FIXED HUMAN ACCOMMODATION REFERENCE POINT (HARP): COMMANDER CAD ACCOMMODATION MODEL VERIFICATION REPORT

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Document Identifier: [OPSEC7901]
Revision: [1.0]
Release Date: [09/18/2023]

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1. VERIFICATION REPORT EXECUTIVE SUMMARY

Military ground vehicles are currently designed using requirements from MIL-STD-1472, the *Department of Defense Design Criteria Standard: Human Engineering*. The MIL-STD, however, is difficult for designers to apply properly because it is often open to interpretation. Easy-to-use Computer-Aided Design (CAD) tools are needed by the ground vehicle community to address this issue. The CAD tools being developed are called accommodation models. Accommodation models are constructed from 3D empirical data for a given seating configuration to provide population workspace boundaries that include the effects of both anthropometry and posture (Zielinski et al 2015). The verification effort is intended to build confidence in accommodation models for use in ground vehicle design.

The model described in this verification report is the Ground Vehicle Systems Center (GVSC) Fixed HARP: Commander CAD accommodation model. The model is applicable to ground vehicle commander workstations where the users interact with a keyboard, screen, and have an adjustable seat back. The model is intended to provide the composite boundaries representing the body of the defined user population, including the effects of posture and protective equipment and gear. The boundaries defined include the required space needed for the equipped users' helmet, torso, elbows, knees, eye location, and boots. The model also generates preferred and acceptable ranges of keyboard locations. Clearances between the user and surrounding interior vehicle surfaces have been added per MIL-STD-1472 (e.g. head clearance required from head (helmet) to vehicle roof line). Direct vision zones, including to screens at eye level, have been added based on MIL-STD-1472 and SAE Recommended Practice J1050.

The Fixed HARP: Commander accommodation model is a statistical model created utilizing data collected from Soldiers at Fort Riley, Kansas, and is documented in the report *Development of Posture Prediction and Accommodation Models for Military Vehicles: Commander and Gunner* (Reed et al, 2021) completed by the University of Michigan Transportation Research Institute (UMTRI). The original model, as provided by UMTRI, consists of a Microsoft Excel workbook. The CAD version of the model was created using PTC Creo® 3D CAD software and is a stand-alone geometric reproduction of the output found in the UMTRI Microsoft Excel spreadsheet.

This CAD accommodation model can be applied early in the vehicle design process to ensure accommodation requirements are met and help explore possible design tradeoffs when conflicts with other design parameters exist. Vehicle designers can use the GVSC Fixed HARP: Commander CAD accommodation model for the following scenarios: 1) during the concept and design phase of new acquisition programs, 2) while upgrading existing ground vehicle platforms, and 3) for assessing a commercial off-the-shelf (COTS) system. Human factors engineers could benefit by working with vehicle designers to perform virtual assessments in CAD when there is not enough time and/or funding to translate vehicle models into formats compatible with human figure modeling and simulation software.

The intention of verification is to build confidence in the CAD accommodation model. Model verification includes ten test scenarios for comparing the Fixed HARP: Commander CAD accommodation model outputs against predefined requirements and acceptability criteria. Specifically, when given the same inputs, accommodation model geometry from the CAD model will be compared to the outputs of the UMTRI *Commander_Accommodation_Models.21, 2023-08-01* spreadsheet; and boundary manikin hip and eye locations were compared to the outputs of the *Commander Posture Prediction.2, 2020-12-12* spreadsheet. Because no other models for comparison exist, Subject Matter Experts (SMEs) were used to determine that CAD model outputs for occupant clearances matched the agreed upon interpretation of MIL-STD-1472.

One issue was discovered during the verification process. Within the knee contour, for both the spreadsheet and CAD model, the thigh segment angle with respect to horizontal did not vary with elevation changes to the Human Accommodation Reference Point (HARP). This issue was corrected. The final outcome from the review was team consensus that the Fixed HARP: Commander CAD accommodation model passed verification.

2. PROBLEM STATEMENT

Military ground vehicles are currently designed using requirements from MIL-STD-1472, the *Department of Defense Design Criteria Standard: Human Engineering*. The requirement to accommodate the central 90 percent of the user population, in which the fully equipped user can sit safely and comfortably while performing all required functions, requires multivariate analysis methods so that both the users' anthropometry and posture can be considered. MIL-STD-1472 is often open to interpretation and is therefore difficult for designers to apply consistently. Easy-to-use, valid design tools and procedures based on these methods are needed to effectively design vehicle workstations. The chosen tools are Computer-Aided Design (CAD) based accommodation models adapted for users in military ground vehicles, that directly parallel long-standing SAE recommended practices used in the commercial automotive and truck domains (Zielinski et al 2015). The fourth such CAD model to be developed is the Fixed HARP: Commander accommodation model, Figure 1.

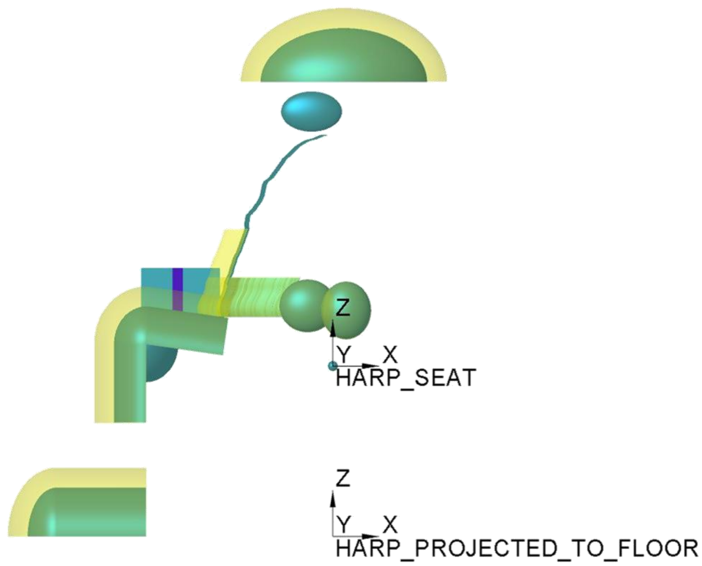

Figure 1: Fixed HARP: Commander Accommodation Model

2.1. INTENDED USE

The Fixed HARP: Commander CAD accommodation model described in this verification report is applicable to ground vehicle commander workstations where the users interact with a keyboard, screen, and have an adjustable seat back.

The Fixed HARP: Commander CAD accommodation model is intended to provide the composite boundaries representing the body of the defined user population, including the effects of posture and protective equipment and gear. The boundaries defined include the required space needed for the equipped users' helmet, torso, elbows, knees, eye location, and boots. The model also generates preferred and acceptable ranges of keyboard locations. Clearances between the user and surrounding interior vehicle surfaces have been added per MIL-STD-1472 (e.g. head clearance required from head (helmet) to vehicle roof line). Direct vision zones, including to screens at eye level, have been added based on MIL-STD-1472 and SAE Recommended Practice J1050.

It should be noted that CAD accommodation models serve as a design tool and are not intended to replace, but rather complement, Human Factors Engineering (HFE) assessment tools.

2.2. M&S OVERVIEW

The Fixed HARP: Commander CAD accommodation model is a statistical model created utilizing data collected from Soldiers at Fort Riley, Kansas, and is documented in the report *Development of Posture Prediction and Accommodation Models for Military Vehicles: Commander and Gunner Positions* (Reed et al 2021) completed by the University of Michigan Transportation Research Institute (UMTRI). The original model consists of a Microsoft

Excel workbook. The CAD version of the model, created using PTC Creo® 3D CAD software, is a stand-alone geometric reproduction of the output found in the UMTRI Microsoft Excel spreadsheet.

Model inputs include the definition of the target design population (a subset of the Army Anthropometric Survey (ANSUR) II), the ensemble (clothing and equipment worn by the user), the desired level of accommodation (for example, 90%), and the target population gender mix. The ensemble is selectable as either Personal Protective Equipment (PPE) which includes the Improved Outer Tactical Vest (IOTV) or Encumbered (ENC) which includes the PPE and Tactical Assault Panel (TAP) with Rifleman kit, both of which are defined in the *Development of Posture Prediction and Accommodation Models for Military Vehicles: Commander and Gunner Positions*. Ideally, the level of accommodation will be set at the central 90% of the target design population to be consistent with MIL-STD-1472 requirements. The two vehicle inputs to the model are the seat height measured above the floor surface (HARP) and the presence of hydration pack relief in the seat. It should be noted that the 2010 MCANSUR of U.S. Marine Corps (USMC) Personnel (Gordon et al 2013) can also be added to the model if USMC anthropometry is needed for design.

The Fixed HARP: Commander CAD accommodation model represents the posture and position variability for the entire selected target user population (e.g., central 90%, 85% male). The model can guide vehicle designers in creating an optimized workspace for the user. The CAD accommodation model, along with additional added space claims for human factors and vision zones, can be used to visualize MIL-STD-1472 requirements. This eliminates the concern of inconsistent application of the MIL-STD by vehicle designers when creating the occupant workspace (Zielinski et al 2015).

2.3. M&S Application

The use of the Fixed HARP: Commander CAD accommodation model provides the opportunity to apply Human Systems Integration (HSI) very early in the acquisition process. The model can be utilized during the Material Solution Analysis Phase prior to Milestone (MS)A and up through and including MSB. Past programs have not actively engaged HSI until MSB or the Engineering Manufacturing and Development (EMD) Phase, resulting in significant design and cost changes.

This Fixed HARP: Commander CAD accommodation model can be used to explore possible design tradeoffs when conflicts with other design parameters exist. Vehicle designers can use the model for the following scenarios: 1) during the concept and design phase of new acquisition programs, 2) while upgrading existing ground vehicle platforms, and 3) for assessing a commercial off-the-shelf (COTS) system. Human factors engineers could benefit by working with vehicle designers to perform virtual assessments in CAD when there is not enough time and/or funding to translate vehicle models into assessment software compatible formats and perform detailed human figure modeling.

2.3.1. Model Origin

The HARP is the origin for the Fixed HARP: Commander CAD accommodation model, Figure 2. All outputs are determined with respect to the HARP.

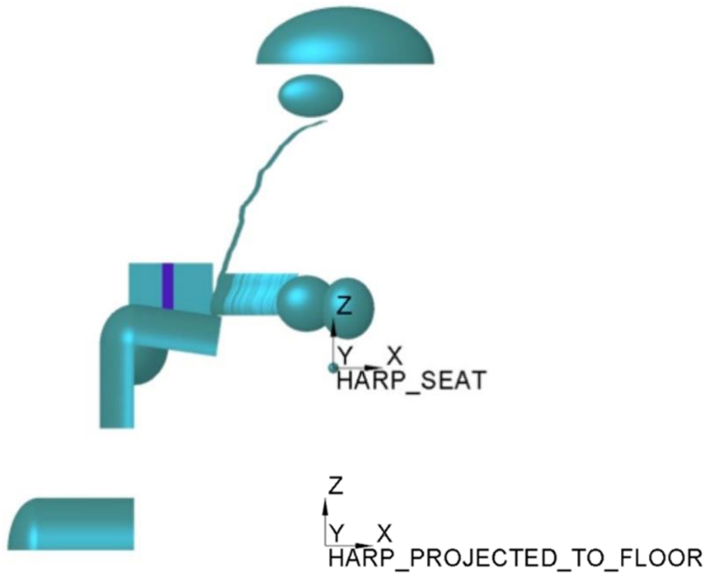

Figure 2: Fixed HARP: Commander Accommodation Model Origin

2.3.2. Model Inputs

The Fixed HARP: Commander accommodation model requires six inputs, listed in Table 1:

Table 1: Fixed HARP: Commander Accommodation Model Inputs

Target Accommodation	The percentage of the target design population to be accommodated. The occupants not accommodated are evenly split between the smaller and larger extremes of the population. In MIL-STD-1472 (2012), the accommodation target has been set at 90%.
Fraction Male	The percentage of males in the defined target design population.
Ensemble	Clothing and equipment available for selection in the model: • [1]PPE = ACU + IOTV + ACH • [2]ENC = ACU + PPE + Rifleman
Human Accommodation Reference Point (HARP)	The seat height measured above the floor surface.
Consider Hydration Pack Relief	A seatback with hydration pack relief can fully accommodate an occupant's hydration pack such that the occupant's position in the seat is the same regardless of wearing a hydration pack. The following selection will be available in the model: • Yes • No

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Human Accommodation Reference Point (HARP) Tool	Indicates which HARP measurement device has been chosen for the occupant's seat. The two options of seat design HARP measurement tools are the SAE J826 H-point manikin and Seat Index Point (SIP) tool (Reed et al 2014). The following selection will be available in the model: • SAE J826 • ISO 5353

[1] Personal Protective Equipment (PPE), Advanced Combat Uniform (ACU), Improved Outer Tactical Vest (IOTV) that included Enhanced Small Arms Protective Insert (ESAPI) plates, Enhanced Side Ballistic Inserts (ESBI), and Advanced Combat Helmet (ACH).
[2] Encumbered (ENC), Rifleman Ensemble defined in the Soldier Load Configurations in Ground Vehicles (McNamara, 2012) and Seated Soldier Study (Reed et al 2013).

2.3.3. Model Outputs – Occupant Composite Body Boundaries and Adjustment Ranges

The primary model outputs include the adjustment range needed for keyboard and screens, adjustment for seat back angle, and the resulting positions for occupant population boundaries for helmet, torso, elbows, knees, and boots. Model outputs are described below in Table 2 and shown in Figure 3.

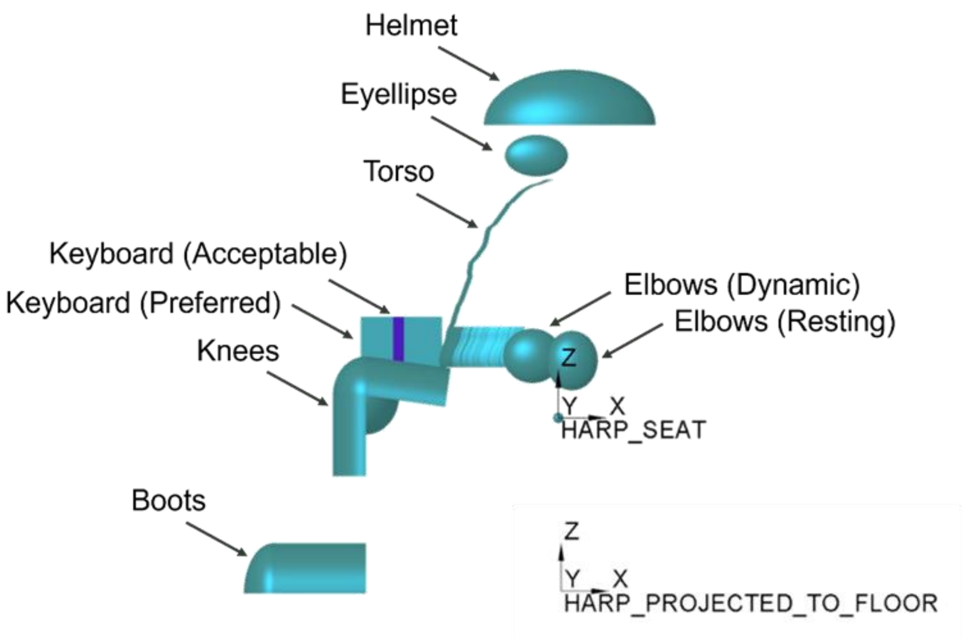

Figure 3: Fixed HARP: Commander Example Output with Travel Ranges

Table 2: Fixed HARP: Commander CAD Model Accommodation Boundary Outputs and Definitions

Keyboard Travel Window (Preferred)	The keyboard travel window depicts the amount of adjustment (fore/aft and up/down) needed to accommodate the desired percentage of the user population.

Keyboard Travel Window (Acceptable)	The keyboard travel window depicts the amount of adjustment (fore/aft and up/down) that is smaller than the preferred range to facilitate trade studies.
Seat Back Angle	The seat back angle describes an adjustment range that will accommodate the desired fraction of the population.
Helmet Boundary	The helmet boundary depicts the distribution of target design population helmet locations in the vehicle. In this model, the Advanced Combat Helmet (ACH) is used. The helmet boundary has a tangent cutoff characteristic and is used to determine or set clearances to the vehicle ceiling and nearby equipment (Reed, 2021).
Eyellipse	The eyellipse (a contraction of the words "eye" and "ellipse") depicts the distribution of occupant eye locations in the vehicle.
Torso Boundary ENC and Torso Boundary PPE	The torso boundary depicts the distribution of user torsos, including the effects of the worn equipment positioned relative to HARP (Reed, 2021).
Knee Boundary, Including Leg and Thigh	The knee boundary with leg and thigh depicts the top, forward, and lateral distribution of the resting knee locations in vehicle where the lower leg is positioned vertically.
Elbow Boundary, Dynamic	This elbow boundary depicts the distribution of occupant elbow locations when hands are performing tasks (i.e., using keyboard) (Reed, 2021).
Elbow Boundary, Resting	This elbow boundary depicts the distribution of occupant elbow locations when not performing tasks (i.e., in a relaxed posture).
Boot Boundary	The boot contours account for clearance in front of the occupant. Legs were assumed to be vertical so that ankles are directly under the knees. The forward boundary accounts for a 95% of toe points used. Lateral accommodation was developed to include accommodation for the boot.

2.3.4. Model Outputs – Occupant Clearances Based on MIL-STD-1472

Additional outputs of the model include interpretation of MIL-STD 1472 for the vehicle designer to utilize when creating the occupant workspace. Clearances consist of an additional 2-inch space claim required between the body boundaries and the vehicle environment. Model outputs are described below in Table 3 and shown in Figure 4.

Table 3: Fixed HARP: Commander CAD Model Clearance Outputs and Definitions

Model Output	Description
Clearance, Helmet	The helmet clearance consists of an additional 2 inches of space claim between the helmet boundary and the vehicle ceiling and nearby equipment.
Clearance, Abdomen	The abdominal clearance consists of an additional 2 inches of space claim between the equipped seated occupant and the steering mechanism.
Clearance, Knee with Leg and Thigh	The knee, leg, and thigh clearance consists of an additional 2 inches of space claim between the knees and any surrounding components such as doors, consoles and racks. The space between the legs is included in the clearance zone.
Clearance, Elbow	The elbow clearance consists of an additional 2 inches of lateral space claim between the elbows and nearby vehicle structures such as door trim. Clearance is provided for both dynamic and resting elbow boundaries.
Clearance, Boots	The boot clearance consists of an additional 2 inches of space claim between the boots and any surrounding components such as a center console or door trim. The space between the boots is included in the clearance zone.

