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Performance Assessment of the Invisio V60 Tactical System with the X5 Dual In-Ear Headset

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14. ABSTRACT
Communication enhancement devices are designed for those who want to maintain natural hearing while protecting their ears from impulse and continuous noises like gunfire, explosions, vehicles, and machinery. There are potential advantages for this technology in military applications, provided an accurate and complete assessment of the performance has been obtained. The Invisio V60 tactical system with the X5 (V60 X5) dual in-ear headset was assessed for: continuous noise attenuation, auditory localization, and speech intelligibility. The Invisio V60 X5 tactical headset caused significant impairments to localization capabilities in comparison to the open ear performance, and that knowledge must be used to determine how and when such devices can be integrated successfully into a mission. Additionally, the Invisio V60 X5 did not reach acceptable speech intelligibility scores for the current military standards at any noise level.

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EXECUTIVE SUMMARY

Understanding the noise attenuation performance of a hearing protection device is important in order to protect the user from excessive noise exposure. Active electronic hearing protection devices were designed to allow for enhanced communication and situational awareness, while at the same time protecting the auditory system from noise. It is critical to evaluate any hearing protection device to gain an accurate and complete performance assessment not only of the device, but also the effect on the auditory performance of the user. The objective of this study was to assess the Invisio V60 tactical system with the X5 dual in-ear headset (V60 X5) for: continuous noise attenuation, auditory localization, and speech intelligibility. The Invisio V60 X5 tactical headset caused significant impairments to localization capabilities in comparison to the open ear performance, and that knowledge must be used to determine how and when such devices can be integrated successfully into a mission. Additionally, the Invisio V60 X5 did not meet acceptable speech intelligibility scores for current military standards at any noise level.

1.0 INTRODUCTION

Today's military personnel often work in unpredictable environments, requiring a more flexible type of hearing protector in order to complete a normal duty day without the risk of permanent hearing loss. Accurate and complete measures of the total performance capabilities of hearing protection devices and their effect on the user are necessary to ensure that military personnel can maintain mission effectiveness while preventing noise induced hearing loss. A multifactorial assessment approach was necessary to adequately determine if currently available hearing protection and communication devices can meet the needs of these personnel, including the following measurements: continuous noise attenuation, auditory localization, and speech intelligibility.

Continuous noise attenuation measurements characterize how much protection a hearing protection device (HPD) provides in an environment where the ambient noise levels are fairly stable (for example, riding in a HMMWV or a helicopter, or working in a machine room). These measurements were conducted in accordance with American National Standards Institute (ANSI) standard S12.6-2008[1] Method A. Understanding the noise attenuation of a hearing protector is critical in order to estimate the user's noise dose. Noise dose is calculated using the estimated level of noise under the hearing protector (using methods described in ANSI S12.68[2]) and the duration of time spent in that noise environment. Speech intelligibility measurements were conducted in accordance with ANSI S3.2-2009[3] and are critical to understand the communication performance for users wearing a hearing protection and communication device in multiple noise environments.

Wearing a hearing protection device may degrade the user's ability to localize low-level sounds, which can be critical to situation awareness. Measurements were conducted to demonstrate the impact of hearing protection devices on auditory localization and on the amount of time required to locate a visual target that is generating noise. Understanding these potential degradations will promote a more informed decision for those in charge of selecting hearing protection for the warfighter so that they may strike a balance between providing adequate hearing protection for the expected noise environment and maintaining a level of situation awareness that is appropriate for the mission.

2.0 BACKGROUND

Military ground operations take place in complex environments that necessitate creating a balance between operational effectiveness and personnel safety. The goal of effectively protecting the hearing of personnel has been complicated by the need for warfighters to maintain access to acoustic cues in the ambient environment (Figure 1). Firing even a small number of rounds from a weapon can cause temporary hearing loss, therefore producing the undesired result of impairing the ability to monitor the environment. Repeated unprotected exposures to small arms fire that may generate these temporary changes can eventually result in permanent hearing loss. Noise exposures from larger weapons and blast events can instantly cause permanent hearing loss if no protection is worn.

Figure 1. Special Operations Forces using Communication Devices in an Operational Environment

The objective of this study was to evaluate the Invisio V60 tactical system with the X5 dual in-ear headset for: continuous noise attenuation, auditory localization, and speech intelligibility. This device was developed to improve situation awareness by providing a hear-thru, or active capability that amplifies low-level sounds while preventing hearing loss and tinnitus by attenuating loud, steady-state and impulse noise. Active devices theoretically should provide improved performance in the areas of face to face communications and auditory localization versus passive hearing protection devices, while continuing to provide adequate attenuation in a hazardous noise environment.

The requirements associated with the military's use of tactical hearing protection and communication devices fueled the development of new performance metrics and measurement methods in order to best determine the impact of these devices on the mission.[4] Traditional passive earplugs and earmuffs may impair the ability of an operator to localize sounds in the environment.[5,6] These systems actively provide some level of ambient listening capability in an attempt to restore the ability of an operator to localize sounds. Several metrics and measurement methods were employed to quantify the effects of these devices on operator performance. The first was a measure of localization error. This metric quantified the amount of errors >45 degrees between the target location and the listener's response. A second metric was the number of front-back reversals of the target location that an individual demonstrated during the task. The third metric was a measure of reaction time, time to find a visual target, when sound is collocated with the visual target. The listener must use the auditory localization information to locate the target and subsequently identify the target in this task. The reaction time was a salient measure of the quality of the localization cue.[7-11]

AFRL conducted a series of measures to describe the performance of hearing protection and communication devices. The measures included passive continuous noise attenuation, input/output gain function, localization error with short duration (250 ms) and long duration (>1 sec) stimuli, reaction time from an aurally guided visual search task with distractors, and speech intelligibility.

