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**Whole-body Vibration Assessment  
of the M1070 Heavy Equipment Transporter  
Volume 1**

By

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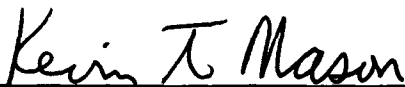
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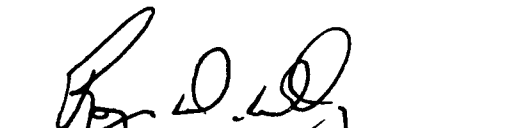
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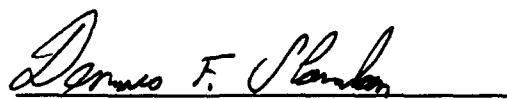
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<p>An evaluation of all new tactical vehicles and aircraft is required to assess potential whole-body vibration (WBV) health hazards to crewmembers. As requested by the U.S. Army Environmental Hygiene Agency (USAEHA), a health hazard assessment (HHA) was performed by the U.S. Army Aeromedical Research Laboratory (USAARL) on the M1070 Heavy Equipment Transporter System (HETS). The HETS was tested on three cross-country courses at Aberdeen Proving Ground (APG), MD, by the U.S. Army Combat Systems Test Activity (USACSTA), in coordination with the Response and Tolerance Branch of USAARL. The M1070 HETS was tested with a M1000 trailer in a loaded and unloaded configuration. The loaded configuration was obtained by placing an M1 tank on the bed of the M1000 trailer. The unloaded configuration consisted of a M1070 tractor with an empty M1000 trailer. While operating the HETS in its intended operational environment, the front passenger was exposed to an overall risk assessment code of 5. This consisted of an overall assignment of hazard severity category IV and hazard probability level D.</p> <p>Volume 1 describes the tests and discusses the results. Volume 2 contains Appendix B, the data plots and graphs.</p>			
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## Introduction

It is a requirement of Army Regulation (AR) 40-10, Health hazard assessment program in support of the Army materiel acquisition process, that an evaluation for potential whole-body vibration (WBV) health hazards be conducted on all new tactical vehicles and aircraft to survey the risk to their crewmembers. In support of this program, the U.S. Army Environmental Hygiene Agency (USAEHA) requested the U.S. Army Aeromedical Research Laboratory (USAARL) to perform a health hazard assessment (HHA) on the M1070 heavy equipment transporter system\* (HETS) truck.

The HETS, shown in Figure 1, is an all-wheel drive (8x8) commercial vehicle manufactured by the Oshkosh Truck Corporation\*. The M1070 HETS was built to fill the need of transporting the M1 Abrams main battle tank (MBT). The HETS is powered by a Detroit Diesel 8V-92TA diesel engine\* generating 500 hp and has a 5-speed automatic Allison transmission\*. The HETS is capable of attaining a maximum speed of 52 km/h and has a range of 724 km.

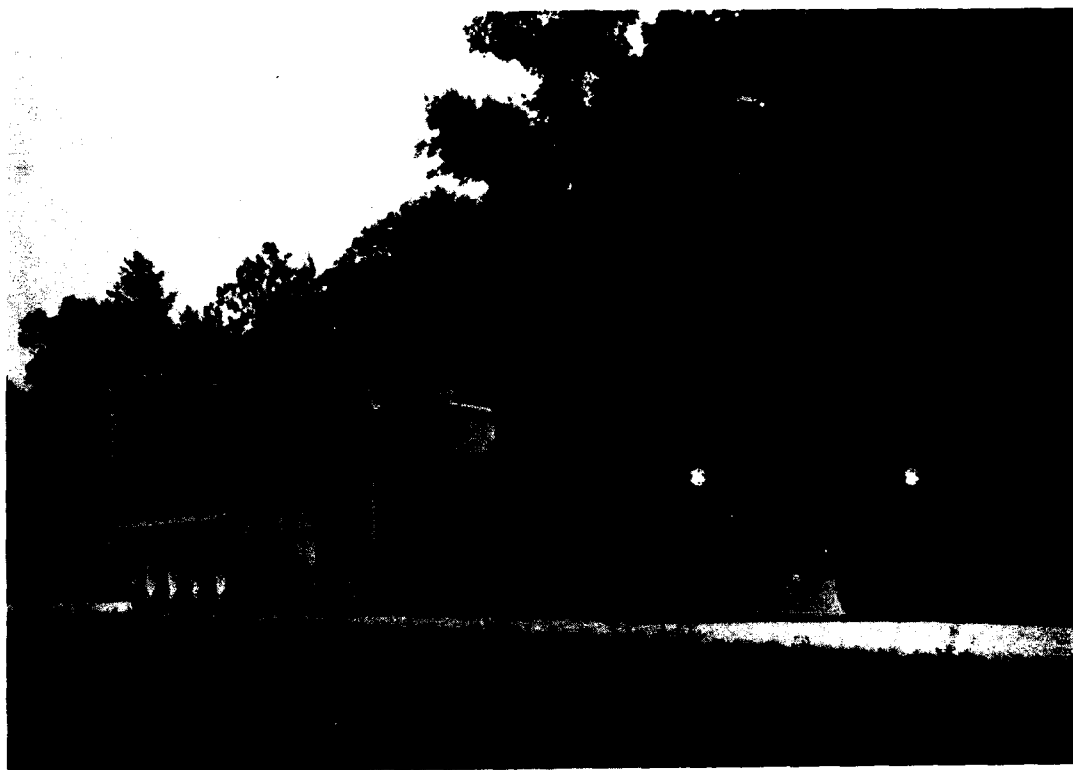


Figure 1. M1070 heavy equipment transporter.

