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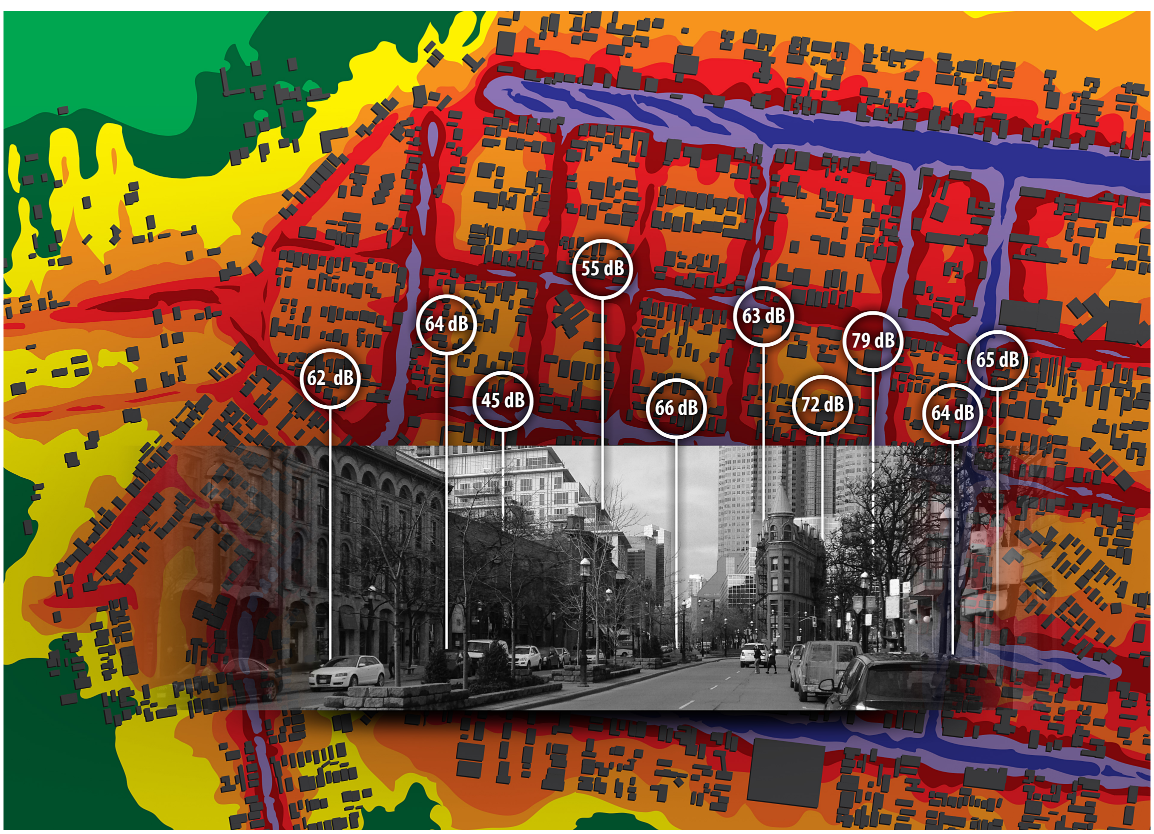

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Acoustique canadienne est publié quantre fois par an, en mars, juin, septembre et décembre. Cette revue trimestrielle est envoyée gratuitement aux membres individuels de l'Association canadienne d'acoustique (ACA) et aux abonnés institutionnels. L'Acoustique canadienne publie des articles arbitrés et des rubriques sur tous les aspects de l'acoustique et des vibrations. Ceci comprend la recherche, les recensions des travaux, les nouvelles, les offres d'emploi, les nouveaux produits, les activités, etc. Les articles concernant les résultats inédits ou les applications de l'acoustique ainsi que les articles de synthèse, les tutoriels et les exposées techniques, en français ou en anglais, sont les bienvenus.L'Association canadienne d'acoustique a sélectionné Paypal comme solution pratique pour le paiement en ligne de vos frais d'abonnement. Paypal prend en charge un large éventail de méthodes de paiement (Visa, Mastercard, Amex, compte bancaire, etc) et ne nécessite pas que vous ayez déjà un compte avec eux. Si vous désirez procéder à un paiement par chèque de votre abonnement, on vous invite à compléter le formulaire d'adhésion et l'envoyer avec votre chèque ou mandat au secrétaire de l'association (voir adresse ci-dessus). - Canadian Acoustical Association/Association Canadienne d'Acoustique P.B. 74068 Ottawa, Ontario K1M 2H9 Canada - - - secretary@caa-aca.ca - Dr. Roberto Racca

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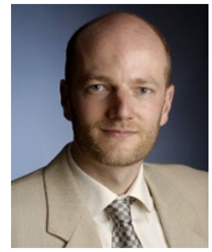
Éditorial
Editor's note



Printemps 2015 (?)

Ce numéro de mars aurait dû annoncer l'arrivée du printemps et du renouveau, mais malgré nos efforts pour retarder sa publication, il semble qu'il n'en soit encore rien dans une bonne partie du pays. Vous trouverez dans ce numéro en plus de deux intéressants articles, une copie exhaustive des documents relatifs au statut officiel de notre association maintenant pérennisé par les efforts de son Comité de direction et en particulier de son président, le professeur Frank Russo. L'appel à soumission spécial, pour une série de numéros portant sur des sujets régionaux, démarre bien et plusieurs contributions ont déjà été reçues pour la grande région de Montréal. Assurez-vous d'y contribuer, car ces numéros devraient rapidement devenir le « Who's Who » en acoustique au sein des principales villes canadiennes. Inscrivez également dans vos agendas la prochaine Semaine canadienne d'acoustique (AWC15), qui se tiendra à Halifax (NS) du 6 au 9 octobre 2015. Et tant qu'à y être, notez également que AWC16 aura lieu du 22 au 24 septembre 2016 à Vancouver (BC), juste après le World Congress on Audiology (WCA2016), permettant ainsi une occasion unique d'échanges inter-disciplinaires sur l'audition et l'acoustique. Deux belles conférences en une semaine, avec une journée commune pour des sessions conjointes!

Et en l'attente d'un temps clément, je vous souhaite une bonne lecture!

Jérémie Voix
Rédacteur-en-chef

Spring 2015 (?)

This March issue should have heralded the arrival of springtime, yet even with our efforts to delay its publication, this issue comes while spring is still awaited in most parts of the country. You will find in this issue two interesting articles as well as a thorough overview of the documents relative to our new official status as an association, now secured thanks to the efforts of our Board of Directors and its president, Professor Frank Russo. The special call for papers for a series of issues with regional content is off to a good start with several paper submissions already received from the greater Montreal area. Make sure to contribute, as these issues will become a veritable “Who's who” in acoustics among Canada's major cities. Also mark your calendar for the upcoming Acoustics Week in Canada (AWC15) that will be held at the Westin Nova Scotia hotel in downtown Halifax (NS), October 6 to 9, 2015. And while you have your calendar out, mark this other important date, the AWC16 will take place September 22 to 24, 2016, in Vancouver (BC), right after the World Congress of Audiology (WCA2016), enabling a singular opportunity for inter-disciplinary discussions about hearing and acoustics. Two great conferences in one week with a day of overlap for joint sessions!

While waiting for spring to arrive, enjoy reading this issue!

Jérémie Voix
Editor

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Urban Noise Assessment Based on Noise Mapping And Measurements

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Abstract

Noise pollution from road traffic was evaluated in a large city in Latin America based on *in situ* measurements taken at 174 points and on noise maps. The noise maps were calculated using Predictor 7810 version 8.11 software, based on the prediction model of the international standard ISO 9613. Three distinct areas in the city of Campo Grande (Brazil) were evaluated: 1) Commercial sector, 2) Mixed sector (commercial and residential), and 3) Residential sector. The noise maps indicate the presence of noise pollution in the Commercial and Mixed sectors, as well as the fact that parts of the Residential sector are noise polluted but that it still has large areas where the noise limit of 55dB(A) is respected.

Keywords: noise pollution, noise mapping, noise assessment, noise limits

Résumé

La pollution sonore de la circulacion routière a été analysée dans une grande ville en Amérique Latine basée sur des mesures *in situ* prise à 174 points et sur les cartes de bruit. Les cartes de bruit ont été calculés en utilisant Predictor 7810 version 8.11 software, grâce à un modèle de prédiction de la norme internationale ISO 9613. Trois zones distinctes dans la ville de Campo Grande (Brésil) ont été évalués: 1) Le secteur commercial, 2) Le secteur mixte (commercial et résidentiel), et 3) Le secteur résidentiel. Les cartes de bruit indiquent la présence de la pollution sonore dans les secteurs commerciaux et mixtes, ainsi que le fait que certaines parties du secteur résidentiel sont polluées par le bruit mais qu'il a encore de grandes zones où la limite de bruit de 55 dB (A) est respectée.

Mots clefs: la pollution sonore, la carte de bruit, l'évaluation du bruit, les limites de bruit

1 Introduction

The expanding urbanization around the world shares a common factor, which is the aggravation of environmental pollution, i.e., gas emissions, water pollution and noise pollution.

Noise pollution in urban environments comes from numerous sources, e.g., sirens, loud music, neighbors, car and home alarms, religious buildings, horns, motorcycles, trucks, passenger cars, buses, planes, trains, etc. [1-14].

The study reported here was conducted in the city of Campo Grande, located in Brazil's Central West region, with a population of approximately 800,000 and a vehicle fleet of about 436,000. The number of vehicles in Campo Grande has increased by about 42% over the last five years [15]. Hence, in view of this growth in the vehicle fleet, an assessment should be made to determine the presence or absence of noise pollution.

Noise pollution was evaluated by means of measurements and the calculation of noise maps. Three distinct areas of the city were evaluated: 1) Residential sector, 2) Commercial sector, and 3) Mixed sector, comprising both residential and commercial areas.

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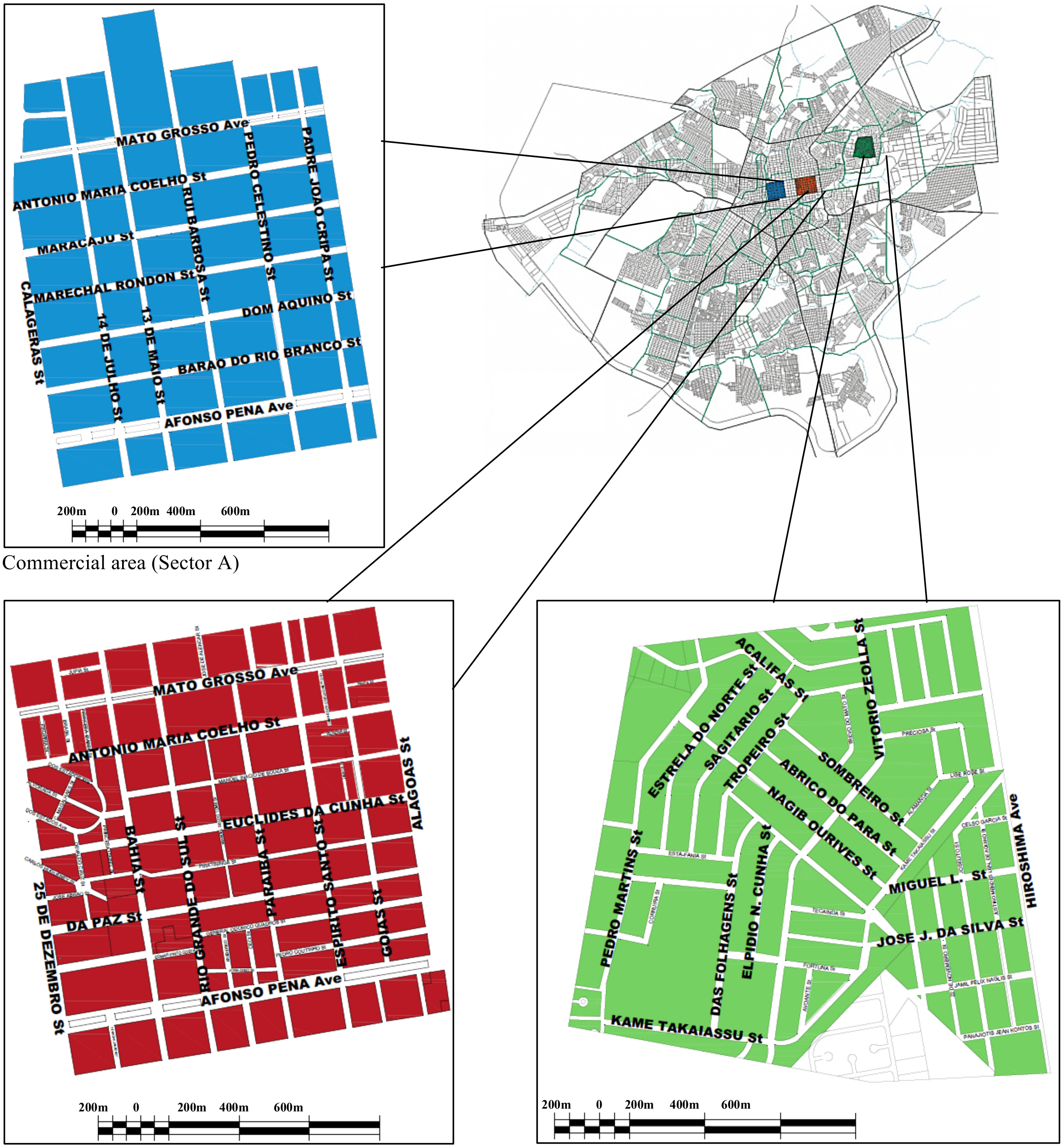
2 Materials and Methods

Three types of areas were evaluated in the city of Campo Grande: 1) a commercial area, 2) a residential area, and 3) a mixed (commercial and residential) area. These three areas, which were chosen because they represent the main zoning types in the city of Campo Grande and are representative of large Brazilian cities, are identified in Figure 1 as Sector A (Commercial), Sector B (Mixed–business and residential) and Sector C (residential).

The equivalent sound pressure level, L_{Aeq}, was measured taken at 174 points in the three areas, as follows: 64 points in Sector A, 60 points in Sector B, and 52 points in Sector C. Data were collected following the procedures established by the city's legislation on the assessment of noise levels in the urban environment, as well as the procedures established by the Brazilian NBR 10151 standard for environmental noise assessments [16, 17]. The daytime measurements were taken at different times between 6:00 a.m. and 6:00 p.m., from Monday to Friday, between June and October 2011.The measuring time at each point, which was 10 minutes, was chosen to coincide with other studies found in the literature and published in a variety of international journals [5, 9, 18-26]. The measurements were taken using an Extech 407790 sound level meter equipped with a with free-field microphone, which was placed on a tripod at a height of 1.5 m from the ground, as recommended by the Brazilian NBR 10151 standard [17]. The noise levels measured in Sectors A and C were compared with the legal levels established by Complementary Law No. 08 (Table 1), while the noise levels measured in Sector B were compared with those established by the Brazilian technical standard NBR 10151 (Table 2). The use of the Brazilian standard was necessary because Campo Grande's municipal law does not establish sound levels for mixed areas (commercial and residential) [16, 17].



Commercial area (Sector A)

Mixed area – Commercial and Residential (Sector B)

Residential area (Sector C)

Figure 1: Location of the sectors

Table 1: Permissible noise levels – Complementary Law Nº. 08 [16]

Zones of use	Daytime (6:00 a.m. - 6:00 p.m.)
Residential areas	55 dB(A)
Commercial areas	60 dB(A)

Table 2: Permissible noise levels according to the use of the area NBR 10151 [17]

Types of areas	Daytime (7:00 a.m. - 7:00 p.m.)
Mixed area, predominantly residential	**55 dB(A)**

2.1 Noise Mapping

Noise mapping was carried out using the Predictor 7810 version 8.11 software package, based on the prediction model of the international standard ISO 9613 [27], which requires the following data: Total vehicle flow; Composition of vehicle traffic; Average speed of the flow; Characteristics of the streets/roads; Topographic data; and Geometry of the buildings.

The traffic flow was determined by counting vehicles manually, while simultaneously measuring the noise levels, considering motorcycles, light vehicles (cars and small trucks) and heavy vehicles (trucks and buses) separately. The vehicles at each measurement point were counted for 10 minutes. Since the traffic flow input data into the software are represented in vehicles/hour, the counts were extrapolated, i.e., the vehicle count in 10 minutes was multiplied by six. The other data required for the simulation were obtained from field surveys (average vehicle speed and pavement characteristics). The topographic information and orthophotos of the areas were obtained from the Campo Grande city hall. Table 3 describes the average vehicle flow measured in the daytime in the three areas, which is characterized mainly by light vehicles, followed by motorcycles and heavy vehicles. Table 3 also shows the total flow measured per hour in each analyzed sector. Table 4 describes the type and quality of pavement and average speed of the traffic flow in the three areas.