3.0 METHODS AND RESULTS

The overall methods and results are described in the following sections. The first section describes the hearing protector that was used in the study. The second section describes how the device settings were configured for the evaluation. The subsequent sections describe each measurement method including a description of the subjects, the facilities, and the details of the specific measurement methods and results.

3.1 Hearing Protection and Communication Device

The Invisio V60 Tactical Headset System was a compact advanced communication system that was designed to allow users to connect, control and communicate across 4 separate channels at the same time. The V60 system was paired with the Invisio X5 dual in-ear headset (Figure 2), using with Comply™ Isolation foam insert tips available in slim, short, standard, and large. The Invisio X5 headset utilized bone conduction microphone technology. The bone conduction microphone was used for speech intelligibility measurements at the levels of 65 and 85 dBA. The Invisio hybrid external boom microphone accessory was added to the system for measurements in a 105 dBA noise environment.

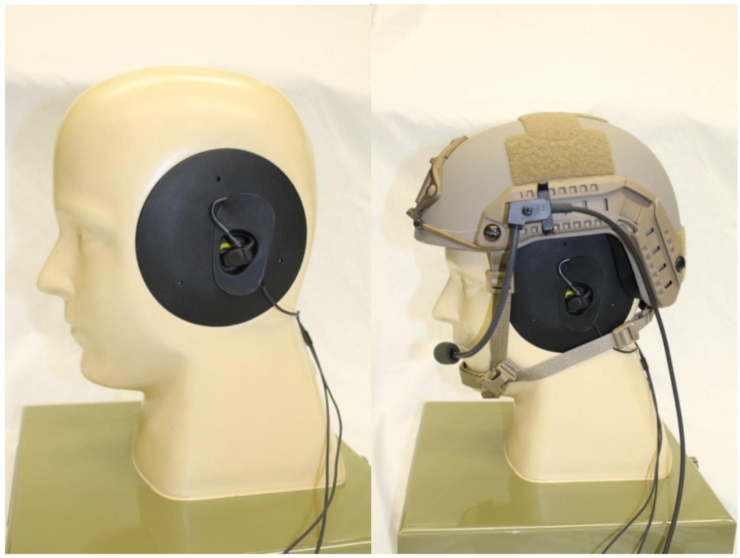

Figure 2. Invisio X5 Headset (left) and Invisio X5 with Ops-Core Helmet (right)

3.2 Device Gain Setting

The Invisio V60 Tactical Headset System was equipped with a hear-thru setting designed to amplify soft sounds and conversational speech while allowing loud sounds to pass through without amplification. To normalize the hear-thru setting, a unity gain measurement was collected in the Audio Localization Facility (ALF) at Wright Patterson Air Force Base (WPAFB). The unity gain of the device refers to the volume setting at which the input/output gain curve of the device best matches the input/output gain curve of the Knowles Electronic Manikin for Acoustic Research (KEMAR). Matching the gain structure created a baseline volume setting and can provide the most accurate comparison of how devices perform in relation to other devices.

KEMAR was equipped with two G.R.A.S Type 26-AC preamps and 40AO prepolarized pressure microphones positioned inside the head, with the microphone diaphragms aligned to each ear canal. KEMAR's gain structure was obtained by measuring specific locations of sounds in ALF with the manikin's ears unoccluded. The unity gain for the X5 headset was determined by activating the hear-thru setting, equipping KEMAR with the device, and collecting the same series of sounds. Starting from either the maximum or minimum volume, the level of the device was adjusted until the gain structure of the device matched that of KEMAR (Figure 3). The unity gain for the Invisio V60 Tactical Headset System was set at ambient medium.