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\* See manufacturers' list.



The HETS has a typical configuration consisting of a fully covered cab, a crew capacity of five, and is designed to tow the M1000 semitrailer. The standard M1070 HETS is equipped with two winches, each having a 25-ton load capacity. The nominal load on the fifth wheel of the vehicle is 20,866 kg. The HETS has a curb weight of 18,598 kg and is transportable in the C-5A and C-17 transport aircraft. The physical characteristics of the M1070 HETS, combined with vehicle speed, load, terrain, and crewmember position, result in a unique WBV signature whose measurement and evaluation are the subject of this report.

The methods for measuring and analyzing WBV are found in the International Organization for Standardization's (ISO) guideline entitled "Guide for the evaluation of human exposure to whole-body vibration (ISO 2631)." ISO 2631 is reflected in MIL-STD-1472D, "Human engineering design criteria for military systems, equipment and facilities." The relative severity of the processed WBV signatures are interpreted using the risk assessment codes (RAC) found in AR 40-10. As a set, these publications define the methods and criteria used in evaluating the WBV signatures of the M1070 HETS.

ISO 2631 identifies three criteria for the evaluation of human exposure to WBV which can be described in terms of intensity, frequency, direction, and duration. These criteria are the preservation of comfort, the preservation of working efficiency, and the preservation of health and safety. They are known formally as the reduced comfort boundary (RCB), fatigue-decreased proficiency boundary (FLPB), and health and safety exposure limit (HSEL), respectively.

The RACs, as described in AR 40-10, Appendix B, require the classification of a health hazard according to its severity and probability. Processing vibration signatures using ISO-2631 results in measurements of vibration severity, but does not yield a measure of the probability of occurrence. Therefore, RACs also are used and are obtained by combining vibration severity with the probability that the test condition will occur in a real life scenario. For vibration, RACs would be determined for each vibration amplitude at each direction and frequency.

### Methods

The WBV data on the M1070 HETS were collected at Aberdeen Proving Grounds (APG), Maryland. A test matrix was developed that represented the planned operating environment of the M1070 HETS with respect to terrain type and vehicle speed (Table 1).

Table 1.

Test matrix for WBV testing of the M1070 HETS.

Test courses						
Speed (mph)	Paved road		Cross-country #2		Secondary road	
	Loaded	Unloaded	Loaded	Unloaded	Loaded	Unloaded
5			X	X		
10			X	X	X	
15			X	X	X	X
20					X	X
25	X	X			X	X
30	X	X				X
35	X	X				
40	X	X				

Experimental conditions

The M1070 HETS was tested over three courses with a M1000 trailer in a loaded and unloaded configuration. Exact characterizations of the three test tracks can be obtained from APG. The loaded configuration was obtained by placing an M1 tank on the bed of the M1000 trailer. The unloaded configuration consisted of a M1070 tractor with an empty M1000 trailer.

The HETS was tested with vehicle speeds ranging from 5 to 40 mph. Specific vehicle speeds were selected in order to mirror likely employment scenarios for each test course. On the cross-country #2 course, the HETS was tested at 5, 10, and 15 mph for both the loaded and unloaded case. Secondary course test speeds were 15, 20, and 30 mph for the loaded case, and 20, 25, and 30 mph for the unloaded case. On the paved course, the HETS was tested at 30, 35, and 40 mph for both the loaded and unloaded configuration.

## Instrumentation

Seat pad accelerations were obtained in the X-, Y-, and Z-axes for the driver, front-seated passenger, and the two rear seated passengers located on the road-side seat and the curb-side seat. The rear-seated center passenger location accelerations were not measured. Three Endevco\* model 2265C-25 accelerometers, in a triaxial arrangement, were attached to disks placed between the seat pad and the subject's buttocks. Each of the accelerometers were connected to a signal conditioner which provided excitation, amplification, calibration, and low pass filtering. The accelerometers were low pass filtered at 100 Hz using a six-pole Butterworth filter. A diagram of the data acquisition system is included as Figure 2.

Filtered acceleration signals from the signal conditioner were connected to an EMR\* model 372-03 pulse code modulation (PCM) encoder. The encoder multiplexed the incoming analog signals which then were sampled at 416.67 Hz per channel. The incoming analog signal was sampled using a sample-and-hold amplifier, digitized using a 10-bit successive approximation analog-to-digital converter, and then converted to a nonreturn-to-zero level (NRZ-L) code for transmission. The encoded PCM data then was input to a Conic\* model CTL 510 transmitter for transmission at 237 MHz to the remote data handling facility. The signal conditioner, encoder, and transmitter were mounted on the back of the HETS cab during the entire test.

