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**Noise Attenuation Performance of the HGU-25/P
Flight Deck Helmet Integrated with the Argonaut
Headset and CEP-Custom Communication Earplugs**

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July 2013

Interim Report

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EXECUTIVE SUMMARY

The intense noise environment on the flight deck of a United States Navy aircraft carrier is a unique one. Aircraft maintainers and flight deck personnel working in this high noise environment are required to wear double hearing protection to protect their hearing. Currently the flight deck crews don the HGU-25/P flight deck helmet with foam earplugs. The Naval Air Warfare Center, Aircraft Division (NAVAIR) is working to improve the hearing protection for those personnel. The noise attenuation performance of a hearing protection device is important in order to estimate the expected noise exposure.

Noise attenuation performance measurements were collected at the Air Force Research Laboratory's (AFRL) Battlespace Acoustics Branch at Wright Patterson Air Force Base from June - July of 2013. Passive noise attenuation was measured using ANSI S12.6-2008 Methods for Measuring the Real-Ear Attenuation of Hearing Protectors, Method A.¹ All real-ear attenuation at threshold (REAT) measurements were completed with the HGU-25/P flight deck helmet integrated with the Argonaut headset and CEP-custom communication earplugs. The noise attenuation results for the passive double hearing configuration were reported for each individual subject as well as mean and standard deviation results for all subjects.

1.0 INTRODUCTION

The HGU-25/P was developed specifically for the flight deck of aircraft carriers to provide both impact protection and hearing protection (Figure 1). The HGU-25/P consists of a cloth liner, impact pads, a headset, and a chin strap. Aegisound's Argonaut Communication Headset (M/A-COM/F/A-18 ICS Variant) was integrated into the HGU-25/P (Figure 2) as a passive hearing protector and communication device. Custom molded communication earplugs were desired to replace the foam earplugs currently being worn. The CEP was developed by Communications and Hearing Protection, Inc. (Figure 3) to provide increased hearing protection as well as improved communication capability to the user. The custom earpieces were manufactured by Westone (CEP508-C15 full shell, non-vented).



Figure 1. HGU-25/P Flight Deck Helmet



Figure 2. Aegisound's Argonaut Communication Headset integrated into the HGU-25/P



Figure 3. CEP-Custom Communication Earplugs

2.0 METHODS

2.1 Subjects

Twenty paid volunteer subjects (9 male, 11 female) participated in the noise attenuation performance measurements. All subjects had hearing threshold levels less than or equal to 25 dB hearing level (HL) from 125 to 8000 Hz. The subjects ranged in age from 20 to 32 with a mean age of 25 years. Subjects' sex and anthropometric head measurements are reported in Table 1. Photographs of each subject wearing the double hearing protection configuration are posted in Attachment 1. All subjects signed an informed consent document and measurements were collected under protocol FWR20070008H approved for human use by the Wright-Site Independent Review Board (IRB).

Table 1. Individual subjects' sex and anthropometric head measurements

Subject ID	Sex	Ear Canal Size		Head Width (cm)	Head Height (cm)	Head Circ (cm)
		L	R			
1584	M	M	M	13.7	12.7	57.0
1438	F	S	M	13.3	12.5	57.7
1564	F	S	S	12.8	12.0	55.0
1581	M	M	M	15.3	14.1	61.0
1487	F	XS	XS	13.0	11.5	57.1
1436	M	M	M	14.3	12.0	60.0
1208	F	M	M	13.6	12.5	57.5
1546	M	M	L	14.0	12.8	58.0
1575	M	M	M	15.5	13.8	56.5
1451	F	S	XS	12.4	12.3	55.0
47	M	XL	XL	13.9	13.3	59.5
1594	F	M	M	13.5	13.8	55.0
1595	M	S	M	15.0	14.0	58.5

1602	F	M	M	13.5	12.5	53.5
1591	F	S	S	13.7	12.5	55.0
1561	F	M	L	13.5	11.5	56.5
1550	M	M	M	13.9	12.5	57.5
1526	F	S	S	14.2	12.0	57.0
1534	M	S	S	13.7	13.0	56.5
1382	F	M	M	13.0	12.5	57.0

