DEPARTMENT OF THE ARMY
US ARMY INSTITUTE OF PUBLIC HEALTH
5158 BLACKHAWK ROAD
ABERDEEN PROVING GROUND MARYLAND 21010-5403

15 MAY 2013

MCHB-IP-OHH

MEMORANDUM FOR Program Manager (SFAE-GCS-SBCT/Mr. Mark Crockett), Stryker Brigade Combat Team, 6501 East Eleven Mile Road, Warren, MI 48397-5000

SUBJECT: Health Hazard Assessment Report (RCS MED-388) No. S.0000993-13, Stryker Double V Hull Mortar Carrier Vehicle, 15 April 2013

1. This memorandum contains a copy of the subject report with an Executive Summary.

2. The Health Hazard Assessment Report (HHAR) contains an assessment of the health hazards identified during normal operation and maintenance of the materiel system, not resulting from a potential mishap or failure. Accordingly, safety or other Manpower and Personnel Integration (MANPRINT) domain assessments may conclude with different risk levels.

3. Provide the enclosed HHAR to System Safety, MANPRINT and Environment, Safety, and Occupational Health coordinators. Incorporate the identified health hazards and associated recommendations into MANPRINT and System Safety issue/hazard tracking logs. Use the HHAR to update the Programmatic Environment, Safety, and Occupational Health Evaluation (PESHE) and the Safety and Health Data Sheets (SHDS).

4. Provide the Army's Health Hazard Assessment (HHA) Program at this Institute with the results of risk mitigation and management decisions associated with the health hazards identified in this HHAR (e.g., SHDS, PESHE, MANPRINT Assessment, safety releases, and other appropriate documents).

5. Direct inquiries regarding the HHAR to the Army HHA Program Project Officer, Mr. Robert Batts, at commercial 410-436-2925, DSN 584-2925, or e-mail: robert.w.batts2.civ@mail.mil.

FOR THE DIRECTOR:

Encl

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AMEDDC&S (MCCS-HTP)
ARL (RDRL-HRM/RDRL-SLE-G)
CRC (CSSC-E)
JTAPIC (MCMR-RTB)

USAPHC

U.S. ARMY PUBLIC HEALTH COMMAND

5158 Blackhawk Road, Aberdeen Proving Ground, Maryland 21010-5403

HEALTH HAZARD ASSESSMENT REPORT (RCS MED-388)
NO. S.0000993-13
Stryker Double V Hull Mortar Carrier Vehicle
15 April 2013

PHC FORM 433-E (MCHB-CS-IP), NOV 12

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Health Hazard Assessment Report: 500A

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DEPARTMENT OF THE ARMY
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MCHB-IP-OHH

EXECUTIVE SUMMARY
HEALTH HAZARD ASSESSMENT REPORT (RCS MED-388)
NO. S.0000993-13
STRYKER DOUBLE V HULL MORTAR CARRIER VEHICLE
15 April 2013

1. PURPOSE. The Stryker Brigade Combat Team Program Manager at Tank-Automotive and Armaments Command, Warren, Michigan, requested that the Army Institute of Public Health provide a Health Hazard Assessment Report (HHAR) for the Stryker Double V Hull Mortar Carrier Vehicle (MCVV). This HHAR supports testing, safety confirmations, and related procurement requirements.

2. CONCLUSIONS.

a. Risk Levels. This HHAR identifies one low risk potential health hazard (radiofrequency radiation (RFR)) and one medium risk potential health hazard (whole-body vibration (WBV)) associated with the use or maintenance of the MCVV. These potential hazards will be reduced if the preferred recommendations listed in the HHAR are applied.

b. Manpower and Personnel Integration (MANPRINT). According to Army Regulation 602-2, potential health hazards with no immediate strategy for mitigation or control equate to critical hazards for the MANPRINT Program. Those with an acceptable strategy equate to major hazards. Those requiring additional data or information for an assessment equate to concern hazards. The potential health hazards identified above equate to two major hazards (RFR and WBV) for the MANPRINT Program.

