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# Powered Electronic Augmentations in Hearing Protection Technology Circa 2010 including Active Noise Reduction, Electronically-Modulated Sound Transmission, and Tactical Communications Devices: Review of Design, Testing, and Research

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Augmented or enhanced hearing protection devices (HPDs), as contrasted with conventional HPDs, which attenuate noise strictly through static, passive means, have proliferated in the past decade. These advancements in HPDs are generally delineated into passive (non-powered) and active (powered electronic) designs. While passive augmentations are reviewed in a parallel paper elsewhere in this issue,<sup>1</sup> active augmentations include various analog and digital circuits for achieving electronic phase cancellation of noise; electronic modulated sound transmission circuits, which amplify a passband of ambient sound and transmit it through the HPD (ceasing to amplify at a pre-determined noise level); and tactical communications and protection systems (TCAPS), which may include any of the aforementioned electronic elements plus microphone/receiver communications elements. The intended benefits of electronic augmented HPDs, some of which are realized in practice and others not, include more natural hearing for the user, improved speech communications and signal detection, reduced noise-induced annoyance, improved military tactics, stealth and gunfire protection, and provision of protection that is somewhat tailored for the user's needs, noise exposure, and/or job requirements. This paper provides a technical overview of active augmented HPDs that were available or have been prototyped circa early-2010. In some cases, no empirical research on the augmentations and their performance was available in the research literature; in these cases, this review relied on patents, corporate literature, and/or the author's experience. For other technologies, a limited amount of empirical, operational performance research was available and it is covered herein. Finally, in view that at the juncture of this article the United States (U.S.) Environmental Protection Agency (EPA) was in the process of promulgating a comprehensive new federal law to govern the testing and labeling of hearing protectors of various types, those elements of the proposed law pertaining to specific augmentation technologies are mentioned herein,<sup>2</sup> along with that proposed law's cited ANSI standards, as well as ISO standards that address hearing protector attenuation testing.

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## 1. INTRODUCTION

In 1996, Casali and Berger published an overview of the state of the technology of hearing protection devices (HPDs).<sup>3</sup> As that article is now outdated, the purposes of this article on active (electronic) augmentations and its parallel article (also in this journal issue)<sup>1</sup> on passive augmentations, are: (1) primarily to update the earlier article with more comprehensive coverage of new technologies, though not intended to be exhaustive as to all manufacturers and models; (2) to briefly present the results of relevant research conducted in the intervening period on augmented HPDs; and (3) to briefly address the issue of testing and labeling augmented HPDs as to their attenuation and other performance characteristics under a recently proposed U.S. EPA regulation<sup>2</sup> that is intended to ultimately supersede the current federal regulation<sup>4</sup>, which does not accommodate most electronic augmentation technologies.<sup>5</sup> The testing issue was not addressed in the 1996 article,<sup>3</sup> but it is becoming increasingly important as consumers and safety professionals attempt to select from a variety of augmented

HPDs that are purported to offer certain hearing and protective advantages, but which could not be comprehensively tested and properly labeled under the current EPA regulation.<sup>4</sup> The discussion of relevant HPD testing standards in this paper concentrates on American National Standards Institute (ANSI) standards because most of these standards have been recently and extensively revised, and they are cited by the EPA in the proposed new regulation.<sup>2</sup> It is important to note, however, that for completeness, this paper also references International Organization for Standards (ISO) standards, which are used by various countries.

### 1.1. Definitions Applied

In this paper and its parallel one,<sup>1</sup> the terms "augmentation" and "augmented hearing protector" are intended to refer to any device that does not consist solely of a static passive attenuator, but that includes features involving electronics or dynamic/adjustable passive acoustical impedance elements. Also, the term "active" hearing protector is operationally de-