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Noise Attenuation Performance of the Joint Service Aircrew Mask (JSAM) Type I (MPU-5) Rotor Wing (RW) with Flight Helmets

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14. ABSTRACT
Noise attenuation performance tests were performed on the Joint Service Aircrew Mask (JSAM) Type I (MPU-5) Rotor Wing (RW) with the HGU-56/P and HGU-84/P helmets at the Air Force Research Laboratory's (AFRL) Acoustics facilities at Wright-Patterson Air Force Base September 2009. The MPU-5 was tested and compared to legacy masks (M-45, AERP, and AR-5). An American National Standards Institute (ANSI) method ANSI S-12.42-1995(R2004) was used to measure the passive attenuation. Passive insertion loss was comparable for all systems in combination with HGU-56/P. The AR-5 did outperform the MPU-5 across all frequencies when tested in combination with HGU-84/P. In addition, the MPU-5 causes significant degradation of the helmet attenuation when comparing the helmet with and without the MPU-5.

15. SUBJECT TERMS
JSAM, MPU-5, HGU-56/P, HGU-84/P, attenuation, MIRE, passive insertion loss, M-45, AERP, AR-5

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EXECUTIVE SUMMARY

Noise attenuation performance tests were performed on the Joint Service Aircrew Mask (JSAM) Type I (MPU-5) Rotor Wing (RW) in combination with service-specific helmets at the Air Force Research Laboratory's (AFRL) acoustics facilities at Wright-Patterson Air Force Base in September 2009. Measurements for legacy systems were also collected to facilitate a direct comparison of octave-band attenuation values for JSAM variants versus legacy systems among the same sample of subjects. An American National Standards Institute (ANSI) method was used to measure the passive attenuation. Passive attenuation was measured using ANSI S-12.42-1995(R2004): Microphone-in-Real-Ear (MIRE) and Acoustic Test Fixture Methods for Measurement of Insertion Loss of Circumaural Hearing Protection Devices. Four chemical/biological hoods (MPU-5, M-45, AERP, and AR-5) were tested in combination with two service-specific helmets (HGU-56/P and HGU-84/P). The MPU-5 was tested in combination with the HGU-56/P and the HGU-84/P helmets. The measurements for the legacy systems were completed using the M-45 mask in combination with the HGU-56/P helmet, the AR-5 mask in combination with the HGU-84/P helmet, and the AERP mask in combination with the HGU-56/P helmet. The noise attenuation performance was measured and then compared between MPU-5 and legacy service configurations. The JSAM-RW Performance Specification [71] requirement defines that when integrated, no more than a 3 dB degradation of the measured one-third octave band hearing attenuation shall result when compared to the original (non – JSAM) configuration. Similar passive insertion loss was found for all systems in combination with the HGU-56/P flight helmet. The AR-5, however, did outperform the MPU-5 when in combination with the HGU-84/P helmet across all frequency bands. In addition, the MPU-5 causes degradation of the helmet noise attenuation when comparing the helmet with and without the MPU-5.

1.0 INTRODUCTION

The JSAM Type I is a light-weight, chemical/biological/radiological (CBR) protective respirator, which provides "above the shoulder" CB protection for aircrews (Figure 1). The Type I is a modular system, with two variants; Type Ia for the AH-64D Apache helicopter and the Type I (MPU-5) for all other rotary wing aircraft (except the TOPOWL aircraft). JSAM will integrate with existing aircrew helmets and aircrew CB protective garments such as the Joint Protective Aircrew Chemical Ensemble (JPACE) to form an integrated CB protective ensemble. Selected components of JSAM will be capable of being donned in-flight (added to other components that were donned before takeoff) such that a complete above the shoulder CB protection is achieved. Aircrews will wear the JSAM based on threat and operational requirements. Aircrews will also perform extended ground duties such as pre-flight, post-flight, rearming, refueling and cargo loading of aircraft while wearing the JSAM and emergency actions such as ground escape and evasion.