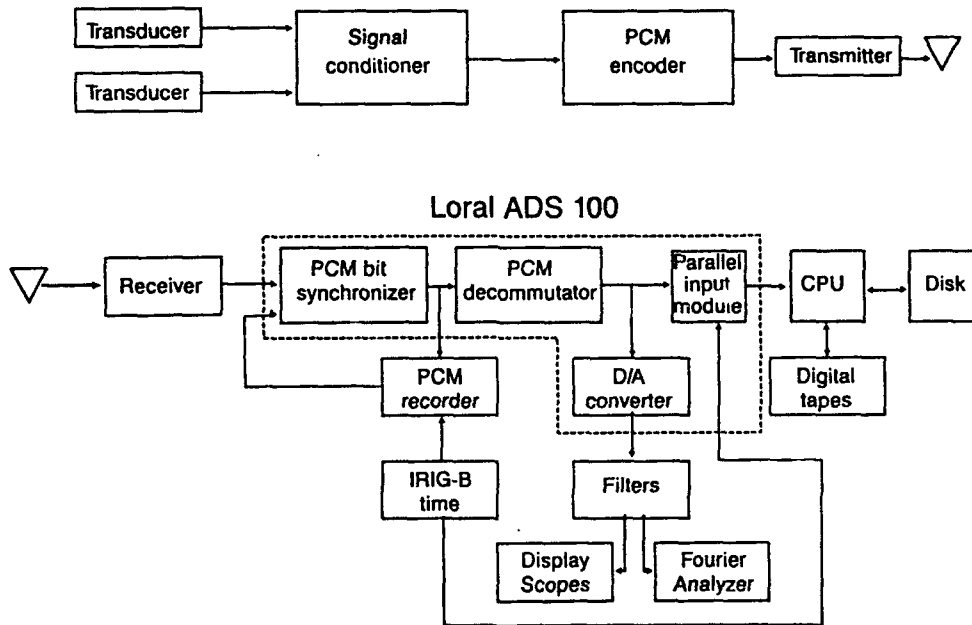


Figure 2. Data acquisition system.

The transmitted NRZ-L code was received by a Scientific Atlanta\* series 420S receiver and passed into a Loral Instrumentation\* ADS-100 system. The input buffer and PCM bit synchronizer modules recovered the serial pulse train from the data link noise and disturbances. The pulse train was recorded on a Honeywell\* model 101 PCM tape recorder along with voice annotation of the individual test runs and an IRIG-B time code. Simultaneously, the PCM pulse train was passed to a PCM demultiplexer and demultiplexed into 16-bit words.

From this point, the pulse train was sent to both a digital-to-analog (D/A) converter and a parallel input module. The D/A converter passed the pulse train through a filter, external to the ADS-100 system, for real time display and Fourier analysis. The parallel input module was used to input digital IRIG-B time code into the ADS-100. The pulse train passed out of the ADS-100 system from the input module to the host computer, a Hewlett-Packard\* (HP) model 21MX-E series minicomputer. The data were stored temporarily on the HP system disk and later transferred to digital tape to provide a permanent storage medium. The ADS-100 system was independent of the host control; however, software residing on the minicomputer controlled the handshaking between the ADS-100 and the HP21MX-E during data acquisition.

### Analysis

Triaxial seat pad vibration data were processed using the methods prescribed in ISO 2631 for broadband signals using third-octave analysis with weighting. Digitized acceleration signals from the X-, Y-, and Z-axis from both the driver and passenger seat pad accelerometers were read into a Dolch\* model 486 portable computer. A USAARL-developed automated analysis program was used to produce tabular and graphic plots of the acceleration data. These plots (Appendix B) were used to identify vibration exposure limits which occurred under projected normal daily operating conditions.

The exposure data then were classified using the RACs from AR 40-10. The RACs require classification of the health hazard according to the hazard severity and probability. Since the ISO 2631 standard does not use RACs, the severity of the hazard reasonably may be estimated from worst-case exposure before the onset of the HSEL for each vibration frequency and direction. An indicator which may be used for the assessment of hazard severity is the duration of safe exposure (DSE). The DSE is defined as the length of time a person can be exposed to WBV before reaching the HSEL. Thus, a long DSE indicates tolerable WBV, whereas a short DSE indicates severe WBV. In order to translate the DSEs to RACs, Table 2 was used to define the category (I-IV) of exposure.

Table 2.

Hazard severity classification.

Attribute	Category	WBV duration of safe exposure
Catastrophic	I	Less than 5 minutes
Critical	II	Between 5 and 30 minutes
Marginal	III	Between 30 minutes and 4 hours
Negligible	IV	More than 4 hours
Hazard severity categories are defined as:		
Category I	Catastrophic: Hazard may cause death or total loss of a bodily system.	
Category II	Critical: Hazard may cause severe bodily injury, severe occupational illness, or major damage to a bodily system.	
Category III	Marginal: Hazard may cause minor bodily injury, minor occupational illness, or minor damage to a bodily system.	
Category IV	Negligible: Hazard would cause less than minor bodily injury, minor occupational illness, or minor bodily system damage.	