Table 3: Average vehicle flow – Daytime.

		Motorcycles	Cars	Heavy vehicles		Total Flow
				Trucks	Buses	
Sec A	Veh/h	2766	10579	70	253	13668
	Total (%)	20.24	77.40	0.51	1.85	100
Sec B	Veh/h	1558	9148	72	105	10883
	Total (%)	14.32	84.06	0.66	0.96	100
Sec C	Veh/h	280	1127	22	15	1444
	Total (%)	19.39	78.05	1.52	1.04	100

Table 4: Average speed, pavement type and quality

	Sector A	Sector B	Sector C
Pavement type and quality	Asphalt in fair condition	Asphalt in fair condition	Asphalt and dirt in fair conditions
Average speed (km/h)	30 – 50	20 – 50	10 – 50

The calculated noise maps were calibrated as recommended by the EU Working Group on the Assessment of Environmental Noise (WG-AEN) and by Licitra & Memoli [29], who suggest that the difference between measured and calculated noise levels should not exceed 4.6 dB(A) [28, 29].

3. Results and Discussion

Figure 2 compares measured and simulated noise levels for the three sectors (see Figure 1). As Figure 2 indicates, only 2 points (one in Sector A and the other in Sector B) show differences that exceed the limit set by the WG-AEN and the 4.6dB(A) recommended by Licitra & Memoli [28, 29].

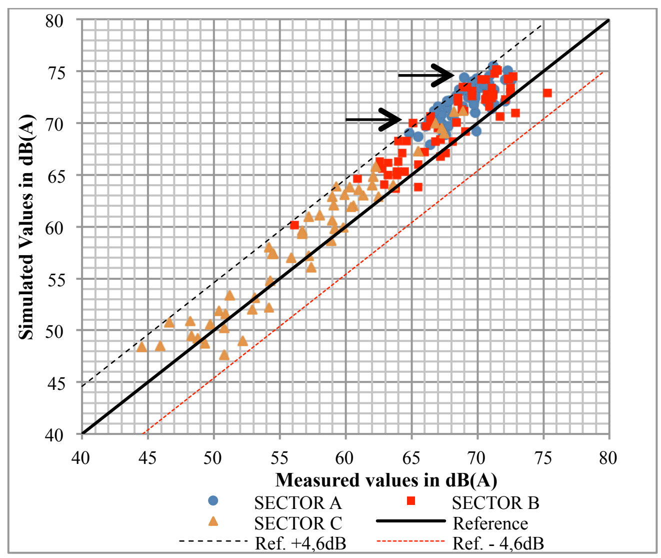


Figure 2: Comparison of the measured and simulated noise levels

The noise maps in Figures 3, 4 and 5 show the current situation of the three sectors. Considering the noise levels indicated in Tables 1 and 2, note that the noise limit in Sector A is exceeded by 0 to 20dB(A), while in most of Sector B it is exceeded by 0 to 15dB(A), reaching up to 20dB(A) in some areas, and in Sector C the limit is exceeded by 0 to 15dB(A). Among the three analyzed areas, Sector C (residential) generally presented the lowest noise levels, mainly due to the lower vehicle traffic and speed in this sector. Moreover, this sector also contains green areas. However, it should be noted that this sector is also becoming increasingly urbanized.

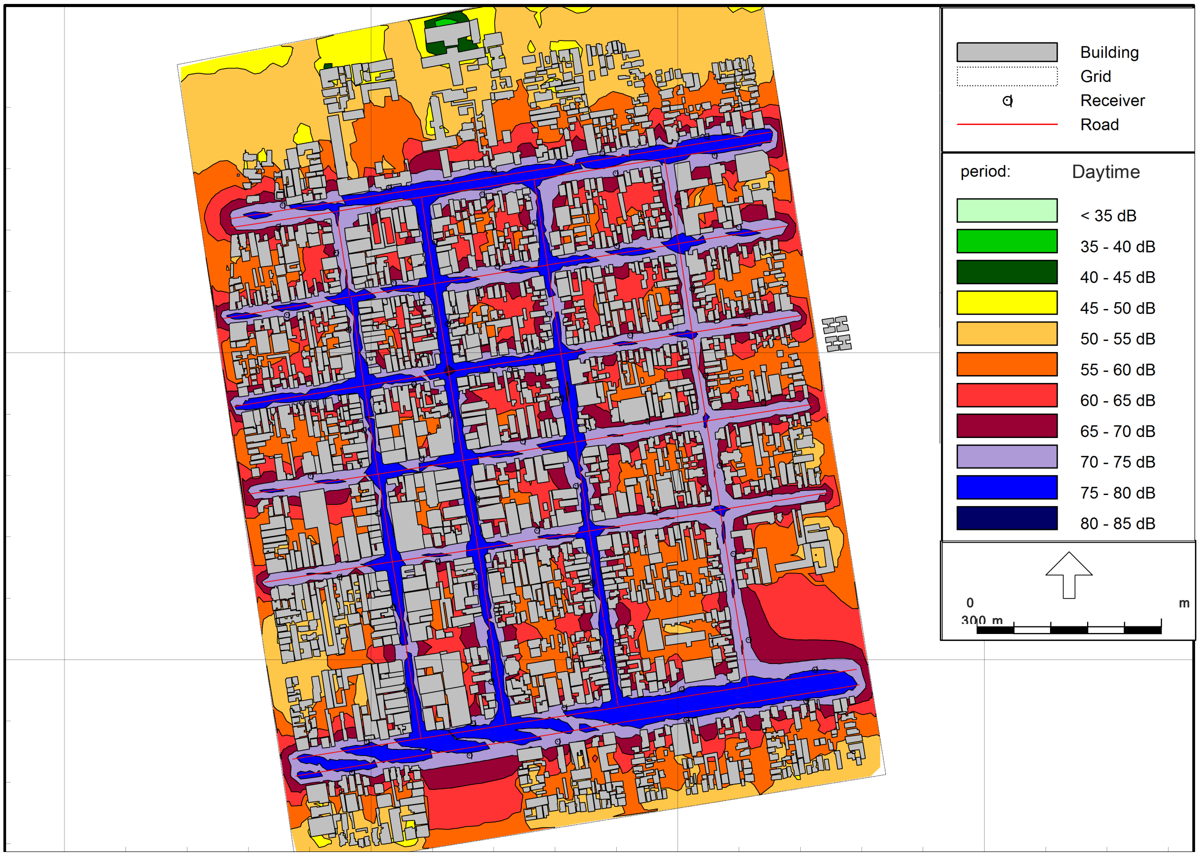


Figure 3: Noise map of Sector A – (Commercial).

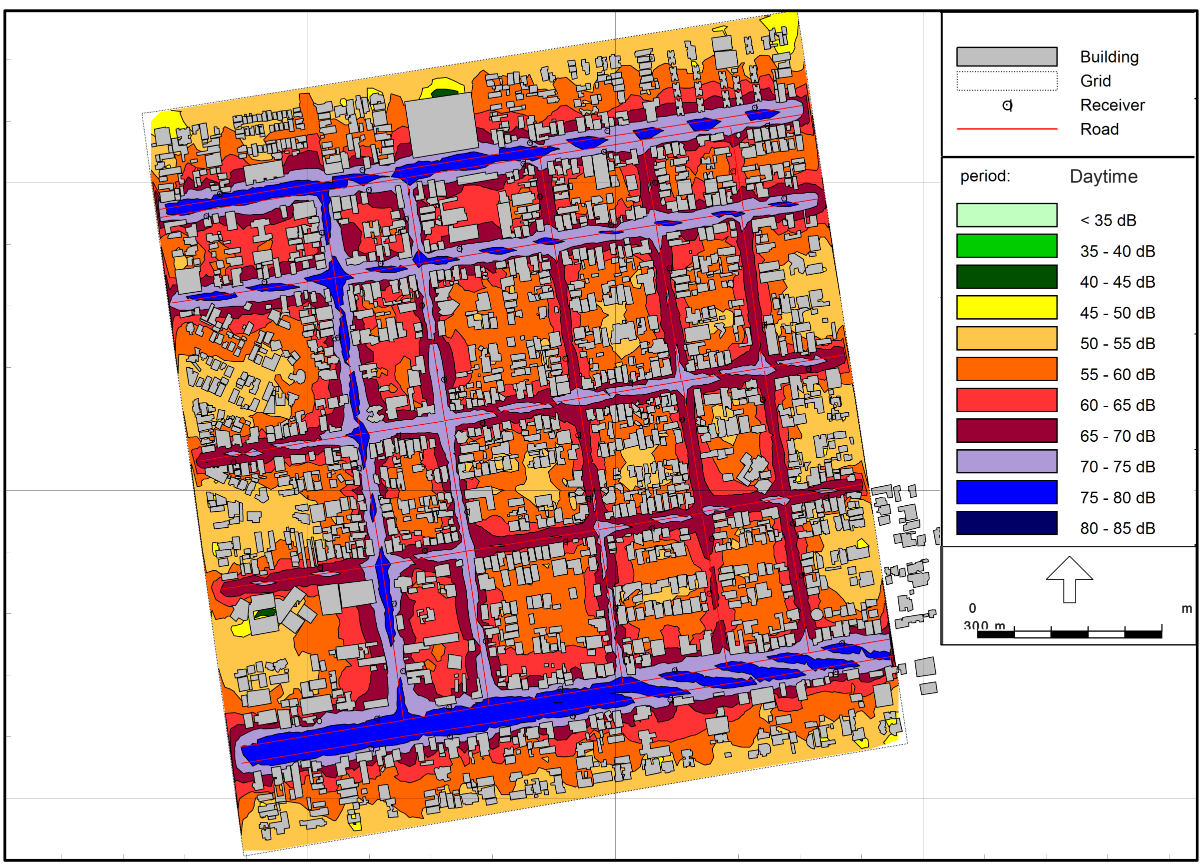


Figure 4: Noise map of Sector B (Mixed residential and commercial)

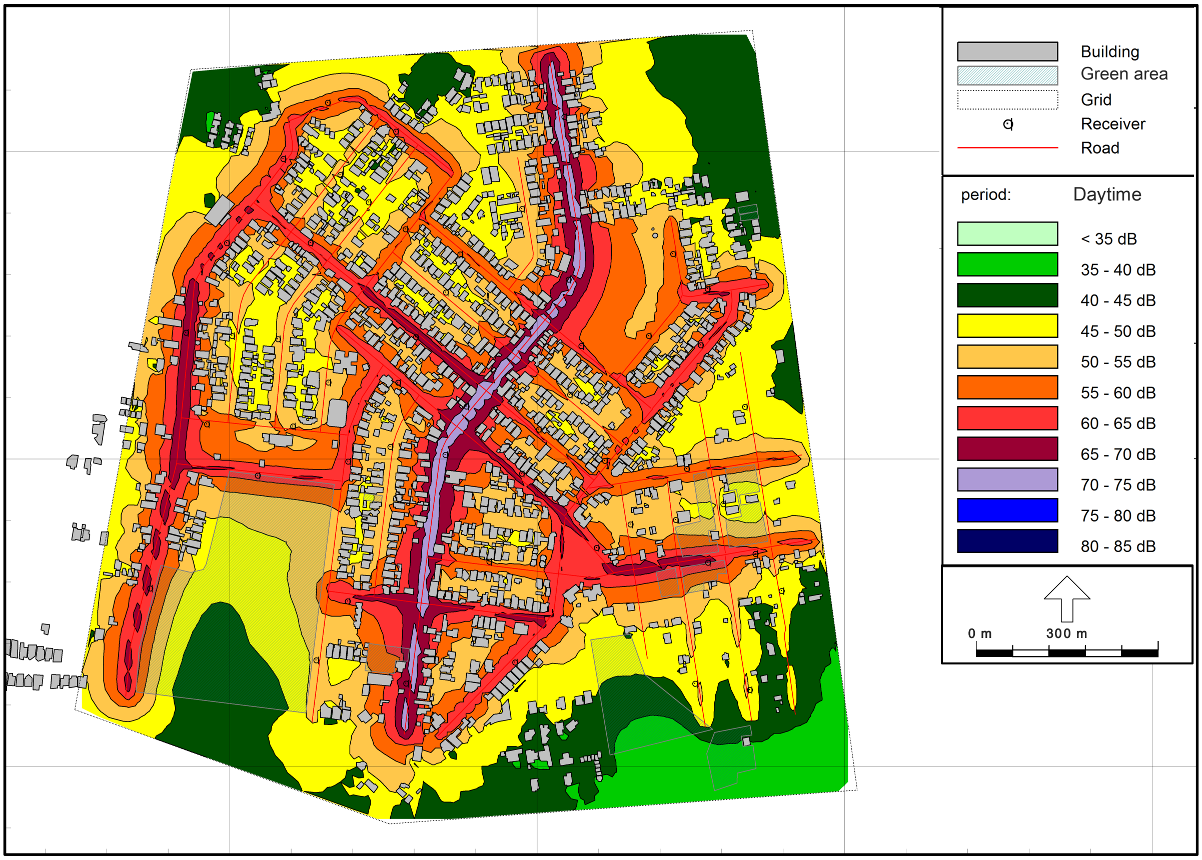


Figure 5: Noise map of Sector C (residential)

In addition to indicating the existing noise levels in a given area, noise maps also serve to identify the portions of each area where the noise levels are lower or higher than the legal limits. This facilitates a possible intervention in noise polluted areas, as well as the maintenance of sound levels in areas where noise levels are within the legally established limits. In this regard, noise maps for the three sectors were created in only two colors, one illustrating the areas where the limits are exceeded and the other showing where they are lower than stipulated, according to Tables 1 and 2. Figures 6, 7 and 8 show that large portions of Sector A (commercial), Sector B (mixed) and Sector C (residential) are acoustically polluted.

As can be seen, Sector A (Figure 6) has few areas that are below the established limit of 60 dB(A). The areas where the noise levels exceed the limit, represented by the blue color, cover almost the entire sector, clearly demonstrating the presence of noise pollution. Like Sector A, Sector B (Figure 7) is also clearly noise polluted. The residential sector, Sector C (Figure 8), shows large areas where the limit of 55dB(A) is not exceeded.

According to Maschke [30], the sound level of 65 dB(A) is considered the recommended exposure limit for populations in urban environments.

5. Conclusion

This study evaluated the problem of noise pollution in a large Brazilian city based on *in situ* measurements taken at 174 points scattered over three distinct commercial, mixed (commercial and residential) and residential areas, which were identified as Sectors A, B and C. Noise maps were also calculated showing the current situation of these sectors. The noise maps clearly indicated the presence of noise pollution in Sectors A (commercial) and B (mixed commercial and residential). The noise maps pinpointed the portions of the investigated areas where the noise levels exceed the limits established by law or by the Brazilian standard for environmental noise assessment. Although parts of Sector C (residential) have noise levels exceeding the limit of55dB(A), it also contains large areas where this limit is not exceeded. This is attributed to the fact that this is a residential neighborhood in Campo Grande, which still contains large green areas. However, the results presented here should serve as a warning for the public authorities, because Sector C is undergoing an increasingly intense process of urbanization. The data presented here may serve to help prevent noise pollution in expansion plans for this neighborhood.

