, the constant error for each signal is near 0°. This is consistent with our expectations, given the right-left symmetry of the experimental set-up.

For the two other error measures, the variable error and the total error, we noted some significant statistical differences between signals. On the other hand, there were no significant differences between the two groups of subjects. The statistical ranking of the signals being the same for both types of error, we retained the results of the total error. This error indicates the global localization error. In Figure 4, the total error is drawn along a vertical axis and the statistical clusters are identified. It is clear that localization performance with the melody signals (signals 3, 4, 5, and 6) varies widely according to the acoustic characteristics of the signals, as defined in Section 2.1. The two bird call signals from the Canadian standard (signals 1 and 2) show very similar performance near the average performance across signals (5.8° error).

In Figure 4, the melody signals that are easier to localize (least error) are the ones with a low fundamental frequency and rich in harmonic content (signals 5 and 6). In contrast, the melody signal with a high fundamental and poor in harmonic content (signal 3) is the least easy to localize. The intermediate melody (signal 4), with a high fundamental but rich in harmonics, ranks between these two extremes. Within the scope of this study, we did not note any localization improvement when the rise/fall times of each note of signal 5 are shortened and when pauses between notes are inserted (signal 6). These modifications have even brought a slight decrease in localization (though not statistically significant).

In Figure 4, we also show the individual and relative appraisal scores for each signal along a vertical axis and identify the

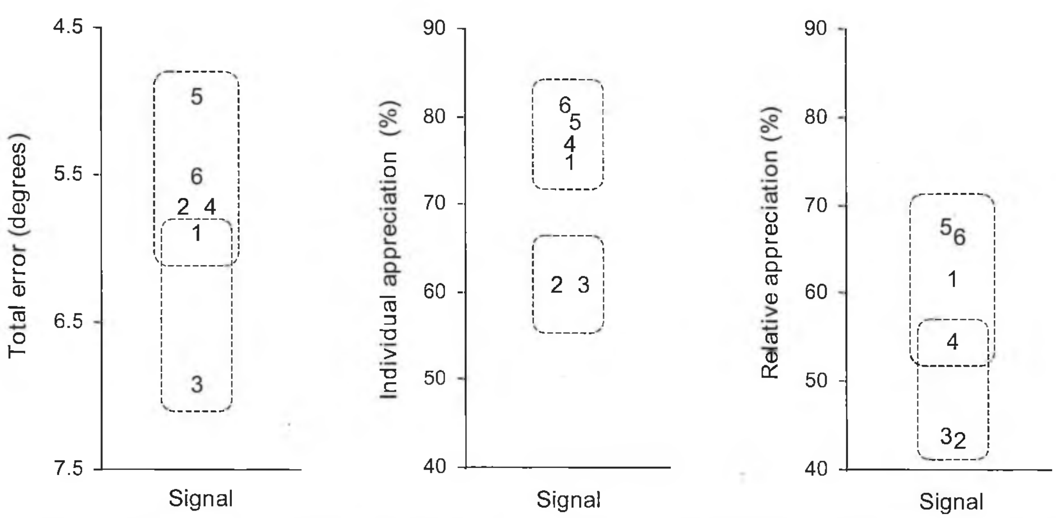

Figure 4: Summary of results for the total localization error and the two measures of subjective appreciation. Results are based on the total of the subjects. The statistical clusters are based on Fisher PLSD post-hoc analyses with a 95% confidence criterion.

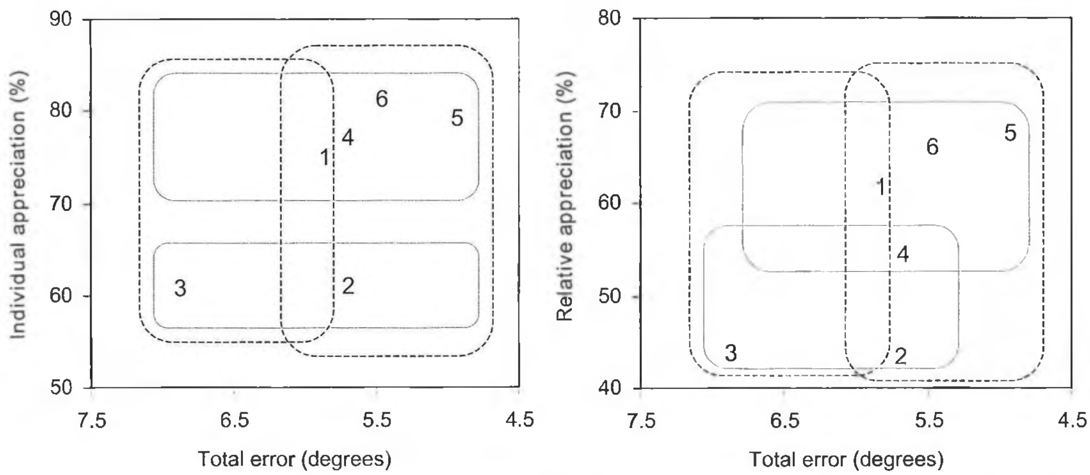

Figure 5: Summary of the results of individual and relative appreciation as a function of the total error of localization. Results are based on the total of the subjects in the experiment. The statistical clusters are based on Fisher PLSD post-hoc analyses with a 95% confidence criterion. The rectangles in solid line are the subjective appreciation statistical clusters. The rectangles in dashed line are the total localization error statistical clusters.

statistical clusters. In both cases, we presented results related to the total of all subjects since there was no group effect for these measures. There was also no group-by-signal cross effect for individual appraisal. For relative appraisal, there was a barely significant group-by-signal cross effect. However, for this measure, the statistical clusters among signals realised with all the subjects were largely dependent on the results from the blind subjects.

It is obvious from Figure 4 that signal 2 (standardized 'peep-peep') and signal 3 (the original melody signal) are significantly less appreciated than other signals. Moreover, these two signals get only 61% in the individual appraisal questionnaire, which means that the subjects' impression is generally neutral. Signals 1 (standardized 'cuckoo') and signal 4 get an individual appraisal score of 75 to 77%, whereas signals 5 and 6 get a score from 79 to 81%. For the latter two signals, this means that they are appreciated or judged to be appropriate by the subjects. It should be noted that, among the two groups of subjects, it is the blind subjects that particularly appreciated signals 5 and 6, at a score of 82 to 84% (Table II).

Finally, we have drawn in Figure 5 the results of individual (or relative) appraisal as a function of the total localization error, and identified two-dimensional statistical clusters of signals. The best signals are found in the upper right corner. The plot of the individual appraisal as a function of total error indicates that the best signals are the melody signals 4, 5, and 6. The plot of relative appraisal as a function of total error indicates that the best signals are melody signals 5 and 6. Overall, signals 5 and 6 thus seem to be the two best choices to facilitate crossings at road intersections by blind pedestrians. Both signals have a low fundamental frequency and are rich in harmonic content. The lack of statistical difference between the two signals indicates that the introduction of a short pause between notes and a shorter rise/fall time for signal 6 did not further improve the design of the melody. Thus, we recommend the use of signal 5. This signal is easier to generate and is more similar to the original concept of a melody signal proposed by Hall et al. (1996) and Ratelle et al. (1998) than signal 6.

4.2 Practical considerations

The results of the preceding sections highlight that the use of melody signal 5 would be associated with better localization performances as well as a subjective appraisal superior to the one associated with signal 3, the original melody. We can now estimate how the 2° difference between the total error associated with signal 5 (4.9°) and signal 3 (6.9°) would translate in everyday life, when a blind pedestrian crosses a road at an intersection?

We calculated the lateral deviation at the end of a typical crossing given an angular localization (alignment) error at the start of the crossing. The basic formula below is used:

$$D = L \times \tan \theta$$

where D is the lateral deviation (m) at the end of the crossing in reference to the central line of the corridor, L is the length of the intersection (m) and θ is the angular error (°) at the start of the crossing. We assume that the pedestrian starts in the centre of the pedestrian corridor and that the traffic device emitting the audible signal is aligned with the centre of the corridor. The pedestrian corridor is assumed to be 3 m wide.

Taking a typical 4-lane intersection with a narrow median (about 20 metres long), an alignment error of 4.9° (signal 5) will result in a crossing 0.2 m outside the lateral boundary of the pedestrian corridor, i.e. at a deviation of 1.7 m from the corridor's central axis. If the error is rather on the order of 6.9° (signal 3), the deviation from the central axis of the corridor will then reach almost 2.4 m, that is almost 1 metre outside the lateral boundary of the corridor. So the larger the localization error, the greater the likelihood of a crossing far exceeding the lateral boundaries of the pedestrian corridor and the higher the risks of accident.

In interpreting these results we have to keep in mind that in practice the pedestrian may be able to compensate for his/her starting alignment error while walking along the crossing and hearing the signal. Still, signal 3 was more difficult to localize and even the compensation made by the pedestrians could be insufficient to ensure a crossing inside the pedestrian's corridor. Moreover, audible traffic signals typically last only during the walking phase of the crossing and not during the clearing phase, which means the pedestrian is often left to complete the crossing without any audible sound. This concept of compensation while crossing is under study in a separate set of experiments.

5. CONCLUSIONS

This study demonstrated that the melody signals are not necessarily easier to localize or judged to be more acceptable than the standardized audible traffic signals based on bird calls by the Transportation Association of Canada. In fact, the original melody signal generated a localization performance statistically inferior to the standard 'peep-peep' and a subjective appraisal score statistically inferior to the standard 'cuckoo'. However, two of the melodies designed in this study offered a superior localization performance and subjective appraisal score than all the other signals, those of Canadian standard included. The proposed signal contains the same four notes as the original melody, but each note is played one octave lower in frequency and is much richer in harmonics.

Hence, the concept of a melody signal should be retained as an audible traffic signal for blind pedestrians, but the choice of the acoustic characteristics of the signal plays a major role in determining the ease of localization in space and the level of subjective appraisal of the sound. The standardized 'peep-peep' signal should be abandoned due to poor subjective appraisal. The standardized 'cuckoo' is found to be adequate.

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EXPOSITION AU BRUIT ENVIRONNEMENTAL EN MILIEU DE GARDE

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SOMMAIRE

L'exposition au bruit des enfants et du personnel dans les centres de la petite enfance (CPE) est un sujet d'intérêt. Les enfants et éducatrices sont non seulement exposés au bruit à l'intérieur des garderies, mais peuvent également être régulièrement exposés à des niveaux de bruit élevés lors des périodes de jeu à l'extérieur. Des mesures de bruit environnemental ont eu lieu à divers endroits dans l'entourage extérieur d'un CPE situé aux abords d'une autoroute. Avant la sortie des enfants, les niveaux équivalents (LA_{eq})de bruit enregistrés dans l'aire de jeu oscillaient entre 62 et 66 dB(A), tandis qu'en présence d'enfants le bruit environnemental dépassait 70 dB(A) plus de 50% du temps. Des différences significatives, de l'ordre de 7 à 11 dB, ont été notées entre les niveaux mesurés en l'absence d'enfants dans l'aire de jeu du CPE en question et ceux obtenus à un second CPE non situé en bordure d'une autoroute. Les niveaux de bruit mesurés sont tous supérieurs aux recommandations de l'Organisation Mondiale de la Santé, en ce qui a trait aux méfaits du bruit les plus susceptibles d'être ressentis au CPE, soit l'interférence avec la communication, la perturbation du sommeil et la gêne. L'impact du bruit dû à la circulation routière se fait sentir non seulement à l'extérieur mais aussi à l'intérieur du CPE, particulièrement lorsque les fenêtres orientées vers la principale source de bruit (la circulation routière) sont ouvertes. Des solutions en matière de réduction du bruit applicables au CPE sont proposées. Cette étude démontre l'importance de bien planifier la construction des services de garde, car il peut être difficile et coûteux de mettre en place des mesures correctives une fois le milieu de garde implanté.

SUMMARY

Noise exposure for children and workers in day care centers is an important issue. Children and childcare workers are not only exposed to noise inside day care centers, but can also be exposed to high noise levels on a regular basis during outside play. Environmental noise measurements occurred at various locations outside a day care center located just a few meters from a busy freeway. Equivalent noise levels (LA_{eq}) measured before the outside play period ranged from 62 to 66 dB(A), while they reached levels greater than 70 dB(A) more than 50% of the time children were out playing. Significant differences (7 to 11 dB) were noted between noise levels measured in the absence of children at this day care center and those recorded at a second day care center not located in the vicinity of a freeway. The recorded noise levels are all higher than the World Health Organization's recommendations regarding the effects of noise most likely to be felt at the day care center: noise interference, sleep disturbance and annoyance. Traffic noise is not only a nuisance during outside play but also for indoor activities, especially when the windows facing the major noise source (the freeway) are opened. Noise reduction solutions that could be applied to the day care center are proposed. This study shows the importance of carefully planning the construction of day care centers since the implementation of corrective measures for reducing noise levels can be somewhat difficult and costly once the day care center has already been established.

1 INTRODUCTION

Au cours des dernières décennies, plusieurs études ont porté sur les niveaux de bruit à l'intérieur des milieux éducationnels et sur les stratégies pour réduire ces niveaux (Truchon-Gagnon & Hétu, 1988 ; Melançon et al., 1989 ; Hétu et al., 1990 ; Picard & Bradley, 2001 ; Hodgson & Nosal, 2002), mais aucune ne semble s'être attardée au bruit environnemental auquel les jeunes enfants sont exposés dans les aires de jeux extérieures. L'Organisation Mondiale de la Santé (OMS) définit le bruit environnemental comme étant le bruit qui provient de toute source mais le distingue du bruit industriel (WHO, 2000). Les principales sources de bruit environnemental sont la circulation aérienne, la circulation routière, la circulation ferroviaire, les activités de construction, les produits commerciaux et ménagers ainsi que le bruit à l'intérieur des bâtiments (Lambert, 1991).

Selon Suter (1992), la source prédominante de bruit environnemental est la circulation routière. En effet, on estime que 80% du niveau de pression acoustique des centres urbains provient de la circulation motorisée (Lambert, 1991). En Europe, environ 40% de la population est exposée à des niveaux de bruit provenant de la circulation routière qui dépassent 55 dB(A) durant la journée, alors que 20% de la population est exposée à des niveaux supérieurs à 65 dB(A) (WHO, 2000).

Malgré l'envergure du problème, il est difficile de mettre en place des normes et règlements pour contrôler le bruit parce que, contrairement à d'autres polluants, il n'existe aucune relation de cause à effet clairement établie entre le bruit et la mort (Lambert, 1991). De plus, comme les conséquences du bruit sur la santé s'étendent d'une perte auditive permanente à des troubles du sommeil, il est difficile de spécifier des niveaux de nocivité ou d'acceptabilité du bruit (WHO, 2000). L'OMS continue cependant de s'attarder au problème posé par le bruit communautaire et fait plusieurs recommandations sur les niveaux sonores qui devraient être respectés afin d'éviter ou de minimiser les effets sur la santé, tout en favorisant le maintien d'une qualité de vie.

Le bruit environnemental touche toutes les populations d'individus. Avec l'accroissement de la population et sa concentration dans les centres urbains, les effets de la pollution sonore sont ressentis par tous. Il n'est donc pas surprenant que les enfants commencent en très bas âge à être exposés à des niveaux de bruit parfois excessifs, souvent au sein même des services de garde, avant l'entrée à l'école. En effet, le niveau de bruit observé dans les centres de la petite enfance (CPE) peut être aussi élevé que 90 dB(A) à certains moments de la journée et est la cause première de plaintes chez les employés des CPE (Journal Le Soleil, 2003).

Le présent document fait état des niveaux de bruit mesurés dans l'entourage extérieur d'un CPE situé en bordure d'une autoroute. Les objectifs de cette étude étaient de : 1)documenter les méfaits du bruit communautaire les plus susceptibles d'être ressentis au CPE, soit l'interférence avec la communication, la gêne (nuisance sonore) et la perturbation du sommeil, 2) mesurer le niveau de pression acoustique à divers endroits à l'extérieur de la garderie, 2) comparer les données recueillies aux valeurs proposées par l'OMS en ce qui a trait aux effets du bruit, 3) comparer les niveaux sonores mesurés à ceux obtenus à l'extérieur d'un second CPE non situé à proximité d'une autoroute et, 4) proposer des solutions en matière de réduction du bruit applicables à l'environnement sonore du service de garde étudié.

2 PRINCIPAUX MÉFAITS DU BRUIT EN MILIEU DE GARDE

2.1 Interférence avec la communication

L'effet du bruit le plus significatif dans les garderies est sans doute son interférence avec la communication. Le bruit a pour conséquence de masquer la parole et nuire ainsi à l'intelligibilité du message transmis. Ce phénomène de masquage est d'autant plus prononcé que le niveau de bruit est élevé et qu'il contient une quantité importante d'énergie dans la région des fréquences les plus critiques à la compréhension de la parole, soit de 300 à 3000 Hz (WHO, 2000). Afin de préserver l'intelligibilité de la parole chez des individus qui ont une audition normale, le rapport signal sur bruit doit être de l'ordre de 15 à 18 dB(A), c'est-à-dire que le niveau de parole doit être 15 à 18 dB(A) plus élevé que le niveau du bruit (WHO, 2000 ; Hétu, 1984). Ceci implique qu'un niveau de bruit supérieur à 35 dB(A) est susceptible de nuire à l'intelligibilité d'un message à un niveau conversationnel normal de 45-50 dB(A) (WHO, 2000). Chez les enfants, le rapport signal/bruit doit être encore plus favorable, soit d'au moins + 20 dB (Hétu et al., 1990). Ce n'est que vers l'âge de 10 ans que les performances des enfants dans le bruit rejoignent celles des adultes (Garabedian, 1999). Pour favoriser la compréhension dans un environnement bruyant, les gens ont tendance à parler plus fort. A long terme, un effort vocal soutenu peut cependant entraîner des troubles de la voix importants, surtout chez les éducatrices qui doivent constamment élever la voix au-dessus du bruit de fond (Hétu, 1984; Suter, 1992).

En ce qui concerne l'interférence à la communication dans les aires de jeu, l'OMS recommande que le niveau de bruit des sources externes ne dépasse pas un L_{Aeq} de 55dB durant la période de jeu. L'OMS indique également que les personnes qui ont une perte auditive, les personnes âgées, les personnes qui ne sont pas familières avec la langue et les enfants en plein processus d'acquisition du langage et de la lecture sont particulièrement vulnérables à cet effet du bruit. Les enfants avec troubles auditifs centraux peuvent également être très vulnérables à l'influence du bruit de fond. (Bellis, 1996).

La clarté du message dépend non seulement de son intensité mais aussi de l'information véhiculée par les consonnes de hautes fréquences (i.e. f, v, s, ch, et j), qui ont tendance à être plus facilement masquées par le bruit (Hétu, 1984). Ainsi, un enfant qui éprouve des difficultés à comprendre la parole en présence de bruit peut développer des troubles du langage et des troubles académiques (Stansfeld et al., 2000). Sauvé (1999) rajoute que les périodes de silence sont plus critiques pour l'apprentissage chez les enfants que chez les adultes puisque l'immaturité de leur système nerveux central ne leur permet pas d'extraire de façon aussi efficace le message du bruit. Enfin, une exposition prolongée au bruit pourrait entraîner chez les enfants de la fatigue, des difficultés de concentration, un manque de confiance en soi, de l'irritation, des difficultés dans les relations humaines et un état perpétuel de stress (Stansfeld et al., 2000 ; Hétu, 1984 ; WHO, 2000), ainsi que des troubles d'attention, de comportement et d'hyperactivité (Sauvé, 1999), des facteurs qui peuvent nuire aux processus d'apprentissage.

2.2 Gêne Subjective

En plus d'interférer avec la communication, le bruit peut occasionner un sentiment de gêne chez certains individus. La gêne est une « sensation perceptive et affective négative exprimée par des personnes qui entendent du bruit » (Mouret et Vallet, 1992). Pour une même source de bruit, le degré de gêne ressentie varie énormément d'un individu à l'autre et se manifeste de multiples façons, allant d'une légère irritation à une dégradation significative de la qualité de vie (Suter, 1992). L'exposition au bruit peut entraîner de l'isolement, des comportements agressifs, de l'impatience, de la dépression, de l'anxiété, de l'agitation et un manque de participation sociale (WHO, 2000). Aucune étude ne semble avoir portée spécifiquement sur la gêne chez les enfants, mais on pourrait supposer que ces conséquences du bruit se manifesteraient également chez cette population.

La perception subjective d'un son suit la règle selon laquelle une augmentation de 10 dB du niveau du bruit correspond à un doublement de sa force acoustique (Rabinowitz, 1989). Selon l'Organisation Mondiale de la Santé, il semble que « durant la journée, peu de gens sont sérieusement gênés par un bruit dont le niveau LAeq-16 heures est inférieur à 55 dBA ou modérément gênés par des niveaux de bruit inférieurs à 50 dBA »(WHO, 2000). L'OMS spécifie que dans les aires de jeu extérieures, le niveau de bruit ne devrait pas dépasser 55 dB(A) durant la période de jeu afin de limiter la gêne. Parmi d'autres facteurs acoustiques qui peuvent influencer la sensation de gêne, le spectre fréquentiel du bruit et les fluctuations du niveau sonore sont fréquemment cités. De façon générale, les bruits dont l'énergie est concentrée dans les hautes fréquences, surtout entre 2000 Hz et 8000 Hz (Stansfeld et. al, 2000), les bruits dont le niveau de pression sonore augmente (Rabinowitz, 1989), et les bruits impulsifs (WHO, 2000) sont jugés comme étant plus gênants que leurs opposés. De plus, un même bruit engendre un plus haut niveau de gêne s'il est présenté dans un environnement silencieux que dans un environnement bruyant (Suter, 1992).

Plusieurs facteurs autres que les paramètres acoustiques régissent cette réaction subjective au bruit. Parmi ceux-ci, on retrouve des facteurs physiques tels que le type de milieu, le moment de la journée, la saison, la prévisibilité du bruit, le contrôle exercé sur la source et la durée d'exposition (Harris, 1979; OMS, 2000; Rabinowitz, 1989; Stansfeld et al., 2000; Suter, 1992).

2.3 Perturbation du sommeil

La perturbation du sommeil peut altérer les processus de réparation, de réorganisation et de formation de nouvelles connexions dans le cortex (Rabinowitz, 1989) et nuire au bon fonctionnement physiologique et mental des gens. Il peut s'en suivre d'importants problèmes de santé (WHO, 2000). Les effets du bruit sur le sommeil se divisent en deux catégories: les effets primaires (qui surviennent durant le sommeil) et secondaires (qui sont ressentis le lendemain). Les effets primaires les plus couramment rapportés sont l'augmentation du temps nécessaire à l'endormissement et une augmentation du nombre d'éveils proportionnelle au niveau sonore ambiant (Stansfeld et al., 2000). De plus, des changements dans les réponses cardiovasculaires ont lieu à l'insu des individus (Suter, 1992; WHO, 1999, Stansfeld et. al, 2000). Les niveaux qui engendrent de tels effets sont environ 10 dB plus bas chez les enfants que chez les adultes (Laroche et al, 2003). Parmi les effets secondaires, le bruit a des conséquences néfastes sur l'humeur et le temps de réaction (Suter, 1992). Au cours de la journée qui suit le sommeil perturbé, les individus rapportent également avoir moins bien dormi (Stansfeld et al., 2000), être plus fatigués et avoir une tolérance réduite au bruit (WHO, 2000).