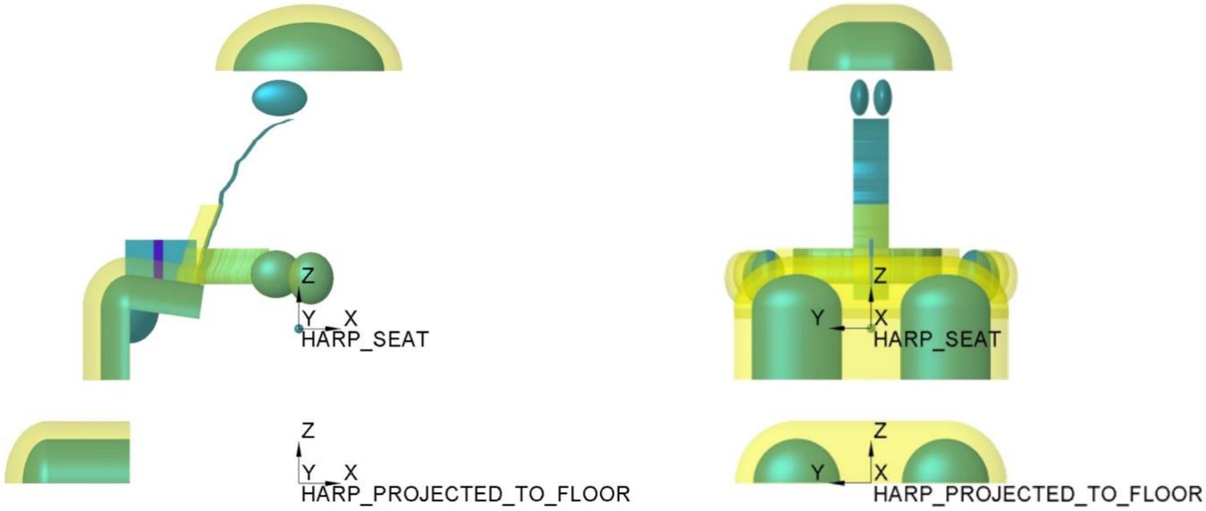

Figure 4: Fixed HARP: Commander Accommodation Model with Clearance Zone Outputs

2.3.5. Model Outputs - Direct Field of View and Ground Intercept

The direct field of view has been divided into primary, secondary, and tertiary zones. The zones were developed with DAC and UMTRI using a combination of vertical and horizontal visual fields described in MIL-STD-1472 and SAE J1050. When members of a population have different eye points, tangents to the eyellipse are used to determine field of view (Huston II, Zielinski, & Reed, 2016). Model outputs are described below in Table 4 and shown in Figure 5.

Table 4: Fixed HARP: Commander CAD Model Vision Zone Outputs and Definitions

Model Output	**Description**
Vision Zone, Primary	The primary vision zone indicates space viewable by all occupants from at least one eye using a minimum of "easy" eye rotation. Combining the limits of MIL-STD-1472G and SAE J1050, "easy" eye rotation is defined laterally as 15 degrees side-to-side from the occupant's centerline and vertically as +15/-30 degrees from horizontal (Huston II, et. al, 2016).
Vision Zone, Secondary	The secondary vision zone includes both "easy" eye rotation and "easy" head turn. Combining the limits of MIL-STD-1472G

	and SAE J1050, “easy” eye rotation and “easy” head turn is defined laterally as 60 degrees side-to-side from the occupant’s centerline (15 degrees eye + 45 degrees head) and vertically as +15/-30 degrees from horizontal (eye rotation only) (Huston II, et. al, 2016).
Vision Zone, Tertiary	The tertiary vision zone includes both “max” eye rotation and “max” head turn. Combining the limits of MIL-STD-1472G and SAE J1050, “max” eye rotation and “max” head turn is defined laterally as 95 degrees side-to-side from the occupant’s centerline (35 degrees eye + 60 degrees head) and vertically as +45 degrees/-65 degrees from horizontal (eye rotation only).
Vision Zone, Screen Adjustment	The vision zone for screen adjustment allows for horizontally directed vison to the center of a screen around a 180-degree arc centered on the neck pivot. Each member of the population will have a viewing distance of 15 to 20 inches if the entire zone is utilized.

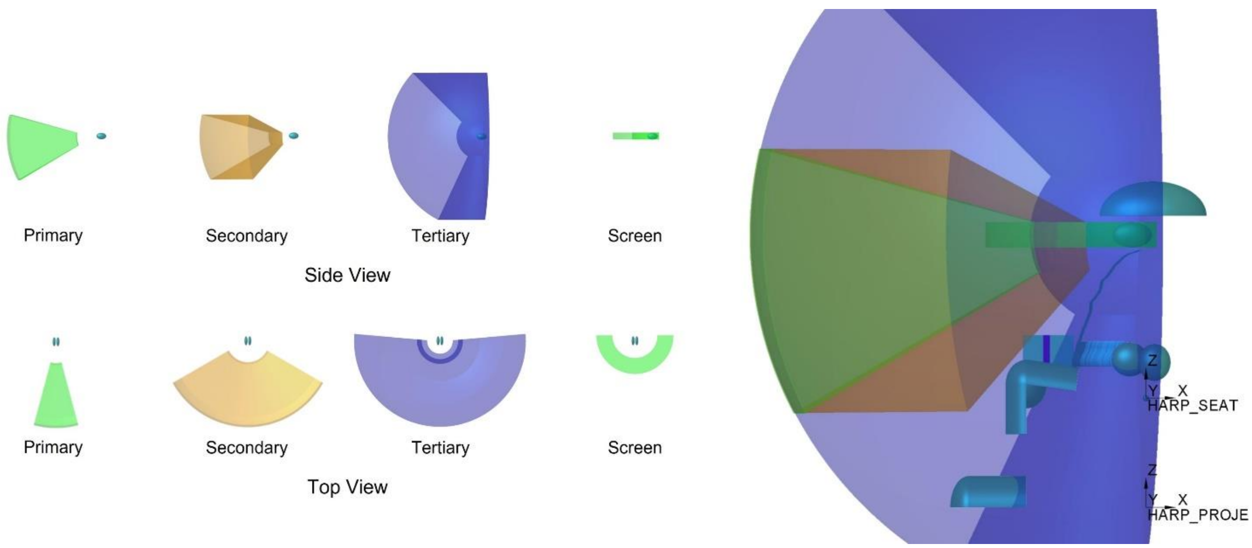

Figure 5: Fixed HARP: Commander CAD Model Vision Zones

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2.3.6. Model Outputs - Manikin Placement

Using the same data underlying the creation of the accommodation boundaries, boundary manikins representing the anthropometric extremes of vehicle workstation design are placed in their nominal positions. This is helpful in understanding how specific individuals in the population fit into the vehicle and aids visualization for those unfamiliar with the accommodation boundaries (Huston II et al 2016). Model outputs are described below in Table 5 and shown in Figure 6.

Table 5: Posture Prediction Model Output and Definitions

Model Output	Description
Boundary Manikin Posture and Position	The boundary manikin posture and position output predicts position and torso posture for a family of simulated drivers based on the vehicle configuration and the anthropometric inputs of stature, body weight, and erect sitting height.

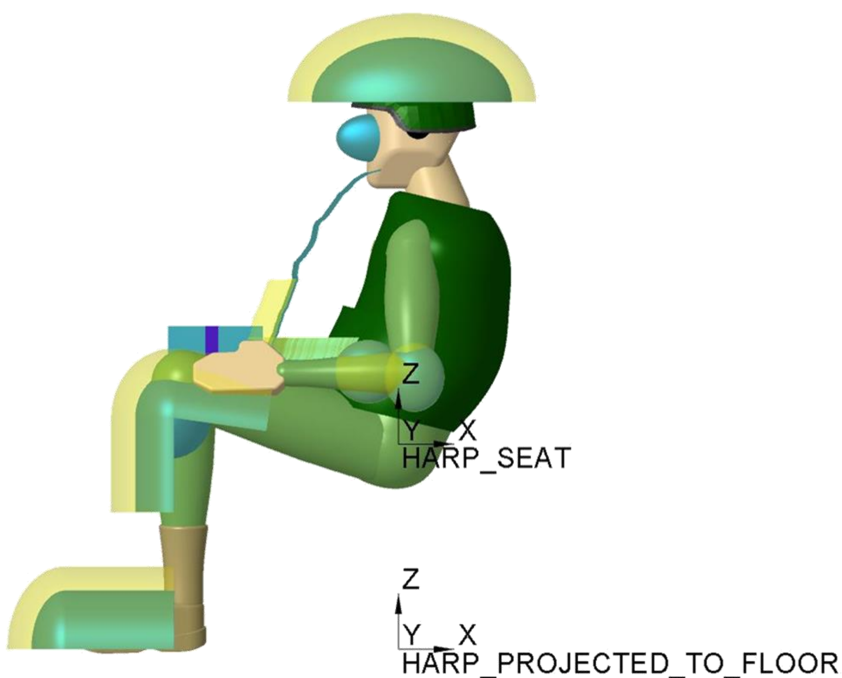

Figure 6: Boundary Manikin and Accommodation Model Overlay Example

2.4. Verification Scope

This report documents the verification of the Fixed HARP: Commander CAD accommodation model, including the activities, results, and recommendations that were gathered during the verification effort. This report will be managed by the DEVCOM GVSC accommodation model Project Lead and will be used to support any future enhancements to the Fixed HARP: Commander CAD accommodation model.

Verification of the model was completed on 15 August 2023 by the Verification Agents listed in Table 9, Section 7. DEVCOM GVSC led the verification effort and requested review, feedback, and concurrence from the key participants listed in Table 9, Section 7.

The goal of verification was to evaluate the PTC Creo® 3D CAD version of the Fixed HARP: Commander CAD accommodation model, per the following:

1) Determine if the accommodation boundaries calculated by the GVSC CAD model match those calculated by the UMTRI Microsoft Excel spreadsheet *Commander_Accommodation _Models.21, 2023-08-01*

2) Determine if the clearance zones calculated by the GVSC CAD model match the Subject Matter Expert (SME) interpretation of MIL-STD-1472H

3) Determine if the hip and eye points calculated by the GVSC CAD model match those calculated by the UMTRI Microsoft Excel spreadsheet *Commander Posture Prediction.2, 2020-12-12*

3. REQUIREMENTS AND ACCEPTABILITY CRITERIA

The Fixed HARP: Commander CAD accommodation model shall meet the requirements shown in Table 6 below:

Table 6: Requirements Relationship Table for Accommodation Model

#	M&S Requirement	Acceptability Criteria	Metrics/Measures
1	Model allows for a target population input (e.g. 90%)	1.1 Target accommodation input option in model	1.1 Representative (Pass) / Non-Representative (Fail)
2	Model allows for input of the population gender mix (e.g. 85% Male : 15% Female)	2.1 Fraction male input option in model	2.1 Representative (Pass) / Non-Representative (Fail)
3	Model allows for selection of ensemble as either PPE or ENC	3.1 Ensemble selection of PPE in model	3.1 Representative (Pass) / Non-Representative (Fail)
		3.2 Ensemble selection of ENC in model	3.2 Representative (Pass) / Non-Representative (Fail)

4	Model allows for input of the HARP	4.1 HARP height input option in model	4.1 Representative (Pass) / Non-Representative (Fail)
5	Model allows for selection of either SAE J826 or ISO 5353 for the Human Accommodation Reference Point (HARP) measurement tool	5.1 HARP measurement tool selection of SAE J826 in model	5.1 Representative (Pass) / Non-Representative (Fail)
		5.2 HARP measurement tool selection of ISO 5353 in model	5.2 Representative (Pass) / Non-Representative (Fail)
6	Model allows for selection of seat hydration pack relief in the seat	6.1 Hydration pack relief selection of "YES" in model	6.1 Representative (Pass) / Non-Representative (Fail)
		6.2 Hydration pack relief selection of "NO" in model	6.2 Representative (Pass) / Non-Representative (Fail)
7	Model predicts the seat back angle	7.1 Model outputs a seat back angle adjustment range for the given population and gender mix that adjusts with different inputs	7.1 Representative (Pass) / Non-Representative (Fail)
		7.2 CAD model matches the UMTRI spreadsheet	7.2 Representative (Pass) / Non-Representative (Fail)
8	Model predicts the keyboard fore/aft and up/down adjustment range	8.1 Model outputs a fore/aft and up/down position for the given population and gender mix that adjusts with different inputs	8.1 Representative (Pass) / Non-Representative (Fail)
		8.2 CAD model matches the UMTRI spreadsheet	8.2 Representative (Pass) / Non-Representative (Fail)
9	Model predicts the dimensions and location of the eyellipse	9.1 Model outputs a left and right eyellipse for the given population and gender mix that adjusts with different inputs	9.1 Representative (Pass) / Non-Representative (Fail)
		9.2 CAD model matches the UMTRI spreadsheet	9.2 Representative (Pass) / Non-Representative (Fail)
10	Model predicts the forward abdominal boundary	10.1 Model outputs an abdominal boundary for the given population and gender mix that adjusts with different inputs	10.1 Representative (Pass) / Non-Representative (Fail)

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		10.2 CAD model matches the UMTRI spreadsheet	10.2 Representative (Pass) / Non-Representative (Fail)
11	Model provides vertical and horizontal direct field of view based on MIL-STD-1472 and SAE J1050	11.1 Model output provides a vertical and horizontal direct Field-of-View (FOV) that matches the intent of MIL-STD-1472G and SAE J1050	11.1 Representative (Pass) / Non-Representative (Fail)
12	Model predicts the screen center fore/aft and up/down adjustment range	12.1 Model outputs a fore/aft and u/down adjustment range for the center of the screen that matches the intent of MIL-STD-1472G and SAE J1050	12.1 Representative (Pass) / Non-Representative
13	Model predicts the helmet contour boundary (helmet locations) with respect to the eye	13.1 Model outputs a helmet contour for the given population and gender mix that adjusts with different inputs	13.1 Representative (Pass) / Non-Representative (Fail)
		13.2 CAD model matches the UMTRI spreadsheet	13.2 Representative (Pass) / Non-Representative (Fail)
14	Model predicts the knee contour with leg and thigh segment angles based on location of resting occupants' knees in vehicle	14.1 Model outputs a knee ellipsoid for the given population and gender mix that adjusts with different inputs	14.1 Representative (Pass)/ Non-Representative (Fail)
		14.2 CAD model matches the UMTRI spreadsheet	14.2 Representative (Pass)/ Non-Representative (Fail)
15	Model predicts elbow contours based on location of resting and dynamic occupants' elbows in vehicle	15.1 Model outputs elbow contours for the given population and gender mix that adjusts with different inputs	15.1 Representative (Pass)/ Non-Representative (Fail)
		15.2 CAD model matches the UMTRI spreadsheet	15.2 Representative (Pass)/ Non-Representative (Fail)
16	Model predicts boot contours based on location of resting occupants' boots in vehicle	16.1 Model outputs boot contours for the given population and gender mix that adjusts with different inputs	16.1 Representative (Pass)/ Non-Representative (Fail)
		16.2 CAD model matches the UMTRI spreadsheet	16.2 Representative (Pass)/ Non-Representative (Fail)
17	Model provides a clearance zone for the head (helmet) to roof line	17.1 Model outputs a 2 inch clearance zone from the top of	17.1 Representative (Pass) / Non-Representative (Fail)

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	based on MIL-STD-1472 requirements	the helmet contour that adjusts with different inputs	
18	Model provides a clearance zone for the knee, leg and thigh based on MIL-STD-1472 requirements	18.1 Model outputs a 2 inch clearance zone from the top and front of the knee contour and the front of the leg segment and top of the thigh (in side-view) that adjusts with different inputs	18.1 Representative (Pass) / Non-Representative (Fail)
19	Model provides a lateral clearance zone for the elbow contours based on MIL-STD-1472 requirements	19.1 Model outputs a 2 inch clearance zone laterally for the resting elbow contours that adjusts with different inputs	19.1 Representative (Pass)/ Non-Representative (Fail)
20	Model provides a clearance zone for the boot based on MIL-STD-1472 requirements	20.1 Model outputs a 2 inch clearance zone from the top of the boot contour that adjusts with different inputs	20.1 Representative (Pass)/ Non-Representative (Fail)
21	Model provides a clearance zone for the torso boundary, with selected ensemble, based on MIL-STD-1472 requirements	21.1 Model outputs a 2 inch clearance zone forward from the torso boundary and adjusts and adjusts with the different inputs	21.1 Representative (Pass)/ Non-Representative (Fail)

Along with using the Fixed HARP: Commander CAD accommodation model, ground vehicle designers will use boundary manikins when creating the interior workspace. The boundary manikins are postured and positioned in CAD using equations from the posture prediction model created by UMTRI. The requirements for posture prediction are shown in Table 7 below:

Table 7: Requirements Relationship Table for Posture Prediction of Boundary Manikins

#	M&S Requirement	Acceptability Criteria	Metrics/Measures
1	Model predicts the location of the hip with respect to the HARP	1.1 Model outputs the location of the hip with respect to the HARP that matches the UMTRI spreadsheet	1.1 Representative (Pass) / Non-Representative (Fail)
		1.2 The manikin hip joint center aligns with the hip point	1.2 Representative (Pass) / Non-Representative (Fail)
2	Model predicts the location of the eye with respect to the HARP	2.1 Model outputs the location of the eye with respect to the HARP that matches the UMTRI spreadsheet	2.1 Representative (Pass) / Non-Representative (Fail)
		2.2 The manikin eye aligns with the eye point	2.2 Representative (Pass) / Non-Representative (Fail)

Numerical values calculated by both the GVSC CAD model and the UMTRI Microsoft Excel spreadsheets must match within +/- 0.100 inches or +/- 0.100 degrees to be considered equivalent.