Acknowledgments

The authors gratefully acknowledge the financial support of the Brazilian Government, through the National Council for Scientific and Technological Development – CNPq, and the German Government, through the German Academic Exchange Service – DAAD, which enabled the purchase of the equipment and software used in this study. The authors also wish to thank the anonymous reviewers for their careful assessment and invaluable suggestion

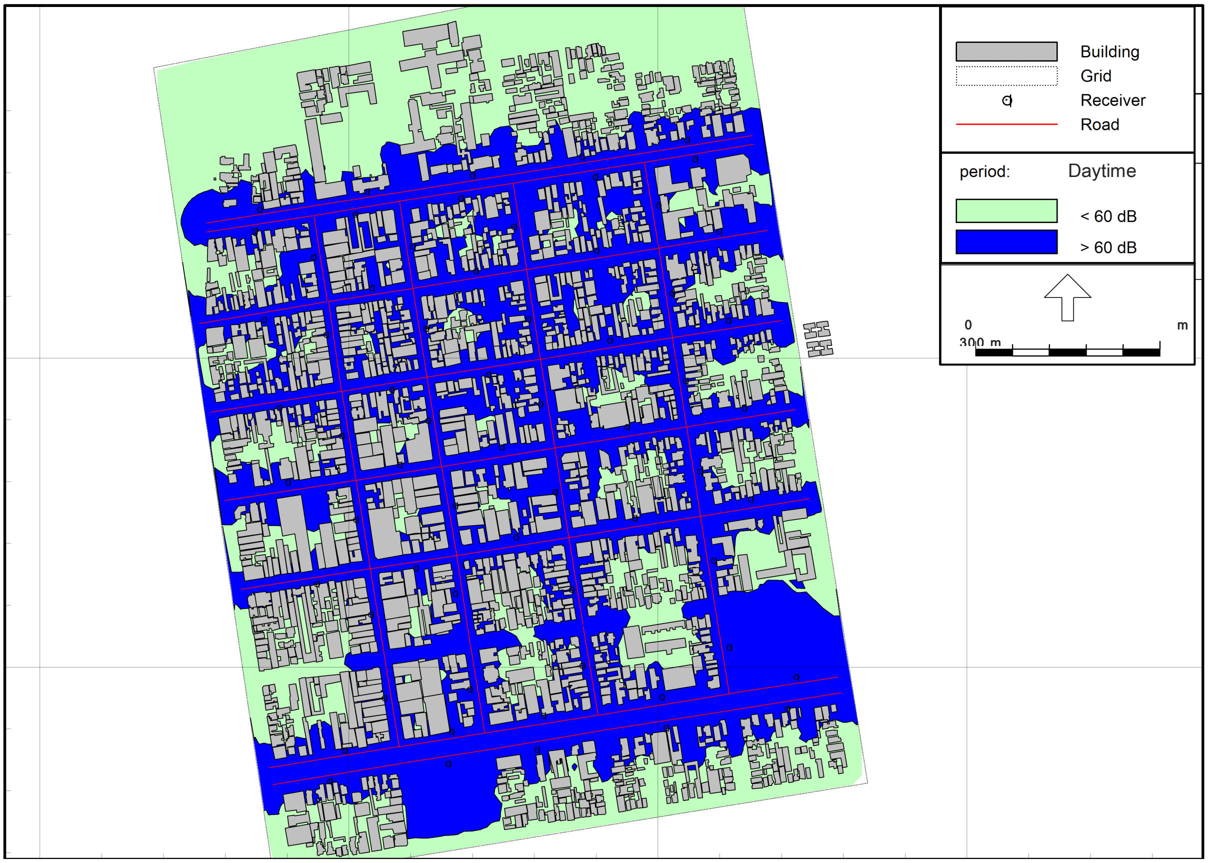


Figure 6: Noise map of Sector A – Limit of 60 dB(A) [16]

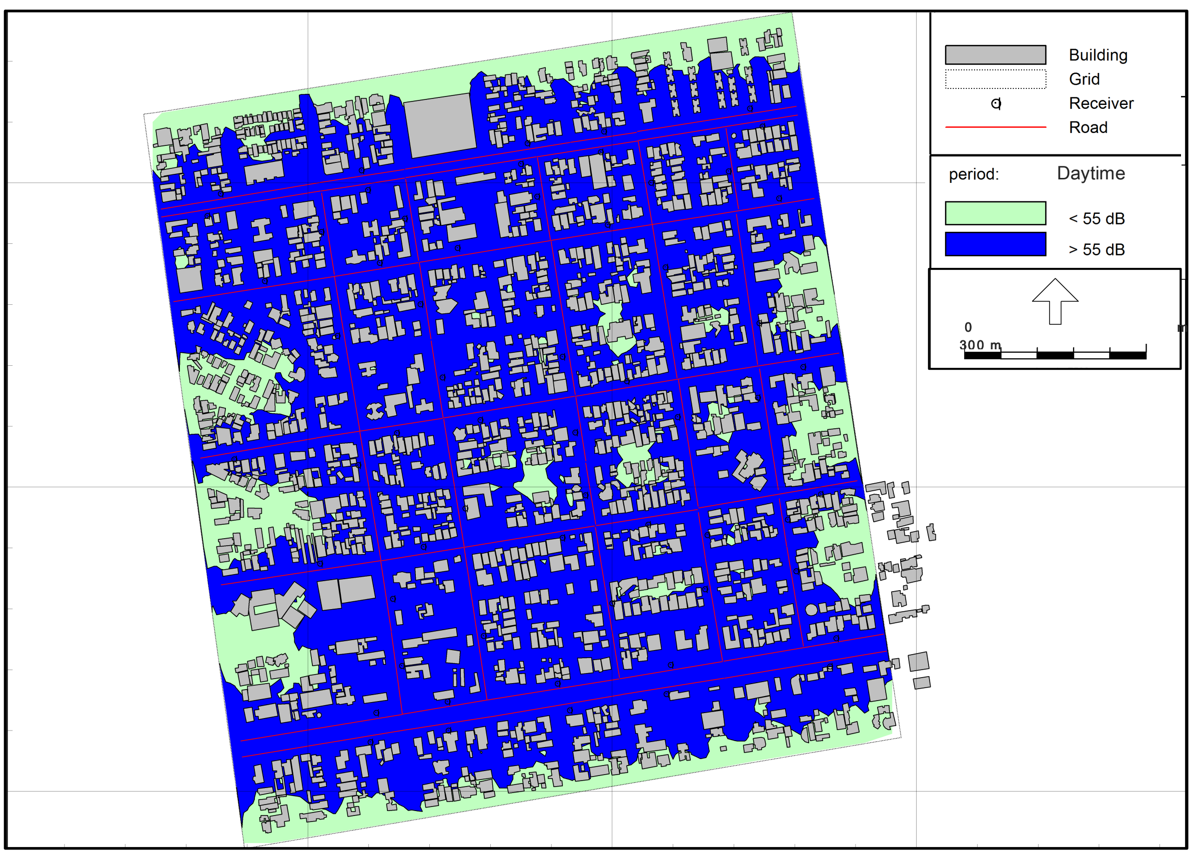


Figure 7: Noise map of Sector B – Limit of 55 dB(A) [17]

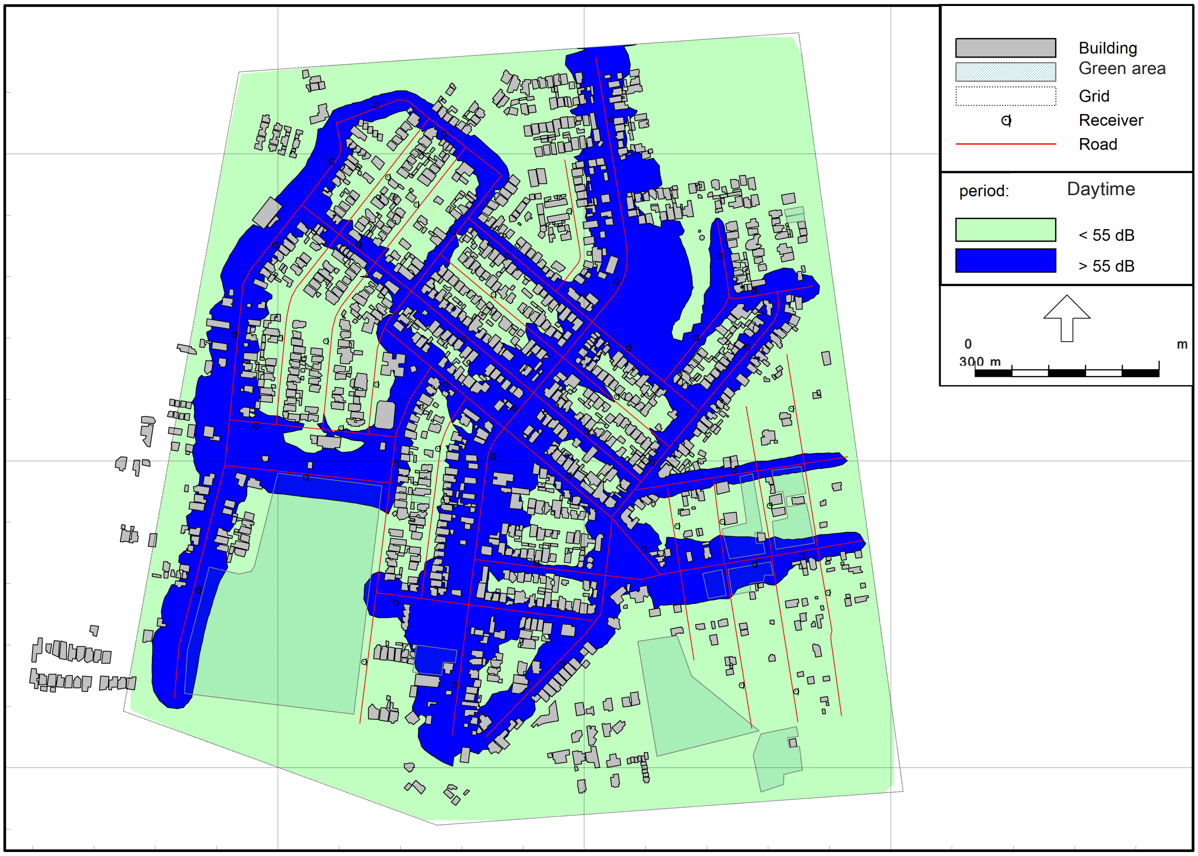


Figure 8: Noise map of Sector C – Limit of 55 dB(A) [16]

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VALIDATION OF A FINITE ELEMENT CODE FOR A CONTINUUM MODEL OF VOCAL FOLD VIBRATION UNDER THE INFLUENCE OF A SESSILE POLYP

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Abstract

Vocal fold vibration has been extensively investigated using numerical simulation through the use of lumped element models, and more recently, through the use of finite element continuum models. Finite element models offer the ability to analyze the effects of detailed and complex geometric models, allowing for the study of the influence of pathologies and phonosurgery on the process of phonation. The present study details the development of a finite element code of vocal fold vibration and a continuum model of a vocal fold with a sessile polyp. The capability of the code to capture major structural vibration trends are illustrated through a validation process, wherein previously explored models are replicated, and computed results are subsequently compared to gauge the code's efficacy. An overview of literature pertinent to the modeling of vocal fold polyps is presented, followed by the discussion of the creation of a continuum model of a vocal fold affected by a sessile polyp. This pathological model is parameterized according to the size and position of the polyp, and trends are explored based on varying these parameters. Polyp size is concluded to have a more profound influence on the fundamental frequency of vibration than position. An inversely proportional relationship is found between polyp size and fundamental frequency, as well as proximity to the anterior-posterior surface and fundamental frequency.

Keywords: Vocal fold, Polyps, Structural vibration, Finite element method

Résumé

Les vibrations des cordes vocales ont été étudiées extensivement par simulation numérique grâce à l'utilisation des modèles de paramètres localisés et, plus récemment, grâce à l'utilisation des modèles des éléments finis. Les modèles des éléments finis offrent la possibilité d'analyser les effets des modèles géométriques complexes et détaillés, facilitant ainsi l'étude de l'influence des pathologies et phonochirurgies sur le processus de phonation. Cette étude décrit le développement d'un code utilisant des éléments finis afin d'analyser les vibrations des cordes vocales. L'étude a aussi développé un modèle de continuum d'une corde vocale avec un polype sessile. La capacité du code à saisir les tendances importantes des vibrations structurelles est illustrée par un processus de validation, où des modèles existants sont répliqués et les résultats calculés sont comparés pour évaluer l'efficacité du code. Une révision de la littérature pertinente sur la modélisation des polypes sur les cordes vocales est présentée, suivie par une discussion sur la création d'un modèle de continuum d'une corde vocale avec un polype sessile. Ce modèle pathologique a été étudié en fonction de la taille et de la position du polype, et les tendances on été étudiées en fonction de ces paramètres. La taille du polype s'est avérée avoir une plus grande influence sur la fréquence fondamentale de la vibration que la position sur la corde vocale. Une relation inversement proportionnelle a été trouvée entre la taille du polype et la fréquence fondamentale, ainsi qu'une relation inversement proportionnelle entre la proximité de la surface antérieur-postérieur et la fréquence fondamentale.

Mots clefs: Cordes vocales, Polypes, Vibrations structurelles, Méthode des éléments finis

1 Introduction

Accurate simulation of structural vibration is dependent on a proficient formulation of a system's equation of motion. The proficiency of such a method is complex to assess for discrete models which are subject to numerous errors stemming from discretization, efficiency concerns, and representation of the physical system itself. Models of vocal fold vibration are susceptible to these issues, and as a result, multiple models have been developed which attempt to predict comparable vibration behaviour through various formulation techniques. These models have advanced with the introduction of continuum models [1–8], which distinguish themselves from traditional lumped element models [9–11] by virtue of their ability to incorporate the effects of complex spatial geometries on vibration behaviour. Notably, continuum models offer an avenue for detailed study of the effects of pathologies on vibration, such as polyps, nodules, and asymmetries.

An early and seminal two-mass lumped element model of vocal fold vibration was developed by Ishizaka and Flanagan [9]. This model approximated vocal folds as two masses coupled by springs and viscous dampers which were subject

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to aerodynamic forces, modeled by Bernoulli flow. The model exhibited realistic self-oscillation properties previously observed only in experimental studies, such as the phase shift in motion between the upper and lower vocal fold edges [9, p. 1266]. The two-mass model was subsequently adopted for the study of the effect of pathologies on the generation of a speech signal, such as asymmetries [12–15] and polyps [16]. Though these models have generated comparable results to in-vivo studies, their use is limited to simulations which forfeit thorough physiological representation in exchange for computational efficiency. Developments of the two-mass model have, however, improved on spatial resolution and refined viscoelastic characterization [10, 11, 17].

Continuum models of laryngeal structure and flow have improved accuracy by virtue of refined and detailed discretization. One such complex vocal fold finite element (FE) model was developed by Alipour et al. [1], which considered a three-dimensional model of a vocal fold. This model uses distinct material properties for the body, cover, and ligament tissues, and approximates fluid interactions through Bernoulli flow. Oliveira Rosa et al. [2] expanded on this model by incorporating the entire larynx, adding longitudinal degrees of freedom, modeling tissue collisions, and modeling flow with the unsteady Navier-Stokes equations. Further extensions of the computational fluid-structure models have been made by incorporating the solution of the acoustic domain, as in [5], wherein a slightly compressible fluid model was used to capture the effects of the compressibility of air on acoustic wave propagation. Subsequent finite element method (FEM) models have examined pathological effects, including vocal trauma risk [18, 19], nodules [3], and asymmetries [20] which complement similar experimental studies [21]. Furthermore, continuum models provide the means for exploration of the governing physics of self-oscillation. Gunter [6] made use of a finite element vocal fold model to validate prediction of vocal fold closure forces and kinematics, drawing relationships between sub-glottal pressure and contact force, area of contact, and medial motion, followed by a similar experimental study [22]. Thomson [8] explored the mechanisms of aerodynamic energy transfer to the vocal folds through the use of both experimental and computational models, quantifying viscous effects and asymmetries in wall pressure due to cyclic vocal fold profile variations.

Advancement of computational vocal fold models requires consideration of realistic geometric and viscoelastic characterization. One such study deviates from the use of idealized vocal fold geometries through generation of a mesh using MRI image slices and various tissue property values [4]. In addition, experimental determinations of vocal fold material property value ranges have been performed to improve the characterization of vocal fold layer anisotropy [23]. The necessity of these realistic models has been explored through sensitivity studies, which asses the effects of both geometric and material idealizations in computational models on mechanical response. Shurtz and Thomson [7] perform one such study in which they assess the effects of the vocal fold collision contact line position, Poisson ratio, and symmetry conditions on the fluid and structural response.

Overall, these computational models of vocal fold vibration have illustrated the ability to predict similar trends of vibration which agree with experimental studies. A natural progression in improving these models is the investigation of the effects of pathologies on these trends, specifically, with detailed modeling of the pathological geometry. The following study is an attempt to validate an in-house FE formulation of the vibration of vocal folds affected by a sessile polyp which is resolved with an in-house solver. This validation is performed as part of the development of a predictive tool intended for further investigations of the effects of pathological tissue on vocal fold vibration. The FE method is used to formulate the equation of motion of the system, and considering free vibration conditions, resolve the system for natural frequencies and mode shapes. These results are subsequently compared with investigations by [24–26]. This validation process is critical for future investigations which will make use of this tool, since experimental data for pathological speech may not provide a precise metric as a comparison.