3. RECOMMENDATIONS.

a. Radiofrequency Radiation. A Risk Assessment Code (RAC) of Low (Hazard Severity (HS) 4, Hazard Probability (HP) C) is assigned. A residual RAC of Low (HS 4, HP D) is assigned for compliance with the following recommendations:

(1) Single Channel Ground and Airborne Radio System (SINCGARS). Attach an RFR warning sign or decal on or near the base of the SINCGARS antennas to prevent RFR exposure exceeding the standards and to avoid the potential for radiofrequency

shock and burn. This sign should specify maintaining a distance of 28 inches (in) from the antenna while it is transmitting.

(2) Duke V3.

(a) Post an RFR warning sign or decal on or near the FRF-105D omni-directional antenna specifying to maintain a distance of 28 in when the antenna is transmitting.

(b) Post an RFR warning sign or decal on or near the FRF-119C directional antenna specifying to maintain a distance of 13 feet when the antenna is radiating.

b. Whole-body Vibration. A RAC of Medium (HS 2, HP D) is assigned. A residual RAC of Low (HS 4, HP D) is assigned for compliance with the following recommendation: Redesign the permanent seats in the MCVV to absorb more vibration energy and improve lumbar support.

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HEALTH HAZARD ASSESSMENT REPORT (RCS MED-388)
NO. S.0000993-13
STRYKER DOUBLE V HULL MORTAR CARRIER VEHICLE
15 April 2013

1. REFERENCES. Appendix A contains a list of references used in this Health Hazard Assessment Report (HHAR).

2. PURPOSE. To determine the potential health hazards associated with the Stryker Double V Hull (DVH) Mortar Carrier Vehicle (MCVV). The HHAR will support the MCVV for testing, safety confirmations, and related procurement requirements.

3. AUTHORITY. The Army's Health Hazard Assessment (HHA) Program is an Army Medical Department initiative in cooperation with and in support of the Army acquisition process. The primary objective of the program is to identify and eliminate or control potential health hazards associated with the life cycle management of weapons, equipment, clothing, training devices, and other materiel systems. The proponent of the HHA Program is The Surgeon General (TSG) of the Army; however, TSG has designated the Army Institute of Public Health (AIPH) as the Lead Agent. The HHA Program provides support to materiel acquisition programs to ensure compliance with requirements contained in references 1 through 6.

4. BACKGROUND (references 7 through 10).

a. System Purpose. The MCVV (Figure 1) functions as a fire support vehicle to the Stryker Brigade Combat Team. It is designed to provide vehicle occupants with increased blast protection from underbody mines and improvised explosive devices (IEDs) without decreasing function and mobility capabilities. The baseline vehicle for the MCVV is the Stryker Double V Hull Infantry Carrier Vehicle (ICVV).

b. System Description. The MCVV is based off of the currently fielded, flat-bottomed, Stryker Mortar Carrier Vehicle with the same subsystems packaged into a new hull design. The MCVV weapon systems include the 120 millimeter (mm) Recoiling Mortar System 6-Light (RMS6-L) and the M240B 7.62 mm machine gun. Both the RMS6-L mortar and the M240B machine gun are found on the legacy system. The MCVV is a 26 ton (approximate) eight-wheeled armored vehicle that can be operated on or off the road. It has a top speed of 62 miles per hour (mph) and can be driven in either an 8x4 mode, with the rear four wheels driving, or in full 8x8 mode. The MCVV has a capacity for five crew members (driver, commander, gunner, assistant gunner, and ammo bearer). The MCVV is a highly mobile vehicle and can be operated on or off road. The vehicle is equipped with the current production Caterpillar C7 diesel engine

and Allison 3200SP automatic transmission. The steering system uses hydraulic power assist. The brakes are improved due to increased DVH vehicle weight and are all pneumatic and include an anti-lock brake system.