L'Organisation Mondiale de la Santé recommande que le niveau de pression acoustique équivalent (L_{Aeq}) d'un son continu ne devrait pas dépasser 30dB(A) $L_{Aeq\text{-}8\ heures}$ max à l'intérieur d'une chambre à coucher et que le niveau de pression acoustique de sons non continus ne devrait pas dépasser un L_A max de 45 dB (le niveau maximal d'un événement sonore) plus de 10-15 fois durant la nuit. Les mêmes valeurs sont recommandées par l'OMS durant les siestes dans les milieux de garde. De plus, l'OMS indique que lorsque les fenêtres sont ouvertes, le niveau extérieur ne devrait pas dépasser un $L_{Aeq\text{-}8\ heures}$ de 45 dB pour les sons continus et un L_A max de 60 dB pour les sons non continus.

Cette brève revue de la littérature sur les méfaits du bruit souligne l'importance d'évaluer les niveaux de bruit dans les services de garde et dans les zones de jeu extérieures, ainsi que de mettre en place des stratégies de contrôle de bruit lorsque nécessaire, puisque les bébés et les enfants sont parmi les plus vulnérables aux effets nocifs du bruit.

3 MÉTHODOLOGIE

3.1 Description de la garderie

Les mesures de bruit ont eu lieu en avril, à l'extérieur d'un service de garde situé aux abords d'une autoroute et d'un boulevard. L'autoroute ainsi que le boulevard comptent 4 voies chacun. La garderie accommode une soixantaine d'enfants, âgés entre 6 mois et 5ans, et compte plusieurs fenêtres et un balcon qui font face à l'autoroute. Une clôture et quelques arbres se retrouvent à la limite du terrain, située à une douzaine de mètres seulement de l'autoroute. Il est important de préciser que ces arbres constituent uniquement un écran visuel et non un écran acoustique.

On retrouve un espace clôturé de chaque côté de la garderie. Un d'entre eux correspond à l'aire de jeu et comprend un carré de sable, une glissade et des tables à pique-nique. Au cours de l'après-midi, les enfants font une sieste d'une durée d'environ 2½ heures, suivie d'une période de jeu à l'extérieur qui peut durer jusqu'à 2 heures (selon l'heure de départ des enfants). Les responsables du service de garde aimeraient agrandir l'établissement afin d'accommoder un nombre supérieur d'enfants. Le cas échéant, une seconde aire de jeu occuperait l'espace du côté opposé de la garderie. Les lieux extérieurs du CPE sont illustrés à l'annexe 1, sur un plan non à l'échelle. Les divers points d'échantillonnage y sont également indiqués.

La source principale de bruit environnemental dans l'entourage de la garderie est la circulation routière, à quoi s'ajoute le bruit généré par les éducatrices, les enfants et les jouets. Sur le boulevard, une limite de vitesse est fixée à 30 km/h. Il est alors justifiable de supposer que le bruit des moteurs prédomine sur le boulevard, comparativement à l'autoroute où le bruit du contact des pneus avec le pavé est la plus importante source de bruit puisque la vitesse excède 60 km/h (WHO, 2000).

3.2 Instrumentation, stratégies d'échantillonnage et lieux de mesure

Les mesures ont eu lieu avant et après la sortie des enfants. Un premier groupe d'enfants est sorti à 15h45 et le second à 15h51. Les mesures se sont déroulées à divers endroits sur le terrain de jeu (côté sud), sur le côté nord de la garderie et sur le balcon (côté ouest). Lors de la période de jeu, les enfants se trouvent principalement dans le terrain de jeu. Des mesures ont cependant été effectuées à d'autres endroits afin de pouvoir mieux décrire l'entourage extérieur sonore du service de garde. Les divers points d'échantillonnage sont décrits au tableau 1.

Tableau 1. Points d'échantillonnage

Site	Description du site	Distance de l'autoroute	Nombres de mesures et instrumentation
A	Terrain de jeu (côté sud) : entre la glissade et les tables de pique-nique	~30 mètres	2*
B	Près des limites du terrain, du côté nord de la garderie	~20 mètres	2*
C	Côté nord	~30 mètres	1*
D	Sur le balcon en bois qui fait face à l'autoroute (côté ouest)	~20 mètres	1*
E	Côté nord, près du stationnement	~45 mètres	1*
F	Terrain de jeu (côté sud) : sur le chemin asphalté près du carré de sable	~20 mètres	2**

*=Sonomètre intégrateur de type 2
**=Logiciel Symphonie DBTRIG32 (v. 4.2)

Lors des mesures extérieures, les conditions météorologiques rencontraient les exigences de la norme ISO 1996-2 (1987, Amd 1:1998).

Deux enregistrements ont été effectués avec le système d'acquisition et de traitement de données Symphonie DBTRIG32 (version 4.2) de la compagnie 01dB. Ce système fonctionne comme un sonomètre intégrateur de type 1 avec une gamme dynamique de 50 à 120 dB(A) et calcule un niveau de pression sonore équivalent en pondération A (LAeq) toutes les 100 millisecondes. Afin de représenter une position intermédiaire entre la hauteur des oreilles des enfants par rapport au sol et celles des éducatrices, un microphone muni d'une boule anti-vent (UA 0237) était fixé sur un trépied, à une hauteur d'environ 1m40. L'équipement a été calibré avant et après à l'aide d'un calibreur source sonore étalon (94 dB à 1000 Hz). Ce système permet une analyse détaillée de l'évolution sonore en fonction du temps. Il a été utilisé au point F, à quelques mètres des enfants, afin de ne pas interrompre le jeu des enfants et pour éviter que ceux-ci trébuchent sur les câbles reliant le microphone au système d'acquisition. Toutefois, de l'avis des auteurs, ce point de mesure est représentatif de l'exposition au bruit des enfants dans l'aire de jeu.

Des mesures additionnelles ont été effectuées à l'aide d'un sonomètre intégrateur de type 2 (SLS 95 # 958 009) qui a une gamme dynamique de 30 à 130 dB(A) et qui intègre le niveau de bruit LAeq toutes les demi-secondes. L'équipement a été calibré avant et après à l'aide d'un calibreur source sonore étalon Norsonic 1443 (19750) (114 dB à 1000 Hz).

4 ANALYSE DES RÉSULTATS

En matière d'exposition au bruit, l'atteinte à l'audition est un domaine où des règlements sont établis et une norme (ISO 1999) existe pour aider à en prédire le risque. Puisque de telles normes ne sont pas disponibles pour prédire l'ampleur des autres effets du bruit (interférence avec la communication, gêne et perturbation du sommeil), les niveaux mesurés seront comparés aux valeurs suggérées par l'OMS afin d'évaluer les effets potentiels du bruit à la garderie.

4.1 Mesures effectuées avec le système Symphonie dBTRIG32

Le premier enregistrement avec le système dBTRIG32 a duré une heure (de 14h58 à 15h58). La figure 1 illustre l'évolution du niveau de pression sonore intégré sur des intervalles de 300ms (LAeq 300ms) en fonction du temps pour la première série de mesures.

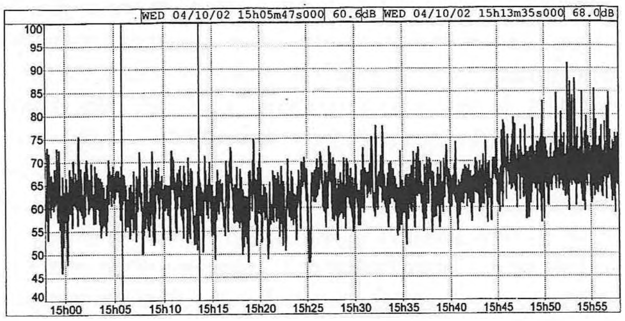

Figure 1. Evolution du niveau de pression sonore (t=300ms) entre 14h58 et 15h58. (axe horizontal = temps ; axe vertical = niveau LAeq)

L'allure générale de ce graphique se traduit par un segment où le niveau sonore est plus ou moins stable, suivi d'une augmentation vers 15h45. Une analyse plus détaillée des données recueillies en l'absence d'enfants (donc avant 15h45) révèle un niveau de pression sonore maximal d'environ 78 dB(A) (vers 15h33) et un niveau minimal d'environ 45 dB(A) (juste avant 15h00). Après la sortie des enfants, le niveau Leq maximal a atteint 92 dB(A) (vers 15h53, lors de la sortie du 2[ième] groupe) tandis que le niveau minimal était de l'ordre de 54 dB(A), mesuré juste après 15h54, soit immédiatement après la sortie du second groupe.

La figure 2 illustre également l'évolution du niveau de pression acoustique pour cette même période de temps, mais sur des périodes de 5 minutes. L'intégration du LAeq sur des périodes de cinq minutes permet de mieux distinguer les périodes où le niveau sonore augmente, diminue ou reste stable. On y retrouve quatre segments distinctifs au cours desquels le niveau sonore semble relativement stable : 1) de 14h58 à 15h23 [Leq varie entre 63 et 65 dB(A)], 2) de 15h23 à 15h43 [Leq varie entre 65 et 66 dB(A)], 3) de 15h43 à 15h48 [Leq=69 dB(A)] et, 4) de 15h48 à 15h58 [71 dB(A)].

Le premier segment pourrait correspondre au niveau de bruit environnemental présent dans l'entourage extérieur de la garderie avant la sortie des enfants. L'augmentation notée au cours de la seconde période pourrait être la conséquence d'une circulation plus dense sur l'autoroute et sur le boulevard, tandis que les troisième et quatrième segments correspondraient plutôt à la sortie du premier et du second groupe d'enfants, respectivement. Une nuance importante doit cependant être ajoutée : l'augmentation notée au cours des deux derniers segments ne peut être uniquement attribuée à la présence des enfants puisqu'une augmentation de la circulation routière aurait également pu contribuer à cette hausse de bruit. Afin d'avoir une idée générale de la densité de la circulation, il aurait été préférable de compter le nombre de véhicules circulant sur l'autoroute pendant les mesures.

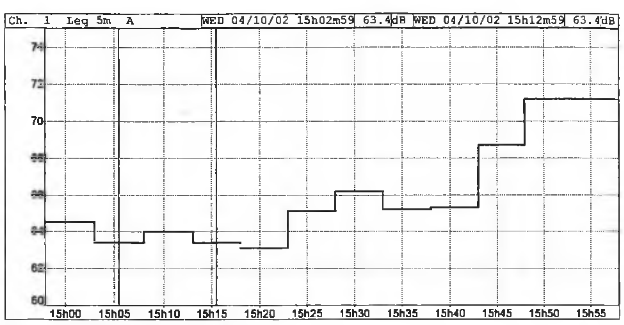

Figure 2. Evolution du niveau de pression sonore (t=5min.) entre 14h58 et 15h58. (axe horizontal = temps ; axe vertical = niveau LAeq)

La distribution des niveaux sonores pour la première mesure avec le système dBTRIG32 a été déterminée et permet d'identifier les niveaux dépassés un certain pourcentage du temps (L95, L90, L50, L10 et L5). Le niveau sonore était supérieur à 56 dB(A) pendant 95% du temps, supérieur à 64 dB(A) pendant 50% du temps, et supérieur à 70 dB(A) pendant 10% du temps.

Le second enregistrement avec le système dBTRIG32 a débuté à 16h31, pour une durée de 15 minutes. La figure 3 (t= 100 ms (haut), t=1 minute (bas)) illustre l'évolution du niveau de pression acoustique en fonction du temps pour cette période durant laquelle les enfants jouaient dans l'aire de jeu.

Le niveau LAeq total mesuré est de 73 dB(A) alors que les niveaux maximum et minimum observés sont 92 dB(A) et 57 dB(A), respectivement. Cette figure suggère une légère augmentation du niveau, suivie d'une diminution vers la fin de la mesure. Cette diminution pourrait être associée au départ de quelques enfants ou même à une réduction dans leur niveau d'excitation, mais il est difficile de se prononcer sur cette explication. Il est possible que d'autres facteurs, telle la densité de la circulation routière, aient également eu un effet. Selon la distribution des niveaux sonores, le bruit

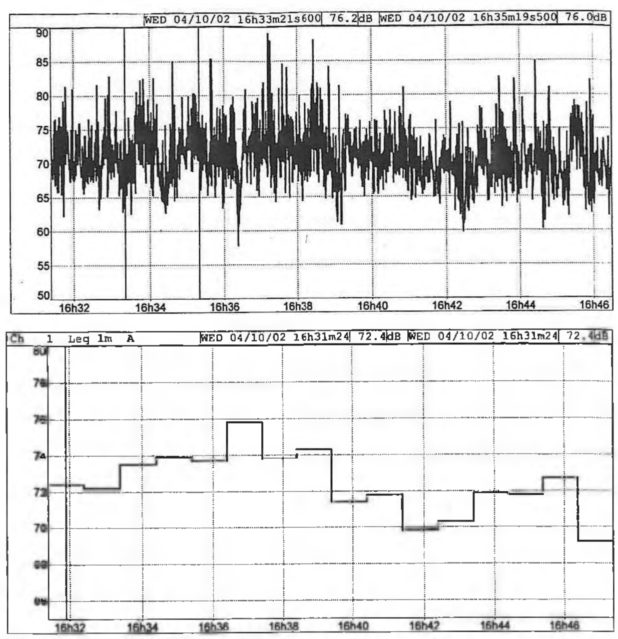

Figure 3. Evolution du niveau de pression sonore (haut: t=100ms ; bas: t=1min.) entre 16h31 et 16h46. (axe horizontal = temps ; axe vertical = niveau LAeq)

environnemental mesuré lors de cette seconde mesure a dépassé 64 dB(A) pendant 95% du temps, 70 dB(A) pendant 50% du temps et 76 dB(A) pendant 10% du temps.

4.2 Mesures additionnelles avec le sonomètre intégrateur de type 2

Des mesures additionnelles ont eu lieu à divers endroits avec le sonomètre intégrateur de type 2 (t= 2min.), avant la sortie des enfants. Le tableau 2 résume les résultats obtenus.

Les niveaux mesurés au point B [64 et 65 dB(A)] correspondent à celui obtenu avec le système dBTRIG32 [65 dB(A)] pour la même période de deux minutes. Ce résultat était attendu puisque les deux points d'échantillonnage étaient situés à environ 20 mètres de l'autoroute. Il est intéressant de noter que les niveaux de bruit enregistrés des deux côtés opposés de la garderie sont similaires (aux sites B et F, ainsi qu'aux sites A et C) en l'absence d'enfants pour une même distance par rapport à l'autoroute.

Un effet de distance a également été noté lors de l'analyse des données en comparant les niveaux mesurés aux sites B et C. Il semble qu'une augmentation de la distance par rapport à l'autoroute a contribué à diminuer le niveau L_{eq}. Cependant, le niveau L_{eq} au site E [61 dB(A)] démontre que l'effet d'une plus grande distance de l'autoroute est probablement réduit par le rapprochement du boulevard puisque le niveau sonore au point E est essentiellement le même que celui au point C, malgré la plus grande distance du point E par rapport à l'autoroute.

Une dernière valeur d'intérêt correspond au niveau sonore mesuré au site D (balcon). Au moment où s'est effectuée la mesure, les fenêtres de la salle qui donne accès au balcon étaient entre-ouvertes. Le niveau L_{eq} obtenu était 64 dB(A), avec une valeur maximale de 70 dB(A) et une valeur minimale de 54 dB(A). Puisque les fenêtres étaient entre-ouvertes, on peut supposer que celles-ci offraient une atténuation du bruit de l'ordre de 15 dB(A) (WHO, 2000) et qu'en conséquence, à l'intérieur de la salle voisine au balcon, la contribution du bruit provenant des sources externes correspond à un niveau L_{eq} d'environ 49 dB(A). Il s'agit d'une estimation du niveau intérieur puisque celui-ci n'a pas été vérifié. Cette valeur représente le niveau sonore le plus bas et peut sous-estimer le niveau actuel, puisque l'estimation prend seulement en considération les sources externes de bruit (i.e. la circulation routière) alors que des sources intérieures de bruit (i.e. système de ventilation, enfants, jouets, etc...) sont susceptibles de s'y ajouter et ainsi faire augmenter le niveau sonore à l'intérieur de cette salle. Cette dernière valeur servira à générer des hypothèses sur la possibilité du bruit d'interférer avec la communication et le sommeil, ainsi que d'occasionner de la gêne chez les occupants de cette salle.

Tableau 2. Mesures effectuées avant la sortie des enfants

Site et heure	Leq, 2 min. [dB(A)]	Max [dB(A)]	Min [dB(A)]
A			
(15h06)	61	68	48
(15h10)	62	68	44
B			
15h25	64	72	54
15h28	65	77	54
C (15h31)	60	65	51
D (15h35)	64	70	54
E (15h40)	61	72	53

5 DISCUSSION

5.1 Bruit dans l'aire de jeu

Si en l'absence d'enfants les niveaux mesurés étaient susceptibles d'interférer avec la communication, il faut s'attendre à ce que la situation soit encore moins favorable après la sortie des enfants. Selon la distribution des niveaux sonores enregistrés au cours de la seconde mesure avec le système dBTRIG32, le niveau sonore dépassait 64 dB(A) pendant 95% du temps. Il est alors justifiable de supposer qu'un tel niveau de bruit environnemental interfère avec la communication, même avec effort vocal, et que la majorité des enfants et éducatrices soient gênés par le bruit.

5.2 Niveau intérieur estimé

Le niveau de pression acoustique estimé à l'intérieur de la salle adjacente au balcon est de 49 dB(A) lorsque les fenêtres sont légèrement ouvertes. Une comparaison avec les valeurs suggérées par l'OMS suppose que ce niveau de bruit serait suffisamment élevé pour interférer avec la communication à un niveau conversationnel normal et perturber le sommeil des enfants (en supposant que la sieste a lieu dans cette salle). De plus, il est possible que certains enfants et éducatrices soient gênés par le bruit au cours d'activités qui se déroulent dans cette salle.

5.3 Comparaison avec un second service de garde

Afin de démontrer l'importance de la circulation routière comme source de bruit au service de garde, les niveaux sonore enregistrés ont été comparés à ceux obtenus à un second service de garde situé à proximité d'une rue résidentielle d'un quartier calme. Les niveaux équivalents de bruit dans l'aire de jeu variaient entre 62 et 66 dB(A) en l'absence d'enfants et entre 69 et 76 dB(A) lorsque les enfants jouaient à l'extérieur de la première garderie tandis que pour la seconde, des niveaux de l'ordre de 55 dB(A) et 65 dB(A) ont été observés en l'absence et en présence d'enfants, respectivement. Il semble que la circulation routière peut expliquer la différence observée entre les deux endroits puisqu'elle demeure significative (7 à 11 dB(A)) lorsque les enfants ne sont pas à l'extérieur. Le nombre d'enfants jouant à l'extérieur était comparable entre les deux milieux.

Le premier service de garde représente une situation bien particulière en étant situé tout près d'une autoroute. Les niveaux de bruit enregistrés ne sont pas négligeables puisque dans certains cas, la durée d'exposition habituelle peut atteindre 2 heures (de 15h45 à 17h45) pour les enfants dont les parents arrivent à la fermeture. Un tel emplacement pour un CPE n'est pas fréquent mais cette étude démontre l'importance de bien planifier l'implantation de milieux de garde, car il est souvent difficile de réagir après la construction.

5.4 Fiabilité des mesures

Par souci de fiabilité, les mesures aux divers points d'échantillonnage devraient être répétées. Puisque plusieurs données devaient être recueillies avant la sortie des enfants, une seule mesure a été complétée à plusieurs endroits. Cependant, un écart inférieur à deux décibels a été obtenu pour les mesures répétées aux sites A et B. L'évaluation a également eu lieu lors d'une journée typique de semaine et les enfants sont sortis à l'heure habituelle pour la période de jeu. De plus, il n'y avait rien d'inhabituel au niveau de la circulation routière qui aurait pu influencer le taux de circulation sur l'autoroute et le boulevard (i.e. festival, accident, travaux de construction, etc.).

5.5 Contrôle du bruit

Les niveaux de bruit environnemental à l'extérieur de la garderie ne respectent pas les valeurs recommandées par l'OMS. L'utilisation de stratégies pour atténuer le bruit est alors fortement suggérée. Il existe trois grandes catégories de procédures de réduction du bruit : on peut réduire le bruit à la source, au point de réception et au niveau de la propagation sonore (Behar, Chasin et Cheesman, 2000). Certaines propositions seraient difficilement réalisables mais doivent tout de même être mentionnées.

Parmi les stratégies de réduction du bruit à la source, des changements au niveau de la composition du revêtement de la chaussée et l'établissement de limites maximales d'émissions sonores seraient avantageux à considérer. Certaines études françaises ont démontré que, par rapport à un revêtement classique, des revêtements de chaussée poreux peuvent réduire de 5 dB le bruit de circulation (Echo Bruit, 1990). Une seconde option est d'imposer des limites de vitesse et d'émissions sonores. A titre d'exemple, le Ministère des Transports du Québec a établi une limite maximale de bruit de circulation de l'ordre de 65 dB(A) Leq24hres et indique que la responsabilité d'atténuer tout niveau supérieur revient au Ministère et à la municipalité concernés, chacun étant responsable de 50% des frais. Le Ministère recommande qu'un niveau maximal de 55 dB(A) soit respecté dans les zones sensibles (zones résidentielles, institutionnelles et récréatives) (Beaudin, Cassetti & Maurice, 1998).

Une réduction du bruit à la source serait profitable non seulement aux enfants et éducatrices de la garderie, mais à la population en général. De telles stratégies sont cependant difficilement réalisables à court terme. D'une part, des matériaux de revêtement efficaces impliqueraient des coûts considérables puisqu'ils sont souvent les moins résistants. De plus, les produits proposés en Europe ne sont pas nécessairement compatibles avec nos hivers rigoureux. D'autre part, la mise en place de limites maximales implique des enjeux politiques importants.

Certaines stratégies de réduction du bruit agissent au point de réception et touche principalement les matériaux de construction. Les matériaux isolants et absorbants peuvent jouer un rôle considérable dans l'atténuation du bruit, mais pour être efficaces les matériaux isolants (brique, métal, verre, béton) doivent être lourds et de faible porosité, alors que les matériaux absorbants (tissus, coussins, tuiles acoustiques), doivent être flexibles et poreux (Behar et al., 2000). Le niveau de bruit à l'intérieur d'un bâtiment dépend également de l'orientation des portes et fenêtres, leur nombre et type (Behar et al., 2000; OMS, 2000; Ministère de l'équipement et de l'aménagement du territoire, 1978).