2 Discretization and Structural Modeling

The equations of motion of a physical system may be derived using Hamilton's principle, which states

$$\int_{t_1}^{t_2} (\delta(T-U) + \delta W_{nc})\mathrm{d}t = 0 \tag{1}$$

where t_1 and t_2 represent time at two distinct points, δ denotes a virtual variable, T is the kinetic energy of the system, U is the strain energy of the system, and W_{nc} represents the work done to the system by non-conservative forces [27, p. 9]. This principle describes the path of a conservative system between two discrete positions given the system's scalar energy functions. For discretized systems, equation (1) can be simplified using Lagrange's equations, given by

$$\begin{aligned} \left\{ \frac{\partial}{\partial t}\left(\frac{\partial T}{\partial \dot{q}(t)}\right)\right\} &= [M]\{\ddot{q}(t)\} \\ \left\{\frac{\partial D}{\partial \dot{q}(t)}\right\} &= [C]\{\dot{q}(t)\} \\ \left\{\frac{\partial U}{\partial q(t)}\right\} &= [K]\{q(t)\} \end{aligned} \tag{2}$$

where $\{q(t)\}$ is a vector of system displacements, $\{\dot{q}(t)\}$ is a vector of system velocities, $\{\ddot{q}(t)\}$ is a vector of system accelerations, $[M]$ is the matrix of inertia, D is a dissipation energy function, $[C]$ is the damping matrix, and $[K]$ is the matrix of stiffness [27, p. 13]. The set of Lagrange's equations can be used to develop the equation of motion for the discrete system given the scalar energy functions, which is given by

$$[M]\{\ddot{q}(t)\} + [C]\{\dot{q}(t)\} + [K]\{q(t)\} = \{F\} \tag{3}$$

where $\{F\}$ is the vector of applied non-conservative forces on the system. For the present study, discrete systems under free-vibration are considered. Free-vibration conditions ignore damping and applied forces. Substituting these conditions into equation (3),

$$[M]\{\ddot{q}(t)\} + [K]\{q(t)\} = 0. \tag{4}$$

This system of equations can be developed by evaluating equation (2) given the kinetic and strain energy functions of the system.

The kinetic energy function for a general three-dimensional solid is given by

$$T = \frac{1}{2}\int_V \rho(\dot{u}^2 + \dot{v}^2 + \dot{w}^2)\mathrm{d}V \tag{5}$$

where V is the volume of the solid, ρ is the density, and u, v, and w represent displacement components in x,y,z Cartesian space, respectively [27, p. 39]. The strain energy function for a general three-dimensional solid is given by

$$U = \frac{1}{2}\int_V \{\epsilon\}^T [D] \{\epsilon\} \mathrm{d}V \tag{6}$$

where $\{\epsilon\}$ is the strain component vector given by

$$\{\epsilon\}^T = \left\{ \frac{\partial u}{\partial x}, \frac{\partial v}{\partial y}, \frac{\partial w}{\partial z}, \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}, \frac{\partial u}{\partial z} + \frac{\partial w}{\partial x}, \frac{\partial v}{\partial z} + \frac{\partial w}{\partial y} \right\}, \tag{7}$$

and $[D]$ is the stiffness matrix of the solid, which can be computed as the inverse of the compliance matrix given by Hooke's law for linearly elastic materials [27, p. 38]. For systems with varying boundary conditions or complex geometries, the energy functions are difficult to derive analytically, and accordingly, the Finite Element Displacement Method (FEDM) is used to approximate each function over discrete volumes of space.

The FEDM approximates the energy functions over elements, which are defined by a collection of Cartesian nodal coordinates, represented as the column vectors $\{u\}_e$, $\{v\}_e$, $\{w\}_e$. Each node of the element, unless constrained by a boundary condition, has three translational degrees of freedom. These displacement and velocity components are approximated by shape functions, and subsequently used to evaluate equations (5) and (12). For an element defined by n nodes, there must exist n shape functions. Each shape function must have a value of unity at its corresponding node, and a value of zero at all other nodes. Displacement functions can be defined based on the set of shape functions, $[N]$, and the nodal coordinates,

$$\begin{aligned} u &= [N]\{u\}_e \\ v &= [N]\{v\}_e \\ w &= [N]\{w\}_e \end{aligned} \tag{8}$$

or

$$\left\{ \begin{array}{c} u \\ v \\ w \end{array} \right\} = [N]\{q(t)\}_e \tag{9}$$

Equation (9) can be substituted into equations (5) and (12) and integrated, resulting in

$$\begin{aligned} T_e &= \tfrac{1}{2}\{\dot{q}(t)\}_e^T [m]_e \{\dot{q}(t)\}_e \\ U_e &= \tfrac{1}{2}\{q(t)\}_e^T [k_e \{q(t)\}_e \end{aligned} \tag{10}$$

where $[m]_e$ is the inertia matrix of the element and $[k]_e$ is the stiffness matrix of the element [27, pp. 103-104]. Rearranging equation (10),

$$\begin{aligned} [m]_e &= \textstyle\int_{V_e} \rho [N]^T [N] \mathrm{d}V \\ [k]_e &= \textstyle\int_{V_e} [B]^T [D][B] \mathrm{d}V \end{aligned} \tag{11}$$

where $[B]$ is the strain matrix of the form [27, p. 200]

$$[B] = \begin{bmatrix} \frac{\partial N_1}{\partial x} & 0 & 0 & \cdots & \frac{\partial N_n}{\partial x} & 0 & 0 \\ 0 & \frac{\partial N_1}{\partial y} & 0 & \cdots & 0 & \frac{\partial N_n}{\partial y} & 0 \\ 0 & 0 & \frac{\partial N_1}{\partial z} & \cdots & 0 & 0 & \frac{\partial N_n}{\partial z} \\ \frac{\partial N_1}{\partial y} & \frac{\partial N_1}{\partial x} & 0 & \cdots & \frac{\partial N_n}{\partial y} & \frac{\partial N_n}{\partial x} & 0 \\ \frac{\partial N_1}{\partial z} & 0 & \frac{\partial N_1}{\partial x} & \cdots & \frac{\partial N_n}{\partial z} & 0 & \frac{\partial N_n}{\partial x} \\ 0 & \frac{\partial N_1}{\partial z} & \frac{\partial N_1}{\partial y} & \cdots & 0 & \frac{\partial N_n}{\partial z} & \frac{\partial N_n}{\partial y} \end{bmatrix}. \tag{12}$$

Equation (11) is evaluated for each element based on the given nodal coordinates and shape functions. The elemental inertia and stiffness matrices are subsequently added to the global equation of motion, equation (4). The global equation of motion is fully assembled once all elemental inertia and stiffness matrices are computed and added to the equation.

2.1 Tetrahedral shape functions

The evaluation of equation (11) can be performed analytically for a four-node tetrahedron because the entries in $[N]$ are constants, and consequently, result in constant strain entries in $[B]$. Accordingly, the four-node tetrahedral elements are called "constant strain elements". Equation (11) was derived analytically for the constant strain elements using the Matlab symbolic toolbox [28], and subsequently evaluated as functions of the nodal coordinates. The ten-node tetrahedron elements have linear strain entries in $[B]$, and accordingly, require a numerical integration method to evaluate equation (11). Consequently, "linear strain elements" will approximate strain gradients more accurately than the constant strain elements, in exchange for computational efficiency.

2.2 Numerical integration of elemental inertia and stiffness matrices

Evaluation of equation (11) for linear strain elements was performed with four-point Gauss-Legendre quadrature. This integration scheme approximates a definite integral through the sum of weighted samples within the domain of integration. For a definite integral I, [29, p. 373]

$$\begin{aligned} I &= \int_0^1 \int_0^{1-\zeta_1} \int_0^{1-\zeta_1-\zeta_2} f(\zeta_1, \zeta_2, \zeta_3, \zeta_4)\mathrm{d}\zeta_3 \mathrm{d}\zeta_2 \mathrm{d}\zeta_1 \\ &= \sum_{i=1}^{4} H_i f(\zeta_1, \zeta_2, \zeta_3, \zeta_4) \end{aligned} \tag{13}$$

where f is the integrand of equation (11), and H_i is a weight applied for sample point i, called the ith "Gauss point" [30, p. 200].

2.3 Solution of the global eigensystem

Once the global mass and stiffness matrices have been assembled, the solution to equation (4) can be computed. The solution is assumed to be of the form

$$u = \phi \sin \omega(t - t_0) \quad (14)$$

where ϕ is an eigenvector of the system, ω is the corresponding frequency of vibration, t is the time variable, and t_0 is a time constant [31, p. 786]. Substituting equation (14) into equation (4), the generalized eigensystem may be expressed

$$[K]\phi = \omega^2[M]\phi, \quad (15)$$

which for an N degree of freedom system yields N pairs of eigenvector, ϕ, and eigenvalue, ω^2, solutions [31, p. 786].

The code was developed to solve the general eigensystem expressed in equation (15). The specifics of the model are input to the solver as the mesh, boundary conditions, and material properties. Once the local inertia and stiffness matrices are generated for each element and subsequently mapped to the global system, the global eigensystem is solved for its eigenvectors and eigenvalues.

3 Validation case 1

The computer program STARS (STructural Analysis RoutineS) was developed by NASA in the 1980's for the purpose of analyzing the static, stability, free-vibration, and dynamic responses of structural systems [24, p. 1]. The documentation which accompanies the software gives several sample problems to illustrate its capabilities. One such problem investigated is the free-vibration of a three-dimensional isotropic cube which is fixed at one face, as shown in Figure 1. Each of the free nodes within the model have three translational degrees of freedom. This same problem is considered as the first validation case. The relevant parameters of the simulation are provided in Table 1.

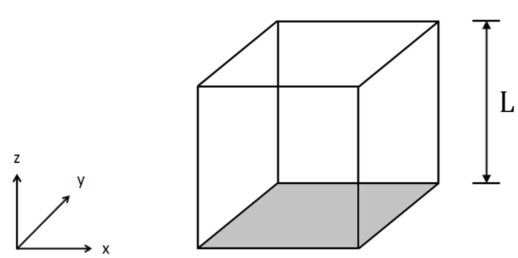


Figure 1: Physical system under consideration for the first validation case. The gray face is fixed, while the transparent faces are free.

To compare the solutions for natural frequencies obtained computationally with the exact solution provided in [24, p. 42], the solutions are normalized according to the following equation :

$$\bar{\omega_i} = \frac{\omega_i}{\sqrt{E/\rho}} \quad (16)$$

Table 1: Physical parameters for the first validation case [24, p. 41]

Parameter	Value (dimensionless)
Side length, L	10
Young's Modulus	10×10^{-6}
Poisson's ratio	0.3
Density	2.349×10^{-4}

where $\bar{\omega_i}$ is the ith normalized form of the ith natural frequency, ω_i.

Convergence behaviour of both the constant strain and linear strain finite element models were investigated by calculating the normalized natural frequencies of the cube for increasingly refined mesh sizes. This behaviour is illustrated in Figure 2. Both models show gradual convergence towards the exact solution, with the linear strain elements approaching the solution at a faster rate than the constant strain elements. Linear strain elements improve accuracy through the use of quadratic shape functions, which results in variable derivatives of the shape functions over the element volume [29, p. 335] which better approximate strain gradients.

A direct comparison of the computationally obtained non-dimensional natural frequencies for both the constant and linear strain elements is shown in Table 2. Linear strain elements show superior accuracy for the first six modes compared to the constant strain model. The percent error lies below 2.6 % and 10.3 % of the exact solution for the linear strain model and constant strain models, respectively. Accordingly, high accuracy solutions may be obtained with a larger number of constant strain elements than linear strain elements. In the following validation cases, the selection between either of these element types will consider this balance of accuracy and efficiency.

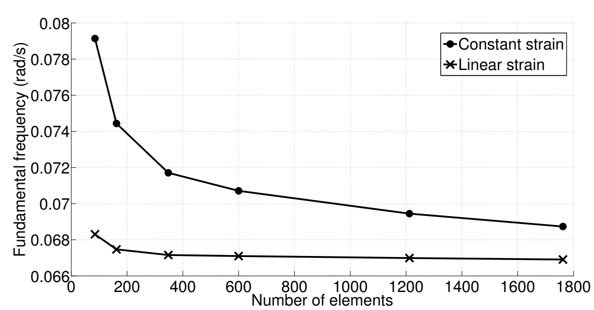


Figure 2: Convergence behaviour of the finite element solution for both constant strain and linear strain elements.

4 Validation case 2

An early continuum model of vocal fold vibration is documented in [25]. This model approximates a single vocal fold as a parallelepiped with three fixed faces representative of the anterior, posterior, and lateral surfaces, as shown in Figure 3. The free-vibration of this model is considered as the second validation case. Relevant physical parameters are tabulated in

Table 2: Comparison of exact natural frequency solution from [24] with developed model for constant and linear strain elements

(a) Constant strain

Mode number	Exact solution	Computed solution	Percent error (%)
1	0.0680	0.0707	4.00
2	0.0680	0.0710	4.35
3	0.0929	0.1024	10.25
4	0.1611	0.1629	1.09
5	0.1819	0.1887	3.74
6	0.1819	0.1890	3.92

(b) Linear strain

Mode number	Exact solution	Computed solution	Percent error (%)
1	0.0680	0.0671	1.34
2	0.0680	0.0672	1.25
3	0.0929	0.0912	1.82
4	0.1611	0.1600	0.69
5	0.1819	0.1772	2.60
6	0.1819	0.1772	2.57

Table 3. The plane of isotropy is in the vertical-lateral plane, while the anterior-posterior direction represents the longitudinal direction with distinct material parameters. The nodes of the model have translational degrees of freedom in the vertical and lateral directions, while anterior-posterior translations are assumed negligible.

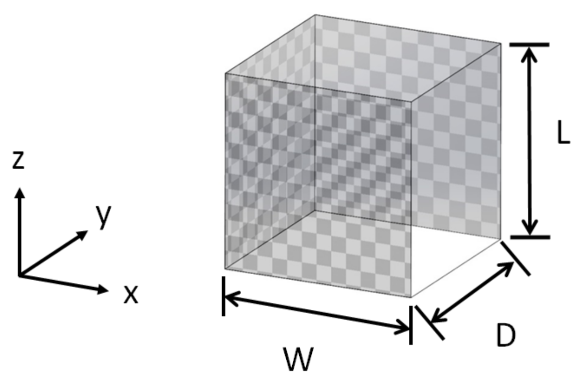


Figure 3: Physical system under consideration for the second validation case. Textured faces are fixed, while the transparent faces are free. x-direction : Lateral. y-direction : Anterior-posterior. z-direction : Vertical.

Table 3 shows two values for the transverse Poisson's ratio. Case 2a represents the completely compressible case, and case 2b represents the nearly incompressible case. The variation of this parameter was shown to alter the computed mode shapes in [25], and accordingly, will be considered as two separate cases as part of the following validation. For each case, the first three natural frequencies and mode shapes are computed, and compared with the results in [25].

Table 3: Physical parameters for the second validation case [25, p. 3349]

Parameter	Value	
Lateral depth, W	1.0 cm	
Longitudinal (anterior-posterior) length, D	1.2 cm	
Vertical thickness, L	0.7 cm	
Density	1.03 g/cm^3	
Transverse Young's modulus	10^5 dyn/cm^2	
Longitudinal shear modulus	10^5 dyn/cm^3	
Transverse Poisson's ratio	Case 2a	Case 2b
	0	0.9999
Longitudinal Poisson's ratio	0	

4.1 Case 2a : Completely compressible case

Convergence behaviour of the model's first three natural frequencies for the compressible case are displayed in Figure 4. Asymptotic behaviour is observed for nearly all model sizes, which illustrates that the purely lateral vibration behaviour requires a model with low resolution to produce accurate predictions of natural frequencies. The predicted natural frequencies entrain on the ranges reported in [25], with numerical values and percent differences tabulated in Table 4. Exact values are not reported in [25] ; accordingly, values were approximated through a digital image extraction from reported plots.

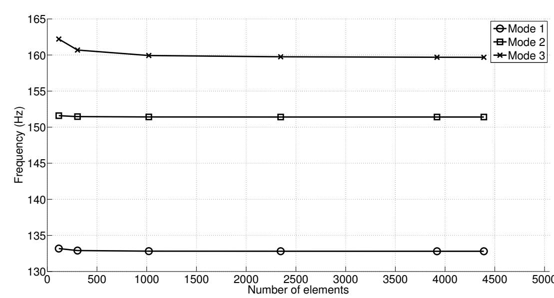
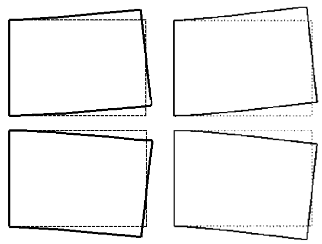


Figure 4: Convergence of the first three natural frequencies of the completely compressible validation case.

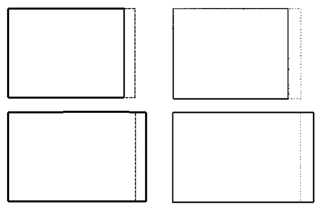
Table 4: Comparison of computed natural frequencies for the completely compressible validation case

Mode number	Computed frequency (Hz)	Frequency from [25] (Hz)	Percent difference (%)
1	132.8002	132.8	0.0002
2	151.4063	151.5	0.0619
3	159.7	159.6	0.048

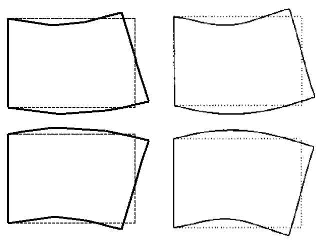
A qualitative comparison of the predicted mode shapes in the mid-coronal plane are illustrated in Figure 5. This figure illustrates that the predicted mode shapes of the present investigation are in general agreement with those from [25].



