

# SONOMAX-ÉTS INDUSTRIAL RESEARCH CHAIR IN IN-EAR TECHNOLOGIES

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## Abstract

The Sonomax-ÉTS Industrial Research Chair in In-Ear Technologies (CRITIAS) focuses on the development of a broad set of technologies applicable to the human ear, from “smart” hearing protection against harmful noise, to the integration of advanced system of inter-personal communication including hearing aids and embedded hearing diagnosis. More fundamental scientific aspects are also discussed, such as micropower generation within a miniaturized in-ear device using jaw-joint movement, to address future autonomy issues.

**Keywords:** acoustics, earplug, signal processing, hearing protection, hearing aids, communication, power harvesting, wearables

## Résumé

La Chaire industrielle de recherche en technologies intra-auriculaires Sonomax-ÉTS (CRITIAS) se concentre sur la mise au point d'un vaste ensemble de technologies applicables à l'oreille humaine, depuis la protection «intelligente» de l'oreille contre le bruit nocif jusqu'à l'intégration de système avancés de communication inter-individuels en passant par l'aide auditive et le diagnostic auditif embarqué. Des aspects scientifiques plus fondamentaux sont également abordés, comme la micro-génération d'énergie électrique au cœur même d'un dispositif intra-auriculaire miniaturisé, utilisant le mouvement de l'articulation temporo-mandibulaire, afin de remédier aux problèmes d'autonomie à venir.

**Mots clefs:** acoustique, bouchons, traitement du signal, protection auditive, prothèse auditive, communication, micro-grapillage énergétique, wearables

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## 1 History

The Sonomax-ÉTS Industrial Research Chair in In-Ear Technologies (CRITIAS) was created in June 2010, as part of a longstanding and successful partnership between Sonomax and École de technologie supérieure (ÉTS).

The partnership was initiated in late 1999 when Jérémie Voix began doctoral work on the development of an “intelligent” earplug for Sonomax under the direction of Professor Frédéric Laville of ÉTS. With financial support from the NSERC Collaborative Research and Development Grants program and Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST), the young researcher launched his work and quickly established himself as an R&D leader within the company. Working together, Jérémie Voix and the team at Sonomax developed a unique technology designed to protect industrial workers from hearing loss. The resulting product, Sonomax Solution™, is protected by over 50 patents and trademarks and has been marketed all over the world, while its core technology, an earplug field attenuation measurement device, is now the property of 3M Innovations (MN,USA).

Following 10 years of collaborative work, the partnership became more firmly established when Jérémie Voix accepted a position as an associate professor at ÉTS and founded the CRITIAS research chair dedicated to his original quest: to de-

velop a true “bionic” ear providing effective protection, amplification, and communication within a single in-ear device.

## 2 Mission , Research Focus and Benefits

In general, the objectives of the Chair are to approach the problematics associated with hearing protection and communication in noise systematically. Specifically and not exhaustively, the work of the Chair will explore the possibilities offered by digital signal processors (DSP), modern radio systems and miniaturized transducers (microphone and speaker) to remedy the difficulties to effectively protect the ear against excessive noise while allowing communication. The research chair activities focus on four areas: **Hearing Protection:** Digital protectors for musicians [1]; Continuous noise dosimetry (24 hours) [2]; **Hearing Aid:** Measurement of hearing fatigue and recovery [3]; Speech enhancement [4] and warning signals detection [5]; **Communication:** In-ear and virtual radio-acoustic environment [6]; **Power Generation:** In-ear energy micro-harvesting using piezoelectric materials [7] .

## 3 Equipment and Technology

The Chair is equipped with dedicated electronic test benches, various electro-acoustic measurement systems, signal processing platforms and development boards as well as a highly isolated double wall audio test booth.

While Sonomax, the industrial partner of the research

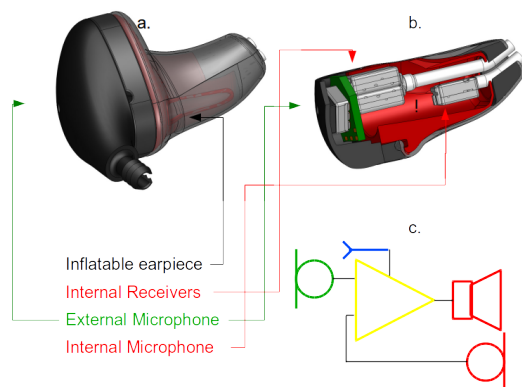
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chair, has commercial rights to all the developed technologies, some technologies, such as the *Auditory Research Platform* are made available to the research community, as open-source hardware/proprietary hardware solutions, as shown in Fig. 1. The ARP consists in a pair of custom earpieces that are instantly custom-fitted using the technology developed by Sonomax and a dedicated hardware circuit with Digital Signal Processor (DSP), Micro-controller and I/O's, as illustrated in Fig. 2. The ARP is available with complete software and hardware support for researchers interested in portable real-time audio processing unit.



**Figure 1:** Overview of Auditory Research Platform, as a pair of instrumented earplugs (here equipped with a generic eartip) and a belt-pack processing unit.



**Figure 2:** Overview of the digital custom earpiece (a), its electro-acoustical components (b), and equivalent schematic with external amplifier (c).

## 4 Collaborations and Training

Since its inauguration, CRITIAS has also undertaken strategic collaborations with key research groups, namely: BRAMS - International laboratory for Brain, Music and Sound Research, a research center is devoted to the study of music cognition with a focus on neuroscience; EREST - the ÉTS occupational health and safety research team; ICAR - a common infrastructure between IRSST and ÉTS for acoustical research; LACIME - a communications and microelectronic integration laboratory at ÉTS; MuSAE - The Multimedia/Multimodal Signal Analysis and Enhancement (MuSAE)

Lab, conducting research at the cross-roads of biomedical engineering and telecommunications. Numerous students and researchers have been trained within the chair and several graduates have already accepted advanced engineering positions in prestigious companies in the Silicon Valley (USA).

## 5 The future

The Sonomax-ÉTS Research Chair in In-Ear Technologies is about to celebrate its 5th year anniversary and can already proudly account significant achievements in the development of several technologies designed to complement the human ear, from “intelligent” protection against extreme noise to hearing support and embedded hearing diagnostics to the integration of advanced inter-individual communication systems. With its new industrial partner, eers Global Technologies, CRITIAS is now actively looking at complementing its expertise in audio processing for the occluded ear in two new highly specialised areas: in-ear micro-energy harvesting and in-ear brain-computer interfaces (BCI) using electroencephalographic (EEG) reading from inside the earcanal [8].

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