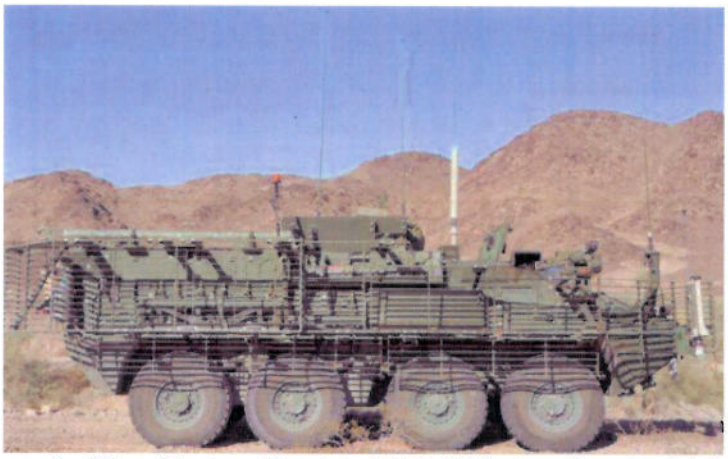

Figure 1. The Stryker Double V Hull Mortar Carrier Vehicle

c. Previous Assessment. An initial HHAR for the MCVV was completed in September 2011 (reference 11). A definitive HHAR on the ICVV, the baseline vehicle for the MCVV, was completed in May 2012 (reference 12). Additional HHARs were conducted on the legacy mortar carrier vehicle (references 13 and 14). This HHAR addresses only those hazards that required additional information, are unique to the MCVV, and were not fully addressed in the May 2012 ICVV HHAR. The hazards and recommendations addressed in the previous HHARs are still applicable.

5. IDENTIFICATION OF HEALTH HAZARD ISSUES. Data requirements, health effects, medical criteria, and references specific to the health hazard types identified in this HHAR may be found at the following website: http://phc.amedd.army.mil/topics/workplacehealth/hha/Pages/default.aspx.

a. Radiofrequency Radiation (RFR).

b. Whole-body Vibration (WBV).

6. HEALTH HAZARD ISSUES: ASSESSMENT AND RECOMMENDATIONS. Department of Defense Instruction 6055.1 and Army Regulation (AR) 40-5 require that personnel not be exposed to health hazards in excess of the limits specified in the Department of Defense safety and occupational health standards or specialized

standards applicable to military-unique equipment, systems, or operations (references 15 and 16). Every effort should be made to eliminate or control hazards through design.

a. Radiofrequency Radiation.

(1) Assessment.

(a) The Department of Defense and Army standards (reference 17) for permissible exposure to RFR in the 3 kilohertz to 300 gigahertz frequency spectrum state that personnel shall not be exposed to RFR fields which would result in whole body specific absorption rates (SARs) of greater than 0.4 Watts per kilogram (W/kg) averaged over a 6-minute period. The equivalent whole-body maximum permissible exposure (MPE) limits, which correspond to the SARs are specified in milliwatts per centimeter squared (mW/cm^2) (i.e., power density levels). These MPEs vary from 1 mW/cm^2 to 100 mW/cm^2, depending upon the frequency of operation of the transmitting source. The maximum permissible level for partial-body and local exposure is 10.0 W/kg or 20-40 mW/cm^2. The primary effect of RFR energy absorbed by the body is thermal, with the lens of the eye as the most sensitive tissue potentially affected.

(b) The RFR sources on the MCVV, per reference 10, include the AN/VRC-91F Single Channel Ground and Airborne Radio System (SINCGARS), the Enhanced Position Location Reporting System (EPLRS) and the Counter Radio-Controlled Improvised Explosive Device Electronic Warfare-2 (CREW-2) (AN/VLQ-12(V)3), also known as the Duke V3. Note that Blue Force Tracking (BFT) units, BFT-1 and/or BFT-2, may be used in place of the EPLRS.

(c) The SINCGARS. The MCVV is equipped with one AN/VRC-91 SINCGARS radio. These very high frequency-frequency modulation radio sets are used for tactical voice and data communications. The AN/VRC-91 SINCGARS includes one or two transceiver units and a power amplifier. This radio set operates in the 30-88 megahertz (MHz) frequency band at an average output power of 5 Watts (W) in the low-power mode and up to 50 W with the power amplifier. The AS-3900 SINCGAR antennas are mounted at the mid-way points on the curb and street sides of the MCVV (Figure 2). The whole-body and partial-body MPEs that apply for these radio sets are 1.0 mW/cm^2 and 20 mW/cm^2, respectively. The whole-body MPE could be emitted to a distance of 28 inches (in) from the antenna. There is also a potential for radiofrequency (RF) shock or burn if hand contact is made with the antenna while it is transmitting.