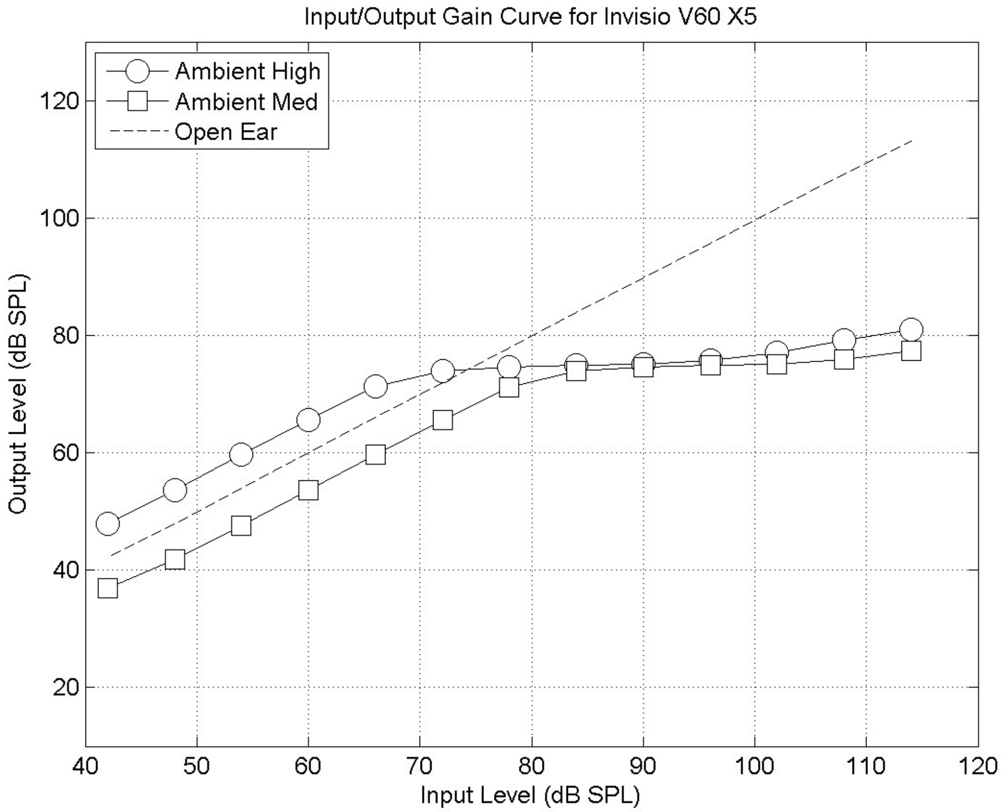

Figure 3. Input/Output gain curves for Invisio V60 X5 as measured on a KEMAR Manikin

3.3 Continuous Noise Attenuation

Continuous noise attenuation performance measurements were collected with the device in the "passive" (electronics off) condition using human subjects. All human subjects were compensated volunteers. There were ten male and ten female subjects, ranging in age from 18 to 34 years. All subjects were required to have a computer administered screening audiogram via Hughson-Westlake method, with behavioral hearing thresholds inside the normal hearing range, which was 25 dB hearing level (HL) or better from 125 Hz to 8000 Hz.

The facility used for this portion of the study was specifically built for the measurement of the sound attenuation properties of passive hearing protection devices. The chamber (Figure 4), its instrumentation, and measurement procedures were in accordance with ANSI S12.6-2008.[1] This standard requires measuring the occluded and unoccluded hearing threshold of human subjects using a von Békésy tracking procedure. The thresholds were measured two times for the unoccluded ear condition and two times for the occluded ear condition (with device in place). The real-ear attenuation at threshold for each subject was computed at each octave frequency, 125 to 8000 Hz, by averaging the two trials (the difference between unoccluded and occluded ear hearing thresholds).

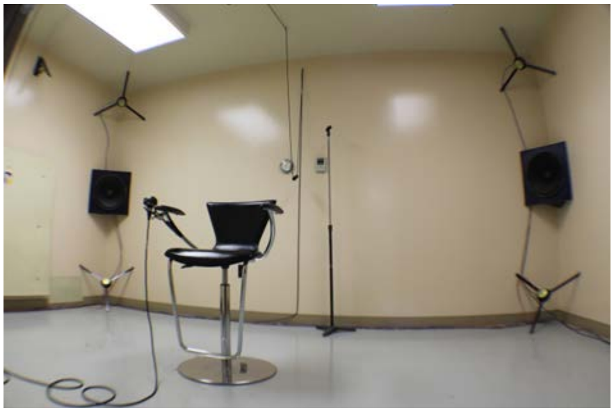

Figure 4. Facility used for measurement of continuous noise attenuation

Passive noise attenuation data were analyzed using the methods described in ANSI S12.68.[2] This ANSI standard details the methods for estimating the effective A-weighted SPL when hearing protectors are worn. The octave band method is the "gold standard" method for estimating a users' noise exposure. This method requires both the noise spectra per octave band and the attenuation data per octave band. Mean and standard deviation (SD) noise attenuation data were calculated across subjects at each octave frequency band. A single Noise Reduction Rating (NRR) was also calculated for mean minus 1 and mean minus 2 standard deviations, Table 1. Figure 5 displays a graphical representation of the attenuation results at each measured frequency (mean minus 2 SD).

Table 1. Passive noise attenuation data for Invisio X5 headset, electronics off

Device		Frequency (Hz)							NRR	
		125	250	500	1000	2000	4000	8000	Mean-1SD	Mean-2SD
Invisio X5 Headset with Comply Canal Tips	Mean	25	26	28	31	34	38	44	25	20
	SD	6	4	5	6	4	3	4		

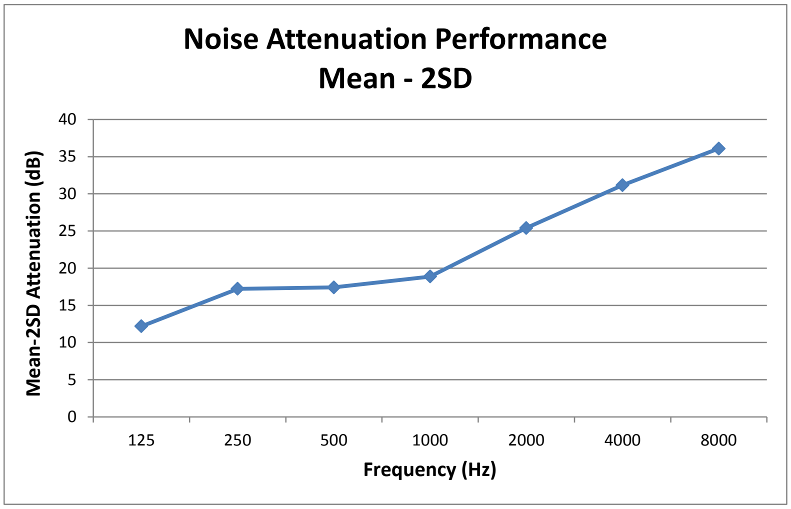

Figure 5. Passive mean -2SD noise attenuation for Invisio X5 headset, electronics off

It is not always possible to calculate the effective A-weighted level under the hearing protector using the octave band method due to the lack of detailed noise data for all noise environments. Two other methods are described in ANSI S12.68: Noise Level Reduction Statistics, Graphical (NRS_G) and Noise Level Reduction Statistics for use with A-Weighting (NRS_A). NRS_G and NRS_A were calculated for the Invisio X5 headset and displayed in Figures 6 and 7, respectively.