The operational environments of the HETS determine the likelihood of occurrence, or probability level, of exposure to WBV. These levels, identified in AR 40-10 as levels A through E, with their corresponding descriptions, are listed in Table 3. The probability levels for each test condition relevant to the WBV signatures in the HETS are listed in Table 4. Table 4 also gives the weighted probability calculated using a coding of 50 - 10 for probability level A - E, respectively. This is divided by the total of the coded probability level for each mission percentage time, and multiplied by the mission percentage. Weighted probabilities A' - E' were found using natural breaks in the sorted weighted probabilities with  $A' > 7$ ,  $3 < B' < 7$ ,  $1 < C' < 3$ , and  $D' < 1$  percent. No weighted probability is given for E' although test engineers at APG suggested this would cover those times the HETS was operated in a bobtail configuration.

Table 3.

Hazard probability classification.

Attribute	Level	Specific individual item	Fleet or inventory
Frequent	A	Likely to occur frequently	Continuously experience
Probable	B	Will occur several times in the life of an item	Will occur frequently
Occasional	C	Likely to occur sometime in the life of an item	Will occur several times
Remote	D	Unlikely but possible to occur in the life of an item	Unlikely but can be reasonably expected to occur
Improbable	E	So unlikely, it can be assumed occurrence may not be experienced	Unlikely to occur, but possible

Table 4.

Hazard probability classification with test operating conditions.

Terrain	Percentage of mission time	Configuration	Speed (mph)	Probability	Probability level	Weighted probability	Weighted probability level
Secondary road	50	Loaded	10	Frequent	A	13.158	A'
			15	Frequent	A	13.158	A'
			20	Frequent	A	13.158	A'
			25	Probable	B	10.526	A'
	5	Unloaded	15	Frequent	A	1.316	C'
			20	Frequent	A	1.316	C'
			25	Frequent	A	1.316	C'
			30	Probable	B	1.053	C'
Paved road	28	Loaded	25	Frequent	A	7.368	A'
			30	Frequent	A	7.368	A'
			35	Frequent	A	7.368	A'
			40	Probable	B	5.895	B'
	2	Unloaded	25	Probable	B	0.444	D'
			30	Probable	B	0.444	D'
			35	Frequent	A	0.556	D'
			40	Frequent	A	0.556	D'
Cross-country	14	Loaded	5	Probable	B	4.000	B'
			10	Frequent	A	5.000	B'
			15	Frequent	A	5.000	B'
	1	Unloaded	5	Probable	B	0.308	D'
			10	Probable	B	0.308	D'
			15	Frequent	A	0.385	D'

Hazard severity categories and hazard probability levels are used to find the RACs for each test condition. Using Table 5, the RACs are found at the intersection of the Hazard Category and Probability Level, here using the primed levels. The overall RAC for the vehicle is determined by averaging and rounding the individual RACs.

Table 5.

RAC determination.

Hazard probability levels					
Hazard category	A	B	C	D	E
I	1	1	1	2	3
II	1	1	2	3	4
III	2	3	3	4	5
IV	3	5	5	5	5

Results

The duration of exposure to reach the HSEL was calculated for all 216 data sets. The minimum durations for HSELS were found for each position, terrain, speed, and load for each of the four seating positions--driver, front passenger, roadside passenger (RS), and curb-side passenger (CS)--and are shown in Tables 6, 7, 8, and 9, respectively. These tables are arranged in order of increasing levels of DSE. Since the HETS requires 10 hours of total mission time in any 24-hour period, the exposure limits of less than 10 hours were flagged for assessment. The DSE is determined from the time required to reach the HSEL (Appendix B) according to ISO-2631. The RACs shown are a measure of the hazard severity of the test condition and are based on the DSE, course terrain, and speed.

The worst case exposure limits were determined from each seating position's lowest DSE. The DSEs below 10 hours were found only for the front passenger seating position under unloaded conditions. Two cases were flagged for assessment: a DSE of 8 hours 4 minutes at a vehicle speed of 15 mph on cross-country terrain (Appendix B, run number 14), and a DSE of 8 hours 52 minutes at a vehicle speed of 30 mph on paved roads (Appendix



B, run number 20). Both DSEs occurred in the Z axis at frequencies of 2.0 and 3.9 Hz, respectively. The hazard severity assigned to these two conditions were found to be Category IV from the DSE ranges of Table 2. Weighted hazard probabilities for these two conditions were combined with hazard categories using Table 5 to yield RACs of 5. With only two test conditions yielding RACs of 5, this vehicle is assigned an overall RAC of 5.

Table 6.

Driver seat HSEL for minimal exposure times with respect to axis, vibration frequency, vehicle speed, and test course.

Determination of hazard severity					Determination of probability level					Overall RAC
DSE (h:m)	Axis	Hz	Hazard severity	Hazard category	Test course	Configuration	Speed (mph)	Hazard probability	Probability level	
8:52	Z	3.9	Negligible	IV	Paved	Unloaded	30	Remote	D'	5
10:22	Z	1.6	Negligible	IV	CC #2	Unloaded	15	Remote	D'	5
13:18	Z	2.5	Negligible	IV	CC #2	Unloaded	20	Remote	D'	5
14:00	Z	2.0	Negligible	IV	Secondary	Loaded	20	Frequent	A'	3
15:18	Z	2.0	Negligible	IV	Secondary	Loaded	15	Frequent	A'	3
16:45	Z	2.5	Negligible	IV	Paved	Loaded	25	Frequent	A'	3

**Table 7.**

Front passenger seat HSEL for minimal exposure times with respect to axis, vibration frequency, vehicle speed, and test course.