Figure 2. Stryker MCVV Antenna Locations

(d) The EPLRS. The EPLRS is a tactical data system that handles simplex and duplex data transmissions in the ultra-high frequency band and works in conjunction with a ground positioning system. The EPLRS transmitter operates at frequencies between 420 and 450 MHz with a selectable maximum peak power of 100 W, 20 W, 3 W and 0.4 W. The duty cycle can vary from an average value of 8 percent to a maximum of 27 percent. The transmitter peak power varies according to an internal algorithm. The variation of the peak power and duty cycle that limits the maximum average power available to the antenna is 8.7 W. The antenna is mounted on the top left rear of the vehicle (Figure 2). The EPLRS is not able to produce spatially and temporally averaged power density levels greater than the 1.4 mW/cm^2 whole-body MPE or the 20 mW/cm^2 local exposure (partial-body) MPE.

(e) The BFT-1 and BFT-2. The BFT-1 and BFT-2 are devices used for battlefield situational awareness using global positioning satellite technology. These devices operate in the 1-2 gigahertz frequency band. The BFT-1 antenna is installed in front of the driver's station on the exterior of the MCVV. The BFT-2 antenna is installed to the left of the driver's station on the exterior of the MCVV. Due to the low power output of these devices, they are not able to produce spatially and temporally averaged power density levels greater than the 3.3 mW/cm^2 whole-body MPE or the 20 mW/cm^2 local exposure MPE and therefore are not subject to radiation protection control.

(f) The CREW-2 (Duke V3 (AN/VLQ-12(V)3)). The Duke V3 is a counter IED system. As installed on the MCVV, the Duke V3 uses an omni-directional antenna (FRF-105D) and a directional antenna (FRF-119C). The omni-directional FRF-105D and FRF-119C directional antennas are installed on the Stryker MCVV as shown in Figure 3. The transmitter power output and transmitting frequencies of the Duke V3 are classified. As such, the most restrictive MPE of 10 mW/cm^2 is adhered to for personnel RFR exposure concerns. When the Duke V3 is radiating, personnel should observe a distance of 28 in from the FRF-105D omni-directional antenna and 13 feet (ft) from the front of the FRF-119C directional antenna when it is transmitting.