2.2 REAT – Passive Noise Attenuation

The AFRL REAT facility was used to measure the passive attenuation performance of hearing protectors. The facility was built for the measurement, analysis, and documentation of the sound attenuation properties of passive hearing protection devices. The chamber, its instrumentation, and measurement procedures were in accordance with ANSI S12.6-2008.¹ Daily noise floor measurements were measured and reported in Table 2. The procedures described in ANSI S12.6 consist of measuring the open ear (without the hearing protector, Figure 4) and occluded ear (with the hearing protector) hearing thresholds of human subjects using a von Békésy tracking task. These psychoacoustic thresholds were measured two times for the open condition and two times for the occluded condition. The real-ear attenuation at threshold for each subject was computed at each octave frequency, 125, 250, 500, 1000, 2000, 4000, and 8000 Hz, by averaging the two trials (the difference between open and occluded ear hearing thresholds). The mean and standard deviation at each frequency was then calculated across all the subjects.

Table 2. Noise floor measurements in REAT facility

NOISE FLOOR DATA 6/3-7/3											
Date	Frequency (Hz)										
	32	63	125	250	500	1000	2000	3150	4000	6300	8000
6/3/2013	43.1	24.3	12.6	1.3	-4.9	-5	-2.8	-7.9	-7.9	-6.4	-6.4
6/4/2013	43.5	31.6	16.1	4.6	0.07	-3.4	-5.1	-7.7	-7.7	-6.3	-6.3
6/5/2013	44	25.6	11.5	2.4	-6.2	-7.5	-6.6	-8	-8	-6.4	-6.4
6/6/2013	43.8	26.9	13.7	2.7	-7.4	-8.3	-6.5	-8.1	-8.1	-6.3	-6.3
6/7/2013	42.4	26	12.1	4.9	-0.5	-5.2	-6.5	-8.2	-8.2	-6.3	-6.3
6/11/2013	43.2	34.8	14.1	3.4	-6.2	-6.1	-5.3	-7.9	-7.9	-6.1	-6.1
6/12/2013	44.5	26.6	14.3	2	-5.1	-5.7	-7	-8	-8	-6.3	-6.3
6/26/2013	38.6	34.7	19.1	7.2	-1.3	-8.4	-5.2	-7.2	-7.2	-5.8	-5.8
6/27/2013	41.2	34	19.7	8.8	0.5	-8.1	-5.3	-7.2	-7.2	-5.8	-5.8
6/28/2013	42.7	34.5	19	8.1	3.2	-2.7	-3.6	-6.5	-6.5	-5.7	-5.7
7/2/2013	39.6	30.8	19.6	8.3	0.8	-6.8	-2.6	-6.9	-6.9	-5.9	-5.9
7/3/2013	41	29.5	20.7	8.5	1.3	-7.3	-6	-7.2	-7.2	-5.8	-5.8



Figure 4. Female subject in REAT facility, open ear condition

2.3 Headband Force

The headband force was measured on all three samples of the HGU-25/P integrated with the Argonaut headset. The force was measured 2 minutes after the hearing protector was positioned on the test fixture in accordance with ANSI S12.6-2008. The average headband force was 19.3 N. The temperature was 74 degrees Fahrenheit and the relative humidity was 44% in the laboratory where the measurements were collected.

3.0 RESULTS

Passive noise attenuation measurements using ANSI S12.6 methods were collected on the HGU-25/P worn in conjunction with the Argonaut headset and custom CEP earplugs. Individual subject data as well as mean and standard deviation data for all subjects are reported.

3.1 REAT – Individual Subject Data

Passive noise attenuation data were measured on the HGU-25/P with the Argonaut headset and custom CEP earplugs at AFRL's REAT facility. The passive attenuation data for two trials (occluded ear minus open ear threshold data) for each subject are shown in Table 3.