Le bruit à l'intérieur de la garderie n'a pas été mesuré puisque ce n'était pas l'objectif de l'évaluation. Cependant, si l'administration de la garderie envisage agrandir l'édifice, il serait avantageux de prendre en considération non seulement les matériaux de construction, mais aussi l'orientation des fenêtres et portes par rapport à la source principale du bruit, soit la circulation routière sur l'autoroute.

La dernière catégorie de stratégies de réduction du bruit vise plutôt à limiter la propagation des ondes sonores qu'à réduire le bruit à la source ou au point de réception, et l'option la plus fréquemment recommandée est l'installation d'écrans ou de barrières acoustiques. Ceux-ci peuvent atténuer le bruit de 20 dB(A) (Behar et al., 2000) et leurs bénéfices seraient certainement appréciés, surtout durant la période estivale où les enfants et éducatrices passent beaucoup de temps à l'extérieur. Il est d'ailleurs surprenant qu'un écran acoustique n'existe pas à cet endroit puisque, selon le règlement municipal, la responsabilité de mettre en place des stratégies de contrôle du bruit pour les terrains résidentiels situés près de l'autoroute revient aux contracteurs.

Le domaine des écrans acoustiques continue d'évoluer grâce à la découverte de nouveaux matériaux qui sont à la fois favorables à l'environnement et à la réduction du bruit. Michel Labrecque, botaniste au Jardin botanique de Montréal, affirme que le « saule rieur », cousin du saule pleureur, possède certaines propriétés (taux de croissance extraordinaire, croissance dans diverses conditions, décontamination des sols et purification de l'air) qui rend cet arbuste un choix prometteur en tant qu'élément constitutif d'un mur anti-bruit végétal (http://radio-canada.ca-actualite/decouverte/nosemissions.html).

La direction du service de garde devrait reconsidérer l'agrandissement du bâtiment. Il a été démontré que les niveaux de bruit mesurés en l'absence d'enfants étaient similaires des deux côtés de la garderie. Une nouvelle aire de jeu du côté nord serait donc sujette aux même niveaux de bruit (et donc aux même conséquences néfastes du bruit) que ceux observés dans le terrain de jeu actuel. Il faut également mentionner qu'en accommodant un plus grand nombre d'enfants, le bruit environnemental risque d'augmenter. Si la direction décide d'aller d'avant avec ce projet, la conception et construction de la nouvelle section doivent faire l'objet d'une planification rigoureuse. D'ailleurs, il serait important d'orienter la nouvelle construction de façon à ce qu'elle agisse en tant qu'écran acoustique pouvant limiter la propagation du bruit provenant de la circulation sur l'autoroute (en se trouvant entre le terrain de jeu et l'autoroute). De plus, la planification devrait également concerner l'environnement interne. La direction du service de garde est fortement encouragée à explorer diverses stratégies pour contrôler le bruit puisque la qualité de la communication, ainsi que le bien-être social, physique (i.e. troubles de la voix) et mental des enfants et des éducatrices peuvent en dépendre.

6 CONCLUSION

Les niveaux de bruit mesurés dans les aires de jeu extérieurs d'un centre de la petite enfance se trouvant en bordure d'une autoroute sont tous supérieurs aux recommandations de l'OMS (WHO, 2000) en ce qui a trait à l'interférence avec la communication, la perturbation du sommeil et la gêne. Des niveaux de 70 dB(A) ont été dépassés plus de 50% du temps pendant que les enfants jouaient à l'extérieur. En l'absence d'enfants, les niveaux oscillaient entre 62 et 66 dB(A) dans l'aire de jeu. Cette étude démontre l'importance de bien planifier la construction des services de garde, car il peut être difficile et coûteux d'implanter des mesures correctives une fois le milieu de garde implanté. L'impact du bruit dû à la circulation routière se fait sentir lorsque les enfants sont à l'extérieur, mais aussi lorsque qu'ils sont à l'intérieur, particulièrement lorsque les fenêtres sont entre-ouvertes et orientées du côté des voies routières majeures.

7 REMERCIEMENTS

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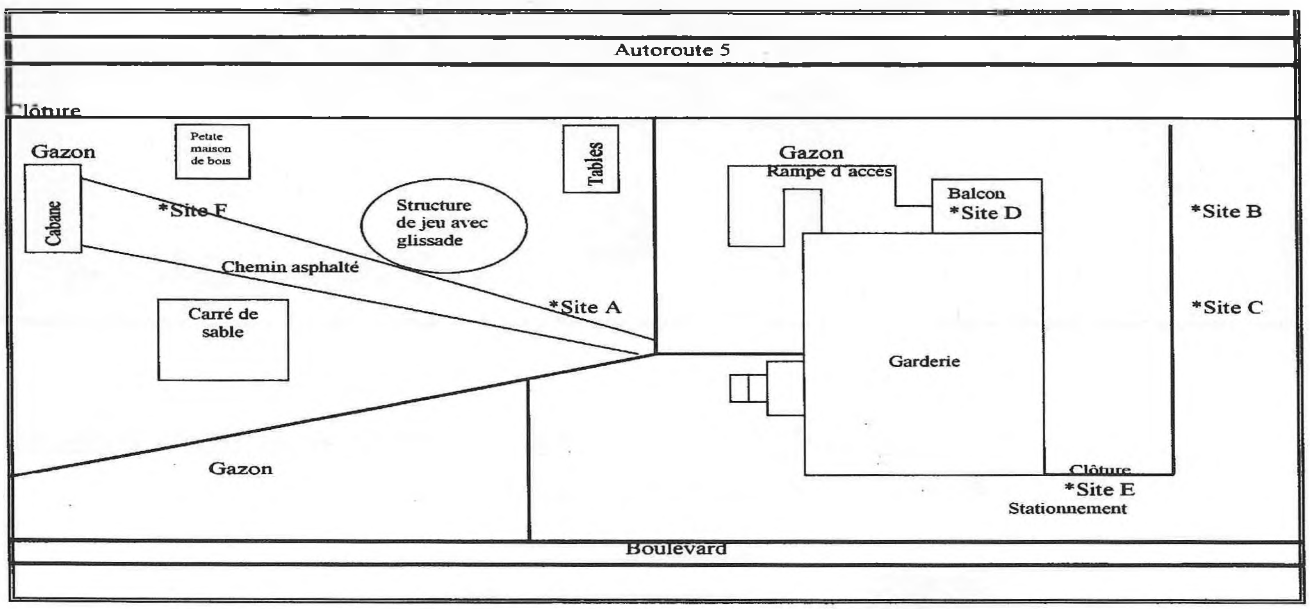
ANNEXE1. Plan des lieux extérieurs du service de garde et points d'échantillionnage.



THE ACOUSTICAL DESIGN OF CONVENTIONAL OPEN PLAN OFFICES

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SUMMARY

This paper uses a previously developed model of sound propagation in conventional open plan offices to explore the influence of each parameter of the office design on the expected speech privacy in the office. The ceiling absorption, the height of partial height panels and the workstation plan size are shown to be most important. However, it is not possible to achieve 'acceptable' speech privacy if all design parameters do not have near to optimum values. A successful open office should also include an optimum masking sound spectrum and an office etiquette that encourages talking at lower voice levels.

SOMMAIRE

Cet article s'appuie sur un modèle de propagation du son dans les bureaux à aires ouvertes mis au point antérieurement afin d'analyser l'influence de chaque paramètre de la conception du bureau sur l'insonorisation du local en question. L'absorption du plafond, la hauteur des cloisons et les dimensions du poste de travail apparaissent être les 3 paramètres les plus importants. Il est cependant impossible d'atteindre une insonorisation "acceptable" si tous les paramètres conceptuels ne sont pas proches de leurs valeurs optimales. Un bureau à aires ouvertes réussi doit aussi comprendre un spectre de son masquant optimal et une politique de bureau qui encourage à parler à voix basse.

1. INTRODUCTION

Open plan offices have existed for many years, and they have gradually become the predominant format of office spacc for a wide range of work activities. Older designs incorporating stand-alone screens and furniture have usually been replaced by modular workstations that are frequently referred to as cubicles. There are modern trends to experiment with so-called innovative designs such as 'team spaces' and other variations where the partial height panels between office workers are absent or much reduced in size. However the vast majority of open plan offices today consist of the rectangular cubicle format and this paper is concerned with the design of this type of open plan office.

Conventional open plan offices are said to be less costly to construct and less costly to rearrange to meet changing accommodation needs. Of course, there are counter arguments that lack of privacy and increased distraction will make office workers less efficient, and that at least point to the need for good acoustical design. Optimising the acoustical design of an open plan office can be a complex task because of the number of design parameters that must be considered. This problem has recently been made much easier to solve as a result of the development of a mathematical model of sound propagation between workstations in conventional open plan offices [1-4]. Using this model one can conveniently and quite accurately predict the speech privacy of a particular open plan office design. This model is used here to demonstrate the importance of each open office design parameter.

This paper will first describe measures of speech privacy that can be used to rate the acceptability of an open plan office design. Then design criteria for speech privacy and office noise levels are reviewed. The influence on speech privacy of ten office design parameters are then demonstrated and finally the overall approach to a successful design is discussed.

2. SPEECH PRIVACY AND NOISE LEVEL CRITERIA

Because of the absence of full height partitions, the challenge for the acoustical design of open offices is to achieve an acceptable degree of acoustical or speech privacy between workstations. This must be done without creating unacceptably noisy conditions. Speech privacy is related to the speech-to-noise ratio and is more or less the opposite of speech intelligibility. If the level of speech is high relative to ambient noise levels, then the speech will be quite intelligible as would be desired in a meeting room. In an open office we would like the level of intruding speech to be low relative to the ambient noise so that speech is less intelligible or so that we will have some speech privacy. An appropriate level of noise can mask or cover up unwanted speech sounds. It is important to mask speech sounds because they are much more disturbing than relatively constant levels of more neutral sounds such as those of typical ventilation noise. Although higher noise levels may better mask the unwanted speech sounds, the higher noise levels can become a source of annoyance and cause people to talk louder and hence they will not optimally improve speech privacy.

The Articulation Index (AI) [5] has been used to assess speech privacy in open plan offices. AI is a weighted signal-to-noise ratio with a value between 0 and 1. It was originally developed to evaluate communication systems and has been widely used to assess conditions for speech in rooms. A value close to 1 should correspond to near perfect speech intelligibility. A value near 0 should indicate near perfect speech privacy. More recently the AI has been replaced by the Speech Intelligibility Index (SII) [6]. This is a little more complex to calculate than AI and includes the masking effect of lower frequency components on each frequency band. Like AI it has a value between 0 and 1, but for the same condition SII values are a little larger than AI values. Appendix I gives a detailed comparison of the two measures.

It has been conventional to refer to two levels of criteria for speech privacy and to relate them to corresponding AI values. 'Confidential privacy' has been said to correspond to AI $\leq$ 0.05 [7,8]. This has been defined as corresponding to 'zero phrase intelligibility with some isolated words being intelligible'. Conditions corresponding to AI $\leq$ 0.15 have been described as 'acceptable' or 'normal privacy' for open plan offices [9]. Such conditions are said to be not too distracting. In practice they correspond to a level of speech privacy that can be achieved in a well designed open plan office. These two speech privacy criteria and their equivalent SII values are included in Table 1. Ongoing work is investigating the interpretation of these criteria.

Level of speech privacy	**AI**	**SII**
Confidential	0.05	0.10
Acceptable	0.15	0.20

Table 1. Speech privacy criteria in terms of AI and SII values.

Speech privacy and the calculation of AI and SII values depend on the speech and noise levels in open plan offices. The AI and SII standards [5,6] include standard speech spectra for 'normal' speech. The 'normal' voice level spectrum in the SII standard corresponds to 59.2 dBA. Although 'normal' speech levels have frequently been used to estimate speech privacy in open plan offices, Warnock and Chu [10] have recently published measurements of speech levels in open offices that indicate people talk more quietly than this 'normal' spectrum. Their data indicate average speech source levels of 50.2 dBA, which are essentially the same as Pearson's 'casual' speech levels [11]. This level represents the average of all talkers that they measured in a number of open plan offices. If this level were used in design calculations, it would underestimate the disturbance caused by the louder half of the talkers that talk more loudly than this average level. Therefore, an Intermediate Office Speech Level (IOSL) spectrum was created that had an A-weighted level approximately 1 standard deviation higher in level than the mean value and corresponds to a speech source level of 53.2 dBA. This is a more conservative speech source level to use in open office design and only about 16% of talkers are expected to talk louder than this. The actual speech spectra are included in Appendix II.

The level and spectrum shape of ambient noise in the office also significantly influences the degree of speech privacy as well as the related AI and SII values. Although increasing noise levels lead to reduced speech privacy, there is a limiting noise level above which the noise becomes more disturbing and less beneficial. Because it is difficult to carefully control the level and spectrum of actual ventilation noise, and because it will vary with the operation of the ventilation system, the desired speech privacy can be more precisely achieved using electronic masking sound. The spectrum of such masking sound should include energy at all frequencies with significant speech energy, and should sound like a neutral ventilation noise. Such spectrum shapes have been specified [12] and an optimum masking spectrum shape is included in Appendix II. There are also rules of thumb that the overall level of masking sound (or natural ambient noise) should not exceed 48 dBA [13]. Recent studies of worker satisfaction in an experimental open office found that an ambient noise level of 45 dBA was preferred [14]. Therefore we can say that an optimum masking noise should have a spectrum like that in Appendix II and have an overall level of 45 dBA. Masking sound levels should probably never exceed 48 dBA.

3. EFFECTS OF OFFICE DESIGN PARAMETERS

The model described by Wang [1-4] was implemented in open office design software and was used here to demonstrate the effects of varying office design parameters. It assumes that the source talker is at the centre of one workstation and the receiver listener is at the centre of an adjacent workstation. The user can specify speech source and noise spectra, geometrical dimensions, as well as the sound absorbing properties of surfaces. The programme calculates speech privacy in terms of the SII value due to the speech propagating from the adjacent workstation and the specified office noise spectrum and level.

In the program, the effects of various reflecting surfaces are determined using an image sources technique. It also includes diffraction over the partial height panel separating the two workstations and includes further reflections of this diffracted sound energy. It was developed because available room acoustics ray tracing programs were not able to include diffraction and subsequent reflections of the diffracted energy. The program also includes empirical corrections for the difference between laboratory measurements of ceiling absorption and those values measured in a large series of tests of propagation in a mock up open office. There are similarly empirical corrections for the effects of ceiling mounted light fixtures. Comparisons with actual measurements have validated the accuracy of the program in the original evaluations [1-4] as well as in more recent tests in actual offices. The RMS differences between measured and predicted SII values have been between 0.02 and 0.03.

The following sections show the results of calculated SII values for variations of 10 different open office design parameters. One could perform calculations for many combinations of these 10 parameters. However, most of these results would lead to unacceptably low speech privacy. 'Acceptable' speech privacy can only be achieved when key office design parameters are close to optimum. Therefore the calculations that are presented are deviations from an 'acceptable' Base case design. These illustrate the range of conditions that should be of most interest to designers.

The sound absorption and sound transmission loss data used were generic data representative of real screens and ceilings. They were obtained by averaging groups of test results for products with similar acoustical properties. The sound absorption ratings are referred to by their Sound Absorption Average (SAA) value. (SAA is the average of the 1/3 octave band absorption coefficients from 200 to 3.15k Hz and replaces NRC rating [15]). The Sound Transmission Class (STC) [16] is used to describe the transmission loss of panels.

Office Design Parameter	Value
Ceiling absorption	SAA=0.95
Screen/panel height	1.7 m (5.6 ft)
Screen/panel absorption	SAA= 0.90
Workstation plan size	3.0 m by 3.0 m (9.8 ft by 9.8 ft)
Floor absorption	SAA=0.19
Screen/panel transmission loss	STC=21
Ceiling height	2.7 m (8.9 ft)
Light fixtures	None
Speech source level	53.2 dBA (IOSL speech)
Noise level 45 dBA	(optimum masking spectrum)

Table 2. Details of the 'acceptable' Base case used in calculations. (SAA, Sound Absorption Average [15], STC, Sound Transmission Class [16], IOSL, Intermediate Office Speech Level).

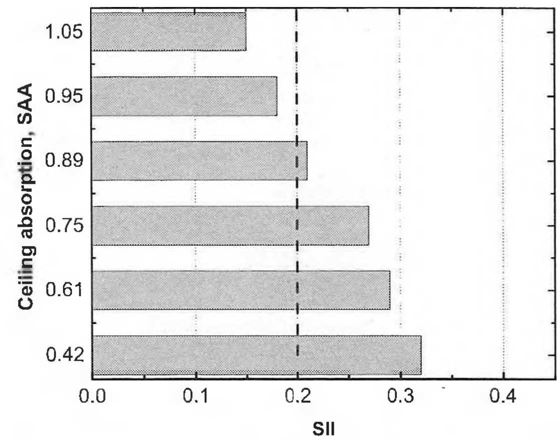

Figure 1. Effect of varied ceiling absorption on Base case.

The 'acceptable' Base case condition is described in Table 2. It had a calculated SII value of 0.19, which is just inside the desired range of SII ≤ 0.2 for 'acceptable' privacy.

a) Ceiling absorption

Figure 1 shows the effect of varying only the ceiling absorption of the Base case workstation design. Reducing the ceiling absorption much below SAA=0.95 significantly increases SII values to well above the range for 'acceptable' privacy. On the other hand a more absorptive ceiling could further enhance speech privacy or in other designs compensate for other less effective components than those in the Base case design. By re-plotting this data as a scatter plot, one can deduce that if the ceiling absorption is less than SAA=0.90, it is not possible to achieve acceptable privacy in an otherwise well designed workstation such as that of the Base case. Earlier work had recommended this same minimum ceiling absorption [17]. The ceiling is the most important reflecting surface in open plan offices and it is most important that it be as highly absorbing as possible.

b) Screen/panel height

The partial height panels separating workstations must be high enough to block the direct path of speech sounds from one workstation to another and also must be high enough that the level of the sound diffracted over the panel is reduced enough to make possible 'acceptable' speech privacy. Figure 2 shows calculated SII values for varied screen heights from 1.3 to 1.9 m high. Again these are variations to the Base case open office workstation design. When seated the mouth of a talker and the ear of the listener in adjacent

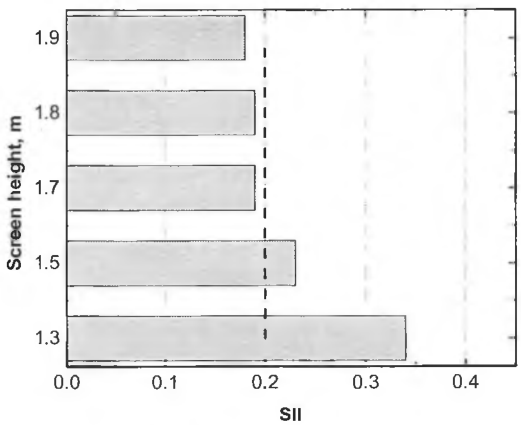

Figure 2. Effect of varied screen height on Base case design.

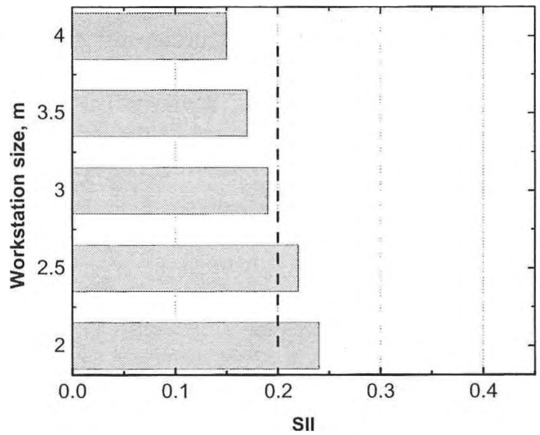

Figure 4. Effect of workstation plan size on Base case design.

workstations are approximately 1.2 m above floor level. The height of the separating panel must be substantially greater than this to make it possible to achieve 'acceptable' privacy. However above a height of 1.7 m, further increases in the height of the separating panel have quite small effects on calculated SII values.

c) Screen/panel absorption

Figure 3 shows the calculated effects of varying the sound absorption of the workstation panels. Decreasing the SAA from 0.9 to 0.6 increased the calculated SII from 0.19 to 0.22. However, using non-absorbing workstation panels (SAA=0.10) is seen to increase the SII much more to a value of 0.29. It is important to have sound absorbing panels but the change in privacy between typical medium and higher absorption workstation panels is small.

d) Workstation plan size

Workstation plan size was varied from a minimum of 2 m by 2 m to a maximum of 4 m by 4 m. SII values systematically decrease as the workstation size is increased. This is due to the increasing distance between the source and receiver at the centre of each workstation. Clearly there is an advantage to having larger workstations when attempting to achieve good speech privacy. Decreasing the workstation size below the base case (3 m by 3 m) decreased speech privacy. Even the 2.5 m by 2.5 m (8.2 ft by 8.2 ft) workstation would not quite meet the 'acceptable' speech privacy criteria.

e) Floor absorption

Figure 5 shows the results of calculations when the floor absorption of the Base case workstation design was varied. These results correspond to thin carpet (SAA=0.19), thick carpet (SAA=0.25) and a hard non-absorbing floor (SAA=0.05). There are only very tiny differences between the two calculations for varied carpet thickness. However, having a non-absorbing floor does decrease the speech privacy above the acceptable SII value. There are other reasons to recommend the use of carpet too. It will reduce some sources of noise such as footsteps and the moving of chairs. It will also help to minimize sound propagation through gaps at the bottom of screens. Although there is no reason to select

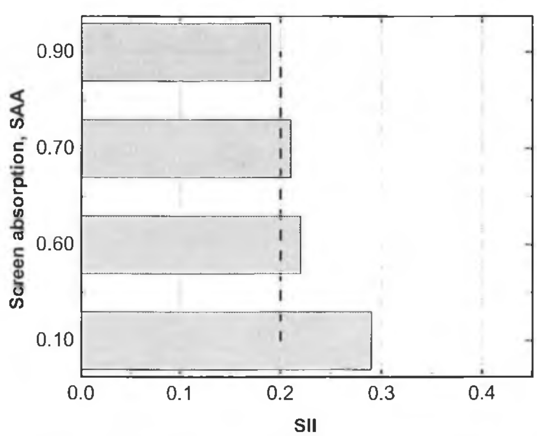

Figure 3. Effect of varied screen absorption on Base case design.

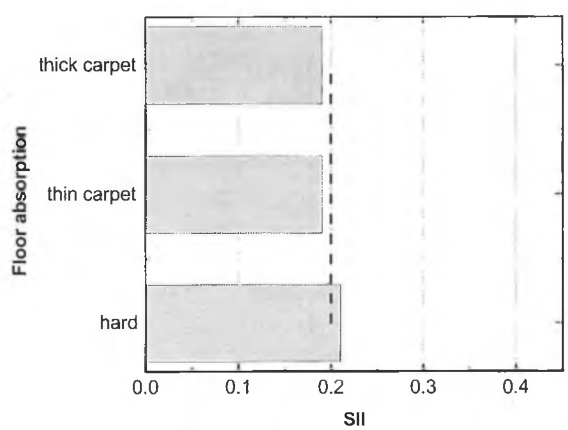

Figure 5. Effect of floor absorption on Base case design.