Determination of hazard severity					Determination of probability level					Over-all RAC
DSE (h:m)	Axis	Hz	Hazard severity	Hazard category	Test course	Configuration	Speed (mph)	Hazard probability	Probability level	
8:04	Z	2.0	Negligible	IV	CC #2	Unloaded	15	Remote	D'	5
11:02	Z	3.9	Negligible	IV	Secondary	Unloaded	30	Remote	C'	5
12:08	Z	2.5	Negligible	IV	Paved	Loaded	25	Frequent	A'	3
14:33	Z	5.0	Negligible	IV	Paved	Unloaded	40	Probable	B'	5
15:52	Z	2.5	Negligible	IV	Secondary	Loaded	20	Frequent	A'	3
16:25	Z	2.0	Negligible	IV	CC #2	Loaded	15	Occasional	B'	5

**Table 8.**

Roadside passenger seat HSEL for minimal exposure times with respect to axis, vibration frequency, vehicle speed, and test course.

Determination of hazard severity					Determination of probability level					Over-all RAC
DSE (h:m)	Axis	Hz	Hazard severity	Hazard category	Test course	Configuration	Speed (mph)	Hazard probability	Probability level	
12:30	Z	1.6	Negligible	IV	CC #2	Unloaded	15	Remote	D'	5
15:41	Z	3.9	Negligible	IV	Paved	Unloaded	30	Remote	D'	5
16:37	Z	5.0	Negligible	IV	CC #2	Unloaded	20	Remote	D'	5
16:37	Z	5.0	Negligible	IV	Paved	Loaded	40	Frequent	A'	3
17:13	Z	2.5	Negligible	IV	Secondary	Loaded	20	Frequent	A'	3
19:45	Z	2.0	Negligible	IV	CC #2	Loaded	15	Occasional	B'	5

Table 9.

Curb side passenger seat HSEL for minimal exposure times with respect to axis, vibration frequency, vehicle speed, and test course.

Determination of hazard severity					Determination of probability level					Overall RAC
DSE (h:m)	Axis	Hz	Hazard severity	Hazard category	Test course	Configuration	Speed (mph)	Hazard probability	Probability level	
10:12	Z	2.0	Negligible	IV	CC #2	Unloaded	15	Remote	D'	5
13:23	Z	3.9	Negligible	IV	Secondary	Unloaded	30	Occasional	C'	5
14:07	Z	5.0	Negligible	IV	Paved	Unloaded	40	Remote	D'	5
15:41	Z	3.9	Negligible	IV	Paved	Loaded	35	Frequent	A'	3
16:45	Z	2.5	Negligible	IV	Secondary	Loaded	20	Frequent	A'	3
20:17	Z	2.0	Negligible	IV	CC #2	Loaded	15	Probable	B'	5

Discussion

Whole-body vibration exposures for the M1070 HETS that were less than the required 10-hour operational period were found for only two conditions. Both these conditions were in the unloaded configuration and occurred on cross-country and paved terrain. These scenarios were projected to have a low probability of occurrence which resulted in a weighted probability level of D, or remote, for both instances. The hazard category was identified as IV with both DSEs being greater than 4 hours. The hazard probability of D, combined with the hazard category of IV, resulted in an overall RAC of 5 implying a low risk level with a decision making authority residing with the program manager (AR 40-10).

The two hazardous WBV exposure conditions that were found occurred at the front seat positions only. The driver position received a DSE of less than 10 hours on the paved terrain, and the front seat passenger received a DSE of less than 10 hours for cross-country terrain. No hazardous WBV exposures were found for the rear seated passengers under loaded conditions--a configuration likely to occur when the M1 tank crew would be riding in the HETS passenger compartment.

The frequency of the hazardous WBV exposures were found to be 2.0 Hz and 3.9 Hz for the driver and front seat passenger, respectively. This trend for a large vibration amplitude at low frequencies was seen in most of the HETS vibration signatures. This low-level frequency response is unusual for heavy equipment with most off-road vehicles showing resonant WBV peaks in the 4-8 Hz range. A potential explanation for this low frequency content is that the seating/suspension system could be very soft resulting in a very low resonant frequency.

The WBV experienced by the vehicle crewmen differed for seating position. The front seat positions typically showed data with lower HSELs as compared to the rear seat passenger positions for most of the data trials. A review of the plotted data of Appendix B shows that the rear seated passengers typically had lower amplitude low frequency components and higher amplitude high frequency components. This implies that the rear seating systems are stiffer than the front seat positions showing less gain in the low frequency bands and more transmission in the higher frequency bands.

### Conclusions

While operating the HETS in its intended operational environment, the front passenger was exposed to an overall RAC of 5. This consisted of an overall assignment of hazard severity category IV and hazard probability level D. It is recommended that exposure to WBV be restricted to:

a. Paved surface at vehicle:

(1) Unloaded trailer configuration: not more than 9 hours continuous operation in any 24-hour period speeds less than 30 mph.

(2) Loaded trailer configuration: not more than 12 hours continuous operation in any 24-hour period speeds less than 25 mph.

b. Cross-country terrain:

(1) Unloaded trailer configuration: not more than 8 hours continuous operation in any 24-hour period at vehicle speeds less than 15 mph.