4. CAPABILITIES, LIMITATIONS, & ASSUMPTIONS (CLA), RISKS/IMPACTS

4.1. M&S Capabilities

The Fixed HARP: Commander CAD accommodation model will provide government and industry partners with the following M&S capabilities:

- Relevant population size/shape boundaries for the user population in an occupant workspace
- Posture prediction for the identified boundary manikins
- Clearances based on interpretation of MIL-STD-1472 and HFE recommendations

4.2. M&S Limitations

The Fixed HARP: Commander CAD accommodation model has limitations based on the ground vehicle requirements for the occupant workspace, as follows:

- Predicts fixed HARP Commander user conditions (e.g., workstation with screens and keyboard) only and does not address other special positions.
- Predicts where users ideally want to posture and position themselves but does not include vehicle limitations such as low ceiling height or limited leg room.
- Model was created with a specific range of clothing and equipment kit weights and depths, so it will have to be reevaluated as the clothing and equipment kits drastically change (e.g., Modular Scalable Vest (MSV) undervest).
- CAD accommodation models serve as a design tool and are not intended to replace, but rather complement, HFE assessment tools.

4.3. M&S Assumptions

The development of a valid Fixed HARP: Commander CAD accommodation model is based on the following assumptions:

- The fixtures created and used by UMTRI to collect the occupant data are representative of a Fixed HARP: Commander type of environment or workstation with a keyboard and screens.
- Analysis methods used by UMTRI accurately predict the users' preferred posture and position.
- Position data collected in a static environment over a short period of time are reasonably similar to users' preferred postures and positions during long durations.

4.4. M&S Risks/Impacts

The constraints and limitations highlighted above could potentially result in an interior workspace design that is not fully optimized. This risk will be mitigated by collaborating with DEVCOM Analysis Center (DAC) HSI SMEs who complete human factors assessments on the proposed designs, COTS vehicles, and demonstrators during the acquisition process IAW AR 602-2. This assessment will be captured in documentation completed by the DAC HSI SMEs.

5. VERIFICATION TASK ANALYSIS

5.1. DATA VERIFICATION TASK ANALYSIS

No specific data verification tasks were needed because UMTRI, as the data developer, documented the methods and results of the data collection. The data and statistical techniques employed by UMTRI are appropriate for the creation of the models. Standard anthropometric data, which correlated to ANSURII data, was collected on the study participants. A whole-body laser scanner was used to record body shape in both seated and standing postures. Statistical analysis of body landmark data was conducted by UMTRI and validation of the data for the models to predict occupant posture, as a function of vehicle factors, was completed (Reed et al 2021). The UMTRI documents capturing this work are listed below:

- *Development of Posture Prediction and Accommodation Models for Military Vehicles: Commander and Gunner Positions: Final Report UMTRI-2021-7*
- *Commander_Accommodation_Models.21, 2023-08-01*, UMTRI Excel spreadsheet
- *Commander Posture Prediction.2, 2020-12-12*, UMTRI Excel spreadsheet

The information provided by UMTRI was utilized to create the Fixed HARP: Commander CAD accommodation model. GVSC ACT reviewed each of UMTRI's Excel spreadsheets to verify that they aligned with the written reports and then used the information as the basis for the creation of the CAD model.

5.2. MODEL VERIFICATION TASK ANALYSIS

Model verification included a total of ten tests, shown below in Table 8, to compare outputs from the Fixed HARP: Commander CAD accommodation model to the UMTRI Commander Accommodation Model (2023) spreadsheet and Commander Posture Prediction (2020) spreadsheets. The blue highlighted values in the table indicate which inputs were changed from the baseline tests (Test #1 and Test #8).

Table 8: Fixed HARP: Commander CAD Accommodation Model Test Matrix

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
1	90%	85%	PPE	17.1 (435 mm)	SAE J826	No	Baseline test
2	90%	85%	PPE	11.8 (300 mm)	SAE J826	No	Vary seat height down
3	90%	85%	PPE	21.7 (550 mm)	SAE J826	No	Vary seat height up
4	95%	85%	PPE	17.1	SAE J826	No	Increase accommodation
5	90%	50%	PPE	17.1	SAE J826	No	Rebalance gender mix
6	90%	85%	PPE	17.1	ISO 5353	No	Use alternate HARP tool
7	90%	85%	PPE	17.1	SAE J826	Yes	Provide hydration pack relief
8	90%	85%	ENC	17.1	SAE J826	No	Change ensemble; ENC baseline
9	90%	85%	ENC	17.1	SAE J826	Yes	Provide hydration pack relief
10	80%	50%	ENC	11.8	ISO 5353	Yes	Vary multiple elements

All tests are compared back to the baseline, Test #1. General observed trends are as follows:

- Geometry for composite body boundaries is constant for a given Target Accommodation and Fraction Male, but position varies with Seat Height
- Changing the HARP measurement tool shifts all geometry in the X-direction
- Hydration Pack Relief only affects the ENC ensemble
- With increased Target Accommodation, composite body boundaries increase in volume
  Geometry for composite body boundaries decreases in volume with a smaller proportion of males

Results from the above tests have been reported both in terms of passing or failing the requirements and acceptability criteria presented previously in Section 3 and a comparison of calculated numerical results between the GVSC CAD and UMTRI spreadsheets. Please refer to Appendix B – Requirements and Acceptability Criteria Results.

6. VERIFICATION RECOMMENDATIONS

One issue was discovered during the verification process. Within the knee contour, for both the spreadsheet and CAD model, the thigh segment angle with respect to horizontal did not vary with elevation changes to the HARP. This issue was corrected. The final outcome from the review was team consensus that the Fixed HARP: Commander CAD accommodation model passed verification. There are no additional recommendations from the team for the model.

7. KEY PARTICIPANTS

Table 9 identifies the participants involved in the verification effort, including their roles and responsibilities.

Table 9: Key Participants for Fixed Eye Point CAD Model Verification Effort

Verification Function	Description	Responsible M&S
M&S Proponent	The organization that has primary responsibility for M&S planning and management that includes development, verification and validation, configuration management, maintenance, use of the model or simulation, and others as appropriate. A Government entity.	Frank J. Huston II, GVSC ACT Gale. L. Zielinski, GVSC ACT
M&S User	The individual, group, or organization that uses the results or products from a specific application of the model or simulation.	Mark D. Shafer, GVSC GVSP Eric S. Paternoster, GVSC PIF HSI SMEs, DEVCOM DAC Government Contractors

Verification Agent	The organization designated by the M&S proponent to perform verification of a model, simulation, or federation of M&S.	Frank J. Huston II, GVSC ACT Gale L. Zielinski, GVSC ACT
M&S Developer	The individual, group or organization responsible for developing or modifying a model or simulation in accordance with a set of design requirements and specifications.	Frank J. Huston II, GVSC ACT Matthew P. Reed, Ph.D, UMTRI
SMEs	Individual who, by virtue of education, training, or experience, has expertise in a particular technical or operational discipline, system, or process.	Frank J. Huston II, GVSC ACT Gale L. Zielinski, GVSC ACT Cheryl A. Burns, DAC David A. Hullinger, DAC Matthew P. Reed, Ph.D, UMTRI

8. ACTUAL VERIFICATION RESOURCES EXPENDED

8.1. Verification Resources Expended

Table 10 identifies the resources used to create the DEVCOM GVSP Fixed HARP: Commander CAD model and complete associated activities, including verification.

Table 10: Verification Resources

Document/Deliverable	Required Resources	POC
Development of Posture Prediction and Accommodation Models for Military Vehicles: Commander and Gunner Positions	M&S Developer and SME support	UMTRI
Fixed HARP: Commander Verification Plan	Verification Agent, M&S Developer and SME support	GVSC ACT
Fixed HARP: Commander Accommodation Model Build	M&S Developer and SME support	GVSC ACT
Fixed HARP: Commander Accommodation Model Verification packet completed	Verification Agent, Validation Agent, M&S Developer and SME support	GVSC ACT
Fixed HARP: Commander Accommodation Model Release into PDMLink	M&S Developer	GVSC ACT
OPSEC of Fixed HARP: Commander Verification Report and CAD Model	M&S Proponent	GVSC ACT
Release of Fixed HARP: Commander Verification Report and CAD Model to the GVSC public website.	M&S Proponent	GVSC ACT

8.2. ACTUAL VERIFICATION MILESTONES AND TIMELINE

Table 11 identifies the major milestone achievements in the creation the Fixed HARP: Commander CAD accommodation model and completion of associated activities, including verification.

Table 11: Verification Milestone Timeline

Document/Deliverable	Delivery Date
Draft Fixed HARP: Commander Accommodation Model Spreadsheet	December 2020
Posture Prediction Spreadsheet	December 2020
UMTRI Report for the Fixed HARP: Commander Accommodation Model	September 2021
Feedback provided to UMTRI on the Fixed HARP: Commander Accommodation Model Report	November 2021
Final Fixed HARP: Commander Accommodation Model Spreadsheet	August 2023
Fixed HARP: Commander CAD template development started	January 2022
Fixed HARP: Commander CAD Accommodation Model Verification Plan	August 2022
Fixed HARP: Commander CAD accommodation model complete	August 2023
Fixed HARP: Commander CAD accommodation model Verification Complete	August 2023
Fixed HARP: Commander CAD Final Model Release into PDMLink	September 2023
Verification Report (Final)	September 2023

9. VERIFICATION LESSONS LEARNED

Verification of the Fixed HARP: Commander CAD accommodation model marks the fourth time that GVSC has verified such a product. Based on lessons learned from the previous verifications, the M&S Proponents and Developers determined that verifying CAD outputs against UMTRI's spreadsheet, given the number of calculations involved, would be too time intensive to complete in front of a live audience. Alternatively, a PowerPoint document (see Appendix B) was compiled for distribution to all participants. This gave participants flexibility to review the document and provide feedback. If particular tests were of interest, the M&S developer could provide more detailed feedback and conduct a live review for the requesting party. This was the most efficient way to complete a verification without having a scheduled live verification event.

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9.1. Appendix A – M&S Description

9.1.1. M&S Development and Structure

The information in this Appendix, is extracted from *Creation of the Driver Fixed Heel Point (FHP) CAD Accommodation Model for Military Ground Vehicle Design* (2016) and *Development of Posture Prediction and Accommodation Models for Military Vehicles: Commander and Gunner Positions* (2021).

Ensuring that a given percentage of the population can sit safely and naturally while performing all required functions requires multivariate analysis methods that consider the physical dimensions of the Soldier (anthropometry) and behavioral effects (posture) in a three-dimensional space. This analysis is available for the Fixed HARP: Commander position as Soldier-specific statistical population accommodation models, developed by UMTRI, that parallel long-standing SAE recommended practices used in the commercial automotive and truck domains. Because vehicle designs are developed from the early concept stages forward using CAD software, UMTRI's work has been encoded into a parametric CAD template that adjusts based on user inputs describing the Soldier population, desired accommodation level, and vehicle environment.

The primary developments that have made it possible to create a reusable CAD template representing user accommodation are UMTRI's predictive models for Soldier posture and the utilization of automated design capabilities available in many current CAD systems.

The automotive industry began introducing statistical population models into vehicle design in the 1960s to better understand various aspects of driver posture. The *Development of Posture Prediction and Accommodation Models for Military Vehicles: Commander and Gunner* (Reed et al, 2021) was completed to capture Soldier preferred posture and position data on commander and gunner workstations.

The UMTRI study (2021) gathered data on 112 Soldiers at Fort Riley, Kansas in the spring of 2019. Soldiers wore the advanced combat uniform (ACU), consisting of the Soldier's own jacket, trousers, shirt, and combat boots and donned two levels of equipment including: 1) personal protective equipment (PPE), consisting of the ACU plus an Improved Outer Tactical Vest (IOTV), Enhanced Small Arms Protective Insert (ESAPI) plates, Enhanced Side Ballistic Inserts (ESBI), and an Advanced Combat Helmet (ACH); and 2) encumbered (ENC), consisting of the ACU and PPE, plus a hydration pack and a Tactical Assault Panel (TAP) with a Rifleman equipment kit (Reed and Ebert, 2021).

The mockup used in the study simulates a Fixed HARP: Commander workstation. The test seat height was set with the HARP 16.9 inches above the floor surface and the seat cushion angle at 5 degrees from horizontal. The seat back angle was initially set to 10 degrees with respect to vertical but was adjusted by the participant to obtain a comfortable seated posture. After the participant was seated, the investigator adjusted the keyboard location to obtain the participant's preferred position. The keyboard was then moved forward and rearward (randomized order) to obtain the "maximum acceptable" deviations from preferred. The screen was then adjusted to the participant's preferred fore-aft position. During the screen adjustment process, the participant was required to reach with the left index finger to "button" targets at each corner of the screen, which displayed a static image. This ensured that the screen was reachable for touchscreen operations. The investigator then moved the screen fore-aft to obtain the maximum acceptable forward and maximum rearward positions, while maintaining the capability to reach to the corner buttons (Reed and Ebert, 2021)

UMTRI's analysis of the data yielded both the average postures for individuals as a function of their body size and equipment level and accommodation boundaries capturing posture variability for everyone across the target population. In particular, the accommodation boundaries indicate the resulting positions for the equipped Soldier population's helmet, torso, elbows, knees, and boots. Preferred and acceptable location of screens and keyboard are also developed. Working models were provided by UMTRI in the form of Microsoft Excel spreadsheets. For a more in-depth discussion of UMTRI's work, please refer to the *Seated Soldier Study* (Reed et al, 2013) and *Development of Posture Prediction and Accommodation Models for Military Vehicles: Commander and Gunner Positions* (2021).

The CAD version of the Fixed HARP: Commander accommodation model was created by GVSC ACT using PTC Creo® 3D CAD software. Functionally, the foundation of the model is a stand-alone geometric reproduction of UMTRI's Microsoft Excel spreadsheets. Clearances between the Soldier population and surrounding interior vehicle surfaces were layered onto the model per the intent of MIL-STD-1472. To aid in understanding how workstation design affects individuals, boundary manikins representing the anthropometric extremes for workstation design were placed in their predicted postures.

After building a static version of the accommodation model (i.e., a single instance of the possible combinations of Soldier population, desired accommodation level, and vehicle environment inputs), the process of automating the model began. This was done using a tool within Creo known as Pro/PROGRAM. Most CAD users already take advantage of the parametric nature of today's design software. For example, depending on how a model is constructed, simple changes can be propagated throughout by delving into a model's geometry and modifying dimensions. Pro/PROGRAM takes this concept a step further and allows for control of a model from outside the model tree, using relations and rules. End users of the Fixed HARP: Commander CAD accommodation model are able to modify a list of parameters that are tied to the underlying geometry. Logical expressions are used to determine which portions of the Pro/PROGRAM code to execute for a given set of input values.

UMTRI's spreadsheets provide the values necessary to reproduce the relatively simple geometric elements comprising the accommodation boundaries (e.g. centroids and axis lengths for several ellipsoids). It was possible to encode the equations from UMTRI's spreadsheets into Creo without modification or the need for further calculations, with two notable exceptions. Because the majority of human anthropometric dimensions are normally distributed, the standard normal cumulative distribution function (CDF) is used throughout UMTRI's work to determine values at the desired level of accommodation. Creo does not contain an equivalent to Microsoft Excel's NORM.DIST function, so the following logistic approximation, having a maximum error of 0.00014 at $z = \pm 3.16$, was used instead (Bowling, Khasawneh, Kaewkuekool, and Rae Cho, 2009).

$$F(z) \sim \frac{1}{1 + e^{-(0.07056 * z^3 + 1.5976 * z)}}$$

The second exception involves the positioning of manikins. UMTRI provides coordinates of body landmarks with respect to the geometric origin of the accommodation model (i.e., the HARP) sufficient to locate the hips, torso articulation, and head. To place these coordinates into the reference systems of the boundary manikins (an axis system located between the hips of each manikin and aligned with the torso) and calculate the joint angles needed to position the limbs in three-dimensional space, Euclidean transformations for both translation and rotation were used.

9.1.2. M&S Use History

The Fixed HARP: Commander CAD accommodation model has not been applied to any vehicle concept, to date. Since this is the fourth model in a suite of CAD accommodation models, there was not a concern that the opportunity did not present itself to apply the model early in the development process. The development of the final model was an iterative process between the CAD M&S Developer and UMTRI to add and refine features.

9.1.3. Configuration Management

The GVSC ACT will manage any changes to the Fixed HARP: Commander CAD accommodation model and upload the latest version.

The Fixed HARP: Commander CAD accommodation model is released in PDMLink at the following location:

Libraries > STANDARD CAD TEMPLATE LIBRARY, 19207 > Accommodation

The following top assemblies have been released:
12682074 GVSC FIXED HARP COMMANDER

Questions related to the CAD model development and application should be sent to:

DEVCOM GVSC Advanced Concepts Team
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Bldg. 200, FCDD-GVR-MSS
MS 207
Warren, MI 48397-5000

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9.2. Appendix B – Requirements and Acceptability Criteria Results

The requirements and acceptability criteria results for accommodation and posture prediction are shown below in Table 12 and Table 13, respectively. Metrics are noted as pass or fail. None of the metrics produced a failing result, so no corrective action plans are required.