(a) Mode shape 1



(b) Mode shape 2



(c) Mode shape 3

Figure 5: Comparison of mode shapes for the completely compressible case. Left : Computed mode shape. Right : Mode shape from [25].

4.2 Case 2b : Nearly incompressible case

Convergence behaviour for the nearly incompressible case is displayed in Figure 6. Asymptotic behaviour is not observed for lower resolution models as in the compressible case, and accordingly, only higher resolution models yield comparable results. Natural frequencies once again entrain on the values reported in [25], with a numerical comparison given in Table 5. Percent differences are larger for the nearly incompressible model than for the completely compressible model. This is likely due to the influence of the transverse vibration introduced due to the change in the transverse Poisson's ratio. Despite this deviation, percent differences are low, with differences peaking at 1.7451 %.

Table 5: Comparison of computed natural frequencies for the nearly incompressible validation case

Mode number	Computed frequency (Hz)	Frequency from [25] (Hz)	Percent difference (%)
1	133.2423	132.4	0.6342
2	153.7600	151.1	1.7451
3	155.3512	152.8	0.048

A qualitative comparison of the predicted mode shapes on the mid-coronal plane are illustrated in Figure 7. This figure illustrates that the predicted mode shapes of the present

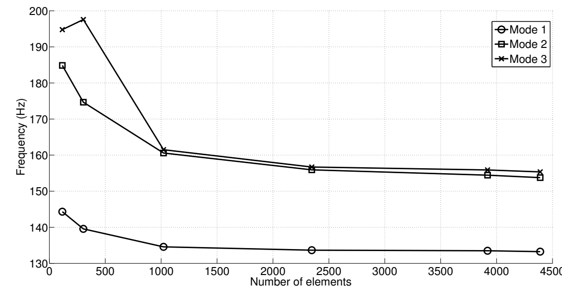
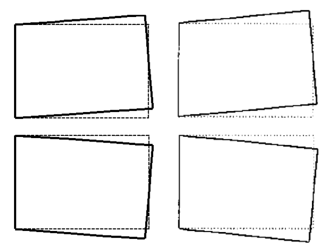
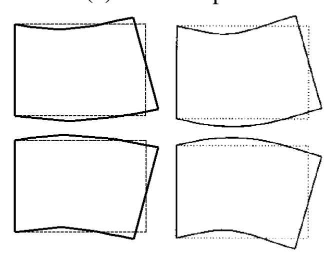


Figure 6: Convergence of the first three natural frequencies of the nearly incompressible validation case.

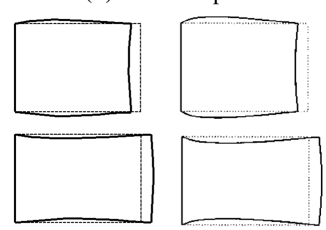
investigation are in general agreement with those from [25].



(a) Mode shape 1



(b) Mode shape 2



(c) Mode shape 3

Figure 7: Comparison of mode shapes for the nearly incompressible case. Left : Computed mode shape. Right : Mode shape from [25].

5 Validation case 3

A model of a multi-layered continuum model of a vocal fold is documented in [26]. This model clearly defines the division of the vocal fold into distinct body, cover, and ligament regions, each with its own material property values. These values are reported in Table 6. The geometry of the model is illustrated in Figure 8, however, detailed geometric considerations are reported in full in [26, p. 9330]. Similar to the second validation case, the vocal fold was fixed along the anterior-posterior surfaces, and the lateral surface. Free nodes of the model were allowed three translational degrees of freedom. The material was treated as transversely isotropic, with the transverse plane in the x-y direction.

Table 6: Physical parameters for the third validation case [26, p. 9316]

Parameter	Body	Cover	Ligament
Transverse shear modulus (kPa)	1.05	0.53	0.87
Longitudinal shear modulus (kPa)	12	10	40
Longitudinal Young's modulus (kPa)	31.2	26	104
Transverse Poisson ratio	0.3	0.3	0.3
Longitudinal Poisson ratio	0.3	0.3	0.3
Density (g/cm^3)	1.0	1.0	1.0

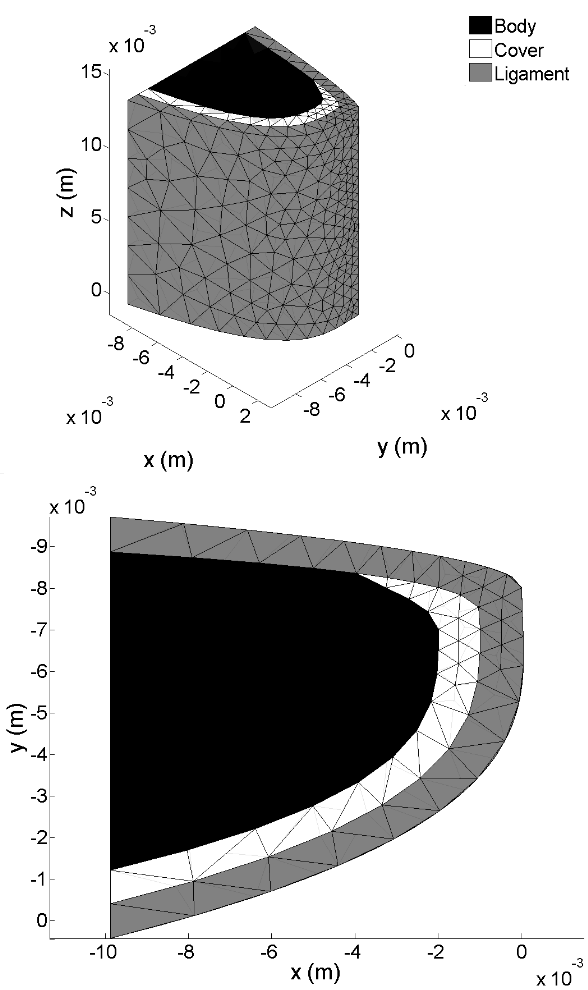


Figure 8: Physical system under consideration for the third validation case. The anterior-posterior faces (x-y surfaces) and the lateral face (x-z surface) are fixed, while the remaining nodes have three translational degrees of freedom.

Convergence behaviour of the model is shown in Figure 9. A large number of elements are required to approach convergence. Accordingly, constant strain elements were used for the analysis in order to preserve efficiency due to an inherently large requirement of degrees of freedom. A comparison of the first four computed natural frequencies is reported in Table 7. The percent differences are minimal, which indicates that the converged solution agrees with the reported values in [26].

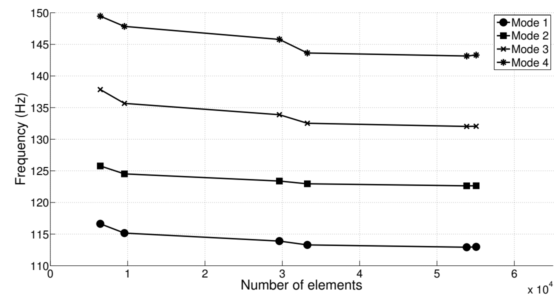


Figure 9: Convergence of the first four natural frequencies of the third validation case.

Table 7: Comparison of computed natural frequencies for the third validation case

Mode number	Computed frequency (Hz)	Frequency from [26] (Hz)	Percent difference (%)
1	112.9847	114	0.90
2	122.6436	125	1.90
3	132.0509	133	0.72
4	143.3063	144	0.5

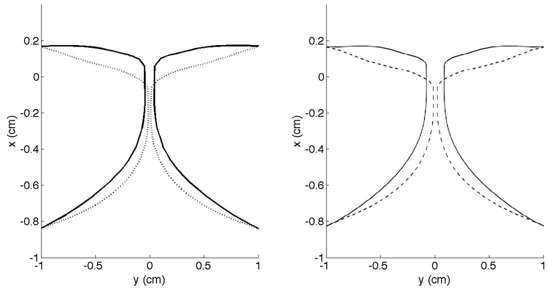
A qualitative comparison of the first four mode shapes is illustrated in Figure 10. Similar to the second validation case, pictured is the periphery of the mid-coronal plane of the vocal fold. Solid and dashed lines represent the positive and negative eigenvector mode shapes respectively. General agreement is shown between the modes, with the exception of the third mode shape. In Figure 10c, a slight difference between the y-component of magnitude can be seen, as parts of the overlapping mode shapes show dissimilarity. This difference may be attributed to the method in which the mode shape was calculated, or slight differences in modeling the vocal fold geometry.

6 Modeling of a polyp

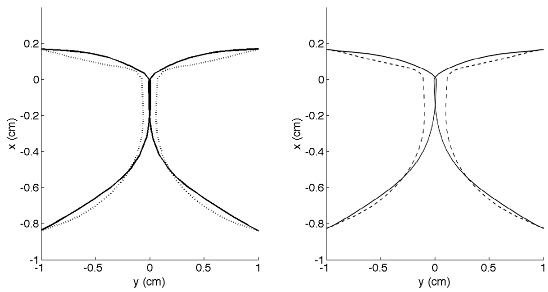
The following analysis is concerned with the documentation of the development of a continuum model of a vocal fold with a unilateral sessile polyp. Similar continuum models of vocal fold polyps [3, 32] have been developed, and accordingly, the trends discussed in these studies will be compared. The model presented herein is concerned with accurate representation of the polyp shape, material behaviour and position on the vocal fold.

6.1 Polyp pathology

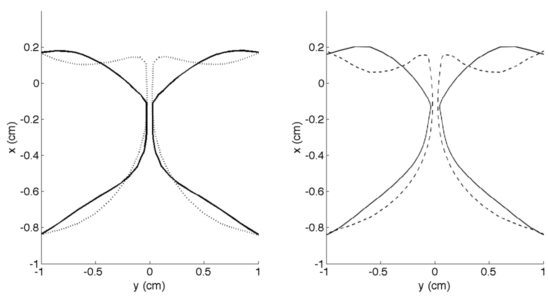
Vocal fold polyps are benign lesions [33] which form on the superficial layer of the vocal fold. These lesions are typically unilateral, meaning they appear on one fold only [34, p. 456],



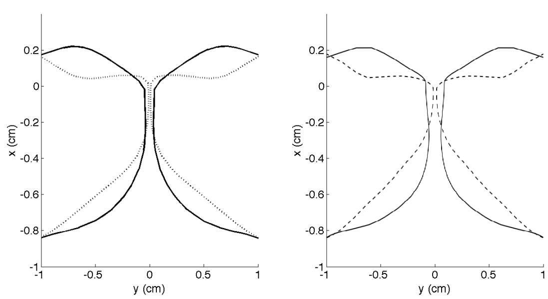
(a) Mode shape 1



(b) Mode shape 2



(c) Mode shape 3



(d) Mode shape 4

Figure 10: Comparison of mode shapes for the third validation case. Left : Computed mode shape. Right : Mode shape from [26].

or they may be bilateral, pedunculated, or sessile [33]. Due to the additional mass, increased stiffness, and damping properties of the polyp, as well as the influence of a gelatinous material which forms on the sub-epithelial layer of the vocal fold [33], mucosal wave propagation is altered on the vocal fold, and voice disorders may arise as a result [21, pp. 93-94]. The sessile polyps often manifest as half ellipses which protrude from the medial surface of the fold [35, p. 268]. Based on this data, the sessile polyp in this model is based on half of a sphere which protrudes from the medial surface of the vocal fold. The sphere's center is placed at the vertical midpoint of the surface, on top of the cover layer of the vocal fold. The polyp's center may be moved along the anterior-posterior direction to simulate asymmetries. In [36], a clinical study was performed which observed polyps as large as 0.7 mm in length, width, and depth. Accordingly, the half-spherical polyp modeled in this study may have a length bounded between 0.3 mm and 0.7 mm.

The material properties of polyps have a wide range of reported values. The typical trend, however, is an increase in stiffness relative to the surrounding vocal fold muscle tissue. In [32], polyp tissue is simulated as a five-fold increase in stiffness. The same assumption is made of the polyp modeled in the present study. The polyp will also be assumed to be isotropic, as there exist no muscle fibers which run through the lesion resulting in transverse isotropy. Subsequently, the Young's modulus of the polyp is assumed to be five times the longitudinal stiffness of the vocal fold ligament, with a Poisson's ratio of 0.3, and the same density as the surrounding tissue.

6.2 Model parameters and simulation setup

The vocal fold geometry described in [26] is adopted for this study, as it sufficiently details the geometry and material properties of a multi-layered vocal fold. The illustration in Figure 11 displays this model with the addition of a 0.7 mm diameter polyp centered along the anterior-posterior direction. The material properties of this model are given in Table 6 and Table 8.

Table 8: Unilateral sessile polyp model parameters

Parameter	Value
Young's Modulus (kPa)	520
Poisson ratio	0.3
Density (g/cm^3)	1.1

For the purpose of this investigation, trends related to the position and size of the polyp will be explored. In [3], the effect of varying these parameters of a point mass nodule on the fundamental frequency of the vocal fold are determined. This study concluded that fundamental frequency decreased as the polyp size increased, and that the fundamental frequency decreased as the polyp approached the center of the anterior-posterior direction. This analysis is repeated with a spatially modeled polyp in order to compare trends. Accordingly, two sets of simulations are run. The first set of five simulations varies the polyp length, s, between 0.3 mm $\leq s \leq$ 0.7 mm in 0.1 mm increments. Figure 12 illustrates the two extreme cases run in this set of simulations. The second set of simulations varies the position of a 0.7 mm polyp along the anterior-posterior direction. Ten positions centered between 0.7 mm and 7 mm along the right side of the vocal fold are selected. By virtue of symmetry, polyps are not placed on the left side of the vocal fold, as computed frequencies would expected to

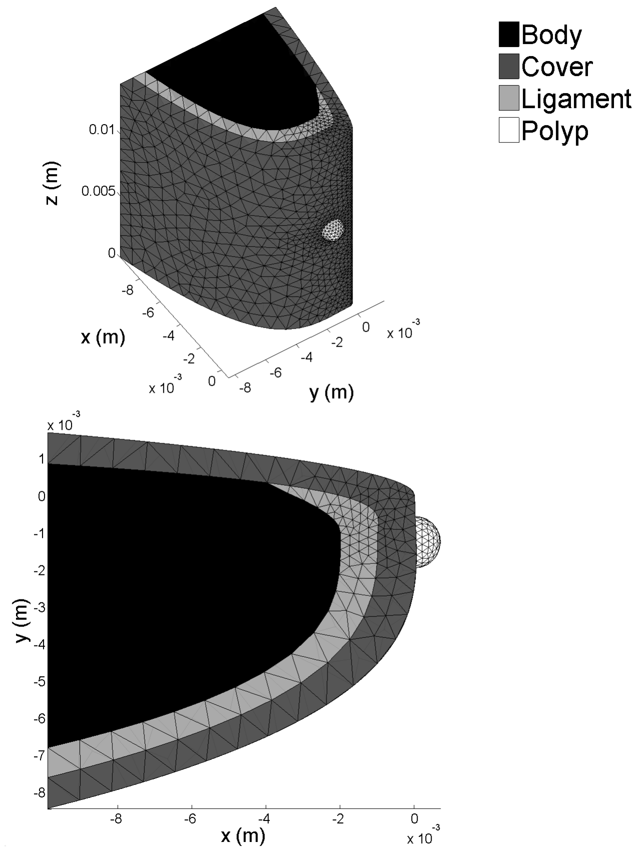
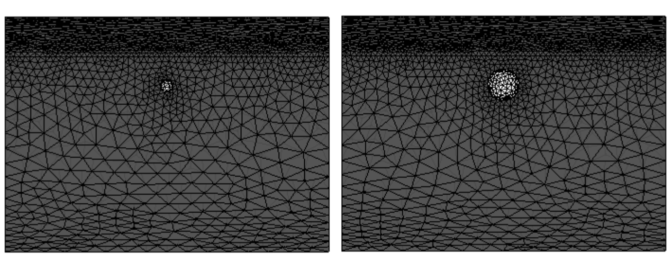


Figure 11: Mesh of a vocal fold with a sessile polyp.

be replicated. Figure 13 illustrates the two extreme cases in the second set of simulations.

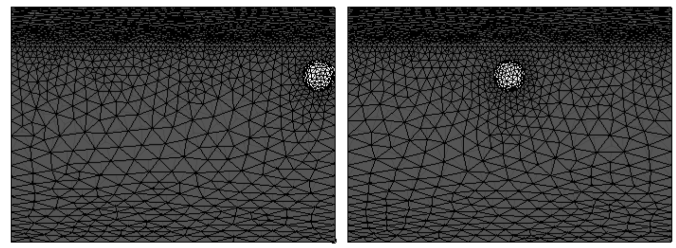


(a) $s = 0.3$ mm and $c = 7$ mm. **(b)** $s = 0.7$ mm and $c = 7$ mm.