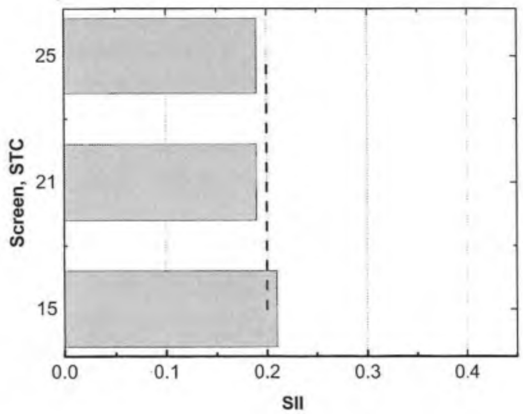

Figure 6. Effect of panel STC on Base case design.

thicker carpets, it is important to include a carpeted floor in open plan offices.

f) Screen transmission loss

Some recommendations specify that the transmission loss of the separating partial height panel should have an STC of at least 20 [17]. This is intended to ensure that the propagation of speech sound energy through the separating panel does not limit speech privacy. Figure 6 shows calculated SII values for varied STC of the separating panel. Decreasing the panel STC from 21 to 15 increased speech privacy to a little above the 'acceptable' criterion. However, increasing the transmission loss of the panel from STC 21 to STC 25 produced only a negligible improvement in SII. A minimum STC of 20 for the separating panel is seen to be adequate to avoid degrading speech privacy.

g) Ceiling height

The height of the ceiling in most open plan offices is usually quite similar to that of the base case (2.7 m). The calculated results in Figure 7 show that increasing the height to

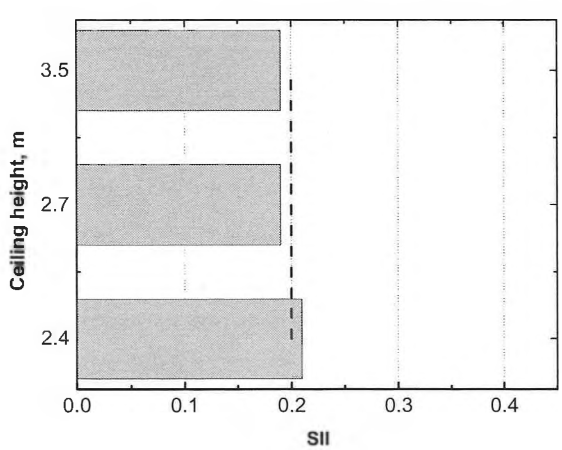

Figure 7. Effect of ceiling height on Base case design.

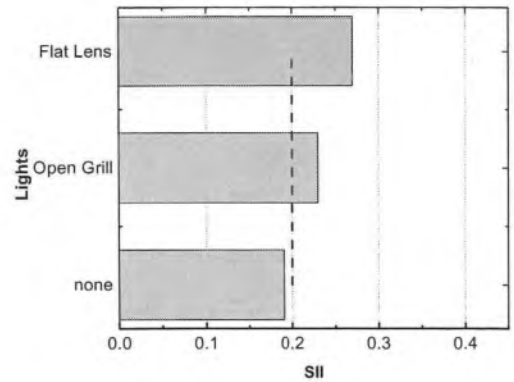

Figure 8. Effect of Ceiling lighting fixtures on Base case design.

3.5 m had a negligible effect on the calculated SII. However, decreasing the height from 2.7 m to 2.4 m did decrease speech privacy to a little above the 'acceptable' privacy criterion. One should therefore avoid particularly low ceiling heights in open plan offices.

h) Light fixtures

Calculations were made for three different ceiling lighting conditions and are shown in Figure 8. The Base case had no ceiling mounted lights. The empirical corrections in the software were then used to estimate the effect of a flat lens light positioned over the separating partial height panel. This would represent the worst possible effect of ceiling light fixtures. This condition led to a substantial increase in the SII values and hence would correspond to significantly decreasing speech privacy. Clearly this lighting configuration should be avoided. Using open grill lighting either positioned over the separating screen or over the centre of the workstations would have a smaller effect but again decreases the speech privacy of the base case so that it is no longer 'acceptable'. Locating flat lens fixtures over the centre of the workstations is more acceptable than over the separating panel. However, lights are usually installed before workstations and it is usually difficult to control their position relative to the location of each workstation. This is especially true after the workstation layout has been modified from the original plan. It is obviously better to use open grill light fixtures if ceiling mounted lighting is required.

i) Speech level

Figure 9 shows the calculated SII values when the source speech levels were varied for the Base case office design. Results were calculated for the 'normal' voice level from the SII standard [6], for the Intermediate Office Speech Level (IOSL), and for a 'casual' speech source level. Voice level can have a very large effect on the resulting SII values. Clearly it is important to use a representative speech source

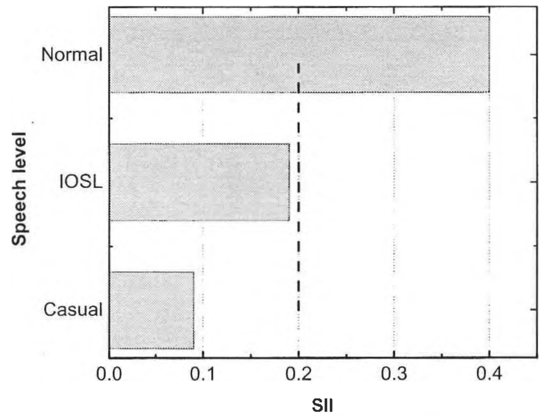

Figure 9. Effect of speech source level on Base case design.

level. As explained earlier, it is thought best to use the IOSL speech spectrum. However, there are further large benefits to be obtained by encouraging office workers to talk with lower voice levels. It is important to promote an office etiquette that encourages the use of lower voice levels and relocating to closed meeting rooms when more extensive discussions are needed. It may be difficult to accommodate work that includes telephone conversations of a more confidential nature in open plan environments.

k) Ambient noise

The effect of varied ambient noise is illustrated in Figure 10. The Base case office included the optimum-masking spectrum described previously and included in Appendix II. Increasing this masking noise from 45 dBA to 48 dBA (corresponding to the maximum masking noise spectrum) is seen to substantially decrease SII values. Although speech privacy would be significantly improved, experience has shown that this will begin to lead to decreased occupant satisfaction. A further calculation was performed with an ambient noise with an RC35 shaped spectrum (corresponding to 42 dBA). This would be representative of a little quieter

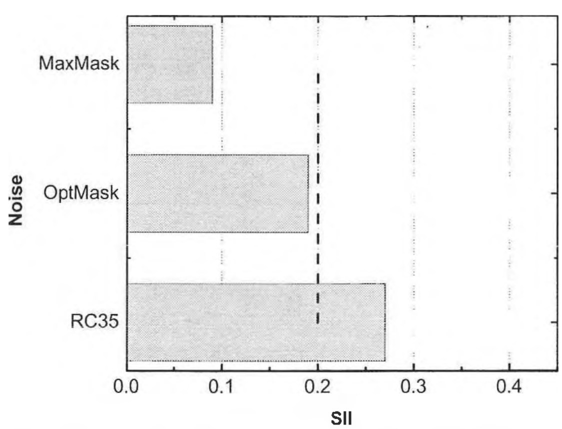

Figure 10. Effect of ambient noise on Base case design.

ventilation noise type spectrum and leads to a substantial decrease in speech privacy. It is clearly important to optimise the level and spectrum of ambient noise by using a masking sound system to create exactly the desired masking sound that will lead to a desirable level of speech privacy without leading to further disturbance of office workers.

4. THE OVERALL DESIGN APPROACH AND DESIGN TRADE-OFFS

The various calculations give clear indications of the importance of each of the office design parameters. The most important factors for achieving 'acceptable' speech privacy are: (a) the sound absorption of the ceiling, (b) the height of panels between workstations, and (c) the workstation plan size. Although less important, one cannot ignore the other open office design parameters: (a) panel absorption, (b) panel transmission loss, (c) floor absorption, (d) ceiling height and (e) the details of ceiling mounted lighting.

The Base case design, described in Table 2, represents a combination of values that just meet the criterion for 'acceptable' privacy. Small degradations of one design parameter can be compensated for by augmenting the values of other parameters to still achieve 'acceptable' speech privacy. For example, decreasing the workstation plan size to 2.5 m by 2.5 m, reducing the separating panel height to 1.6 m and reducing the panel absorption to SAA=0.70 would still result in an SII of 0.19 if the ceiling absorption were increased to an SAA of 1.03. Alternatively the same increased ceiling absorption could be used to compensate for reduced plan size and the addition of open grill lighting. The details of these examples are compared with those of the Base case in Table 3. A difference in SII of less than 0.03 is probably not detectable.

These examples illustrate that there is not much room to compromise in trading off increases in one parameter to compensate for decreases in another. Most significant deviations from the Base case will result in open offices with less than 'acceptable' speech privacy. In particular the reduction of workstation plan size must be accompanied by an improved ceiling absorption to maintain conditions of 'acceptable' speech privacy. The expected saving for a higher density office with smaller workstations may be reduced by the increased cost of a more absorptive ceiling.

The speech and noise levels in the open plan office are at least as important as the office design for achieving 'acceptable' speech privacy. Therefore, in addition to a near-perfect office design, one is forced to the conclusion that an electronic masking sound system is an essential part of a successful open office design. The masking sound system should produce ambient noise levels similar to the optimum masking spectrum in Appendix II. These levels should be evenly distributed throughout the office. When adding such systems to existing offices, it is desirable to increase the level gradually over several weeks to allow office workers a

Office Design	Base case	Example #1	Example #2
Ceiling absorption	SAA=0.95	SAA=1.03	SAA=1.03
Screen/panel height	1.7 m	1.6 m	1.7 m
Screen/panel	SAA= 0.90	SAA=0.70	SAA=0.90
Workstation size	3.0 m by 3.0 m	2.5 m by 2.5 m	2.5 m by 2.5 m
Floor absorption	SAA=0.19	SAA=0.19	SAA=0.19
Panel transmission	STC=21	STC=21	STC=21
Ceiling height	2.7 m	2.7 m	2.7 m
Light fixtures	None	None	Open grill
Speech source level	53.2 dBA (IOSL)	53.2 dBA (IOSL)	53.2 dBA (IOSL)
Noise level	45 dBA (Opt	45 dBA (Opt	45 dBA (Opt
SII	0.19	0.19	0.21

Table 3. Details of open office designs with approximately 'acceptable' speech privacy.

chance to adapt to the new conditions.

The design of the open office can reduce the propagation of speech sounds from one workstation to another. It is also very important to reduce speech levels at the source by encouraging an office etiquette of talking more quietly. More extensive discussions, and especially those involving more than 2 people, should be relocated to a closed meeting room. Of course telephone conversations can be a source of disturbance. Where reduced voice levels are not possible or where the information is confidential, this activity is not compatible with a typical open office environment.

Although the new model allows precise examination of the effects of various parameters, in many cases such detailed design may not be necessary. Success requires that almost all design parameters are near to optimum and one could readily specify minimum requirements for most of them. This would avoid the need for future detailed design calculations. The examples in Table 3 could form a basis for such minimum design values. Using these values will result in conditions that approximately correspond to the minimum criterion for 'acceptable' speech privacy. Of course this approach should include an optimum masking noise spectrum and an office etiquette that encourages using lower voice levels.

5. CONCLUSIONS

The results in this paper demonstrate the effects of each open office design parameter. They indicate that the values of each parameter must be near to optimum to ensure 'acceptable' speech privacy in conventional (cubicle type) open plan offices. Examples of combinations of values of 10 parameters are given that would lead to 'acceptable' speech privacy. Although one can, to some extent, trade off increases in one parameter to compensate for decreases in another, the range of such compromises is very limited.

The present results describe the average characteristics of cubicle type open plan offices because the source and receiver were positioned at the centre of adjacent workstations. The actual speech privacy experienced will also depend on each individual's location within their workstation as well as the direction in which talkers are facing.

The main argument in favour of open plan offices is the expected reduced cost relative to closed offices with full height partitions. The cost savings may be a little reduced with the extra expense of meeting 'acceptable' speech privacy requirements. However, these additional costs are usually assumed to be small relative to the costs of decreased performance by distracted office workers. It is difficult to accurately assess the costs of poor office design and future research should consider this issue. It would also be useful to investigate which types of office work activity are most suitable to be performed in open plan office environments.

ACKNOWLEDGMENTS

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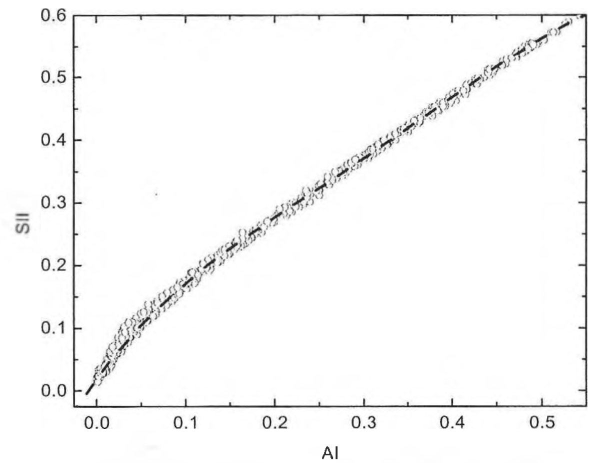

Figure A1. Relationship between SII and AI values.

Appendix I.
Relation Between SII and AI Values

Measured attenuations in a series of mock up workstation tests were used to calculate both AI and SII values. By repeating these calculations for a range of speech and noise levels a very wide range of values of each measure was obtained. The resulting SI values are plotted versus AI values in Figure A1. The regression line shown on this plot is a fourth order polynomial that very accurately fits the data between AI values of 0 and 0.5. Its equation is as follows,

$$SII = 0.0194 + 1.942\ AI - 5.263\ AI^2 + 11.731\ AI^3 - 9.247\ AI^4$$

Alternatively one can approximate the relationship by two simple straight lines.

For $0 \le AI \le 0.05$, $SII = 1.9755\ AI + 0.0163$,

and for $0.05 \le AI \le 0.5$, $SII = 0.9915\ AI + 0.0721$.

Appendix II.
Data Used in the Calculations

This appendix includes the speech and noise spectra used in the calculations of this report. Figure A2 plots the speech source level spectra used. 'Normal' corresponds to the 'normal' speech source spectrum in the SII standard [6]. IOSL is the intermediate office speech level spectrum created in this work as approximately 1 standard deviation greater than the average speech levels found in open plan offices. 'Casual' is the mean of the average speech levels found in open plan offices [10] and Pearson's very similar 'casual' speech source spectrum [11].

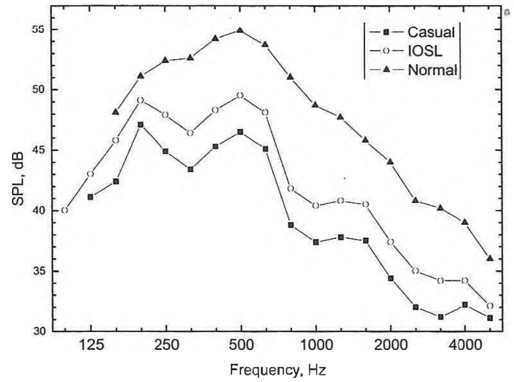

Figure A2. Speech source spectra used in calculations.

Figure A3 plots the Optimum masking spectrum and the Maximum masking spectrum that were used in the calculations of the current work.

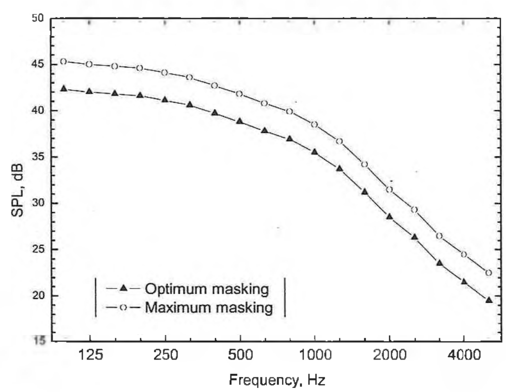

Figure A3. Masking noise spectra used in calculations.

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CONDENSER MICROPHONES A TUTORIAL*

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ABSTRACT

This tutorial discusses the operation of several types of condenser microphone including standard omnidirectrional measuring microphones, simple cardioid microphones, and studio microphones with adjustable response pattern. The physics underlying their operation is discussed, and the approach to a detailed analysis using electrical network analogs is outlined.

***Note:** *This article by Neville Fletcher originally appeared in the December 2002 issue of Acoustics Australia and is reproduced here with the permission of the author and the Australian journal.*

1. INTRODUCTION

Fifty years ago the number of microphone types in common use was very large. Dynamic microphones were the most common, and came in both omnidirectional and cardioid response patterns, but broadcasting and recording studios often used ribbon microphones, usually with figure-eight response patterns. Omnidirectional condenser microphones were in use for acoustic measurements, and were beginning to penetrate the recording and broadcasting fields. Today the situation is very different: nearly all microphones in common use are condenser types, from simple cheap microphones in telephones and other voice recorders, through studio microphones with variable response patterns, to sophisticated measuring microphones. It is the purpose of this tutorial paper to give a brief survey of these condenser microphone types and to explain their operating principles, particularly in relation to frequency response and directional pattern.

Because microphones are so fundamental to the practice of acoustics, most classic books on practical acoustics, such as those by Olson[1], Beranek[2], Kinsler et al.[3], and Rossing and Fletcher[4] have a chapter on various common microphone types and their operation. More recently there is a whole book devoted to microphones, edited by Michael Gayford[4], and a specialised book on condenser microphones of the measurement type edited by George Wong and Tony Embleton[5]. Despite this, it is not easy to find a treatment along the lines to be attempted here.

2. ELECTRIC NETWORK ANALOGS

The behaviour of mechanically simple systems can usually be analysed by considering quite directly the motion of the mechanical elements when acted upon by an acoustic pressure signal. As the system becomes more complex, however, so does the analysis, and it has been found simplest to calculate this behaviour in terms of an electrical analog in which voltage V represents acoustic pressure p and electric current i represents acoustic volume flow U. (The same idea can be applied to mechanical systems by taking voltage to represent force rather than pressure, and current to represent velocity rather than volume flow, but it is simpler to use the acoustical analog from the beginning.) The one significant limitation of this approach is that it is essentially one-dimensional like the wires of an electrical circuit. More complex three-dimensional ideas have to be added later.

In this electric analog system an acoustic resistance, such as a layer of felt, becomes an electrical resistance, and Ohm's law $V=iR$ becomes the acoustic flow law $p=RU$. Similarly, a mass m that presents an area S to the acoustic pressure is represented by an electrical inductance $L=m/S$ and a mechanical spring by a capacitance C proportional to the compliance of the spring. A sealed cavity of volume V is represented by a capacitance of magnitude $C=V/\rho c^2$, where ρ is the density of air and c the velocity of sound in air, these relations being derived by considering the physics of the resulting motion or air flow. All the standard techniques of electrical circuit analysis can then be applied to work out the behaviour of the acoustic system being studied. In what follows we shall sometimes use these techniques, but also try to explain in physical terms what is going on.

3. MEASUREMENT MICROPHONES

An omnidirectional measuring microphone of standard design is shown schematically in Fig. 1(a). A strong thin metal diaphragm is stretched tightly over the entry to the microphone capsule and a plane insulated electrode is positioned about 20μm away from it. The capsule is sealed except for a fine capillary tube that provides a leak and prevents long-term build-up or deficit of pressure inside the capsule. The electrode is perforated by a number of holes for a reason that will become clear later.

When an oscillating acoustic pressure is applied to the outside of the diaphragm, this tends to move it towards the electrode, but the motion is resisted by the need to accelerate the mass of the diaphragm, by the diaphragm stiffness, and by the need to move air from between the diaphragm and the electrode through the vent holes and into the cavity behind the electrode. This back cavity itself has some acoustic elasticity, as noted above, and there is the vent to outside to be considered, but we ignore these for the moment. The microphone behaviour can therefore be analysed in terms of the analog circuit shown in Fig. 1(b), in which we want to calculate the current through the diaphragm impedance in terms of the applied pressure. The small extra stiffness from the air in the air enclosed in the cavity can be neglected in comparison with the diaphragm stiffness, which we do by assuming the analog cavity capacitance to be very large, and we also neglect the effect of the slow leak into the cavity, shown by the dashed-line part of the network. At low frequencies, diaphragm stiffness impedance $1/j\omega C$ is dominant over the diaphragm mass impedance $j\omega L$ and resistive losses R, and the diaphragm displacement is simply proportional to the acoustic pressure.

In use, the microphone electrode is charged to a potential of perhaps 200 volts through a very large resistor (perhaps 1000 megohms). This charging may take several seconds, so that effectively the charge on the electrode is constant. The electrical capacitance C_E between the electrode and the diaphragm is $\varepsilon_0 S/d$ where S is the electrode area, d is its separation from the diaphragm, and ε_0 is the permittivity of free space. Since the charge on this electrical capacitor is fixed despite the rapid diaphragm motion, the voltage across it is inversely proportional to the capacitance C_E, and therefore proportional to the diaphragm spacing d, which follows the acoustic pressure with just a change in sign. The electrical signal will therefore be a faithful replica of the acoustic pressure signal.

At higher frequencies things get more complicated. The

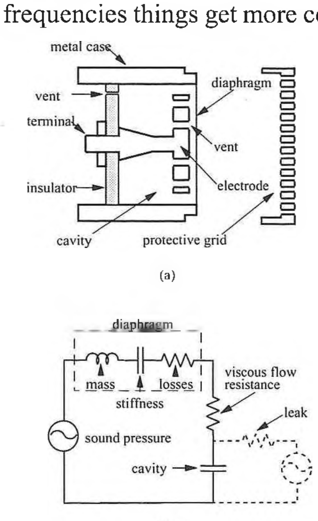

Figure 1. (a) Schematic diagram of an omnidirectional condenser measurement microphone. (b) Electrical analog network for the microphone in (a); the added effect of the slow leak is shown with dashed lines, since it is important only at very low frequencies.

motion of the diaphragm must now be considered in terms of its mass, its stiffness, and the resistive losses provided by the viscosity of the air as it is forced to move between the diaphragm and the electrode. As shown in Fig. 1(b), these elements are all in series, as is plain when it is considered that each one is separately resisting the diaphragm motion, which is equivalent to the electrical current in the circuit. The circuit is that of a simple resonator with resonance frequency f^* given by $2\pi f^* = (1/LC)^{1/2}$, and quality factor $Q = mf^*/2\pi R$, where the acoustic analog values are used for L, C, and R. The existence of this resonance means that the diaphragm motion will be increased by a factor Q at the resonance frequency f^* , the width of this resonance being about f^*/Q. Above the resonance, the diaphragm response will decline by 12 dB/octave.