Table 12: Accommodation Model Requirements Results

#	M&S Requirement	Acceptability Criteria	Metrics/Measures
1	Model allows for a target population input (e.g. 90%)	1.1 Target accommodation input option in model	1.1 Representative (Pass) / Non-Representative (Fail)
2	Model allows for input of the population gender mix (e.g. 85% Male : 15% Female)	2.1 Fraction male input option in model	2.1 Representative (Pass) / Non-Representative (Fail)
3	Model allows for selection of ensemble as either PPE or ENC	3.1 Ensemble selection of PPE in model	3.1 Representative (Pass) / Non-Representative (Fail)
		3.2 Ensemble selection of ENC in model	3.2 Representative (Pass) / Non-Representative (Fail)
4	Model allows for input of the HARP	4.1 HARP height input option in model	4.1 Representative (Pass) / Non-Representative (Fail)
5	Model allows for selection of either SAE J826 or ISO 5353 for the Human Accommodation Reference Point (HARP) measurement tool	5.1 HARP measurement tool selection of SAE J826 in model	5.1 Representative (Pass) / Non-Representative (Fail)
		5.2 HARP measurement tool selection of ISO 5353 in model	5.2 Representative (Pass) / Non-Representative (Fail)
6	Model allows for selection of seat hydration pack relief in the seat	6.1 Hydration pack relief selection of "YES" in model	6.1 Representative (Pass) / Non-Representative (Fail)
		6.2 Hydration pack relief selection of "NO" in model	6.2 Representative (Pass) / Non-Representative (Fail)
7	Model predicts the seat back angle	7.1 Model outputs a seat back angle adjustment range for the given population and gender mix that adjusts with different inputs	7.1 Representative (Pass) / Non-Representative (Fail)
		7.2 CAD model matches the UMTRI spreadsheet	7.2 Representative (Pass) / Non-Representative (Fail)

8	Model predicts the keyboard fore/aft and up/down adjustment range	8.1 Model outputs a fore/aft and up/down position for the given population and gender mix that adjusts with different inputs	8.1 Representative (Pass) / Non-Representative (Fail)
		8.2 CAD model matches the UMTRI spreadsheet	8.2 Representative (Pass) / Non-Representative (Fail)
9	Model predicts the dimensions and location of the eyellipse	9.1 Model outputs a left and right eyellipse for the given population and gender mix that adjusts with different inputs	9.1 Representative (Pass) / Non-Representative (Fail)
		9.2 CAD model matches the UMTRI spreadsheet	9.2 Representative (Pass) / Non-Representative (Fail)
10	Model predicts the forward abdominal boundary	10.1 Model outputs an abdominal boundary for the given population and gender mix that adjusts with different inputs	10.1 Representative (Pass) / Non-Representative (Fail)
		10.2 CAD model matches the UMTRI spreadsheet	10.2 Representative (Pass) / Non-Representative (Fail)
11	Model provides vertical and horizontal direct field of view based on MIL-STD-1472 and SAE J1050	11.1 Model output provides a vertical and horizontal direct Field-of-View (FOV) that matches the intent of MIL-STD-1472G and SAE J1050	11.1 Representative (Pass) / Non-Representative (Fail)
12	Model predicts the screen center fore/aft and up/down adjustment range	12.1 Model outputs a fore/aft and u/down adjustment range for the center of the screen that matches the intent of MIL-STD-1472G and SAE J1050	12.1 Representative (Pass) / Non-Representative
13	Model predicts the helmet contour boundary (helmet locations) with respect to the eye	13.1 Model outputs a helmet contour for the given population and gender mix that adjusts with different inputs	13.1 Representative (Pass) / Non-Representative (Fail)
		13.2 CAD model matches the UMTRI spreadsheet	13.2 Representative (Pass) / Non-Representative (Fail)
14	Model predicts the knee contour with leg and thigh segment angles based on location of resting occupants' knees in vehicle	14.1 Model outputs a knee ellipsoid for the given population and gender mix that adjusts with different inputs	14.1 Representative (Pass)/ Non-Representative (Fail)

		14.2 CAD model matches the UMTRI spreadsheet	14.2 Representative (Pass)/ Non-Representative (Fail)
15	Model predicts elbow contours based on location of resting and dynamic occupants' elbows in vehicle	15.1 Model outputs elbow contours for the given population and gender mix that adjusts with different inputs	15.1 Representative (Pass)/ Non-Representative (Fail)
		15.2 CAD model matches the UMTRI spreadsheet	15.2 Representative (Pass)/ Non-Representative (Fail)
16	Model predicts boot contours based on location of resting occupants' boots in vehicle	16.1 Model outputs boot contours for the given population and gender mix that adjusts with different inputs	16.1 Representative (Pass)/ Non-Representative (Fail)
		16.2 CAD model matches the UMTRI spreadsheet	16.2 Representative (Pass)/ Non-Representative (Fail)
17	Model provides a clearance zone for the head (helmet) to roof line based on MIL-STD-1472 requirements	17.1 Model outputs a 2 inch clearance zone from the top of the helmet contour that adjusts with different inputs	17.1 Representative (Pass) / Non-Representative (Fail)
18	Model provides a clearance zone for the knee, leg and thigh based on MIL-STD-1472 requirements	18.1 Model outputs a 2 inch clearance zone from the top and front of the knee contour and the front of the leg segment and top of the thigh (in side-view) that adjusts with different inputs	18.1 Representative (Pass) / Non-Representative (Fail)
19	Model provides a lateral clearance zone for the elbow contours based on MIL-STD-1472 requirements	19.1 Model outputs a 2 inch clearance zone laterally for the resting elbow contours that adjusts with different inputs	19.1 Representative (Pass)/ Non-Representative (Fail)
20	Model provides a clearance zone for the boot based on MIL-STD-1472 requirements	20.1 Model outputs a 2 inch clearance zone from the top of the boot contour that adjusts with different inputs	20.1 Representative (Pass)/ Non-Representative (Fail)
21	Model provides a clearance zone for the torso boundary, with selected ensemble, based on MIL-STD-1472 requirements	21.1 Model outputs a 2 inch clearance zone forward from the torso boundary and adjusts and adjusts with the different inputs	21.1 Representative (Pass)/ Non-Representative (Fail)

Table 13: Posture Prediction Model Results

#	M&S Requirement	Acceptability Criteria	Metrics/Measures
1	Model predicts the location of the hip with respect to the HARP	1.1 Model outputs the location of the hip with respect to the HARP that matches the UMTRI spreadsheet	1.1 Representative (Pass) / Non-Representative (Fail)
		1.2 The manikin hip joint center aligns with the hip point	1.2 Representative (Pass) / Non-Representative (Fail)
2	Model predicts the location of the eye with respect to the HARP	2.1 Model outputs the location of the eye with respect to the HARP that matches the UMTRI spreadsheet	2.1 Representative (Pass) / Non-Representative (Fail)
		2.2 The manikin eye aligns with the eye point	2.2 Representative (Pass) / Non-Representative (Fail)

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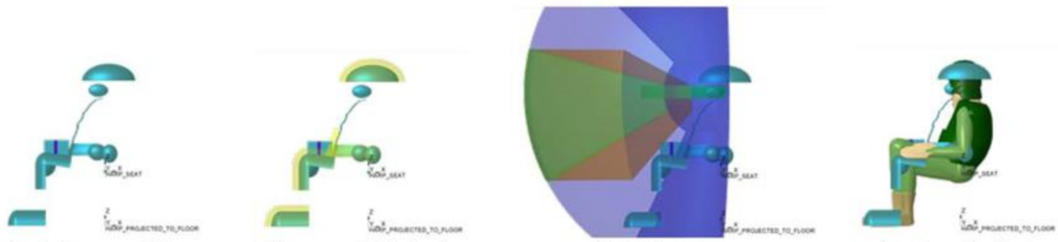
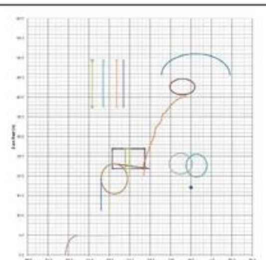
9.2.1. Test #1 – Numerical Results

TEST #1: PPE BASELINE

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
1	90%	85%	PPE	17.1 (435 mm)	SAE J826	No	Baseline test



Basic Accommodation | Clearance (2.0 inches) | Vision Zones | Boundary Manikins



UMTRI Spreadsheet

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.010 degrees

Manikin Placement:
0.000 inches

Values in agreement

14

TEST #1: RESULTS, ACCOMMODATION

HARP

	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	17.126	in	17.126	in	0.000	in

Eyellipse

	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-2.134	in	-2.134	in	0.000	in
EYELLIPSE_CENTROID_Y(+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	42.679	in	42.680	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	6.126	in	6.130	in	0.004	in
EYELLIPSE_Y_AXIS_LENGTH	2.046	in	2.048	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.031	in	4.032	in	0.001	in

Helmet Boundary

	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	1.114	in	1.114	in	0.000	in
HELMET_CONTOUR_CENTROID_Y(+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	45.663	in	45.664	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	16.728	in	16.732	in	0.004	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.716	in	9.717	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	10.803	in	10.803	in	0.001	in

Seat Back Angle

	UMTRI Value		GVSC Value		Difference	
SEAT_BACK_ANGLE_MEAN	16.232	deg	16.232	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	14.535	deg	14.545	deg	0.010	deg

Torso Boundary

	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_PPE_X	-5.232	in	-5.233	in	0.001	in
TORSO_WEIGHTED_REF_PT_PPE_Z	34.373	in	34.373	in	0.000	in
TORSO_ROTATION_WRT_HARP	2.638	deg	2.638	deg	0.000	deg

Keyboard Position -- Preferred

	UMTRI Value		GVSC Value		Difference	
KBOARD_PREF_CTR_OF_TRAVEL_X	-15.293	in	-15.293	in	0.000	in
KBOARD_PREF_CTR_OF_TRAVEL_Z	24.442	in	24.442	in	0.000	in
KBOARD_PREF_FORE_AFT_TRAVEL	7.920	in	7.922	in	0.002	in
KBOARD_PREF_VERTICAL_TRAVEL	5.035	in	5.036	in	0.001	in

Keyboard Position -- Acceptable

	UMTRI Value		GVSC Value		Difference	
KBOARD_OK_CTR_OF_TRAVEL_X	-15.580	in	-15.581	in	0.000	in
KBOARD_OK_CTR_OF_TRAVEL_Z	24.442	in	24.442	in	0.000	in
KBOARD_OK_FORE_AFT_TRAVEL	1.060	in	1.061	in	0.001	in
KBOARD_OK_VERTICAL_TRAVEL	5.035	in	5.036	in	0.001	in

Knee Boundary

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.751	in	-18.751	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y(+/	8.246	in	8.246	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.313	in	19.313	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.463	in	6.465	in	0.003	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.997	in	10.000	in	0.003	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.594	in	7.596	in	0.002	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	8.151	deg	8.151	deg	0.000	deg

Elbow Boundary

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-2.528	in	-2.528	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y(	11.459	in	11.459	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	23.169	in	23.169	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	5.690	in	5.694	in	0.004	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	3.727	in	3.728	in	0.001	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	5.291	in	5.293	in	0.003	in

Elbow Boundary -- Resting

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	1.338	in	1.338	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y(	12.379	in	12.379	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	22.708	in	22.708	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	5.021	in	5.024	in	0.003	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.777	in	3.777	in	0.000	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.788	in	5.790	in	0.003	in

Boot Boundary

	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-27.753	in	-27.753	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y(+/-)	8.246	in	8.246	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	5.815	in	5.818	in	0.003	in
BOOT_TOE_Y_AXIS_LENGTH	9.666	in	9.669	in	0.003	in
BOOT_TOE_Z_AXIS_LENGTH	9.843	in	9.843	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.004 inches
0.010 degrees

Values in agreement

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TEST #1: RESULTS, MANIKIN POSITIONING

Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-2.176	in	-2.176	in	0.000	in
POSTURE_DHM1_HIP_Z	16.717	in	16.717	in	0.000	in
POSTURE_DHM1_EYE_X	-1.666	in	-1.666	in	0.000	in
POSTURE_DHM1_EYE_Z	39.832	in	39.832	in	0.000	in
Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-1.913	in	-1.913	in	0.000	in
POSTURE_DHM2_HIP_Z	16.956	in	16.956	in	0.000	in
POSTURE_DHM2_EYE_X	-1.899	in	-1.899	in	0.000	in
POSTURE_DHM2_EYE_Z	41.482	in	41.483	in	0.000	in
Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-1.915	in	-1.915	in	0.000	in
POSTURE_DHM3_HIP_Z	17.239	in	17.239	in	0.000	in
POSTURE_DHM3_EYE_X	-1.897	in	-1.897	in	0.000	in
POSTURE_DHM3_EYE_Z	43.230	in	43.230	in	0.000	in
Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.942	in	-1.942	in	0.000	in
POSTURE_DHM4_HIP_Z	17.384	in	17.384	in	0.000	in
POSTURE_DHM4_EYE_X	-1.874	in	-1.874	in	0.000	in
POSTURE_DHM4_EYE_Z	44.125	in	44.125	in	0.000	in
Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-1.956	in	-1.956	in	0.000	in
POSTURE_DHM5_HIP_Z	17.390	in	17.390	in	0.000	in
POSTURE_DHM5_EYE_X	-1.861	in	-1.861	in	0.000	in
POSTURE_DHM5_EYE_Z	44.238	in	44.238	in	0.000	in
Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.787	in	-1.787	in	0.000	in
POSTURE_DHM6_HIP_Z	17.439	in	17.439	in	0.000	in
POSTURE_DHM6_EYE_X	-2.011	in	-2.011	in	0.000	in
POSTURE_DHM6_EYE_Z	44.456	in	44.456	in	0.000	in
Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.554	in	-1.554	in	0.000	in
POSTURE_DHM7_HIP_Z	17.516	in	17.516	in	0.000	in
POSTURE_DHM7_EYE_X	-2.217	in	-2.217	in	0.000	in
POSTURE_DHM7_EYE_Z	45.204	in	45.204	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.000 inches

Values in agreement

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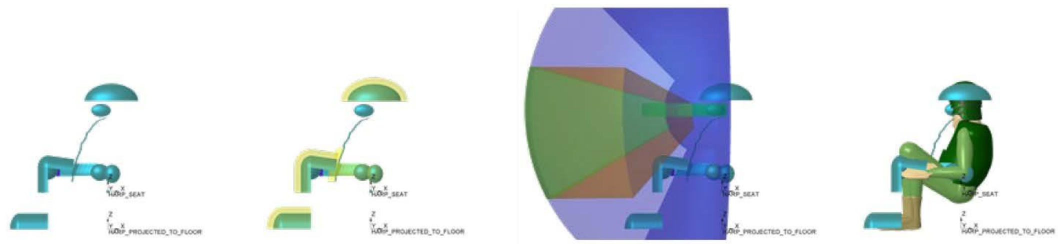
DISTRIBUTION STATEMENT A. APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED. OPSEC#7901.

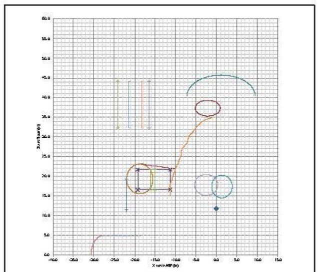
9.2.2. Test #2 – Numerical Results

TEST #2: VARY SEAT HEIGHT (MIN)

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
2	90%	85%	PPE	11.8 (300 mm)	SAE J826	No	Vary seat height down



Basic Accommodation | Clearance (2.0 inches) | Vision Zones | Boundary Manikins



UMTRI Spreadsheet

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.010 degrees

Manikin Placement:
0.000 inches

Values in agreement

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TEST #2: RESULTS, ACCOMMODATION

HARP

	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	11.811	in	11.811	in	0.000	in

Eyellipse

	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-2.134	in	-2.134	in	0.000	in
EYELLIPSE_CENTROID_Y(+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	37.364	in	37.365	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	6.126	in	6.130	in	0.004	in
EYELLIPSE_Y_AXIS_LENGTH	2.046	in	2.048	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.031	in	4.032	in	0.001	in

Helmet Boundary

	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	1.114	in	1.114	in	0.000	in
HELMET_CONTOUR_CENTROID_Y(+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	40.348	in	40.349	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	16.728	in	16.732	in	0.004	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.716	in	9.717	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	10.803	in	10.803	in	0.001	in

Seat Back Angle

	UMTRI Value		GVSC Value		Difference	
SEAT_BACK_ANGLE_MEAN	16.232	deg	16.232	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	14.535	deg	14.545	deg	0.010	deg

Torso Boundary

	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_PPE_X	-5.232	in	-5.233	in	0.001	in
TORSO_WEIGHTED_REF_PT_PPE_Z	29.059	in	29.059	in	0.000	in
TORSO_ROTATION_WRT_HARP	2.638	deg	2.638	deg	0.000	deg

Keyboard Position -- Preferred

	UMTRI Value		GVSC Value		Difference	
KBOARD_PREF_CTR_OF_TRAVEL_X	-15.293	in	-15.293	in	0.000	in
KBOARD_PREF_CTR_OF_TRAVEL_Z	19.128	in	19.128	in	0.000	in
KBOARD_PREF_FORE_AFT_TRAVEL	7.920	in	7.922	in	0.002	in
KBOARD_PREF_VERTICAL_TRAVEL	5.035	in	5.036	in	0.001	in

Keyboard Position -- Acceptable

	UMTRI Value		GVSC Value		Difference	
KBOARD_OK_CTR_OF_TRAVEL_X	-15.580	in	-15.581	in	0.000	in
KBOARD_OK_CTR_OF_TRAVEL_Z	19.128	in	19.128	in	0.000	in
KBOARD_OK_FORE_AFT_TRAVEL	1.060	in	1.061	in	0.001	in
KBOARD_OK_VERTICAL_TRAVEL	5.035	in	5.036	in	0.001	in

Knee Boundary

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.751	in	-18.751	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y(+/	8.246	in	8.246	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.313	in	19.313	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.463	in	6.465	in	0.003	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.997	in	10.000	in	0.003	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.594	in	7.596	in	0.002	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	8.151	deg	8.151	deg	0.000	deg

Elbow Boundary

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-2.528	in	-2.528	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y(	11.459	in	11.459	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	17.854	in	17.854	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	5.690	in	5.694	in	0.004	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	3.727	in	3.728	in	0.001	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	5.291	in	5.293	in	0.003	in

Elbow Boundary -- Resting

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	1.338	in	1.338	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y(	12.379	in	12.379	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	17.394	in	17.394	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	5.021	in	5.024	in	0.003	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.777	in	3.777	in	0.000	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.788	in	5.790	in	0.003	in

Boot Boundary

	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-27.753	in	-27.753	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y(+/-)	8.246	in	8.246	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	5.815	in	5.818	in	0.003	in
BOOT_TOE_Y_AXIS_LENGTH	9.666	in	9.669	in	0.003	in
BOOT_TOE_Z_AXIS_LENGTH	9.843	in	9.843	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.004 inches
0.010 degrees

Values in agreement

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TEST #2: RESULTS, MANIKIN POSITIONING