Figure 12: Illustration of extreme cases of the first set of simulations. Holding $c = 7$ mm, the polyp size is varied.

7 Results

The first set of simulations was used to generate data to define a relationship between the fundamental frequency of the pathological vocal fold and polyp size, which is illustrated in Figure 14. This figure shows that, similar to [3], an inverse proportionality exists between the fundamental frequency and the polyp size. Asymptotic behaviour can be observed for the largest and smallest polyps. Small polyps have a negligible effect on the fundamental frequency, indicating that the small



(a) $c = 0.7$ mm and $s = 0.7$ mm. **(b)** $c = 7$ mm and $s = 0.7$ mm.

Figure 13: Illustration of extreme cases of the second set of simulations. Holding $s = 0.7$ mm, the polyp position is varied.

localized change in mass and stiffness has little influence on the natural frequency. Inversely, for large polyps, a more substantial region of the vocal fold is affected by the mass and stiffness change, and consequently, the rate of decrease of the fundamental frequency is significant.

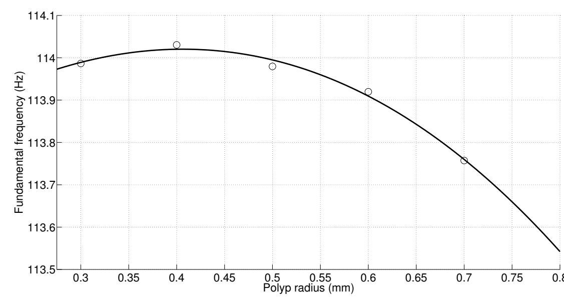


Figure 14: Relationship between vocal fold size and fundamental frequency of the pathological vocal fold.

The results of the second set of simulations can be used to show that when the polyp is centered along the anterior-posterior direction, fundamental frequency is minimized. This relationship is illustrated in Figure 15. A linear trend was fitted to this data, which indicates that anterior-posterior position of the polyp may not have as profound of an influence on the natural frequency as the polyp size. Due to symmetry, a mirror image of this plot would be expected for samples between 7 mm $\leq c \leq$ 17 mm.

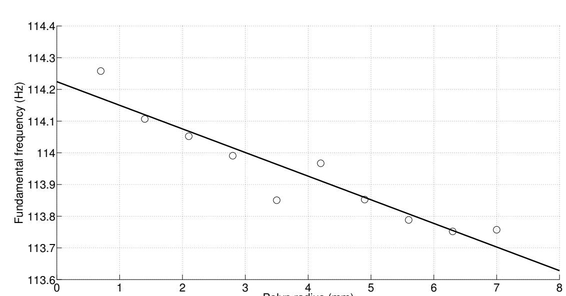


Figure 15: Relationship between vocal fold position and fundamental frequency of the pathological vocal fold.

The non-linear relationship between polyp size and fundamental frequency is the result of adding an increasing volume of stiff material to the vocal fold. Since the parameter s is a measure of polyp length, increasing s by a factor of n results in the increase of polyp volume by a factor of n^3. This addition of mass and stiffness to the overall system results in a sharp decrease in fundamental frequency. Due to the influence of the zero degree of freedom boundary conditions at the anterior and posterior surfaces of the vocal fold, the excess mass and stiffness of the polyp have less of an effect on fundamental frequency near these surfaces. Consequently, the minimization of fundamental frequency occurs when the polyp manifests at the center of the vocal fold, where the excess mass and stiffness of the polyp has more influence on the overall system.

8 Conclusions

The validation process of the preceding finite element code is a necessary procedure to ensure accurate prediction of structural vibration behaviour for pathological vocal fold models. This process was documented through direct comparison of natural frequencies and mode shapes for several different models of varying complexity, including various orthotropic material conditions, boundary conditions, and complex geometries. These quantitative and qualitative comparisons show good agreement, indicating that the code is suitable for use as a predictive tool. The tool was subsequently tested through the solution of a model of a vocal fold affected with a unilateral sessile polyp which illustrated the expected trends of fundamental frequency variation with polyp size and position.

The model of a unilateral sessile polyp presented in this study is an attempt at modeling a pathology in a continuum medium. Polyp size, material properties, position, and geometry were considered based on a literature survey of clinical data, in some cases with upper and lower bounds presented to account for tissue variation across multiple specimens. This model was validated by considering two sets of simulations which assessed the effect of polyp size and position on the fundamental frequency of the system. The results presented in this study show agreement with previous investigations of the same relationships. Increasing the length of the half-spherical polyp was shown to result in a non-linear decrease in fundamental frequency due to the corresponding exponential increase in mass and stiffness in the model. Polyp position was shown to vary the fundamental frequency linearly along the medial plane due to the balance of the influence of the polyp and the boundary conditions. This indicates that the model is valid in a structural sense, and is suitable for future in-depth studies of the effect of polyps on the free-vibration of vocal folds.

Future investigations with this code are concerned with the numerical prediction of the dynamic response of the vocal fold system coupled with the surrounding fluid and sound propagation. Transient acoustic radiation will then be computed and assessed with the pathological models to assess the effects of polyps on the radiated sound.

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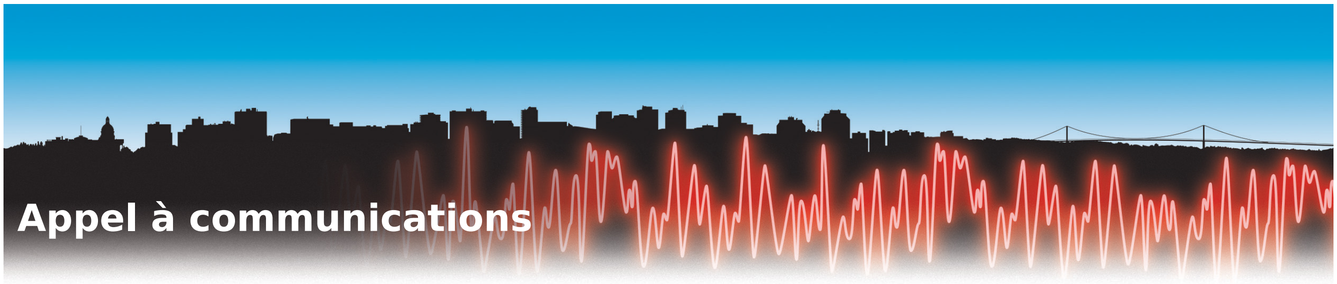

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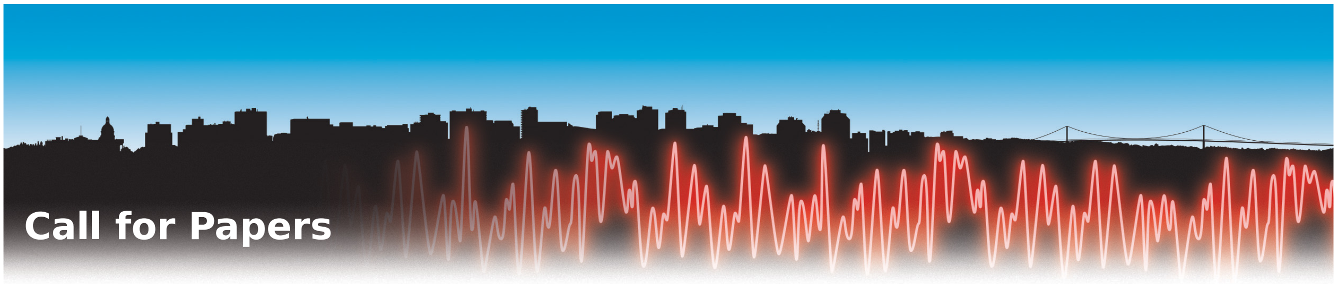

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Venez découvrir ce que les visiteurs ont connu pendant des siècles - Halifax est une ville que vous ne serez pas prêt d'oublier!

Lieu et hébergement

L'hôtel historique Westin Nova Scotian est idéalement situé près de toutes les services dans le quartier passionnant Seaport de Halifax avec une vue sur le port. L'hôtel Westin Nova Scotian propose 310 chambres de luxe, 23 000 pieds carrés d'espace de réunion moderne et des centres de service complet. Le restaurant primé de l'hôtel, Elements, propose une cuisine locale. Les autres services comprennent le spa Sykea, un centre de mise en forme, et une piscine couverte. Les chambres seront disponibles aux participants du congrès au taux préférentiel de 159 $ par nuit.

Séances plénières et sessions scientifiques

La Semaine canadienne d'acoustique 2015 mettra en vedette plusieurs présentations plénières dans des domaines actuels d'intérêt en acoustique et mettant en évidence l'expertise et le cadre régional. Des sessions scientifiques porteront sur tous les domaines principaux d'intérêt en acoustique, y compris la prévention des pertes auditives, la normalisation, l'acoustique architecturale, le contrôle du bruit, les chocs et les vibrations, l'audition et les sciences de la parole, l'acoustique musicale, l'acoustique sous-marine, la bioacoustique marine, et d'autres sujets. Si vous désirer proposer ou organiser une session spéciale sur un sujet précis veuillez communiquer avec le directeur scientifique dès que possible.

Expositions et commandites

Il y aura un espace d'exposition pour l'équipement en acoustique, les produits et les services le jeudi 8 octobre 2015. Si vous ou votre entreprise êtes intéressés à exposer, ou si vous seriez intéressés à commanditer un événement social du congrès, une session scientifique, des pauses café, ou des prix d'étudiants, veuillez contacter le coordonnateur de l'exposition. Le congrès offre une excellente occasion de présenter votre entreprise et vos produits ou services.

Participation des étudiants

Les étudiants sont chaleureuxment encouragés à participer au congrès. Des subventions de voyage et les frais d'inscription réduits seront disponibles. Les présentateurs étudiants sont également admissibles à gagner des prix pour les meilleures présentations.

Soumissions

La date limite pour les résumés est le 16 juin, 2015. Des articles de deux pages pour publication dans les actes de congrès sont dues pour le 1er août, 2015. Veuillez voir plus de détails sur le site de la conférence.

Inscription

Les détails seront disponibles sous peu sur le site web du congrès : awc.caa-aca.ca

Contacts / Comité d'organisation

Présidents de la conférence: Michael Kiefte, Dalhousie University
Sean Pecknold, RDDC Centre de recherches de l'Atlantique

Directeur scientifique: Steve Aiken, Dalhousie University
Coordinateur exposition technique: Roberto Racca, JASCO Applied Sciences

Site web du congrès:
http://awc.caa-aca.ca/index.php/AWC/AWC15

President's Message
Message du Président

The *Canada Not-for-profit Corporations Act* provides not-for-profit corporations with a new set of rules that are described by Industry Canada as "modern, flexible and better suited to the needs of today's not-for-profit sector." For the most part our practices were consistent with these new rules. However, as a not-for-profit corporation operating in Canada, we were required to come into compliance with the act by updating our Letters and Patent (replacing the original from 1977) and by-laws (replacing those passed in 2001). We also chose to take advantage of this opportunity to change the name of the corporation from "THE CANADIAN ACOUSTICAL ASSOCIATION – L'ASSOCIATION CANADIENNCE DE L'ACOUSTIQUE" to "CANADIAN ACOUSTICAL ASSOCIATION – ASSOCIATION CANADIENNE D'ACOUSTIQUE". This change brings the English and French names into better alignment and corrects a grammatical blunder with the French name. To help with the process the board agreed to recruit the help of a not-for-profit law firm, Blumberg Segal LLP.

The matter was first discussed with the membership at the Annual General Meeting in Winnipeg (October, 2014). A special meeting of members was subsequently held at 105 Bond Street, Toronto, on the 2nd day of December 2014, to consider and vote on a Special Resolution authorizing the Corporation to file Articles of Continuance under the Act and to adopt the new By-law. Advanced notice of this meeting was provided to members via email and all associated documents were posted on the association website by October 29, 2014.

Details of the December 2, 2014 meeting:

1. Members who were unable to attend the meeting in person had the right to vote by proxy. We also made a provision for members to participate via teleconference.
2. Eleven members were present in person and 17 participated by proxy.
3. The motion to accept the documents was raised by Alberto Behar (Ryerson) and seconded by Alan Oldfield (AECOM). Our existing bylaws required quorum (12 or more) and 2/3 in favor for the motion to carry. We received unanimous support.

Legal proceedings since the Special Meeting:

1. Kate Robertson of Blumberg Segal LLP filed the documents with Corporations Canada and the Canada Revenue Agency (CRA) on January 8, 2015.
2. The certificate of compliance was received and subsequently filed with the CRA on January 14, 2015. Our approval under the Charities act is under review as is our mandatory filing with the Ontario Ministry of Government and Consumer Services (we are registered with an Ontario address).

In the pages that follow, copies of all documents have been reproduced for posterity.

- Article of Continuance
- Address and First Board of Directors
- New By-Law
- Certificate of Continuance

Industry Canada Industrie Canada

Canada Not-for-profit Corporations Act (NFP Act)
Form 4031
Articles of Continuance (transition)

To be used only for a continuance from the *Canada Corporations Act,* Part II.

1 - Current name of the corporation

THE CANADIAN ACOUSTICAL ASSOCIATION
L'ASSOCIATION CANADIENNE DE L'ACOUSTIQUE

2 - If a change of name is requested, indicate proposed corporate name

CANADIAN ACOUSTICAL ASSOCIATION
ASSOCIATION CANADIENNE D'ACOUSTIQUE

3 - Corporation number

0 2 0 1 7 9 – 1

4 - The province or territory in Canada where the registered office is situated

Ontario

5 - Minimum and maximum number of directors *(for a fixed number, indicate the same number in both boxes)*

Minimum number 3 **Maximum number** 20

6 - Statement of the purpose of the corporation

Please see attached Schedule "A".

7 - Restrictions on the activities that the corporation may carry on, if any

None.

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Canada

Industry Canada Industrie Canada

Canada Not-for-profit Corporations Act (NFP Act)
Form 4031
Articles of Continuance (transition)

8 - The classes, or regional or other groups, of members that the corporation is authorized to establish

The Corporation is authorized to establish one class of members. Each member shall be entitled to receive notice of, attend and vote at all meetings of the members of the Corporation.

9 - Statement regarding the distribution of property remaining on liquidation

Any property remaining on liquidation of the Corporation, after discharge of liabilities, shall be distributed to one or more qualified donees within the meaning of subsection 248(1) of the Income Tax Act.

10 - Additional provisions, if any

Please see attached Schedule "B".

11 - Declaration

I hereby certify that I am a director or an authorized officer of the corporation continuing into the NFP Act.

Signature: [signature]

Print name: FRANK RUSSO

Phone Number: 416-979-5000

Note: A person who makes, or assists in making, a false or misleading statement is guilty of an offence and liable on summary conviction to a fine of not more than $5,000 or to imprisonment for a term of not more than six months or to both (subsection 262(2) of the NFP Act).

Canada

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Form 4031 - Articles of Continuance (transition)

Schedule “A”

CANADIAN ACOUSTICAL ASSOCIATION
ASSOCIATION CANADIENNE D'ACOUSTIQUE

6) Statement of the purpose of the corporation:

The purposes of the Corporation are:

(a) the fostering of a high standard of scientific, engineering and medical endeavour in all the branches of acoustics in Canada;

(b) the encouraging of liaison between individuals, governments and other organisations engaged in activities relating to acoustics; and

(c) the dissemination of knowledge relating to acoustics and its applications.

It is not the purpose of the Association to seek to establish the professional status of its members, believing this is the concern of other organisations.

It may, however, give special recognition or awards to individuals who, in the opinion of the board of directors of the Association, are particularly meritorious.

Form 4031 - Articles of Continuance (transition)

Schedule “B”

CANADIAN ACOUSTICAL ASSOCIATION
ASSOCIATION CANADIENNE D'ACOUSTIQUE

10) Additional provisions, if any:

a) The corporation shall be carried on without the purpose of gain for its members, and any profits or other accretions to the corporation shall be used in furtherance of its purposes;

b) Directors shall serve without remuneration, and no director shall directly or indirectly receive any profit from his or her position as such, provided that a director may be reimbursed for reasonable expenses incurred in performing his or her duties. A director shall not be prohibited from receiving compensation for services provided to the corporation in another capacity; and

c) The directors may appoint one or more directors, who shall hold office for a term expiring not later than the close of the next annual general meeting of members, but the total number of directors so appointed may not exceed one-third of the number of directors elected at the previous annual general meeting of members.