To make a microphone with a good flat frequency response therefore requires a high resonance frequency f^*, and sufficient damping that the response peak near f^* is not too prominent. Measurement microphones have strong metal diaphragms that can be tensioned so as to give resonance frequencies in the range 15 to 50 kHz, the higher frequencies applying to microphones of smaller diameter. The damping can be adjusted by changing the diaphragm spacing and also the diameter and spacing of the holes in the electrode so that the resonance peak is nearly eliminated, but too much damping will also reduce the response at frequencies a little below the resonance.

There are a few other things to be considered in design of this simple type of microphone. The vent hole in the capsule has already been mentioned, and the addition this makes to the network is shown dotted in Fig. 1(b). If the vent has an acoustic flow resistance R_V, then the time constant for pressure equalisation within the capsule by flow through the vent is $R_V C$ where C is the acoustic analog capacitance of the cavity volume. The vent resistance is normally adjusted so that this lower cut-off frequency is about 10–20 Hz, since that is below the range of human hearing, and this prevents the microphone from being too sensitive to pressure changes from shutting doors or other influences.

The second thing is that the one-dimensional model is too simple sound can reach the microphone from different directions and this can have an effect. If the sound incidence direction is along the axis of the microphone and normal to the diaphragm, then there is no problem at low frequencies, and the microphone diaphragm samples the pressure in the acoustic wave. If, however, the diaphragm diameter were to be very large, then the wave would be reflected from it, and the pressure on the diaphragm would be doubled, an increase of 6 dB. This increase occurs when the sound wave frequency is high enough that the sound wavelength is less than the diameter of the diaphragm. At this same sort of frequency, the microphone response also becomes increasingly directional, favouring signals arriving normally from along its axis. The reason for this can be seen by examining a signal arriving at right angles to the axis and thus tangential to the diaphragm. If the wavelength is about equal to the diaphragm diameter, then half of the diaphragm will feel a positive acoustic pressure and half a negative pressure, nearly cancelling.

All these things have to be taken into account in the design of a microphone, particularly if it is to be used for precise measurements for which accuracy better than 1 dB is required over the whole frequency range. For this reason these microphones are divided into sub-classes designed for measuring either free fields or else simply acoustic pressure, which is more suitable for randomly incident sound.

4. SIMPLE MICROPHONES

A variant of the design discussed above is used in many practical microphones. The main difference is that the diaphragm is made from polymer material about 10–20 μm in thickness, and has an evaporated gold film over its central portion to make it electrically conducting. The electrode then becomes part of the microphone case, which is held at ground potential, and there is a separate connection to the metallised part of the diaphragm. The main difference that this design change makes is that, because the plastic diaphragm cannot support a large tension, its resonance frequency is only about 1–3 kHz, depending upon the diameter of the microphone. To obtain adequate frequency response it is therefore necessary to make use of the added elastic stiffness provided by the air enclosed behind the diaphragm to raise the effective resonance frequency to 15–29 kHz. In the case of measurement microphones, the diaphragm tension was so high that this extra contribution to stiffness could be neglected.

The electric analog circuit for this case is identical with that in Fig. 1(b). The difference is that the cavity stiffness can no longer be neglected and is, indeed, now much larger than the diaphragm stiffness. The circuit arrangement can be justified by the consideration that air flow caused by displacement of the diaphragm, which activates its mechanical stiffness, flows equally into the cavity, as does the electric current in the analog circuit. Analysis of the resonance behaviour is similar to that for a measurement microphone.

Use of a plastic diaphragm rather than a metallic one has another consequence. When the electrical potential is applied to activate the microphone, this imposes a mechanical stress on the diaphragm attracting it towards the electrode. In the case of a measuring microphone with a metallic diaphragm this causes very little displacement because the diaphragm tension is so high, but for a plastic diaphragm the normal displacement is perhaps as great as 5–10μm. It can further be shown that, if this displacement exceeds about one fifth of the total separation between diaphragm and electrode, then the diaphragm will collapse against the electrode and the microphone will become inoperative. For this reason, the electrical polarising voltage used in a microphone of this type is generally much less than in a measurement microphone, and the initial diaphragm separation is larger, which decreases the sensitivity.

One further feature used in some of these microphones is to do away with the external polarising voltage altogether and use instead an electret film deposited on the surface of the electrode, or sometimes built into the diaphragm itself. The great advantage of not requiring an external power supply makes electret microphones ideal for portable apparatus and also reduces the overall cost. The only disadvantage is that the polarisation of the electret material gradually changes with time, so that the microphone sensitivity is less stable than for an externally powered design.

5. DIRECTIONAL MICROPHONES

The simplest sort of directional microphone is the pressure-gradient design. Suppose that sound is allowed equal access to both sides of the diaphragm and that the entry ports to the two sides are a distance d apart. Then if a sound wave of amplitude p and frequency f is incident at an angle θ to the axis of the microphone, the pressure tending to move the diaphragm is $p_1 - p_2$ where,

$$p_1 = p \exp^{(jkd/2)}; \quad p_2 = p \exp^{(-jkd/2)} \qquad (1)$$

with $k=2\pi f/c$ and $j=\surd(-1)$. If the separation between the two ports is much less than the sound wavelength, then $p_1 - p_2 \approx jpkd$. If we extend this model to sound coming in at an angle θ to the microphone axis, then the effective distance between the two ports is not d but rather $d \cos\theta$, and the amplitude of diaphragm motion is proportional to $pkd \cos\theta$, so that the microphone has a "figure eight" or $\cos^2\theta$ directional response. Such a microphone thus responds to the component of the acoustic pressure gradient parallel to its axis, and has a response proportional to f and thus rising with frequency at 6 dB/octave unless some other design feature enters. We shall see later what this is.

There is another feature of ideal pressure-gradient microphones that should be noted. Since a spreading spherical pressure wave has a form like $p(r) = (1/r)\, e^{j(\omega t - kr)}$, differentiating this to find the gradient inserts a factor $[1 + (kr)^{-1}]$ relative to a plane wave and so gives a strong bass boost if $kr<1$, which means within about $\lambda/2\pi$ of the source. This boost must be corrected for, or at least recognised.

6. CARDIOID MICROPHONES

A figure-eight directional response is sometimes useful, but more often the requirement is for a response concentrated in the forward direction along the microphone axis. If some way could be found to combine the response pattern of a pressure-gradient microphone with that of a simple pressure microphone, then the result would be

$$p(A + B \cos\theta) \qquad (2)$$

where A and B are constants. If the value of B/A could be varied, then a variety of directional patterns could be achieved, ranging from omnidirectional for $B = 0$ to figure-eight for $A = 0$ and with a particular cardioid (heart-shaped) pattern for $B = A$. These possibilities, plotted on a polar decibel scale, are shown in Fig. 2. The one remaining problem is the frequency dependence of the gradient response, which would cause the pattern to be omnidirectional at low frequencies and gradient-like at high frequencies because the pressure gradient at a given pressure amplitude increases with increasing frequency as shown by (1).

A solution to all these problems is given by the design in Fig. 3(a). Here we see the cavity behind the perforated electrode of a simple microphone vented to the surroundings through some sort of partition with an acoustic impedance Z_P. If Z_D is the acoustic impedance of the diaphragm and Z_C that of the cavity, both of which we have discussed before, then the whole microphone can be represented by the network analog shown in Fig. 3(b). The topology of the network can be understood by considering the paths by which acoustic volume moves from one component to anotherif the same flow moves through each, then they must be in series, while if the flows combine then they must be in parallel. Solution of this network is simple, and the calculated value of the acoustic volume flow through the diaphragm, caused by its movement, is

$$U = [Z_P p_1 + Z_C(p_1 - p_2)]\,[Z_P Z_D + Z_P Z_C + Z_C Z_D]^{-1} \quad (3)$$

where p_1 and p_2 have the form given in (1). If the impedance Z_P of the partition is made a simple resistance R, then the numerator of this expression, which is the only part containing the angular factor $\cos\theta$, takes the simple form $R + d \cos\theta /cC$, where C is the analog capacitance of the cavity. This is of just the form in equation (2), and the response can be made cardioid in form by arranging that $R = d/cC$, the frequency dependence of this part of (2) cancelling out. The denominator of (3) is nearly inversely proportional to frequency over most of the operating range, so that U is nearly proportional to frequency and the diaphragm displacement is nearly independent of frequency, as it should be for a flat response. Because it is not possible to vary the various impedances once the microphone has been built, its directional characteristic, generally either cardioid or hypercardioid, is fixed at the design stage.

Looked at physically, what happens is that, if the partition is simply resistive, then the pressure acting on the inside of the diaphragm for a given sound wave amplitude varies inversely with frequency above the value of $1/RC$ for the cavity, and this cancels out the frequency-dependent rise in the magnitude of the pressure gradient, giving a constant response amplitude and pattern. This no longer holds for frequencies below $1/RC$, when the internal pressure approaches the external pressure and the response declines.

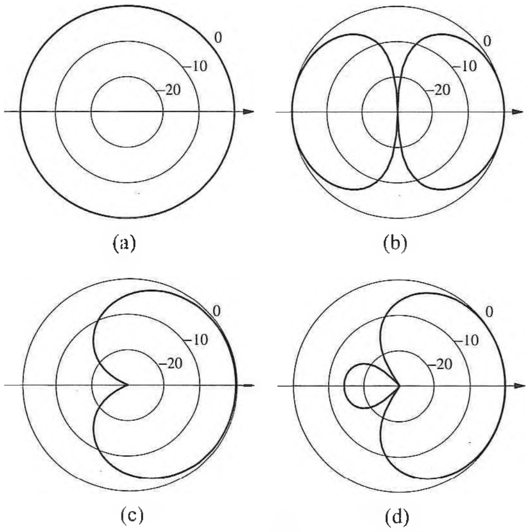

Figure 2. Response patterns obtainable by varying the constant A in equation (2): (a) omnidirectional when $B = 0$; (b) figure-eight when B/A >>1; cardioid when $B/A = 1$; (c) a form of hypercardioid when $B/A = 1.5$. Relative levels are in decibels in all cases.

7. STUDIO MICROPHONES

The final type of microphone to be discussed is the studio microphone, which generally has a response characteristic that can be varied between all the patterns shown in Fig. 3. The general idea, developed more than thirty years ago, is essentially to mount two condenser microphones back-to-back with some sort of acoustic coupling between them, and then to control the directional response by varying the voltages applied to the two diaphragms.

Figure 4(a) shows the design of a traditional studio

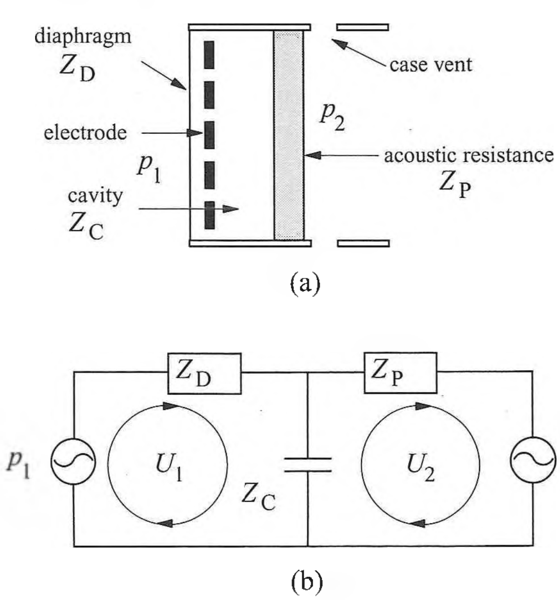

Figure 3. (a) Design of a simple cardioid microphone. (b) Analog network circuit for this microphone.

microphone. The electrodes are made of thick metal with cavities to provide acoustic stiffness to the plastic diaphragm, and about half of these cavities lead through small holes to the thin central space which provides a resistive coupling between the two microphone elements. We can identify two basic modes for this microphone. In the first the two diaphragms move inwards together so that there is no flow through the central space, and the response is essentially to the pressure signal at the mid-point of the microphone axis. In the second mode, one diaphragm moves in while the other moves out, and the main impedance to the motion is the resistance of the central space through which the acoustic current must flow. The response in this case is to the difference between the pressures on the two diaphragms, and thus to the gradient of the acoustic wave pressure. If the diaphragm tension is low, so that the impedance to motion is largely that of air flow through the central resistance, then the diaphragm velocities will be proportional to the pressure gradient and their displacements will have a $(\text{frequency})^{-1}$ factor that cancels out the frequency factor in the gradient, thus giving a flat response for the figure-eight pattern.

In the accompanying electric preamplifier, the two diaphragms are connected to a differential input. If, therefore, the polarising voltages on the two diaphragms are equal, the response to a simple pressure signal will be zero, but the response to a gradient signal will be a maximum. Conversely, if the polarising voltages are equal and opposite, then the gradient response will be zero and the pressure response will be at a maximum. Somewhere in between, perhaps with one voltage nearly equal to zero, the response will have a cardioid pattern.

Fig. 4(b) shows the analog circuit for this microphone

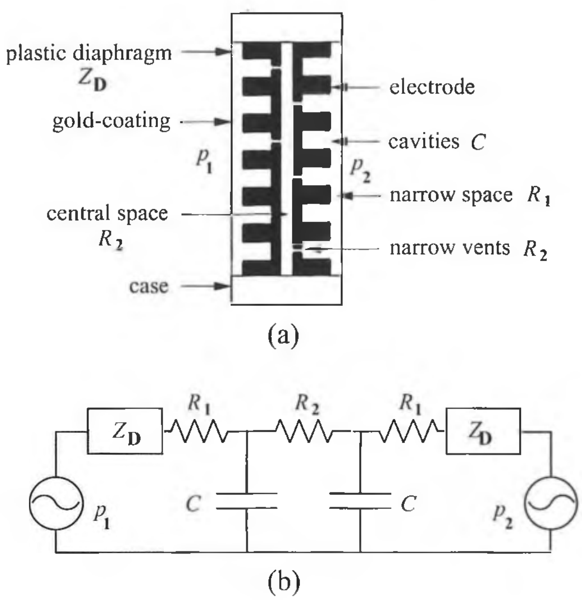

Figure 4. (a) Design of a simple studio microphone. (b) The analog circuit.

from which the motion of the two diaphragms under the influence of a signal at angle θ to the microphone axis can be calculated, and the design parameters varied to give the desired frequency response and directional pattern. Solution of the network equations is straightforward but algebraically a little complicated, since there are three separate meshes to the network, implying three equations, and each is complex so is really two separate equations. Nevertheless these equations were solved long ago and microphone designs with excellent frequency response and directional characteristics were produced. Some of these designs, with improved manufacturing and the use of transistor rather than valve preamplifiers, are now widely sought after in the recording industry. The microphone capsule, of course, is mounted within a metal mesh enclosure, both to provide mechanical protection and also to reduce breath noise.

8. CONCLUSION

There has been space in this review to consider only the basic types of microphone design, and even within this limited field there is an immense amount of technical variation, from large studio microphones with double capsules up to 30 mm in diameter to tiny microphones for in-ear hearing aids with diameter less than 2 mm. Diaphragms of thin taut metal and of much softer plastic have been mentioned, but some microphones now use diaphragms etched out of crystals of silicon so that they can be in close proximity to components of the electronic circuit. With sight and hearing providing the primary sensory links between humans and the environment, the development of new microphone types is bound to continue.

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Re: Measuring Acoustic Transmission Loss Using the 3-Point Method by S. Bilawchuck, and K.R. Fyfe, Vol. 30, No 4, 2002

The authors present a method that is claimed to provide a means of in-situ testing of dissipative splitter-type silencers. The manuscript contains a number of errors, which render the analysis and experiment invalid.

It is well known that transmission loss is defined as a ratio of acoustic powers. The authors chose to use intensity: that is the flux of energy, a vector with dimensions of W/m^2. Under very restrictive conditions the numerical value of magnitude of the acoustic intensity may equal the acoustic power. In any event the division of vectors is not a valid mathematical operation. A proper definition would have been appropriate. After all, it is not the function of papers published in a scientific journal to mislead non-expert readers.

The inappropriate use of vectors is also found in the discussion of spectra, particularly the cross-spectra. These are normally complex valued functions. Although there are certain superficial similarities between complex numbers and vectors, the spectra referred to in the paper are not vectors, and should not be defined as such.

It is claimed that $P=P_i e^{-ikx} + P_r e^{ikx}$ is the general solution of the one-dimensional wave equation. Now it is easy to show that $f(t-x/c)+g(t+x/c)$ is the general solution of the wave-equation. This was already well known to Euler who noted that the functions f and g could be arbitrary and did not have to be continuous, a dilemma only resolved much later with the introduction of generalized functions. Even though some readers may be able to 'read between the lines' and add the phrase "for pure tones" there is no reason to the so sloppy. There are also typographical errors in 2a,b.

The authors then present an equation, which purports to extract the incident sound power from measured data. The formalism assumes the incident acoustic power to be invariant along the duct. It follows that any equation describing it cannot be a function of a single distance from the face of the silencer. Terms containing only X1 or X2 are quite suspect. On physical grounds forms containing (X1-X2) have at least the potential of being valid. The appearance of $(e^{-i}+e^{i}) =2\cos(1) \sim 1.0806$ is also puzzling. This writer has certain suspicions about the genesis of the term. It is known to appear, albeit infrequently, when students unfamiliar with the algebra of exponents try to factor complex numbers.

The illustration of the apparatus shows the duct height to be 2ft. If the width is no larger than 2ft, the assumption of 1D waves in the duct fails for frequencies greater than about 280 Hz, rendering all measurements above that frequency invalid. I find it hard to believe that the authors are not aware of this fundamental feature sound in ducts!

Downstream of the silencer only a single measurement is performed. Again, as was the case upstream, there are higher order duct modes. Even below the cut-on frequency the sound field is not uniform: the sound waves emerge from the air-passage, and not the splitters. Also, fiberglass terminations of the kind shown do not perform well at low frequencies ($f < 300$ Hz).

The technique relies on phase and magnitude differences between the two field points, one would expect that matched microphones (phase and amplitude) are required. No reference is made of this rather important point. The expression for the incident sound power is singular. The incident sound power is completely arbitrary and does not depend on the choice of the field point separation. The result is an artifact of the technique, similar to the limits imposed the measurement of acoustic intensity with two closely spaced (phase matched) microphones. While important issues such as singularities are ignored, the authors, for some un-explicable reason, stress that cross-spectra must be measured simultaneously.

The statement that one must seek out special locations for 'best results' is also quite troublesome. Who decides what are 'good results'? One may speculate that the algorithm returns negative incident powers for 'badly chosen locations'.

The authors propose their method as an 'in situ' technique. Silencers of the type tested are normally installed in HVAC ducts, and the air is in motion. The acoustics of a moving medium differs significantly from that of a quiescent medium. This is especially true for the energy flux. No attempt has been made to warn potential users of this, and other measurement problems that arise in a moving fluid.

Even if the analysis is revised to make the equations valid, there is no magic wand that can impart any degree of validity to the measured data presented in the paper.

Werner Richarz, Ph.D, FASA
Aercoustics Engineering Ltd.
Toronto, ON

Steven Bilawchuk Responds:

First, we trust that the reader understands that this was a STUDENT paper presented in a conference proceeding and only allowed 2 pages to summarize an involved topic. The following are direct responses to the specific items noted in the letter.

Indeed definition of TL should have been stated as the ratio of acoustic powers.

We used the term "vectors" to denote that the values of pressure are not just at a single frequent, but rather over a range of frequencies. Using matrix notation, we typically denote a single column matrix as a vector. This is not to be confused with a value which has magnitude and direction. We are sorry if this caused any confusion.

It was not our intent to mislead the readers regarding solution to the wave equation. When dealing with 1-D waves, the equation as we have stated is correct. There is an error in the equation when defining the wave number, k. The "p" in the equation should be the symbol for Pi and is such in the version we sent in for publishing. This must be an error in format when publishing.

It was not stated (although it should have been) at the beginning of the paper that the method is only valid while plane wave propagation exists. This means that the sound pressure level is indeed constant throughout the cross section. It is not sure what the issue is regarding X1-X2. This is a simple subtraction of two distances. Also, the comments on the exponential terms are not relevant and the information presented in the paper is correct.

The upper frequency limit of 280 Hz is correct. We are currently looking into methods to go beyond the plane wave propagation limitation, thus enabling higher frequency measurements.

Again, the limitations of plane wave propagation enable the single measurement point. We agree that it would be better to have two points downstream since the equipment and analysis techniques are already in place.

Indeed phase matched microphones were used for the test. Alternatively, non phase matched mics could be used if a "normal" and "reversed" test is completed to cancel out the phase differences (as outlined in ASTM E 1050-98). This was not stated in the paper for lack of space. We felt it important to point out the simultaneous requirements for the cross-spectrum.

There were many tests performed for mic location. The results were not discussed in detail due to the lack of space. A "snapshot" of the results was presented. As with any acoustical measurement, there is going to be a degree of error. We were simply trying to find that range of error for various measurement locations. Differences for all locations were still small (less than 1-2 dB, which falls within any reasonably expected instrumentation/operation error). This amount of difference was not stated as it perhaps should have been.

Indeed the work presented was for motionless air. Also it assumed homogeneous fluid conditions throughout. We understand that real world systems are not this ideal, but the work has to start somewhere. Once basic methods are in place, they can be built on for more accurate results. Again, due to the limited space in which to convey the "gist" of the topic, we did not mention this.

We feel that the equations are valid within the range of plane wave propagation and that they need no revision. Indeed, beyond the maximum valid frequency, the results are not to be generally accepted. However, we are puzzled by the fact that the two methods still match each other so closely throughout a very large frequency range.

We apologize to any readers who may have been mislead or confused by our paper. The information presented is important in that it conveys a basic premise for measuring in-situ TL. Work still is required to extend the basic relationships to a more general method. At this time, we do not recommend use of the method other than to get a general idea of the TL performance, and not necessarily an exact result. In addition, we feel that the learned author of the letter could have used much more tact in wording his concerns. They are indeed valid concerns which address some oversights on our part. This could have been pointed out in a more constructive way which better serves to contribute to an overall increase in knowledge among professional colleagues.

Thank you for allowing us the opportunity to reply.

Steven Bilawchuk, M.Sc., E.I.T.
ACI Acoustical Consultants Inc.

Aeroacoustic Measurements
Editor: Thomas J. Mueller
Springer Verlag
ISBN 3-540-41757-5 2002, 313 Pages - US$99.00

One of the first steps in any analysis of noise control is the evaluation of the amount of control potential. In many instances, such an evaluation is possible only through measurements, either directly in the field or through simulated test facilities. The measurement process involves different procedures, from a simple single microphone system to complex measures involving hundreds of microphones such as different source localization techniques. Even though there are many standards in the literature that describe measurement procedures, one is always faced with a lack of adequate information systems that deal with complex methodologies. One such complex system is the area of aeroacoustic measurements. Many complex field conditions complicate the analysis in aeroacoustics, even for a single microphone measurement scheme. Here is a manual in a textbook format that comes to the rescue of a noise control practitioner. The book, *Aeroacoustic Measurements*, is a compilation of five articles, ably edited by Prof. T. J. Mueller of the University of Notre Dame, Indiana, USA.