Small Overall Female

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-2.176	in	-2.176	in	0.000	in
POSTURE_DHM1_HIP_Z	11.402	in	11.402	in	0.000	in
POSTURE_DHM1_EYE_X	-1.666	in	-1.666	in	0.000	in
POSTURE_DHM1_EYE_Z	34.517	in	34.517	in	0.000	in

Small Overall Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-1.913	in	-1.913	in	0.000	in
POSTURE_DHM2_HIP_Z	11.641	in	11.641	in	0.000	in
POSTURE_DHM2_EYE_X	-1.899	in	-1.899	in	0.000	in
POSTURE_DHM2_EYE_Z	36.168	in	36.168	in	0.000	in

Average Size Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-1.915	in	-1.915	in	0.000	in
POSTURE_DHM3_HIP_Z	11.924	in	11.924	in	0.000	in
POSTURE_DHM3_EYE_X	-1.897	in	-1.897	in	0.000	in
POSTURE_DHM3_EYE_Z	37.915	in	37.915	in	0.000	in

Widest Shoulders Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.942	in	-1.942	in	0.000	in
POSTURE_DHM4_HIP_Z	12.069	in	12.069	in	0.000	in
POSTURE_DHM4_EYE_X	-1.874	in	-1.874	in	0.000	in
POSTURE_DHM4_EYE_Z	38.810	in	38.810	in	0.000	in

Longest Torso Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-1.956	in	-1.956	in	0.000	in
POSTURE_DHM5_HIP_Z	12.075	in	12.075	in	0.000	in
POSTURE_DHM5_EYE_X	-1.861	in	-1.861	in	0.000	in
POSTURE_DHM5_EYE_Z	38.923	in	38.923	in	0.000	in

Longest Legs Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.787	in	-1.787	in	0.000	in
POSTURE_DHM6_HIP_Z	12.124	in	12.124	in	0.000	in
POSTURE_DHM6_EYE_X	-2.011	in	-2.011	in	0.000	in
POSTURE_DHM6_EYE_Z	39.142	in	39.142	in	0.000	in

Large Overall Male

	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.554	in	-1.554	in	0.000	in
POSTURE_DHM7_HIP_Z	12.201	in	12.201	in	0.000	in
POSTURE_DHM7_EYE_X	-2.217	in	-2.217	in	0.000	in
POSTURE_DHM7_EYE_Z	39.889	in	39.889	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.000 inches

Values in agreement

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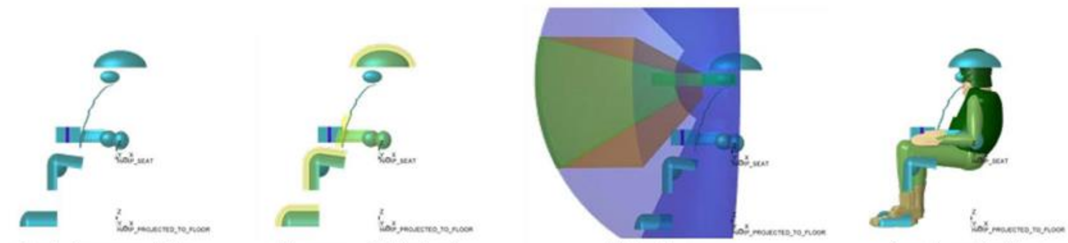
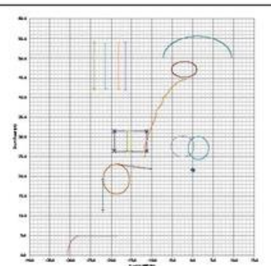
9.2.3. Test #3 – Numerical results

TEST #3: VARY SEAT HEIGHT (MAX)

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
3	90%	85%	PPE	21.7 (550 mm)	SAE J826	No	Vary seat height up



Basic Accommodation Clearance (2.0 inches) Vision Zones Boundary Manikins



UMTRI Spreadsheet

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.010 degrees

Manikin Placement:
0.000 inches

Values in agreement

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TEST #3: RESULTS, ACCOMMODATION

HARP	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	21.654	in	21.654	in	0.000	in

Eyellipse	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-2.134	in	-2.134	in	0.000	in
EYELLIPSE_CENTROID_Y(+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	47.207	in	47.207	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	6.126	in	6.130	in	0.004	in
EYELLIPSE_Y_AXIS_LENGTH	2.046	in	2.048	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.031	in	4.032	in	0.001	in

Helmet Boundary	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	1.114	in	1.114	in	0.000	in
HELMET_CONTOUR_CENTROID_Y(+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	50.191	in	50.192	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	16.728	in	16.732	in	0.004	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.716	in	9.717	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	10.803	in	10.803	in	0.001	in

Seat Back Angle	UMTRI Value		GVSC Value		Difference	
SEAT_BACK_ANGLE_MEAN	16.232	deg	16.232	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	14.535	deg	14.545	deg	0.010	deg

Torso Boundary	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_PPE_X	-5.232	in	-5.233	in	0.001	in
TORSO_WEIGHTED_REF_PT_PPE_Z	38.901	in	38.901	in	0.000	in
TORSO_ROTATION_WRT_HARP	2.638	deg	2.638	deg	0.000	deg

Keyboard Position -- Preferred	UMTRI Value		GVSC Value		Difference	
KBOARD_PREF_CTR_OF_TRAVEL_X	-15.293	in	-15.293	in	0.000	in
KBOARD_PREF_CTR_OF_TRAVEL_Z	28.970	in	28.970	in	0.000	in
KBOARD_PREF_FORE_AFT_TRAVEL	7.920	in	7.922	in	0.002	in
KBOARD_PREF_VERTICAL_TRAVEL	5.035	in	5.036	in	0.001	in

Keyboard Position -- Acceptable	UMTRI Value		GVSC Value		Difference	
KBOARD_OK_CTR_OF_TRAVEL_X	-15.580	in	-15.581	in	0.000	in
KBOARD_OK_CTR_OF_TRAVEL_Z	28.970	in	28.970	in	0.000	in
KBOARD_OK_FORE_AFT_TRAVEL	1.060	in	1.061	in	0.001	in
KBOARD_OK_VERTICAL_TRAVEL	5.035	in	5.036	in	0.001	in

Knee Boundary	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.751	in	-18.751	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y(+/	8.246	in	8.246	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.313	in	19.313	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.463	in	6.465	in	0.003	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.997	in	10.000	in	0.003	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.594	in	7.596	in	0.002	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	8.151	deg	8.151	deg	0.000	deg

Elbow Boundary	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-2.528	in	-2.528	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y(	11.459	in	11.459	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	27.696	in	27.696	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	5.690	in	5.694	in	0.004	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	3.727	in	3.728	in	0.001	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	5.291	in	5.293	in	0.003	in

Elbow Boundary -- Resting	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	1.338	in	1.338	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y(	12.379	in	12.379	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	27.236	in	27.236	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	5.021	in	5.024	in	0.003	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.777	in	3.777	in	0.000	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.788	in	5.790	in	0.003	in

Boot Boundary	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-27.753	in	-27.753	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y(+/-)	8.246	in	8.246	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	5.815	in	5.818	in	0.003	in
BOOT_TOE_Y_AXIS_LENGTH	9.666	in	9.669	in	0.003	in
BOOT_TOE_Z_AXIS_LENGTH	9.843	in	9.843	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.004 inches
0.010 degrees

Values in agreement

22

Test #3: Results, Manikin Positioning

Small Overall Female	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-2.176	in	-2.176	in	0.000	in
POSTURE_DHM1_HIP_Z	21.245	in	21.245	in	0.000	in
POSTURE_DHM1_EYE_X	-1.666	in	-1.666	in	0.000	in
POSTURE_DHM1_EYE_Z	44.360	in	44.360	in	0.000	in

Small Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-1.913	in	-1.913	in	0.000	in
POSTURE_DHM2_HIP_Z	21.483	in	21.483	in	0.000	in
POSTURE_DHM2_EYE_X	-1.899	in	-1.899	in	0.000	in
POSTURE_DHM2_EYE_Z	46.010	in	46.010	in	0.000	in

Average Size Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-1.915	in	-1.915	in	0.000	in
POSTURE_DHM3_HIP_Z	21.766	in	21.766	in	0.000	in
POSTURE_DHM3_EYE_X	-1.897	in	-1.897	in	0.000	in
POSTURE_DHM3_EYE_Z	47.757	in	47.757	in	0.000	in

Widest Shoulders Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.942	in	-1.942	in	0.000	in
POSTURE_DHM4_HIP_Z	21.912	in	21.912	in	0.000	in
POSTURE_DHM4_EYE_X	-1.874	in	-1.874	in	0.000	in
POSTURE_DHM4_EYE_Z	48.653	in	48.653	in	0.000	in

Longest Torso Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-1.956	in	-1.956	in	0.000	in
POSTURE_DHM5_HIP_Z	21.917	in	21.917	in	0.000	in
POSTURE_DHM5_EYE_X	-1.861	in	-1.861	in	0.000	in
POSTURE_DHM5_EYE_Z	48.766	in	48.766	in	0.000	in

Longest Legs Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.787	in	-1.787	in	0.000	in
POSTURE_DHM6_HIP_Z	21.966	in	21.966	in	0.000	in
POSTURE_DHM6_EYE_X	-2.011	in	-2.011	in	0.000	in
POSTURE_DHM6_EYE_Z	48.984	in	48.984	in	0.000	in

Large Overall Male	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.554	in	-1.554	in	0.000	in
POSTURE_DHM7_HIP_Z	22.044	in	22.044	in	0.000	in
POSTURE_DHM7_EYE_X	-2.217	in	-2.217	in	0.000	in
POSTURE_DHM7_EYE_Z	49.731	in	49.731	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.000 inches

Values in agreement

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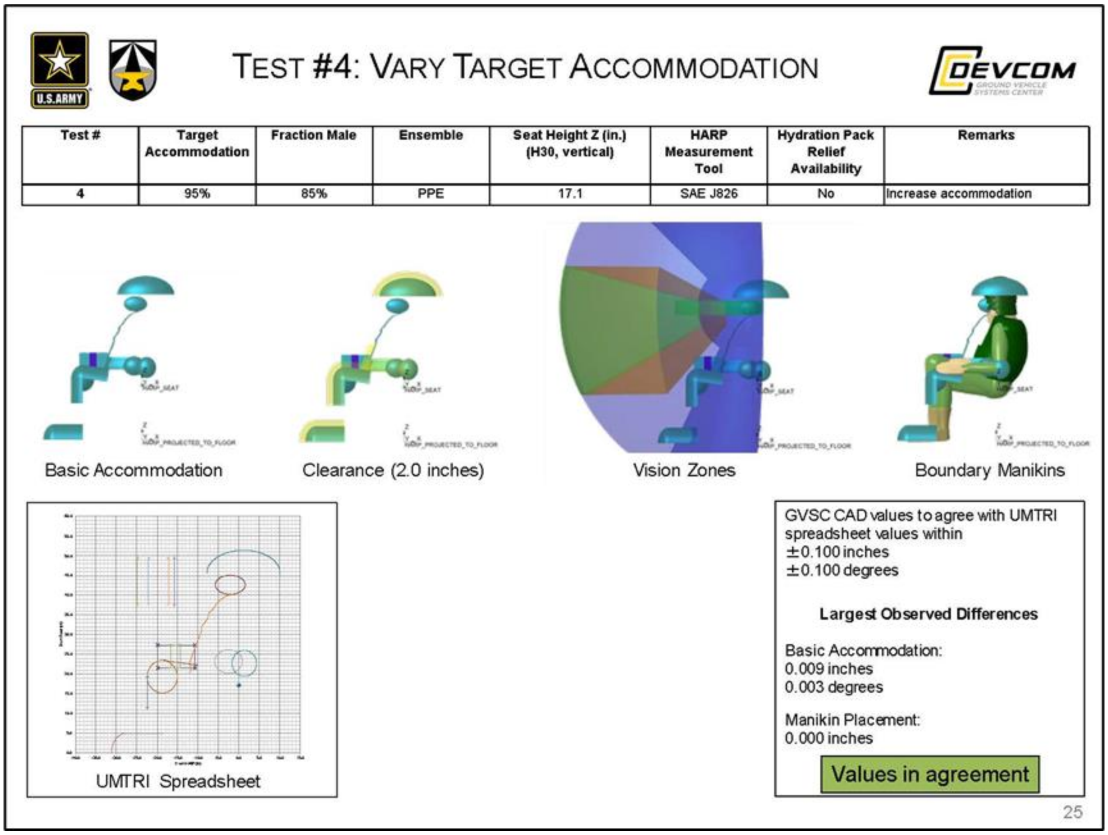
9.2.4. Test #4 – Numerical Results



TEST #4: RESULTS, ACCOMMODATION

HARP

	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	17.126	in	17.126	in	0.000	in

Eyellipse

	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-2.1	in	-2.134	in	0.000	in
EYELLIPSE_CENTROID_Y(+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	42.647	in	42.648	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	7.299	in	7.301	in	0.002	in
EYELLIPSE_Y_AXIS_LENGTH	2.438	in	2.439	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.808	in	4.806	in	0.001	in

Helmet Boundary

	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	1.114	in	1.114	in	0.000	in
HELMET_CONTOUR_CENTROID_Y(+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	45.631	in	45.632	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	17.901	in	17.903	in	0.002	in
HELMET_CONTOUR_Y_AXIS_LENGTH	10.108	in	10.108	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.579	in	11.578	in	0.001	in

Seat Back Angle

	UMTRI Value		GVSC Value		Difference	
SEAT_BACK_ANGLE_MEAN	16.229	deg	16.229	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	17.319	deg	17.322	deg	0.003	deg

Torso Boundary

	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_PPE_X	-5.544	in	-5.545	in	0.000	in
TORSO_WEIGHTED_REF_PT_PPE_Z	34.373	in	34.373	in	0.000	in
TORSO_ROTATION_WRT_HARP	2.638	deg	2.638	deg	0.000	deg

Keyboard Position -- Preferred

	UMTRI Value		GVSC Value		Difference	
KBOARD_PREF_CTR_OF_TRAVEL_X	-15.293	in	-15.293	in	0.000	in
KBOARD_PREF_CTR_OF_TRAVEL_Z	24.443	in	24.443	in	0.000	in
KBOARD_PREF_FORE_AFT_TRAVEL	9.089	in	9.080	in	0.009	in
KBOARD_PREF_VERTICAL_TRAVEL	5.778	in	5.772	in	0.005	in

Keyboard Position -- Acceptable

	UMTRI Value		GVSC Value		Difference	
KBOARD_OK_CTR_OF_TRAVEL_X	-15.528	in	-15.529	in	0.001	in
KBOARD_OK_CTR_OF_TRAVEL_Z	24.443	in	24.443	in	0.000	in
KBOARD_OK_FORE_AFT_TRAVEL	2.227	in	2.218	in	0.009	in
KBOARD_OK_VERTICAL_TRAVEL	5.778	in	5.772	in	0.005	in

Knee Boundary

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.751	in	-18.751	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y(+/	8.246	in	8.246	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.313	in	19.313	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	7.341	in	7.342	in	0.001	in
KNEE_CONTOUR_Y_AXIS_LENGTH	11.093	in	11.092	in	0.001	in
KNEE_CONTOUR_Z_AXIS_LENGTH	8.302	in	8.304	in	0.001	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	8.151	deg	8.151	deg	0.000	deg

Elbow Boundary

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-2.528	in	-2.528	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y(	11.459	in	11.459	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	23.169	in	23.169	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	6.780	in	6.782	in	0.002	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	4.458	in	4.457	in	0.002	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	6.039	in	6.040	in	0.001	in

Elbow Boundary -- Resting

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	1.338	in	1.338	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y(	12.379	in	12.379	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	22.708	in	22.708	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	5.983	in	5.984	in	0.001	in
ELBOW_CON_REST_Y_AXIS_LENGTH	4.520	in	4.518	in	0.002	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	6.634	in	6.635	in	0.001	in

Boot Boundary

	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-27.753	in	-27.753	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y(+/-)	8.246	in	8.246	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	6.893	in	6.895	in	0.002	in
BOOT_TOE_Y_AXIS_LENGTH	10.762	in	10.762	in	0.000	in
BOOT_TOE_Z_AXIS_LENGTH	9.843	in	9.843	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.009 inches
0.003 degrees

Values in agreement

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TEST #4: RESULTS, MANIKIN POSITIONING

Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-2.176	in	-2.176	in	0.000	in
POSTURE_DHM1_HIP_Z	16.717	in	16.717	in	0.000	in
POSTURE_DHM1_EYE_X	-1.666	in	-1.666	in	0.000	in
POSTURE_DHM1_EYE_Z	39.832	in	39.832	in	0.000	in
Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-1.913	in	-1.913	in	0.000	in
POSTURE_DHM2_HIP_Z	16.956	in	16.956	in	0.000	in
POSTURE_DHM2_EYE_X	-1.899	in	-1.899	in	0.000	in
POSTURE_DHM2_EYE_Z	41.482	in	41.483	in	0.000	in
Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-1.915	in	-1.915	in	0.000	in
POSTURE_DHM3_HIP_Z	17.239	in	17.239	in	0.000	in
POSTURE_DHM3_EYE_X	-1.897	in	-1.897	in	0.000	in
POSTURE_DHM3_EYE_Z	43.230	in	43.230	in	0.000	in
Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.942	in	-1.942	in	0.000	in
POSTURE_DHM4_HIP_Z	17.384	in	17.384	in	0.000	in
POSTURE_DHM4_EYE_X	-1.874	in	-1.874	in	0.000	in
POSTURE_DHM4_EYE_Z	44.125	in	44.125	in	0.000	in
Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-1.956	in	-1.956	in	0.000	in
POSTURE_DHM5_HIP_Z	17.390	in	17.390	in	0.000	in
POSTURE_DHM5_EYE_X	-1.861	in	-1.861	in	0.000	in
POSTURE_DHM5_EYE_Z	44.238	in	44.238	in	0.000	in
Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.787	in	-1.787	in	0.000	in
POSTURE_DHM6_HIP_Z	17.439	in	17.439	in	0.000	in
POSTURE_DHM6_EYE_X	-2.011	in	-2.011	in	0.000	in
POSTURE_DHM6_EYE_Z	44.456	in	44.456	in	0.000	in
Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.554	in	-1.554	in	0.000	in
POSTURE_DHM7_HIP_Z	17.516	in	17.516	in	0.000	in
POSTURE_DHM7_EYE_X	-2.217	in	-2.217	in	0.000	in
POSTURE_DHM7_EYE_Z	45.204	in	45.204	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.000 inches