The NRS_G rating requires knowledge of both the C- and A-weighted noise levels, and uses this additional information about the noise spectrum to more precisely estimate the range of protection provided. For example, if the C-weighted noise was measured at 100 dB and the A-weighted noise was measured at 94 dB then the difference between the two weighting levels would be 6. Therefore, the range of protection provided by the hearing protector could be found in Figure 6 and/or Table 2 where B = 6. NRS_A is appropriate for unpredictable noise environments that may vary widely as is the case with many military operations. However, if one is considering a noise environment that is relatively constant (e.g., aircraft or other vehicles) then NRS_G should be used to calculate more accurate attenuation performance values.

Table 2. NRS_G results for Invisio X5 headset, electronics off

Device		$B = L_C - L_A$			
		-1	**2**	**6**	**13**
Invisio X5 Headset with Comply Canal Tips	**80%**	31.0	26.5	24.4	21.4
	20%	37.4	34.0	31.8	30.0

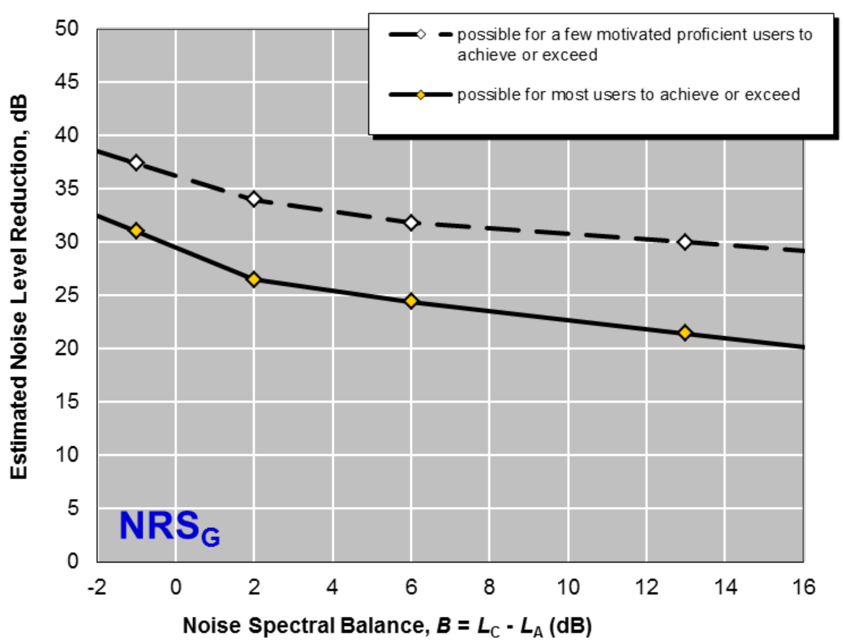

Figure 6. NRSG results for Invisio X5 headset, electronics off

NRS_A is the simplest method and can be used by subtracting the value from the measured A-weighted noise level to estimate the level of sound at the ear under the hearing protector. This method offers several advantages over the well-known NRR. The NRR was developed to be subtracted from the C-weighted noise exposure, with a 7-dB adjustment that must be applied prior to subtracting it from A-weighted exposure values. C-weighted exposure values are often not known, and therefore the rating for subtraction from A-weighted exposures with the NRS_A eliminates these problems with the NRR. Another advantage of the NRS_A is that it calculates two levels of protection to indicate the range of performance that was achieved (Figure 7); this range reflects both the variation across the subjects in the test panel providing insight into how hard/easy the device may be to fit, as well as variation in noise level reduction with the noise spectrum in which the device is used.[12] The majority of users (80%) will achieve the performance specified by the lower value in the range, with only the most motivated proficient users (20%) able to achieve the higher value. A narrow range indicates the hearing protection device provides a more stable and predictable level of protection. When the methods described in ANSI S12.68 (octave band method, NRS_G, and NRS_A) cannot be used, the use of the NRR (mean-2SD) is acceptable with the use of appropriate deratings.

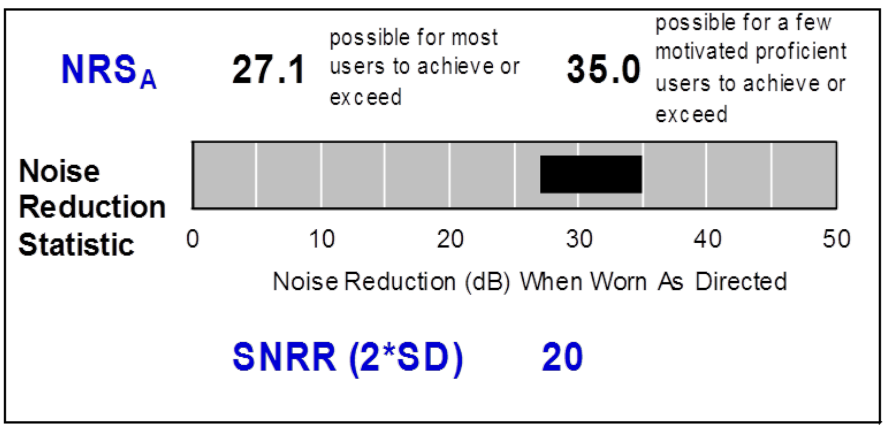

Figure 7. NRSA results for Invisio X5 headset, electronics off

3.4 Auditory Localization

Localization performance was measured for 8 paid volunteer subjects; 4 male and 4 female subjects ranging from 18 to 32 years of age. All subjects had bilateral hearing threshold levels less than or equal to 15 dB from 125 to 8000 Hz. These 8 subjects were a subset of the 20 subjects used for continuous noise attenuation measurements.

