# OVERVIEW OF ACOUSTICS RESEARCH AT DRDC – TORONTO RESEARCH CENTRE

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## Résumé

La recherche acoustique à Recherche et développement pour la défense Canada – Centre de recherches de Toronto est axée sur l'optimisation de la protection et de la performance auditive dans un environnement opérationnel militaire. Nous formulons des recommandations aux Forces armées canadiennes en ce qui a trait à la préservation de l'ouïe (au moyen de limites d'exposition et de mesures de protection) et à l'adoption de pratiques exemplaires de communication auditive efficace.

**Mots clefs:** bruit militaire, bruit impulsif, protection auditive, communication auditive.

## Abstract

Acoustics research at Defence Research and Development Canada – Toronto Research Centre is focussed on optimizing auditory protection and performance in military operational environments. We make recommendations to the Canadian Armed Forces for hearing conservation (exposure limits and protective measures) and best practices for effective auditory communication.

**Keywords:** military noise, impulse noise, hearing protection, auditory communication.

## 1 Introduction

Acoustics research at Defence Research and Development Canada – Toronto Research Centre (DRDC – Toronto Research Centre) focusses on the optimization of auditory performance for the Canadian Armed Forces (CAF). CAF members require a high level of performance readiness for operations that may include extreme environments and conditions (e.g., heat and humidity, Arctic cold, high-performance aircraft) and prolonged or repeated exposure to high-level continuous and impulsive noise. In such conditions, hearing protection and communication issues are difficult to resolve, especially when compatibility with other personal protective equipment such as helmets or gas masks must be considered. As the operational requirements and CAF equipment change, and tactical communication and hearing protection technologies evolve, we continually adapt our research to meet these needs.

## 2 Equipment

DRDC – Toronto Research Centre has two main laboratories for hearing research: the noise simulation facility (NSF) and the hearing research laboratory (HRL). The NSF is a 10.6x6.1x3.1m$^3$ semi-reverberant room with a system of 16 loudspeakers at one end of the room, powered by 14 amplifiers (Figure 1). The background noise of the facility is about 28 dBA. The NSF was designed to simulate the acoustics of CAF operational environments (e.g., inside aircraft and armoured land vehicles) at noise levels of up to 130 dB SPL. The NSF is used for research on auditory overload, speech understanding with hearing protection devices (HPDs) and measurement of the insertion loss of HPDs and helmets with an acoustic test fixture (GRAS Sound and Vibration, Denmark). Psychoacoustic experiments are run using a Psychoacoustics Workstation (Tucker-Davis Technologies, Alachua, FL).

**Figure 1:** Speaker system and acoustic manikin in the Noise Simulation Facility. Photo credit: Jim Clark.

The HRL includes a doubled-walled 3.5x2.7x2.3m$^3$ audiometric booth (IAC acoustics, UK), a 2-channel clinical audiometer (Interacoustics, Denmark) and a programmable system for running several auditory perception protocols (Figure 2). We also have the capability to measure otoacoustic emissions (Intelligent Hearing Systems, Miami, FL). The HRL is used for studies of auditory detection, speech understanding and sound localization with HPDs as well as audiometric screening for study participants. We have access to many types of military and commercial off-the-shelf hearing protection and communication devices.

Our portable equipment for noise measurements in the field includes a number of high-amplitude and standard microphones (PCB Piezotronics, Depew, NY and GRAS),

sound level meters (Larson-Davis, Depew, NY), blast gauges (BlackBox Biometrics Inc., Rochester, NY), hydrophones (Ocean Sonics Ltd, Great Village, NS) and a four-channel Soundbook (SINUS, Germany). We have ANSI S12.42:2010 compliant equipment for measuring the impulse peak insertion loss (IPIL) of HPDs (GRAS).

**Figure 2:** Sound localization set up in the Hearing Research Laboratory. Photo credit: Jim Clark.

## 3 Research Themes

### 3.1 Impulse Noise and Blast

We are in the process of collecting noise data for in-service CAF weapons and ammunition to make recommendations for updating the hearing conservation doctrine for training safety. Data for small calibre weapons (i.e., hand-held rifles) have already been collected and analyzed [1]. Plans to collect and analyze artillery and blast data are in progress. We have completed IPIL measurements for several types of passive HPDs to account for their use in the calculation of the allowed exposures during weapons training [2].

In addition to weapon noise, some CAF personnel experience blast exposure in air and underwater. For tactical breaching training, instructors and students are exposed repeatedly to low-level blasts. We are quantifying the exposure levels and studying the effects on psychological and physiological function, including hearing. CAF clearance divers are exposed to blasts underwater, and safe stand-off distances are only defined for limited charge weights and conditions. To contribute knowledge in this domain, we have completed joint international trials to study underwater blast in shallow littoral environments [3].

### 3.2 Auditory Protection and Performance

Studies of sound localization with hearing protection and communication devices are not frequently reported in the literature. We have compared sound localization performance with communication headsets with passive and active noise reduction, and with the use of helmets [4]. The study results help to inform the CAF of how the ability to localize sounds and threats would be affected by wearing different types of hearing protection and communication headsets.

We have completed a series of studies looking at ways to mitigate auditory overload (from noise and radio communications) in command and control posts [5].We have studied speech understanding through military radio systems in our laboratory [6] and with hearing-impaired listeners through contractors [7]. Recognizing the high percentage of Francophones in the CAF, we have also studied the impact of non-fluency on speech understanding with radios [8,9]. Auditory communication research is also relevant to Royal Canadian Navy (RCN) platforms, and we are planning to conduct a noise survey and observation of communication interference at sea [10].

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