Figure 1. Test subject wearing the MPU-5

AFRL, 711th Human Performance Wing, Human Effectiveness Directorate, Warfighter Interface Division, Battlespace Acoustics Branch (711 HPW/RHCB) was requested to evaluate the noise attenuation performances of the MPU-5 in combination with the HGU-56/P (Army/AF helicopter helmet, Figure 2a) and the HGU-84/P (Navy helicopter helmet, Figure 2b). The M-45 mask (Figure 3a) in combination with the HGU-56/P helmet, the AR-5 mask (Figure 3b) in combination with the HGU-84/P helmet, and the AERP mask (Figure 3c) in combination with the HGU-56/P helmet was also tested. The noise attenuation tests were performed at the 711 HPW/RHCB facilities in September 2009. The test objectives were to identify any operability shortcomings and determine if sound attenuation goals are met for the MPU-5 and also to compare the MPU-5 with the legacy systems. The JSAM requirement is shown below.

> [71] *The JSAM when integrated with existing and developmental head-mounted personal/life support equipment in Appendix E shall result in no more than a 3 dB degradation of the measured one-third octave band hearing attenuation compared to the original (non-JSAM) configuration.*

Ten subjects participated in the attenuation tests, as ten subjects is the minimum amount for Microphone-in-Real-Ear tests, ANSI S12.42-1995(R2004). All subjects were expertly fitted by a trained program representative.

a. b.

Figure 2. Legacy flight helmets a. HGU-56/P b. HGU-84/P

a. b. c.

Figure 3. Legacy CB masks a. M-45 b. AR-5 c. AERP

2.0 METHODS

2.1 Subjects

Ten paid volunteer subjects (5 male, 5 female) participated in the attenuation tests on the HGU-56/P and the HGU-84/P helmets in combination with the MPU-5, M-45. AR-5, and the AERP mask, Table 1. All subjects were given a visual otoscopic examination and had hearing threshold levels no worse than 15 dB HL at 250, 500, 1000, 2000, 3150, 4000, 6300, and 8000 Hz. The ten subjects ranged in age from 18 to 25 with a mean age of 22 years. The average head width was 15.0 cm, ranging from 13.9 to 15.8 cm and the average head length was 19.1 cm, ranging from 18.2 to 20.2.

2.2 Microphone in Real Ear Testing

2.2.1 Equipment

The Air Force Research Laboratory's MIRE facility and measurements were operated in accordance with ANSI S12.42-1995(R2004). The MIRE facility was used to generate the 105 dB SPL ambient sound field and to collect the open and occluded noise measurements at the entrance to the ear canal. The miniature microphones used to measure the sound pressure levels at the subject's ears were Knowles, model BT-1759. There are three wires from the microphone; two of the wires are AWG 28 and the third wire is AWG 34. These wires were run between the ear seal and the subject's head with negligible acoustic leakage, ANSI S12.42. Sound level measurements were made from the outputs of the microphones to a National Instruments PCI-44472 dynamic signal acquisition card. The HGU-56/P flight helmet with MPU-5 in the MIRE facility is shown in Figure 4.

Figure 4. The HGU-56/P flight helmet with MPU-5 in MIRE facility

2.2.2 Procedure

The standard procedures as described in ANSI S12.42-1995(R2004) were used to collect all the hearing protection data in the MIRE facility. Insertion loss measurements were made for both ears simultaneously with a Knowles microphone in each ear. Insertion loss is defined as the algebraic difference in decibels between the sound pressure levels measured at the reference point with and without the hearing protection device in place.

The microphone was positioned in the region of the entrance to the ear canal of the subject and the sensing surface of the microphone was parallel to the plane of the ear canal opening. To keep the microphone secured and in correct position with the fitting and refitting of the hearing protection device a stem was glued to the back of the microphone. The stem was then inserted into an earplug tube and the wires were routed around the ear.

Three open ear and three occluded ear (open before each occluded) measurements were made with the ten subjects. The device was visually checked by the fitter prior to the start of each trial to ensure proper placement. Mean attenuation values were computed by averaging the insertion loss at each third-octave band for all subjects using a Labview Sound and Vibration toolkit.