Table 3. Individual Subject Threshold Data per Trial

Subject ID	Trial	Frequency (Hz)						
		125	250	500	1000	2000	4000	8000
1584	1	20.33	19	28.33	32	38.5	47.83	40.67
	2	15.67	16.67	22.67	25.67	32	40.5	33.33
1438	1	26	32.33	34	36.67	38	49.17	46
	2	25.33	33.67	33.67	41	38	49.33	46

1564	1	27.33	26.33	32	37.33	38.5	49.67	51.33
	2	13.33	25.33	28.67	34.33	42.17	38.83	53
1581	1	12.17	9.33	24.67	33.33	44	44	49.5
	2	6.33	14.33	24	33.5	41.17	47	54.83
1487	1	22.67	28.67	27.33	32.67	31	45	54
	2	13.33	29	34.67	37.5	35	48.33	47.33
1436	1	28.67	36.33	36.67	36.33	35.5	43.33	50.67
	2	28	36	36	37.67	37.5	43	52.67
1208	1	23.67	30.67	30.67	36.17	36.5	50	50
	2	29.33	32.67	35.67	40.5	39.67	50.67	50
1546	1	11	34.67	32	34.33	40	49.67	53.67
	2	9.67	14.33	29	35.33	41.33	49	47.17
1575	1	20.67	27.83	25.83	27.83	32	46.67	56.33
	2	30.5	33.67	23	26.33	39.17	48.33	60.17
1451	1	9.33	23	29.33	41	37	50.33	49
	2	33	39.67	34	42.83	37.67	49.83	48
47	1	11.67	24.67	17	23.5	34.83	44.17	50.33
	2	16.33	27	17.67	25.5	35	47.67	52.83
1595	1	22.33	31	25.67	34	39.17	40	56
	2	29.67	29	31.67	38	38.83	42.33	53.83
1594	1	7.33	18.33	29.67	36.67	42	53.5	55.33
	2	19.33	31.67	33.67	38.67	43.67	49.5	55.17
1602	1	26	28.33	33.67	26.33	31.33	48.17	55.67
	2	27.33	25.67	26	27.33	32.33	47.83	50.33
1591	1	37	34	36.33	42.17	41	50	52
	2	32	38	27.33	38.67	36.67	51.17	50
1561	1	12.67	20.33	26.33	26.67	25.67	55.33	53.33
	2	28.67	25.33	24.33	26	28	46.33	47.67
1550	1	19	35	28	32.67	39.17	40.83	55.33
	2	22.67	34	27	37.5	42.5	47.5	57.17
1526	1	12.33	32.5	31.67	31.33	34.5	48.5	57.17
	2	23.67	35.33	34.5	31.83	32.83	48.33	53.17
1534	1	31	30.33	26.67	36.33	37.5	40.17	46.33
	2	43	42	39.67	49	30.83	57.83	54
1382	1	23.67	28.67	28	34.67	34.33	45.33	48.33
	2	21.33	20.67	23.33	25.33	34.67	44.83	45

3.2 REAT – Mean and Standard Deviation

Mean threshold values and standard deviation results are shown numerically in Table 2 and graphically in Figure 5 for each frequency from 125-8000 Hz for the HGU-25/P with the Argonaut headset and custom CEP earplugs. As expected for passive hearing protection devices, as frequency increases so does noise attenuation.

Table 4. Mean and standard deviation REAT data for all subjects

		Frequency (Hz)						
		125	250	500	1000	2000	4000	8000
HGU-25/P with Argonaut headset and custom CEP earplugs	Mean	22	28	29	34	37	47	51
	SD	7	7	4	5	4	3	5