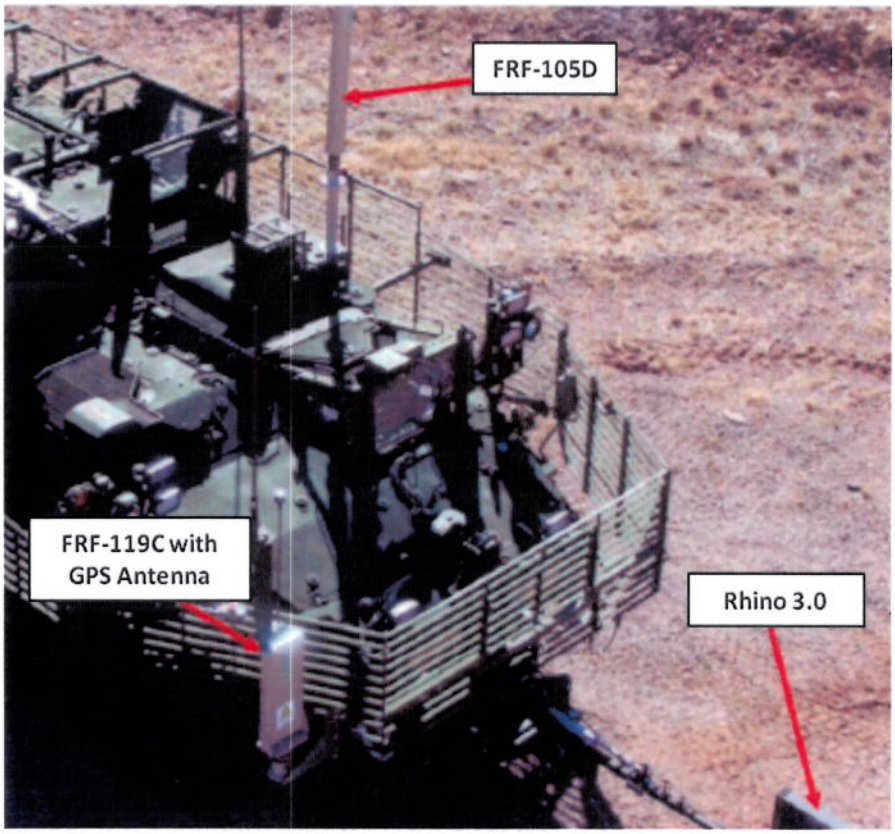

Figure 3. Duke V3 FRF-119C and FRF105D Antenna Locations

(2) Recommendations. A Risk Assessment Code (RAC) of Low (Hazard Severity (HS) 4, Hazard Probability (HP) C) is assigned. A residual RAC of Low (HS 4, HP D) is assigned for compliance with the following recommendations:

(a) The SINCGARS. Attach an RFR warning sign or decal on or near the base of the SINCGARS antennas to prevent RFR exposure exceeding the standards and to avoid the potential for RF shock and burn. This sign should specify maintaining a distance of 28 in from the antenna while it's transmitting.

(b) Duke V3.

i. Post an RFR warning sign or decal on or near the FRF-105D omni-directional antenna specifying to maintain a distance of 28 in when the antenna is transmitting.

ii. Post an RFR warning sign or decal on or near the FRF-119C directional antenna specifying to maintain a distance of 13 ft when the antenna is radiating.

b. Whole-body Vibration.

(1) Data assumptions. Whole-body Vibration data was collected at the Aberdeen Proving Grounds (APG) by the Aberdeen Test Center (ATC). The AIPH assessor was not present at the time of the data collection therefore, the data provided to the assessor is assumed to have been collected in accordance with AR 40-10 (reference 1) and, subsequently, International Organization of Standardization (ISO) standard ISO 2631-1: 1997 (reference 18). The data was collected on three test tracks. The data collected is assumed to have been collected in a manner that is representative of the mission profile of the MCVV and is typical of expected vibration exposures.

(2) Assessment.

(a) Mission Profile. The WBV analysis uses the Mission Profile information for calculation of hazard probability. The Mission Profile concerning terrain usage is listed in Table 1 (reference 19). Wartime operations are based on a 9 day mission, which involves a 24 hour mission scenario. Actual vehicle movement times of up to 4 hours per 24 hour cycle can be expected. Missions can be preceded by up to a 150 kilometer road march.

Table 1. Mission Profile MCVV

Wartime Operational Mode Summary		
Course	Reconnaissance Percent Time	All Other Percent Time
Primary	10%	20%
Secondary	40%	50%
Trails/Cross-Country	50%	30%

(b) Test procedures and data analysis. The MCVV traversed the H Fields 1, 2, 3, 4, and PTA-2 and -3 test courses. A triaxial seat pad accelerometer was fixed to four locations within the vehicle; the driver, commander, gunner, and rear seat. An onboard pulse code modulation data acquisition system was used to acquire acceleration data while the MCVV was operated on the test courses. All data channels were digitized sequentially at 500 samples per second after having been low-pass filtered at 100 hertz for the accelerometer. The data was collected, processed and weighted according to ISO 2631-1 by engineers at ATC.

(c) Vibration data. Data analysis was conducted by the AIPH from the frequency-weighted root mean square accelerations (Wrms) for the longitudinal (X), transverse (Y), and vertical (Z) axis provided by ATC (reference 20). From this data, the upper limits of the health guidance cautions zone were calculated per ISO 2631-1:1997 for each of the test conditions.

(d) Health effects. This HHAR addresses the adverse health effects or serious injuries that may occur as a result to WBV exposure. This is a separate issue from the ride quality associated with comfort or fatigue of the crew and occupants. Ride quality may affect the performance of their tasks but does not necessarily and directly cause injury. The current seating is not designed to accommodate Individual Body Armor and therefore it allows for increased flexion of an occupant's lumbar region when encountering seated WBV.