2.2.3 Configurations

Table 1. MIRE test configuration

	Chemical/Biological Mask			
Helmet	MPU-5	M-45	AR-5	AERP
HGU-56/P	X	X		X
HGU-84/P	X		X	

3.0 RESULTS

3.1 Comparison of MPU-5 and Legacy Service Configurations

The MPU-5, M-45, and AERP were all tested in MIRE in combination with the HGU-56/P flight helmet. The MPU-5 was also tested along with the AR-5 in combination with the HGU-84/P flight helmet. A comparison of the MPU-5 with each legacy service configuration is shown below, Figures 5-7. The measured attenuation is plotted per frequency (100 to 10000 Hz). The higher the attenuation, the greater the noise reduction.

3.1.1 MIRE Comparison – HGU-56/P with MPU-5 and M-45

The passive attenuation data of the MPU-5 in combination with the HGU-56/P was similar in performance or provided greater attenuation for the entire frequency range (Figure 5) than the M-45 in combination with the HGU-56/P.

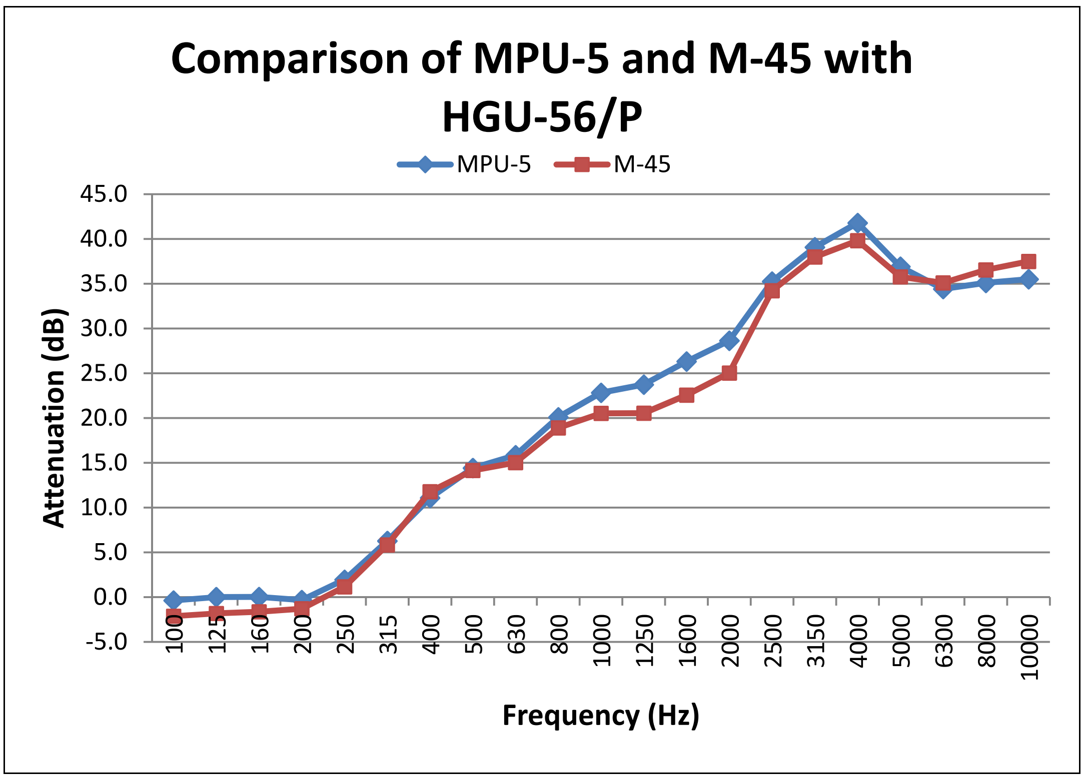

Figure 5. The MIRE results comparing the passive attenuation data of the MPU-5 and the M-45 with the HGU-56/P flight helmet

3.1.2 MIRE Comparison – HGU-56/P with MPU-5 and AERP

The MPU-5 with HGU-56/P had similar attenuation performance (within 3 dB) when compared to the AERP with HGU-56/P from 100 to 5000 Hz, Figure 6. The legacy system slightly outperformed the MPU-5 system at the higher frequencies (6.3 to 10 kHz) but without exceeding the total 8 dB difference over the various octave bands stated in the pass/fail criteria.