All measurements were collected in ALF (Figure 8) at WPAFB. The aluminum-frame geodesic sphere is 14 feet in diameter with 4.5 inch loudspeakers, each of which was equipped with four light-emitting diodes (LEDs) located at each of the 277 vertices on its inside surface. The ALF apparatus was housed within an anechoic chamber. The subject stood on a platform in the center of the sphere. The location of the platform had the potential to distort the signals from the speakers located directly below the subject, therefore only 237 loudspeakers, evenly distributed, above -45° elevation, were used in this study. The distance between speakers ranged roughly between 12° and 15°.

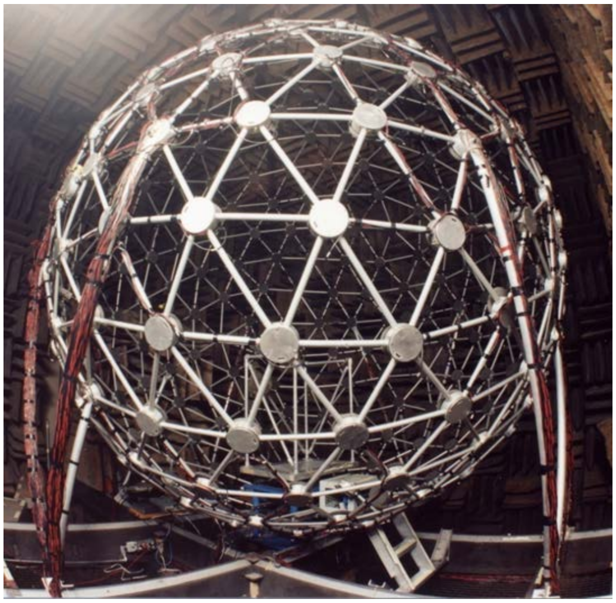

Figure 8. Auditory Localization Facility (ALF) at WPAFB

Subjects registered their responses with an Intersense IS-900 tracking system (Figure 9). The IS-900 used inertial-ultrasonic hybrid tracking technology to provide precise position and orientation information. The tracking system included a head tracker coupled with a response wand. The head tracker was mounted on the subjects' head to provide tracking data on the X, Y, and Z coordinate location of the head, as well as the yaw, pitch and roll during the duration of each trial. The head tracker also assisted the subject in aligning his/her head to the 0° azimuth, 0° elevation speaker location to begin each trial. The response wand was equipped with a joystick and five buttons which could be programmed for various purposes depending on the task. For this study, the subjects were required to press a single button while pointing the wand at their desired response location.

Figure 9. Intersense IS-900 tracking system

The stimuli were presented to the subjects in two different conditions. In one condition, the stimulus was a 250-ms burst of broadband (200 Hz - 16 kHz) pink noise. This duration was chosen in order to reduce the possibility that a subject would initiate a head movement during the stimulus presentation. Such a movement would provide dynamic localization cues, which would result in improved performance. In addition many real world sounds encountered by the user are likely to be short duration (e.g. weapons fire, explosions). In another condition, a broadband (200 Hz - 16 kHz) pink noise was presented continuously until a localization response was made. This allowed subjects to make use of dynamic localization cues and move their heads during stimulus presentation to orient to the sound.

The test configurations were the Invisio V60 X5 alone, the Ops-Core helmet alone, the Invisio V60 X5 with Ops-Core helmet, and a control configuration labeled as "Open," (unoccluded ear). The experiment was coded and executed using the MATLAB programming language by Mathworks™. For each configuration the subject fit him/herself with the appropriate device according to the directions provided by the manufacturer. The fit was verified by the experimenter, the hear-thru mode was activated, and the unity gain was set. The experimenter then directed the subject from the control room, where the fitting took place, into ALF. Once inside the sphere, the standing subject was raised or lowered by adjusting the height of the platform to ensure the subject's head was in the center of the sphere.

To start each trial the subject aligned his/her head to a loudspeaker located directly in front of them (0° azimuth, 0° elevation) and pressed a button on the response wand. A stimulus was presented randomly from one of the 237 speakers in the sphere. The stimulus was either a 250 ms burst of pink noise or a presentation of continuous pink noise. The subject would then locate and select the target speaker by pointing at it with the wand and clicking the response button to enter his/her selection. The LEDs on the speakers were tracked to the wand's movement so the subject could verify the location of his/her response. After a response was recorded, the LEDs of the target speaker were activated to give the subject feedback on his/her performance.

Each of the 8 subjects completed 320 trials in the burst noise condition and 64 trials under the continuous noise condition for each device configuration and one control condition in which no device was worn. Both burst and continuous stimuli could be presented in a single block of trials. All stimuli were presented at 65 dB.