(2) Loaded trailer configuration: not more than 15 hours continuous operation in any 24-hour period at vehicle speeds less than 15 mph.

c. Secondary terrain:

(1) Unloaded trailer configuration: not more than 11 hours continuous operation in any 24-hour period at vehicle speeds less than 30 mph.

(2) Loaded trailer configuration: not more than 14 hours continuous operation in any 24-hour period at vehicle speeds less than 20 mph.

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Appendix A.

Manufacturers' list.

Conic/Loral Data Systems  
9020 Balboa Avenue  
San Diego, CA 92123

EMR/Fairchild Weston Systems  
P.O. Box 3041  
Sarasota, FL 33578

Honeywell  
Honeywell Plaza  
Minneapolis, MN 55408

Hewlett-Packard Company  
4700 Bayou Boulevard  
Pensacola, FL 32502

Loral Instrumentation  
8401-T Aero Dr.  
San Diego, CA 92123

Oshkosh Truck Corporation  
PO Box 2566  
Oshkosh, WI 54903

Initial distribution

Commander, U.S. Army Natick Research,  
Development and Engineering Center  
ATTN: SATNC-MIL (Documents  
Librarian)  
Natick, MA 01760-5040

Library  
Naval Submarine Medical Research Lab  
Box 900, Naval Sub Base  
Groton, CT 06349-5900

Chairman  
National Transportation Safety Board  
800 Independence Avenue, S.W.  
Washington, DC 20594

Executive Director, U.S. Army Human  
Research and Engineering Directorate  
ATTN: Technical Library  
Aberdeen Proving Ground, MD 21005

Commander  
10th Medical Laboratory  
ATTN: Audiologist  
APO New York 09180

Commander  
Man-Machine Integration System  
Code 602  
Naval Air Development Center  
Warminster, PA 18974

Naval Air Development Center  
Technical Information Division  
Technical Support Detachment  
Warminster, PA 18974

Commander  
Naval Air Development Center  
ATTN: Code 602-B  
Warminster, PA 18974

Commanding Officer, Naval Medical  
Research and Development Command  
National Naval Medical Center  
Bethesda, MD 20814-5044

Commanding Officer  
Armstrong Laboratory  
Wright-Patterson  
Air Force Base, OH 45433-6573

Deputy Director, Defense Research  
and Engineering  
ATTN: Military Assistant  
for Medical and Life Sciences  
Washington, DC 20301-3080

Director  
Army Audiology and Speech Center  
Walter Reed Army Medical Center  
Washington, DC 20307-5001

Commander, U.S. Army Research  
Institute of Environmental Medicine  
Natick, MA 01760

Commander/Director  
U.S. Army Combat Surveillance  
and Target Acquisition Lab  
ATTN: SFAE-IEW-JS  
Fort Monmouth, NJ 07703-5305



Director  
Federal Aviation Administration  
FAA Technical Center  
Atlantic City, NJ 08405

Commander, U.S. Army Test  
and Evaluation Command  
Directorate for Test and Evaluation  
ATTN: AMSTE-TA-M (Human Factors  
Group)  
Aberdeen Proving Ground,  
MD 21005-5055

Naval Air Systems Command  
Technical Air Library 950D  
Room 278, Jefferson Plaza II  
Department of the Navy  
Washington, DC 20361

Director  
U.S. Army Ballistic  
Research Laboratory  
ATTN: DRXBR-OD-ST Tech Reports  
Aberdeen Proving Ground, MD 21005

Commander  
U.S. Army Medical Research  
Institute of Chemical Defense  
ATTN: SGRD-UV-AO  
Aberdeen Proving Ground,  
MD 21010-5425

Commander  
USAMRDALC  
ATTN: SGRD-RMS  
Fort Detrick, Frederick, MD 21702-5012

Director  
Walter Reed Army Institute of Research  
Washington, DC 20307-5100

HQ DA (DASG-PSP-O)  
5109 Leesburg Pike  
Falls Church, VA 22041-3258

Harry Diamond Laboratories  
ATTN: Technical Information Branch  
2800 Powder Mill Road  
Adelphi, MD 20783-1197

U.S. Army Materiel Systems  
Analysis Agency  
ATTN: AMXSU-PA (Report Processing)  
Aberdeen Proving Ground  
MD 21005-5071

U.S. Army Ordnance Center  
and School Library  
Simpson Hall, Building 3071  
Aberdeen Proving Ground, MD 21005

U.S. Army Environmental  
Hygiene Agency  
ATTN: HSHB-MO-A  
Aberdeen Proving Ground, MD 21010

Technical Library Chemical Research  
and Development Center  
Aberdeen Proving Ground, MD  
21010-5423

Commander  
U.S. Army Medical Research  
Institute of Infectious Disease  
ATTN: SGRD-UIZ-C  
Fort Detrick, Frederick, MD 21702

Director, Biological  
Sciences Division  
Office of Naval Research  
600 North Quincy Street  
Arlington, VA 22217