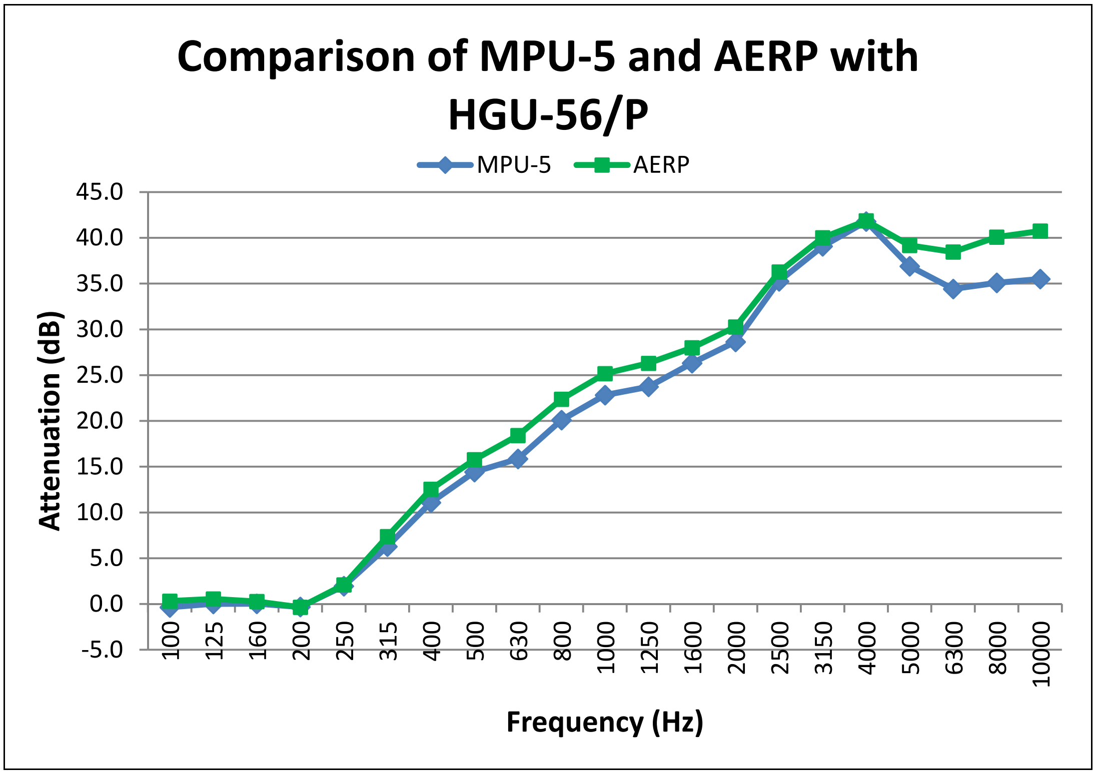

Figure 6. The MIRE results comparing the passive attenuation data of the MPU-5 and the AERP with the HGU-56/P flight helmet

3.1.3 MIRE Comparison – HGU-84/P with MPU-5 and AR-5

The MPU-5 had a decrease in attenuation performance of 4.8 dB or more when compared to the legacy system, AR-5, in combination with the HGU-84/P flight helmet as shown in Figure 7.