The five articles that comprise the five chapters of the book are: 1) "Microphone Measurements in and out of Airstream" by P. T. Soderman and C. S. Allen; 2) "Beamforming in Acoustic Testing" by R. P. Dougherty; 3) "Aeroacoustic Phased Array Testing in Low Speed Wind Tunnels" by J. R. Underbrink; 4) "Source Characterization by Correlation Techniques" by W. K. Blake and D. A. Lynch; and 5) "An Anechoic Facility for Basic Aeroacoustic Research" by T. J. Mueller and Denis A. Lynch. All of the contributors are specialists from agencies such as NASA, Boeing Aerospace, and the University of Notre Dame, and are closely connected with aeroacoustic measurements. The compendium's goal is to provide a basis for assessing the mechanisms of noise generation, and to assist the engineer to acquire a deep understanding of the experimental facility utilized, measurement instrumentation, and data analysis techniques.

The five chapters approach the stated goal from the point of view of providing a set of instructions as well as detailing the methodologies that are applied in the analysis of measured results. The book is very succinct in its presentation (only 313 pages to describe complex methods), and the reader is expected to possess an understanding of the basic acoustics of sources in complex flow fields such as an aerofoil in a turbulent wall boundary layer of a wind tunnel airstream.

Chapter 1 goes directly to the heart of the subject and starts with the enumeration of various noise sources one commonly encounters in a wind tunnel. Some of the examples are the fan drive, self noise of microphones, the noise of struts that hold the microphone inside the airstream, jet flow noise, and noise of wall boundary layer. Soderman and Allen have, succintly, addressed the positioning of the microphone and the resultant effects of such factors as directivity, near-field influences, impact of ambient sound, as well as reverberant effects. Each subsection briefly describes the complete details that are usually encountered in a wind tunnel as the experimentalist attempts to understand the physical, theoretical, and experimental aspects of the test facility. Chapter 1 focuses on the general concepts of the noise sources and their propagation to the observer location through the complicated flow field.

Chapter 2 describes "Beamforming," one of the multiple array measurement techniques. In a mere 35 pages, the author Robert Dougherty describes the necessary information required for a thorough understanding of the state-of-the-art measurement technique. Beamforming is a non-intrusive experimental tool, where a large set of microphones is used for source localization. Source localization implies that the identification of the source location as well as its amplitude spectra are determined. Beamforming has been applied in a number of related fields such as underwater acoustics, teleconferencing systems, and antennae analysis. Since the main aim of this book is aeroacoustic measurements in wind tunnel model testing, the basic acoustic equations are derived through the high-frequency geometrical acoustic approximation and extended to source-array receiver model. Beamforming, where the microphone array is steered towards the source, is first described. Dougherty, then, goes on to enumerate the impact of the various factors such as wind tunnel walls, and flow noise. The necessary formulation required to omit spurious data such as side lobe is described.

Chapter 3 is the main thrust of this book, where all the necessary details for undertaking a phase-array measurement scheme is utilized in a wind tunnel. After providing the justification for using an expensive measurement tool, James Underbrink, systematically and methodically, lays the groundwork for the design, installation, setting up, calibration, measurements, data acquisition, data reduction, and analysis of beamforming method of aeroacoustic measurements in a wind tunnel. This chapter is a procedure manual and a must for any wind tunnel experimentalist. This chapter also describes two case studies, at NASA Ames and NASA Langley, where phase array was installed inside an existing facility to conduct aeroacoustic measurements. Without any taxing mathematical formulations, Underbrink is able to assist the experimentalist to get a clear understanding of both the pitfalls as well as the useful information that can be gathered while using a complex measurement technique.

Chapter 4 digresses from the previous two chapters and describes another aeroacoustic measurement tool, namely, "Source Characterization through Correlation Techniques." For those familiar with sound intensity or other correlation techniques, this chapter is more of a refresher. Blake and Lynch start with a quick definition of the applicable terms and then present a brief introduction to correlation application in aeroacoustics. Examples of correlation terms, such as those between fluid variables and acoustic variables, are presented next. The chapter also contains three very useful examples of correlation applications. The first two examples deal with trailing edge noise of a wing flap. The application of correlation method to extract source contribution in low signal-to-noise ratio environment as well as the determination of source characteristics is described in detail. The full experimental set-up, the measurement procedure, data acquisition, and reduction and the analysis procedure are described in detail. In the same way, Example 3 presents the details of the determination of a propeller fan sound character in turbulent flow through correlation technique between sound pressure and surface pressure. These three examples are a valuable teaching tool for anyone who is contemplating aeroacoustic measurements in a wind tunnel.

Chapter 5 is a manual for someone who is contemplating building an anechoic facility to conduct basic aeroacoustic research. It provides a step-by-step way of designing the various sections that constitute the facility. It also provides the specifications that were used in such a facility at the University of Notre Dame in Indiana. The necessary methods for commissioning, i.e., conducting a performance test, of the facility are also described. Finally, the use of the facility to study a propeller subjected to distorted in-flow conditions are presented. Both aerodynamic and acoustic measurements are presented and the analysis method to describe the impact on the propeller is highlighted.

In conclusion, this book is a valuable compendium to aeroacousticians. The book is well-edited and the graphics are of a high quality. Even though the five chapters are written by different individuals, the book's flow is seamless. This book will take up permanent residence on my bookshelf, next to two of my well-used acoustic textbooks, one by Kinsler & Frey, and the other by Morse & Ingard.

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Prediction Software Review / Revue des logicials de prédiction

PlantNoise

Cd$2000 from UBC or US$1000 through 01dB Inc.

A plant usually consists of a number of acoustical parameters such as myriad sets of sources, absorbing and/or rigid plant envelopes (such as floors, walls and hanging panels), and many pieces of equipment that have varying acoustic characteristics. In noisy plant environments, the shop foreman and plant manager, under the rules and guidelines of Occupational Safety and Health Laws, would always be interested in the noise character of their plants. In addition, the noise control engineer would also be interested in knowing the distribution of sound levels around the plant floor.

PlantNoise, a sound level prediction software from the University of British Columbia researchers, Murray Hodgson and Nelson Heerema, provides a valuable tool for the above stated purposes. The intent of the software, at least as per the understanding of this reviewer, is to provide a novel hardware and software for predicting, visualizing and auralizing industrial noise as one (foreman, manager, engineer) walks through the plant floor, and hence, strong acoustical background is not a prerequisite. The software, in the event, does provide adequate opportunities to realize the simulated walk-through.

The software is based on empirical models from 30 industrial simulations where image-source models of cavity sound prediction were used. The software was easily usable with simple (for the most part) input requirements, such as plant dimensions, the envelope acoustical details and source sound power levels. A special sound card (that has sound fonts) is needed to auralize the sound levels as one undertakes the simulated walk-through.

PlantNoise is very valuable, except for two shortcomings. The software and the various publications of Murray Hodgson and Nelson Heerema use the term "plant fittings" to lump together the effect of the various pieces within the plant that can absorb sound. No detailed guidelines are forthcoming as to the exact manner in which the "fittings" parameter would be modelled. This would be difficult for novices such as plant managers and shop foremen, as well as noise control engineers, who may not have the time to browse through the half-dozen reference publications cited in the manual. The second point is the two dimensional representation of the plant floor. A three-dimensional representation of the plant as one walks through it would be visually more appealing. *PlantNoise*, however, is a simple tool that can be valuably used by noise control engineers to visually and aurally present the effect of control measures to the plant owners. The cost is not overly prohibitive.

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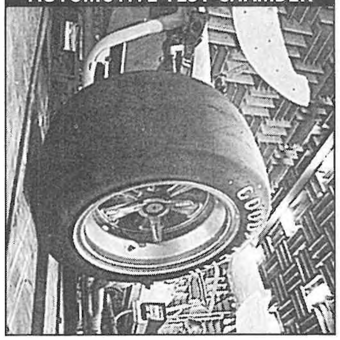

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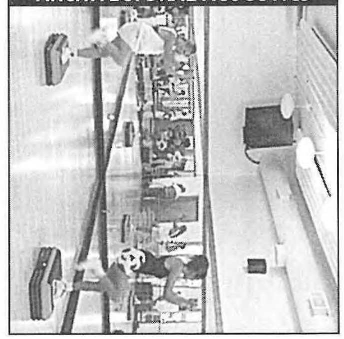

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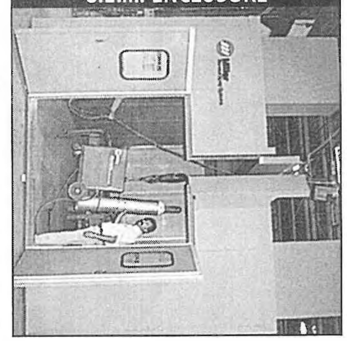

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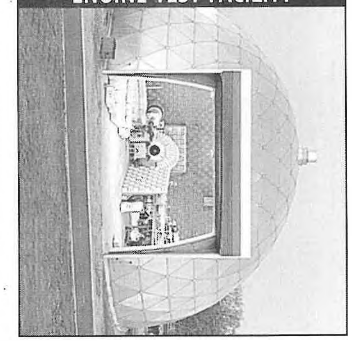

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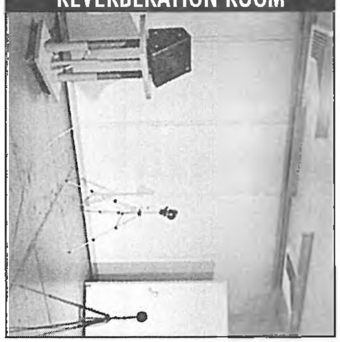

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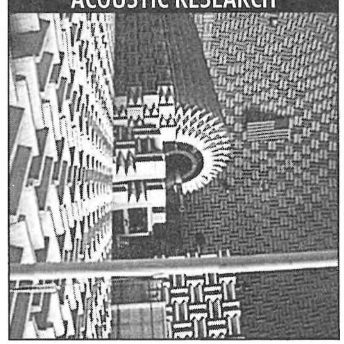

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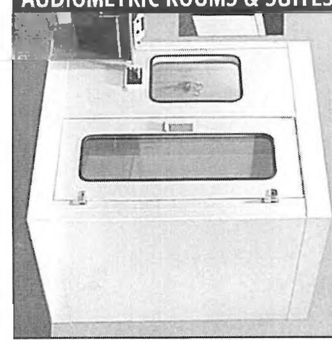
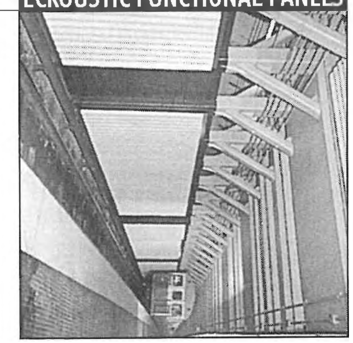


ECKOUSTIC FUNCTIONAL PANELS



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Canadian Acoustical Association

Minutes of the Board of Directors Meeting
10 May 2003
Toronto, Ontario

Present: J. Bradley, D. Giusti, D. Quirt, C. Buma, M. Cheesman, K. Fraser, M. Hodge, R. Ramakrishnan, D. Stredulinsky, C. Giguère, M. Cheng

Regrets: A. Behar

The meeting was called to order at 10:00 a.m. Minutes of Board of Directors meeting on 8 October 2002 were approved as published in Canadian Acoustics (Dec. 2002 issue). *(Approval moved by D. Giusti, seconded by R. Ramakrishnan, carried).*

President's Report

John Bradley reported that there have been no major changes or problems in the affairs of the Association. The website is becoming increasingly useful, as discussed under a later item. As agreed at previous meetings, the President has confirmed CAA sponsorship of the ASA conference in Vancouver in 2005; this does not involve a financial commitment for our association, but it was noted that members are playing leading roles in the organizing committee. Three directors were replaced in September 2002 (as required) with Alberto Behar, Christian Giguère, and Mark Cheng joining as the new Directors. Our first two nominees as Member Emeritus were notified by the president, and have accepted the honor. John Bradley announced that he does not plan to continue for another term.

Treasurer's Report

The Treasurer provided an itemized report of the Association's finances, including a summary for the last four years. The report shows a solid financial position. As of 30 April, total assets are $238,054, most of which is invested to fund our awards. In 2000 and 2001, revenues exceeded operating costs, with significant boosts from the financially successful conferences. The conference in 2002 also provided a small financial gain (see further comments under conferences). However, due to low interest rates, continuing avoidance of new expenses is needed, to ensure sufficient funds are available for prizes. In 2002/03, $6550 in awards was distributed, down from $8100 the year before, because several prizes were not awarded.

The Treasurer provided a checklist of annual information requirements for the auditor, and requested that the executive provide their parts of the information promptly at the end of the fiscal year. In the context of audit issues, the implications of charitable status were queried; the Treasurer was requested to confirm with the auditor how this should be reflected in annual receipts for dues and subscriptions, and in financial planning.

Our VISA merchant's account was used after June 2002 for annual membership dues. This is working very well. To reduce problems with charges for international payments, and to minimize the need for individuals to pay (and subsequently recover) the costs for other corporate expenses, the Treasurer has also acquired a corporate credit card.

(Acceptance moved by M. Cheesman, seconded R. Ramakrishnan, carried)

Secretary's Report

David Quirt reported that in FY2002/03 the membership seems to be steady at essentially the same level observed last year and through the '90's. As of 7 May, the total paid membership stood at 307. About 80% of the members are located in Canada, with the remaining 20% divided between the USA and overseas. The number of Sustaining Subscribers has risen, but there is a reduction in subscriptions via agents, presumably due to major disruptions in that business sector. A reminder has been sent to those overdue (about 15%, as usual) and responses are trickling in.

To ease membership renewal, the Secretary and Treasurer have implemented a process to permit payments by VISA; 27% of the renewals have used VISA.

Secretarial operating costs for the first ten months of FY01/02 were $1184, which includes mailing costs and maintaining the address database including the annual membership renewal process. The secretarial account balance was $314, as of 7 May; this should be sufficient for expected costs to the end of the fiscal year (31 August).

Options to promote increased membership were discussed at some length. Two main themes emerged: the benefit of active local chapters, and the need to provide useful service to various subsets of the acoustical community, from environmental noise control to audiology. No action plan emerged.

After many years of faithful and effective service, Maria Clancy has resigned from her role providing secretarial support and database management for CAA. Maria ensured a smooth transition by coaching and supporting the Secretary as he assumed the database management activity. The Board expressed a unanimous vote of thanks to Maria for her many years of service.

Editor's Report

A number of specific issues related to the publication process for *Canadian Acoustics* were discussed. Ramani Ramakrishnan reported that all issues have been published on schedule, a color cover has become the norm, and color figures are published occasionally. Color pages are printed as 4-page sheets; the Editor and Advertising Manager were encouraged to explore the option for color advertising, and to proceed with this if it offers a revenue benefit without excessive extra workload. The June issue will be digitally printed, which offers both simpler production process and more predictable appearance.

Several aspects of content were also discussed. The Editorial Board has not been fully effective in its intended role of delivering technical papers, and changes will be made. The core of the June 2004 issue will be refereed proceedings of a symposium on underwater sound – this sort of special topic issue was strongly endorsed by the Directors, and other such special issues will be considered as opportunities arise.

Karen Fraser reported on advertising in *Canadian Acoustics;* revenue is steady at about $2500 per issue, and the backlog of unpaid invoices has been reduced to under $1000. It was noted that some regular advertisers are not members or subscribers, and the Directors decided that the Secretary should investigate ways to involve these potential members in CAA.

(D. Giusti moved acceptance of Editor's report, M. Cheesman seconded, carried.)

Past and Future Conferences

2002 Charlottetown: A report from Annabel Cohen (conference chair) was presented and discussed. The conference was very successful from a technical perspective, with over 100 presentations spanning a wide range of subjects, interesting special sessions, and an exhibit of acoustical products. Attendance was good, there were many positive comments about the accommodations and food, and the conference achieved a small surplus ($1500) essentially as planned. Much of the discussion focused on the very effective use of the website, developed by Dave Stredulinsky. It was agreed that website use for registration, paper submission, and program information is a pattern that should be maintained for future meetings.
(Motion of thanks to the organizers by D. Quirt, seconded M. Cheesman, unanimous)

2003 Edmonton: Corjan Buma provided a report on arrangements for the 2003 meeting. The organizing committee includes:

Chair:	Corjan Buma
Technical Program:	Gary Faulkner
Treasurer:	Eugene Bolstad
Secretary:	Megan Hodge
Conference Website and Registration:	Ken Fyfe
Promotions, Marketing, Publicity:	Izzy Gliener
Facilities Arrangements:	Kelly Kruger, Steve Bilawchuk
Social/Hospitality Program Convener:	Eugene Bolstad

Two-page announcements started with the December issue of Canadian Acoustics, the website is operational, plenary speakers have been confirmed, and all arrangements are proceeding. A large lockable room has been booked for exhibitor space and coffee breaks. As requested at the AGM, a specific presentation format (PowerPoint 2000) is requested, and all presenters will be asked to submit their presentations a few days in advance of the meeting, to facilitate loading and organizing all presentations on the computers that will be provided in each room. Overhead projectors will also be available, and presenters are encouraged to have a backup set of transparencies. As always, the two-page paper is optional (except for those seeking student awards), and a longer format will be used for publishing the plenary talks.

2004 Ottawa: John Bradley reported that he is assembling an organizing team, and will select a site and present a detailed plan for approval at the meeting in October.

2005 Conference: The location for the meeting in 2005 was discussed. CAA members' involvement in the organization of the ASA conference in Vancouver, 16-20 May 2005 makes a west coast site unsuitable for CAA, but does not rule out a CAA conference in October of 2005. The Board agreed that we should have such a conference. The preferred location would be somewhere in Québec or New Brunswick, but southern Ontario was also suggested as an alternative.

CAA Website

Dave Stredulinsky, our webmaster, reported on recent progress in the CAA website (caa-aca.ca), which is now hosted by Telus. The site has ~150 visits/day; in April these included visitors from 55 countries. Content includes the CAA operations manual, information on CAA awards, a sustaining subscribers' page, membership and subscription forms, a job-posting page, and the site for the annual conference.

Board members agreed that this has become the most accessible and complete repository for information about CAA, and agreed that for information such as awards details the website should be treated as the primary source for CAA information. This places a duty on Board members to keep their parts of the information current, by sending updates to the webmaster.

As requested at the previous meeting, the webmaster has investigated options that would support online use of credit cards for membership payment and other transactions for CAA activities such as the conference. These were discussed at length. Some very powerful packages are available, but the cost is significantly greater than the current CAA operational budget. No decision was made at this time, but the webmaster will continue to explore options for transactions via the website. Overall, there was enthusiastic support for the many improvements.

Awards

Christian Giguère was welcomed as new Chair of the Awards Committee.

Those responsible for specific awards were confirmed to be: Christian Giguère (Directors'), Stan Dosso (Shaw), Dave Chapman (Fessenden), Megan Hodge (Bell), Murray Hodgson (Eckel), Meg Cheesman (Hétu), Dave Stredulinsky (Underwater & Signal Processing), Annabel Cohen (Science Fair), Karen Fraser (Student Presentations)

For this meeting, John Bradley led an extended discussion of all awards, as the first stage in establishing complete and current information about awards on the CAA web site (which will henceforth be the primary source for this information). There were specific decisions regarding several of the awards:

The Board confirmed the intent to keep the Shaw Prize as a one-year award.

The Hétu Prize will include a student membership plus a book, and the process will be simplified: a faculty member will submit a nomination letter with suitable supporting material, on/before April 15.

The Directors' Awards may be reduced to two. The Awards Coordinator will explore the possibility of merging the two professional awards into a single professional award without age categories (plus one for students) starting in 2004. This will be decided at the October meeting.

A single-page advertisement will be prepared for Canadian Acoustics, naming all the awards and providing a brief outline of their intent and value, but pointing to the CAA website for full details. Christian Giguère will handle this.

Concern was expressed about the lack of applicants for some prizes, and it was agreed that a new approach should be used to distribute a notice. An advertisement suitable for posting (pointing to the website for details and application forms) will be prepared and distributed both by mailing and via e-mail. The Secretary is to provide the list used in the last such mailing to suitable university departments, plus an email list for the CAA membership to the Awards Committee.

Other Business

None was identified.

Adjournment

R. Ramakrishnan moved to adjourn the meeting, seconded by D. Giusti, carried. Meeting adjourned at 3:10 p.m.

Special Action Items Arising from the Meeting

Each Member: Review CAA website contents within agreed areas of responsibility, and send updates to webmaster by end of June.

J. Bradley: In collaboration with Past President, identify candidates for expected vacancies in Executive and other Directors. Ensure Ottawa Conference team is organized, and report to next meeting.

D. Quirt: Provide suitable e-mail and mailing lists to C. Giguère and M. Hodge for mailing to advertise and promote awards. Provide financial and membership data for auditor at end of August.

D. Giusti: Collaborate with Edmonton conference committee to establish process for payments by VISA.

R. Ramakrishnan: Proceed to implement color advertising and/or changes to Editorial Board, and report on these to October meeting.

D. Stredulinsky: Continue to investigate cost and benefits of adding secure transaction capability to website, and report by October meeting.

C. Giguère: Ensure website information and Canadian Acoustics page on prizes are suitably updated. Prepare and distribute notice about CAA prizes to Canadian university departments and via e-mail to CAA members.