Values in agreement

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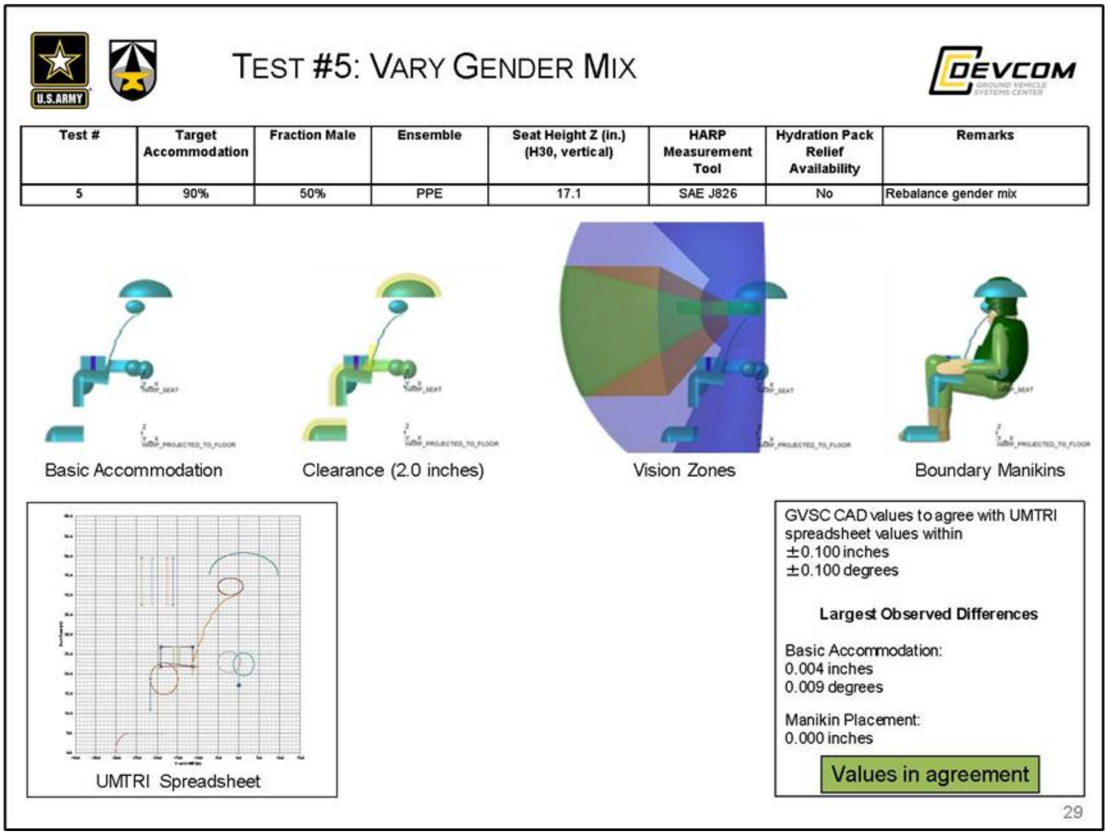
9.2.5. Test #5 – Numerical results



Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
5	90%	50%	PPE	17.1	SAE J826	No	Rebalance gender mix

TEST #5: RESULTS, ACCOMMODATION

HARP

	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	17.126	in	17.126	in	0.000	in

Eyellipse

	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-2.069	in	-2.069	in	0.000	in
EYELLIPSE_CENTROID_Y (+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	42.227	in	42.227	in	0.000	in
EYELLIPSE_X_AXIS_LENGTH	6.124	in	6.129	in	0.004	in
EYELLIPSE_Y_AXIS_LENGTH	2.046	in	2.048	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.343	in	4.343	in	0.000	in

Helmet Boundary

	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	1.179	in	1.179	in	0.000	in
HELMET_CONTOUR_CENTROID_Y (+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	45.211	in	45.211	in	0.000	in
HELMET_CONTOUR_X_AXIS_LENGTH	16.727	in	16.731	in	0.004	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.716	in	9.717	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	11.115	in	11.115	in	0.000	in

Seat Back Angle

	UMTRI Value		GVSC Value		Difference	
SEAT_BACK_ANGLE_MEAN	15.682	deg	15.682	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	14.638	deg	14.647	deg	0.009	deg

Torso Boundary

	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_PPE_X	-5.139	in	-5.140	in	0.001	in
TORSO_WEIGHTED_REF_PT_PPE_Z	33.982	in	33.982	in	0.000	in
TORSO_ROTATION_WRT_HARP	2.324	deg	2.324	deg	0.000	deg

Keyboard Position -- Preferred

	UMTRI Value		GVSC Value		Difference	
KBOARD_PREF_CTR_OF_TRAVEL_X	-15.210	in	-15.210	in	0.000	in
KBOARD_PREF_CTR_OF_TRAVEL_Z	24.380	in	24.380	in	0.000	in
KBOARD_PREF_FORE_AFT_TRAVEL	7.918	in	7.920	in	0.002	in
KBOARD_PREF_VERTICAL_TRAVEL	5.032	in	5.034	in	0.001	in

Keyboard Position -- Acceptable

	UMTRI Value		GVSC Value		Difference	
KBOARD_OK_CTR_OF_TRAVEL_X	-15.268	in	-15.269	in	0.000	in
KBOARD_OK_CTR_OF_TRAVEL_Z	24.380	in	24.380	in	0.000	in
KBOARD_OK_FORE_AFT_TRAVEL	1.510	in	1.511	in	0.001	in
KBOARD_OK_VERTICAL_TRAVEL	5.032	in	5.034	in	0.001	in

Knee Boundary

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.298	in	-18.298	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y (+/	7.850	in	7.850	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	18.776	in	18.776	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.736	in	6.737	in	0.000	in
KNEE_CONTOUR_Y_AXIS_LENGTH	10.101	in	10.103	in	0.002	in
KNEE_CONTOUR_Z_AXIS_LENGTH	8.078	in	8.077	in	0.000	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	6.884	deg	6.884	deg	0.000	deg

Elbow Boundary

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-2.434	in	-2.434	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y (	11.097	in	11.097	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	23.056	in	23.056	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	5.688	in	5.692	in	0.004	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	3.834	in	3.835	in	0.001	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	5.280	in	5.283	in	0.003	in

Elbow Boundary -- Resting

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	1.161	in	1.161	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y(	11.976	in	11.976	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	22.501	in	22.501	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	5.042	in	5.045	in	0.003	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.883	in	3.883	in	0.000	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.826	in	5.829	in	0.002	in

Boot Boundary

	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-27.076	in	-27.076	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y (+/-)	7.850	in	7.850	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	6.321	in	6.321	in	0.000	in
BOOT_TOE_Y_AXIS_LENGTH	9.770	in	9.772	in	0.002	in
BOOT_TOE_Z_AXIS_LENGTH	9.843	in	9.843	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.004 inches
0.009 degrees

Values in agreement

30

TEST #5: RESULTS, MANIKIN POSITIONING

Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-2.176	in	-2.176	in	0.000	in
POSTURE_DHM1_HIP_Z	16.717	in	16.717	in	0.000	in
POSTURE_DHM1_EYE_X	-1.666	in	-1.666	in	0.000	in
POSTURE_DHM1_EYE_Z	39.832	in	39.832	in	0.000	in
Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-1.913	in	-1.913	in	0.000	in
POSTURE_DHM2_HIP_Z	16.956	in	16.956	in	0.000	in
POSTURE_DHM2_EYE_X	-1.899	in	-1.899	in	0.000	in
POSTURE_DHM2_EYE_Z	41.482	in	41.483	in	0.000	in
Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-1.915	in	-1.915	in	0.000	in
POSTURE_DHM3_HIP_Z	17.239	in	17.239	in	0.000	in
POSTURE_DHM3_EYE_X	-1.897	in	-1.897	in	0.000	in
POSTURE_DHM3_EYE_Z	43.230	in	43.230	in	0.000	in
Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.942	in	-1.942	in	0.000	in
POSTURE_DHM4_HIP_Z	17.384	in	17.384	in	0.000	in
POSTURE_DHM4_EYE_X	-1.874	in	-1.874	in	0.000	in
POSTURE_DHM4_EYE_Z	44.125	in	44.125	in	0.000	in
Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-1.956	in	-1.956	in	0.000	in
POSTURE_DHM5_HIP_Z	17.390	in	17.390	in	0.000	in
POSTURE_DHM5_EYE_X	-1.861	in	-1.861	in	0.000	in
POSTURE_DHM5_EYE_Z	44.238	in	44.238	in	0.000	in
Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.787	in	-1.787	in	0.000	in
POSTURE_DHM6_HIP_Z	17.439	in	17.439	in	0.000	in
POSTURE_DHM6_EYE_X	-2.011	in	-2.011	in	0.000	in
POSTURE_DHM6_EYE_Z	44.456	in	44.456	in	0.000	in
Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.554	in	-1.554	in	0.000	in
POSTURE_DHM7_HIP_Z	17.516	in	17.516	in	0.000	in
POSTURE_DHM7_EYE_X	-2.217	in	-2.217	in	0.000	in
POSTURE_DHM7_EYE_Z	45.204	in	45.204	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.000 inches

Values in agreement

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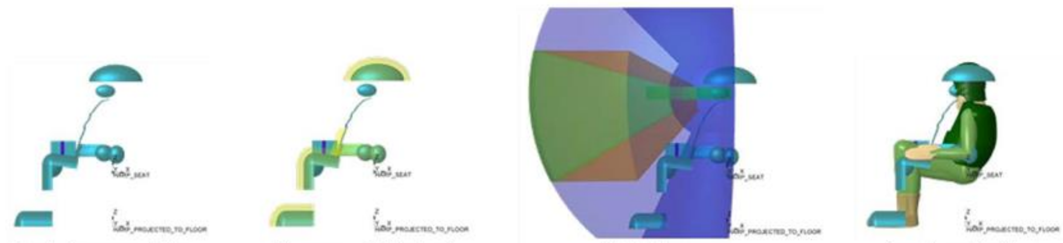
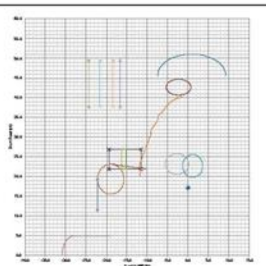
9.2.6. Test #6 – Numerical results

TEST #6: USE ALTERNATE HARP TOOL

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
6	90%	85%	PPE	17.1	ISO 5353	No	Use alternate HARP tool



Basic Accommodation | Clearance (2.0 inches) | Vision Zones | Boundary Manikins



UMTRI Spreadsheet

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.010 degrees

Manikin Placement:
0.000 inches

Values in agreement

33

TEST #6: RESULTS, ACCOMMODATION

HARP

	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	17.126	in	17.126	in	0.000	in

Eyellipse

	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-2.330	in	-2.330	in	0.000	in
EYELLIPSE_CENTROID_Y(+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	42.679	in	42.680	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	6.126	in	6.130	in	0.004	in
EYELLIPSE_Y_AXIS_LENGTH	2.046	in	2.048	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.031	in	4.032	in	0.001	in

Helmet Boundary

	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	0.918	in	0.918	in	0.000	in
HELMET_CONTOUR_CENTROID_Y(+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	45.663	in	45.664	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	16.728	in	16.732	in	0.004	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.716	in	9.717	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	10.803	in	10.803	in	0.001	in

Seat Back Angle

	UMTRI Value		GVSC Value		Difference	
SEAT_BACK_ANGLE_MEAN	16.232	deg	16.232	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	14.535	deg	14.545	deg	0.010	deg

Torso Boundary

	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_PPE_X	-5.428	in	-5.430	in	0.001	in
TORSO_WEIGHTED_REF_PT_PPE_Z	34.373	in	34.373	in	0.000	in
TORSO_ROTATION_WRT_HARP	2.638	deg	2.638	deg	0.000	deg

Keyboard Position -- Preferred

	UMTRI Value		GVSC Value		Difference	
KBOARD_PREF_CTR_OF_TRAVEL_X	-15.489	in	-15.489	in	0.000	in
KBOARD_PREF_CTR_OF_TRAVEL_Z	24.442	in	24.442	in	0.000	in
KBOARD_PREF_FORE_AFT_TRAVEL	7.920	in	7.922	in	0.002	in
KBOARD_PREF_VERTICAL_TRAVEL	5.035	in	5.036	in	0.001	in

Keyboard Position -- Acceptable

	UMTRI Value		GVSC Value		Difference	
KBOARD_OK_CTR_OF_TRAVEL_X	-15.777	in	-15.777	in	0.001	in
KBOARD_OK_CTR_OF_TRAVEL_Z	24.442	in	24.442	in	0.000	in
KBOARD_OK_FORE_AFT_TRAVEL	1.060	in	1.061	in	0.001	in
KBOARD_OK_VERTICAL_TRAVEL	5.035	in	5.036	in	0.001	in

Knee Boundary

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.948	in	-18.948	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y(+/	8.246	in	8.246	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.313	in	19.313	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.463	in	6.465	in	0.003	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.997	in	10.000	in	0.003	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.594	in	7.596	in	0.002	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	8.151	deg	8.151	deg	0.000	deg

Elbow Boundary

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-2.725	in	-2.725	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y(	11.459	in	11.459	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	23.169	in	23.169	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	5.690	in	5.694	in	0.004	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	3.727	in	3.728	in	0.001	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	5.291	in	5.293	in	0.003	in

Elbow Boundary -- Resting

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	1.141	in	1.141	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y(	12.379	in	12.379	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	22.708	in	22.708	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	5.021	in	5.024	in	0.003	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.777	in	3.777	in	0.000	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.788	in	5.790	in	0.003	in

Boot Boundary

	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-27.950	in	-27.950	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y(+/-)	8.246	in	8.246	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	5.815	in	5.818	in	0.003	in
BOOT_TOE_Y_AXIS_LENGTH	9.666	in	9.669	in	0.003	in
BOOT_TOE_Z_AXIS_LENGTH	9.843	in	9.843	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.004 inches
0.010 degrees

Values in agreement

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Test #6: Results, Manikin Positioning

Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-2.372	in	-2.372	in	0.000	in
POSTURE_DHM1_HIP_Z	16.717	in	16.717	in	0.000	in
POSTURE_DHM1_EYE_X	-1.863	in	-1.863	in	0.000	in
POSTURE_DHM1_EYE_Z	39.832	in	39.832	in	0.000	in

Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-2.110	in	-2.110	in	0.000	in
POSTURE_DHM2_HIP_Z	16.956	in	16.956	in	0.000	in
POSTURE_DHM2_EYE_X	-2.096	in	-2.096	in	0.000	in
POSTURE_DHM2_EYE_Z	41.482	in	41.483	in	0.000	in

Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-2.112	in	-2.112	in	0.000	in
POSTURE_DHM3_HIP_Z	17.239	in	17.239	in	0.000	in
POSTURE_DHM3_EYE_X	-2.094	in	-2.094	in	0.000	in
POSTURE_DHM3_EYE_Z	43.230	in	43.230	in	0.000	in

Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-2.138	in	-2.139	in	0.000	in
POSTURE_DHM4_HIP_Z	17.384	in	17.384	in	0.000	in
POSTURE_DHM4_EYE_X	-2.071	in	-2.070	in	0.000	in
POSTURE_DHM4_EYE_Z	44.125	in	44.125	in	0.000	in

Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-2.153	in	-2.153	in	0.000	in
POSTURE_DHM5_HIP_Z	17.390	in	17.390	in	0.000	in
POSTURE_DHM5_EYE_X	-2.058	in	-2.058	in	0.000	in
POSTURE_DHM5_EYE_Z	44.238	in	44.238	in	0.000	in

Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.984	in	-1.984	in	0.000	in
POSTURE_DHM6_HIP_Z	17.439	in	17.439	in	0.000	in
POSTURE_DHM6_EYE_X	-2.208	in	-2.208	in	0.000	in
POSTURE_DHM6_EYE_Z	44.456	in	44.456	in	0.000	in

Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.751	in	-1.751	in	0.000	in
POSTURE_DHM7_HIP_Z	17.516	in	17.516	in	0.000	in
POSTURE_DHM7_EYE_X	-2.414	in	-2.414	in	0.000	in
POSTURE_DHM7_EYE_Z	45.204	in	45.204	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.000 inches

Values in agreement

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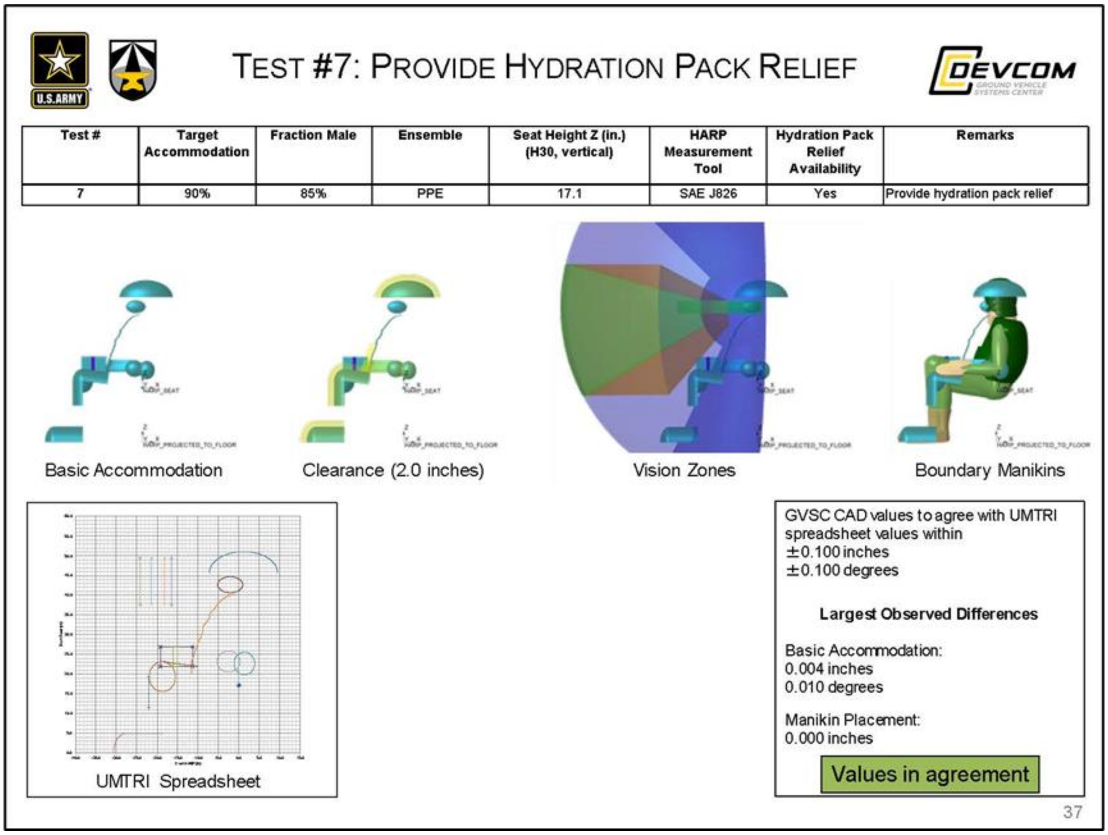
9.2.7. Test #7 – Numerical results