**Commandant**  
U.S. Army Aviation  
Logistics School ATTN: ATSQ-TDN  
Fort Eustis, VA 23604

**Headquarters (ATMD)**  
U.S. Army Training  
and Doctrine Command  
ATTN: ATBO-M  
Fort Monroe, VA 23651

**IAF Liaison Officer for Safety**  
USAF Safety Agency/SEFF  
9750 Avenue G, SE  
Kirtland Air Force Base  
NM 87117-5671

**Naval Aerospace Medical  
Institute Library**  
Building 1953, Code 03L  
Pensacola, FL 32508-5600

**Command Surgeon**  
HQ USCENTCOM (CCSG)  
U.S. Central Command  
MacDill Air Force Base, FL 33608

**Director**  
Directorate of Combat Developments  
ATTN: ATZQ-CD  
Building 515  
Fort Rucker, AL 36362

**U.S. Air Force Institute  
of Technology (AFIT/LDEE)**  
Building 640, Area B  
Wright-Patterson  
Air Force Base, OH 45433

**Henry L. Taylor**  
Director, Institute of Aviation  
University of Illinois-Willard Airport  
Savoy, IL 61874

**Chief, National Guard Bureau**  
ATTN: NGB-ARS  
Arlington Hall Station  
111 South George Mason Drive  
Arlington, VA 22204-1382

**Commander**  
U.S. Army Aviation and Troop Command  
ATTN: AMSAT-R-ES  
4300 Goodfellow Bouvelard  
St. Louis, MO 63120-1798

**U.S. Army Aviation and Troop Command  
Library and Information Center Branch**  
ATTN: AMSAV-DIL  
4300 Goodfellow Boulevard  
St. Louis, MO 63120

**Federal Aviation Administration**  
Civil Aeromedical Institute  
Library AAM-400A  
P.O. Box 25082  
Oklahoma City, OK 73125

**Commander**  
U.S. Army Medical Department  
and School  
ATTN: Library  
Fort Sam Houston, TX 78234

**Commander**  
U.S. Army Institute of Surgical Research  
ATTN: SGRD-USM  
Fort Sam Houston, TX 78234-6200

**AAMRL/HEX**  
Wright-Patterson  
Air Force Base, OH 45433

**Air University Library  
(AUL/LSE)**  
Maxwell Air Force Base, AL 36112

Product Manager  
Aviation Life Support Equipment  
ATTN: SFAE-AV-LSE  
4300 Goodfellow Boulevard  
St. Louis, MO 63120-1798

Commander and Director  
USAE Waterways Experiment Station  
ATTN: CEWES-IM-MI-R,  
CD Department  
3909 Halls Ferry Road  
Vicksburg, MS 39180-6199

Commanding Officer  
Naval Biodynamics Laboratory  
P.O. Box 24907  
New Orleans, LA 70189-0407

Assistant Commandant  
U.S. Army Field Artillery School  
ATTN: Morris Swott Technical Library  
Fort Sill, OK 73503-0312

Mr. Peter Seib  
Human Engineering Crew Station  
Box 266  
Westland Helicopters Limited  
Yeovil, Somerset BA20 2YB UK

U.S. Army Dugway Proving Ground  
Technical Library, Building 5330  
Dugway, UT 84022

U.S. Army Yuma Proving Ground  
Technical Library  
Yuma, AZ 85364

AFFTC Technical Library  
6510 TW/TSTL  
Edwards Air Force Base,  
CA 93523-5000

Commander  
Code 3431  
Naval Weapons Center  
China Lake, CA 93555

Aeromechanics Laboratory  
U.S. Army Research and Technical Labs  
Ames Research Center, M/S 215-1  
Moffett Field, CA 94035

Sixth U.S. Army  
ATTN: SMA  
Presidio of San Francisco, CA 94129

Commander  
U.S. Army Aeromedical Center  
Fort Rucker, AL 36362

Strughold Aeromedical Library  
Document Service Section  
2511 Kennedy Circle  
Brooks Air Force Base, TX 78235-5122

Dr. Diane Damos  
Department of Human Factors  
ISSM, USC  
Los Angeles, CA 90089-0021

U.S. Army White Sands  
Missile Range  
ATTN: STEWS-IM-ST  
White Sands Missile Range, NM 88002

U.S. Army Aviation Engineering  
Flight Activity  
ATTN: SAVTE-M (Tech Lib) Stop 217  
Edwards Air Force Base, CA 93523-5000

Ms. Sandra G. Hart  
Ames Research Center  
MS 262-3  
Moffett Field, CA 94035

Commander  
USAMRDALC  
ATTN: SGRD-UMZ  
Fort Detrick, Frederick, MD 21702-5009

Commander  
U.S. Army Health Services Command  
ATTN: HSOP-SO  
Fort Sam Houston, TX 78234-6000

U. S. Army Research Institute  
Aviation R&D Activity  
ATTN: PERI-IR  
Fort Rucker, AL 36362

Commander  
U.S. Army Safety Center  
Fort Rucker, AL 36362

U.S. Army Aircraft Development  
Test Activity  
ATTN: STEBG-MP-P  
Cairns Army Air Field  
Fort Rucker, AL 36362

Commander  
USAMRDALC  
ATTN: SGRD-PLC (COL R. Gifford)  
Fort Detrick, Frederick, MD 21702