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 francine.desharnais@drdc-rddc.gc.ca

2003

8-13 June: XVIII International Evoked Response Audiometry Study Group Symposium, Puerto de la Cruz, Tenerife, Canary Islands, Spain. Fax: +34 922 27 03 64; Web: www.ierasg-2003.org

16-18 June: ACOUSTICS – Modeling & Experimental Measurements, Cadiz, Spain. Contact: Acoustics03, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton SO40 7AA, UK; Fax: +44 238 029 2853; Web: www.wessex.ac.uk/conference/2003/acoustics/index.html

23-25 June: NOISE-CON 2003, Cleveland, OH. Contact: INCE Business Office, Iowa State Univ., 212 Marston Hall, Ames, IA 50011-2153; Fax: 515-294-3528; E-mail: ibo@ince.org

29 June – 3 July: 8th Conference on Noise as a Public Health Problem, Amsterdam-Rotterdam, The Netherlands. Contact: Congress Secretariat, PO Box 1558, 6501 BN Nijmegen, The Netherlands; Fax: +31 24 360 1159; E-mail: office.nw@prompt.nl

30 June – 3 July: Ultrasonics International (UI'03), Granada, Spain. Contact: T. Collier, UI'03 Secretariat, 7 Gibbs Road, Banbury OX16 3HJ, UK; Fax: +44 1295 253 334; Web: www.ccmr.cornell.edu/~ui03 or www.ui03.com

7-11 July: 10th International Congress on Sound and Vibration, Stockholm, Sweden. Contact: Congress Secretariat, Congrex Sweden AB; Tel: +46 8 459 66 00; Fax: +46 8 8 661 91 25; E-mail: icsv10@congrex.se; Web: www.congex.com/icsv10

14-16 July: 8th International Conference on Recent Advances in Structural Dynamics, Southampton, UK. Web: www.isvr.soton.ac.uk/sd2003

6-9 August: Stockholm Music Acoustics Conference 2003 (SMAC03), Stockholm, Sweden. Contact: www.speech.kth.se/music/smac03

25-27 August: Inter-Noise 2003, Jeju Island, Korea. Contact: Dept. of Mechanical Engineering, KAIST, 373-1, Kusong-dong, Yusong-gu, Taejon 305-701, Korea; Fax: +82 42 869 8220; Web: www.icjeju.co.kr

25-29 August: XIII Session of the Russian Acoustical Society, Moscow, Russia. Fax: +7 095 126 0100; Web: www.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 courriel à francine.desharnais@drdc-rddc.gc.ca

2003

8-13 juin: XVII Symposium international du Groupe expérimental sur l'audiométrie des potentiels évoqués, Puerto de la Cruz, Tenerife, Iles Canaries, Espagne. Fax: +34 922 27 03 64; Web: www.ierasg-2003.org

16-18 juin: ACOUSTICS – Modélisation et mesures expérimentales, Cadiz, Espagne. Info: Acoustics03, Wessex Institute of Technology, Ashurst Lodge, Ashurst, Southampton SO40 7AA, UK; Fax: +44 238 029 2853; Web: www.wessex.ac.uk/conference/2003/acoustics/index.html

23-25 juin: NOISE-CON 2003, Cleveland, OH. Info: INCE Business Office, Iowa State Univ., 212 Marston Hall, Ames, IA 50011-2153; Fax: 515-294-3528; Courriel: ibo@ince.org

29 juin – 3 juillet: 8e conférence sur le bruit, un problème de santé publique, Amsterdam-Rotterdam, Pays-Bas. Info: Congress Secretariat, PO Box 1558, 6501 BN Nijmegen, The Netherlands; Fax: +31 24 360 1159; Courriel: office.nw@prompt.nl

30 juin – 3 juillet: Ultrasonics International (UI'03), Granada, Espagne. Info: T. Collier, UI'03 Secretariat, 7 Gibbs Road, Banbury OX16 3HJ, UK; Fax: +44 1295 253 334; Web: www.ccmr.cornell.edu/~ui03 or www.ui03.com

7-11 juillet: 10e Congrès international sur le bruit et les vibrations, Stockholm, Suède. Info: Congress Secretariat, Congrex Sweden AB; Tél.: +46 8 459 66 00; Fax: +46 8 8 661 91 25; Courriel: icsv10@congrex.se; Web: www.congex.com/icsv10

14-16 juillet: 8e Conférence internationale sur les développements récents en dynamique structurelle, Southampton, Royaume-Uni. Web: www.isvr.soton.ac.uk/sd2003

6-9 août: Conférence 2003 d'acoustique musicale de Stockholm (SMAC03), Stockholm, Suède. Info: www.speech.kth.se/music/smac03

25-27 août: Inter-Noise 2003, Île Jeju, Corée. Info: Dept. of Mechanical Engineering, KAIST, 373-1, Kusong-dong, Yusong-gu, Taejon 305-701, Korea; Fax: +82 42 869 8220; Web: www.icjeju.co.kr

25-29 août: XIIIe Session de la Société russe d'acoustique, Moscou, Russie. Fax: +7 095 126 0100; Web: www.akin.ru

1-4 September: Eurospeech 2003, Geneva, Switzerland. Contact: SYMPORG SA, Avenue Krieg 7, 1208 Geneva, Switzerland; Fax: +41 22 839 8485; Web: www.symporg.ch/eurospeech2003

7-10 September: World Congress on Ultrasonics, Paris, France. Web: www.sfa.asso.fr/wcu2003

16-19 September: Autumn Meeting of the Acoustical Society of Japan, Nagoya, Japan. Fax: +81 3 5256 1022; Web: wwwsoc.nii.ac.jp/asj/index-e.html

18-19 September: Surface Acoustics 2003, Salford University, Manchester, UK. Web: www.ioa.org.uk/salford2003

23-25 September: 2nd International Symposium on Fan Noise, Senlis, France. Contact: CETIAT, B.P. 2042, 69603 Villeurbanne, France; Fax: +33 4 72 44 49 99; Web: www.fannoise2003.org

5-8 October: IEEE International Ultrasonics Symposium, Honolulu, HI. Contact: W.D. O'Brien, Jr., Bioacoustics Research Lab., Univ. of Illinois, Urbana, IL 61801-2991; Fax: 217-244-0105; Web: www.ieee-uffc.org

15-17 October: Acoustics Week in Canada, Edmonton, Alberta, Canada. Fax: +1 780 414 6376; Web: caa-aca.ca/edmonton-2003.html

15-17 October: 34th Spanish Congress on Acoustics, Bilbao, Spain. Contact: Sociedad Española de Acústica, Serrano 144, 28006 Madrid, Spain; Fax: +34 91 411 7651; Web: www.ia.csic.es/sea/index.html

10-14 November: 146th Meeting of the Acoustical Society of America, Austin, TX. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; E-mail: asa@aip.org; Web: asa.aip.org

19-21 November: Workshop on detection and localization of marine mammals using passive acoustics, Dartmouth, NS, Canada. Contact: francine.desharnais@drdc-rddc.gc.ca

10-12 December: 3rd International Workshop on Models and Analysis of Vocal Emissions for Biomedical Applications, Firenze, Italy. Fax: +39 55 479 6767; Web: www.maveba.org

2004

17-19 March: Spring Meeting of the Acoustical Society of Japan, Atsugi, Japan. Fax: +81 3 5256 1022; Web: wwwsoc.nii.ca.jp/asj/index-e.html

22-26 March: Joint Congress of the French and German Acoustical Societies (SFA-DEGA), Strasbourg, France. Contact: Société Française d'Acoustique, 23 avenue Brunetière, 75017 Paris, France; Fax: +49 441 798 3698; E-mail: sfa4@wanadoo.fr

31 March – 3 April: International Symposium on Musical Acoustics (ISMA2004), Nara, Japan. Fax: +81 774 95 2647; Web: www2.crl.go.jp/jt/al32/isma2004

1-4 septembre: Eurospeech 2003, Genève, Suisse. Info: SYMPORG SA, Avenue Krieg 7, 1208 Geneva, Switzerland; Fax: +41 22 839 8485; Web: www.symporg.ch/eurospeech2003

7-10 septembre: Congrès mondial sur les ultra-sons, Paris, France. Web: www.sfa.asso.fr/wcu2003

16-19 septembre: Rencontre d'automne de la Société japonaise d'acoustique, Nagoya, Japon. Fax: +81 3 5256 1022; Web: wwwsoc.nii.ac.jp/asj/index-e.html

18-19 septembre: Acoustique de surface 2003, Salford University, Manchester, Royaume-Uni. Web: www.ioa.org.uk/salford2003

23-25 septembre: 2e Symposium international sur le bruit de ventilateur, Senlis, France. Info: CETIAT, B.P. 2042, 69603 Villeurbanne, France; Fax: +33 4 72 44 49 99; Web: www.fannoise2003.org

5-8 octobre: Symposium international IEEE sur les ultrasons, Honolulu, HI. Info: W.D. O'Brien, Jr., Bioacoustics Research Lab., Univ. of Illinois, Urbana, IL 61801-2991; Fax: 217-244-0105; Web: www.ieee-uffc.org

15-17 octobre: Semaine canadienne d'acoustique, Edmonton, Alberta, Canada. Fax: +1 780 414 6376; Web: caa-aca.ca/edmonton-2003.html

15-17 octobre: 34e Congrès espagnole d'acoustique, Bilbao, Espagne. Info: Sociedad Española de Acústica, Serrano 144, 28006 Madrid, Spain; Fax: +34 91 411 7651; Web: www.ia.csic.es/sea/index.html

10-14 novembre: 146e rencontre de l'Acoustical Society of America, Austin, TX. Info: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tél.: 516-576-2360; Fax: 516-576-2377; Courriel: asa@aip.org; Web: asa.aip.org

19-21 novembre: Atelier sur la détection et la localisation de mammifères marins par l'acoustique passive, Dartmouth, NE, Canada. Info: francine.desharnais@drdc-rddc.gc.ca

10-12 décembre: 3e Atelier international sur les modèles et analyse d'émissions vocales avec applications bio-médicales, Florence, Italie. Fax: +39 55 479 6767; Web: www.maveba.org

2004

17-19 mars: Rencontre de printemps de la Société japonaise d'acoustique, Atsugi, Japon. Fax: +81 3 5256 1022; Web: wwwsoc.nii.ca.jp/asj/index-e.html

22-26 mars: Congrès conbiné des Sociétés française et allemande d'acoustique (SFA-DEGA), Strasbourg, France. Info: Société Française d'Acoustique, 23 avenue Brunetière, 75017 Paris, France; Fax: +49 441 798 3698; Courriel: sfa4@wanadoo.fr

31 mars – 3 avril: Symposium international sur l'acoustique musicale (ISMA2004), Nara, Japon. Fax: +81 774 95 2647; Web: www2.crl.go.jp/jt/al32/isma2004

5-9 April: 18th International Congress on Acoustics (ICA2004), Kyoto, Japan. Web: ica2004.or.jp

11-13 April: International Symposium on Room Acoustics (ICA2004 Satellite Meeting), Hyogo, Japan. Fax: +81 78 803 6043; Web: rad04.iis.u-tokyo.ac.jp

24-28 May: 75th Anniversary Meeting (147th Meeting) of the Acoustical Society of America, New York, NY. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; E-mail: asa@aip.org; Web: asa.aip.org

8-10 June: Joint Baltic-Nordic Acoustical Meeting, Mariehamm, Åland, Finland. Contact: Acoustical Society of Finland, Helsinki University of Technology, Laboratory of Acoustics and Signal Processing, P.O. Box 3000, 0215 TKK, Finland; Fax: +358 09 460 224; e-mail: asf@acoustics.hut.fi

5-8 July: 7th European Conference on Underwater Acoustics ECUA 2004, Delft, The Netherlands. Contact: Debbie Middendorp, Secretariat of the 7th European Conference on Underwater Acoustics ECUA 2004, D'Launch Communications, Forellendaal 141, 2553 JE The Hague, The Netherlands; Tel.: +31 70 3229900; Fax: +31 70 3229901; E-mail: middendorp@dlaunch.nl

11-16 July: 12th International Symposium on Acoustic Remote Sensing (ISARS), Cambridge, UK. Contact: S. Bradley, School of Acoustics and Electronic Engineering, Brindley Building, Room 301, University of Salford, Salford M5 4WT, UK; Fax: +44 161 295 3815; Web: www.isars.org.uk

3-7 August: 8th International Conference of Music Perception and Cognition, Evanston, IL. Contact: School of Music, Northwestern Univ., Evanston, IL 60201; Web: www.icmpc.org/conferences.html

23-27 August: 2004 IEEE International Ultrasonics, Ferroelectrics, and Frequency Control 50th Anniversary Conference, Montreal, Canada. Contact: R. Garvey, Datum, 34 Tozer Road, Beverly, MA 01915-5510; Fax: +1 978 927 4099; Web: www.ieee-uffc.org/index2-asp

24-27 August: Inter-noise 2004, Prague, Czech Republic. Contact: I-INCE, Herrick Laboratories, Purdue University, West Lafayette, Indiana, USA; Fax: +1 765 494 0787; Web: www.i-ince.org

13-17 September: 4th Iberoamerican Congress on Acoustics, 4th Iberian Congress on Acoustics, 35th Spanish Congress on Acoustics, Guimarães, Portugal. Contact: Sociedade Portuguesa de Acústica, Laboratório Nacional de Engenharia Civil, Avenida do Brasil 101, 1700-066 Lisboa, Portugal; Fax: +351 21 844 3028; E-mail: dsilva@lnec.pt

15-19 November: 148th Meeting of the Acoustical Society of America, San Diego, CA. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; E-mail: asa@aip.org; Web: asa.aip.org

5-9 avril: 18e Congrès international sur l'acoustique (ICA2004), Kyoto, Japon. Web: ica2004.or.jp

11-13 avril: Symposium international sur l'acoustique des salles (Rencontre satellite de ICA2004), Hyogo, Japon. Fax: +81 78 803 6043; Web: rad04.iis.u-tokyo.ac.jp

24-28 mai: 75e rencontre anniversaire (147e rencontre) de l'Acoustical Society of America, New York, NY. Info: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tél.: 516-576-2360; Fax: 516-576-2377; Courriel: asa@aip.org; Web: asa.aip.org

8-10 juin: Rencontre acoustique jointe Baltique-Nordique, Mariehamm, Åland, Finlande. Info: Acoustical Society of Finland, Helsinki University of Technology, Laboratory of Acoustics and Signal Processing, P.O. Box 3000, 0215 TKK, Finland; Fax: +358 09 460 224; courriel: asf@acoustics.hut.fi

5-8 juillet: 7e Conférence européenne sur l'acoustique sous-marine ECUA 2004, Delft, Pays-Bas. Info: Debbie Middendorp, Secretariat of the 7th European Conference on Underwater Acoustics ECUA 2004, D'Launch Communications, Forellendaal 141, 2553 JE The Hague, The Netherlands; Tél.: +31 70 3229900; Fax: +31 70 3229901; Courriel: middendorp@dlaunch.nl

11-16 juillet: 12e Symposium international sur la télédetection acoustique (ISARS), Cambridge, Royaume-Uni. Info: S. Bradley, School of Acoustics and Electronic Engineering, Brindley Building, Room 301, University of Salford, Salford M5 4WT, UK; Fax: +44 161 295 3815; Web: www.isars.org.uk

3-7 août: 8e Conférence internationale sur la perception et la cognition de la musique, Evanston, IL. Info: School of Music, Northwestern Univ., Evanston, IL 60201; Web: www.icmpc.org/conferences.html

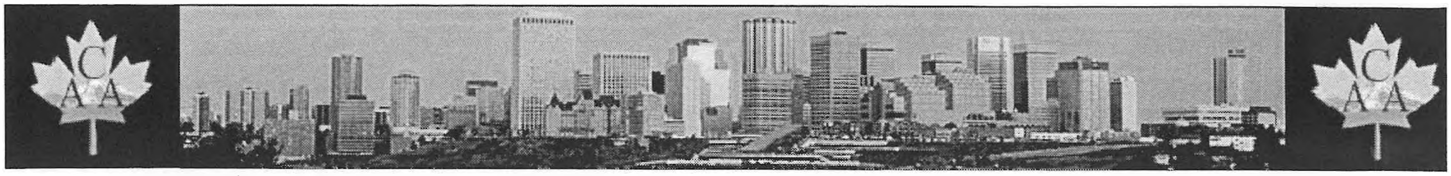
23-27 août: 50e Conférence anniversaire internationale IEEE 2004 sur les ultra-sons, la ferroélectricité et la régulation par la fréquence, Montréal, Canada. Info: R. Garvey, Datum, 34 Tozer Road, Beverly, MA 01915-5510; Fax: +1 978 927 4099; Web: www.ieee-uffc.org/index2-asp

24-27 août: Inter-noise 2004, Prague, République tchèque. Info: I-INCE, Herrick Laboratories, Purdue University, West Lafayette, Indiana, USA; Fax: +1 765 494 0787; Web: www.i-ince.org

13-17 septembre: 4e Congrès ibéro-américain d'acoustique, 4e Congrès ibérien d'acoustique, 35e Congrès espagnol d'acoustique, Guimarães, Portugal. Info: Sociedade Portuguesa de Acústica, Laboratório Nacional de Engenharia Civil, Avenida do Brasil 101, 1700-066 Lisboa, Portugal; Fax: +351 21 844 3028; Courriel: dsilva@lnec.pt

15-19 novembre: 148e rencontre de l'Acoustical Society of America, San Diego, CA. Info: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tél.: 516-576-2360; Fax: 516-576-2377; Courriel: asa@aip.org; Web: asa.aip.org

The Future of Quiet ?



Acoustics Week in Canada October 14–17, 2003 Edmonton, Alberta The Westin Edmonton
www.caa-aca.ca/edmonton-2003.html

THIRD ANNOUNCEMENT

Conference Theme: "The Future of Quiet ?": Where is the "happy medium" between privacy and being connected to others? We all appreciate that there are times we need to be by ourselves or in limited company and other times where large numbers of us want to communicate. The 2003 Edmonton Conference of the Canadian Acoustical Association aims to use this underlying theme for the plenary and technical sessions to be held 14-17 October 2003. The start of the Conference is fast approaching and Abstracts representing the diverse range of topics in acoustics has been filling the Steering Committee's "Inbox".

Scientific and Technical Papers: As in previous Acoustics Week in Canada conferences, the 2003 Edmonton Conference will ensure that all areas of acoustics are represented. The plenary lectures planned include Senator Tommy Banks (providing a musician's perspective), Dr. Jos Eggermont (AHMRF Scientist, Calgary) reflecting on the influence of noise on the development of hearing in the human brain and Mr. Dave DeGagne representing the Alberta Energy and Utilities Board with an introduction of the newest version of Alberta's Noise Control Directive (regulating energy sector noise and due for release later this year). Contributed papers in the following technical areas are being received:

Industrial Noise	Building/Architectural acoustics	Vibration
Outdoor sound propagation	Speech perception	Occupational hearing loss
Hearing protection	Acoustic materials	Underwater acoustics
Physiological acoustics	Sound quality	Legislation/Environmental noise
Transportation noise	Canadian standards	Instrumentation
Computer applications	Community noise	Musical acoustics

Abstracts: Abstracts (maximum: 250 words) should have been submitted by **Friday, 30-May-2003** (for late submissions please contact the Conference Chair by email). Notification of acceptance of a paper will be by the end of June 2003. Included in this Notification will be a Registration Form. Upon acceptance of Abstracts, these will be posted on the Conference web-site (unless you request non-posting). The 2-page **Proceedings copy** of your Paper will be required by **Friday, 01-August-2003**. This deadline is firm for inclusion in the Proceedings Issue (September 2003) of the journal Canadian Acoustics. The Proceedings Copy of your Paper can be submitted in any common word-processing format or as 2 separate "pdf" files (1 file per page). For Papers received after the deadline, inclusion in the September Proceedings issue cannot be guaranteed but may, at the discretion of the Journal Editor, be included in the December-2003 issue.

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 Edmonton. To apply for this subsidy, students must submit an Application for Student Travel Subsidy. Forms are available on the web-site. Lastly, a one-time **accommodation subsidy** may be applied for (one-time reimbursement of 50$CDN, in absence of other support); presentation of hotel receipt will be required. NB: to be eligible for either awards or subsidies, students **must** have membership in CAA ($15).

Accommodation: The Westin Edmonton is located in the heart of downtown Edmonton and will provide accommodation and meeting space (http://www.thewestinedmonton.com). The special (double/single occupancy) room rate for delegates is $117.00 per night; a block of 60 guest-rooms has been made available to CAA conference delegates. The rate applies for two days prior to and after the conference (subject to availability). To reserve accommodation, please contact the hotel directly by telephone (1-800-WESTIN1; 1-780-493-8999, Fax 1-780-493-8968) or email (tara.jeffery@westin.com) and mention the CAA meeting. The reservation cut-off date is **5 p.m., Friday 12-September-2003**. After this date, the special rates are subject to availability. Should the Conference Hotel be fully booked, other hotels, for every budget, are located within walking distance of the Conference site (check the web-site: http://www.edmonton.ca).

Registration Form: the Conference Registration Form, with pricing, is presently available at the Conference web-site and is reproduced in this issue of Canadian Acoustics.

Exhibits: An exhibition of the latest technologies in acoustics and vibration equipment, materials and software will occur Wednesday and Thursday, 15?16 October. Exhibitors will be well integrated into the conference setting and featured in a special session of the conference program. Sponsorship by Exhibitors of breaks and/or lunches is also welcome. (Contact the Conference Convenor or Izzy Gliener).

Canadian Standards Association: Canadian Standards Association Committee Z 107 in Acoustics and Noise Control will hold a meeting (organizer: Cameron Sherry, Cwsherry@aol.com). All welcome.

Hospitality: In the tradition of past CAA meetings, preparations are underway for a delegate reception (Tuesday, 14-Oct), some joint lunches and a Conference Banquet with awards-ceremony. As much as feasible, opportunity will be provided for you to personally sample some of the best Edmonton hospitality, entertainment and culture. Remember, weather in Edmonton in October is unpredictable: it may be either mild/late-summer or snowed-in (i.e. bring a sweater ...). To begin exploring what Edmonton has to offer, check the web-site http://www.edmonton.ca and click on "Enjoying Edmonton".

Important Dates 2003	
Friday, 30-May	Deadline for receipt of abstracts
Friday, 27-June	Notice of acceptance of abstracts
Friday 01-August	Deadline for receipt of summary paper and early registration
Monday 01-September	Cut-off for early Registration
Friday 12-September	Cut-off, WESTIN reservation
Tuesday, 14-October	Acoustics Week in Canada begins: Registration, Workshops & Seminars
Wed.-Fri., 15-17 October	Acoustics Week in Canada: Technical Program and Exhibition

Contacts & Information	
Main Address:	#102, 9920 – 63 Avenue Edmonton, AB, T6E 0G9 Phone: (780) 414-6373 FAX: (780) 414-6376
Web-site address:	http://caa-aca.ca/edmonton-2003.html
e-mail Address	conference@caa-aca.ca
Convenor:	Corjan Buma
Secretary:	Megan Hodge
Co-coordinator Technical Program:	Gary Faulkner
Exhibitor Co-ordinator:	Izzy Gliener
Web-Master:	Steven Bilawchuk

L'avenir du silence ?

Semaine canadienne d'acoustique, 14–17 octobre 2003, Edmonton, Alberta The Westin Edmonton
www.caa-aca.ca/edmonton-2003.html

DEUXIÈME ANNONCE ET APPEL DE COMMUNICATIONS

Thème du congrès : " L'avenir du silence ? " : Peut-on trouver un juste milieu entre l'intimité et les relations interpersonnelles ? La plupart d'entre nous apprécions tout autant les moments de solitude ou en compagnie restreinte que les activités sociales ou professionnelles où nous souhaitons communiquer avec un grand nombre de personnes. Le Congrès 2003 de l'Association canadienne d'acoustique (ACA) à Edmonton vise à sonder ce thème fondamental du silence lors des sessions plénières et techniques qui auront lieu du 14 au 17 octobre 2003. Le début du congrès approche à grands pas et déjà plusieurs résumés de communication couvrant une diversité de thèmes en acoustique ont été reçus par le comité organisateur.