TEST #7: RESULTS, ACCOMMODATION

HARP

	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	17.126	in	17.126	in	0.000	in

Eyellipse

	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-2.134	in	-2.134	in	0.000	in
EYELLIPSE_CENTROID_Y(+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	42.679	in	42.680	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	6.126	in	6.130	in	0.004	in
EYELLIPSE_Y_AXIS_LENGTH	2.046	in	2.048	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.031	in	4.032	in	0.001	in

Helmet Boundary

	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	1.114	in	1.114	in	0.000	in
HELMET_CONTOUR_CENTROID_Y(+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	45.663	in	45.664	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	16.728	in	16.732	in	0.004	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.716	in	9.717	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	10.803	in	10.803	in	0.001	in

Seat Back Angle

	UMTRI Value		GVSC Value		Difference	
SEAT_BACK_ANGLE_MEAN	16.232	deg	16.232	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	14.535	deg	14.545	deg	0.010	deg

Torso Boundary

	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_PPE_X	-5.232	in	-5.233	in	0.001	in
TORSO_WEIGHTED_REF_PT_PPE_Z	34.373	in	34.373	in	0.000	in
TORSO_ROTATION_WRT_HARP	2.638	deg	2.638	deg	0.000	deg

Keyboard Position -- Preferred

	UMTRI Value		GVSC Value		Difference	
KBOARD_PREF_CTR_OF_TRAVEL_X	-15.293	in	-15.293	in	0.000	in
KBOARD_PREF_CTR_OF_TRAVEL_Z	24.442	in	24.442	in	0.000	in
KBOARD_PREF_FORE_AFT_TRAVEL	7.920	in	7.922	in	0.002	in
KBOARD_PREF_VERTICAL_TRAVEL	5.035	in	5.036	in	0.001	in

Keyboard Position -- Acceptable

	UMTRI Value		GVSC Value		Difference	
KBOARD_OK_CTR_OF_TRAVEL_X	-15.580	in	-15.581	in	0.000	in
KBOARD_OK_CTR_OF_TRAVEL_Z	24.442	in	24.442	in	0.000	in
KBOARD_OK_FORE_AFT_TRAVEL	1.060	in	1.061	in	0.001	in
KBOARD_OK_VERTICAL_TRAVEL	5.035	in	5.036	in	0.001	in

Knee Boundary

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.751	in	-18.751	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y(+/	8.246	in	8.246	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.313	in	19.313	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.463	in	6.465	in	0.003	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.997	in	10.000	in	0.003	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.594	in	7.596	in	0.002	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	8.151	deg	8.151	deg	0.000	deg

Elbow Boundary

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-2.528	in	-2.528	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y(	11.459	in	11.459	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	23.169	in	23.169	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	5.690	in	5.694	in	0.004	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	3.727	in	3.728	in	0.001	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	5.291	in	5.293	in	0.003	in

Elbow Boundary -- Resting

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	1.338	in	1.338	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y(	12.379	in	12.379	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	22.708	in	22.708	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	5.021	in	5.024	in	0.003	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.777	in	3.777	in	0.000	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.788	in	5.790	in	0.003	in

Boot Boundary

	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-27.753	in	-27.753	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y(+/-)	8.246	in	8.246	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	5.815	in	5.818	in	0.003	in
BOOT_TOE_Y_AXIS_LENGTH	9.666	in	9.669	in	0.003	in
BOOT_TOE_Z_AXIS_LENGTH	9.843	in	9.843	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.004 inches
0.010 degrees

Values in agreement

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TEST #7: RESULTS, MANIKIN POSITIONING

Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-2.176	in	-2.176	in	0.000	in
POSTURE_DHM1_HIP_Z	16.717	in	16.717	in	0.000	in
POSTURE_DHM1_EYE_X	-1.666	in	-1.666	in	0.000	in
POSTURE_DHM1_EYE_Z	39.832	in	39.832	in	0.000	in
Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-1.913	in	-1.913	in	0.000	in
POSTURE_DHM2_HIP_Z	16.956	in	16.956	in	0.000	in
POSTURE_DHM2_EYE_X	-1.899	in	-1.899	in	0.000	in
POSTURE_DHM2_EYE_Z	41.482	in	41.483	in	0.000	in
Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-1.915	in	-1.915	in	0.000	in
POSTURE_DHM3_HIP_Z	17.239	in	17.239	in	0.000	in
POSTURE_DHM3_EYE_X	-1.897	in	-1.897	in	0.000	in
POSTURE_DHM3_EYE_Z	43.230	in	43.230	in	0.000	in
Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.942	in	-1.942	in	0.000	in
POSTURE_DHM4_HIP_Z	17.384	in	17.384	in	0.000	in
POSTURE_DHM4_EYE_X	-1.874	in	-1.874	in	0.000	in
POSTURE_DHM4_EYE_Z	44.125	in	44.125	in	0.000	in
Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-1.956	in	-1.956	in	0.000	in
POSTURE_DHM5_HIP_Z	17.390	in	17.390	in	0.000	in
POSTURE_DHM5_EYE_X	-1.861	in	-1.861	in	0.000	in
POSTURE_DHM5_EYE_Z	44.238	in	44.238	in	0.000	in
Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.787	in	-1.787	in	0.000	in
POSTURE_DHM6_HIP_Z	17.439	in	17.439	in	0.000	in
POSTURE_DHM6_EYE_X	-2.011	in	-2.011	in	0.000	in
POSTURE_DHM6_EYE_Z	44.456	in	44.456	in	0.000	in
Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.554	in	-1.554	in	0.000	in
POSTURE_DHM7_HIP_Z	17.516	in	17.516	in	0.000	in
POSTURE_DHM7_EYE_X	-2.217	in	-2.217	in	0.000	in
POSTURE_DHM7_EYE_Z	45.204	in	45.204	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.000 inches

Values in agreement

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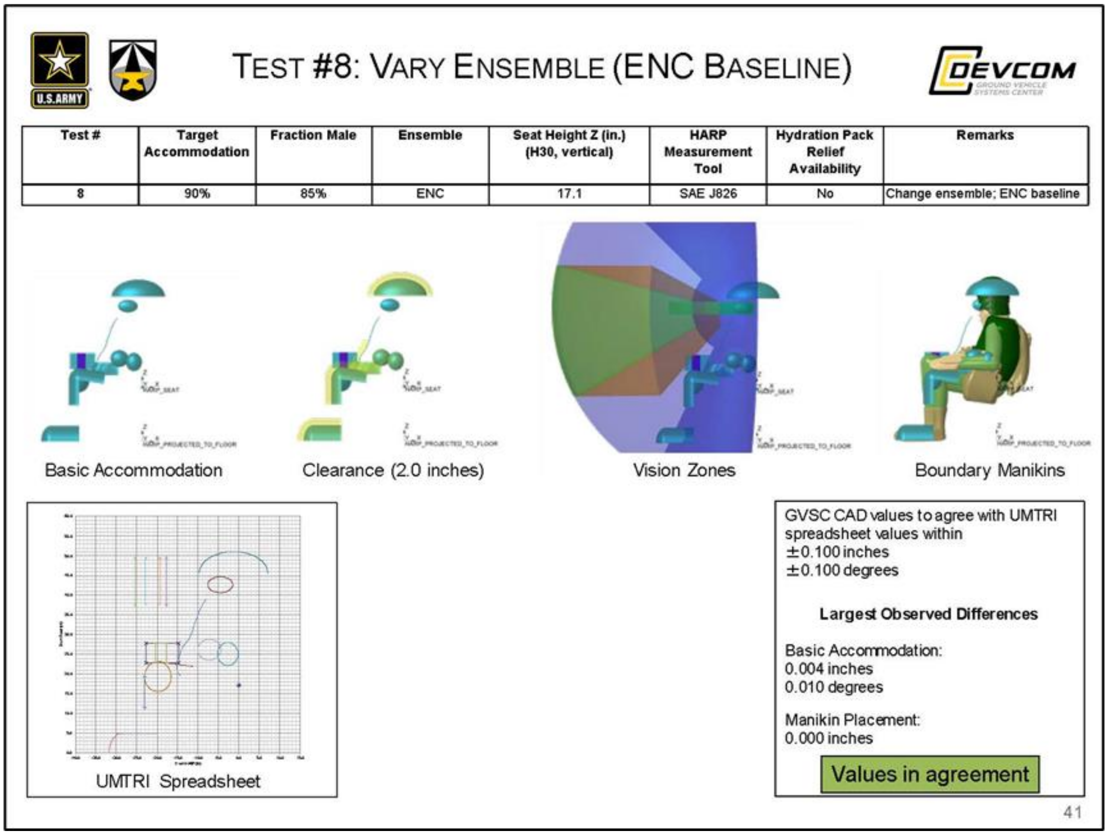
9.2.8. Test #8 – Numerical results



Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
8	90%	85%	ENC	17.1	SAE J826	No	Change ensemble; ENC baseline

TEST #8: RESULTS, ACCOMMODATION

HARP

	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	17.126	in	17.126	in	0.000	in

Eyellipse

	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-4.551	in	-4.551	in	0.000	in
EYELLIPSE_CENTROID_Y(+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	42.679	in	42.680	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	6.126	in	6.130	in	0.004	in
EYELLIPSE_Y_AXIS_LENGTH	2.046	in	2.048	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.031	in	4.032	in	0.001	in

Helmet Boundary

	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	-1.303	in	-1.303	in	0.000	in
HELMET_CONTOUR_CENTROID_Y(+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	45.663	in	45.664	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	16.728	in	16.732	in	0.004	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.716	in	9.717	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	10.803	in	10.803	in	0.001	in

Seat Back Angle

	UMTRI Value		GVSC Value		Difference	
SEAT_BACK_ANGLE_MEAN	19.232	deg	19.232	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	14.535	deg	14.545	deg	0.010	deg

Torso Boundary

	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_ENC_X	-12.759	in	-12.761	in	0.002	in
TORSO_WEIGHTED_REF_PT_ENC_Z	28.898	in	28.898	in	0.000	in
TORSO_ROTATION_WRT_HARP	4.938	deg	4.938	deg	0.000	deg

Keyboard Position -- Preferred

	UMTRI Value		GVSC Value		Difference	
KBOARD_PREF_CTR_OF_TRAVEL_X	-18.742	in	-18.741	in	0.000	in
KBOARD_PREF_CTR_OF_TRAVEL_Z	25.336	in	25.336	in	0.000	in
KBOARD_PREF_FORE_AFT_TRAVEL	7.920	in	7.922	in	0.002	in
KBOARD_PREF_VERTICAL_TRAVEL	5.035	in	5.036	in	0.001	in

Keyboard Position -- Acceptable

	UMTRI Value		GVSC Value		Difference	
KBOARD_OK_CTR_OF_TRAVEL_X	-19.129	in	-19.130	in	0.000	in
KBOARD_OK_CTR_OF_TRAVEL_Z	25.336	in	25.336	in	0.000	in
KBOARD_OK_FORE_AFT_TRAVEL	2.623	in	2.624	in	0.001	in
KBOARD_OK_VERTICAL_TRAVEL	5.035	in	5.036	in	0.001	in

Knee Boundary

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-19.834	in	-19.834	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y(+/	8.246	in	8.246	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.313	in	19.313	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.463	in	6.465	in	0.003	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.997	in	10.000	in	0.003	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.594	in	7.596	in	0.002	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	8.151	deg	8.151	deg	0.000	deg

Elbow Boundary

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-7.202	in	-7.202	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y(	12.715	in	12.715	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	26.177	in	26.177	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	5.690	in	5.694	in	0.004	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	3.727	in	3.728	in	0.001	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	5.291	in	5.293	in	0.003	in

Elbow Boundary -- Resting

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	-2.687	in	-2.687	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y(	14.677	in	14.677	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	25.071	in	25.071	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	5.021	in	5.024	in	0.003	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.777	in	3.777	in	0.000	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.788	in	5.790	in	0.003	in

Boot Boundary

	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-28.836	in	-28.836	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y(+/-)	8.246	in	8.246	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	5.815	in	5.818	in	0.003	in
BOOT_TOE_Y_AXIS_LENGTH	9.666	in	9.669	in	0.003	in
BOOT_TOE_Z_AXIS_LENGTH	9.843	in	9.843	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.004 inches
0.010 degrees

Values in agreement

42

Test #8: Results, Manikin Positioning

	UMTRI Value		GVSC Value		Difference	
Small Overall Female						
POSTURE_DHM1_HIP_X	-3.573	in	-3.573	in	0.000	in
POSTURE_DHM1_HIP_Z	16.516	in	16.516	in	0.000	in
POSTURE_DHM1_EYE_X	-4.084	in	-4.084	in	0.000	in
POSTURE_DHM1_EYE_Z	39.832	in	39.832	in	0.000	in
Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-3.310	in	-3.310	in	0.000	in
POSTURE_DHM2_HIP_Z	16.755	in	16.755	in	0.000	in
POSTURE_DHM2_EYE_X	-4.317	in	-4.317	in	0.000	in
POSTURE_DHM2_EYE_Z	41.482	in	41.483	in	0.000	in
Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-3.313	in	-3.313	in	0.000	in
POSTURE_DHM3_HIP_Z	17.038	in	17.038	in	0.000	in
POSTURE_DHM3_EYE_X	-4.315	in	-4.315	in	0.000	in
POSTURE_DHM3_EYE_Z	43.230	in	43.230	in	0.000	in
Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-3.339	in	-3.339	in	0.000	in
POSTURE_DHM4_HIP_Z	17.183	in	17.183	in	0.000	in
POSTURE_DHM4_EYE_X	-4.291	in	-4.291	in	0.000	in
POSTURE_DHM4_EYE_Z	44.125	in	44.125	in	0.000	in
Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-3.354	in	-3.354	in	0.000	in
POSTURE_DHM5_HIP_Z	17.189	in	17.189	in	0.000	in
POSTURE_DHM5_EYE_X	-4.278	in	-4.278	in	0.000	in
POSTURE_DHM5_EYE_Z	44.238	in	44.238	in	0.000	in
Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-3.184	in	-3.184	in	0.000	in
POSTURE_DHM6_HIP_Z	17.238	in	17.238	in	0.000	in
POSTURE_DHM6_EYE_X	-4.428	in	-4.428	in	0.000	in
POSTURE_DHM6_EYE_Z	44.456	in	44.456	in	0.000	in
Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-2.952	in	-2.952	in	0.000	in
POSTURE_DHM7_HIP_Z	17.315	in	17.315	in	0.000	in
POSTURE_DHM7_EYE_X	-4.635	in	-4.635	in	0.000	in
POSTURE_DHM7_EYE_Z	45.204	in	45.204	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.000 inches

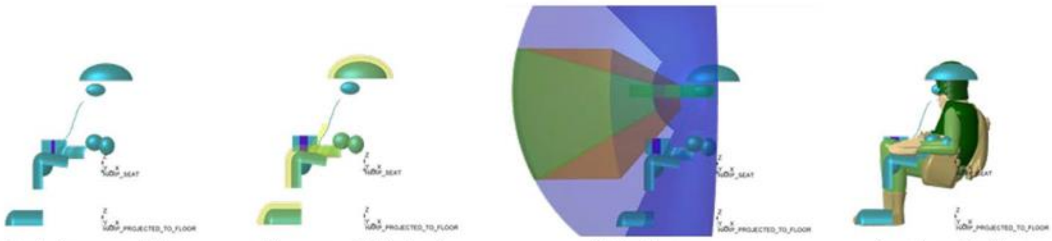
Values in agreement

43

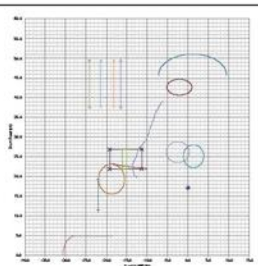
9.2.9. Test #9 – Numerical results

Test #9: Provide Hydration Pack Relief

Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
9	90%	85%	ENC	17.1	SAE J826	Yes	Provide hydration pack relief



Basic Accommodation | Clearance (2.0 inches) | Vision Zones | Boundary Manikins



UMTRI Spreadsheet

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences

Basic Accommodation:
0.004 inches
0.010 degrees

Manikin Placement:
0.000 inches

Values in agreement

45

Test #9: Results, Accommodation

HARP

	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	17.126	in	17.126	in	0.000	in

Eyellipse

	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-2.134	in	-2.134	in	0.000	in
EYELLIPSE_CENTROID_Y(+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	42.679	in	42.680	in	0.001	in
EYELLIPSE_X_AXIS_LENGTH	6.126	in	6.130	in	0.004	in
EYELLIPSE_Y_AXIS_LENGTH	2.046	in	2.048	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	4.031	in	4.032	in	0.001	in

Helmet Boundary

	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	1.114	in	1.114	in	0.000	in
HELMET_CONTOUR_CENTROID_Y(+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	45.663	in	45.664	in	0.001	in
HELMET_CONTOUR_X_AXIS_LENGTH	16.728	in	16.732	in	0.004	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.716	in	9.717	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	10.803	in	10.803	in	0.001	in