(e) Literature. The ISO 2631-1 standard includes this brief discussion of the health effects of WBV:

> "The relevant literature on the effects of long-term high-intensity whole-body vibration indicates an increased health risk to the lumbar spine and the connected nervous system of the segments affected. This may be due to the

biodynamic behavior of the spine: horizontal displacement and torsion of the segments of the vertebral column. Excessive mechanical stress and/or disturbances of the nutrition of and the diffusion to the disk tissue may contribute to a degenerative process in the lumbar segments (spondylosis deformans, osteochondrosis intervertebralis, arthrosis deformans). Whole-body vibration exposure may also worsen certain endogenous pathologic disturbances of the spine."

(f) Risk assessment code. The ISO 2631-1:1997 standard does not employ risk assessment terminology and methods that are consistent with Military Standard (MIL-STD) 882 E (reference 21). This MIL-STD requires that the hazard (such as WBV) be assigned a hazard severity category (1, 2, 3 or 4) and a hazard probability (A, B, C, D, E or F). The U.S. Army Aeromedical Research Laboratory uses the classification scheme to translate WBV exposure limits to "hazard severity categories" (1, 2, 3 and 4). Hazard probabilities (A, B, C, and D) are assigned to the WBV exposure based on the description of utilization rates of the system. Once the severity category and probability level have been determined, MIL-STD 882-E provides a matrix to assign a RAC to the system under evaluation.

(g) Hazard severity MCVV. According to AR 40-10, hazard severity is a factor used to describe the most reasonable credible health consequence to Soldiers associated with the normal use of the materiel system. For WBV assessments, this statement is interpreted as the maximum vibration value attained during the testing of the vehicle for each of the terrain types tested. The limiting acceleration value for the MCVV driver seat was 5.94 meters per second squared (m/s^2) on H Field 1 at 18 mph. This acceleration value equates to a 0.17 hours daily exposure limit per ISO 2631-1:1997. The 0.17 hours daily exposure limit equates to a HS category of 2 (Critical) for the MCVV. Therefore, an overall HS of 2 (Critical) is assigned to the MCVV.

(h) Hazard probability MCVV. The hazard probability is based on the mission and mobility profile of the MCVV. There were 280 vibration measurements made on the MCVV. Of those 280 measurements, 11 were of the HS of 2, all on cross-country terrain. The mission profile calls for the vehicle to drive over trails or cross-country terrain 50 percent of the time. This indicates that the operator will experience vibration that exceeds the health guidance caution zone. Therefore, a HP of D (Remote) is assigned to the MCVV.

(3) Recommendations. A RAC of Medium (HS 2, HP D) is assigned. A residual RAC of Low (HS 4, HP D) is assigned for compliance with the following

recommendation: Redesign the permanent seats in the MCVV to absorb more vibration energy and improve lumbar support.

7. PREPARER IDENTIFICATION. The AIPH, Aberdeen Proving Ground, MD 21010-5403, prepared this HHAR. The point of contact in the Army Health Hazard Assessment Program is Mr. Robert Batts, commercial 410-436-2925, DSN 584-2925, or e-mail: robert.w.batts2.civ@mail.mil. This Institute's Radiofrequency Radiation Program (Mr. Brad Roberts) and Ergonomics Program (Ms. Lauren Costanzi and Mr. Steven Chervak) contributed to this HHAR. This Institute's Occupational Medicine Program reviewed the medical aspects of this assessment.

TIMOTHY A. KLUCHINSKY, DrPH
Manager
Health Hazard Assessment Program

APPENDIX A

REFERENCES

1. Army Regulation 40-10, Health Hazard Assessment Program in Support of the Army Acquisition Process, 27 Jul 07.

2. Army Regulation 70-1, Army Acquisition Policy, 22 Jul 11.

3. Army Regulation 385-10, The Army Safety Program, 23 Aug 07 (RAR 4 Oct 11).

4. Army Regulation 602-2, Manpower and Personnel Integration (MANPRINT) in the System Acquisition Process, 1 Jun 01.

5. Department of Defense Instruction 5000.02, Operation of the Defense Acquisition System, 8 Dec 08.

6. Memorandum, Under Secretary of Defense, Acquisition, Technology, and Logistics, 23 Sep 04, subject: Defense Acquisition System Safety.