Communications scientifiques et techniques: Tout comme pour les Semaines canadiennes d'acoustique antérieures, le Congrès de 2003 à Edmonton s'assurera que toutes les branches de l'acoustique seront représentées. Les conférenciers invités lors des sessions plénières comprendront le sénateur Tommy Banks pour le point de vue du musicien, Dr Jos Eggermont (scientifique AHMRF, Calgary) sur l'effet du bruit sur le développement de l'audition au niveau du cerveau et M. Dave Dégagné (Alberta Energy and Utility Board) pour une introduction à la nouvelle version de la réglementation sur le contrôle du bruit en Alberta (régissant le bruit dans le secteur de l'énergie) qui devrait paraître plus tard cette année. Des résumés de communications nous ont été soumis dans les domaines techniques suivants:

Bruits industriels	Acoustique architecturale	Vibrations
Propagation des bruits d'extérieur	Perception du langage	Perte d'audition professionnelle
Protection de l'ouïe	Matériaux acoustiques	Acoustique sous-marine
Acoustique physiologique	Qualité du son	Réglementation/Bruits environnementaux
Bruits de transport	Normes canadiennes	Instrumentation
Applications numériques	Bruits communautaires	Acoustique musicale

Résumés: Les résumés (maximum de 250 mots) de communication devraient avoir été soumis **avant le vendredi 30 mai 2003** (pour les soumissions en retard, prière de vous adresser au Président du congrès par courriel). Les avis d'acceptation de communication seront rendus avant la fin de juin 2003. Le formulaire d'inscription sera joint à cet avis. Les résumés retenus seront affichés sur le site Internet du Congrès (à moins d'avis contraire de la part des auteurs). Un **article** d'au plus deux pages devra être remis avant le **vendredi 1er août 2003**, s'il doit être inclus dans les Actes du Congrès. Cette date d'échéance est fixe pour les fins de publication dans le Cahier des Actes (septembre 2003) du journal Acoustique Canadienne. L'article doit être soumis en format électronique, soit à l'aide d'un logiciel courant de traitement de texte ou en deux fichiers de format " pdf " (une page par fichier). La parution dans le numéro de septembre du journal n'est pas assurée pour les articles reçus après la date de tombée; ils pourraient toutefois paraître dans le numéro de décembre 2003, selon la discrétion de l'éditeur du journal.

L'Association **incite les étudiants** à participer à la Semaine canadienne d'acoustique. Des **prix** seront décernés aux étudiants dont la conférence, lors du Congrès, sera jugée remarquable. Pour participer à cette compétition, les étudiants doivent s'y inscrire en joignant à leur résumé le formulaire «Prix annuel de la meilleure présentation étudiante» dûment rempli. De plus, les étudiants qui vivent à plus de 150 Km d'Edmonton peuvent bénéficier d'une aide financière de voyage pour leur permettre de présenter une conférence lors du Congrès. Pour demander cette subvention, les étudiants doivent soumettre le formulaire «Subvention de voyage pour étudiants». Les formulaires sont disponibles sur notre site Internet. Enfin, les étudiants peuvent aussi formuler une demande unique d'aide financière d'hébergement (un seul remboursement de 50$CDN, en l'absence d'autre soutien), sur présentation d'un reçu de l'hôtel. Note : Seuls les étudiants membres de l'ACA (15$) sont éligibles aux prix et aux subventions de voyage.

Hébergement : Le Westin Edmonton est situé au cœur du centre-ville d'Edmonton, à proximité du district des arts (*Citadel Theatre, Winspear Concert Hall, Edmonton Art Gallery*, etc.) et des lieux majeurs de magasinage et de récréation, incluant le réseau de sentiers du parc *North Saskatchewan River valley*. Le Westin Edmonton fournira l'hébergement et les salles de conférence (http://www.thewestinedmonton.com). Un bloc de 60 chambres à été mis à la disposition des délégués au Congrès de l'ACA; le tarif spécial des chambres (occupation simple /double) pour les délégués est de $117.00 la nuitée. Ce taux sera en vigueur deux jours avant et deux jours après la conférence (selon la disponibilité). Pour réserver, veuillez contacter l'hôtel directement par téléphone (1-800-WESTIN1; 1-780-493-8999), par fax (1-780-493-8968) ou par courriel (tara.jeffery@westin.com) et mentionnez votre participation au Congrès de l'ACA. La date limite de réservation est le vendredi 12 septembre 2003 à 17h00. Après cette date, le tarif spécial dépendra de la disponibilité des chambres. Advenant que l'hôtel du Congrès soit complet, d'autres hôtels, de tarifs divers, sont situés près du site du Congrès (visitez le site internet http://www.edmonton.ca).

FORMULAIRE D'INSCRIPTION: Le formulaire d'inscription pour le congrès, comprenant les tarifs d'inscription, est présentement disponible sur le site internet du congrès et est aussi inclus dans la présente édition du journal Acoustique Canadienne. N.B.: Le paiement des frais du congrès peut se faire par chèque ou par carte VISA.

EXPOSITIONS: Il y aura une exposition des plus récentes technologies en matière d'équipement, de matériaux et de logiciels d'acoustique et de vibrations, les mercredi et jeudi 15 et 16 octobre. Les exposants seront bien intégrés au déroulement de la conférence et se distingueront lors d'une session spéciale du programme du Congrès. Nous accueillons les commandites de la part des exposants pour les repas et les pauses (contactez le comité organisateur du Congrès ou Izzy Gliener).

NORMES CANADIENNES EN ACOUSTIQUE: Il y aura une réunion du comité Z 107 en Acoustique et contrôle du bruit, de l'Association canadienne de la normalisation (organisateur : Cameron Sherry, Cwsherry@aol.com). Bienvenue à tous !

HOSPITALITÉ: Dans le respect des traditions des réunions de l'ACA, des préparations sont en cours pour l'accueil des délégués (mardi, le 14 oct.), les dîners conjoints et un banquet avec cérémonie de remise des prix. Dans la mesure du possible, des occasions vous seront fournies pour découvrir ce qu'il y a de mieux en termes d'hospitalité, de divertissement et de culture à Edmonton. N'oubliez pas que les conditions météorologiques d'Edmonton au mois d'octobre sont imprévisibles : il pourrait faire un temps de fin d'été, comme il pourrait y avoir de la neige (apportez-vous un chandail !). Pour de plus amples renseignements sur la ville d'Edmonton, visitez le site Internet http://www.edmonton.ca et cliquez sur «Enjoying Edmonton».

Dates à retenir pour 2003	
Vendredi 30 mai	Échéance pour la réception des résumés courts
Vendredi 27 juin	Avis d'acceptation des résumés
Vendredi 01 août	Échéance pour la réception des articles et l'inscription hâtive
Lundi 01 septembre	Date limite pour l'inscription hâtive
Vendredi 12 septembre	Date limite pour réservation au WESTIN
Mardi 14 octobre	Lancement de la Semaine Canadienne d'Acoustique: Inscription, Ateliers & Séminaires
mer.-ven.15-17 octobre	Semaine Canadienne d'Acoustique : Programme technique et exposition

Contacts & Information	
Adresse de correspondance:	#102, 9920 – 63 Avenue, Edmonton, AB, T6E 0G9, Tél.: (780) 414-6373, Fax: (780) 414-6376
Adresse internet:	http://caa-aca.ca/edmonton-2003.html
Courriel:	conference@caa-aca.ca
Président du congrès:	Corjan Buma
Secrétaire:	Megan Hodge
Coordonnateur Programme Technique:	Gary Faulkner
Coordonnateur des exposants:	Izzy Gliener
Web-Master:	Steven Bilawchuk

ACOUSTICS WEEK IN CANADA 2003
SEMAINE CANADIENNE D'ACOUSTIQUE 2003

October 15, 16 and 17, 2003 / *du 15 au 17 octobre 2003*
The Westin Hotel, Edmonton, Alberta

REGISTRATION FORM / *FORMULAIRE D'INSCRIPTION*

(1) Full Three Day Registration. Includes:

Conference + exhibits
Lunch each day for 2 days (15th, 16th)
Coffee breaks, morning and afternoon
Entertainment
Banquet Thursday night (except students)
All taxes & gratuities

(1) Inscription complète. *Comprend:*

La participation à la conférence + l'exhibition
Le dîner pendant 2 jours (le 15 et le 16)
Les pauses café, le matin et l'après-midi
L'hospitalité/le divertissement
Le banquet du jeudi soir (sans étudiants)
Toutes les taxes et les pourboires

Registration/ ***Inscription***	**CAA Members** ***Membres de l'ACA***	**Non-members** ***Autres***	**Students** ***Etudiant(e)s***	
			CAA Membres	**Autres**
Before Sept. 1/ ***Avant*** *le 1 sept.*	$250.00	$300.00	$25.00	$40.00*
After Sept. 1/ ***Après*** *le 1 sept.*	$275.00	$330.00	$25.00	$40.00*

*non-member student registration includes a 1 year CAA membership
**inclut l'adhésion à l'ACA pendant un an*

(2) Daily Rates. Includes:

Conference
Lunch each day
All taxes & gratuities

(2) Tarif à la journée. *Comprend*

Une journée à la conférence
Le dîner pour une journée
Toutes les taxes et les pourboires

CAA Members ***Membres de l'ACA***	**Students** ***Etudiant(e)s***	**Non-Members** ***Autres***
$140.00	$25.00	$160.00

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

(3) Extras/ *Suppléments*

Student Banquet Tickets / *Etudiant Billet pour le Banquet* — $15.00 each/*par personne*

Additional Banquet Ticket / *Billet Supplémentaire pour le Banquet* — $45.00 each/*par personne*

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

REGISTRATION FORM / *FORMULAIRE D'INSCRIPTION*

Name/*Nom*:______________________________

Company/*Institution*:______________________________

Address/*Adresse*:______________________________

______________________________Postal Code/*Code Postal*:______________

Tel:______________________________E-mail/*courriel*:______________________________

Full 3 day Conference	$__________	***Inscription complète***
Additional banquet ticket(s)	$__________	*Billet(s) supplémentaire(s) pour le banquet*
Total	$__________	*Total*

Daily Rate Check applicable day(s)	Wednesday *mercredi*	Thursday *jeudi*	Friday *vendredi*	***Inscription à la journée*** *Entourez le(s) jour(s) choisi(s)*
Daily rate		$__________		*Montant*
Banquet ticket(s)		$__________		*Billet(s) pour le banquet*
Total		$__________		*Total*

Payable by cheque in Canadian Funds made out to CAA Conference 2003, or payable by **VISA**
Payable par chèque, en dollars canadiens, à l'ordre de **CAA Conference 2003,** *ou par carte* ***VISA***

VISA Number/*Numéro*:______________________________ Expiry Date/*Date d'expiration*:______________

Name on VISA card / *Nom sur la carte VISA* : ______________________________

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

Mail/Fax to:
Expédier ou faxer à:

Mr. Corjan Buma
ACI Acoustical Consultants Inc.
Suite 107, 9920-63Ave
Edmonton, Alberta
T6E 0G9

Fax: (780) 414-6376

Tel: (780) 414-6373

Please note: Hotel rooms must be booked by Sept. 12, 2003 to guarantee availability.
Veuillez noter : Pour des questions de disponibilité, les chambres d'hôtel doivent être réservées avant le 12 septembre 2003.

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

The Canadian Acoustical Association
L'Association Canadienne d'Acoustique

PRIZE ANNOUNCEMENT • ANNONCE DE PRIX

A number of prizes and subsidies are offered annually by The Canadian Acoustical Association. Preference will be given to citizens and permanent residents of Canada. Applicants can obtain full eligibility conditions, deadlines, application forms, past recipients, and the names of the individual prize coordinators on the CAA Website (http://www.caa-aca.ca). · Plusieurs prix et subventions sont décernés à chaque année par l'Association Canadienne d'Acoustique. La préférence sera accordée aux citoyens et aux résidents permanents du Canada. Les candidats peuvent se procurer de plus amples renseignements sur les conditions d'éligibilités complètes, les dates limites, les formulaires de demande, les récipiendaires des années passées, ainsi que le nom des coordonnateurs des prix en consultant le site Web de l'ACA (http://www.caa-aca.ca).

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

$3,000 for full-time postdoctoral research training in an established setting other than the one in which the Ph.D. was earned. The research topic must be related to some area of acoustics, psychoacoustics, speech communication or noise. • $3,000 pour une formation recherche à temps complet au niveau postdoctoral dans un établissement reconnu autre que celui où le candidat a reçu son doctorat. Le thème de recherche doit être relié à un domaine de l'acoustique, de la psycho-acoustique, de la communication verbale ou du bruit.

Alexander Graham Bell Graduate Student Prize in Speech Communication and Behavioural Acoustics • Prix Étudiant Alexandre Graham Bell en Communication verbale et Acoustique comportementale

$800 for a graduate student enrolled at a Canadian academic institution and conducting research in the field of speech communication or behavioural acoustics. • $800 à un(e) étudiant(e) inscrit(e) au 2e ou 3e cycle dans une institution académique canadienne et menant un projet de recherche en communication verbale ou acoustique comportementale.

Fessenden Graduate Student Prize in Underwater Acoustics • Prix Étudiant Fessenden en Acoustique sous-marine

$500 for a graduate student enrolled at a Canadian academic institution and conducting research in underwater acoustics or in a branch of science closely connected to underwater acoustics. • $500 à un(e) étudiant(e) inscrit(e) au 2e ou 3e cycle dans une institution académique canadienne et menant un projet de recherche en acoustique sous-marine ou dans une discipline reliée à l'acoustique sous-marine.

Eckel Graduate Student Prize in Noise Control • Prix Étudiant Eckel en Contrôle du bruit

$500 for a graduate student enrolled at a Canadian academic institution and conducting research related to the advancement of the practice of noise control. • $500 à un(e) étudiant(e) inscrit(e) au 2e ou 3e cycle dans une institution académique canadienne et menant un projet de recherche relié à l'avancement de la pratique du contrôle du bruit.

Raymond Hétu Undergraduate Prize in Acoustics • Prix Étudiant Raymond Hétu en Acoustique

One book in acoustics of a maximum value of $100 and a one-year subscription to *Canadian Acoustics* for an undergraduate student enrolled at a Canadian academic institution and having completed, during the year of application, a project in any field of acoustics or vibration. · Un livre sur l'acoustique et un abonnement d'un an à la revue *Acoustique Canadienne* à un(e) étudiant(e) inscrit(e) dans un programme de 1er cycle dans une institution académique canadienne et qui a réalisé, durant l'année de la demande, un projet dans le domaine de l'acoustique ou des vibrations.

Canada-Wide Science Fair Award • Prix Expo-sciences pancanadienne

$400 and a one-year subscription to *Canadian Acoustics* for the best project related to acoustics at the Fair by a high-school student · $400 et un abonnement d'un an à la revue *Acoustique Canadienne* pour le meilleur projet relié à l'acoustique à l'Expo-sciences par un(e) étudiant(e) du secondaire.

Directors' Awards • Prix des Directeurs

$500 for the best refereed research, review or tutorial paper published in *Canadian Acoustics* by a student author - $250 for the best paper by a professional author under 30 years of age - $250 for the best paper by a professional author above 30 years age. · $500 pour le meilleur article de recherche, de recensement des travaux ou d'exposé didactique arbitré et publié dans l'*Acoustique Canadienne* par un(e) étudiant(e) - $250 pour le meilleur article par un(e) professionnel(le) âgé(e) de moins de 30 ans - $250 pour le meilleur article par un(e) professionnel(le) âgé(e) d'au moins 30 ans

Student Presentation Awards • Prix pour communications étudiantes

Three $500 awards for the best student oral presentations at the Annual Symposium of The Canadian Acoustical Association. · Trois prix de $500 pour les meilleures communications orales étudiant(e)s au Symposium Annuel de l'Association Canadienne d'Acoustique.

Student Travel Subsidies • Subventions pour frais de déplacement pour étudiants

Travel subsidies are available to assist student members who are presenting a paper during the Annual Symposium of The Canadian Acoustical Association, if they live at least 150 km from the conference venue. · Des subventions pour frais de déplacement sont disponibles pour aider les membres étudiants à venir présenter leurs travaux lors du Symposium Annuel de l'Association Canadienne d'Acoustique, s'ils demeurent à au moins 150 km du lieu du congrès.

Underwater Acoustics and Signal Processing Student Travel Subsidies • Subventions pour frais de déplacement pour étudiants en Acoustique sous-marine et Traitement du signal

One $500 or two $250 awards to assist students traveling to national or international conferences to give oral or poster presentations on underwater acoustics and/or signal processing. · Une bourse de $500 ou deux de $250 pour aider les étudiant(e)s à se rendre à un congrès national ou international pour y présenter une communication orale ou une affiche dans le domaine de l'acoustique sous-marine ou du traitement du signal.

INSTRUCTIONS TO AUTHORS FOR THE PREPARATION OF MANUSCRIPTS

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

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

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

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

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

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

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

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

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

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

Photographs: Submit original glossy, black and white photograph.

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

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

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

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

DIRECTIVES A L'INTENTION DES AUTEURS PREPARATION DES MANUSCRITS

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

Application for Membership

CAA membership is open to all individuals who have an interest in acoustics. Annual dues total $55.00 for individual members and $15.00 for Student members. This includes a subscription to *Canadian Acoustics*, the Association's journal, which is published 4 times/year. New membership applications received before September 1 will be applied to the current year and include that year's back issues of *Canadian Acoustics*, if available. New membership applications received after September 1 will be applied to the next year.

Subscriptions to *Canadian Acoustics* *or* Sustaining Subscriptions

Subscriptions to *Canadian Acoustics* are available to companies and institutions at the institutional subscription price of $55.00. Many companies and institutions prefer to be a Sustaining Subscriber, paying $250.00 per year, in order to assist CAA financially. A list of Sustaining Subscribers is published in each issue of *Canadian Acoustics*. Subscriptions for the current calendar year are due by January 31. New subscriptions received before September 1 will be applied to the current year and include that year's back issues of *Canadian Acoustics*, if available.

Please note that electronic forms can be downloaded from the CAA Website at **caa-aca.ca**

Address for subscription / membership correspondence:

Name / Organization ______________________________

Address ______________________________

____

City/Province ______________ Postal Code ______________ Country ______________

Phone ______________ Fax ______________ E-mail ______________

Address for mailing Canadian Acoustics, if different from above:

Name / Organization ______________________________

Address ______________________________

____

City/Province ______________ Postal Code ______________ Country ______________

Areas of Interest: (Please mark 3 maximum)

1. Architectural Acoustics
2. Engineering Acoustics/Noise Control
3. Physical Acoustics / Ultrasound
4. Musical Acoustics / Electro-acoustics
5. Psychological/Physiological Acoustic
6. Shock and Vibration
7. Hearing Sciences
8. Speech Sciences
9. Underwater Acoustics
10. Signal Processing / Numerical Methods
11. Other

For student membership, please also provide:

(University) *(Faculty Member)* *(Signature of Faculty Member)* *(Date)*

I have enclosed the indicated payment for:

[ ] CAA Membership $ 55.00
[ ] CAA Student Membership $ 15.00
[ ] Institutional Subscription $ 55.00
[ ] Sustaining Subscriber $ 250.00
includes subscription (4 issues /year) to ***Canadian Acoustics.***

Payment by: [ ] Cheque
[ ] Money Order
[ ] VISA credit card *(Only VISA accepted)*

For payment by VISA credit card:

Card number ______________________________

Name of cardholder ______________________________

Expiry date ______________________________

(Signature) (Date)

Mail this application and attached payment to:
D. Quirt, Secretary, Canadian Acoustical Association, PO Box 74068, Ottawa, Ontario, K1M 2H9, Canada

l'Association Canadienne d'Acoustique
The Canadian Acoustical Association

Formulaire d'adhésion

L'adhésion à l'ACA est ouverte à tous ceux qui s'intéressent à l'acoustique. La cotisation annuelle est de 55.00$ pour les membres individuels, et de 15.00$ pour les étudiants. Tous les membres reçoivent l'Acoustique Canadienne, la revue de l'association. Les nouveaux abonnements reçus avant le 1 septembre s'appliquent à l'année courante et incluent les anciens numéros (non-épuisés) de l'Acoustique Canadienne de cette année. Les nouveaux abonnements reçus après le 1 septembre s'appliquent à l'année suivante.

Abonnement pour la revue Acoustique Canadienneet abonnement de soutien

Les abonnements pour la revue Acoustique Canadienne sont disponibles pour les compagnies et autres établissements au coût annuel de 55.00$. Des compagnies et établissements préfèrent souvent la cotisation de membre bienfaiteur, de 250.00$ par année, pour assister financièrement l'ACA. La liste des membres bienfaiteurs est publiée dans chaque issue de la revue Acoustique Canadienne. Les nouveaux abonnements reçus avant le 1 juillet s'appliquent à l'année courante et incluent les anciens numéros (non-épuisés) de l'Acoustique Canadienne de cette année. Les nouveaux abonnements reçus après le 1 septembre s'appliquent à l'année suivante.

Pour obtenir des formulaires electroniques, visitez le site Web: caa-aca.ca

Pour correspondence administative et financière:

Nom / Organisation ______________________________

Adresse ______________________________

Ville/Province ______________________________ *Code postal*

Pays ______________________________

Téléphone ______________________________ *Téléc.*

Courriel ______________________________

Adresse postale pour la revue Acoustique Canadienne

Nom / Organisation ______________________________

Adresse ______________________________

Ville/Province ______________ *Code postal* ____________ *Pays* ______________

City/Province ______________ Postal Code __________ Country ______________

Areas of Interest: (Please mark 3 maximum)

1. Acoustique architecturale
2. Génie acoustique / Contrôlc du bruit
3. Acoustique physique / Ultrasons
4. Acoustique musicale/Electro-acoustique
5. Physio / Psycho-acoustique
6. Chocs et vibrations
7. Audition
8. Parole
9. Acoustique sous-marine
10. Traitement des signaux /Méthodes numériques
11. Autre

Prière de remplir pour les étudiants et étudiantes:

(Université) (Nom d'un membre du corps professoral) (Signature du membre du corps professoral) (Date)

Cocher la case appropriée:

[ ] Membre individuel $ 55.00

[ ] Membre étudiant(e) $ 15.00

[ ] Abonnement institutionnel $ 55.00

[ ] Abonnement de soutien $ 250.00

(comprend l'abonnement à L'acoustique Canadienne)

Méthode de paiement:

[ ] Chèque au nom de l'Association Canadienne d'Acoustique

[ ] Mandat postal

[ ] VISA (Seulement VISA)

Pour carte VISA: Carte n° ______________

Nom: ______________

Date d'expiration: ______________

(Signature): ______________ (Date): ________

Prière d'attacher votre paiement au formulaire d'adhésion. Envoyer à:

D. Quirt, Secrétaire exécutif, Association Canadienne d'Acoustique, Casier Postal 74068, Ottawa, K1M 2H9, Canada

The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

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