TRADOC Aviation LO  
Unit 21551, Box A-209-A  
APO AE 09777

Netherlands Army Liaison Office  
Building 602  
Fort Rucker, AL 36362

British Army Liaison Office  
Building 602  
Fort Rucker, AL 36362

Italian Army Liaison Office  
Building 602  
Fort Rucker, AL 36362

Directorate of Training Development  
Building 502  
Fort Rucker, AL 36362

Chief  
USAHEL/USAAVNC Field Office  
P. O. Box 716  
Fort Rucker, AL 36362-5349

Commander, U.S. Army Aviation Center  
and Fort Rucker  
ATTN: ATZQ-CG  
Fort Rucker, AL 36362

Chief  
Test & Evaluation Coordinating Board  
Cairns Army Air Field  
Fort Rucker, AL 36362

Canadian Army Liaison Office  
Building 602  
Fort Rucker, AL 36362

German Army Liaison Office  
Building 602  
Fort Rucker, AL 36362

French Army Liaison Office  
USAAVNC (Building 602)  
Fort Rucker, AL 36362-5021

Australian Army Liaison Office  
Building 602  
Fort Rucker, AL 36362

Dr. Garrison Rapmund  
6 Burning Tree Court  
Bethesda, MD 20817

Commandant, Royal Air Force  
Institute of Aviation Medicine  
Farnborough, Hampshire GU14 6SZ UK

Defense Technical Information  
Cameron Station, Building 5  
Alexandra, VA 22304-6145

Commander, U.S. Army Foreign Science  
and Technology Center  
AIFRTA (Davis)  
220 7th Street, NE  
Charlottesville, VA 22901-5396

Commander  
Applied Technology Laboratory  
USARTL-ATCOM  
ATTN: Library, Building 401  
Fort Eustis, VA 23604

Commander, U.S. Air Force  
Development Test Center  
101 West D Avenue, Suite 117  
Eglin Air Force Base, FL 32542-5495

Aviation Medicine Clinic  
TMC #22, SAAF  
Fort Bragg, NC 28305

Dr. H. Dix Christensen  
Bio-Medical Science Building, Room 753  
Post Office Box 26901  
Oklahoma City, OK 73190

Commander, U.S. Army Missile  
Command  
Redstone Scientific Information Center  
ATTN: AMSMI-RD-CS-R  
/ILL Documents  
Redstone Arsenal, AL 35898

Director  
Army Personnel Research Establishment  
Farnborough, Hants GU14 6SZ UK

U.S. Army Research and Technology  
Laboratories (AVSCOM)  
Propulsion Laboratory MS 302-2  
NASA Lewis Research Center  
Cleveland, OH 44135

Commander  
USAMRDALC  
ATTN: SGRD-ZC (COL John F. Glenn)  
Fort Detrick, Frederick, MD 21702-5012

Dr. Eugene S. Channing  
166 Baughman's Lane  
Frederick, MD 21702-4083

U.S. Army Medical Department  
and School  
USAMRDALC Liaison  
ATTN: HSMC-FR  
Fort Sam Houston, TX 78234

Dr. A. Kornfield  
895 Head Street  
San Francisco, CA 94132-2813

NVESD  
AMSEL-RD-NV-ASID-PST  
(Attn: Trang Bui)  
10221 Burbeck Road  
Fort Belvoir, VA 22060-5806

CA Av Med  
HQ DAAC  
Middle Wallop  
Stockbridge, Hants S020 8DY UK

Dr. Christine Schlichting  
Behavioral Sciences Department  
Box 900, NAVUBASE NLON  
Groton, CT 06349-5900

Aerospace Medicine Team  
HQ ACC/SGST3  
162 Dodd Boulevard, Suite 100  
Langley Air Force Base,  
VA 23665-1995

Commander  
Aviation Applied Technology Directorate  
ATTN: AMSAT-R-TV  
Fort Eustis, VA 23604-5577

COL Yehezkel G. Caine, MD  
Surgeon General, Israel Air Force  
Aeromedical Center Library  
P. O. Box 02166 I.D.F.  
Israel

HQ ACC/DOHP  
205 Dodd Boulevard, Suite 101  
Langley Air Force Base,  
VA 23665-2789

41st Rescue Squadron  
41st RQS/SG  
940 Range Road  
Patrick Air Force Base,  
FL 32925-5001

48th Rescue Squadron  
48th RQS/SG  
801 Dezonias Road  
Holloman Air Force Base,  
NM 88330-7715

35th Fighter Wing  
35th FW/SG  
PSC 1013  
APO AE 09725-2055

66th Rescue Squadron  
66th RQS/SG  
4345 Tyndall Avenue  
Nellis Air Force Base, NV 89191-6076

71st Rescue Squadron  
71st RQS/SG  
1139 Redstone Road  
Patrick Air Force Base,  
FL 32925-5000

Director  
Aviation Research, Development  
and Engineering Center  
ATTN: AMSAT-R-Z  
4300 Goodfellow Boulevard  
St. Louis, MO 63120-1798

Commander  
USAMRDALC  
ATTN: SGRD-ZB (COL C. Fred Tyner)  
Fort Detrick, Frederick, MD 21702-5012

Commandant  
U.S. Army Command and General Staff  
College  
ATTN: ATZL-SWS-L  
Fort Leavenworth, KS 66027-6900