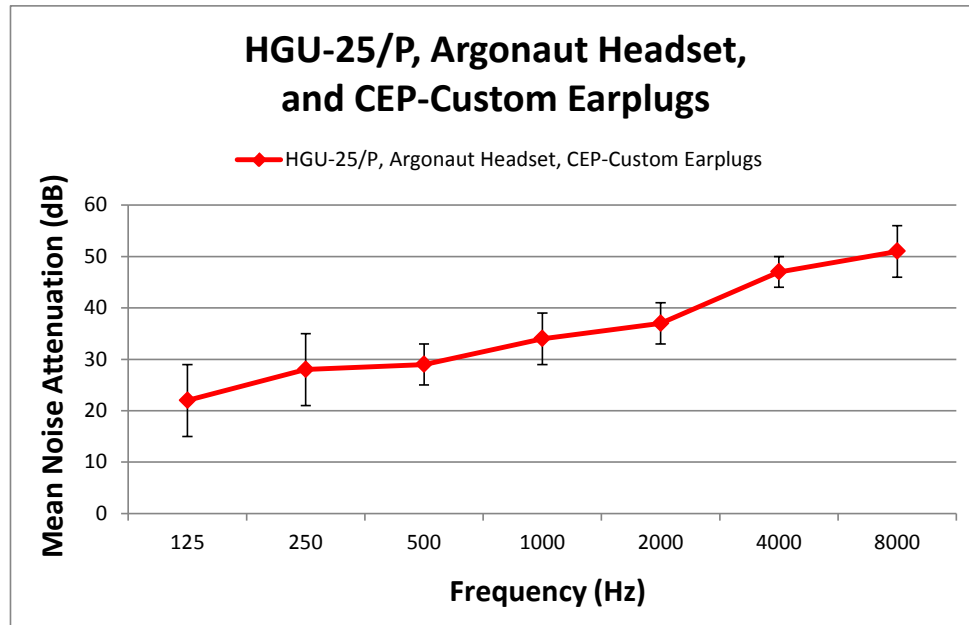


Figure 5. Mean and standard deviation across all subjects

4.0 CONCLUSIONS

REAT methods were used to collect noise attenuation performance data. REAT methods are psychoacoustic measurements and the data can be used in conjunction with the applicable service-specific and/or Department of Defense (DoD) hearing conservation program regulations to estimate the noise level at the ear of the user and, when integrated with the exposure time, to estimate the noise dose.

Passive noise attenuation (REAT) data were collected on the HGU-25/P integrated with Aegisound's Argonaut communication headset and CEP-custom communication earplugs. All measurements were collected in accordance with ANSI S12.6-2008. As with most passive hearing protection devices, an increase in frequency resulted in an increase in noise attenuation. The REAT data presented in this report are suitable for use in noise exposure calculations for the DoD and individual service hearing conservation programs.

5.0 REFERENCES

1. ANSI S12.6-2008 American National Standard Methods for Measuring the Real-Ear Attenuation of Hearing Protectors
2. Flight Deck Cranial Specification (NAVAIRIMISC-2008/45 PMA202-080001R-3A)

Attachment 1

Volunteer subjects wearing the double hearing protection configuration: HGU-25/P integrated with the Argonaut headset and CEP-custom communication earplugs



Subject 1584



Subject 1438



Subject 1564



Subject 1581



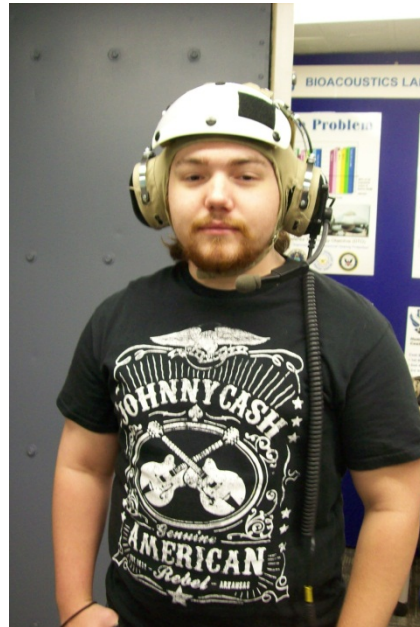
Subject 1487



Subject 1436



Subject 1208



Subject 1546



Subject 1575



Subject 1451



Subject 47



Subject 1595



Subject 1594



Subject 1602



Subject 1591



Subject 1561



Subject 1550



Subject 1526



Subject 1534



Subject 1382