Industry Canada / Industrie Canada

Canada Not-for-profit Corporations Act (NFP Act)

FORM 4002

INITIAL REGISTERED OFFICE ADDRESS AND FIRST BOARD OF DIRECTORS

(To be filed with articles of incorporation, continuance (transition), amalgamation, or continuance (import))

1 - Corporate name

CANADIAN ACOUSTICAL ASSOCIATION
ASSOCIATION CANADIENNE D'ACOUSTIQUE

2 - Complete address of the registered office *(cannot be a post office box)*

Number and street name: 411 Confederation Parkway, Unit 19

City	Province or Territory	Postal code
Concord	Ontario	L4K 0A8

3 - Directors of the corporation *(if space available is insufficient, complete attached schedule)*

First and last name	Address *(cannot be a post office box)*
FRANK RUSSO	Department of Psychology, Ryerson University 350 Victoria Street, Toronto, ON M5B 2K3
CHRISTIAN GIGUÈRE	Université d'Ottawa, 451 Chemin Smyth, Ottawa, ON K1H 8M5
CHANTAL LAROCHE	Université d'Ottawa/University of Ottawa 451, chemin Smyth, pièce 3062 Ottawa, ON K1H 8M5
DALILA GIUSTI	Jade Acoustics 411 Confederation Parkway, Unit 19 Concord, ON L4K 0A8
JÉRÉMIE VOIX	Université du Québec 1100 Notre-Dame Street West, Montreal, QC, H3C 1K3

4 - Declaration

I hereby certify that I am an incorporator of the new corporation, or that I am a director or an authorized officer of the corporation continuing into or amalgamating under the NFP Act.

Signature: [signature] DEC 2, 2014

Print name: FRANK RUSSO *Phone Number:* 416-979-5000

Note: A person who makes, or assists in making, a false or misleading statement is guilty of an offence and liable on summary conviction to a fine of not more than $5,000 or to imprisonment for a term of not more than six months or to both (subsection 262(2) of the NFP Act).

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Canada

Industry Canada / Industrie Canada

Schedule
(item 3 of Form 4002)
Directors of the corporation
To be used if space on form is insufficient

1 - Corporate Name

CANADIAN ACOUSTICAL ASSOCIATION
ASSOCIATION CANADIENNE D'ACOUSTIQUE

3 - Directors of the corporation

First and last name	Address *(cannot be a post office box)*
ALBERTO BEHAR	307-335 St Clair W, Toronto, ON M5P 1N5
KATHY PICHORA FULLER	Dpt. of Psychology, University of Toronto Mississauga 3359 Mississauga Road N., Mississauga, ON L5L 1C6
BILL GASTMEIER	HGC Engineering Howe Gastmeier Chapnik Limited 2000 Argentia Rd Suite 203, Mississauga, ON L5N 1P7
BRYAN GICK	Dpt. of Linguistics, University of British Columbia 2613 West Mall, Vancouver, BC V6T 1Z4
HUGUES NÉLISSE	505 Boul. de Maisonneuve ouest Montréal, QC H3A 3C2
SEAN PECKNOLD	Defence Research and Development Canada - Atlantic 9 Grove Street, Dartmouth, NS B2Y 3Z7
ROBERTO RACCA	JASCO Applied Sciences 2305 - 4464 Markham Street, Victoria, BC V8Z 7X8
KAREN TURNER	Protec Hearing Inc. 77 Redwood Ave Unit E, Winnipeg, MB R2W 5J5

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Canada

CANADIAN ACOUSTICAL ASSOCIATION
ASSOCIATION CANADIENNE D'ACOUSTIQUE

(the "Corporation")

BY-LAW NO. 1

Pursuant to the *Canada Not-for-profit Corporations Act* (S.C. 2009, c.23) and the continuance of the Corporation from the *Canada Corporations Act* (R.S.C. 1970, c. C-32) to the *Canada Not-for-profit Corporations Act*, this By-law No. 1, being a by-law relating generally to the conduct of the affairs of the Corporation, replaces all by-laws of the Corporation under the *Canada Corporations Act*.

TABLE OF CONTENTS

SECTION 1 – GENERAL

1.01 Definitions

In this by-law and all other by-laws of the Corporation, unless the context otherwise requires:

(a) "Act" means the *Canada Not-for-profit Corporations Act* S.C. 2009, c.23 including the Regulations made pursuant to the Act, and any statute or regulations that may be substituted, as amended from time to time;

(b) "articles" means the original or restated articles of incorporation or articles of amendment, amalgamation, continuance, reorganization, arrangement or revival of the Corporation;

(c) "board" means the board of directors of the Corporation and "director" means a member of the board;

(d) "by-law" means this by-law and any other by-laws of the Corporation as amended and which are, from time to time, in force and effect;

(e) "meeting of members" includes an annual meeting of members or a special meeting of members;

(f) "ordinary resolution" means a resolution passed by a majority of the votes cast on that resolution;

(g) "Regulations" means the regulations made under the Act, as amended, restated or in effect from time to time; and

(h) "special resolution" means a resolution passed by a majority of not less than two-thirds (2/3) of the votes cast on that resolution.

1.02 Interpretation

In the interpretation of this by-law, words in the singular include the plural and vice-versa, words in one gender include all genders, and "person" includes an individual, body corporate, partnership, trust and unincorporated organization. Other than as specified in section 1.01 above, words and expressions defined in the Act have the same meanings when used in these by-laws.

1.03 Corporate Seal

The Corporation may have a corporate seal in the form approved from time to time by the board. If a corporate seal is approved by the board, the secretary of the Corporation shall be the custodian of the corporate seal.

1.04 Execution of Documents

Deeds, transfers, assignments, contracts, obligations and other instruments in writing requiring execution by the Corporation must be signed by any two (2) of its officers or directors, subject to the following: the board may from time to time direct the manner in which and the person or persons by whom a particular document or type of document shall be executed. Any person authorized to sign any document may affix the corporate seal (if any) to the document. Any signing officer may certify a copy of any instrument, resolution, by-law or other document of the Corporation to be a true copy thereof.

1.05 Financial Year End

The financial year end of the Corporation shall be determined by the board.

1.06 Banking Arrangements

The banking business of the Corporation shall be transacted at such bank, trust company or other firm or corporation carrying on a banking business in Canada or elsewhere as the board may designate, appoint or authorize from time to time by resolution. The banking business or any part of it shall be transacted by an officer or officers of the Corporation and/or other persons as the board may by resolution from time to time designate, direct or authorize.

1.07 Annual Financial Statements

The Corporation shall send to the members a copy of the annual financial statements and other documents referred to in subsection 172(1) (Annual Financial Statements) of the Act or a copy of a publication of the Corporation reproducing the information contained in the documents. Instead of sending the documents, the Corporation may send a summary to each member along with a notice informing the member of the procedure for obtaining a copy of the documents themselves free of charge. The Corporation is not required to send the documents or a summary to a member who, in writing, declines to receive such documents.

1.08 Borrowing Powers

The directors of the Corporation may, without authorization of the members,

(a) borrow money on the credit of the Corporation;

(b) issue, reissue, sell, pledge or hypothecate debt obligations of the Corporation;

(c) give a guarantee on behalf of the Corporation to secure performance of an obligation of any person; and

(d) mortgage, hypothecate, pledge or otherwise create a security interest in all or any property of the Corporation, owned or subsequently acquired, to secure any debt obligation of the Corporation.

SECTION 2 – MEMBERSHIP

2.01 Membership Conditions

Subject to the articles, there shall be one class of members in the Corporation. Membership in the Corporation shall be available to persons interested in furthering the Corporation's purposes and who have applied for and been accepted into membership in the Corporation by resolution of the board and confirmed by ordinary resolution of the existing members of the Corporation. Each member shall be entitled to receive notice of, attend and vote at all meetings of the members of the Corporation.

Pursuant to subsection 197(1) (Fundamental Changes) of the Act, a special resolution of the members is required to make any amendments to this section of the by-law if those amendments affect membership rights and/or conditions described in paragraphs 197(1)(e), (h), (l) or (m).

2.02 Notice of Members' Meeting

Notice of the time and place of a meeting of members shall be given to each member entitled to vote at the meeting by the following means:

(a) by mail, courier or personal delivery to each member entitled to vote at the meeting, during a period of 21 to 60 days before the day on which the meeting is to be held; or

(b) by telephonic, electronic or other communication facility to each member entitled to vote at the meeting, during a period of 21 to 35 days before the day on which the meeting is to be held.

Pursuant to subsection 197(1) (Fundamental Changes) of the Act, a special resolution of the members is required to make any amendment to the by-laws of the Corporation to change the manner of giving notice to members entitled to vote at a meeting of members.

2.03 Absentee Voting at Members' Meetings

2.03.1 Voting by Mailed-In or Electronic Ballot

Pursuant to section 171(1) (Absentee Voting) of the Act, a member entitled to vote at a meeting of members may vote by mailed-in ballot or by means of a telephonic, electronic or other communication facility if the Corporation has a system that:

(a) enables the votes to be gathered in a manner that permits their subsequent verification, and

(b) permits the tallied votes to be presented to the Corporation without it being possible for the Corporation to identify how each member voted.

Pursuant to subsection 197(1) (Fundamental Changes) of the Act, a special resolution of the members is required to make any amendment to the by-laws of the Corporation to change this method of voting by members not in attendance at a meeting of members.

2.03.2 Voting by Proxy

a. Pursuant to Section 171(1) of the Act, a member entitled to vote at a meeting of members may vote by proxy by appointing in writing a proxyholder, and one or more alternate proxyholders, to attend and act at the meeting in the manner and to the extent authorized by the proxy and with the authority conferred by it subject to the requirements for proxies set out in the Act.

b. Any notice to members of the time and place of a meeting of members shall either enclose a form of proxy or contain a reminder of the right to appoint a proxyholder.

Pursuant to Section 197(1) (Fundamental Changes) of the Act, a special resolution of the members is required to make any amendment to the articles or by-laws of the Corporation to change this method of voting by members not in attendance at a meeting of members.

SECTION 3 – MEMBERSHIP DUES AND TERMINATION

3.01 Membership Dues

Members shall be notified in writing of the membership dues at any time payable by them, if any, and, if any such membership dues are not paid within one (1) calendar month of the membership renewal date the members in default shall automatically cease to be members of the Corporation.

3.02 Termination of Membership

A membership in the Corporation is terminated when:

(a) the member dies, or, in the case of a member that is a corporation, the corporation is dissolved;

(b) the member resigns;

(c) the member is removed from membership in accordance with section 3.03 below;

(d) the member's term of membership, if any, expires;

(e) the Corporation is liquidated and dissolved under the Act; or

(f) the member’s membership is otherwise terminated in accordance with the articles or by-laws.

Subject to the articles, upon any termination of membership, the rights of the member automatically cease to exist.

3.03 Removal from Membership

The board shall have authority to remove any member from the Corporation for any one or more of the following grounds:

(a) violating any provision of the articles, by-laws, or written policies of the Corporation;

(b) carrying out any conduct which may be detrimental to the Corporation as determined by the board in its sole discretion; or

(c) for any other reason that the board in its sole and absolute discretion considers to be reasonable, having regard to the purpose of the Corporation.

In the event that the board determines that a member should be removed from membership in the Corporation, the chair of the board, or such other officer as may be designated by the board, shall provide twenty (20) days written notice of the proposed removal of the member from membership to the member and shall provide written reasons for the proposed removal. The member may make written submissions to the chair of the board, or such other officer as may be designated by the board, in response to the notice received within such twenty (20) day period.

If no written submission is received by the chair of the board, the chair of the board, or such other officer as may be designated by the board, may proceed to notify the member that the member is removed from membership in the Corporation. If a written submission is received in accordance with this section, the board shall consider such submissions in arriving at a final decision and shall notify the member concerning such final decision within a further 20 days from the date of receipt of the submission. The board's decision shall be final and binding on the member, without any further right of appeal.

SECTION 4 – MEETINGS OF MEMBERS

4.01 Place of Members' Meeting

Subject to compliance with section 159 (Place of Members' Meetings) of the Act, meetings of the members may be held at any place within Canada or elsewhere as the board may determine.

4.02 Persons Entitled to be Present

The only persons entitled to be present at a meeting of members shall be those entitled to vote at the meeting, the directors and the public accountant of the Corporation and such other persons who are entitled or required under any provision of the Act, articles or by-laws of the Corporation to be present at the meeting. Any other person may be admitted only on the invitation of the chair of the meeting or by resolution of the members.

4.03 Chair of the Meeting

In the event that the chair of the board and the vice-chair of the board are absent, the members who are present and entitled to vote at the meeting shall choose one of their number to chair the meeting.

4.04 Quorum

A quorum at any meeting of the members (unless a greater number of members are required to be present by the Act) shall be the lesser of: (i) 50% of the members entitled to vote at the meeting, or (ii) two (2) members entitled to vote at the meeting. If a quorum is present at the opening of a meeting of members, the members present may proceed with the business of the meeting even if a quorum is not present throughout the meeting.

4.05 Votes to Govern

At any meeting of members every question shall, unless otherwise provided by the articles or by-laws or by the Act, be determined by a majority of the votes cast on the question. The chair of the meeting shall not exercise a vote except in the case of an equality of votes either on a show of hands or on a ballot or on the results of electronic voting.

SECTION 5 – DIRECTORS

5.01 Directors' Powers

The directors may exercise all such powers and do all such acts or things as may be exercised or done by the Corporation that are not by the Act, articles or by-laws expressly directed or required to be done in some other manner. Subject to the Act, articles and by-laws the board shall manage or supervise the management of the activities and affairs of the Corporation.

5.02 Number of Directors

The board shall consist of the number of directors specified in the articles. If the articles provide for a minimum and maximum number of directors, the board shall be comprised of the fixed number of directors as determined from time to time by the members by ordinary resolution or, if the ordinary resolution empowers the directors to determine the number, by resolution of the board. In the case of a soliciting corporation the minimum number of directors may not be fewer than three (3), at least two of whom are not officers or employees of the Corporation or its affiliates.

5.03 Election and Term

Subject to the articles, the members will elect the directors at each annual meeting at which an election of directors is required, and the directors shall be elected to hold office for a term expiring not later than the close of the next annual meeting of members following the election. If an election of directors is not held at the proper time, the incumbent directors shall continue in office until their successors are elected.

5.04 Removal of Directors

Subject to the Act, the members may by ordinary resolution passed at an annual or special meeting of members remove any director from office, and the vacancy created by such removal may be filled at the same meeting by the members, failing which it may be filled by the board.

5.05 Vacancy in Office of Director

The office of a director shall be automatically vacated if:

(a) the director dies;

(b) the director delivers a written notice of resignation to the Corporation;

(c) the director ceases to be qualified for election as a director; or

(d) the director is removed from office by the members in accordance with section 5.04.

5.06 Filling Vacancy in Office of Director

Subject to the Act, a quorum of the board may fill a vacancy in the board, except for a vacancy resulting from:

(a) an increase in the number or minimum number of directors; or

(b) a failure of the members to elect the number or minimum number of directors provided for in the articles.

5.07 Appointment of Additional Directors

Where the articles of the Corporation so provide, the directors may appoint one or more directors who shall hold office for a term expiring not later than the close of the next annual meeting of members, but the total number of directors so appointed may not exceed one-third (1/3) the number of directors elected at the last annual meeting of members.

SECTION 6 – MEETINGS OF DIRECTORS

6.01 Calling of Meetings

Meetings of the board may be called by the chair of the board, the vice-chair of the board or any two (2) directors at any time.

6.02 Notice of Meeting

Notice of the time and place for the holding of a meeting of the board shall be given in the manner provided in Section 9.01 (Method of Giving Notices) of this by-law to every director of the Corporation not less than forty-eight (48) hours before the time when the meeting is to be held, if delivered or sent other than by mail. Notice by mail shall be sent at least fourteen (14) days prior to the meeting. Notice of a meeting shall not be necessary if all of the directors are present, and none objects to the holding of the meeting, or if those absent have waived notice of or have otherwise signified their consent to the holding of such meeting. Notice of an adjourned meeting is not required if the time and place of the adjourned meeting is announced at the original meeting. Unless the by-law otherwise provides, no notice of meeting need specify the purpose or the business to be transacted at the meeting except that a notice of meeting of directors shall specify any matter referred to in subsection 138(2) (Limits on Authority) of the Act that is to be dealt with at the meeting.

6.03 Regular Meetings

The board may appoint a day or days in any month or months for regular meetings of the board at a place and hour to be named. A copy of any resolution of the board fixing the place and time of such regular meetings of the board shall be sent to each director forthwith after being passed, but no other notice shall be required for any such regular meeting except if subsection 136(3) (Notice of Meeting) of the Act requires the purpose thereof or the business to be transacted to be specified in the notice.

6.04 Quorum

A majority of directors in office, from time to time, but no less than two (2) directors, shall constitute a quorum for meetings of the board.