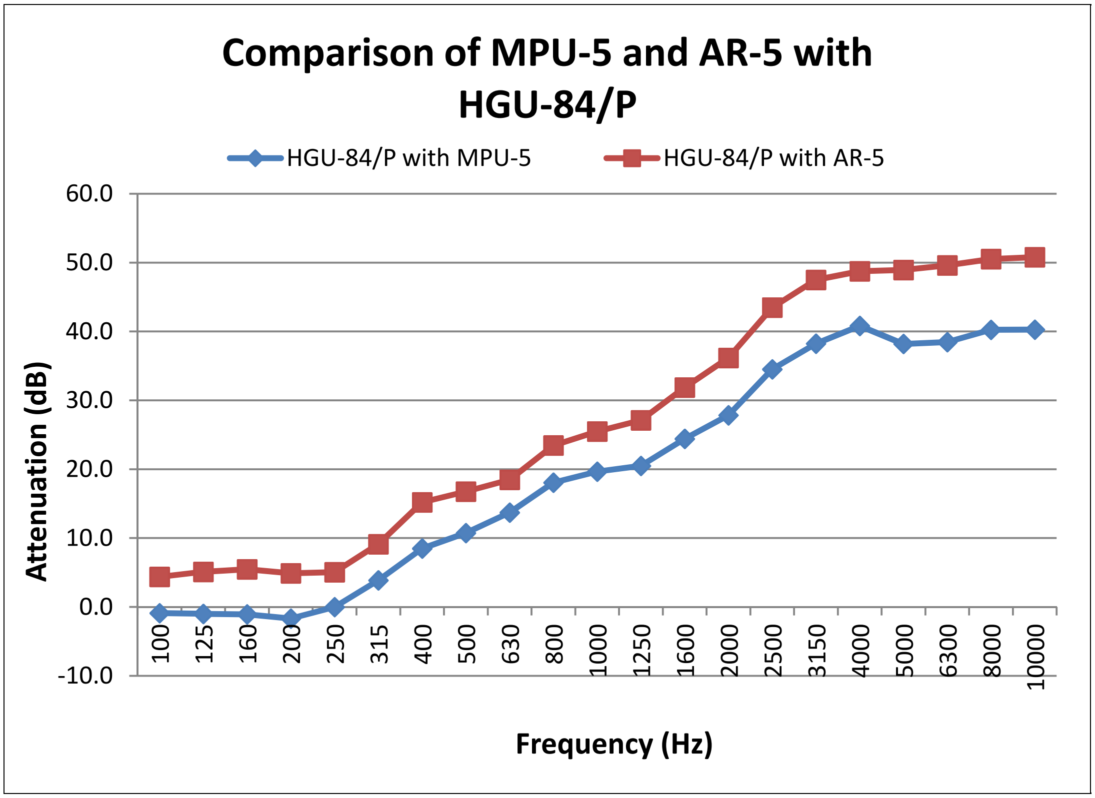

Figure 7. The MIRE results comparing the passive attenuation data of the MPU-5 and the AR-5 with the HGU-84/P flight helmet

3.2 Comparison of helmet with and without MPU-5

The HGU-56/P and the HGU-84/P helmets were tested previously in MIRE with the same 10 subjects to determine the passive noise attenuation performance. The results of the MIRE insertion loss comparisons between the flight helmets with and without the masks are shown below, Figures 8-9. The measured attenuation is plotted per frequency (100 to 10000 Hz). The higher the attenuation, the greater the noise reduction.

3.2.1 MIRE Comparison – HGU-56/P Helmet with and without the MPU-5

The addition of the MPU-5 in combination with the HGU-56/P helmet, negatively affects the attenuation of the system when compared to the helmet alone. A decrease of 4.7 dB or more was found across all frequencies as seen in Figure 8, except at 3150 Hz where there was a difference of 1.4 dB.