7. Memorandum, Project Manager, Stryker Brigade Combat Team, 13 Jul 11, subject: Health Hazard Assessment (HHA) to support the Urgent Materiel Release (UMR) of the Stryker Double "V" Hull Infantry Carrier Vehicle (ICVV); Stryker Double "V" Hull Engineers Squad Vehicle (ESVV); Stryker Double "V" Hull Commanders Vehicle (CVV); Stryker Double "V" Hull Fire Support Vehicle (FSVV); Stryker Double "V" Hull Medical Evacuation Vehicle (MEVV); Stryker Double "V" Hull Mortar Carrier Vehicle (MCVV); Stryker Double "V" Hull Anti-Tank Gun Vehicle (ATGMVV).

8. Safety Assessment Report for the Stryker Double V Hull Mortar Carrier Vehicle, General Dynamics Land Systems, 22 Aug 11.

9. Memorandum, Aberdeen Test Center, TEDT-AT-ADF, 4 May 12, subject: Recommendation for Safety Confirmation to Support Fielding of the Double V-Hull (DVH) Mortar Carrier (MCVV), ATEC Project No. 20101-DT-ATC-STDVH-E7928.

10. Memorandum, TEAE-MG, 6 Apr 12, subject: Safety Confirmation for the XM1252 Double V Hull (DVH) Mortar Carrier Vehicle (MCVV) in Support of Fielding.

11. Memorandum, Army Institute of Public Health (MCHB-IP-OHH), 20 Sep 11, subject: Initial Health Hazard Assessment Report on the Stryker Double Vee Hull Mortar Carrier Vehicle, No. 69-MP-0F0D-11.

12. Memorandum, Army Institute of Public Health (MCHB-IP-OHH), 23 May 12, subject: Health Hazard Assessment Report on the Stryker Double Vee Hull Infantry Carrier Vehicle and Scout Configuration, No. 69-MP-0F0F-11.

13. Memorandum, Army Institute of Public Health (MCHB-IP-OHH), 12 Jun 03, subject: Updated Health Hazard Report on the Stryker Mortar Carrier Vehicle – Version B (MC-B) (Soltam), No. 69-374102-03.

14. Memorandum, Army Institute of Public Health (MCHB-IP-OHH), 14 Nov 03, subject: Health Hazard Assessment Report on the Stryker Mortar Carrier Vehicle – Version B (MC-B) (Soltam), No. 69-MP-4102-04.

15. Department of Defense Instruction 6055.1, DoD Safety and Occupational Health (SOH) Program, 19 Aug 98.

16. Army Regulation 40-5, Preventative Medicine, 25 May 07.

17. Department of Defense Instruction 6055.11, Protection of Personnel from Electromagnetic Fields, 19 Aug 09.

18. International Standards Organization 2631-1, Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole-body Vibration Part 1: General Requirements, 97.

19. Email, Yuma Test Center, Mr. Shepherd Okamura, 1 Aug 12, subject: MCVV Stryker OMS/MP.

20. Email, Aberdeen Test Support Services, Mr. Ira Carlson, 19 Jul 12, subject: MCVV RQ Report.

21. Military Standard 882 E, Department of Defense Standard Practice: System Safety, 11 May 12.

APPENDIX B

WHOLE-BODY VIBRATION ANALYSIS

B-1. AUTHORITY. Military Standard 1472G, Department of Defense Design Criteria Standard, Human Factors Engineering, 11 Jan 12.

B-2. BACKGROUND. The relevant literature on the effects of long-term high-intensity whole-body vibration (WBV) indicates an increased health risk to the lumbar spine and the connected nervous system of the segments affected.

B-3. DATA COLLECTION REQUIREMENTS. Whole-body vibration exposure is dependent on several variables including, but not limited to, vehicle condition, vehicle load, speed, and terrain conditions. In order to properly assess military vehicles for WBV health risks, the following information must be provided:

a. Vehicle Mission Profile/Operational Mission Profile (MP/OMP) Summary. The summary should include:

(1) Terrain usage break out.

(2) Speed range of vehicle on each type of terrain.

(3) Length of mission.