Two metrics of particular interest were percentage of angular errors > 45˚, and percentage of front-back reversals. Both of these metrics were obtained from the same data set. Table 3 and Figure 10 show the percentage of mean angular errors that were >45º with each hearing protector for the burst and continuous noise conditions. Angular error is the difference between the actual target location and the subject's response location as measured by the distance between the two points along the surface of the sphere. The rationale behind this measurement was its operational relevance. In general, we assume that if an operator's attention can be directed to within 45°, he/she will then be able to use other sensory information, especially vision, to acquire the target. Subject data was collected with an “open” ear configuration (unoccluded ear) in order to serve as a reference point for determining how wearing a hearing protection and communication device affects localization performance. Subjects had errors >45° 1.4% of the time in the burst noise condition and 0.4% in the continuous noise condition when no device was worn. The data demonstrates that localization performance was degraded significantly when the Invisio V60 X5 was worn, with errors >45° 45.3% of the time in the burst noise condition and 27.7% of the time in the continuous noise condition. The addition of the Ops-Core helmet to the headset had no negative effect on localization performance with or without the headset.

Table 3. Percentage of mean angular errors > 45˚ for burst and continuous noise conditions

Device	Burst (%)	Continuous (%)
Open Ear	1.4	0.4
Ops Core Helmet	1.8	0.8
Invisio V60 X5 Headset	45.3	27.7
Invisio V60 X5 with Ops Core	44.6	25.2

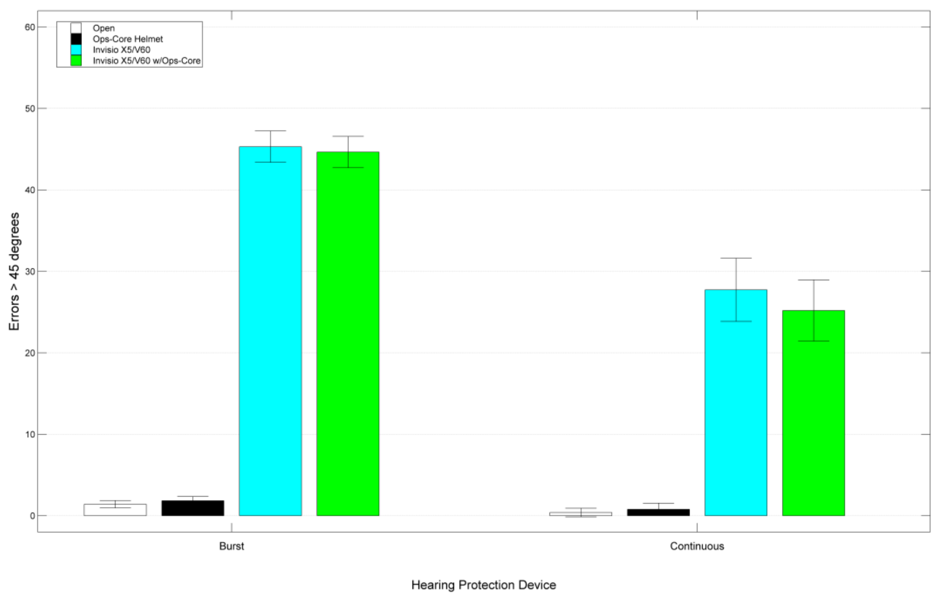

Figure 10. Percentage of mean angular errors > 45˚ for burst and continuous noise conditions

Front-back reversals occur when a subject is unable to determine whether a sound is in front of them or behind them. The percentage of front-back reversals is displayed in Table 4 and Figure 11. As previously stated, the percentages for front-back reversal are compiled from the same measurement as the errors >45°; these metrics are two different ways to interpret the same data set. In the ”Open” configuration the subjects had front-back confusions only 4.0% of the time in the burst noise condition and 0.9% in the continuous noise condition. The data for front-back reversals demonstrate that localization performance for burst noise was degraded when the Invisio V60 X5 was worn. However, analogous to the data from angular errors >45°, the addition of the Ops-Core helmet to any configuration had no negative effect on localization performance.

The percentages of front-back reversals for the continuous noise conditions for the Invisio with and without Ops Core helmet were similar to the open ear data.

Table 4. Percentage of front-back reversals for the burst and continuous noise conditions

Device	Burst (%)	Continuous (%)
Open Ear	3.9	1
Ops Core Helmet	5.1	0.6
Invisio V60 X5 Headset	23.8	3.1
Invisio V60 X5 with Ops Core	26.2	4.1

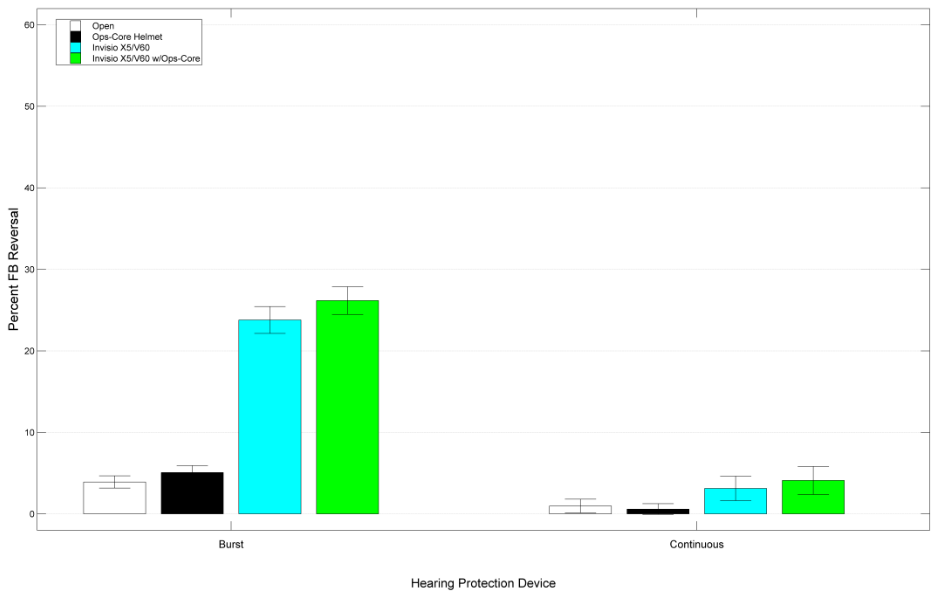

Figure 11. Percentage of front-back reversals for the burst and continuous noise condition

3.5 Aurally Guided Visual Search

Data were collected in an aurally guided visual search task using the same eight subjects that participated in localization measurements. All measurements were collected in ALF at WPAFB. The facility design and setup, as well as the subject fitting procedure and setup procedure once inside facility, are described in detail in the localization section above.