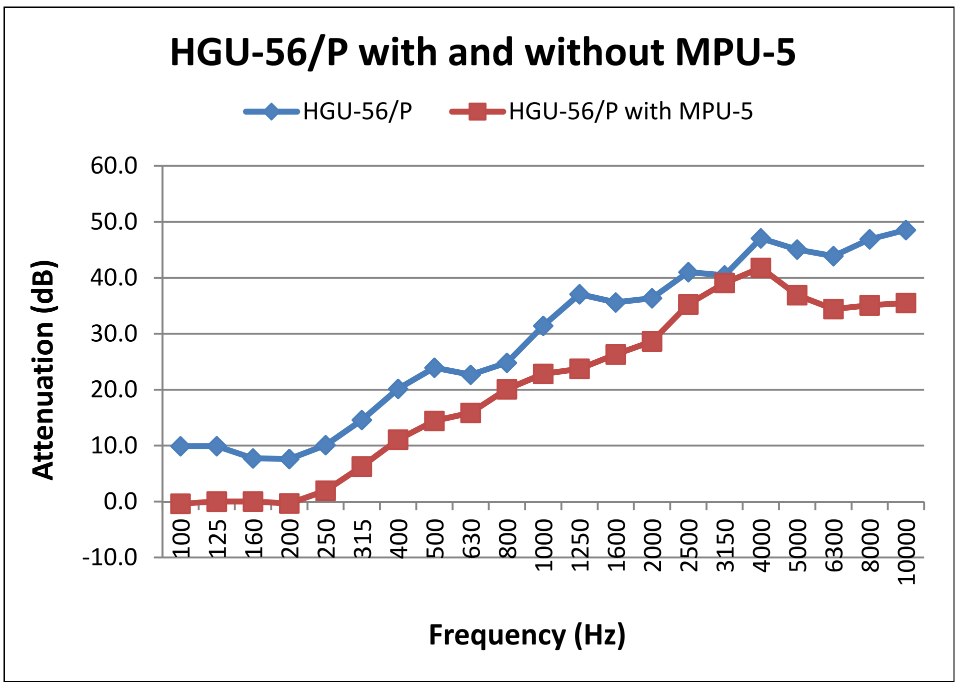

Figure 8. The HGU-56/P MIRE results comparing the helmet passive attenuation data with the MPU-5 and alone

3.2.2 MIRE Comparison – HGU-84/P Helmet with and without the MPU-5

The addition of the MPU-5 in combination with the HGU-84/P helmet, negatively affects the attenuation of the system when compared to the helmet alone. A decrease of 6.1 dB or more was found across all frequencies as seen in Figure 9.

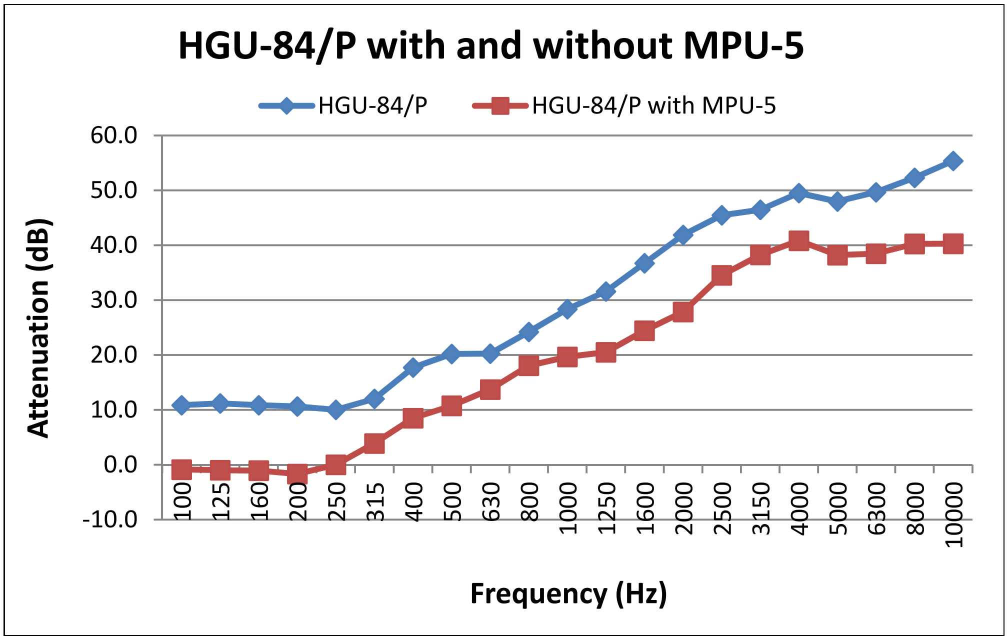

Figure 9. The HGU-84/P MIRE results comparing the helmet passive attenuation data with the MPU-5 and alone

4.0 DISCUSSION

The JSAM requirement is shown below.