(4) Hours of operation.

(5) Expected distance of travel.

(6) Number in crew.

(7) Crew positions (diagram if possible).

b. Vibration Data. Data must be collected in a manner that is representative of the mission profile of the vehicle and is typical of the expected exposures. Duration of measurements shall be sufficient to ensure statistical precision. Whole-body vibration data must be collected in accordance with International Organization for Standardization (ISO) 2631-1:1997 and ISO 2631-5:2004. Refer to ISO 2631-1 and ISO 2631-5 for

complete data collection guideline details. The following are some general collection guidelines for WBV:

(1) Collection specifications. Data must be collected using a triaxial seat pad accelerometer at the point of principal contact between the body and the vibrating surface. For seated subjects, that point is the seat surface.

(2) Test condition. Test conditions should simulate MP/OMP including representative speeds, load conditions, and terrain surfaces. Data should be recorded in speed increments of 5 miles per hour (mph) for each terrain condition, from 5 mph to max speed as indicated by the MP/OMP.

(3) Signal conditioning, sample rate and measurement duration. The dynamic range of the signal conditioning equipment shall be adequate for the highest and lowest signals. In order to use the Jolt program, the sample rate must be at least 160 hertz (Hz). The duration of measurement shall be sufficient to ensure a reasonable statistical representation of the assessed exposures.

B-4. DATA FILE STRUCTURE.

a. The collected vibration data should be stored in simple text files. The data collected must be in British Columbia Research (BCR) format, which is a text file with the extension ".BCR." The filenames must have the ".BCR" extension because it is the only extension recognized by the Jolt software. The files should contain two sections, Header and Data, and should be formatted as shown in Figure B-1.

(1) Header. Each BCR file starts with a header that includes three descriptive groups of information about the test parameters (channel labels, engineering units, sampling rate, etc.). The filename (maximum of 12 characters) appears on the first line of the header. A descriptive title can be placed on the first and second line starting at column 17. Header information is placed in blocks that start with a label that is surrounded by angle brackets: <TEST>, <SAMPLING>, and <CHANNELS>. Blank lines in the header section are ignored.

(2) Data. The Data section begins with the label <DATA>, followed by a line containing the format of the data (in Fortran style) and then the numeric data itself organized in columns with each column representing one channel of data. The data may be delimited by commas, tabs, or spaces, with one row representing one time sample of all signals. Each data point can have a maximum seven characters. The best way to accomplish this is to limit the resolution of the data to thousandths (0.001).

b. The Jolt program is designed to treat each triaxial accelerometer as a single data file. Therefore, for each measurement location, there needs to be a separate BCR data file containing the acceleration data for that location. The Jolt program is also designed to read input from each of the three axes (X, Y, Z) of the accelerometer simultaneously. Therefore, the BCR data file has to contain three columns of acceleration data with the order of X being the first column, Y being the second, and Z being the final column. Data may only span 512 characters across each row of data.

c. The program requires the acceleration data be in the units of meters per second squared (m/s^2). For convenience of the user, and for those files in units other than m/s^2 (such as g's), the user may specify a conversion factor and have the program convert the data to m/s^2. Figure B-1 is an example of the BCR file data structure. Note: You must include keywords as they are shown in red (including colons).

```
A_Sample.BCR     THIS IS A SAMPLE TITLE
                 Human response to shock and vibration

<TEST>
Description:          Phase 2 - Vehicle Data
Test Location:        outside track
Vehicle Type:         SUV
Seat Position:        Driver
Test Terrain:         gravel
Vehicle Speed:        15 mph

<SAMPLING>
Number of Channels:  3
Samples per channel: 25298
Sampling rate (Hz):  416.667
Signal duration (s): 60.7

<CHANNELS> -------------------------123456--12345678
01  seat x acceleration              m/s^2   XAC seat
02  seat y acceleration              m/s^2   YAC seat
03  seat z acceleration              m/s^2   ZAC seat

<DATA> ***************************************************
1(F7.2),2(F8.2) [Obsolete Fortran format … It is ignored]
   0.05     0.21     0.14
   0.05     0.19     0.13
   ----- etc...
```

Figure B-1. BCR Data Structure