As previously indicated, a cluster of four LEDs was mounted at the center of each speaker in ALF. Subjects were tasked to complete an aurally guided visual search task where they identified a visual target in the presence of 50 visual distracters at randomly selected positions around the sphere. For this task, the target stimulus was a cluster of LEDs in which either two or four LEDs were illuminated. The distracter stimuli were clusters of LEDs with either one or three illuminated LEDs. In addition, a 250 ms burst of broadband (200 Hz - 16 kHz) pink noise was played from the speaker at the target location at a predetermined sound level. The time required for the subject to find and identify the target was measured as a function of the noise-burst SPL with the communication device, with the “Open” configuration (unoccluded ear) as a reference.

To start each trial the subject aligned his/her head with a designated loudspeaker located directly in front of them (defined as 0° azimuth, 0° elevation) and pressed the trigger button on the underside of the response wand. At this point, 50 distracter stimuli were illuminated along with the one target stimulus. The subjects’ task was to quickly locate the target stimulus and identify whether two or four LEDs were illuminated at the target location by pressing a response button on the top of the ALF response wand. After the subject recorded his/her response, he/she would realign to the front speaker to begin the next trial.

The configurations were the Invisio V60 X5 and a control condition labeled as “Open,” (unoccluded ear). Each of the eight subjects completed 180 trials per configuration, with 60 trials at 15, 40, and 70 dB. In addition, each subject completed 60 trails in an unoccluded (open) visual only condition where the subject was given no auditory clue and forced to visually search for the target. Levels were selected that spanned a range from quiet to easily audible (not to exceed 85 dB SPL at the eardrum).

Previous results from our lab have shown a large reduction in the time it takes to acquire a visual target when a sound that is easily detectable and localizable was played from the target location, relative to a visual search with no aural guide. A reference point for the visual only search was added to Figure 12. The subjects took at least 5 more seconds to find the target when wearing the Invisio V60 X5 in comparison to the open-ear condition regardless of the generated noise level. The averaged response times decreased with increasing presentation level as the auditory stimuli become more audible and localizable (Figure 14). However, even at the maximum presentation level the performance was still degraded when wearing the Invisio V60 X5 in comparison to the open-ear condition.

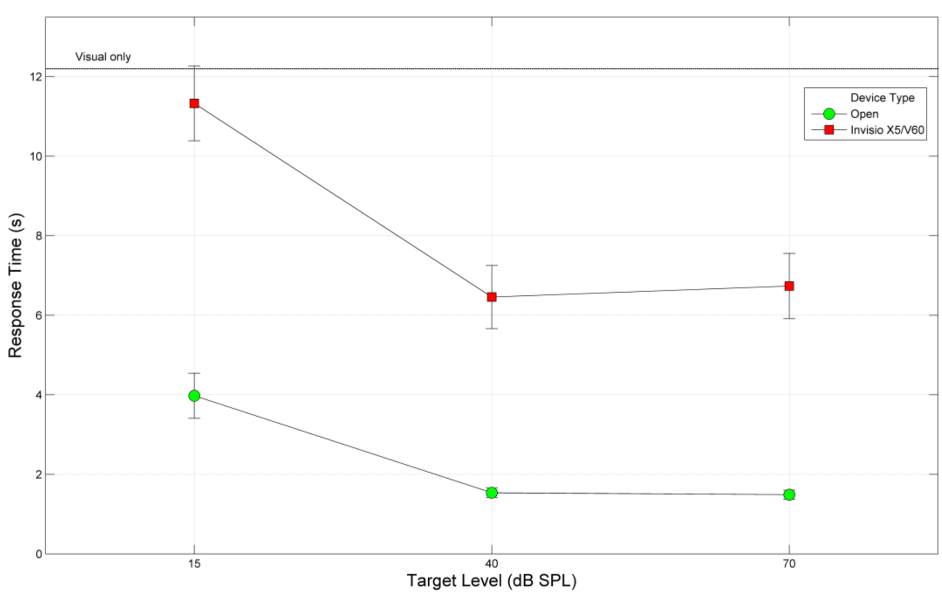

Figure 12. Average response time for an aurally guided visual search task

3.6 Speech Intelligibility

The AFRL VOice Communication Research and Evaluation System (VOCRES) facility was used to measure speech intelligibility performance with the Invisio V60 X5. VOCRES was designed to evaluate voice communication effectiveness in operationally-realistic acoustic environments. The facility consists of a programmable, high-power sound system housed in a large, reverberant chamber, capable of generating high-level (130 dB SPL) noise emulating acoustic environments in operational situations. Ten operator workstations were positioned in the facility (Figure 13), each equipped with a touch-screen display and communication system capable of replicating end-to-end military communication chains (i.e., intercoms, oxygen systems, headsets, microphones, and helmets). In this way, full communication systems, as well as individual system components, may be evaluated under operational conditions to determine the impact these systems might have on speech intelligibility and communication effectiveness.