> [71] *The JSAM when integrated with existing and developmental head-mounted personal/life support equipment in Appendix E shall result in no more than a 3 dB degradation of the measured one-third octave band hearing attenuation compared to the original (non-JSAM) configuration.*

The implied intent of this requirement was that no individual JSAM configuration one-octave band attenuation would be perceptively different from the original (non-JSAM) configuration attenuation. The just noticeable intensity difference for a non-expert listener is 3 dB. In laboratory conditions with well trained subjects the just noticeable intensity difference is 1 dB.

4.1 Microphone in Real Ear (MIRE)

The MIRE measurement method (ANSI S12.42) was developed for engineering controls and product development/assurance. This method was selected as the test methodology for assessing the difference between configurations and thereby the compliance with the JSAM requirement [71]. The basic requirement was that the JSAM should be no more than 3 dB worse than the baseline (legacy) system. Differences of 4 dB and greater contribute to the overall failure consideration with each dB over the target maximum difference at 3 dB per band additional to the potential for failure. If multiple bands are over by more than 1 dB or the total dB over the various bands exceeds 8, the individual test would be considered a failure.

The MPU-5 had similar passive attenuation performance when compared to the service specific legacy systems in combination with the HGU-56/P flight helmet. The MPU-5 was comparable, provided greater attenuation, than the M-45 with the HGU-56/P. The MPU-5 was also comparable to the AERP with the HGU-56/P at all octave-band frequencies except the highest frequencies. Overall, the MPU-5 passed the specified criteria when compared to the legacy systems in combination with the HGU-56/P. The MPU-5 had a decrease in attenuation performance when compared to the AR-5 in combination with the HGU-84/P across all octave bands.

When comparing the flight helmets with and without the MPU-5, the HGU-56/P and the HGU-84/P attenuation performances were degraded when tested with the MPU-5. The degradation caused by the addition of the MPU-5 could be due to the folds in the material. A fold in the material may cause a leak; a direct path for noise to reach the ear. A small leak can reduce attenuation by as much as 10 dB. The insertion loss was 8 and 10 dB for the HGU-56/P and HGU-84/P respectively. The use of a custom earplug (CEP or similar) could potentially improve attenuation of the system.

5.0 CONCLUSIONS

The JSAM program established a requirement that MPU-5 should not degrade noise attenuation more than 3 dB at any one-third octave band. The data presented in this report demonstrate that the MPU-5, when compared to legacy systems, does meet that requirement when tested in combination with the HGU-56/P. Personnel using the MPU-5 will not notice degradation in noise attenuation and in most user noise environments there should not be an increase in personnel noise exposure. However, the HGU-84/P helmet, when tested with the MPU-5, does not meet that requirement when compared to the legacy system. Personnel using MPU-5 may notice degradation in noise attenuation. When comparing the flight helmets with and without the MPU-5, a decrease in attenuation may be noticed when the MPU-5 is employed.

The MPU-5 and legacy system attenuation performances were collected in accordance with ANSI procedures for measuring the attenuation of hearing protectors and hearing protection systems.

6.0 REFERENCES

ANSI S12.42 – 1995(R2004) American National Standard Microphone-in-Real-Ear and Acoustic Test Fixture Methods for the Measurement of Insertion Loss of Circumaural Hearing Protection Devices.

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Test Protocol: Hearing Performance and Protection Associated with Personal Protective Equipment. F-WR-2008-0007-H.

LIST OF ABBREVIATIONS AND ACRONYMS

711 HPW/RHCB	711th Human Effectiveness Directorate, Warfighter Interface Division, Battlespace Acoustics Branch
AERP	legacy CBR mask
AFRL	Air Force Research Laboratory
AH-64D	Apache helicopter
ANSI	American National Standards Institute
AR-5	legacy CBR mask
CBR	chemical/biological/radiological
HGU-56/P	Army/Air Force helicopter helmet
HGU-84/P	Navy helicopter helmet
JPACE	Joint Protective Aircrew Chemical Ensemble
JSAM	Joint Service Aircrew Mask
MIRE	Microphone-in-Real-Ear
M-45	legacy CBR mask
MPU-5	Type I
RW	rotor wing