Seat Back Angle

	UMTRI Value		GVSC Value		Difference	
SEAT_BACK_ANGLE_MEAN	16.232	deg	16.232	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	14.535	deg	14.545	deg	0.010	deg

Torso Boundary

	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_ENC_X	-11.031	in	-11.032	in	0.001	in
TORSO_WEIGHTED_REF_PT_ENC_Z	28.898	in	28.898	in	0.000	in
TORSO_ROTATION_WRT_HARP	4.938	deg	4.938	deg	0.000	deg

Keyboard Position -- Preferred

	UMTRI Value		GVSC Value		Difference	
KBOARD_PREF_CTR_OF_TRAVEL_X	-15.293	in	-15.293	in	0.000	in
KBOARD_PREF_CTR_OF_TRAVEL_Z	24.443	in	24.442	in	0.000	in
KBOARD_PREF_FORE_AFT_TRAVEL	7.920	in	7.922	in	0.002	in
KBOARD_PREF_VERTICAL_TRAVEL	5.035	in	5.036	in	0.001	in

Keyboard Position -- Acceptable

	UMTRI Value		GVSC Value		Difference	
KBOARD_OK_CTR_OF_TRAVEL_X	-15.580	in	-15.581	in	0.000	in
KBOARD_OK_CTR_OF_TRAVEL_Z	24.443	in	24.442	in	0.000	in
KBOARD_OK_FORE_AFT_TRAVEL	1.060	in	1.061	in	0.001	in
KBOARD_OK_VERTICAL_TRAVEL	5.035	in	5.036	in	0.001	in

Knee Boundary

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.751	in	-18.751	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y(+/	8.246	in	8.246	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	19.313	in	19.313	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	6.463	in	6.465	in	0.003	in
KNEE_CONTOUR_Y_AXIS_LENGTH	9.997	in	10.000	in	0.003	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.594	in	7.596	in	0.002	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	8.151	deg	8.151	deg	0.000	deg

Elbow Boundary

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-2.528	in	-2.528	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y(	12.715	in	12.715	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	26.177	in	26.177	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	5.690	in	5.694	in	0.004	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	3.727	in	3.728	in	0.001	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	5.291	in	5.293	in	0.003	in

Elbow Boundary -- Resting

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	1.338	in	1.338	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y(	14.611	in	14.611	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	25.157	in	25.157	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	5.021	in	5.024	in	0.003	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.777	in	3.777	in	0.000	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	5.788	in	5.790	in	0.003	in

Boot Boundary

	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-27.753	in	-27.753	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y(+/-)	8.246	in	8.246	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	5.815	in	5.818	in	0.003	in
BOOT_TOE_Y_AXIS_LENGTH	9.666	in	9.669	in	0.003	in
BOOT_TOE_Z_AXIS_LENGTH	9.843	in	9.843	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.004 inches
0.010 degrees

Values in agreement

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TEST #9: RESULTS, MANIKIN POSITIONING

	UMTRI Value		GVSC Value		Difference	
Small Overall Female						
POSTURE_DHM1_HIP_X	-2.176	in	-2.176	in	0.000	in
POSTURE_DHM1_HIP_Z	16.717	in	16.717	in	0.000	in
POSTURE_DHM1_EYE_X	-1.666	in	-1.666	in	0.000	in
POSTURE_DHM1_EYE_Z	39.832	in	39.832	in	0.000	in
Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-1.913	in	-1.913	in	0.000	in
POSTURE_DHM2_HIP_Z	16.956	in	16.956	in	0.000	in
POSTURE_DHM2_EYE_X	-1.899	in	-1.899	in	0.000	in
POSTURE_DHM2_EYE_Z	41.482	in	41.483	in	0.000	in
Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-1.915	in	-1.915	in	0.000	in
POSTURE_DHM3_HIP_Z	17.239	in	17.239	in	0.000	in
POSTURE_DHM3_EYE_X	-1.897	in	-1.897	in	0.000	in
POSTURE_DHM3_EYE_Z	43.230	in	43.230	in	0.000	in
Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-1.942	in	-1.942	in	0.000	in
POSTURE_DHM4_HIP_Z	17.384	in	17.384	in	0.000	in
POSTURE_DHM4_EYE_X	-1.874	in	-1.874	in	0.000	in
POSTURE_DHM4_EYE_Z	44.125	in	44.125	in	0.000	in
Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-1.956	in	-1.956	in	0.000	in
POSTURE_DHM5_HIP_Z	17.390	in	17.390	in	0.000	in
POSTURE_DHM5_EYE_X	-1.861	in	-1.861	in	0.000	in
POSTURE_DHM5_EYE_Z	44.238	in	44.238	in	0.000	in
Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.787	in	-1.787	in	0.000	in
POSTURE_DHM6_HIP_Z	17.439	in	17.439	in	0.000	in
POSTURE_DHM6_EYE_X	-2.011	in	-2.011	in	0.000	in
POSTURE_DHM6_EYE_Z	44.456	in	44.456	in	0.000	in
Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.554	in	-1.554	in	0.000	in
POSTURE_DHM7_HIP_Z	17.516	in	17.516	in	0.000	in
POSTURE_DHM7_EYE_X	-2.217	in	-2.217	in	0.000	in
POSTURE_DHM7_EYE_Z	45.204	in	45.204	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.000 inches

Values in agreement

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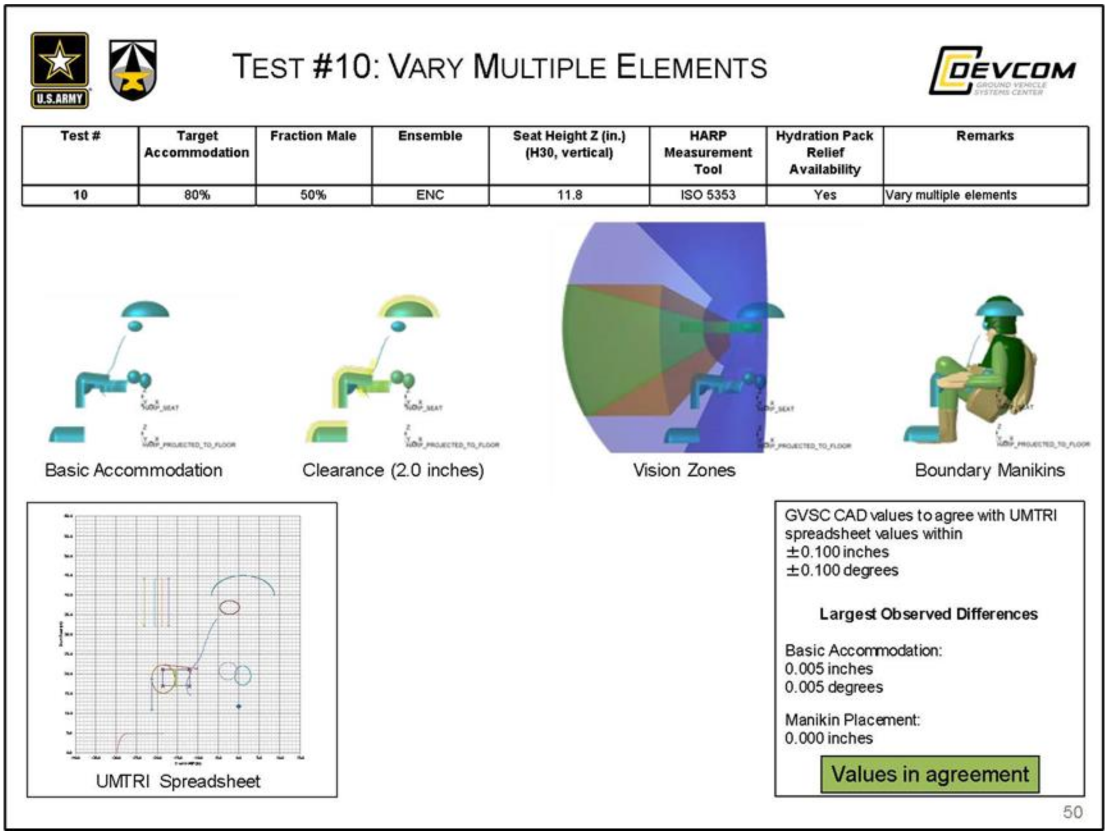
9.2.10. Test #10 – Numerical results



Test #	Target Accommodation	Fraction Male	Ensemble	Seat Height Z (in.) (H30, vertical)	HARP Measurement Tool	Hydration Pack Relief Availability	Remarks
10	80%	50%	ENC	11.8	ISO 5353	Yes	Vary multiple elements

TEST #10: RESULTS, ACCOMMODATION

HARP

	UMTRI Value		GVSC Value		Difference	
HARP_X	0.000	in	0.000	in	0.000	in
HARP_Z	11.811	in	11.811	in	0.000	in

Eyellipse

	UMTRI Value		GVSC Value		Difference	
EYELLIPSE_CENTROID_X	-2.266	in	-2.266	in	0.000	in
EYELLIPSE_CENTROID_Y(+/-)	1.280	in	1.280	in	0.000	in
EYELLIPSE_CENTROID_Z	36.902	in	36.902	in	0.000	in
EYELLIPSE_X_AXIS_LENGTH	4.772	in	4.774	in	0.002	in
EYELLIPSE_Y_AXIS_LENGTH	1.594	in	1.595	in	0.001	in
EYELLIPSE_Z_AXIS_LENGTH	3.436	in	3.435	in	0.001	in

Helmet Boundary

	UMTRI Value		GVSC Value		Difference	
HELMET_CONTOUR_CENTROID_X	0.982	in	0.982	in	0.000	in
HELMET_CONTOUR_CENTROID_Y(+/-)	2.185	in	2.185	in	0.000	in
HELMET_CONTOUR_CENTROID_Z	39.887	in	39.887	in	0.000	in
HELMET_CONTOUR_X_AXIS_LENGTH	15.374	in	15.376	in	0.002	in
HELMET_CONTOUR_Y_AXIS_LENGTH	9.264	in	9.264	in	0.001	in
HELMET_CONTOUR_Z_AXIS_LENGTH	10.208	in	10.207	in	0.001	in

Seat Back Angle

	UMTRI Value		GVSC Value		Difference	
SEAT_BACK_ANGLE_MEAN	15.682	deg	15.681	deg	0.000	deg
SEAT_BACK_ANGLE_RANGE	11.406	deg	11.411	deg	0.005	deg

Torso Boundary

	UMTRI Value		GVSC Value		Difference	
TORSO_WEIGHTED_REF_PT_ENC_X	-10.861	in	-10.862	in	0.001	in
TORSO_WEIGHTED_REF_PT_ENC_Z	23.583	in	23.583	in	0.000	in
TORSO_ROTATION_WRT_HARP	4.624	deg	4.624	deg	0.000	deg

Keyboard Position -- Preferred

	UMTRI Value		GVSC Value		Difference	
KBOARD_PREF_CTR_OF_TRAVEL_X	-15.406	in	-15.406	in	0.000	in
KBOARD_PREF_CTR_OF_TRAVEL_Z	19.064	in	19.064	in	0.000	in
KBOARD_PREF_FORE_AFT_TRAVEL	6.575	in	6.580	in	0.005	in
KBOARD_PREF_VERTICAL_TRAVEL	4.179	in	4.182	in	0.003	in

Keyboard Position -- Acceptable

	UMTRI Value		GVSC Value		Difference	
KBOARD_OK_CTR_OF_TRAVEL_X	-15.525	in	-15.525	in	0.000	in
KBOARD_OK_CTR_OF_TRAVEL_Z	19.064	in	19.064	in	0.000	in
KBOARD_OK_FORE_AFT_TRAVEL	0.170	in	0.174	in	0.004	in
KBOARD_OK_VERTICAL_TRAVEL	4.179	in	4.182	in	0.003	in

Knee Boundary

	UMTRI Value		GVSC Value		Difference	
KNEE_CONTOUR_WEIGHTED_CENT_X	-18.495	in	-18.495	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Y(+/	7.850	in	7.850	in	0.000	in
KNEE_CONTOUR_WEIGHTED_CENT_Z	18.776	in	18.776	in	0.000	in
KNEE_CONTOUR_X_AXIS_LENGTH	5.653	in	5.653	in	0.000	in
KNEE_CONTOUR_Y_AXIS_LENGTH	8.834	in	8.836	in	0.001	in
KNEE_CONTOUR_Z_AXIS_LENGTH	7.155	in	7.154	in	0.001	in
KNEE_SHIN_ANGLE	0.000	deg	0.000	deg	0.000	deg
KNEE_THIGH_ANGLE	6.884	deg	6.884	deg	0.000	deg

Elbow Boundary

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_DYN_WEIGHTED_CENT_X	-2.631	in	-2.631	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Y(	12.353	in	12.353	in	0.000	in
ELBOW_CON_DYN_WEIGHTED_CENT_Z	20.749	in	20.749	in	0.000	in
ELBOW_CON_DYN_X_AXIS_LENGTH	4.431	in	4.433	in	0.002	in
ELBOW_CON_DYN_Y_AXIS_LENGTH	3.006	in	3.006	in	0.000	in
ELBOW_CON_DYN_Z_AXIS_LENGTH	4.420	in	4.422	in	0.002	in

Elbow Boundary -- Resting

	UMTRI Value		GVSC Value		Difference	
ELBOW_CON_REST_WEIGHTED_CENT_X	0.964	in	0.964	in	0.000	in
ELBOW_CON_REST_WEIGHTED_CENT_Y(	14.208	in	14.208	in	0.000	in
ELBOW_REST_DYN_WEIGHTED_CENT_Z	19.635	in	19.635	in	0.000	in
ELBOW_CON_REST_X_AXIS_LENGTH	3.930	in	3.931	in	0.002	in
ELBOW_CON_REST_Y_AXIS_LENGTH	3.055	in	3.055	in	0.000	in
ELBOW_REST_DYN_Z_AXIS_LENGTH	4.845	in	4.847	in	0.001	in

Boot Boundary

	UMTRI Value		GVSC Value		Difference	
BOOT_TOE_WEIGHTED_CENT_X	-27.273	in	-27.273	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Y(+/-)	7.850	in	7.850	in	0.000	in
BOOT_TOE_WEIGHTED_CENT_Z	0.000	in	0.000	in	0.000	in
BOOT_TOE_X_AXIS_LENGTH	4.954	in	4.953	in	0.001	in
BOOT_TOE_Y_AXIS_LENGTH	8.504	in	8.505	in	0.001	in
BOOT_TOE_Z_AXIS_LENGTH	9.843	in	9.843	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.005 inches
0.005 degrees

Values in agreement

51

TEST #10: RESULTS, MANIKIN POSITIONING

Small Overall Female						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM1_HIP_X	-2.372	in	-2.372	in	0.000	in
POSTURE_DHM1_HIP_Z	11.402	in	11.402	in	0.000	in
POSTURE_DHM1_EYE_X	-1.863	in	-1.863	in	0.000	in
POSTURE_DHM1_EYE_Z	34.517	in	34.517	in	0.000	in
Small Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM2_HIP_X	-2.110	in	-2.110	in	0.000	in
POSTURE_DHM2_HIP_Z	11.641	in	11.641	in	0.000	in
POSTURE_DHM2_EYE_X	-2.096	in	-2.096	in	0.000	in
POSTURE_DHM2_EYE_Z	36.168	in	36.168	in	0.000	in
Average Size Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM3_HIP_X	-2.112	in	-2.112	in	0.000	in
POSTURE_DHM3_HIP_Z	11.924	in	11.924	in	0.000	in
POSTURE_DHM3_EYE_X	-2.094	in	-2.094	in	0.000	in
POSTURE_DHM3_EYE_Z	37.915	in	37.915	in	0.000	in
Widest Shoulders Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM4_HIP_X	-2.138	in	-2.139	in	0.000	in
POSTURE_DHM4_HIP_Z	12.069	in	12.069	in	0.000	in
POSTURE_DHM4_EYE_X	-2.071	in	-2.070	in	0.000	in
POSTURE_DHM4_EYE_Z	38.810	in	38.810	in	0.000	in
Longest Torso Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM5_HIP_X	-2.153	in	-2.153	in	0.000	in
POSTURE_DHM5_HIP_Z	12.075	in	12.075	in	0.000	in
POSTURE_DHM5_EYE_X	-2.058	in	-2.058	in	0.000	in
POSTURE_DHM5_EYE_Z	38.923	in	38.923	in	0.000	in
Longest Legs Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM6_HIP_X	-1.984	in	-1.984	in	0.000	in
POSTURE_DHM6_HIP_Z	12.124	in	12.124	in	0.000	in
POSTURE_DHM6_EYE_X	-2.208	in	-2.208	in	0.000	in
POSTURE_DHM6_EYE_Z	39.142	in	39.142	in	0.000	in
Large Overall Male						
	UMTRI Value		GVSC Value		Difference	
POSTURE_DHM7_HIP_X	-1.751	in	-1.751	in	0.000	in
POSTURE_DHM7_HIP_Z	12.201	in	12.201	in	0.000	in
POSTURE_DHM7_EYE_X	-2.414	in	-2.414	in	0.000	in
POSTURE_DHM7_EYE_Z	39.889	in	39.889	in	0.000	in

GVSC CAD values to agree with UMTRI spreadsheet values within
±0.100 inches
±0.100 degrees

Largest Observed Differences:
0.000 inches

Values in agreement

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9.3. Appendix C – References

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9.4. Appendix D – Distribution List

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9.5. APPENDIX E – VERIFICATION PLAN

The *Fixed Human Accommodation Reference Point (HARP): Commander CAD Accommodation Model Verification Plan* (2022) can be found on the DEVCOM GVSC website at http://www.usarmygvsc.com/index.php/accommodation-models/

The reference for the final plan is below:

Zielinski, G. and Huston II, F. (2022). U.S. Army DEVCOM Ground Vehicle Systems Center (GVSC) Fixed Human Accommodation Reference Point (HARP): Commander CAD Accommodation Model Verification Plan 31Aug2022v1. http://www.usarmygvsc.com/index.php/accommodation-models/. U.S. Army DEVCOM GVSC, Warren, MI.