Figure 13. AFRL's VOCRES facility used to measure speech intelligibility performance

Participants were monitored by the experimenter using a closed-circuit camera and monitor system. Verbal instructions regarding experimental procedures were provided to participants. Speech stimuli were presented by live talker. Cueing of target words for the talker and recording of listener responses were both accomplished via a custom MatLab 7.0 application. A laptop computer with a graphical user interface (GUI) was utilized for subject response. The talker and listeners had individual computers at their respective work stations.

Measurements were conducted in accordance with ANSI S3.2[3] with the exception of the number of subjects. Specifically, four talkers and four listeners rather than the standard five talkers and five listeners were run due to limited equipment availability. The Modified Rhyme Test (MRT) was selected for the test material. The MRT consists of 50 six-word lists of rhyming monosyllabic English words. Measurements for the device were collected in 65, 85, and 105 dB overall sound pressure level. The talker and listeners were in the same noise environment. The goal was to quantify the ability of trained listeners to correctly identify target words transmitted by a trained talker using the combination of Multi-Band Intra/Inter Team Radio (MBITR) and the Invisio V60 X5 Headsets.

For data collection, each presentation of a MRT list consisted of one talker position and three listener positions. Each talker completed three MRT lists in each noise condition. During the experimental task, the talker was presented with the stimulus on the computer screen ("You will mark MRT word, please"). The talker then communicated the phrase to the three listeners via the MBITR radio and headset combination. Listeners selected the word heard by using a pen to click on the correct word from a list of six words on the tablet screen. Responses were recorded and an average score was calculated. An example of the MRT format for the talker and listener stations is provided in Figure 14.

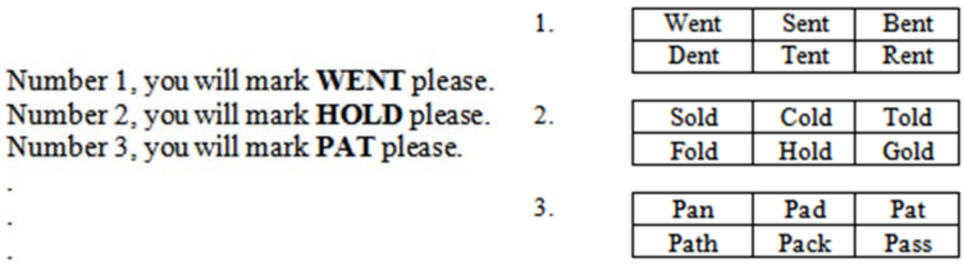

Figure 14. Examples of the talker (left) and listener (right) ensembles

Speech intelligibility results were combined for all subjects for each noise level. The subjects' scores were adjusted for guessing as described in ANSI S3.2.[3] An overall average was then calculated for all subjects.

$$Score = 2(R - \frac{W}{n-1})$$

Where:

$Score$ = Percent Correct (Adjusted For Guessing)

R = Number Correct

W = Number Incorrect

n = 6 (number of choices available to listener)

The bone conduction microphone embedded in the X5 headset was used during the 65 and 85 dB measurements and the Invisio hybrid external boom microphone was used during the 105 dB measurements.

Table 5. Speech Intelligibility Scores with Invisio V60 X5

Noise Level (dB)	% Correct
65 dB	77.9
85 dB	70.4
105 dB *	71.1

* Invisio hybrid boom microphone

4.0 DISCUSSION

All hearing protection devices can and should be assessed in multiple ways to describe the performance of the device and the effects on an operator's ability to perform the mission. Subjective and objective measurements can be conducted to characterize a device's noise attenuation performance as well as any effect on situational awareness that may result. Passive attenuation in continuous noise environments, auditory localization capabilities, and speech intelligibility were all assessed for the Invisio V60 X5.

4.1 Localization versus Attenuation

Military personnel are exposed to various noise environments depending on their mission: continuous and/or impulsive, predictable and unpredictable. Also, dependent on their mission, the metrics measuring the performance of the hearing protection device may carry different weighting. For some missions, auditory localization may be more important than noise attenuation while for other missions attenuation may be more important than localization. These different weightings should be considered by those who are selecting hearing protection and communication devices for a particular mission or group of users. It is critical to consider the environment of the end user, and evaluate the pros and cons for each assessment area independently for an informed decision. The end user must be aware that their ability to localize environmental sounds will not be as good as the unoccluded ear when using the Invisio V60 X5.

4.2 Speech Intelligibility

The Invisio V60 X5 did not perform in the acceptable range for speech intelligibility for any of the noise conditions. A score of 80% or greater would be considered acceptable according to current military standards.[13] The addition of the boom mic at 105 dBA yielded an equivalent speech intelligibility score to the performance of the Invisio V60 X5 with the bone conduction microphone at 85 dBA. Therefore, it may be advisable to consider consistent use of the Invisio hybrid external boom microphone with the Invisio system in all noise conditions to improve speech intelligibility performance.

5.0 CONCLUSION

Hearing protection and communication devices that have active components have been designed to provide the user with enhanced communication abilities and amplify low level sounds to allow localization capabilities while still providing protection from noise. The Invisio V60 X5 tactical headset caused significant impairments to localization performance versus the unoccluded ear. Additionally, the Invisio V60 X5 did not meet acceptable speech intelligibility scores for the current military standards at any of the measured noise levels. The results of the hearing protector and communication device performance assessment may provide insight into the development of design criteria for the next generation of devices.

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