6.05 Votes to Govern

At all meetings of the board, every question shall be decided by a majority of the votes cast on the question. The chair of the meeting shall not exercise a vote except in the case of an equality of votes either on a show of hands or on a ballot or on the results of electronic voting.

SECTION 7 – OFFICERS

7.01 Appointment

The board may designate the offices of the Corporation, appoint officers on an annual or more frequent basis, specify their duties and, subject to the Act, delegate to such officers the power to manage the affairs of the Corporation. A director may be appointed to any office of the Corporation. An officer may, but need not be, a director unless these by-laws otherwise provide. Two or more offices may be held by the same person.

7.02 Description of Offices

Unless otherwise specified by the board (which may, subject to the Act modify, restrict or supplement such duties and powers), the offices of the Corporation, if designated and if officers are appointed, shall have the following duties and powers associated with their positions:

(a) Chair of the Board – The chair of the board, if one is to be appointed, shall be a director. The chair of the board, if any, shall, when present, preside at all meetings of the board and of the members. The chair shall have such other duties and powers as the board may specify.

(b) Vice-Chair of the Board – The vice-chair of the board, if one is to be appointed, shall be a director. If the chair of the board is absent or is unable or refuses to act, the vice-chair of the board, if any, shall, when present, preside at all meetings of the board and of the members. The vice-chair shall have such other duties and powers as the board may specify.

(c) President – If appointed, the president shall be the chief executive officer of the Corporation and shall be responsible for implementing the strategic plans and policies of the Corporation. The president shall, subject to the authority of the board, have general supervision of the affairs of the Corporation.

(d) Secretary – If appointed, the secretary shall attend and be the secretary of all meetings of the board, members and committees of the board. The secretary shall enter or cause to be entered in the Corporation's minute book, minutes of all proceedings at such meetings; the secretary shall give, or cause to be given, as and when instructed, notices to members, directors, the public accountant and members of committees; the secretary, or such other officer or employee as designated by the secretary, shall be the custodian of all books, papers, records, documents and other instruments belonging to the Corporation.

(e) Treasurer – If appointed, the treasurer shall keep, or cause to be kept, proper accounting records as required by the Act. The treasurer shall deposit, or cause to be deposited, all monies received by the Corporation in the Corporation's bank account; the treasurer shall, under the direction of the board, supervise the safekeeping of securities and the disbursement of the funds of the Corporation; the treasurer shall render to the board, whenever required, an account of all his or her transactions as treasurer and of the financial position of the Corporation; and the treasurer shall perform such other duties as may from time to time be prescribed by the board.

The powers and duties of all other officers of the Corporation shall be such as the terms of their engagement call for or the board or president requires of them. The board may from time to time and subject to the Act, vary, add to or limit the powers and duties of any officer. In the event that any of the officers above are not appointed, to the extent that such officers have any responsibilities pursuant to any other provisions of this by-law, the board may assign those responsibilities to another officer or employee of the Corporation.

7.03 Vacancy in Office

In the absence of a written agreement to the contrary, the board may remove, whether for cause or without cause, any officer of the Corporation. Unless so removed, an officer shall hold office until the earlier of:

(a) the officer's successor being appointed;

(b) the officer's resignation;

(c) such officer ceasing to be a director (if a necessary qualification of appointment); or

(d) such officer's death.

If the office of any officer of the Corporation shall be or become vacant, the directors may, by resolution, appoint a person to fill such vacancy.

SECTION 8 – COMMITTEES

8.01 Committees

The board may from time to time establish any committee or other advisory body, as it deems necessary or appropriate for such purposes and, subject to the Act, with such powers as the board shall see fit, or terminate any committee or other advisory body, as it deems necessary or appropriate. The size, composition, structure and election process for members of any such committee shall be established by the board. Any such committee shall operate within the rules and directions as the board may from time to time make. Any committee member may be removed by resolution of the board.

SECTION 9 – NOTICES

9.01 Method of Giving Notices

Any notice (which term includes any communication or document), other than notice of a meeting of members, to be given (which term includes sent, delivered or served) pursuant to the Act, the articles, the by-laws or otherwise to a member, director, officer or member of a committee of the board or to the public accountant shall be sufficiently given:

(a) if delivered personally to the person to whom it is to be given or if delivered to such person’s address as shown in the records of the Corporation or, in the case of notice to a director, if delivered to the director’s latest address as shown in the records of the Corporation or in the last notice that was sent by the Corporation in accordance with section 128 (Notice of directors) or 134 (Notice of change of directors) and received by the Director appointed by the federal Minister of Industry under the Act to administer the Act;

(b) if mailed by prepaid ordinary or air mail to such person at such person's recorded address, or in the case of notice to a director to the latest address as shown in the records of the Corporation or in the last notice that was sent by the Corporation in accordance with section 128 (Notice of directors) or 134 (Notice of change of directors) and received by the Director appointed by the federal Minister of Industry under the Act to administer the Act;

(c) if sent to such person by telephonic, electronic or other communication facility at such person's recorded address for that purpose; or

(d) if provided in the form of an electronic document in accordance with Part 17 of the Act.

A notice so delivered shall be deemed to have been given when it is delivered personally or to the recorded address as aforesaid; a notice so mailed shall be deemed to have been given when deposited in a post office or public letter box; and a notice so sent by any means of transmitted or recorded communication shall be deemed to have been given when dispatched or delivered to the appropriate communication company or agency or its representative for dispatch. The secretary may change or cause to be changed the recorded address of any member, director, officer, public accountant or member of a committee of the board in accordance with any information believed by the secretary to be reliable. The declaration by the secretary that notice has been given pursuant to this by-law shall be sufficient and conclusive evidence of the giving of such notice. The signature of any director or officer of the Corporation to any notice or other document to be given by the Corporation may be written, stamped, type-written or printed or partly written, stamped, type-written or printed.

9.02 Omissions and Errors

The accidental omission to give any notice to any member, director, officer, member of a committee of the board or public accountant, or the non-receipt of any notice by any such person where the Corporation has provided notice in accordance with the by-law or any error in any notice not affecting its substance shall not invalidate any action taken at any meeting to which the notice pertained or otherwise founded on such notice.

SECTION 10 – ELECTRONIC MEETINGS

10.01 Participation by Electronic Means

If the Corporation chooses to make available a telephonic, electronic or other communication facility that permits all participants to communicate adequately with each other during a member or director meeting, any person entitled to attend such meeting may participate in the meeting by means of such telephonic, electronic or other communication facility in the manner provided by the Act.

A person participating in a meeting by such means is deemed to be present at the meeting.
Notwithstanding any other provision of this by-law, any person participating in a meeting pursuant to this section who is entitled to vote at that meeting may vote, in accordance with the Act, by means of any telephonic, electronic or other communication facility that the Corporation has made available for that purpose.

10.02 Meeting Held Entirely by Electronic Means

If the directors or members of the Corporation call a meeting pursuant to the Act, those directors or members, as the case may be, may determine that the meeting shall be held, in accordance with the Act and the Regulations, entirely by means of a telephonic, electronic or other communication facility that permits all participants to communicate adequately with each other during the meeting.

SECTION 11 – INDEMNITIES TO DIRECTORS AND OTHERS

11.01 Indemnification

Subject to the Act, the Corporation shall indemnify a director or officer, a former director or officer, or a person who acts or acted at the Corporation's request as a director or an officer or in a similar capacity of another entity, against all costs, charges and expenses, including an amount paid to settle an action or satisfy a judgment, reasonably incurred by the individual in respect of any civil, criminal, administrative, investigative or other proceeding in which the individual is involved because of that association with the Corporation or other entity, if such individual (a) acted honestly and in good faith with a view to the best interests of the Corporation or, as the case may be, to the best interests of the other entity for which the individual acted as director or officer or in a similar capacity at the Corporation's request; and (b) in the case of a criminal or administrative action or proceeding that is enforced by a monetary penalty, had reasonable grounds for believing that such conduct was lawful. The Corporation shall also indemnify such person in such other circumstances as the Act or law permits or requires. Nothing in this by-law shall limit the right of any person entitled to indemnity to claim indemnity apart from the provisions of this by-law.

SECTION 12 – DISPUTE RESOLUTION (ONLY IF ONTARIO, IF NOT REMOVE)

12.01 Dispute Resolution Mechanism

If a dispute or controversy among members, directors, officers or committee members of the Corporation arising out of or related to the articles or by-laws, or out of any aspect of the activities or affairs of the Corporation is not resolved in private meetings between the parties, then such dispute or controversy shall be settled by a process of dispute resolution as follows to the exclusion of such persons instituting a lawsuit or legal action:

(a) the dispute shall be settled by arbitration before a single arbitrator, in accordance with the *Arbitration Act, 1991* (Ontario) or as otherwise agreed upon by the parties to the dispute. All proceedings relating to arbitration shall be kept confidential, and there shall be no disclosure of any kind. The decision of the arbitrator shall be final and binding and shall not be subject to appeal on a question of fact, law or mixed fact and law; and

(b) all costs of the arbitrator shall be borne by such parties as may be determined by the arbitrator.

SECTION 13 – BY-LAWS AND AMENDMENTS

13.01 By-laws and Amendments

The board may not make, amend or repeal any by-laws that regulate the activities or affairs of the Corporation without having the by-law, amendment or repeal confirmed by the members by ordinary resolution. The by-law, amendment or repeal is only effective on the confirmation of the members and in the form in which it was confirmed.

This section does not apply to a by-law that requires a special resolution of the members according to subsection 197(1) (Fundamental Changes) of the Act.

13.02 Invalidity of any provisions of this by-law

The invalidity or unenforceability of any provision of this by-law shall not affect the validity or enforceability of the remaining provisions of this by-law.

SECTION 14 – EFFECTIVE DATE

14.01 Effective Date

This By-law shall come into force on the date that the Corporation continues under the *Canada Not-for-profit Corporations Act.*

CERTIFIED to be By-Law No. 1 of the Corporation, passed by the Board of the Corporation by resolution on the 8th day of October 2014, and confirmed by the members of the Corporation by special resolution on the 2nd day of December 2014, and to be effective on the date that the Corporation continues under the *Canada Not-for-profit Corporations Act.*

DATED as of the 2nd day of December, 2014 .

FRANK RUSSO – Director

ALBERTO BEHAR – Director

This By-Law No. 1 came into force on January 8, 2015, the date of continuance as reflected on the Certificate of Continuance issued by Industry Canada under the *Canada Not-for-profit Corporations Act.*

Industry Canada Industrie Canada

Certificate of Continuance

Canada Not-for-profit Corporations Act

Certificat de prorogation

Loi canadienne sur les organisations à but non lucratif

CANADIAN ACOUSTICAL ASSOCIATION
ASSOCIATION CANADIENNE D'ACOUSTIQUE

Corporate name / Dénomination de l'organisation

020179-1

Corporation number / Numéro de l'organisation

I HEREBY CERTIFY that the above-named corporation, the articles of continuance of which are attached, is continued under section 211 of the *Canada Not-for-profit Corporations Act*.

JE CERTIFIE que l'organisation susmentionnée, dont les statuts de prorogation sont joints, a été prorogée en vertu de l'article 211 de la *Loi canadienne sur les organisations à but non lucratif.*

Virginie Ethier

Virginie Ethier

Director / Directeur

2015-01-08

Date of Continuance (YYYY-MM-DD)
Date de prorogation (AAAA-MM-JJ)

Canada

CANADIAN ACOUSTICS TELEGRAM ANNOUNCEMENTS - ANNONCES TÉLÉGRAPHIQUES DE L'ACOUSTIQUE CANADIENNE

CAA Guide to Acoustic Standards Now Available!

The CAA Standards Committee is pleased to announce that the CAA Guide to Acoustic Standards is now available free of charge on the Standards Committee page of the CAA website.

CAA Guide to Acoustic Standards Now Available The CAA Standards Committee is pleased to announce that the CAA Guide to Acoustic Standards is now available free of charge on the Standards Committee page of the CAA website. This Guide describes Canadian and international acoustical and noise control Standards recommended for use in Canada. In addition, recommendations are provided for the appropriate application and use of each Standard. At present the document is primarily in English with references to French versions where they are available. We are looking for help to produce either a French version or to make the document bilingual. This is our first Standards Committee publication and we would appreciate feedback from readers on its content and usefulness. If any organization is interested in sponsoring this standard, and more particularly its translation into French, please contact Tim Kelsall at tkelsall@hatch.ca

September 16th 2014

Recognition of Per Brüel on his 100th Birthday

Per Bruel will be 100 years of age next month, on 6 March 2015.

The Canadian Acoustical Association congratulates Per Brüel on reaching 100 years of age on 6 March 2015 and recognizes his outstanding contributions to acoustics during the century. Per was a founder of the Danish Acoustical Society and the Swedish Acoustical Society, both member societies of the International Commission for Acoustics. A celebratory webpage has been created at www.icacommission.org/per.html

February 12th 2015

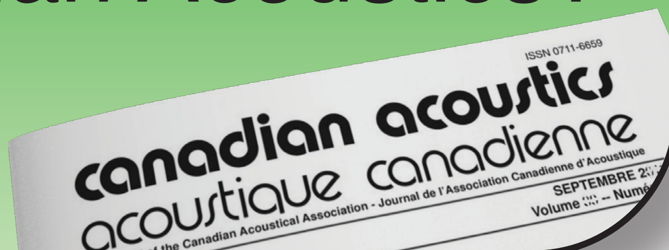
DISCOVERY OF SOUND IN THE SEA

Discovery of Sound in the Sea (DOSITS; www.dosits.org), which introduces its visitors to the science and uses of sound in the sea. The DOSITS Team is DEVELOPING RESOURCES FOR THE INTERNATIONAL REGULATORY COMMUNITY, and are again reaching out to members of this group to learn more about their needs and the types of information/tools to which they would like access.

WWW.DOSITS.ORG [1] is a comprehensive, educational website on underwater sound, designed to provide accurate scientific information at levels appropriate for all audiences, including regulators and policy-makers. Regulatory decision makers have needs for comprehensive, easy to understand, and rapidly accessible resources. To meet these needs, the DOSITS team will be developing targeted resources over the next 12 months. To best serve the regulatory community, the team has created a brief survey designed to identify high priority topics and resource formats. The survey will take approximately 15 minutes to complete. All members of the regulatory decision making community (government employees, federal and state contractors, NGO employees, and industry representatives that deal with underwater sound and/or marine animals) are encouraged to complete the survey. Your responses will directly influence the development of these new resources, which will be publically available on the DOSITS website. The survey is anonymous and no personal data will be collected. To complete the 2015 DOSITS Needs Assessment for the regulatory decision making community, please follow this link: HTTPS://WWW.SURVEYMONKEY.COM/S/DOSITS2015 Please note, the SURVEY WILL CLOSE ON MONDAY, APRIL 20, 2015. This research is conducted by the University of Rhode Island. If you have questions please contact Chris Knowlton at cknowlton@uri.edu.

March 30th 2015

Why publish in Canadian Acoustics?



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- Une publication trimestrielle en format papier et électronique, rejoignant une large communauté d'experts à travers le monde

- Une publication "accès libre" dont le contenu est disponible à tous, 12 mois après publication

- Une alternative intéressante pour une évaluation par les pairs, fournissant aux auteurs des commentaires pertinents, objectifs et constructifs

Application for Membership

CAA membership is open to all individuals who have an interest in acoustics. Annual dues total $100.00 for individual members and $50.00 for student members. This includes a subscription to ***Canadian Acoustics***, the journal of the Association, which is published 4 times/year, and voting privileges at the Annual General Meeting.

Subscriptions to *Canadian Acoustics* *or* Sustaining Subscriptions

Subscriptions to ***Canadian Acoustics*** are available to companies and institutions at a cost of $100.00 per year. Many organizations choose to become benefactors of the CAA by contributing as Sustaining Subscribers, paying $475.00 per year (no voting privileges at AGM). The list of Sustaining Subscribers is published in each issue of ***Canadian Acoustics*** and on the CAA website.

Please note that online payments will be accepted at http://jcaa.caa-aca.ca

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For individuals or organizations wishing to pay by check, please register online at *http://jcaa.caa-aca.ca* and then mail your check to:

Executive Secretary, The Canadian Acoustical Association, PO Box 74068, Ottawa, Ontario, K1M 2H9, Canada

CAA ACA

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L'adhésion à l'ACA est ouverte à tous ceux qui s'intéressent à l'acoustique. La cotisation annuelle est de 100.00$ pour les membres individuels, et de 50.00$ pour les étudiants. Tous les membres reçoivent ***l'Acoustique Canadienne***, la revue de l'association. Les nouveaux abonnements reçus avant le 31 août 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 31 août s'appliquent à l'année suivante.

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Secrétaire exécutif, Association canadienne d'acoustique, BP 74068, Ottawa, Ontario, K1M 2H9, Canada

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